51st CMOS Congress | 51e Congrès de la SCMO

Future Earth

Weather, Oceans, Climate

La Terre de l'avenir

Météo, océans, climat

CANADA 150

June 4 - 8th | 4 au 8 juin

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Welcome from the Premier of Ontario

Premier of Ontario • Première ministre de l'Ontario

June 5 – 8, 2017

A PERSONAL MESSAGE FROM THE PREMIER

On behalf of the Government of Ontario, I am delighted to extend warm wishes to the delegates of the 51st annual Canadian Meteorological and Oceanographic Society (CMOS) Scientific Congress.

I commend the members of CMOS for their commitment to advancing meteorology and oceanography in Canada. Like you, I and my colleagues in government recognize the global threat posed by climate change. Emissions do not recognize borders, and that is why it is very important for all industries, all jurisdictions and all disciplines to work together to reduce greenhouse gasses, develop clean energy, fight the effects of climate change, and work toward sustainable and clean growth.

Your members are valued partners in this endeavour, and we would like to welcome you here to Toronto.

Please accept my best wishes for a productive congress.

Kathleen Wynne
Premier

Bienvenue du premier ministre de l'Ontario

Premier of Ontario · Première ministre de l'Ontario

5 au 8 juin 2017

MESSAGE PERSONNEL DE LA PART DE
LA PREMIÈRE MINISTRE

Au nom du Gouvernement de l'Ontario, c'est avec grand plaisir que j'accueille chaleureusement les participants du 51[e] Congrès scientifique annuel de la Société canadienne de météorologie et d'océanographie.

Je félicite les membres de la SCMO pour leur dévouement à faire avancer la météorologie et l'océanographie au Canada. Comme vous, mes collègues du gouvernement et moi-même reconnaissons la menace mondiale que posent les changements climatiques. Les émissions ignorent les frontières. Pour cette raison, il importe que toutes les industries, tous les pouvoirs en place et toutes les disciplines soient mobilisés dans le but de réduire les gaz à effet de serre, de développer des énergies propres, de lutter contre les effets des changements climatiques et de viser une croissance durable et propre.

Vos membres sont des partenaires précieux de cette entreprise et nous leur souhaitons la bienvenue à Toronto.

Je vous offre mes meilleurs vœux pour un congrès productif.

Kathleen Wynne
Première ministre de l'Ontario

(Remarque : la version originale de la lettre de bienvenue est en anglais. Cette traduction en français est fournie par la SCMO.)

Welcome from the Mayor of Toronto

CITY OF

TORONTO

Message from the Mayor

It gives me great pleasure to extend greetings and a warm welcome to everyone attending the Canadian Meteorological and Oceanographic Society's 51st annual CMOS Scientific Congress.

As Canada's largest city and the fourth largest in North America, Toronto is a global centre for business, finance, arts and culture and is dedicated to being a model of sustainable development. I welcome everyone to our city and encourage you to enjoy Toronto at this time of year and learn about our vibrant neighbourhoods.

On behalf of Toronto City Council, please accept my best wishes for an informative and enjoyable event.

Yours truly,

John Tory
Mayor of Toronto

OFFICE OF THE MAYOR

100 QUEEN STREET WEST, TORONTO, ONTARIO MSH 2N2

Mot de bienvenue du maire de Toronto

TORONTO

Message du maire

C'est avec grand plaisir que j'accueille chaleureusement tous les participants du 51e Congrès scientifique annuel de la Société canadienne de météorologie et d'océanographie.

En tant que plus grande ville du Canada et quatrième en importance en Amérique du Nord, Toronto est un centre mondial du commerce, de la finance et de la culture, et il nous tient à cœur d'être un modèle de développement durable. Je vous souhaite la bienvenue dans notre ville. N'hésitez pas à profiter du printemps à Toronto et à explorer nos quartiers dynamiques.

De la part du conseil de ville de Toronto, je vous souhaite un congrès informatif et des plus agréables.

Sincèrement,

John Tory
Maire de Toronto

(Remarque : la version originale de la lettre de bienvenue est en anglais. Cette traduction en français est fournie par la SCMO.)

OFFICE OF THE MAYOR
100 QUEEN STREET WEST, TORONTO, ONTARIO M5H 2N2

Welcome from the Minister of Fisheries, Oceans and the Canadian Coast Guard

A message from the
Honourable Dominic LeBlanc
Minister of Fisheries, Oceans
and the Canadian Coast Guard

On behalf of the Government of Canada, I would like to welcome over 600 ocean, atmosphere and climate researchers and professionals to the 51st Congress of the Canadian Meteorological and Oceanographic Society.

The theme of this year's conference is aptly "*Future Earth: Weather, Oceans, Climate*". Given the rate at which each of these is changing, the need for coordinated science, research and stewardship has never been more important.

As Minister of Fisheries, Oceans and the Canadian Coast Guard, I understand the impact that changing atmospheric conditions are having on the world's oceans and weather patterns, and the threat this poses to our aquatic resources, coastal communities and marine industries. One of the key elements of my mandate is to examine the implications of climate change on Arctic marine ecosystems.

Addressing the complex issue of climate change requires extensive coordination, collaboration and cooperation both here at home and abroad. Science needs to be the foundation of all of our work. At Fisheries and Oceans Canada, scientific research, evidence, data and observations inform our decision-making, policies, regulations and enforcement measures.

That's why our government made an historic investment in aquatic science last year. This funding is allowing us to hire 135 scientists, designate more marine protected areas, foster vital partnerships and a host of other great work. Our new $1.5 billion Oceans Protection Plan also contains funding specific to scientific research that will be used to study our oceans and coastal areas.

Going forward, Fisheries and Oceans Canada will continue to contribute to national and international oceanographic programs and be an active member of the Intergovernmental Oceanographic Commission. We will also work with our partners on ocean climate models including the Canadian Centre for Climate Modelling and Analysis, the Canadian Foundation for Climate and Atmospheric Science, and the United States National Oceanic and Atmospheric Administration.

Our Government firmly believes that tackling climate change is a long-term, collective effort that must be framed within the context of scientific evidence, sound data and facts. We will continue to keep climate change at the forefront of our agenda as we help Canadians transition to a low carbon economy and understand that a strong economy and a clean environment go hand-in-hand.

I want to thank each of you for your scientific contributions and wish you all a productive conference.

Sincerely,

The Honourable Dominic LeBlanc, P.C., Q.C., M.P.
Minister of Fisheries, Oceans and the Canadian Coast Guard

Mot de bienvenue de ministre des Pêches, des Océans et de la Garde côtière canadienne

Un message de
l'honorable Dominic LeBlanc,
ministre des Pêches, des Océans
et de la Garde côtière canadienne

Au nom du gouvernement du Canada, j'aimerais souhaiter la bienvenue à plus de 600 chercheurs et professionnels en océanographie, en sciences atmosphériques et en climatologie au 51e Congrès de la Société canadienne de météorologie et d'océanographie.

Le thème de la conférence de cette année est approprié : « *La Terre de l'avenir : Météo, océans, climat* ». Compte tenu de la vitesse à laquelle ces éléments évoluent, la coordination des activités scientifiques, de la recherche et de l'intendance est plus importante que jamais.

En tant que ministre des Pêches, des Océans et de la Garde côtière canadienne, je comprends les répercussions des conditions atmosphériques changeantes sur les modèles océaniques et météorologiques de la planète, et la menace que cela représente pour nos ressources aquatiques, nos collectivités côtières et nos industries maritimes. Un des éléments clés de mon mandat consiste à examiner les répercussions du changement climatique sur les écosystèmes maritimes de l'Arctique.

Le traitement de l'enjeu complexe qu'est le changement climatique nécessite une coordination, une collaboration et une coopération étendues tant à l'échelle nationale qu'à l'étranger. La science doit être la pierre angulaire de tout notre travail. À Pêches et Océans Canada, la recherche scientifique, les éléments probants, les données et les observations aident à éclairer notre prise de décisions, nos politiques, nos règlements et nos mesures d'application de la loi.

C'est pourquoi notre gouvernement a effectué un investissement historique dans les sciences aquatiques l'an dernier. Ce financement nous permet d'embaucher 135 scientifiques, de désigner plus d'aires marines protégées, de favoriser des partenariats essentiels et beaucoup d'autres travaux remarquables. Notre tout nouveau Plan de protection des océans de 1,5 milliard de dollars comprend aussi des fonds destinés tout particulièrement à la recherche scientifique qui seront utilisés pour étudier nos océans et nos zones côtières.

À l'avenir, Pêches et Océans Canada continuera de contribuer aux programmes d'océanographie nationaux et internationaux, et d'être un membre actif de la Commission océanographique intergouvernementale. Nous travaillerons également avec nos partenaires sur les modèles climatiques océaniques, notamment avec le Centre canadien de la modélisation et de l'analyse climatique, la Fondation canadienne pour les sciences du climat et de l'atmosphère et la *National Oceanic and Atmospheric Administration* des États-Unis.

Notre gouvernement est fermement convaincu que la lutte contre le changement climatique représente un effort collectif à long terme, qui doit être encadré par des preuves scientifiques, des données fiables et des faits. Nous continuerons de garder le changement climatique au premier plan de notre programme, alors que nous aidons les Canadiens à passer à une économie à faible émission de carbone et à comprendre qu'une économie solide et un environnement propre vont de pair.

Je tiens à remercier chacun d'entre vous pour votre contribution à la science et vous souhaite à tous une conférence productive.

Cordialement,

L'honorable Dominic LeBlanc, C.P., c.r., député
Ministre des Pêches, des Océans et de la Garde côtière canadienne

Welcome from the Minister of Environment and Climate Change

Environment and Climate Change Canada | Environnement et Changement climatique Canada

Welcome from The Honorable Catherine McKenna
Minister of Environment and Climate Change Canada

I am very pleased to welcome you to the 51st Congress of the Canadian Meteorological and Oceanographic Society.

The theme "Future Earth: Weather, Oceans, Climate" and additional sessions on atmosphere, air quality, and inter-disciplinary science, resonate for me both professionally and personally. These are areas that are fundamental to the well-being of Canadians, and of our environment.

About one in ten Canadians earn their livings in the natural resource, agriculture, fisheries, and tourism sectors. Additionally, our environment supports recreational and healthy living activities, and sustains traditional indigenous lifestyles. This speaks to the importance of natural sciences particularly given that climate change represents one of the greatest challenges of our time.

Addressing climate change is an opportunity to transition to a strong, diverse and competitive low-carbon economy. The Pan-Canadian Framework on Clean Growth and Climate Change is Canada's plan – developed with the provinces and territories and in consultation with Indigenous peoples – to meet our emissions reduction target, building resilience to the impacts of climate change, and grow the economy. The Framework recognizes the importance of building climate resilience and sets out measures to help Canadians understand, plan for, and take action to adapt to the unavoidable impacts of climate change. United, and supported by academia, NGOs, and the private sector, we will undertake these challenges and commitments together. Your contributions to the body of relevant credible science help identify risks and opportunities, supporting decisions that will define our collective future.

The CMOS Congress is well timed with World Environment Day on June 5th, which Canada has the privilege to host this year. The theme is "Connecting People to Nature – in the city and on the land, from the poles to the equator". Having a connection to nature is something that will help all Canadians take ownership of the future of this planet.

I thank you for your valued contributions in atmospheric, ocean and earth sciences, and wish you all the best for a successful Congress.

Catherine McKenna
Minister of Environment and Climate Change Canada

Canada

Mot de bienvenue du Ministre d’Environnement et Changement climatique Canada

Environnement et Changement climatique Canada | Environment and Climate Change Canada

Mot de bienvenue de l’honorable Catherine McKenna

Ministre d’Environnement et Changement climatique Canada

Je suis très heureuse de vous souhaiter la bienvenue au 51e Congrès de la Société canadienne de météorologie et d’océanographie.

Le thème de votre Congrès, « Terre de l’avenir : Météo, océans, climat », ainsi que les thèmes des séances prévues portant sur l’atmosphère, la qualité de l’air et la science multidisciplinaire, sont une source d’inspiration pour moi, tant sur les plans professionnel que personnel. Ces domaines sont essentiels au bien-être des Canadiens et des Canadiennes ainsi que de notre patrimoine naturel.

Environ un Canadien sur dix gagne sa vie dans le secteur des ressources naturelles, de l’agriculture, des pêches et du tourisme. Notre environnement se prête à des activités récréatives et physiques saines, en plus de soutenir des modes de vie traditionnels autochtones. Cela témoigne de l’importance des sciences naturelles étant donné que les changements climatiques constituent désormais l’un des plus grands défis de notre société.

La lutte contre les changements climatiques est une occasion de réaliser une transition vers une économie à faible émission de carbone qui reste forte, diversifiée et compétitive. Le Cadre pancanadien sur la croissance propre et les changements climatiques, mis au point avec les provinces et territoires et en consultation avec les peuples autochtones, constitue le plan du Canada pour atteindre nos objectifs de réduction des émissions et améliorer notre résilience face aux changements climatiques, tout en favorisant la croissance économique. Le Cadre tient compte de l’importance d’accroître la résilience face aux changements climatiques et prévoit des mesures pour aider les Canadiens à mieux comprendre de quoi il s’agit et à se préparer activement afin de s’adapter à leurs effets inévitables. Ensemble, avec le soutien de chercheurs, d’organisations non gouvernementales et du secteur privé, nous relèverons ces défis et prendrons des engagements. Vos contributions aux données scientifiques pertinentes et crédibles aident à déterminer les risques et les possibilités, et ainsi d’éclairer les décisions qui définiront notre avenir commun.

Le Congrès de la SCMO arrive à point pour la Journée mondiale de l’environnement du 5 juin, que nous aurons le privilège d’organiser ici au Canada. Le thème sera « Rapprocher les gens de la nature – dans la ville et sur la terre, des pôles à l’équateur ». Ce rapprochement avec la nature saura aider les Canadiens et les Canadiennes à prendre en main l’avenir de la planète.

Je vous remercie pour votre contribution en sciences de la terre, des océans et de l’atmosphère et vous souhaite un Congrès fructueux.

Catherine McKenna
Ministre d’Environnement et Changement climatique Canada

Canada

Welcome from the President of the Canadian Meteorological and Oceanographic Society

On behalf of the Canadian Meteorological and Oceanographic Society (CMOS), I welcome you to our 51th Congress in Toronto, Canada. CMOS has a long and distinguished history of advancing meteorology and oceanography in Canada. Our scientific congresses attract attendees from academia, government and the private sector from cross Canada and around the world. Welcome back and welcome aboard.

We are looking at enhancing the Congress this year with a downloadable App to promote communication and ease of access to Congress information. This will allow Congress participants to be active with their programs and activities. With the help of the App, I also encourage all delegates to make good use of their time this week, and take advantage of all the great science and social programs that have been established by the congress organizers.

This year to coincide with the 50th Anniversary of CMOS, student membership to CMOS was opened up as a FREE membership. Already we have seen student membership double since this has come into effect last year. I believe this is strategically important for the sustainability of our Society. Welcome and thank you Canadian Students!!. To those who are not currently members, we urge you to become members of YOUR society and strengthen it by participating in its activities during and after the Congress.

I am making a strong pitch to all members to attend the Annual General Meeting (AGM) on Monday evening, where plans for the upcoming year and society issues will be discussed, including a discussion on the newly drafted Strategic Plan for CMOS and its future.

I cannot express my pride of the CMOS organisation. This national organization is largely run by volunteers, with truly amazing dedication and commitment. From the 14 centres across Canada to the national Executive in Ottawa who keep the boat afloat every year to ensure growth, sustainability and a prosperous future. I have been interfacing with the Chair of the Local Arrangements Committee, Ron Bianchi and the Chair of the Science Program Committee, Dr. Peter Taylor, whom over the past 18 months have encountered numerous obstacles in the preparation and execution of this Congress, supported by many hours of work by local volunteers. We are off to the races and this congress promises to be one of the most successful as a result of the hard work of all the volunteers. This event would not be possible without them. Bravo Zulu to all.

Thank you for your ongoing support of CMOS. I wish you a productive and enjoyable congress!

Martin L. Taillefer

President, CMOS

Mot de bienvenue du président de la Société canadienne de météorologie et d'océanographie

Au nom de la Société canadienne de météorologie et d'océanographie (SCMO), je vous souhaite la bienvenue à notre 51e Congrès, à Toronto (Canada). La SCMO possède une longue et remarquable histoire liée à l'avancement de la météorologie et de l'océanographie au Canada. Nos congrès scientifiques attirent des participants des secteurs universitaire, gouvernemental et privé provenant de partout au Canada et d'ailleurs. Bienvenue aux nouveaux comme aux vétérans.

Nous comptons améliorer le Congrès cette année à l'aide d'une application téléchargeable qui facilitera la communication et l'accès aux renseignements relatifs à cet événement. Cette nouveauté permettra aux congressistes d'organiser dynamiquement leur programme et leurs activités préférées. J'encourage les participants à tirer pleinement parti de leur semaine, grâce à cette application, et à profiter des programmes scientifiques et sociaux qu'ont préparés les organisateurs du Congrès.

Cette année, en raison du 50e anniversaire de la Société, l'adhésion des étudiants à la SCMO était gratuite. Nous avons déjà vu le nombre de membres étudiants doubler depuis l'entrée en vigueur de cette dispense. Je pense que cette décision s'avère stratégiquement importante pour la pérennité de notre société. Bienvenue et merci aux étudiants du Canada! Nous encourageons ceux d'entre vous qui ne sont pas déjà membres à adhérer à la SCMO, afin de renforcer VOTRE société et de participer à ses activités, durant et après le Congrès.

Je souhaite ardemment voir tous les membres de la SCMO participer à l'assemblée générale annuelle (AGA) de lundi soir. Nous y discuterons des enjeux touchant la Société et de la planification de l'année qui vient, y compris la nouvelle ébauche du plan stratégique de la SCMO et de son avenir.

J'ai peine à exprimer la fierté que je ressens envers l'organisation qu'est la SCMO. Cette société savante nationale est en grande partie dirigée par des bénévoles, dont le dévouement et la mobilisation restent véritablement remarquables. Ceux-ci travaillent à partir de 14 centres couvrant le Canada et au sein du comité exécutif d'Ottawa, et ils tiennent la barque à flot chaque année, afin d'assurer notre croissance, notre pérennité et la prospérité de notre avenir. Je me suis souvent entretenu avec le président du comité local d'organisation, Ron Bianchi, et avec le président du comité du programme scientifique, Peter Taylor, qui ont dû surmonter, au cours des 18 derniers mois, bien des obstacles quant à l'organisation et à la mise en œuvre de ce congrès, et ce, avec l'aide considérable de plusieurs bénévoles locaux. Nous sommes fin prêts! Et ce congrès promet d'être l'un des plus réussis, grâce au travail acharné de tous les bénévoles. Cet événement n'aurait pas vu le jour sans eux. Bravo Zulu, à tous!

Je vous suis reconnaissant de votre soutien indéfectible de la SCMO. Je vous souhaite un congrès productif et des plus plaisants.

Martin L. Taillefer

Président de la SCMO

Welcome Message from the Scientific Program Committee

Canadian Meteorological and Oceanographic Society
La Société canadienne de météorologie et d'océanographie

CMOS-SCMO, P.O. Box / C.P. 3211, Stn./Succ. D, Ottawa, ON, Canada K1P 6H7

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Homepage: www.cmos.ca   Page d'accueil: www.scmo.ca

Dear Congress participants,

On behalf of the 2017 CMOS Scientific Program Committee (SPC) let me welcome you to our 51st annual CMOS Congress, being held this year in Toronto. We had a very good response to our call for abstract submissions and will have approximately 300 papers presented orally as well as 150 poster presentations. We have 8 invited plenary speakers, many parallel sessions, panel discussions and workshops to keep you busy and interested during the congress. It is a full program and the session chairs will do their best to keep things on time. If you are presenting orally, please keep to time and allow a few minutes for questions at the end of your talk. If you have a poster please attend the designated poster session. These can often be the best way to present your work to others with interests in the same area and provide an excellent opportunity to make new contacts, explain your work and benefit from others advice. All congress participants should make a serious effort to engage in discussions around the posters, both to learn and, where appropriate, to provide sage and helpful guidance and ideas.

On a personal note, I just missed the first CMOS congress in Ottawa, but I was at the second (1968) in Calgary along with at least two fellow members of this year's SPC. I think all three of us have attended most of the congresses between then and now and I sincerely hope that the SPC and fellow session conveners, together of course with all of the presenters, have put together a program to match the high standards achieved over the past 50 years.

Dr. Peter Taylor, Scientific Program Committee Co-Chair (pat@yorku.ca)

Mot de bienvenue du Comité du programme scientifique

Canadian Meteorological and Oceanographic Society
La Société canadienne de météorologie et d'océanographie

CMOS-SCMO, P.O. Box / C.P. 3211, Stn./ Succ. D, Ottawa ON, Canada K1P 6H7

Tel: (613) 990-0300; e-mail: CMOS@cmos.ca

Homepage: www.cmos.ca Page d'accueil: www.scmo.ca

Aux participants du congrès,

Au nom du comité du programme scientifique du congrès 2017 de la SCMO, je vous souhaite la bienvenue à notre 51e Congrès annuel, tenu cette année à Toronto. L'appel de communications s'est avéré un franc succès. Nous vous offrirons donc environ 300 présentations orales et 150 présentations par affiche. Huit conférenciers participeront aux séances plénières. En outre, plusieurs séances parallèles, panels de discussions et ateliers vous tiendront occupés et susciteront votre intérêt tout au long du congrès. Le programme est bien rempli et les responsables de séances veilleront à éviter tout retard. Si vous faites une présentation orale, veuillez vous en tenir au temps alloué et réserver quelques minutes pour les questions, à la fin de votre exposé. Si vous présentez une affiche, veuillez ne pas manquer la séance qui vous est assignée. Ce type de présentation est souvent la meilleure façon de communiquer vos recherches aux gens partageant les mêmes champs d'intérêt, et fournit une excellente occasion d'établir de nouveaux contacts, d'expliquer vos travaux et de profiter des conseils de vos collègues. Tous les participants au congrès devraient prendre part aux discussions que suscitent les affiches, tant pour apprendre que pour émettre, si cela convient, de sages conseils et des idées pertinentes.

Sur une note personnelle, j'ai jadis raté le premier congrès de la SCMO à Ottawa, mais j'ai participé au second (en 1968) à Calgary, avec au moins deux membres de ce comité du programme scientifique. Je crois que tous les trois nous avons participé à la plupart des congrès jusqu'à aujourd'hui et j'espère sincèrement que le comité du programme scientifique et les responsables des séances, tout comme les présentateurs, bien sûr, auront su proposer un programme à la hauteur des standards atteints au fil des 50 dernières années.

Dr. Peter Taylor, coprésident du comité du programme scientifique (pat@yorku.ca)

Welcome Message from the Local Arrangements Committee

Welcome to Toronto!

The Local Arrangements Committee would like to extend you a warm welcome to our 51st Canadian Meteorological and Oceanographic Society (CMOS) Congress and Annual Meeting.

The theme of the Congress, “Future Earth: Weather, Oceans, Climate", provides opportunity for our scientists to engage with each other, the media and the general public.

I have always viewed our annual Congress as a “touchstone” which ensures that our Canadian scientists deliver impactful and leading--edge environmental research in Canada. I know that the work presented here at this Congress will translate into positive actions in all areas of our Society and policy. Over 450 abstracts and 300 oral sessions, with 150 student posters will provide us insights and valuable new knowledge to bring forth in our science. There will be many opportunities to dialogue with colleagues on a variety of topics during this Congress.

This year, the 50th anniversary of the creation of the Canadian Meteorological Society, we will host an important public lecture, given by Dr. Francis Zwiers, “Changing Weather Extremes - Why it isn’t an «Alternative Fact»”. Dr. Zwiers will explain how we reconcile the findings of climate science with what we experience at a localized level.

The CMOS Congress, as always, offers not just a robust and varied scientific program, but also the opportunity to meet new colleagues and old friends. We will again be hosting a number of events and opportunities to socialize. This includes the customary icebreaker on Sunday night, the Patterson-Parsons luncheon on Tuesday, and our traditional banquet on Wednesday evening, a student pub night on Monday, plus a few tours as well. Remember to take the time to reconnect with your colleagues and to make a few new ones.

We hope you will take some time to see visit our vibrant and interesting city during your stay. Toronto boasts some of the best restaurants in the country, the CN tower, the Royal Ontario Museum and the Ontario Science Centre, just to name a few attractions.

We are pleased to welcome you to this Congress and appreciate your participation. We hope that you leave this Congress energized to take on future challenges that are presented in our work and in our environment.

Ron Bianchi

Chair – Local Arrangements Committee

Mot de bienvenue du Comité local des préparatifs

Bienvenue à Toronto !

Le Comité local d'organisation souhaite vous accueillir chaleureusement à notre 51^{e} Congrès de la Société canadienne de météorologie et d’océanographie (SCMO) et à notre réunion annuelle.

Le thème du Congrès "Terre du futur: Météo, Océans, Climat" offre à nos scientifiques une opportunité de s'engager mutuellement ainsi qu'avec les médias et le grand public.

J'ai toujours considéré notre Congrès annuel comme la «pierre angulaire» d'une structure qui garantit que nos scientifiques canadiens réalisent des recherches environnementales significatives et influentes au Canada. Je sais que les travaux présentés ici lors de ce Congrès se traduiront par des actions positives dans tous les domaines de notre société et de notre politique. Plus de 450 résumés, 300 présentations orales et 150 affiches d'étudiants nous fourniront des idées et de nouvelles connaissances précieuses qui feront avancer notre science. Les possibilités de dialoguer avec des collègues sur divers sujets au cours de ce congrès seront abondantes.

Cette année, pour marquer notre 50^{e} anniversaire de la création de la Société canadienne de météorologie, nous organisons une conférence publique majeure, présentée par le Dr Francis Zwiers, intitulée «Des conditions météorologiques extrêmes changeantes - pourquoi ce n'est pas un« fait alternatif » (en anglais). Le Dr Zwiers expliquera comment concilier les résultats de la science du climat avec ce que nous expérimentons localement.

Comme toujours, le Congrès de la SCMO, offre non seulement un programme scientifique robuste et varié, mais aussi l'opportunité de rencontrer de nouveaux collègues et de vieux amis. Nous organisons également un certain nombre d'événements et de possibilités pour socialiser. Cela comprend le coquetel habituel de bienvenue le dimanche soir, le déjeuner Patterson - Parsons le mardi, notre banquet traditionnel le mercredi soir, une soirée étudiante au pub lundi soir, et quelques visites également. N'oubliez pas de prendre le temps de vous reconnecter avec vos collègues et de faire la connaissance avec quelques nouveaux.

Nous espérons que vous prendrez le temps de visiter notre ville dynamique et intéressante lors de votre séjour. Toronto possède certains des meilleurs restaurants du pays, la tour du CN, le Musée royal de l'Ontario et le Centre des sciences de l'Ontario, pour ne citer que quelques attractions à visiter.

Nous sommes heureux de vous accueillir à ce congrès et apprécions votre participation. Nous espérons qu'en quittant ce congrès, vous aurez fait le plein pour faire face aux défis futurs présentés dans notre travail et dans notre environnement.

Ron Bianchi

Président - Comité local d’organisation

Local Arrangements Committee | Comité des arrangements locaux

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Andrew Leung	Xuesong Zhang

Thank you to all of our amazing volunteers, Local Organizing Committee members, and Scientific Program Committee members. Without the tireless work of the Local Arrangements Committee, the Scientific Program Committee and the Congress Volunteers this congress would not be possible. We thank them for their time, effort and expertise.

Merci à tous nos bénévoles, membres du comité d'organisation local, et les membres du comité du programme scientifique extraordinaires. Sans le travail acharné de ces comités et les bénévoles du Congrès ce congrès ne serait pas possible. Nous les remercions pour tout leur temps, efforts et expertise.

Week at a Glance | La semaine en coup d'oeil

Time Heures	Sunday Dimanche 4 June/juin		Monday Lundi 5 June/juin	Tuesday Mardi 6 June/juin		Wednesday Mecredi 7 June/juin	Thursday Jeudi 8 June/juin	Time Heures
0800 - 0830	Meetings and Workshops Réunions et ateliers		Opening ceremony Cérémonie d'ouverture					0800 - 0830
0830 - 0900				Plenaries/Plénières Steve Goodman, Claire Martin		Plenaries/Plénières Katja Fennel, Christian Haas	Plenaries/Plénières Réne Laprise, Dianne Saxe	0830 - 0900
0900 - 0930		GOES-16 Workshop / Atelier	Plenaries/Plénières David Grimes, Howard Wheater					0900 - 0930
0930 - 1000								0930 - 1000
1000 - 1030				Coffee Break / Pause café		Coffee Break / Pause café	Coffee Break / Pause café	1000 - 1030
1030 - 1100			Coffee Break / Pause café	Parallel Sessions Sessions parallèles	Teachers' Day / Journée des enseignants	Parallel Sessions Sessions parallèles	Parallel Sessions Sessions parallèles	1030 - 1100
1100 - 1130			Parallel Sessions Sessions parallèles					1100 - 1130
1130 - 1200								1130 - 1200
1200 - 1230				Patterson Parsons Luncheon / déjeuner		Lunch/Déjeuner	Workshops / Ateliers	1200 - 1230
1230 - 1300			Lunch (on your own) Déjeuner (à votre choix)					1230 - 1300
1300 - 1330						Parallel Sessions Sessions parallèles		1300 - 1330
1330 - 1400								1330 - 1400
1400 - 1430			Parallel Sessions Sessions parallèles	Parallel Sessions Sessions parallèles				1400 - 1430
1430 - 1500						Coffee Break / Pause café		1430 - 1500
1500 - 1530						Poster Session Session d'affiches		1500 - 1530
1530 - 1600			Coffee Break / Pause café	Coffee Break / Pause café				1530 - 1600
1600 - 1630			Poster Session Session d'affiches	Parallel Sessions Sessions parallèles				1600 - 1630
1630 - 1700						Parallel Sessions Sessions parallèles		1630 - 1700
1700 - 1730								1700 - 1730
1730 - 1800			CMOS AGM AGA de SCMO					1730 - 1800
1800 - 1830	Ice Breaker Soirée d'ouverture			Public Lecture/ Conférence publique Francis Zwiers		Cash bar		1800 - 1830
1830 - 1900			Student Night Soirée étudiante			CMOS / SCMO Banquet		1830 - 1900
1900 - 1930								1900 - 1930
1930 - 2000								1930 - 2000
2000 - 2030							51st CMOS Congress 2017	2000 - 2030
2030 - 2100							51e Congrès de la SCMO 2017	2030 - 2100
2100 - 2130							revised / mise à jour	2100 - 2130
2130 - 2200							2017-04-18	2130 - 2200

Social Events

Event	Start Time	Information
2nd Annual CMOS Pitch Talk Competition & Student Meet and Greet	Sunday 4:00 PM	Join us in kicking off the Toronto 2017 CMOS Congress by getting to know your fellow students, and other early career scientists at our pre-ice breaker! By submitting a short pitch, students will have an opportunity to take the spotlight -- presenting a brief introduction of both themselves and their research through means of a friendly student competition. For those that do not wish to partake in the competition, all are welcomed to be in attendance! Pitch talks will be evaluated by a panel of three judges: Douw Steyn (CMOS Director of Publication), Eilise Norris (Managing Editor, Taylor & Francis Group), and Sarah Knight (CMOS Bulletin Editor). Prizes will be awarded to the finalists! Gain insights into improving your presentation skills, and learn tips for submitting to academic journals as our panel of judges promise three can't-miss presentations. This will be an excellent introductory event, and we look forward to seeing you all here!
Icebreaker	Sunday 6:00 PM	Mingle with old peers or meet new friends! Start the Congress off with a bang by joining the Icebreaker in Toronto Rooms I,II,III. A cash bar and finger food will be provided. Extra Tickets $30.
Student Dine & Learn Networking Event	Monday 6:00 PM	Take advantage of a great opportunity to explore prospective careers in the fields of atmospheric science, meteorology, and oceanography by participating in the Toronto 2017 CMOS Congress Student Dine & Learn! Enthusiastic prominent professionals in industry, government, and academia will be present for a unique networking experience whilst sharing briefly their very own motivations and professional backgrounds, as well as some helpful information about career and volunteer opportunities. Only the first 40 registered students will be accepted into the Student Dine & Learn event, and will be provided a full buffet-style dinner courtesy of Firkin on King (a mere 10 minute walk from the Hilton Hotel)!
Student Pub Night	Monday 8:00 PM	Back by popular demand, CMOS presents Student Pub Night! Immediately following the Student Dine & Learn, this year's CMOS team welcomes you to an enjoyable evening at Firkin on King (a 10 minute walk from the Hilton Hotel)! Get to know other students and early professionals over a delicious assortment of appetizers and refreshments. Two complimentary drink tickets and appetizers will be guaranteed only to the first 75 guests to RSVP (strictly on a

		first-come, first-serve basis). Mingle with fellow peers who share your interests, engage in thought-provoking discussions, and even learn a thing or two by gaining a variety of unique perspectives. Hope to see you there!
Patterson-Parsons Luncheon	Tuesday 12:00 PM	Enjoy a sit down, plated meal and honour the recipients of the Patterson and Parsons Medals awards. Extra tickets $40
Awards Banquet	Wednesday 6:00 PM	Share stories of the past year at a cash bar before the evening dinner begins, you may even be charmed by Yan Markson, Illusionist, as he roams. Sit down to a three course dinner and honour the recipients of various CMOS prizes and awards. Extra tickets $70. Cash bar opens at 18:00, dinner starts at 19:00.
Yan Markson - Ilusionist	Wednesday 9:30 PM	Join Yan Markson, a psychological entertainer who combines comedy and mentalism into one killer act, after dinner. He is a mastermind when it comes to new ideas that will captivate any audience.
RWDI Tour	Thursday 1:00 PM	RWDI is a Canadian-based firm of consulting engineers and scientists who tackle complex problems in the built environment. RWDI's core practice areas of climate engineering, building performance and environmental engineering brings together a diverse array of capabilities to create buildings and infrastructure that are resilient to extreme weather, hospitable, sustainable, and that meet environmental stewardship goals. The company's headquarters in Guelph showcases state-of-the-art wind tunnels and a water tunnel. RWDI will also have several exhibits demonstrating the wide variety of technical services. Depart hotel at 13:00, tour begins at 14:00. Safety & security requirements: NO PHOTOS ALLOWED in wind tunnel and model shop areas. For wind tunnel access safety glasses are mandatory, closed toe shoes a must, and no stiletto heels. Safety glass station located at wind tunnel entrance for pick-up of safety glasses at beginning of tour, and drop off at end. Please make sure everyone stays inside the yellow or barricaded walkways

Activités sociaux

Activité	Temps de commence	Informations
2e compétition de présentation éclair de la SCMO et soirée d'accueil	Dimanche 16h00	Profitez à plein du Congrès 2017 de Toronto en commençant par rencontrer vos collègues étudiants et d'autres scientifiques en début de carrière à notre soirée pré-accueil. En soumettant une courte présentation, les étudiants auront l'occasion d'être sous les feux de la rampe, de se présenter et de faire connaître leur travail tout en participant à une compétition amicale entre étudiants. Ceux qui ne souhaitent pas participer à la compétition sont les bienvenus comme spectateurs. Un jury composé de Douw Steyn (directeur des publications de la SCMO), Eilise Norris (directrice de la rédaction, Taylor & Francis Group) et Sarah Knight (rédactrice en chef du Bulletin de la SCMO) jugera les présentations éclair. Les finalistes recevront des prix! Renforcez vos aptitudes de présentation et apprenez à soumettre un article à une revue scientifique, tandis que notre jury vous promet trois présentations à ne pas manquer. Cette activité vous permettra de briser la glace. Nous vous y attendons en grand nombre.
Soirée d'accueil	Dimanche 18h00	Revoyez de vieux amis ou rencontrez de nouveaux visages! Commencez le congrès en lion en participant à la soirée d'accueil dans les salles Toronto I, II et III. Profitez du bar payant et dégustez des amuse-gueule. Billet supplémentaire : 30 $.
Souper-causerie et réseautage	Lundi 18h00	Profitez d'une excellente occasion d'explorer les carrières potentielles dans les domaines des sciences atmosphériques, de la météorologie et de l'océanographie en participant au souper-causerie du Congrès 2017 de la SCMO à Toronto. Des professionnels chevronnés et enthousiastes des secteurs privé, gouvernemental et universitaire vous offriront une chance unique de réseautage, tandis qu'ils partageront avec vous leurs propres motivations et leur expérience, ainsi que des renseignements utiles sur les possibilités de carrière et de bénévolat. Seuls les 40 premiers étudiants inscrits pourront assister au souper-causerie. Nous fournissons le buffet du souper, une gracieuseté du resto-pub Firkin on King (à 10 minutes de marche du Hilton de Toronto).
Soirée « pub »	Lundi 20h00	À la demande générale, la soirée « pub » des étudiants est de retour. Tout de suite après le souper-causerie, l'équipe de la SCMO de cette année vous convie à une agréable soirée au resto-pub Firkin on King (à 10 minutes de marche du Hilton de Toronto). Rencontrez d'autres étudiants et des professionnels en début de carrière en profitant d'un délicieux assortiment d'amuse-gueules et de boissons. Nous garantissons aux 75 premières personnes à avoir répondu à l'invitation (premier

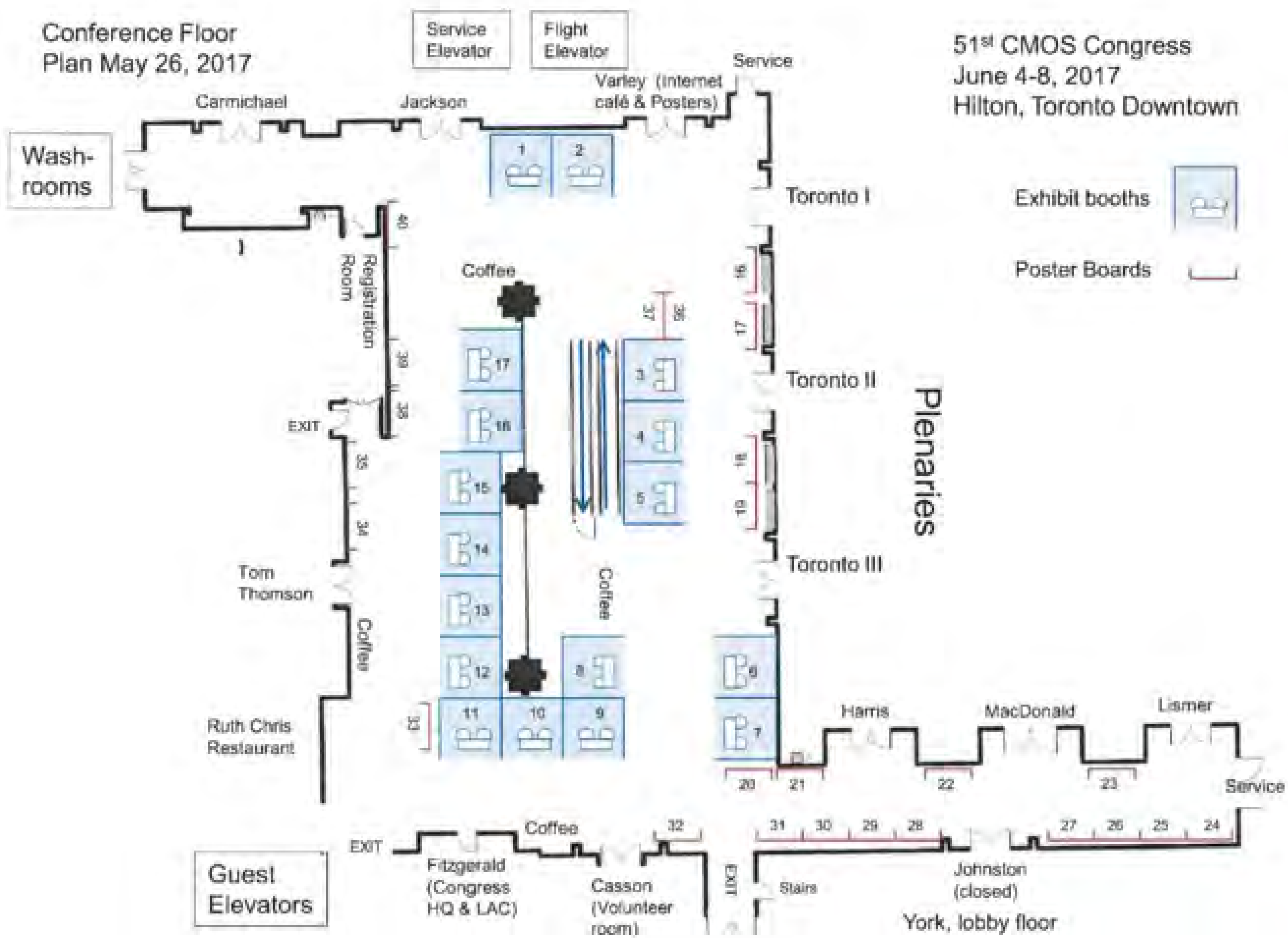
		arrivé, premier servi) deux coupons chacune donnant droit à des boissons gratuites et à des amuse-gueules. Mêlez-vous aux collègues qui partagent vos domaines d'intérêt, débattez de sujets inspirants et élargissez vos horizons en découvrant de nouvelles perspectives. Au plaisir de vous rencontrer!
Dîner Patterson et Parsons	Mardi 12h00	Savourez un repas servi aux tables et rendez honneur aux récipiendaires des médailles Patterson et Parsons. Billet supplémentaire : 40 $.
Banquet des récompenses	Mercredi 18h00	Accoudé au bar, partagez les anecdotes de l'année, avant de vous attabler pour le souper. Vous pourriez même être charmé par l'illusionniste Yan Markson, tandis qu'il se balade d'un invité à l'autre. Prenez part à un souper trois services et rendez honneur aux gagnants des prix et distinctions de la SCMO. Billet supplémentaire : 70 $. Le bar payant ouvre à 18 h et le souper commence à 19 h.
Yan Markson - Illusionniste	Mercredi 21h30	Après le souper, accueillez Yan Markson, un « psycho-animateur » qui combine humour et divination en un spectacle étonnant, un virtuose innovateur qui fascine tout auditoire.
MétéoMédia	Jeudi 13h00	Profitez d'une visite guidée par le chef météorologiste de MétéoMédia! Vous verrez où se créent les prévisions météorologiques, vous visiterez la zone nationale du programme « En alerte » pour y suivre une brève leçon d'histoire. Ensuite vous vous aventurerez dans la salle de régie et finalement vous aurez l'occasion d'entrer dans le studio où vous courrez la chance d'expérimenter la vie d'une personnalité télévisuelle. Départ de l'hôtel à 13h00, la tournée commence à 14h00.
La soufflerie aérodynamique de RWDI	Jeudi 13h00	RWDI est une entreprise canadienne regroupant des ingénieurs et des scientifiques qui s'attaquent aux problèmes complexes des milieux bâtis. Les domaines de prédilection de RWDI, le génie appliqué au climat, le rendement de bâtiments et le génie appliqué à l'environnement, se fondent sur diverses compétences afin de créer des édifices et des infrastructures qui résistent aux extrêmes météorologiques, qui sont accueillants, durables et conformes aux objectifs environnementaux. La maison mère de la compagnie se trouve à Guelph et possède des tunnels aérodynamique et hydrodynamique. RWDI présentera aussi sa vaste gamme de services techniques. Départ de l'hôtel à 13h00, la tournée commence à 14h00. Exigences de sûreté et sécurité: AUCUNE PHOTO N'EST PERMISE dans les souffleries et les ateliers de fabrication de maquettes. Dans la soufflerie, les lunettes de sécurité et le port de chaussures fermées sont obligatoires. Les chaussures à talon haut et sandales ne sont pas permises. Les lunettes de sécurité peuvent être ramassées à une station à

		l'entrée de la soufflerie et peuvent être déposées à la fin de la visite. Assurez-vous de rester à l'intérieur des allées jaune ou barricadées.

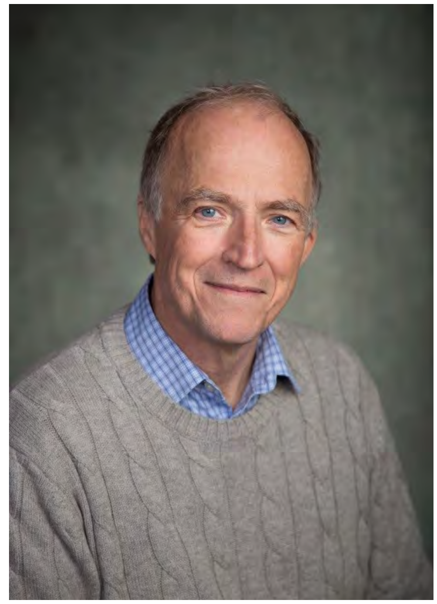
Exhibitors List | Liste des exposants

Booth Number	Exhibitor	Website
1, 2	CMOS	http://cmos.ca
3	ROPOS Canadian Scientific Submersible Facility	http://www.ropos.com
4	Advances in Atmospheric Sciences	http://www.springer.com/earth+sciences+and+geography/atmospheric+sciences/journal/376
5	Candac	http://www.candac.ca
6	Campbell Scientific Inc	https://www.campbellsci.ca
7	Info-Electronics Systems Inc	http://www.info-electronics.com
8	Hoskin Scientific Ltd	http://www.hoskin.ca
9	MetOcean Telematics	http://www.metocean.com
10	CMOS Halifax	http://cmos.ca
11	ROMOR Ocean Solutions	http://www.romor.ca
12	RBR Ltd	https://rbr-global.com
13	COMET	http://www.comet.ucar.edu
14	ATS Services Ltd	http://www.atsservices.ca
16	Selex ES GmbH	www.selex-es.de
17	Vaisala	http://www.vaisala.com

Exhibitor Layout | Plan des exposants



Public Lecture | Lecture publique



Dr. Francis Zwiers is director of the Pacific Climate Impacts Consortium (PCIC) at the University of Victoria. His former roles include chief of the Canadian Centre for Climate Modelling and Analysis and director of the Climate Research Division, both at Environment and Climate Change Canada. As a research scientist, his expertise is in the application of statistical methods to the analysis of observed and simulated climate variability and change. Dr. Zwiers is an Honorary Research Professor at the University of Victoria, a Fellow of the Royal Society of Canada and of the American Meteorological Society, a recipient of the Patterson Medal and the President's Prize, has served as an IPCC Coordinating Lead Author of the Fourth Assessment Report and as an elected member of the IPCC Bureau for the Fifth Assessment Report.

Francis Zwiers (Ph. D.) est directeur du Pacific Climate Impacts Consortium (PCIC) de l'Université de Victoria. Il a occupé au sein d'Environnement et Changement climatique Canada les deux postes suivants : chef du Centre canadien de la modélisation et de l'analyse climatique et directeur de la Division de la recherche climatique. L'expertise de ce chercheur porte sur l'application de méthodes statistiques à l'analyse d'observations et de simulations de la variabilité et de l'évolution du climat. Monsieur Zwiers est professeur honoraire de recherche à l'Université de Victoria, membre émérite de la Société royale du Canada et de l'American Meteorological Society, récipiendaire de la médaille Patterson et lauréat du Prix du président. En outre, il a agi comme auteur principal et coordonnateur du Quatrième rapport d'évaluation du GIEC et comme membre élu du Bureau du GIEC pour le Cinquième rapport d'évaluation.

Changing weather extremes - why it isn't an "alternative fact"

Stories about extreme weather and climate events around the world often make media front-page headlines, alongside the recent upswing in "alternative fact", or fake, news. These stories about extremes draw our attention because of their immediacy and the devastating impacts, which often include deaths and up to billions of dollars in damage.

Two Canadian examples include the Fort McMurray wildfire (2016, >$3.6B in insured losses) or the Calgary floods (2013, $6.7B USD in total losses). In the aftermath of such devastation, media ask whether such extreme events are now more frequent or intense than in the past, whether they are caused by human influence on the climate and if they represent a harbinger of the future.

In most cases, climate science does find that human influence played a role, consistent with the overwhelming body of evidence indicating a human contribution to the observed changes in average climatic conditions over the past century.

Nevertheless, at a localized level, the effects of climate change can be hard to detect, leading to possible discrepancies between our own personal experience of climate change and the findings of climate science. In this new era of “alternative facts”, it would be a fallacy to rely solely on personal experience, reject the findings of the climate science community and consequently fail to prepare for the climatic changes ahead.

L’évolution des extrêmes météorologiques – pourquoi il ne s’agit pas d’un fait « alternatif »

Partout dans le monde, des histoires sur des phénomènes météorologiques ou climatiques extrêmes font souvent la une des médias, au côté d’une recrudescence de faits « alternatifs » ou de fausses nouvelles. Ces histoires portant sur des extrêmes attirent notre attention en raison de leur impact immédiat et dévastateur, qui inclut souvent des pertes de vie et de milliards de dollars en dommages.

Notons deux exemples canadiens : l’incendie de Fort McMurray en 2016 (plus de 3,6 milliards de dollars de pertes assurées) et les inondations de Calgary en 2013 (6,7 milliards de dollars américains en pertes totales). À la suite d’une telle dévastation, les médias se demandent si ces événements extrêmes surviennent plus souvent ou avec plus de force qu’avant, s’ils sont causés par l’influence humaine sur le climat et s’ils représentent ce que nous réserve l’avenir.

Dans la plupart des cas, la science du climat indique que l’influence humaine n’y est pas étrangère. Cette conclusion concorde avec les preuves inéluctables, qui démontrent une contribution humaine aux changements observés relativement aux moyennes climatologiques du dernier siècle.

Toutefois, à l’échelle locale, les effets des changements climatiques ne se détectent pas toujours facilement. Il semble donc exister des incohérences entre notre expérience personnelle et les conclusions des études climatologiques, en ce qui concerne les changements climatiques. En cette ère de faits « alternatifs », il serait dommageable de se fier uniquement à notre expérience personnelle et de rejeter les conclusions des spécialistes du climat, et ainsi de négliger de se préparer à affronter les changements climatiques à venir.

Plenaries

David Grimes has been Assistant Deputy Minister and head of Environment Canada's Meteorological Service of Canada since July 2006. He has been Canada's Permanent Representative with World Meteorological Organization since December 2006. David was re-elected President of the WMO by the Seventeenth World Meteorological Congress in 2015 for another four-year term. He has more than 25 years of experience working with WMO initiatives and programs. He has over 40 years of scientific, operations, research and management experience at Environment Canada. His experience also includes a significant number of challenging positions and assignments over the years, ranging from weather forecast operations to science policy. He occupied the positions of Director General with the Meteorological Service of Canada for 15 years. David has extensive educational experience in the domains of science and management (MBA level). He holds a Bachelor of Science in physics, mathematics and meteorology. He has also been trained and carried out the responsibilities as an operational meteorologist.

The Future of the Weather Enterprise with a Look Back over the Past

The Government of Canada has been providing weather, water, climate and air quality services to Canadians, their governments, and public and private sector institutions for almost 150 years. Since its beginnings in 1871, Environment and Climate Change Canada's Meteorological Service provides high-quality and timely warnings and forecasts, services and information to reduce risks to health & safety and to help the public and private sector benefit from opportunities related to related to environmental changes. A strong research foundation and high performance computing capacity are essential to deliver on this unique federal mandate.

Today, in Canada and around the world, national meteorological and hydrological services provide more than basic weather, water and climate information; weather enterprises strive to provide information on the anticipated impacts of expected events in order to help citizens and other stakeholders to make informed decisions and adapt their behaviour. With growing public concerns about changes in weather and climate, demands are growing from the public for faster, more comprehensive information delivered in a wider range of ways, including social media. The weather enterprise is also being called upon to provide the essential science-based foundations to support the global agenda and societal needs in areas such as sustainable development, disaster risk reduction, and climate change, including the Paris Agreement and domestic action under the Pan Canadian Framework on Clean Growth and Climate Change.

This talk will take a look back at the history of the Meteorological Service of Canada, and the vast improvements in the science and technology of weather predictions and services over the past century. It will provide an overview of the future priorities of the weather enterprise, not only in Canada but around the world, from the current President of the World Meteorological Organization, considering the opportunities and challenges facing the weather enterprise such as Big Data, crowdsourcing, advances in modeling, and the growing engagement with partners in the private and academic sector.

Professor Howard Wheater is Canada Excellence Research Chair in Water Security, Director of the Global Institute for Water Security at the University of Saskatchewan, and Distinguished Research Fellow and Emeritus Professor of Hydrology at Imperial College London. A leading expert in hydrological science and modelling, he has published more than 200 refereed articles and 6 books. He is a Fellow of the Royal Academy of Engineering and the American Geophysical Union and winner of the Prince Sultan bin Abdulaziz International Prize for Water. He has initiated and led national and international research programmes in the UK and Canada, and has advised states, provinces and national governments on flood, water resource and water quality issues. He represented Hungary and Argentina at the International Court of Justice, and recently sat on an International Court of Arbitration concerning the Indus Waters Treaty. He was, until 2014, vice-chair of the World Climate Research Programme's Global Energy and Water Cycle Exchange (GEWEX) project and leads UNESCO's GWADI arid zone water program. In Canada, he leads the Changing Cold Regions Network, focused on the analysis and prediction of hydrological change in western Canada, and the Global Water Futures Program, focused on managing water futures in Canada and other cold regions where global warming is changing landscapes, ecosystems, and the water environment. His role as Chair of the Council of Canadian Academies Expert Panel on Sustainable Management of Water in the Agricultural Landscapes of Canada saw release of a report in February 2013 entitled Water and Agriculture in Canada: Towards Sustainable Management of Water Resources.

Water Futures in Changing Cold Regions

Canada is experiencing some of the world's most rapid rates of climate warming; with a water environment dominated by snow, ice and frozen soils, Canada is losing her cold. Climate and landscapes are changing, and historical patterns of water availability are no longer a reliable guide to the future. Adaptation to change requires new science to understand the changing earth system, new monitoring systems to warn of critical environmental change, new modelling tools that can represent non-stationary and tipping points, and more effective methods to translate new scientific knowledge into societal action. We report on two major Canadian research programs that aim to prepare Canada to meet these challenges. The Changing Cold Regions Network (2012-2018) focusses on monitoring and modelling environmental change in western Canada. Global Water Futures (2016-2023) aims to deliver transdisciplinary science, working with users to address the question 'How can we best forecast, prepare for and manage water futures in the face of rapid change and increasing water-related risks?'

Dr. Steven Goodman is the Senior Program Scientist for the NOAA geostationary satellite program. His research interests include the global distribution and variability of thunderstorms, lightning and precipitation physics, and the application of space-based remote sensing to improve the short-range forecasts and warnings of severe storms. As the Senior Program Scientist for the GOES-R Program, he serves as the primary science authority for the United States next generation geostationary environmental satellite program, a joint agency development managed by NOAA and NASA. Following a 20-year career with NASA and prior to joining the GOES-R Program Office, he served as the Deputy Director of the NESDIS Office for Satellite Research and Applications and as the Acting Deputy Director for the Joint Center for Satellite Data Assimilation. He is a past recipient of the NASA Medal for Exceptional Scientific Achievement and a Fellow of the American Meteorological Society.

An Introduction to the GOES-R Satellite Series

NOAA's Geostationary Operational Environmental Satellites (GOES) have been a mainstay of weather forecasts and environmental monitoring for the past 40+ years. The next generation of GOES satellites, known as the GOES-R Series, will usher in a new era in geostationary environmental satellites. It has been 22 years since the last major instrument advance with the GOES I-M series. The first satellite in the GOES-R series, now GOES-16, was launched in November 2016 and is producing stunning imagery and undergoing on-orbit post launch testing for approximately 12 months before being placed into operations replacing either the GOES-E or GOES-W satellite. The GOES-R satellites will continue to provide continuous imagery and atmospheric measurements of Earth's Western Hemisphere that will foster a host of improved and new environmental products and services. GOES-R's primary instrument, the Advanced Baseline Imager (ABI), will provide three times the spectral resolution and four times the spatial resolution while scanning the Earth nearly five times faster than the current GOES. GOES-R will also host a new instrument, the Geostationary Lightning Mapper (GLM) that is designed to continuously map in-cloud and cloud-to-ground lightning with 8 km spatial resolution over the Western Hemisphere. It will provide information to improve storm monitoring and warnings and contribute to improved aircraft safety and efficient flight route planning. GOES-R's space weather instruments will provide improved observations of the sun and space environment with more timely dissemination and early warning to a diverse user community. This presentation will provide an overview and status update of the GOES-R program and the activities leading to an operational GOES-R system. The new observations will provide dramatically improved weather, water, and space environmental services in the coming decades, enhancing public safety and providing economic benefits to the U.S. and our international partners.

Claire Martin, an award winning TV host/presenter and a veteran of the Canadian media industry, has worked in the public service, as well as on and off camera for public and private broadcasters for nearly 30 years. Martin is currently employed with Environment and Climate Change Canada (ECCC) and is tasked with bringing her experience in engaging Canadians via television and other broadcast media, as well as her knowledge of meteorology & social media, to the public service. This new position was created to complement the team in the National Programs and Business Development Division of Prediction Services Directorate. The goal of this position is to re-engage, rebuild and strengthen relationships with Canadians (clients, stakeholders and the general public) and the Meteorological Service of Canada. A qualified meteorologist and passionate environmentalist, Martin ran as the Green Party candidate in North Vancouver in the Canadian 2015 federal election campaign. Despite losing to the Liberal candidate, Martin has stated that the experience offered an "exceptionally unique opportunity to examine and develop the best practices in engaging the general public in an open and frank dialogue about the effects of climate change in Canada". Claire Martin started winning over audiences in Edmonton, Alberta where in 1999 and again in 2000, she was awarded AMPIA's (Alberta Motion Picture Industry Award) for "Best Female Host" and "Best Produced Educational Video" for writing and appearing in science videos designed to promote the Grade 5-8 science unit in the Alberta Public School science curriculum. The International Weather Festival awarded Claire Martin the honour of "Best Weather Presenter in the World" in 2000 (Paris, France), 2001 (Quebec City, Canada) and 2003 (Zagreb, Croatia). beating out representatives from the likes of CNN and the BBC. In 2011 the University of Alberta awarded Martin it's most prestigious award - the Distinguished Alumni Award - recognizing her achievements that had earned her national and international prominence, as well as her ongoing volunteer work with the World Meteorological Organization (a specialized agency of the United Nations). Claire Martin grew up in England (is in fact, a true cockney) and moved to Canada in 1989. She is a niece of Barbara Edwards, who in 1974 became the BBC's first female weather presenter in the UK.

OK Granny, listen up..

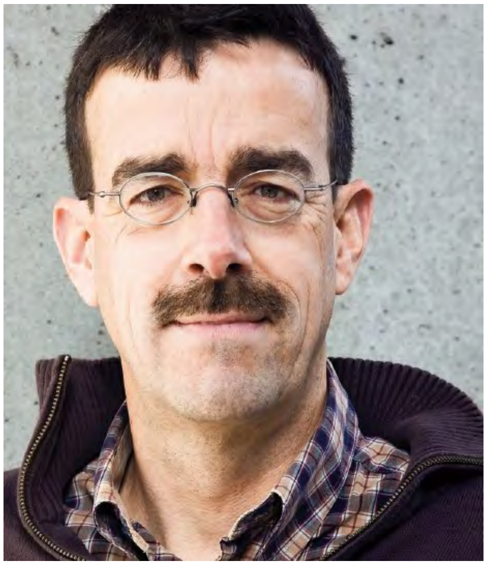
Apparently Albert Einstein once said that "you really don't understand something unless you can explain it to your grandmother". This quote, though not referring to my Granny who obtained 5 bachelor degrees in her life, should be tattooed on the forehead of any professional meteorologist currently trying to communicate their work in the highly politicalized rabbit-warren world of alternative-facts strewn science.
At best it is a challenge; at worst it can be career-ending.
So how does a good scientist learn to become a good communicator? Furthermore what makes a good science story? And most importantly, why bother?
Simply put: for informed decision making we need great science communicators.
The good news is that there is a consummate thirst for our particular niche of scientific information. Arguably in fact, weather and climate are the most important science topics talked about today..
But, this then places a great deal of responsibility on the shoulders of those scientists who personally volunteer to help get their message out. Poorly devised communication, with unclear or a badly executed delivery can backfire on the subject matter, the scientist under the spotlight, and sometimes even the meteorological community as a whole.

Good science communication is an art.
The first hurdle is overcoming the very nature of the subject matter – it's complicated! Learning to deliver the tricky nuanced details about the fluid-in-motion we call the atmosphere, is tough. But if it was easy, well, as they say, "everyone would do it".
The biggest hurdle though, is in the delivery. And that's where scientists can and (in my mind) should be given more training. An enthusiastic and willing scientist can be taught the tools to master any type of interview. Genuinely authentic scientists (read: nerdy) are widely recognized as credible, trustworthy promoters of our profession – something we desperately need in these times of cleverly concealed "fake news".
So, listen up grandmothers, and grandfathers, and indeed everyone else – let's start embracing good science communication.

Dr. Katja Fennel is Professor in the Department of Oceanography at Dalhousie University. As head of the Marine Environmental Modeling Group (http://memg.ocean.dal.ca) she leads the development of marine ecosystem and biogeochemical models at Dalhousie. For over two decades, Dr. Fennel has developed and applied numerical models of marine ecosystems and biogeochemistry with particular focus on continental shelf systems and the cycling of nitrogen, carbon and oxygen. In addition to implementing biogeochemical models, Dr. Fennel has developed and applied methods for the assimilation of observations into these models in order to improve their predictive capabilities. She serves as co-editor-in-chief of the high-impact journal Biogeosciences, and has served on the editorial boards of three other scientific journals and on several international science advisory bodies including the IMBER/LOICZ Continental Margins Task Team and the CLIVAR Working Group on Ocean Model Development. Currently she is science team member of GODAE OceanView, co-chairs the GODAE Marine Ecosystem Analysis and Prediction Task Team, and serves on the science advisory boards of the Copernicus Marine Environment Monitoring Service in Europe, the Ocean Frontier Institute at Dalhousie, and the international Biogeochemical Argo Steering Committee.

Biogeochemical Trends and Their Ecosystem Impacts in Atlantic Canada

In the ocean, coastal ecosystems are the most vulnerable to the combined stressors of warming, deoxygenation, acidification, eutrophication and fishing while being the most relevant for human activities. The representation of coastal oceans in global climate models is difficult, making projections of future coastal trends and their ecosystem impacts challenging. These regions also have large air-sea fluxes of carbon dioxide, making them an important but poorly quantified component of the global carbon cycle. Regional model applications that are nested within large-scale or global models are necessary for detailed studies of coastal regions. We present results from such a regional biogeochemical model for the continental shelves and adjacent deep ocean of Atlantic Canada. The model is an implementation of the Regional Ocean Modeling System (ROMS) and includes a lower trophic level ecosystem model with explicit representation of dissolved oxygen and inorganic carbon. The region is at the confluence of the Gulf Stream and Labrador Current making it highly dynamic, a challenge for analysis and prediction, and prone to large changes. Historically a rich fishing ground, coastal ecosystems in Atlantic Canada have undergone dramatic changes including the collapse of several economically important fish stocks and the listing of many species as threatened or endangered. It is unclear whether the region is a net source or sink of atmospheric carbon dioxide with estimates of the size and direction of the net air-sea flux of carbon dioxide remaining controversial. We will discuss simulated patterns of primary production, inorganic carbon fluxes and oxygen trends in the context of circulation features and shelf residence times for the present ocean state and present future projections.



Prof. Christian Haas is Canada Research Chair for Arctic Sea Ice Geophysics at York University and is also affiliated with the Alfred Wegener Institute for Polar and Marine Research in Germany. His research is concerned with the role of sea ice in the climate, eco-, and human systems. Christian studies sea ice and in particular ice thickness variations by means of satellite and airborne remote sensing and in-situ measurements, e.g. during snowmobile surveys with hunters in the Canadian Arctic.

Canada – The Last Ice Area?

Observations and model predictions suggest that the Arctic will become free of sea ice during summer within the next 30 to 100 years. These changes will have huge climatic, ecologic, and socio-economic consequences. It is also expected that the Canadian Arctic will be the last region where sea ice will survive before disappearing completely. The region could become a last refuge for Arctic animals like Polar Bears. Supporting observations include satellite data of ice concentration, ice age, and ice thickness. I will summarize this evidence and complement it with results from airborne and snowmobile ice thickness surveys from various regions in the Canadian Arctic carried out in the past ten years. These provide more insights into thickness changes and regional and local variability than satellite observations can do. Results confirm that the thickest sea ice of the Arctic still resides in Canada, and that multiyear ice may not have thinned as strongly as first-year ice. This implies that ice conditions in the Beaufort Sea and Northwest Passage still have to be considered hazardous where the ice survives summer melt. Our measurements also show the ubiquitous occurrence of local thin ice in narrow straits or over shoals where ocean heat flux can be increased. With warmer conditions, these thin ice regions may become open polynyas throughout the winter, changing local weather and contributing to more rapid ice disintegration during spring. While the presented results support the notion of Canada as the Last Ice Area, they also imply that future ice conditions may not be the same as presently, changing its importance for local climate, ecosystem, and northern residents.

René Laprise is professor in Atmospheric Sciences and Climate Physics at the Université du Québec à Montréal (UQAM). He is recognized as the godfather of regional climate modelling in Canada, a research field that he initiated 25 years ago. He was principal investigator of the Canadian network on regional climate modelling and diagnostics for 15 years. Under his leadership successive versions of the Canadian Regional Climate Model were developed, the most recent one (CRCM5) being used operationally by the Ouranos Consortium to produce high-resolution climate projections over North America. Recently he has designed a detailed formulation of the atmospheric energy cycle applicable over limited regions of the Earth; this diagnostic will allow furthering our understanding of the physical mechanisms responsible for the maintenance, variations and evolution of climate at regional scale. He was a Lead Author of Chapter 11 “Regional Climate Projections” of the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4) “Climate Change 2007: The Physical Science Basis”. In 2008-2009, he chaired the Task Force on Regional Climate Downscaling, set-up by the World Climate Research Programme (WCRP), aiming at improving collaboration between regional climate modelling groups, in order to coordinate efforts towards forthcoming IPCC reports. His team participates actively to the international project CORDEX (COrdinated Regional Downscaling EXperiment, http://www.cordex.org). During his career he has trained over 100 highly qualified personnel and published over 130 papers in peer-reviewed journals.

Regional climate downscaling: Achievements, challenges and prospects

Since the pioneering work initiated at the National Center for Atmospheric Research (NCAR) three decades ago, dynamical downscaling with limited-area models has become increasingly used to achieve unprecedented high-resolution climate simulations and projections over regions of interest.

A recent World Climate Research Programme (WCRP) major project, the Coordinated Regional Downscaling Experiment (CORDEX), provides a common framework to assess and compare regional climate models (RCM) simulations over 14 continental-scale domains. CORDEX provides datasets to stakeholders for climate vulnerability, impact and adaptation studies, and will eventually contribute regional-scale projections ensembles that could be used in the Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC), as the Coupled Model Intercomparison Project (CMIP) does at global scale.

The presentation will give an overview of the added value afforded by high-resolution regional climate model (RCM) hindcast simulations driven by reanalyses for various regional and local climate processes. Some examples of the inherent limitations of dynamical downscaling will also be illustrated when ocean surface and atmospheric lateral boundary conditions driving datasets are imperfect. Finally prospects offered by on-going RCM developments such as convection-permitting resolution, coupling ocean-atmosphere, climate-vegetation, climate-aerosols, and others, will be discussed.

Dianne Saxe is the Environmental Commissioner of Ontario, a tough but fair watchdog over government compliance with the Environmental Bill of Rights. The ECO is a bridge between the public and the government on environmental issues, and is required by law to report to the Ontario Legislature on energy use and conservation, environmental rights and environmental protection, and climate change. Before her appointment, Dianne was one of Canada’s most respected and best-loved environmental lawyers, with 40 years’ experience in environmental and energy law and litigation.

Facing Climate Change

Dianne Saxe, the Environmental Commissioner of Ontario, will explain her role and introduce her report to the Ontario Legislature, Facing Climate Change. The presentation will focus on why the Commissioner considers climate change to be the most important and most urgent problem facing humanity, and how much it is already affecting Canada.

Plénières

David Grimes occupe le poste de sous-ministre adjoint et de chef du Service météorologique du Canada du ministère de l'Environnement depuis juillet 2006. Depuis décembre 2006, il agit à titre de représentant permanent pour le Canada au sein de l'Organisation météorologique mondiale. David a été réélu à la présidence de l'OMM par le Dix-septième Congrès météorologique mondial en 2015 et restera en poste quatre autres années. Il possède plus de 25 ans d'expérience en matière d'initiatives et de programmes de l'OMM. Il cumule plus de 40 ans d'expérience dans les domaines de la recherche et des opérations, ainsi qu'en gestion au sein d'Environnement et Changement climatique Canada. Un grand nombre d'affectations et de postes enrichissants jalonnent son parcours : des prévisions opérationnelles, jusqu'aux politiques scientifiques. D. Grimes a exercé la fonction de directeur général du Service météorologique du Canada durant 15 ans. Il possède de vastes connaissances de niveau universitaire dans les domaines des sciences et de la gestion (niveau MBA). Il détient un baccalauréat ès sciences, avec spécialisation en physique, en mathématiques et en météorologie, en plus d'avoir une formation et de l'expérience en prévision opérationnelle.

L'avenir de l'entreprise météorologique et coup d'œil sur le passé

Le gouvernement du Canada fournit des services en météorologie, hydrologie, climatologie et qualité de l'air aux Canadiens, à leurs gouvernements et aux organismes des secteurs public et privé depuis près de 150 ans. Depuis ses débuts en 1871, le service météorologique d'Environnement et Changement climatique Canada a fourni en temps utile des prévisions et des avertissements de haute qualité, ainsi que des services et des informations visant à réduire les risques menaçant la santé et la sûreté, et à aider les secteurs public et privé à profiter d'occasions relativement aux changements environnementaux. L'exécution d'un tel mandat est immanquablement fondée sur de fortes activités de recherche et une capacité informatique à haut rendement.

De nos jours, au Canada et ailleurs, les services météorologiques et hydrologiques nationaux fournissent plus que de simples informations de base sur le temps, l'eau et le climat. Les entreprises météorologiques cherchent à fournir des renseignements sur les impacts que produiront les phénomènes prévus, afin d'aider les citoyens et les autres intervenants à prendre des décisions éclairées et à adapter leur comportement. La préoccupation croissante du public relativement à l'évolution des phénomènes météorologiques et du climat fait en sorte que la population exige la diffusion rapide et complète d'informations, et ce, par divers moyens de communication, y compris les médias sociaux. L'entreprise météorologique est aussi appelée à fournir la base scientifique sur laquelle s'appuieront les priorités mondiales et les besoins sociaux en ce qui concerne le développement durable, la réduction des risques de catastrophes et les changements climatiques, y compris l'Accord de Paris et les mesures prises conformément au Cadre pancanadien sur la croissance propre et les changements climatiques.

Cette présentation passera en revue l'histoire du Service météorologique du Canada et les progrès considérables accomplis en matière de sciences et de technologies relatives aux prévisions et aux services météorologiques au fil des cent dernières années. Elle donnera un aperçu des priorités à venir de l'entreprise météorologique, non seulement au Canada, mais ailleurs dans le monde, du point de vue du président de l'Organisation météorologique mondiale, en tenant compte des occasions et des défis qui s'offriront à l'entreprise météorologique, comme les données massives (big data), l'externalisation ouverte (crowdsourcing), les avancées de la modélisation et la mobilisation croissante de partenaires des secteurs privé et universitaire.

Le professeur Howard Wheater est titulaire de la Chaire d'excellence en recherche du Canada sur la sécurité de l'eau, directeur du Global Institute for Water Security de l'Université de la Saskatchewan, et chercheur universitaire distingué et professeur émérite en hydrologie de l'Imperial College London. Expert de premier plan en sciences hydrologiques et en modélisation, il a publié 6 livres et plus de 200 articles évalués par des pairs. Il est membre émérite de la Royal Academy of Engineering et de l'American Geophysical Union. Il a en outre reçu le prix international du Prince Sultan bin Abdulaziz pour l'eau. Il a instauré et dirigé des programmes de recherche nationaux et internationaux au Canada et au Royaume-Uni. Des représentants d'États, de provinces et de gouvernements nationaux ont profité de ses conseils en matière d'inondations, de ressources en eau et de qualité de l'eau. Il a représenté la Hongrie et l'Argentine devant la Cour internationale de Justice, et a récemment siégé à la Cour internationale d'arbitrage relativement au Traité sur les eaux de l'Indus. Jusqu'en 2014, il était vice-président de l'Expérience mondiale sur les cycles de l'énergie et de l'eau (GEWEX) et il dirige maintenant le programme du Réseau Mondial d'Information sur l'Eau et le Développement dans les Zones Arides relevant de l'UNESCO. Au Canada, il dirige le Changing Cold Regions Network, qui analyse et modélise les changements hydrologiques dans l'ouest du Canada, et l'initiative L'avenir de l'eau dans le monde, qui porte sur la gestion de l'avenir de l'eau au Canada et dans d'autres régions froides où le réchauffement de la planète modifie le paysage, les écosystèmes et l'environnement aquatique. Lorsqu'il présidait le comité d'experts sur la gestion durable de l'eau des terres agricoles du Canada relevant du Conseil des académies canadiennes, un rapport intitulé L'eau et l'agriculture au Canada : vers une gestion durable des ressources en eau a paru en février 2013.

Le futur de l'eau dans les régions froides en évolution

Le Canada subit certains des taux de réchauffement climatique les plus rapides de la planète. Comme la neige, la glace et les sols gelés dominent l'environnement aquatique, le Canada prend une véritable « dégelée ». Le climat et le paysage se modifient. Le cycle typique de la disponibilité de l'eau ne constitue plus un guide fiable pour l'avenir. L'adaptation aux changements nécessite de nouvelles avancées scientifiques pour comprendre l’évolution du système terrestre, de nouveaux systèmes de surveillance pour nous avertir de changements environnementaux critiques, de nouveaux outils de modélisation qui simulent des phénomènes non stationnaires et des points de bascule, et des méthodes efficaces pour traduire nos nouvelles connaissances scientifiques en mesures sociales. Nous présenterons deux programmes canadiens majeurs de recherche qui aspirent à préparer le Canada. Le Changing Cold Regions Network (2012-2018) vise à surveiller et à modéliser les changements environnementaux touchant l’ouest du Canada. L’initiative L’avenir de l’eau dans le monde (2016-2023) suit une approche scientifique transdisciplinaire et travaille avec les utilisateurs pour répondre à la question : comment pouvons-nous bien prévoir et gérer l’avenir de l’eau et nous y préparer dans le contexte des changements rapides et croissants des risques liés à l’eau?

Steven Goodman (Ph. D.) est le scientifique principal du programme de la NOAA pour les satellites géostationnaires. Ses travaux portent entre autres sur la répartition et la variabilité mondiales des orages, sur la physique de la foudre et des précipitations, ainsi que sur l’application de la télédétection spatiale dans le but d’améliorer la prévision à courte échéance et les avertissements d’orages violents. En tant que scientifique principal du programme GOES-R, il est le premier conseiller scientifique du programme de satellites géostationnaires environnementaux de prochaine génération aux États-Unis, une initiative conjointe que mènent la NOAA et la NASA. Après une carrière d’une vingtaine d’années à la NASA et avant de se joindre au programme GOES-R, il occupait le poste de directeur adjoint du bureau du NEDSIS pour la recherche et les applications relatives aux satellites, et le poste de directeur adjoint intérimaire pour le Joint Center for Satellite Data Assimilation. Il a reçu la médaille de la NASA pour réalisation scientifique exceptionnelle et il est membre émérite de l’American Meteorological Society.

Une introduction à la série de satellites GOES-R

Les satellites géostationnaires environnementaux opérationnels (GOES) de la NOAA font partie intégrante de la prévision météorologique et de la surveillance de l’environnement depuis plus de 40 ans. La prochaine génération de satellites GOES, qu’on appelle la série GOES-R, inaugurera une nouvelle ère en matière de satellites géostationnaires environnementaux. Vingt-deux années ont passé depuis la dernière avancée majeure des instruments embarqués sur la série GOES I-M. Le premier satellite de la série GOES-R, GOES-16, a été lancé en novembre 2016. Il produit des images incroyables et fait actuellement l'objet de 12 mois de tests en orbite avant d'être totalement opérationnel et de remplacer le satellite GOES-E ou GOES-W. Les satellites GOES-R continueront de transmettre en continu des images et des mesures atmosphériques de l'hémisphère ouest de la Terre et permettront l'amélioration et la création de produits et de services relatifs à l'environnement. L'instrument principal de GOES-R, un imageur de base avancé (Advanced Baseline Imager; ABI), transmettra des données possédant trois fois la résolution spectrale et quatre fois la résolution spatiale des données GOES actuelles, et balayera la Terre à une vitesse d'environ cinq fois supérieure à celle des satellites GOES existants. GOES-R embarquera aussi un nouvel instrument qui cartographiera la foudre (Geostationary Lightning Mapper; GLM). Celui-ci est conçu pour cartographier en continu les éclairs nuage-nuage et nuage-sol, sur l'hémisphère ouest, avec une résolution spatiale de 8 km. Il fournira des informations qui amélioreront les avertissements et la surveillance des orages, et il contribuera à accroître la sûreté aérienne et l'efficacité de la planification des vols. Les instruments météorologiques spatiaux de GOES-R fourniront des observations enrichies du Soleil et de l'espace. Ils permettront une diffusion améliorée d'avertissements précoces à divers types d'utilisateurs. Cette présentation offrira un survol du programme GOES-R et de ses progrès, ainsi que de l'information sur l'implantation opérationnelle du système GOES-R. Les nouvelles observations amélioreront nettement les services environnementaux relatifs au temps, à l'eau et à l'espace au cours des prochaines décennies. Elles renforceront la sûreté du public et le rendement économique des États-Unis et de nos partenaires internationaux.

Claire Martin, une animatrice et présentatrice primée de la télévision et une vétérante des médias canadiens, a travaillé au sein de la fonction publique, ainsi que devant et derrière la caméra pour des diffuseurs privés et publics pendant près de 30 ans. Madame Martin est actuellement à l'emploi d'Environnement et Changement climatique Canada (ECCC). Elle apporte au sein de la fonction publique son expérience de mobilisation des Canadiens par le truchement de la télévision et d'autres médias, ainsi que sa connaissance de la météorologie et des médias sociaux. Ce nouveau poste a vu le jour pour compléter l'équipe de la Division des Programmes nationaux et du développement des affaires de la Direction des services de prévisions. Ce poste permettra au Service météorologique du Canada de mobiliser le public, et de rebâtir et renforcer ses liens avec les Canadiens (clients, intervenants et grand public). Madame Martin, météorologiste professionnelle et environnementaliste passionnée, a été candidate du Parti Vert dans la circonscription de North Vancouver aux élections fédérales de 2015. Bien que la candidate libérale l'ait devancée, madame Martin affirme que cette expérience lui a offert une « occasion unique et exceptionnelle d'étudier et d'élaborer des pratiques exemplaires visant la participation du public à des dialogues francs et ouverts sur les effets des changements climatiques au Canada ». Claire Martin a conquis les auditoires d'Edmonton (Alberta), où elle a reçu en 1999 et en 2000 le prix de l'Alberta Motion Picture Industry (AMPIA) dans les catégories « meilleure animatrice » et « meilleure production vidéo éducative » pour avoir rédigé et animé des vidéos destinées à promouvoir auprès des élèves de la 5e à la 8e année les objectifs du programme scientifique des écoles publiques de l'Alberta. Le Festival international de météo a décerné à Claire Martin le prix du « meilleur présentateur météo du monde » en 2000 (Paris, France), en 2001 (Québec, Canada) et en 2003 (Zagreb, Croatie), devançant ainsi des représentants de CNN et de la BBC. En 2011, l'Université de l'Alberta a remis à madame Martin sa distinction la plus prestigieuse, le Distinguished Alumni Award, qui récompense les réalisations qui lui ont valu sa notoriété nationale et internationale, ainsi que son bénévolat auprès de l'Organisation météorologique mondiale (un organe spécialisé de l'Organisation des Nations Unies). Claire Martin, véritable Cockney, a grandi en Angleterre et a déménagé au Canada en 1989. Elle est la nièce de Barbara Edwards, qui en 1974 a été la première femme à présenter le bulletin météo à la BBC (Royaume-Uni).

Allez, mémé, ouvre les oreilles!

Il semble qu'Albert Einstein ait dit « Tu ne comprends pas vraiment un point, à moins que tu ne réussisses à l'expliquer à ta grand-mère. » Cette citation, bien qu'elle ne fasse pas référence à ma propre grand-mère, qui détient cinq baccalauréats, devrait être tatouée sur le front de tout météorologiste professionnel qui tente actuellement de communiquer ses travaux dans le contexte d'esprit de clocher hautement politisé que sont les faits « alternatifs » qui minent la science.

Au mieux, il s'agit d'un défi; au pire, c'est le glas d'une carrière qui sonne.

Donc, comment un bon scientifique apprend-il à bien communiquer? Comment une bonne histoire scientifique se bâtit-elle? Et surtout, quelle utilité?

En somme, la prise de décisions éclairées découle de bonnes communications scientifiques.

Bonne nouvelle! Il existe déjà une soif pressante pour notre type particulier d'information scientifique. Effectivement, de nos jours, la météo et le climat restent sans doute les sujets scientifiques débattus les plus importants.

Cette visibilité place toutefois une lourde responsabilité sur les épaules des scientifiques qui se portent volontaires pour diffuser leur message. Une communication peu organisée, qui manque de clarté et qu'on présente mal peut se retourner contre la cause, contre le scientifique sous les projecteurs et parfois même contre toute la communauté des sciences météorologiques.

Une bonne communication scientifique est un art.

Le premier obstacle à surmonter demeure la nature même du sujet : il est compliqué!

Il est difficile d'apprendre à communiquer les nuances subtiles du fluide en mouvement qu'on nomme l'atmosphère. Si c'était facile, eh bien, tout le monde le ferait.

Le plus gros obstacle reste toutefois la présentation. À mon avis, il s'agit là du domaine où les scientifiques devraient suivre une formation adéquate. Un scientifique enthousiaste et volontaire peut s'approprier les outils nécessaires à la réussite de tout type d'entrevue. Les vrais de vrais scientifiques (lire les geeks à lunettes) sont largement reconnus comme étant les promoteurs crédibles et fiables de notre profession : donc désespérément indispensables en ces temps de fausses nouvelles habilement tournées.

Donc, ouvrez les oreilles, mémé, pépé et tous les autres, il est temps de se tourner résolument vers la bonne communication scientifique.

Katja Fennel (Ph. D.) est professeure au département d'océanographie de l'Université Dalhousie. En tant que chef du groupe de modélisation de l'environnement marin (http://memg.ocean.dal.ca), elle dirige le développement des modèles biogéochimiques et d'écosystèmes marins à Dalhousie. Depuis plus d'une vingtaine d'années, madame Fennel développe et applique des modèles numériques d'écosystèmes marins et de biogéochimie, notamment pour simuler les systèmes du plateau continental et les cycles de l'azote, du carbone et de l'oxygène. En plus de mettre en œuvre des modèles biogéochimiques, madame Fennel développe et applique des méthodes d'assimilation des observations dans ces modèles, de façon à améliorer leur capacité de prévision. Elle occupe le poste de corédacteur en chef de la revue à fort impact Biogeosciences. Elle a siégé au comité de rédaction de trois autres revues scientifiques et à divers comités consultatifs scientifiques internationaux, y compris l'équipe spéciale IMBER/LOICZ pour les marges continentales et le groupe de travail CLIVAR sur le développement de modèles océaniques. Elle fait actuellement partie de l'équipe scientifique GODAE OceanView, copréside l'équipe spéciale GODAE sur la prévision et l'analyse des écosystèmes marins, et siège aux comités consultatifs scientifiques du Copernicus Marine Environment Monitoring Service en Europe et de l'Ocean Frontier Institute de Dalhousie, ainsi qu'au comité directeur international d'Argo en matière de biogéochimie.

Les tendances biogéochimiques et leurs impacts sur les écosystèmes du Canada atlantique

Dans l'océan, bien que les écosystèmes côtiers restent les plus utiles aux activités humaines, ils s'avèrent aussi les plus vulnérables sous l'influence des facteurs de stress combinés que sont le réchauffement, la désoxygénation, l'acidification, l'eutrophisation et la pêche. Il est difficile de représenter dans les modèles mondiaux de climat les zones océaniques côtières. En conséquence, les tendances le long des côtes et leurs impacts sur les écosystèmes restent aussi difficiles à prévoir. De plus, ces régions possèdent des flux air-mer élevés de dioxyde de carbone, un facteur important mais mal quantifié du cycle planétaire du carbone. L'étude détaillée des zones côtières nécessite l'utilisation de modèles régionaux imbriqués dans des modèles mondiaux ou de grande échelle. Nous présentons les résultats d'un tel modèle biogéochimique régional, appliqué aux plateaux continentaux et à l'océan profond adjacent, dans le Canada atlantique. Ce modèle est une version du Regional Ocean Modeling System (ROMS). Il inclut un modèle des bas niveaux trophiques de l'écosystème et une représentation explicite de l'oxygène dissous et du carbone inorganique. Le domaine à l'étude se trouve à la confluence du Gulf Stream et du courant du Labrador, une région hautement dynamique, difficile à analyser et à simuler, et propice à des changements importants. Les écosystèmes côtiers du Canada atlantique, jadis lieux de pêche abondante, ont subi des changements draconiens, y compris la disparition de nombreuses populations de poissons d'importance économique et l'inscription de plusieurs espèces sur la liste des espèces menacées ou en voie de disparition. Nous ne savons pas si la région est une source ou un puits net de dioxyde de carbone atmosphérique, car les estimations de l'intensité et de la direction du flux air-mer net de dioxyde de carbone restent controversées. Nous discuterons de la répartition simulée de la production primaire, des flux de carbone inorganique et des tendances de l'oxygène selon les caractéristiques de la circulation et le temps de résidence sur le plateau, en ce qui concerne les états actuel et projetés de l'océan.

Le professeur Christian Haas est titulaire de la chaire de recherche du Canada pour la géophysique de la glace marine arctique à l'Université York. Il est aussi affilié à l'institut Alfred Wegener pour la recherche polaire et marine en Allemagne. Ses travaux portent sur la fonction de la glace marine dans les systèmes climatique, écologique et humain. Monsieur Haas étudie la glace marine, notamment la variation de l'épaisseur de la glace, à l'aide d'instruments de télédétection satellitaire et aérienne et de mesures in situ, par exemple durant des levés en motoneige avec des chasseurs de l'Arctique canadien.

Le Canada – dernière zone glaciaire??

Les observations et les prévisions numériques laissent penser que l'Arctique demeurera libre de glace marine estivale au cours des 30 à 100 prochaines années. Ces changements entraîneront des conséquences énormes sur les aspects climatique, écologique et socioéconomique de notre environnement. Il semble aussi que l'Arctique canadien sera la dernière région où persistera la glace marine avant que celle-ci ne disparaisse complètement. La région pourrait s'avérer le dernier refuge d'animaux arctiques comme l'ours polaire. Les observations qui étayent ces conclusions comprennent des données satellitaires de concentration, d'âge et d'épaisseur de la glace. Nous résumerons ces faits et les compléterons avec des données d'épaisseur de glace mesurées au cours des dix dernières années à partir d'aéronefs et de motoneiges, et provenant de diverses régions de l'Arctique canadien. Ces données nous renseignent davantage sur les changements d'épaisseur de la glace et sur ses variabilités locale et régionale que les observations par satellites. Les résultats confirment que la glace de mer la plus épaisse de l'Arctique se trouve toujours au Canada et que la glace de plusieurs années pourrait ne pas s'être autant amincie que la glace de première année. Il semble donc que les conditions glaciaires dans la mer de Beaufort et dans le passage du Nord-Ouest demeurent toujours dangereuses là où la glace résiste à la fonte d'été. Nos mesures montrent aussi l'omniprésence de glace locale mince dans les détroits étroits ou au-dessus des hauts-fonds où les flux océaniques de chaleur sont accrus. En cas de réchauffement, ces régions de glace mince pourraient former des polynies ouvertes tout au long de l'hiver, modifiant ainsi les conditions météorologiques locales et contribuant à une désintégration accrue de la glace au printemps. Bien que les résultats que nous présentons ici étayent la notion du Canada comme dernière zone glaciaire, ils indiquent aussi que les conditions de glace futures pourraient différer de celles d'aujourd'hui, ce qui modifierait leur influence sur le climat local, les écosystèmes et les résidents du Nord.

René Laprise est professeur en sciences de l'atmosphère et physique du climat à l'UQAM. Il est reconnu comme le parrain de la modélisation régionale du climat au Canada, une thématique de recherche qu'il a initié il y a 25 ans. Il a dirigé le Réseau canadien de recherche en modélisation et diagnostic du climat régional pendant près de 15 ans. Son équipe a développé plusieurs générations du modèle régional canadien du climat, et la plus récente version (MRCC5) est présentement exploitée par le Consortium Ouranos pour effectuer des projections à haute résolution des changements climatiques sur l'Amérique du Nord. Il a récemment mis au point une formulation détaillée du cycle de l'énergie atmosphérique applicable sur des régions limitées; ce diagnostic permettra de parfaire notre compréhension des mécanismes physiques responsables du maintien, des variations et de l'évolution du climat à l'échelle régionale. Il a participé comme auteur principal (Lead Author) à la rédaction du Chapitre 11 Regional Climate Projections du 4e Rapport d'évaluation (AR4) du Groupe d'experts intergouvernemental sur l'évolution du climat (GIEC) Climate Change 2007: The Physical Science Basis. De 2008 à 2009, il a présidé le Task Force on Regional Climate Downscaling, mis sur pied par le Programme mondial de recherches sur la climat (PMRC/WCRP), avec mission de favoriser une collaboration des groupes œuvrant en modélisation régionale du climat, en vue d'assurer une coordination des efforts pour les prochains rapports du GIEC. Son équipe participe activement au projet international CORDEX (COrdinated Regional Downscaling EXperiment, http://www.cordex.org). En carrière il a formé plus d'une centaine de personnels hautement qualifiés et publié plus de 130 articles dans des revues avec comité de lecture.

La mise à l'échelle **régionale du climat : réalisations, défis et avenir**

Suivant les travaux de pointe qu'a entrepris le National Center for Atmospheric Research (NCAR) il y a 30 ans, nous utilisons de plus en plus la mise à l'échelle dynamique qu'offrent les modèles à aire limitée, et ce, afin d'obtenir des simulations et des projections du climat à des résolutions sans précédent sur une région donnée.

Un projet majeur récent du Programme mondial de recherche sur le climat (PMRC), l'Expérience coordonnée de modélisation du climat régional (CORDEX), fournit un cadre commun d'analyse et de comparaison des simulations issues de modèles régionaux de climat (MRC) sur 14 domaines, à l'échelle continentale. CORDEX offre aux intervenants des données applicables aux études sur la vulnérabilité et l'adaptation face au climat, ainsi que sur ses impacts. Cette initiative produira à terme et à l'échelle régionale des ensembles de projections, qui pourront servir aux rapports d'évaluation du Groupe d'experts intergouvernemental sur l'évolution du climat (GIEC), tout comme le projet d'intercomparaison des modèles couplés (CMIP) le fait pour l'échelle planétaire.

La présentation résumera la valeur ajoutée que génèrent les simulations a posteriori, pilotées par des réanalyses et issues des modèles régionaux de climat de haute résolution (MRC), qu'on applique à divers processus climatiques régionaux et locaux. Nous présenterons quelques exemples des limites inhérentes de la réduction dynamique d'échelle quand les conditions limites latérales de l'atmosphère et celles de la surface de l'océan, qui pilotent les données, sont imparfaites. Finalement, nous discuterons des possibilités qu'introduit le développement continu des MRC, comme des résolutions qui permettent la convection ainsi que le couplage océan-atmosphère, climat-végétation, climat-aérosols et autres.

Dianne Saxe occupe le poste de commissaire à l'environnement de l'Ontario (CEO) et agit comme protectrice vigilante mais juste de la Charte des droits environnementaux. La CEO fait office de pont entre le public et le gouvernement en matière d'enjeux environnementaux. Elle doit, conformément à la loi, faire rapport à l'Assemblée législative de l'Ontario concernant les questions de conservation et d'utilisation d'énergie, de droits environnementaux, de protection de l'environnement et de changements climatiques. Avant sa nomination, madame Saxe était l'une des avocates en droit de l'environnement les plus respectées et les plus appréciées au Canada. Elle a accumulé 40 années d'expérience en litige et en matière de lois sur l'environnement et l'énergie en l'Ontario.

Se préparer aux changements climatiques

Dianne Saxe, la commissaire à l'environnement de l'Ontario, expliquera sa fonction et présentera son rapport sur les changements climatiques (*Facing Climate Change*) destiné à l'Assemblée législative de l'Ontario. La présentation montrera pourquoi, de l'avis de la commissaire, les changements climatiques constituent le problème le plus important et le plus urgent touchant l'humanité et à quel point ceux-ci affectent déjà le Canada.

Guidelines for Presenters

Poster Presentation Guidelines:

There are two poster sessions. Poster Session 1 (1708010) is on Monday and Tuesday, Poster Session 2 (1708011) is on Wednesday and Thursday.

Posters will be on display throughout the two days of the sessions, but poster presenters should be present at their posters to answer questions during the poster sessions on Monday or Wednesday afternoon. The Exhibits Floor Plan will show the poster board areas.

The maximum poster size is 120 cm x 120 cm but slightly smaller may be advisable. Poster presenters are responsible for hanging and removing their own posters. Velcro fastener supports will be provided. Be sure to hang your poster on the assigned numbered board to allow grouping by theme and avoid confusion. Volunteers will be available to help finding board locations.

Posters should be up by 11:00 am on Monday for the first poster session and 10:30 am Wednesday for the second poster session. Any posters not removed by 13:00 on Thursday will be discarded.

Prizes will be awarded by CMOS for the best student poster in Oceanography, the best student poster in Meteorology and best student poster in "other" areas, including Climate, Air Quality, Limnology and Ice. Student poster presenters wishing to be considered for these prizes must sign up on the lists (Oceanography, Meteorology or Other) BEFORE 12.00 on the day of their poster session. Lists will be at the Registration Desk. Including your photo in the poster is a good plan. Judges may want to discuss your poster with you.

Oral Presentation Guidelines:

Each oral presentation has been allotted 15 minutes, including 12 minutes for presenting and 3 minutes for questions/comments. Some invited speakers have been allotted 30 minutes total and plenary speakers have been allotted 45 minutes.

Please arrive well ahead of time (30 minutes is suggested) to your session to ensure your presentation can be loaded on to the session computer from your USB drive before the session begins. Please be sure to have your presentation on a standard USB Thumb drive to ensure compatibility with session computers. **Session computers will not be able to load from DVDs. You should also bring a pdf version of your presentation** in case there are any compatibility issues with your presentation software.

Lecture room screens will be best suited to slides with the 16:9 aspect ratio (widescreen) but the older (standard) 4:3 ratio slides should be projected satisfactorily.

Naming presentation files

All file and folder names should contain your Last Name followed by First Name and Abstract ID. File types acceptable for oral presentations: PowerPoint (.ppt, .pptx), Adobe Reader (.pdf), QuickTime.

PowerPoint embeds image files directly into the file when you save them, while video files are not embedded. Only a link is made to the video file. Copy the video clips you want to insert into the same folder as the PowerPoint file before linking them into your presentation. This will eliminate the problem of PowerPoint losing the link to the file. Be sure you upload both the video files and the PowerPoint files to your USB drive. Video/audio can also be played independently of PowerPoint using the VLC media player, which supports various formats (e.g. wmv, .mpg, .avi, .mov, etc.). Please prepare your files accordingly.

Computer and A/V Equipment

Using your own computer will not be possible. All meeting rooms will be equipped with a Windows 10 based PC with MS Office 2016, QuickTime, VLC media player, Windows media player, and Adobe Acrobat Reader. Please remember to verify proper performance of your presentation in advance, particularly if it includes audio, video, or animation files. Internet access will not be available during your presentation. Each session room will be equipped with a screen, LCD projector, timer, laser pointer and lectern with a microphone.

Instructions pour les présentateurs

Directives de présentation d’une affiche :

Il y a deux séances de présentation par affiche : 1re séance (1708010), lundi et mardi et 2e séance (1708011), mercredi et jeudi.

Les affiches seront exposées durant les deux jours réservés à chaque séance, mais le présentateur devrait être présent, afin de répondre aux questions, durant les périodes de présentation par affiche, lundi ou mercredi après-midi. Le plan de l’exposition montrera l’emplacement des tableaux d’affichage.

L’affiche ne doit pas mesurer plus de 120 cm sur 120 cm, et une taille légèrement inférieure est conseillée. Le présentateur est responsable de la pose et du retrait de son affiche. Des attaches Velcro seront fournies. Assurez-vous d'installer votre affiche sur le tableau numéroté indiqué, afin de respecter le regroupement par thème et d'éviter la confusion. Des bénévoles vous aideront à trouver le tableau qui vous a été assigné.

L'installation des affiches de la première séance s'effectuera avant 11 h lundi et celle de la seconde séance, avant 10 h 30 mercredi. Nous mettrons au rebut toute affiche toujours fixée aux tableaux après 13 h jeudi.

La SCMO décernera des prix aux étudiants ayant présenté la meilleure affiche en océanographie, la meilleure affiche en météorologie et la meilleure affiche dans les autres sujets, incluant le climat, la qualité de l'air, la limnologie at les glaces. Les étudiants souhaitant concourir pour ces prix doivent s'inscrire sur l'une des trois listes (océanographie, météorologie ou "autres") AVANT 12 h le jour de leur séance de présentation par affiche. Les listes se trouveront au kiosque d'inscription. L'ajout de votre photo sur l'affiche est un atout. Les juges pourraient vouloir vous rencontrer.

Directives de présentation orale :

Chaque présentation orale durera 15 minutes, soit un exposé de 12 minutes et une période de questions ou de commentaires de 3 minutes. Certains conférenciers disposent de 30 minutes en tout et les conférenciers des séances plénières disposent de 45 minutes.

Nous vous conseillons d'arriver 30 minutes avant le début de la séance, afin de garantir le transfert adéquat de votre présentation sur l'ordinateur de la séance à partir de votre clé USB, avant le début des présentations. Assurez-vous que votre présentation est enregistrée sur une clé USB de format standard pour garantir sa compatibilité avec l'ordinateur de la séance. **Les ordinateurs de séances n'acceptent pas les DVD. Vous devriez aussi apporter une version PDF de votre présentation** au cas où un problème de compatibilité empêcherait son bon fonctionnement.

Les écrans de la salle de conférence seront mieux adaptés aux diapositives de format 16:9 (écran large), mais les diapositives de format 4:3 (normal) devraient projeter de manière satisfaisante.

Nom des fichiers de présentation

Le nom des fichiers et des répertoires doit se composer de votre nom de famille, suivi de votre prénom et du numéro du résumé. Les types de fichiers acceptables en soutien aux présentations orales sont : PowerPoint (.ppt, .pptx), Adobe Reader (.pdf) et QuickTime.

PowerPoint incorpore directement les images dans le fichier de présentation durant la sauvegarde, mais exclut les vidéos. Il ne crée qu'un lien entre la vidéo et le fichier de présentation. Sauvegardez la vidéo associée à votre présentation dans le même répertoire que le fichier PowerPoint avant de le lier à celui-ci. De cette façon, le lien entre le fichier PowerPoint et la vidéo restera valide. Veillez à sauvegarder tant les fichiers PowerPoint que les vidéos sur votre clé USB. Il est possible de lire des fichiers vidéo ou audio sans PowerPoint, à l'aide du lecteur multimédia VCL, qui est compatible avec divers formats (.wmv, .mpg, .avi, .mov, etc.). Veuillez préparer vos fichiers adéquatement.

Ordinateur et équipement audiovisuel

Il vous sera impossible d'utiliser votre propre ordinateur. Toutes les salles de présentation comprendront un PC exploitant Windows 10 et équipé de MS Office 2016, des lecteurs QuickTime, VLC et Windows Media, ainsi que d'Adobe Acrobat Reader. N'oubliez pas de vérifier bien à l'avance le fonctionnement de votre présentation, notamment si elle comprend des fichiers audio/vidéo ou des animations. Vous n'aurez pas accès à Internet durant votre présentation. Chaque salle est équipée d'un écran, d'un projecteur ACL, d'un minuteur, d'un pointeur laser et d'un lutrin avec microphone.

Session Schedule

Time	Monday 5 June									Time
	Toronto I	Toronto II	Toronto III		Carmichael-Jackson		Thompson	York	Varley	
			MacD-Lismer	Harris	Carmichael	Jackson			Internet Cafe	
0800-0830	Opening Ceremonies									0800-0830
0830-0900										0830-0900
0900-0930										0900-0930
0930-1000	Plenaries - David Grimes, Howard Wheater									0930-1000
1000-1030										1000-1030
1030-1100	Coffee Break									1030-1100
1100-1130										1100-1130
1130-1200	Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 1	High-Impact Weather and Climate - Part 1	A Transdisciplinary Approach to Future Earth		Physical Oceanography - Part 1		Remote Sensing of the Atmosphere and Surface from Space - Part 1	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1		1130-1200
1200-1230										1200-1230
1230-1300										1230-1300
1300-1330	Lunch						UPEC Meeting	Lunch		1300-1330
1330-1400										1330-1400
1400-1430										1400-1430
1430-1500	Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 2	High-Impact Weather and Climate - Part 2	Clouds: Microphysics, Aerosols, and Radiation		Physical Oceanography - Part 2		Planetary Atmospheres, Oceans and Ice - Part 1	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2		1430-1500
1500-1530										1500-1530
1530-1600	Coffee Break									1530-1600
1600-1630										1600-1630
1630-1700	Poster Session 1 (Climate, Interdisciplinary, Air Quality)									1630-1700
1700-1730										1700-1730
1730-1800							CMOS Annual Meeting			1730-1800
1800-1830										1800-1830
1830-1900										1830-1900
1900-1930										1900-1930
1930-2000		Student Night (not in hotel)								1930-2000
2000-2030										2000-2030
2030-2100										2030-2100
2100-2130										2100-2130
2130-2200										2130-2200

Session Theme Colour Key
Weather
Oceans
Climate
Atmosphere
Air Quality
Interdisciplinary
Workshops and Panels

Time	Tuesday 6 June									Time
	Toronto I	Toronto II	Toronto III		Carmichael-Jackson		Thompson	York	GG	
			MacD-Lismer	Harris	Carmichael	Jackson				
0830-0900	Plenaries - Steve Goodman, Claire Martin							Teachers' Day		0830-0900
0900-0930										0900-0930
0930-1000										0930-1000
1000-1030	Coffee Break									1000-1030
1030-1100	Monitoring - Renewal and Modernization	Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans	Atmosphere, Ocean and Climate Dynamics - Part 1		Recent Advances in Remote Sensing of the Atmosphere - Part 1	Climate Change, Air Quality and Interconnections to Human Health	Climate Variability and Predictability - Part 1		Coupled Environmental Prediction	1030-1100
1100-1130										1100-1130
1130-1200										1130-1200
1200-1230	Patterson-Parsons Awards Lunch									1200-1230
1230-1300										1230-1300
1300-1330										1300-1330
1330-1400										1330-1400
1400-1430					General Session - Climate	Measurements and modeling of air pollution - Part 1	Climate Variability and Predictability - Part 2		The Year of Polar Prediction + Harsh Marine Environments	1400-1430
1430-1500	GOES-R Readiness in Canada - Part 1	Physical Oceanography - Part 3	Planetary Atmospheres, Oceans and Ice - Part 2							1430-1500
1500-1530										1500-1530
1530-1600	Coffee Break									1530-1600
1600-1630	GOES-R Readiness in Canada - Part 2	Government and/or Private Sector Provision of Weather Services – Where is Canada Going? – Panel Discussion	Atmosphere, Ocean and Climate Dynamics - Part 2	Physical Oceanography - Part 4	High-impact Weather and Climate - Part 3	Measurements and modeling of air pollution - Part 2	Climate Variability and Predictability - Part 3		Strategies for Arctic Ocean Observing	1600-1630
1630-1700										1630-1700
1700-1730										1700-1730
1730-1745										1730-1745
1745-1800	Climate Clock - H. Damon Matthews									1745-1800
1800-1830	Public Lecture - Francis Zwiers									1800-1830
1830-1900										1830-1900
1900-1930										1900-1930

Time	Wednesday 7 June									Time
	Toronto I	Toronto II	Toronto III		Carmichael-Jackson		Thompson	York	Varley	
			MacD-Lismer	Harris	Carmichael	Jackson			*Internet Café*	
0830-0900	Plenaries - Katja Fennel, Christian Haas									0830-0900
0900-0930										0900-0930
0930-1000										0930-1000
1000-1030	Coffee Break									1000-1030
1030-1100	Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1	Atmosphere, Ocean and Climate Dynamics - Part 3	Boundary-Layer Studies	Weather forecasting applications	Artificial Intelligence, Big Data, Open Data and Open Innovation: what are the implications for the future?	The Changing Arctic Atmosphere from IPY to YOPP - Part 1	Coastal Oceanography and Inland Waters - Part 1		1030-1100
1100-1130										1100-1130
1130-1200										1130-1200
1200-1230	Lunch									1200-1230
1230-1300										1230-1300
1300-1330	Extreme climatic and weather events	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2	Remote Sensing of the Atmosphere and Surface from Space - Part 2	CMOS Strategic Plan 2018-2020 Discover what's being proposed	Climate Change Resiliency	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1	The Changing Arctic Atmosphere from IPY to YOPP - Part 2	Coastal Oceanography and Inland Waters - Part 2		1300-1330
1330-1400										1330-1400
1400-1430										1400-1430
1430-1500	Coffee Break									1430-1500
1500-1530	Poster Session 2 (Oceans, Weather, Atmosphere)									1500-1530
1530-1600										1530-1600
1600-1630										1600-1630
1630-1700	Poster Session Continues				ARRCU	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2	Arctic Special Interest Group	Coastal Oceanography and Inland Waters - Part 3		1630-1700
1700-1730										1700-1730
1730-1800										1730-1800
1800-1830	Cash Bar									1800-1830
1830-1900										1830-1900
1900-1930	CMOS Banquet									1900-1930
1930-2000										1930-2000
2000-2030										2000-2030
2030-2100										2030-2100
2100-2130										2100-2130
2130-2200										2130-2200

Time	Thursday 8 June									Time
	Toronto I	Toronto II	Toronto III		Carmichael-Jackson		Thompson	York	Varley	
			MacD-Lismer	Harris	Carmichael	Jackson			*Internet Café*	
0830-0900	Plenaries - René Laprise, Dianne Saxe									0830-0900
0900-0930										0900-0930
0930-1000										0930-1000
1000-1030	Coffee Break									1000-1030
1030-1100	The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation	Measurements and modeling of air pollution - Part 3	Numerical Methods and Model Development	ARRCU2	Recent Advances in Remote Sensing of the Atmosphere - Part 1	Atmospheric Convection: Physics, Dynamics, and Roles in Climate	General Session - Oceans	Coastal Oceanography and Inland Waters - Part 4		1030-1100
1100-1130										1100-1130
1130-1200										1130-1200
1200-1230						NSERC Information Session				1200-1230
1230-1300										1230-1300
1300-1330					MEMO- Community of Practice Meeting	Optional for extra workshops/meetings				1300-1330
1330-1400										1330-1400
1400-1430										1400-1430
1430-1500										1430-1500
1500-1530	Congress closes									1500-1530

Horaire des sessions

Temps	Lundi 5 juin									Temps
	Toronto I	Toronto II	Toronto III		Carmichael-Jackson		Thompson	York	Varley	
			MacD-Lismer	Harris	Carmichael	Jackson			Internet Café	
0800-0830	Cérémonie d'ouverture									0800-0830
0830-0900										0830-0900
0900-0930	Plénières - David Grimes, Howard Wheater									0900-0930
0930-1000										0930-1000
1000-1030										1000-1030
1030-1100	Pause café									1030-1100
1100-1130	Les extrêmes hydrométéorologiques et les changements climatiques : bénéfices des outils de réduction d'échelle améliorés - Partie 1	Les phénomènes météorologiques de fort impact et le climat - Partie 1	Une approche transdisciplinaire appliquée à la Terre de l'avenir		L'océanographie physique - Partie 1		La télédétection spatiale de l'atmosphère et de la surface - Partie 1	L'assimilation des données, la prévision d'ensemble et la prévisibilité intrinsèque - Partie 1		1100-1130
1130-1200										1130-1200
1200-1230										1200-1230
1230-1300	Déjeuner						Réunion de l'UPEC	Déjeuner		1230-1300
1300-1330										1300-1330
1330-1400										1330-1400
1400-1430	Les extrêmes hydrométéorologiques et les changements climatiques : bénéfices des outils de réduction d'échelle améliorés - Partie 2	Les phénomènes météorologiques de fort impact et le climat - Partie 2	Les nuages : microphysique, aérosols et rayonnement		L'océanographie physique - Partie 2		Les atmosphères, les océans et les glaces d'autres planètes - Partie 1	L'assimilation des données, la prévision d'ensemble et la prévisibilité intrinsèque - Partie 2		1400-1430
1430-1500										1430-1500
1500-1530										1500-1530
1530-1600	Pause café									1530-1600
1600-1630	Session d'affiche - Partie 1 (Le climat, La qualité de l'air, Sujets interdisciplinaires)									1600-1630
1630-1700										1630-1700
1700-1730										1700-1730
1730-1800							Réunion annuelle de la SCMO			1730-1800
1800-1830		Soirée des étudiants (pas dans l'hôtel)								1800-1830
1830-1900										1830-1900
1900-1930										1900-1930
1930-2000										1930-2000
2000-2030										2000-2030
2030-2100										2030-2100
2100-2130										2100-2130
2130-2200										2130-2200

Clé de couleur de thème session
La météorologie
Les océans
Le climat
L'atmosphère
La qualité de l'air
Une perspective interdisciplinaire
Ateliers et discussions

Temps	Toronto I	Toronto II	Toronto III – MacD-Lismer	Toronto III – Harris	Carmichael-Jackson – Carmichael	Carmichael-Jackson – Jackson	Thompson	York	GG	Temps
	Mardi 6 juin									
0830-0900	Plénières - Steve Goodman, Claire Martin							Journée des enseignants		0830-0900
0900-0930										0900-0930
0930-1000										0930-1000
1000-1030	Pause café									1000-1030
1030-1100	La surveillance — Renouveau et modernisation	Les trois océans du Canada : l'évolution de la science des océans Arctique, Atlantique et Pacifique	La dynamique de l'atmosphère, des océans et du climat - Partie 1		Les faits nouveaux dans le domaine de la télédétection de l'atmosphère - Partie 1	Les changements climatiques, la qualité de l'air et l'interconnexion avec la santé humaine	La variabilité et la prévisibilité du climat - Partie 1		La prévision environ-nementale couplée	1030-1100
1100-1130										1100-1130
1130-1200										1130-1200
1200-1230	Déjeuner Patterson-Parsons									1200-1230
1230-1300										1230-1300
1300-1330										1300-1330
1330-1400										1330-1400
1400-1430					Séance générale - Le climat	La mesure et la modélisation de la pollution atmosphérique - Partie 1	La variabilité et la prévisibilité du climat - Partie 2		L'Année de la prévision polaire + Les environ-nements marins hostiles	1400-1430
1430-1500	La préparation du Canada en vue de l'arrivée de GOES-R - Partie 1	L'océanographie physique - Partie 3	Les atmosphères, les océans et les glaces d'autres planètes - Partie 2							1430-1500
1500-1530										1500-1530
1530-1600	Pause café									1530-1600
1600-1630	La préparation du Canada en vue de l'arrivée de GOES-R - Partie 2	La prestation de services météorologiques gouvernementale ou privée, quel avenir pour le Canada? — Discussion	La dynamique de l'atmosphère, des océans et du climat - Partie 2	L'océanographie physique - Partie 4	Les phénomènes météorologiques de fort impact et le climat - Partie 3	La mesure et la modélisation de la pollution atmosphérique - Partie 2	La variabilité et la prévisibilité du climat - Partie 3		Stratégies appliquées à l'observation de l'océan Arctique	1600-1630
1630-1700										1630-1700
1700-1730										1700-1730
1730-1745										1730-1745
1745-1800	Horloge de climat - H. Damon Matthews									1745-1800
1800-1830	Conférence publique - Francis Zwiers									1800-1830
1830-1900										1830-1900
1900-1930										1900-1930

Temps	Toronto I	Toronto II	Toronto III – MacD-Lismer	Toronto III – Harris	Carmichael-Jackson – Carmichael	Carmichael-Jackson – Jackson	Thompson	York	Varley – *Internet Café*	Temps
	Mercredi 7 juin									
0830-0900	Plénières - Katja Fennel, Christian Haas									0830-0900
0900-0930										0900-0930
0930-1000										0930-1000
1000-1030	Pause café									1000-1030
1030-1100	L'évaluation de la neige et de la glace marine au Canada : le passé récent et les décennies à venir	La collaboration dans le développement, l'évaluation et l'analyse des modèles physiques et biogéochimiques couplés de l'océan - Partie 1	La dynamique de l'atmosphère, des océans et du climat - Partie 3	L'étude de la couche limite	La prévision météorologique appliquée	Intelligence artificielle, données massives, données ouvertes et innovation participative : qu'est-ce que cela signifie pour l'avenir?	L'évolution de l'atmosphère arctique, de l'API à l'APP - Partie 1	L'océanographie côtière et les eaux intérieures - Partie 1		1030-1100
1100-1130										1100-1130
1130-1200										1130-1200
1200-1230	Déjeuner									1200-1230
1230-1300										1230-1300
1300-1330	Les événements climatiques et météorologiques extrêmes	La collaboration dans le développement, l'évaluation et l'analyse des modèles physiques et biogéochimiques couplés de l'océan - Partie 2	La télédétection spatiale de l'atmosphère et de la surface - Partie 2	Plan stratégique de SCMO 2018-2020 Découvrir ce qui est proposé	La résilience face aux changements climatiques	Intelligence artificielle et données massives dans des applications météorologiques et environnementales - Partie 1	L'évolution de l'atmosphère arctique, de l'API à l'APP - Partie 2	L'océanographie côtière et les eaux intérieures - Partie 2		1300-1330
1330-1400										1330-1400
1400-1430										1400-1430
1430-1500	Pause café									1430-1500
1500-1530	Session d'affiche - Partie 2 (Les océans, La météorologie, L'atmosphère)									1500-1530
1530-1600										1530-1600
1600-1630										1600-1630
1630-1700	La session d'affiche continue				ARRCUI	Intelligence artificielle et données massives dans des applications météorologiques et environnementales - Partie 2	Arctic Special Interest Group	L'océanographie côtière et les eaux intérieures - Partie 3		1630-1700
1700-1730										1700-1730
1730-1800										1730-1800
1800-1830	Bar payant									1800-1830
1830-1900										1830-1900
1900-1930	Banquet de la SCMO									1900-1930
1930-2000										1930-2000
2000-2030										2000-2030
2030-2100										2030-2100
2100-2130										2100-2130
2130-2200										2130-2200

Temps	Jeudi 8 juin									Temps
	Toronto I	Toronto II	Toronto III		Carmichael-Jackson		Thompson	York	Varley	
			MacD-Lismer	Harris	Carmichael	Jackson			*Internet Café*	
0830-0900	Plénières - René Laprise, Dianne Saxe									0830-0900
0900-0930										0900-0930
0930-1000										0930-1000
1000-1030	Pause café									1000-1030
1030-1100	La cible de 1,5 °C : impacts et implications relativement à l'atténuation des gaz à effet de serre	La mesure et la modélisation de la pollution atmosphérique - Partie 3	Les méthodes numériques et le développement de modèles	ARRCU2	Les faits nouveaux dans le domaine de la télédétection de l'atmosphère - Partie 2	La convection atmosphérique : physique, dynamique et rôle dans le climat	Séance générale — Les océans	L'océanographie côtière et les eaux intérieures - Partie 4		1030-1100
1100-1130										1100-1130
1130-1200										1130-1200
1200-1230						Session d'information du CRSNG				1200-1230
1230-1300										1230-1300
1300-1330					Réunion de la communauté de pratique MEMO	Plage facultative pour les réunions et ateliers supplémentaires				1300-1330
1330-1400										1330-1400
1400-1430										1400-1430
1430-1500										1430-1500
1500-1530	Fin du congrès									1500-1530

Presentation Schedule | Horaire des presentations

Attention!! The schedule below reflects the schedule as of 2 June 2017. Changes may occur after this date so please check the app or CMOS Congress website for the most up-to-date information.

Monday June 5 Oral Presentation Schedule						
THEME	**SESSION**	**TITLE**	**Presenter**		**Time**	**Room**
Plenaries	Plenary	The Future of the Weather Enterprise with a Look Back over the Past	David	Grimes	9:00	Toronto
Plenaries	Plenary	Sponsor and Exhibitor Presentations	Peter	Taylor	9:40	Toronto
Plenaries	Plenary	Water Futures in Changing Cold Regions	Howard	Wheater	9:50	Toronto
Parallel Sessions 11:00-12:30						
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1	Depicting the Predictable Patterns of Asian and Western Pacific Climate on Seasonal and Subseasonal Time Scales	Song	Yang	11:00	York
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1	A practical scheme of the sigma-point Kalman filter for high-dimensional systems	Youmin	Tang	11:15	York
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1	Determining the spectrum of the nonlinear local Lyapunov exponents in a multidimensional chaotic system	Ruiqiang	Ding	11:30	York
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1	Verification of convective-scale ensemble forecasts system during the OLYMPEX (Olympics Experiment) field campaign in Washington State during December 2015	Jonathan	Doyle	11:45	York
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1	Study of Nonlinear Forcing Singular Vector on Tropical Cyclone predictability	Xiaohao	Qin	12:00	York
Climate	Data Assimilation, Ensemble Prediction,	Key observing locations for advancing beyond the winter predictability	Rong	Feng	12:15	York

	and Intrinsic Predictability - Part 1	barrier of Indian Ocean dipole events				
Climate	Hydro-meteorological extremes in a changing climate: improved tools for downscaling – Part 1	The representation of extreme orographic precipitation events in an intermediate complexity atmospheric model	Ethan	Gutmann	11:00	Toronto I
Climate	Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 1	High-resolution dynamical downscaling of precipitation and temperature over western Canada by Pseudo-Global Warming method using WRF model	Zilefac Elvis	Asong	11:30	Toronto I
Climate	Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 1	The diurnal cycle of summertime precipitation over Alberta using a convection-permitting model	Lucia	Scaff	11:45	Toronto I
Climate	Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 1	Very high-resolution (1-km) dynamical downscaling of continental scale 4-km WRF regional climate simulation and its evaluation in Central U.S.	Zhe	Zhang	12:00	Toronto I
Interdisciplinary and others	A Transdisciplinary Approach to Future Earth	The economics of disaster management	Paul	Kovacs	11:00	Toronto III
Interdisciplinary and others	A Transdisciplinary Approach to Future Earth	Weather Extremes and Human Health: Adaptation to Protect Canadians in a Changing Climate	Peter	Berry	11:00	Toronto III
Interdisciplinary and others	A Transdisciplinary Approach to Future Earth	Future Earth, Future Transport	Jean	Andrey	11:00	Toronto III
Interdisciplinary and others	A Transdisciplinary Approach to Future Earth	Transdisciplinary approaches of the Future Earth Ocean Knowledge-Action Network	David	Oram	11:00	Toronto III
Interdisciplinary and others	A Transdisciplinary Approach to Future	Addressing the Transdisciplinary Approach through Global Research	Gordon	McBean	11:00	Toronto III

	Earth	Programs				
Interdisciplinary and others	A Transdisciplinary Approach to Future Earth	Toward seamless weather-climate and environmental prediction	Gilbert	Brunet	11:00	Toronto III
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 1	A Summary of Canadian Progress in Spatial Heterodyne Spectroscopy (SHS)	Gordon	Shepherd	11:00	Thomson
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 1	Long-Term, Episodic and Quasi-periodic CO Events as Seen in the MOPITT Dataset.	James	Drummond	11:15	Thomson
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 1	ACE-FTS satellite measurements of HCN in the upper troposphere to N_{2}O in the lower thermosphere	Patrick	Sheese	11:30	Thomson
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 1	Studies in support of greenhouse gas observations in the Arctic and boreal regions from a highly elliptical orbit (HEO) mission	Joseph	Mendonca	11:45	Thomson
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 1	The Orbiting Carbon Observatory-2	Debra	Wunch	12:00	Thomson
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 1	Overview and Validation Results from the Canadian Atmospheric Chemistry Experiment (ACE) Satellite Mission	Kaley	Walker	12:15	Thomson
Oceans	Physical Oceanography - Part 1	Conservation laws and inertial-symmetric instability	Nicolas	Grisouard	11:00	Carmichael - Jackson
Oceans	Physical Oceanography - Part 1	Ekman boundary layers in a large-scale gravity current experiment	Shahrzad	Davarpanah Jazi	11:15	Carmichael - Jackson
Oceans	Physical Oceanography - Part	Surface tides in the Strait of Georgia near the Fraser River plume	Mark	Halverson	11:30	Carmichael - Jackson

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Oceans	Physical Oceanography - Part 1	Convective instabilities in internal solitary waves of depression shoaling over gentle slopes	Gustavo	Rivera	11:45	Carmichael - Jackson
Oceans	Physical Oceanography - Part 1	Instability properties under a model mode-1 internal tide.	John	Segreto	12:00	Carmichael - Jackson
Oceans	Physical Oceanography - Part 1	A conceptual model of the ocean overturning circulation with two closed basins and a reentrant channel.	Louis-Philippe	Nadeau	12:15	Carmichael - Jackson
Weather	High-Impact Weather and Climate - Part 1	"The Future of High-Impact Weather Forecasting" the human forecaster versus computer modelling	Jerry	Shields	11:00	Toronto II
Weather	High-Impact Weather and Climate - Part 1	The Severe Weather Outbreak of the Summer: 2 August 2015	Steve	Knott	11:30	Toronto II
Weather	High-Impact Weather and Climate - Part 1	Without Warning: An Ingredients-Based Investigation of the 2016 Windsor Ontario Tornado	Eyad	Atallah	11:45	Toronto II
Weather	High-Impact Weather and Climate - Part 1	Spatial Verification of Lightning Forecasts Made During the Toronto 2015 Pan Am Games	Dominique	Brunet	12:00	Toronto II
Weather	High-Impact Weather and Climate - Part 1	Signatures of Tornadoes seen with VHF Windprofiler Radars	Wayne	Hocking	12:15	Toronto II
Parallel Sessions 14:00-15:30						
Atmosphere	Clouds: Microphysics, Aerosols, and Radiation	Sensitivity of Tropical Cyclone Intensification to Axisymmetric Heat Sources: The Role of Different Microphysical Properties	Georgina	Paull	14:00	Toronto III
Atmosphere	Clouds: Microphysics, Aerosols, and Radiation	Turbulence effect on cloud droplet collision: how does the droplet size distribution evolve in cumulus clouds?	Sisi	chen	14:15	Toronto III
Atmosphere	Clouds: Microphysics, Aerosols, and Radiation	Measuring and Modeling Nonlinear Diffusion in Single Aerosol Particles	Ali	Moridnejad	14:30	Toronto III
Atmosphere	Clouds: Microphysics, Aerosols, and	Impact of Saharan dust aerosols on radiation and cloud microphysics over	Abdulla	Mamun	14:45	Toronto III

	Radiation	the tropical east Atlantic Ocean				
Atmosphere	Clouds: Microphysics, Aerosols, and Radiation	Internal Mixing of Black Carbon Aerosols and Its impact on Climate	Jiangnan	Li	15:00	Toronto III
Atmosphere	Clouds: Microphysics, Aerosols, and Radiation	A sensibility study of the impacts of ice multiplication process in predicting high ice water content condition by Canadian high-resolution NWP model	Zhipeng	Qu	15:15	Toronto III
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2	An improved 2015 El Niño hindcast using the CNOP approach to optimize initial conditions and model parameters in a coupled model	Rong-Hua	Zhang	14:00	York
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2	Developing a 2D Hybrid Data Assimilation System for Surface Analysis	Zheng	Wang	14:15	York
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2	Improved ensemble-mean forecasting of ENSO events by a zero-mean stochastic error model of an intermediate coupled model	Fei	Zheng	14:30	York
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2	Role of sensitive physical parameter combinations in reducing simulation and forecast errors of sensible heat flux and latent heat flux in China	Guodong	Sun	14:45	York
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2	The formulation of vector weights in localized particle filter	Zheqi	Shen	15:00	York
Climate	Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2	A study of predictability of a heavy rainfall event in steep domains by using BVs and ESVs	Feifan	Zhou	15:15	York
Climate	Hydro-meteorological extremes in a changing climate: improved tools for	A 50-member ensemble from a regional climate model at 12-km resolution to address local impacts from natural variability and	Martin	Leduc	14:00	Toronto I

	downscaling - Part 2	extreme events under climate change				
Climate	Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 2	Multivariate quantile mapping bias correction: An N-dimensional probability density function transform for climate model simulations of multiple variables	Alex	Cannon	14:30	Toronto I
Climate	Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 2	The Added Value of Convection-permitting Simulations for Dynamically Downscaling Precipitation Extremes	Andre	Erler	14:45	Toronto I
Climate	Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 2	Evaluation of the added value of high resolution in the Canadian Regional Climate Model for freezing rain	Médéric	St-Pierre	15:00	Toronto I
Climate	Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 2	Probabilistic Projections of Regional Climatic Changes Through an Ensemble Modeling Approach	Gordon	Huang	15:15	Toronto I
Interdisciplinary and others	Planetary Atmospheres, Oceans and Ice - Part 1	Trace gas retrievals for the ExoMars Trace Gas Orbiter Atmospheric Chemistry Suite mid-infrared channel	Kevin	Olsen	14:00	Thomson
Interdisciplinary and others	Planetary Atmospheres, Oceans and Ice - Part 1	The GEM-Mars General Circulation Model for Mars	Lori	Neary	14:15	Thomson
Interdisciplinary and others	Planetary Atmospheres, Oceans and Ice - Part 1	Characterizations of Martian Water-Ice Cloud Crystal Geometries From Phase Functions Derived Using MARCI Image Data	Brittney	Cooper	14:30	Thomson
Interdisciplinary and others	Planetary Atmospheres, Oceans and Ice - Part	Inter-annual and diurnal variability in clouds observed from MSL over two Martian years	Jacob	Kloos	14:45	Thomson

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Interdisciplinary and others	Planetary Atmospheres, Oceans and Ice - Part 1	Dust within Gale Crater, Mars: Observations from the Mars Science Laboratory	Casey	Moore	15:00	Thomson
Interdisciplinary and others	Planetary Atmospheres, Oceans and Ice - Part 1	Estimating the Altitude of Martian Clouds at the Mars Science Laboratory Rover Landing Site	Charissa	Campbell	15:15	Thomson
Oceans	Physical Oceanography - Part 2	Interannual Variability of Global Overturning Circulation Dominated by Pacific Variability	Neil	Tandon	14:00	Carmichael - Jackson
Oceans	Physical Oceanography - Part 2	The variations of the Atlantic Meridional Overturning Circulation from an eddy-resolving North Atlantic model	Zeliang	Wang	14:15	Carmichael - Jackson
Oceans	Physical Oceanography - Part 2	Long-term versus decadal-scale variability in deep-water ventilation in the Labrador Sea	Igor	Yashayaev	14:30	Carmichael - Jackson
Oceans	Physical Oceanography - Part 2	Interannual to decadal variability of the upper ocean over the northeast Pacific	Patrick	Cummins	14:45	Carmichael - Jackson
Oceans	Physical Oceanography - Part 2	Dynamics of Quasi-Geostrophic Meddy-Type Vortices	Benjamin	Storer	15:00	Carmichael - Jackson
Oceans	Physical Oceanography - Part 2	The Stability of the Gulf of Oman Current	Francis	Poulin	15:15	Carmichael - Jackson
Weather	High-Impact Weather and Climate - Part 2	The 2013 Billion Dollar Flash Flood in Toronto - Challenges for Operational Forecasting and Nowcasting	David	Sills	14:00	Toronto II
Weather	High-Impact Weather and Climate - Part 2	A Case Study on Snow Squall Lines in comparison with Warm Season Squall Lines	Brandon	Taylor	14:15	Toronto II
Weather	High-Impact Weather and Climate - Part 2	Automated Forecast Products for Arctic Blizzard Conditions	William	Burrows	14:30	Toronto II

Weather	High-Impact Weather and Climate - Part 2	High-resolution wind fields using an optical flow technique for GOES-R/ABI	Robert	Rabin	14:45	Toronto II
Weather	High-Impact Weather and Climate - Part 2	Applying New Satellite Techniques and Products for Forecasting Rapid Cyclogenesis and Extratropical Transition of Tropical Cyclones	Michael	Folmer	15:00	Toronto II
Weather	High-Impact Weather and Climate - Part 2	Size Matters with Hurricanes: A New Component for a Hurricane Scale	Athena	Masson	15:15	Toronto II

Tuesday June 6 Oral Presentation Schedule						
Plenaries	Plenary	An Introduction to the GOES-R Satellite Series	Steven	Goodman	8:30	Toronto
Plenaries	Plenary	Exhibitor Presentations	Peter	Taylor	9:10	Toronto
Plenaries	Plenary	"OK Granny, listen up.."	Claire	Martin	9:20	Toronto
Parallel Sessions 10:30-12:00						
Air Quality	Climate Change, Air Quality and Interconnections to Human Health	Air Quality Forecasting in Canada and worldwide: past, present and future	Veroniqu e	Bouchet	10:30	Jackson
Air Quality	Climate Change, Air Quality and Interconnections to Human Health	Coordinating Climate and Air Quality Policies through Inclusion of Air Quality Co-benefits of GHG Reduction	Amir	Hakami	11:00	Jackson
Air Quality	Climate Change, Air Quality and Interconnections to Human Health	Quantifying Environmental Damages from Pavement Management Activities	Filzah	Nasir	11:30	Jackson
Air Quality	Climate Change, Air Quality and Interconnections to Human Health	Mitigating climate change’s impact on human health through photocatalytic air pollution control	Stephani e	Shaw	11:45	Jackson

Atmosphere	General Session - Atmosphere	The May 4, 2016 Fort McMurray Pyrocumulonimbus	Bob	Kochtubajda	10:30	Carmichael
Atmosphere	General Session - Atmosphere	Synoptic controls on orographic precipitation distributions during OLYMPEX	Daniel	Kirshbaum	10:45	Carmichael
Atmosphere	General Session - Atmosphere	Source apportionment of aerosols on Sable Island, Nova Scotia, Canada	Loay	Jabre	11:00	Carmichael
Climate	Climate Variability and Predictability - Part 1	Pacific-Atlantic interactions heat up: Evidence from El Nino and Mid-latitude Blobs	Jin-Yi	YU	10:30	Thomson
Climate	Climate Variability and Predictability - Part 1	Impact of cloud radiative effects on midlatitude jet variability in an aquaplanet GCM	Oliver	Watt-Meyer	11:00	Thomson
Climate	Climate Variability and Predictability - Part 1	Variations of Mid-Oceanic Troughs and Associated Atmospheric Teleconnection Patterns: Roles of Tropical SST and Arctic Sea Ice	Song	Yang	11:15	Thomson
Climate	Climate Variability and Predictability - Part 1	Changing association of Northern Hemisphere teleconnection patterns with ENSO	Nicholas	Soulard	11:30	Thomson
Climate	Climate Variability and Predictability - Part 1	Teleconnection over Afro-eurasia and Influence of Tropical Sea Surface Temperature on It	Shan	He	11:45	Thomson
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 1	The Fully Nonlinear Stratified Geostrophic Adjustment Problem	Aaron	Coutino	10:30	Toronto III
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 1	Internal Solitary Wave Generation: Effects of a Mean Background Current	Kevin	Lamb	10:45	Toronto III
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 1	Upper ocean physical and biological response to Typhoon Cimaron (2006) in the South China Sea	Yujuan	Sun	11:00	Toronto III
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 1	Scaling estimates of tracer flux though a submarine canyon	Karina	Ramos-Musalem	11:15	Toronto III
Oceans	Canada's Three	Modelled Arctic Freshwater	Susan	Allen	10:30	Toronto II

	Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans	Components from Dissolved Barium and $\delta^{18}O$				
Oceans	Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans	Spatial and temporal variability of internal wave energy and its potential effect on mixing in the Canadian Arctic Ocean	Melanie	Chanona	10:45	Toronto II
Oceans	Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans	Quantifying the impact of internal tide mixing on shelf-basin exchange in a numerical model of the Arctic Ocean	Jacquie-Lee	Thibault	11:00	Toronto II
Oceans	Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans	The Arctic hydrosphere-cryosphere complex: a dynamic nexus of biogenic dimethysulfide production during summer.	Martine	Lizotte	11:15	Toronto II
Oceans	Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans	Role of Increasing Barents Sea Flux on the Intermediate Circulation in the Canada Basin	Susan	Allen	11:30	Toronto II
Oceans	Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans	Labrador Sea Water formation rate and its impact on the meridional overturning circulation	Charlene	Feucher	11:45	Toronto II
Weather	Coupled Environmental Prediction	The New Coupled Global Deterministic Prediction System: Sensitivity of Operational NWP Forecasts to Coupling with an Ice-Ocean Model	Greg	Smith	10:30	Governor General
Weather	Coupled Environmental	Developing a dynamical-statistical observation operator for SST data	Sam	Pimentel	10:45	Governor General

	Prediction	assimilation				
Weather	Coupled Environmental Prediction	Variational Computation of Sensible and Latent Heat Flux over Lake Superior	Zuohao	Cao	11:00	Governor General
Weather	Coupled Environmental Prediction	Validation of the operational Regional Model Prediction System of the Gulf of St. Lawrence with in situ temperature and salinity data from an autonomous profiler.	Denis	Gilbert	11:15	Governor General
Weather	Coupled Environmental Prediction	Subseasonal Forecast of Arctic Sea Ice Concentration	Lei	Wang	11:30	Governor General
Weather	Coupled Environmental Prediction	Skillful regional prediction of Arctic sea ice on seasonal timescales	Mitch	Bushuk	11:45	Governor General
Weather	Monitoring - Renewal and Modernization	MSC - Atmospheric Monitoring - Training Needs Assessment	John	MacPhee	10:30	Toronto I
Weather	Monitoring - Renewal and Modernization	Designing Monitoring Networks to Better Understand the Past and Predict the future: The Meteorological Service of Canada's Needs Index Decision Support Model and the Collaborative Monitoring Initiative	Alexande r	Zucconi	10:45	Toronto I
Weather	Monitoring - Renewal and Modernization	Data Management Systems	Tom	Kralidis	11:00	Toronto I
Weather	Monitoring - Renewal and Modernization	Marine Transformation	Laura	Medeiros	11:15	Toronto I
Weather	Monitoring - Renewal and Modernization	Replacement of the Canadian Weather Radar Network	Peter	Leibiuk	11:30	Toronto I
Weather	Monitoring - Renewal and Modernization	Upper Air Automation	Patti	Edwards	11:45	Toronto I
Atmosphere	Recent Advances in Remote Sensing of the Atmosphere - Part 1	An intercomparison of simultaneous island and aircraft overflight observations of aerosols and trace gases as part of the NASA North Atlantic Aerosols and Marine	Mark	Gibson	11:15	Carmichael

		Ecosystems Study (NAAMES).				
Atmosphere	Recent Advances in Remote Sensing of the Atmosphere - Part 1	Spatiotemporal Variability of Ammonia over North America from CrIS Satellite Observations	Mark W.	Shephard	11:30	Carmichael
Atmosphere	Recent Advances in Remote Sensing of the Atmosphere - Part 1	Impact of far infrared measurements on analyses of temperature and humidity	Laurence	Coursol	11:45	Carmichael
Parallel Sessions 14:00-15:30						
Air Quality	Measurements and modeling of air pollution - Part 1	Canadian Air Quality Modelling Platform for Policy Emission Reduction scenarios	Sophie	Cousineau	14:00	Jackson
Air Quality	Measurements and modeling of air pollution - Part 1	Carbon Monoxide Over Canada as Seen from the MOPITT instrument	James	Drummond	14:30	Jackson
Air Quality	Measurements and modeling of air pollution - Part 1	Quantifying emissions of CO and NO_x using satellite observations of multiple chemical species	Xuesong	Zhang	14:45	Jackson
Air Quality	Measurements and modeling of air pollution - Part 1	INVESTIGATING AIRCRAFT-BASED EMISSIONS ESTIMATES USING GEM-MACH WITH THE TOP-DOWN EMISSION RATE RETRIEVAL ALGORITHM (TERRA)	Sepehr	Fathi	15:00	Jackson
Air Quality	Measurements and modeling of air pollution - Part 1	Long-term trend of ground-level ozone in Windsor, Canada	Tianchu	Zhang	15:15	Jackson
Climate	Climate Variability and Predictability - Part 2	The Dynamical Influence of Separate Teleconnections from the Pacific and Indian Oceans on the Northern Annular Mode	Christoph er	Fletcher	14:00	Thomson
Climate	Climate Variability and Predictability - Part 2	Connections linking the Spring Pacific-Arctic Dipole and Summer Sea Ice in the Beaufort-Chukchi Seas	Will	Perrie	14:15	Thomson
Climate	Climate Variability	The Asian-Bering-North American	Bin	Yu	14:30	Thomson

	and Predictability - Part 2	teleconnection: Seasonality, maintenance, and climate impact on North America				
Climate	Climate Variability and Predictability - Part 2	A Decadal-scale Air-sea Interaction Theory for North Atlantic Multidecadal Variability: the NAT-NAO-AMOC-AMO Coupled Mode and Its Remote Influences	Cheng	Sun	14:45	Thomson
Climate	Climate Variability and Predictability - Part 2	Coupled modes of large-scale features and hydroclimate variables in western Canada during the warm season	Kit	Szeto	15:00	Thomson
Climate	Climate Variability and Predictability - Part 2	The Impact of Natural Climate Variability and Bias-correction on Hydrological Simulations of Climate Change	Andre	Erler	15:15	Thomson
Climate	General Session - Climate	CCDP: GIS-Based Data Portal for Climate Change Impact Assessment	Xiuquan	Wang	14:00	Carmichael
Climate	General Session - Climate	Oceanic origin of the transient climate response to cumulative CO2 emissions	Andrew	MacDougall	14:15	Carmichael
Climate	General Session - Climate	Impact of Arctic Sea Ice loss on large-scale atmospheric circulation based on fully-coupled sensitivity experiments	Thomas	Oudar	14:30	Carmichael
Climate	General Session - Climate	The Canadian Earth System Model version 5	Neil	Swart	14:45	Carmichael
Climate	General Session - Climate	Terrestrial rock weathering and the carbon cycle in the UVic Earth System Climate Model (ESCM): Applications to past and future climates	Lawrence	Mysak	15:00	Carmichael
Climate	General Session - Climate	Analyzing the future climate change on winter road systems in Ontario's Far North, Canada, using climate model projections	Yukari	Hori	15:15	Carmichael

Interdisciplinary and others	The Year of Polar Prediction	The Year of Polar Prediction: Environment and Climate Change Canada's objectives and planned activities.	Paul	Pestieau	14:00	Governor General
Interdisciplinary and others	The Year of Polar Prediction	MEOPAR's Contribution to the Year of Polar Prediction	Alexa	Reedman	14:15	Governor General
Interdisciplinary and others	The Year of Polar Prediction	The Cambridge Bay Observatory: A Laboratory for Thermodynamic Sea-Ice Modelling	Richard	Dewey	14:30	Governor General
Atmosphere	GOES-R Readiness in Canada - Part 1	Preparing the Meteorological Service of Canada for GOES-R	David	Bradley	14:30	Toronto I
Atmosphere	GOES-R Readiness in Canada - Part 1	Early GOES-R image examples over Canada	Ronald	Goodson	14:45	Toronto I
Atmosphere	GOES-R Readiness in Canada - Part 1	The Advanced Baseline Imager (ABI) on GOES-16	Tim	Schmit	15:00	Toronto I
Atmosphere	GOES-R Readiness in Canada - Part 1	GOES-R Product Readiness: Post-Launch Product Testing Status of the L2+ Algorithms	Wayne	MacKenzie	15:15	Toronto I
Interdisciplinary and others	Planetary Atmospheres, Oceans and Ice - Part 2	Surface shielding of UV radiation on Mars from idealized spacecraft components	Christina	Smith	14:30	Toronto III
Interdisciplinary and others	Planetary Atmospheres, Oceans and Ice - Part 2	Laboratory Studies of Deliquescence and Adsorption at the Surface of Mars with Raman Scattering	George	Nikolakakos	14:45	Toronto III
Interdisciplinary and others	Planetary Atmospheres, Oceans and Ice - Part 2	An Investigation into how Water is Transported to the Moon's Polar Regions	Jasmeer	Sangha	15:00	Toronto III
Interdisciplinary and others	Planetary Atmospheres, Oceans and Ice - Part 2	Penitentes at Tartarus Dorsa, Pluto	John	Moores	15:15	Toronto III
Oceans	Physical Oceanography - Part	Midlatitude-equatorial dynamics of a grounded deep western boundary	Gordon	Swaters	14:30	Toronto II

	3	current				
Oceans	Physical Oceanography - Part 3	Impacts of the IOD-associated temperature and salinity anomalies on the intermittent Equatorial Undercurrent anomalies	Junde	Li	14:45	Toronto II
Oceans	Physical Oceanography - Part 3	Real-time buoy observations for typhoons in the South China Sea	Jin	Weifang	15:00	Toronto II
Oceans	Physical Oceanography - Part 3	Underwater Glider Measurements and Simulations of Storm-Induced Abrupt Upper Ocean Mixing	Will	Perrie	15:15	Toronto II
Interdisciplinary and others	Harsh Marine Environments	Explosive cyclogenesis over the North Atlantic: progress, challenges and new research opportunities	John	Gyakum	14:45	Governor General
Interdisciplinary and others	Harsh Marine Environments	An ocean surface current analysis (GlobCurrent) calibration and validation	Rick	Danielson	15:00	Governor General
Interdisciplinary and others	Harsh Marine Environments	The Characteristics of Fog Offshore Newfoundland	George	Isaac	15:15	Governor General
Parallel Sessions 16:00-17:30						
Air Quality	Measurements and modeling of air pollution - Part 2	What measurements tell us about the sources and sinks of atmospheric ammonia	Jennifer	Murphy	16:00	Jackson
Air Quality	Measurements and modeling of air pollution - Part 2	Estimation of nitrogen dioxide (NO2), sulfur dioxide (SO2) and ammonia (NH3) dry deposition over North America from satellite observations	Shailesh Kumar	Kharol	16:30	Jackson
Air Quality	Measurements and modeling of air pollution - Part 2	Validation of CrIS Satellite Ammonia Retrieval	Jacob	Siemons	16:45	Jackson
Air Quality	Measurements and modeling of air pollution - Part 2	Improving site selection for tower-based deposition measurements with multiple sources in complex topography	Timothy	Jiang	17:00	Jackson
Air Quality	Measurements and modeling of air	Characterization of biomass burning emissions of two wildfires through	Keane	Tobin	17:15	Jackson

	pollution - Part 2	dispersion modeling and OP-FTIR measurements during summer 2016 in Halifax, NS.				
Atmosphere	GOES-R Readiness in Canada - Part 2	Anticipating GOES-R impact in weather prediction using HIMAWARI-8 and METEOSAT-10 data	Louis	Garand	16:00	Toronto I
Atmosphere	GOES-R Readiness in Canada - Part 2	Validation of the GOES-R Geostationary Lightning Mapper over Canada	David	Sills	16:15	Toronto I
Atmosphere	GOES-R Readiness in Canada - Part 2	Geostationary Fire Detection Using the GOES-R Series Advanced Baseline Imager	Christoph er	Schmidt	16:30	Toronto I
Atmosphere	GOES-R Readiness in Canada - Part 2	Use of GOES-16 High Resolution Data to Nowcast Thunderstorms	Victor Kwok K	Chung	16:45	Toronto I
Atmosphere	GOES-R Readiness in Canada - Part 2	GOES-R Training in the Meteorological Service of Canada (MSC)	R. Paul	Ford	17:00	Toronto I
Atmosphere	GOES-R Readiness in Canada - Part 2	GOES-R and Himawari-8 Training using SIFT	Scott	Lindstrom	17:15	Toronto I
Climate	Climate Variability and Predictability - Part 3	Surface Current in “Hotspot” Serves as a New and Effective Precursor for El NiÃ±o Prediction	Youyu	Lu	16:00	Thomson
Climate	Climate Variability and Predictability - Part 3	Cloud feedback during ENSO	Allison	Kolly	16:15	Thomson
Climate	Climate Variability and Predictability - Part 3	Seasonal Predictability of North American Coastal Storm Activity during the Cold Months in the Canadian Seasonal to Interannual Prediction System (CanSIPS)	Katherine	Pingree-Shippee	16:30	Thomson
Climate	Climate Variability and Predictability - Part 3	Seasonal hindcasts with the GEM-NEMO global coupled model	Hai	Lin	16:45	Thomson
Climate	Climate Variability and Predictability - Part 3	A robust empirical seasonal prediction of winter NAO and surface climate	Lei	Wang	17:00	Thomson

Climate	Climate Variability and Predictability - Part 3	Multivariate analysis of extreme Net Basin Supplies in the Great Lakes	dorra	hammami	17:15	Thomson
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 2	Large Eddy Simulation of Turbulence under an Internal Solitary Wave of Depression	Peter	Diamessis	16:00	MackD/Lismer
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 2	Spectral analysis of in situ measurements from Honeoye lake: episodic events and dimension reduction	Justin	Shaw	16:15	MackD/Lismer
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 2	Subsurface Cores in Internal Solitary Waves	Yangxin	He	16:30	MackD/Lismer
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 2	Internal Gravity Wave Fluxes Radiated by a Stably Stratified Turbulent Wake	Kristopher	Rowe	16:45	MackD/Lismer
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 2	Scaling up experimental scale DNS	Marek	Stastna	17:00	MackD/Lismer
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 2	Cross-boundary layer transport due to shoaling mode-2 internal waves	David	Deepwell	17:15	MackD/Lismer
Oceans	Physical Oceanography - Part 4	Modelling Greenland icebergs: pathways and freshwater contribution	Juliana	Marson	16:00	Harris
Oceans	Physical Oceanography - Part 4	Mapping platelet ice and ocean heat flux under Antarctic landfast sea ice	Christian	Haas	16:15	Harris
Oceans	Physical Oceanography - Part 4	Impact of ice strength parametrization and ice thickness distribution on the Canadian 1/12th degree resolution Arctic-North Atlantic ice-ocean prediction system	Frédéric	Dupont	16:30	Harris
Oceans	Physical Oceanography - Part 4	Pacific Water Pathway in the Arctic Ocean Revealed by Online Passive Tracer in NEMO Simulations	Xianmin	Hu	16:45	Harris

Oceans	Physical Oceanography - Part 4	Turbulent Dissipation Rates, Mixing, and Heat Fluxes in the Canadian Arctic from Glider-based Microstructure Measurements	Benjamin	Scheifele	17:00	Harris
Oceans	Physical Oceanography - Part 4	Dissipation of low frequency wind-driven ocean flow by forced near-inertial motion: a modelling study	David	Straub	17:15	Harris
Oceans	Strategies for Arctic Ocean Observing	ROV Support to Arctic Ocean Cabled Observatories	Douglas	Bancroft	16:00	Governor General
Oceans	Strategies for Arctic Ocean Observing	Real-time ocean/ice observations from the Northwest Passage: Past successes and recent developments	Clark	Richards	16:30	Governor General
Oceans	Strategies for Arctic Ocean Observing	Ocean Networks Canada - Cabled Observatories and Community Monitoring in Canada's Arctic	Ryan	Flagg	16:45	Governor General
Oceans	Strategies for Arctic Ocean Observing	Spatial Variability of Sea Ice Velocity in the Continental Margin of the Canadian Beaufort Sea from a Dense Array of Moored Upward Looking Sonar Instruments	David	Fissel	17:00	Governor General
Weather	High-Impact Weather and Climate - Part 3	"2016" The Costliest Year in Canadian History- An Update on Canadian Catastrophe Trends	Carolyn	Rennie	16:00	Carmichael
Weather	High-Impact Weather and Climate - Part 3	Increasing economic impacts due to cold/wet extremes in Canada, with particular reference to western Canada	Ray	Garnett	16:15	Carmichael
Weather	High-Impact Weather and Climate - Part 3	Future Changes in Convective Precipitation and Severe Weather Environment in Western Canada	Jennifer	Bruneau	16:30	Carmichael
Weather	High-Impact Weather and Climate - Part 3	A Synoptic Climatology of Long-Duration Freezing Rain Events over North America	Christopher	McCray	16:45	Carmichael
Weather	High-Impact Weather and Climate - Part 3	Extreme Levels of Temperatures, Wind Speeds and Precipitation over British Columbia, Canada	Pedro	Odon	17:00	Carmichael

Weather	High-Impact Weather and Climate - Part 3	The importance of wave break events for synoptic-scale buildups of Northern Hemisphere zonal available potential energy	Kevin	Bowley	17:15	Carmichael
			Public Lecture			
Plenaries	Public Lecture	Changing weather extremes - why it isn't an "alternative fact"	Francis	Zwiers	18:00	Toronto

			Wednesday June 7 Oral Presentation Schedule			
Plenaries	Plenary	Biogeochemical Trends and Their Ecosystem Impacts in Atlantic Canada	Katja	Fennel	8:30	Toronto
Plenaries	Plenary	Canada - The Last Ice Area?	Christian	Haas	9:15	Toronto
			Parallel Sessions 10:30-12:00			
Atmosphere	The Changing Arctic Atmosphere from IPY to YOPP - Part 1	Aerosols as Arctic Climate Forcers	Knut	von Salzen	10:30	Thomson
Atmosphere	The Changing Arctic Atmosphere from IPY to YOPP - Part 1	Far IR Spectral Measurements Applied to Atmospheric Water Cycle and Links to Arctic Aerosols	Jean-Pierre	Blanchet	11:00	Thomson
Atmosphere	The Changing Arctic Atmosphere from IPY to YOPP - Part 1	Land-atmosphere interactions of thawing boreal forest-wetland landscapes in northwestern Canada	Manuel	Helbig	11:15	Thomson
Atmosphere	The Changing Arctic Atmosphere from IPY to YOPP - Part 1	Seasonality of the Arctic temperature inversion and its dependence on sea ice	Line	Bourdages	11:45	Thomson
Climate	Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades	Recent Variability and Trends in Arctic Snow and Sea Ice Thickness	Sinead L.	Farrell	10:30	Toronto I
Climate	Assessment of Canadian Snow and Sea Ice for the	Simulation of FMCW radar returns over Arctic sea ice	Thomas	Newman	10:45	Toronto I

	Recent Past and the Coming Decades					
Climate	Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades	Reassessing the Role of Sea Ice Drift in Arctic Sea Ice Loss	Neil	Tandon	11:00	Toronto I
Climate	Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades	Sources of uncertainty and variability in historical trends and future projections of snow cover extent and snow water equivalent	Lawrence	Mudryk	11:15	Toronto I
Climate	Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades	Influences of temperature and precipitation on historical and future snowpack variablity over North America in the Fourth-Generation Canadian Regional Climate Model (CanRCM4)	Reinel	Sospedra-Alfonso	11:30	Toronto I
Climate	Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades	Assessment of Canadian Snow and Sea Ice: Trends (1981-2016) and Projections (2020-2050)	Paul	Kushner	11:45	Toronto I
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 3	A Minimum Diffusive Model for the Bipolar Seesaw	Guido	Vettoretti	10:30	MacD/Lismer
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 3	Hot spots of atmospheric warming under climate change	Timothy	Merlis	10:45	MacD/Lismer
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 3	A nonlinear model for dynamical-chemical processes in the atmosphere	Lucy	Campbell	11:00	MacD/Lismer
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 3	Stimulated imbalance of barotropic flow by large amplitude Poincarre waves in a two layer shallow water setting	David	Straub	11:15	MacD/Lismer

Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 3	Normal Mode Decomposition of Mesoscale Simulations	Matthew	Ambacher	11:30	MacD/Lismer
Interdisciplinary and others	Atmosphere, Ocean and Climate Dynamics - Part 3	On Boussinesq turbulence near the tropopause	Olivier	Asselin	11:45	MacD/Lismer
Interdisciplinary and others	Boundary-Layer Studies	A New Diagnostic Turbulence Scheme in CanAm4 Climate Models	Yanping	He	10:30	Harris
Interdisciplinary and others	Boundary-Layer Studies	Idealized Simulations of Sea Breezes over Mountainous Islands	Chun-Chih	Wang	10:45	Harris
Interdisciplinary and others	Boundary-Layer Studies	Mesoscale numerical modeling of surface turbulent fluxes in the littoral environment	David	Flagg	11:00	Harris
Interdisciplinary and others	Boundary-Layer Studies	The Role of Coherent Structures and Coupling Between the Atmosphere and Forest Canopy on Atmospheric Chemistry	Sarah	Kavassalis	11:15	Harris
Interdisciplinary and others	Boundary-Layer Studies	The effects of forest sheltering on peatland evapotranspiration in the Boreal Plains, Alberta, Canada	Adam	Green	11:30	Harris
Interdisciplinary and others	Boundary-Layer Studies	Measurements of Aerosol, Trace Gas and Turbulent Fluxes and Vehicle-Induced Turbulence (VIT) from a Mobile Car Platform on the Highway	Stefan	Miller	11:45	Harris
Oceans	Coastal Oceanography and Inland Waters- Part 1	Development and Applications of Shelf Circulation Models for the Eastern Canadian Shelf	Jinyu	Sheng	10:30	York
Oceans	Coastal Oceanography and Inland Waters- Part 1	The Mean Tilt of Coastal Sea Level in Shallow, Tidally-Dominated Regions	Christoph	Renkl	10:45	York
Oceans	Coastal Oceanography and Inland Waters- Part 1	Assessing the Performance of Formulations for Nonlinear Feedback of Surface Gravity Waves on Ocean Currents over Coastal Waters	Pengcheng	Wang	11:00	York
Oceans	Coastal Oceanography and	Simulation of wave-current interactions under hurricane	Yujuan	Sun	11:15	York

	Inland Waters- Part 1	conditions using unstructured grid model FVCOM: The impact on wave and current fields				
Oceans	Coastal Oceanography and Inland Waters- Part 1	Development and applications of a next-generation coastal ocean forecast system for the eastern Canadian seaboard	Kyoko	Ohashi	11:30	York
Oceans	Coastal Oceanography and Inland Waters- Part 1	Modelling the baroclinic response of Placentia Bay to Hurricane Leslie	Zhimin	Ma	11:45	York
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1	Impact of turbidity from the Fraser River plume on modelled primary production in the Strait of Georgia	Elise	Olson	10:30	Toronto II
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1	Effects of Arctic sea ice retreat on primary production and emissions of climatically important trace gas dimethylsulfide (DMS): a model study	Hakase	Hayashida	10:45	Toronto II
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1	A model approach to carbon exchange in the air, sea, and ice of the marine Arctic	Eric	Mortenson	11:00	Toronto II
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-	Coupling a regional climate model to a lake tile model for prediction dissolved oxygen profiles in lakes	Aidin	Jabbari	11:15	Toronto II

	biogeochemical ocean models - Part 1					
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1	Exploring the Relationship Between Vertical Mixing, Overturning Circulation, and AABW Volume During the Last Glacial Maximum	Margaret	Valerio	11:30	Toronto II
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1	Pan-Arctic Exchange, the Labrador Sea and the AMOC	Paul	Myers	11:45	Toronto II
Weather	Weather forecasting applications	Open Access to Canadian Weather Data via Geospatial Web Services	Tom	Kralidis	10:30	Carmichael
Weather	Weather forecasting applications	Transformation of the 24/7 Operations in Canadian Meteorological Centre	Paul	Yang	10:45	Carmichael
Weather	Weather forecasting applications	How Graphic Design can be used to change audience perception of weather data and improve its communicative capacity	Philippe	Jean	11:00	Carmichael
Weather	Weather forecasting applications	Snowfall Rate Estimation Using C-Band Polarimetric Radars	Diar	Hassan	11:15	Carmichael
Weather	Weather forecasting applications	Précision des prévisions saisonnières à long terme pour l'énergie éolienne	Olivia	Beauregard-Harvey	11:30	Carmichael
Weather	Weather forecasting applications	Notes on ICAO cold temperature correction procedures for aircraft barometric altimeters	Stefano	RAPISARD A	11:45	Carmichael
Parallel Sessions 13:00-14:30						
Atmosphere	The Changing Arctic Atmosphere from IPY	Sources and sinks of ammonia in the summertime arctic boundary layer:	Alexande r	Moravek	13:00	Thomson

	to YOPP - Part 2	spatial and temporal variability				
Atmosphere	The Changing Arctic Atmosphere from IPY to YOPP - Part 2	A decade of atmospheric composition measurements at the Polar Environment Atmospheric Research Laboratory	Kimberly	Strong	13:30	Thomson
Atmosphere	The Changing Arctic Atmosphere from IPY to YOPP - Part 2	Using the Optimal Estimation Method (OEM) for Retrieval of Stratospheric Ozone Profiles from DIAL lidar measurements	Ghazal	Farhani	13:45	Thomson
Atmosphere	The Changing Arctic Atmosphere from IPY to YOPP - Part 2	Identifying long-range transport of wildfire emissions to the Arctic using a network of ground-based FTIR spectrometers, satellite observations, and transport models	Erik	Lutsch	14:00	Thomson
Atmosphere	The Changing Arctic Atmosphere from IPY to YOPP - Part 2	Characterization of the chemical, physical and optical properties of atmospheric aerosols in the Canadian High Arctic	Samanth a	Tremblay	14:15	Thomson
Climate	Climate Change Resiliency	Updating CWEEDS Weather Files used for Building and Solar Energy System Simulation and Design	Robert	Morris	13:00	Carmichael
Climate	Climate Change Resiliency	Impacts of Climate Change on Building Envelope Energy Efficiency	Paul	Carter	13:15	Carmichael
Climate	Climate Change Resiliency	Climate Data for Building Design: Advances in Understanding and Future Needs	Duncan	Phillips	13:30	Carmichael
Climate	Climate Change Resiliency	Establishing a Climate Change Resiliency Assessment Framework for Buildings	Brandon	Law	13:45	Carmichael
Climate	Climate Change Resiliency	Application of Temperature to Augment Precipitation Projections in Ontario	Eric	Soulis	15:15	Carmichael
Climate	Extreme climatic and weather events	Understanding Regional Projections of Extreme Precipitation	Neil	Tandon	13:00	Toronto I
Climate	Extreme climatic and weather events	Characterizing extreme impact compound events emerging from	Martin	Leduc	13:15	Toronto I

		natural climate variability and their dependence to climate change using a 50-member ensemble of high-resolution simulations				
Climate	Extreme climatic and weather events	Improving the representation of historical Climate Precipitation Indices using Optimal Interpolation methods	Alexis	Pérez Bello	13:30	Toronto I
Climate	Extreme climatic and weather events	Attributing Extreme Fire Risk in Western Canada to Human Emissions	Francis	Zwiers	13:45	Toronto I
Climate	Extreme climatic and weather events	Case studies of winter storms over eastern Canada in a climate change context	Sébastien	Marinier	14:00	Toronto I
Climate	Extreme climatic and weather events	Past and future evolution of streamflow in three watersheds in southern Ontario	Olivier	Champagne	14:15	Toronto I
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1	High Resolution Forecast Prediction using Machine Learning	Ulrik	Soderstrom	13:00	Jackson
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1	Comparative Study of Machine Learning Algorithms and the Future of Weather Forecasts	Ulrik	Soderstrom	13:15	Jackson
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1	Towards nonlinear updatable model outputs statistics via machine learning	Aranildo	Lima	13:30	Jackson
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1	Use of artificial neural network for fecal indicator nowcasting in a sewage impacted recreational water source	Nicolas	Fortin St-Gelais	13:45	Jackson

Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1	Automated Detection of Mesoscale Boundaries from Multiple Sensors: a Bayesian Framework	Dominique	Brunet	14:00	Jackson
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1	Sea ice concentration from SAR imagery using a convolutional neural network and comparison with a passive microwave retrieval	Andrea	Scott	14:15	Jackson
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 2	EarthCARE radiative transfer algorithms and products: A summary and application to A-train data	Jason	Cole	13:00	MacD/Lismer
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 2	Evaluating the relationship between C-band SAR backscatter and sea ice thickness in the Beaufort Sea	Alec	Casey	13:15	MacD/Lismer
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 2	Using O2 bands to improve MAESTRO tangent height profiles	Omid	Moeini	13:30	MacD/Lismer
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 2	Characterizing Wheat Yield Sensitivity to the Timing and Duration of Soil Moisture Extremes Observed from Microwave Satellites	Jenelle	White	13:45	MacD/Lismer
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 2	Moving towards Operational Drought Monitoring Using the Vegetation Drought Response Index	Patrick	Cherneski	14:00	MacD/Lismer
Interdisciplinary and others	Remote Sensing of the Atmosphere and Surface from Space - Part 2	Cloud-assisted retrieval of stratospheric water vapor from nadir view satellite measurements	Jing	Feng	14:15	MacD/Lismer
Oceans	Coastal Oceanography and	Patterns of SST variability along the west coast of North America	Charles	Hannah	13:00	York

	Inland Waters - Part 2					
Oceans	Coastal Oceanography and Inland Waters - Part 2	Wind-driven currents in the Strait of Georgia from recent model hindcasts	Ben	Moore-Maley	13:15	York
Oceans	Coastal Oceanography and Inland Waters - Part 2	Barotropic to baroclinic energy conversion in a modelling study of the Salish Sea	Nancy	Soontiens	13:30	York
Oceans	Coastal Oceanography and Inland Waters - Part 2	A modelling study of the wind-driven and estuarine circulation of the Kitimat Fjord System	Shiliang	Shan	13:45	York
Oceans	Coastal Oceanography and Inland Waters - Part 2	Dispersion and transport in the Fraser River plume: Insight from drifting buoy trajectories	Mark	Halverson	14:00	York
Oceans	Coastal Oceanography and Inland Waters - Part 2	Tidal propagation in Fraser River Estuary	Yongsheng	Wu	14:15	York
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2	Developing CanNEMO - the ocean component of the Canadian Earth System Model	Neil	Swart	13:00	Toronto II
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2	Evaluation of a high-resolution model of the Northeast Pacific based on NEMO	Jean-Philippe	Paquin	13:15	Toronto II
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical	Diagnosing the dynamics of the barotropic transport in the North Atlantic Ocean with a high-resolution circulation model	Yuan	Wang	13:30	Toronto II

	ocean models - Part 2					
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2	Development of a coastal circulation model in support of the Manolis-L operation	Guoqi	Han	13:45	Toronto II
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2	NEMO_Nowcast: A Software Automation Framework for Research-Operational Deployments of NEMO	Doug	Latornell	14:00	Toronto II
Oceans	Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2	Discussion on development, evaluation and analysis of physical and coupled biogeochemical ocean models	Youyu	Lu	14:15	Toronto II
Parallel Sessions 16:30-18:00						
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2	PAVICS : A platform for multidisciplinary climate analysis	David	Huard	16:30	Jackson
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2	Scalable machine learning on big climate data with Scispark	Jean-Francois	Rajotte	16:45	Jackson
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and	Toward improved estimates of snow water equivalent in a mixed alpine region: data fusion of gridded data	Andrew	Snauffer	17:00	Jackson

	environmental applications - Part 2	products via machine learning				
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2	Use of climate and satellite data in crop yield forecasting and early-warning for decision support	Aston	Chipanshi	17:15	Jackson
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2	Forecasting crop heat stress with Bayesian learning networks	Nathaniel	Newlands	17:30	Jackson
Interdisciplinary and others	Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2	Machine Learning Classification of Extreme Climate Events in Australia	Michael	Richman	17:45	Jackson
Oceans	Coastal Oceanography and Inland Waters - Part 3	Sub-tidal circulation in a deep-silled fjord: Douglas Channel, British Columbia	Di	Wan	16:30	York
Oceans	Coastal Oceanography and Inland Waters - Part 3	Nine Years of Extremely Large Internal Waves in the Strait of Georgia	Lan	Li	16:45	York
Oceans	Coastal Oceanography and Inland Waters - Part 3	A Data Science Approach to Understanding Coastal Primary Productivity Dynamics	Tereza	Jarnikova	17:00	York
Oceans	Coastal Oceanography and Inland Waters - Part 3	Drifter dispersion in a multiply connected fjord system in the context of estimating oil spill extents	Hauke	Blanken	17:15	York
Oceans	Coastal Oceanography and Inland Waters - Part 3	Physical Controls on Extremes of Carbon and Oxygen in Coastal Upwelling Regions	Zelalem	Engida	17:30	York
Oceans	Coastal Oceanography and Inland Waters - Part 3	Observations of enhanced mixing and dissipation in the central Canadian Arctic Archipelago	Kenneth	Hughes	17:45	York

Thursday June 8 Oral Presentation Schedule						
Plenaries	Plenary	Regional climate downscaling: Achievements, challenges and prospects	J.P. René	Laprise	8:30	Toronto
Plenaries	Plenary	Facing Climate Change	Dianne	Saxe	9:15	Toronto
Parallel Sessions 10:30-12:00						
Air Quality	Measurements and modeling of air pollution - Part 3	Air pollution emissions from satellite observations: methods and applications	Mark W.	Shephard	10:30	Toronto II
Air Quality	Measurements and modeling of air pollution - Part 3	Analysis of Air Quality across the Windsor Area (Canada) based on Satellite and Ground Level Observations	Xiaohong	Xu	11:00	Toronto II
Air Quality	Measurements and modeling of air pollution - Part 3	The prediction of aerosol size and composition in the regional particulate pollution, analyses and sensitivity simulations	Surandok ht	Nikzad	11:15	Toronto II
Air Quality	Measurements and modeling of air pollution - Part 3	Improving plume rise algorithms within the GEM-MACH model: a comparison to stack plume measurements in the Athabasca oil sands	Mark	Gordon	11:30	Toronto II
Air Quality	Measurements and modeling of air pollution - Part 3	Air Quality Monitoring - What the Future Holds	James	Young	11:45	Toronto II
Atmosphere	Recent Advances in Remote Sensing of the Atmosphere - Part 2	CO2 profile retrieval from near-infrared spectra	Sébastien	Roche	10:30	Carmichael
Atmosphere	Recent Advances in Remote Sensing of the Atmosphere - Part 2	Far InfraRed Radiometer Arctic campaign	Ludovick	S.Pelletier	10:45	Carmichael
Atmosphere	Recent Advances in Remote Sensing of the Atmosphere - Part	Balloon demonstrator imaging Fourier transform spectrometer for the measurement of methane and carbon	Zahra	Vaziri Zanjani	11:00	Carmichael

	2	dioxide				
Atmosphere	Recent Advances in Remote Sensing of the Atmosphere - Part 2	Calibrating Water Vapour Mixing Ratio Measurements from the MeteoSwiss RAman Lidar for Meteorological Observations (RALMO) using a Radiosonde Trajectory Method	Shannon	Hicks	11:15	Carmichael
Atmosphere	Recent Advances in Remote Sensing of the Atmosphere - Part 2	The Purple Crow Lidar Middle Atmospheric Temperature Climatology Using the Optimal Estimation Method	Ali	Jalali	11:30	Carmichael
Atmosphere	Recent Advances in Remote Sensing of the Atmosphere - Part 2	The Application of the Optimal Estimation Method (OEM) for Tropospheric Rotational Raman Temperature Retrieval	Shayamil a	Mahagamm ulla Gamage	11:45	Carmichael
Climate	Atmospheric Convection: Physics, Dynamics, and Roles in Climate	A population dynamics approach to parameterizing fractional areas for shallow and deep moist convection	Norman	McFarlane	10:30	Jackson
Climate	Atmospheric Convection: Physics, Dynamics, and Roles in Climate	Accurate simulation of the temperature profile in actively convecting regions of the tropics using a convective parameterization	Ian	Folkins	11:00	Jackson
Climate	Atmospheric Convection: Physics, Dynamics, and Roles in Climate	Topographic Impacts on the Spatial Distribution of Deep Convection over Southern Quebec	Daniel	Kirshbaum	11:15	Jackson
Climate	Atmospheric Convection: Physics, Dynamics, and Roles in Climate	Cases of Elevated Convection Initiation on Frontal Surfaces in 2015	Scott	Kehler	11:30	Jackson
Climate	Atmospheric Convection: Physics, Dynamics, and Roles in Climate	Influence of Bores on Nocturnal Convective Initiation During PECAN and on the Canadian Prairies: A Case Study Analysis	Kyle	Ziolkowski	11:45	Jackson

Climate	The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation	Observationally-constrained carbon budgets consistent with 1.5°C warming	Katarzyna (Kasia)	Tokarska	10:30	Toronto I
Climate	The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation	Exploring the reversibility of changes in ocean conditions under net-negative CO2 emissions	Xinru	Li	10:45	Toronto I
Climate	The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation	Effect of carbon-cycle uncertainty on estimates of the 1.5°C carbon budget	Nadine	Mengis	11:00	Toronto I
Climate	The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation	The impact of anthropogenic aerosol emission reductions on achieving the 1.5-degree target	Antti-Ilari	Partanen	11:15	Toronto I
Climate	The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation	Can differences between 1.5 and 2.0°C of global warming be detected locally?	Neil	Swart	11:30	Toronto I
Climate	The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation	North2Warm: The Impact of 1.5°C or Greater Global Warming on Canada's North	Paul	Kushner	11:45	Toronto I

Interdisciplinary and others	Numerical Methods and Model Development	A post-processing technique for stabilizing the discontinuous pressure projection operator in marginally-resolved incompressible inviscid flow	Peter	Diamessis	10:30	MacD/Lismer
Interdisciplinary and others	Numerical Methods and Model Development	How to choose the filter in pseudospecral DNS simulations?	David	Deepwell	10:45	MacD/Lismer
Interdisciplinary and others	Numerical Methods and Model Development	A projected model for internal wave propagation	Michael	Dunphy	11:00	MacD/Lismer
Interdisciplinary and others	Numerical Methods and Model Development	A higher-order finite volume method for quasi-uniform spherical grids	Christopher	Subich	11:15	MacD/Lismer
Interdisciplinary and others	Numerical Methods and Model Development	Three dimensional graphics as a tool for studying dynamics	Laura	Chandler	11:30	MacD/Lismer
Interdisciplinary and others	Numerical Methods and Model Development	The evolution of Environment Canada's numerical prediction systems over the past 50 years	Benoit	Archambault	11:45	MacD/Lismer
Oceans	Coastal Oceanography and Inland Waters - Part 4	Investigating the flushing dynamics of Parry Sound	Bryan	Flood	10:30	York
Oceans	Coastal Oceanography and Inland Waters - Part 4	Observations of surface drift in a very shallow embayment: Part I instrument design	Jennifer	Shore	10:45	York
Oceans	Coastal Oceanography and Inland Waters - Part 4	Linkage between the flushing mechanisms and water quality patterns in the nearshore of South-eastern Georgian Bay	Lakshika	Ralahamill	11:00	York
Oceans	Coastal Oceanography and Inland Waters - Part 4	Frequent hypoxic upwelling events in Hamilton Harbour driven by wind forcing	Mathew	Wells	11:15	York
Oceans	Coastal	Circulation and thermal regime in	Matthew	Wells	11:30	York

	Oceanography and Inland Waters - Part 4	shallow embayments of a coastal lagoon: Combining field observations and hydrodynamic modelling				
Oceans	Coastal Oceanography and Inland Waters - Part 4	Modelling environmental uncertainty in acoustic transmission loss and comparison to measurements in the Capraia Basin, Mediterranean Sea	Cristina	Tollefsen	11:45	York
Oceans	General Session - Oceans	VITALS - Ventilation, Interactions and Transports Across the Labrador Sea	Paul	Myers	10:30	Thomson
Oceans	General Session - Oceans	Biogeochemical Argo - an extension of the Argo array	Blair	Greenan	11:00	Thomson
Oceans	General Session - Oceans	Advancing oceanographic habitat ecology with in-situ remote-sensing from autonomous gliders	Kimberley	Davies	11:15	Thomson
Oceans	General Session - Oceans	Operational Wave Prediction System at Environment and Climate Change Canada: Going Global to Improve Regional Forecast Skill	Syd	Peel	11:30	Thomson
Oceans	General Session - Oceans	Great Lakes Wave Prediction Systems: Offering Guidance over Lead Times of Hours to Three Days drawing from Locally Refined Forecasts to Lakes wide Ensemble Forecasts.	Syd	Peel	11:45	Thomson

Poster Session 1, June 5 16:00-17:30 Session d'affiches 1, 5 juin 16h00-17h30

Poster Theme	Abstract Title	Presenter		Poster Order
Thème de l'affiche	**Titre du résumé**	**Présentateur**		**Ordre des affiches**
Climate	Evaluate the surface coupling strength of a continental scale 4-km WRF regional climate simulation	Yanping	Li	1704020P01
Climate	Application of CanESM2 to Project Future Soil Temperature at a Northern Quebec Location with Statistical Downscaling Model (SDSM) software	Andrew	Leung	1704020P02
Climate	Central U.S. WRF composite radar verification using MODE-Time Domain	Jason	Flemke	1704020P04
Climate	The Lagrangian identification of moisture sources for precipitation over Western Canada	Sopan	Kurkute	1704020P05
Climate	Carbon cycle feedbacks in the context of negative CO2 emissions	Claude-Michel	Nzotungicimpay e	1704030P02
Climate	Path Independence of Climate-Carbon Cycle Response Over a Broad Range of Cumulative Emissions	Tyler	Herrington	1704030P03
Climate	Reductions in carbon budgets due to non-CO2 greenhouse gases	Katarzyna (Kasia)	Tokarska	1704030P04
Climate	Projecting yield change of canola on the Canadian Prairies under climate scenarios of the 1.5Â°C climate target	Budong	Qian	1704030P05
Climate	Nitrogen availability dampens optimism for the positive impacts of CO2 fertilization on carbon/water cycles	Liming	He	1704030P06
Climate	How much half a degree in global warming may affect the extreme precipitation change in China?	Wei	Li	1704030P08
Climate	New blended sea ice thickness dataset	Marie-Ève	Gagné	1704040P01
Climate	Uncertainty quantification of snow-related parameters in the Canadian Land Surface Scheme (CLASS)	Bakr	Badawy	1704040P02
Climate	Assessing land-surface initialization in CanSIPS using bias-corrected operational GEM analysis.	Manoj	Nambiar	1704040P03
Climate	Updating the Canadian Historical Snow Survey Dataset	Anne	Walker	1704040P04
Climate	Impact of climate change on climate indices in latitudes across Canada	Hussein	Wazneh	1704050P01

Climate	High Resolution Regional Climate Change Projections for Ontario	Ziwang	Deng	1704050P02
Climate	Optimally Growing Initial Errors of ENSO in CESM Model	Hui	Xu	1704050P03
Climate	Stratospheric polar vortex characteristics and winter temperature cold anomalies in North America	Zhenhua	Li	1704050P05
Climate	High-Resolution Meteorological Surface Analysis using 2D-Variational Method	Zhan	Li	1704060P01
Climate	A particle swarm optimizer based on directions and its application to the four dimensional variational data assimilation	Qin	Zheng	1704060P02
Climate	A New Targeted Observing Strategy based on Particle Filter and Its Application	Wansuo	Duan	1704060P03
Climate	On the linearity of Arctic sea ice loss and doubled CO2 in a coupled system	Paul	Kushner	1704070P01
Climate	Subseasonal Predictability over the United States assessed from Two Operational Ensemble Prediction Systems	Lei	Wang	1704070P02
Climate	A New Index representing Circumglobal Variability	Nicholas	Soulard	1704070P03
Climate	Separating linear and nonlinear interference effects in stratosphere-troposphere interactions	Chengzhu	Xu	1704070P04
Climate	Modeling the Interannual Variability of Tornado Occurrences In North America: Influence of Madden-Julian Oscillation and El-Nino/Southern Oscillation	Vincent	Cheng	1704070P05
Climate	Extended range forecast over East Asia during boreal summer using the ECCC monthly forecasting system	Ping	Liang	1704070P06
Climate	Barrier Effect of the Maritime Continent on the MJO in the in the Superparameterized CAM	Teng	Wang	1704070P07
Climate	Interannual variability of spring intraseasonal variability and Mei-Yu onset	Yonghong	Yao	1704070P08
Climate	Response of convection to large-scale forcings in spCAM5 and CanAM4	Toni	Mitovski	1704080P01
Climate	Evaluating cumulus entrainment retrieval methods using large-eddy simulation	Sonja	Drueke	1704080P02
Climate	A novel convective scheme for the CAM4 AGCM and impacts on the tropical circulation.	Shawn	Corvec	1704080P03
Climate	Post-treatment of the Climate Forecast System	Dikra	Khedhaouiria	1704090OP5

	Reanalysis (CFSR) daily precipitations across Canada			
Climate	On the variability of upper-level winds over southern Ontario	Peter	Taylor	1704090P01
Climate	Trend analysis of long-term hydrometeorological time series in the Great Lakes Basin, with an emphasis in the Lake Huron-Michigan System.	Vincent	Cheng	1704090P02
Weather	Statistical Homogenization of Undocumented Monthly Temperature Data in British Columbia for Trend Analysis	Yaqiong	Wang	1704090P03
Climate	Nocturnal Relative Humidity Maxima above the Boundary Layer in the American Midwest	Amanda	Mercer	1704090P04
Climate	Assessing the consistency of temperature and precipitation between observations and gridded products across southern NWT, Canada	Bhaleka	Persaud	1704090P06
Climate	Projected changes of mixed precipitation over southern Quebec using high-resolution climate simulations.	Dominic	Matte	1704090P07
Climate	A comparison of the atmospheric response to sea ice loss in isolation among coupled climate models	Stephanie	Hay	1704090P08
Air Quality	Charactersitics of Smog in Ontario	Siliang	Cui	1706010P01
Air Quality	Spectral analysis of large-scale meteorological patterns preceding summer ozone episodes and heat waves in North America	Edward Charles	White	1706010P02
Air Quality	Health risk assessment of PM2.5 bound compounds in Windsor, Canada	Yangfan	Chen	1706010P03
Air Quality	Long Term Forecast and Modelling of South Athabasca Oil Sands and Provincial Emissions in Alberta	Xin	Qiu	1706010P04
Air Quality	Atmospheric Pollution in Coastal Environments: A Nova Scotia Perspective	Aldona	Wiacek	1706030P01
Air Quality	Modeling the impact of marine fugitive VOC emissions from the transport and handling of petroleum products on summertime ground level ozone in southwestern British Columbia.	Bruce	Ainslie	1706030P02
Air Quality	Trace gas measurements by Open-path Fourier Transform Infrared (OP-FTIR) spectroscopy at Halifax, Canada: vehicles and ships emissions	Li	Li	1706030P03
Air Quality	Long term trends of sulphur dioxide emissions and ambient concentrations in Ontario, Canada	Basith	Weerasundara	1706030P04

Air Quality	Monitoring trace gases in downtown Toronto using open-path Fourier transform infrared spectroscopy	Brendan	Byrne	1706030P05
Interdisciplinary and others	Propagation and Directional Scattering of Ocean Waves in the Marginal Ice Zone and Neighbouring Seas	Will	Perrie	1707010P01
Interdisciplinary and others	PEARL and YOPP	James	Drummond	1707010P02
Interdisciplinary and others	The importance of detritus in idealized models of planktonic ecosystems	Emilee	Carson	1707020P01
Interdisciplinary and others	Effects of moisture and precipitation in a simple model of baroclinic beta-plane turbulence.	Eric	Bembenek	1707020P03
Interdisciplinary and others	Interpreting Changes in the Eddy Moist Isentropic Circulation to Surface Perturbations in a Relatively Simple Model	Robert	Fajber	1707020P04
Interdisciplinary and others	The spontaneous radiation of spiral inertia-gravity waves and the imbalance in tropical cyclone-like vortices - Evidence from fully nonlinear simulations.	Konstantinos	Menelaou	1707020P05
Interdisciplinary and others	Non-linear interactions between internal wave beams: beyond the traditional approximation	Christian	Ogbonna	1707020P06
Oceans	From DNS of shear instability to cross-layer transport	Andrew	Grace	1707020P07
Interdisciplinary and others	Satellite validation of CFCs over the High Arctic	Ralf	Bauer	1707030P01
Interdisciplinary and others	Characterizing Wheat Yield Sensitivity to the Timing and Duration of Soil Moisture Extremes Observed from Microwave Satellites	Jenelle	White	1707030P02
Interdisciplinary and others	Long-Term Variations of Tropospheric Ozone over Asia from 1980 to 2000	Yingjie	Li	1707030P03
Interdisciplinary and others	Using O2 bands to improve MAESTRO tangent height profiles	Omid	Moeini	1707030P05
Interdisciplinary and others	A Fast and Accurate Scheme for Sea Ice Dynamics with Pseudo Subgrid Resolution	Clint	Seinen	1707040P01
Interdisciplinary and others	QG SPINS : A Spectral QG Model with Channel Geometry	Benjamin	Storer	1707040P02
Interdisciplinary and others	Atmosphere-Biosphere Interaction: A Quantitative Study of Ozone Dynamics over a Mixed Forest	Shihao	Wang	1707070P01
Interdisciplinary and others	Grand Banks fog - a tale of cold air advection, turbulent mixing and radiative fluxes.	Peter	Taylor	1707080P01

Interdisciplinary and others	Risk Forecasting in Harsh Offshore Environments	Steven	Beale	1707080P02
Interdisciplinary and others	Forecasting Outdoor Residential Water Consumption using Ensembles of Regression Trees	Valerie	Platsko	1708010P02

Poster Session 2, June 6 15:00-17:00 Session d'affiches 2, 6 juin 15h00-17h00

Poster Theme Thème de l'affiche	Abstract Title Titre du résumé	Presenter Présentateur		Poster Order Ordre des affiches
Weather	An investigation into Kamloops flash flooding events	Rodger	Wu	1702010P01
Weather	Synoptic Forcing on Mesocale Circulations During Heat Waves at Vancouver, British Columbia.	Daniel	Betancourt	1702010P02
Weather	Ensemble-Based Forecast Verification of Typhoon Haikui (2012)	Feng	Zhiming	1702010P03
Weather	December 23rd 2014 and January 4th 2015 Freezing Rain Events in Montreal Or Aiming at better assessing the duration of a freezing rain event in Montreal	Raphaell	Brochu	1702010P05
Weather	Forecasting flood-producing water levels in the Ottawa River and Lake Ontario: May, 2017	Dorothy	Durnford	1702020P01
Weather	CONCEPTS Coupled Environmental Prediction Systems	Hal	Ritchie	1702020P05
Oceans	Surface Seiching in Quesnel Lake, BC	Samuel	Brenner	1702030P04
Weather	The study of the microphysical and dynamical processes of in-flight icing environments and icing intensity forecast at Cold Lake Alberta, Canada	Di	Wu	1702040P01
Weather	Predicting Heavy Snowfall Along the Eastern Rocky Mountains: An Examination Into Hydrometeor Drift	Heather	Pimiskern	1702040P02
Weather	Wind Rose Renewal Project	Lindsay	Sutton	1702060P01
Weather	Impact of augmenting the quantity of assimilated surface observations in a regional forecast system	Mateusz	Reszka	1702060P02
Weather	Synoptic-scale zonal available potential energy increases in the Northern Hemisphere	Kevin	Bowley	1702060P03
Oceans	CTD dynamic corrections for an unpumped inductive conductivity cell on autonomous platforms	Clark	Richards	1703010P01
Oceans	Observations of the transport of organic material from the shelf to the abyssal sea off the west coast of Vancouver Island.	Fabio	De Leo Carbera	1703010P02
Oceans	Characterization of the Flow Dynamics in a Wide, Arctic Canyon	Idalia	Machuca	1703010P03

Oceans	Frequency analysis of wind forcing over ocean gyres	Yanxu	Chen	1703010P05
Oceans	Moored observation of abyssal flow and temperature near a hydrothermal vent on the Southwest Indian Ridge	BeiFeng	Zhou	1703010P06
Oceans	The role of Antarctic sea ice on the meridional overturning circulation.	Matthieu	Gavelle	1703010P07
Oceans	Long-term performance of the RBR conductivity sensor: Evaluation from an autonomous float	Mark	Halverson	1703010P08
Oceans	Conversion of Pressure to Depth for Moored Instruments Using a Reference Bottom Mounted Pressure Sensor	Tao	Ding	1703010P09
Oceans	Decadal simulations of sea surface salinity in the Arctic Ocean	Zhenxia	Long	1703010P10
Oceans	Understanding ocean temperature and salinity variability in the Coast of Bays Region, NL	Andry	Ratsimandresy	1703020P03
Oceans	Internal Solitary Wave Reflection near Dongsha Atoll, the South China Sea	Xiaolin	Bai	1703020P05
Oceans	Use of Dorado as a Platform for the Validation of High Resolution Ocean Circulation Models	Chris	L'Esperance	1703020P06
Oceans	Sea state indices for a coastal strait	Richard	Dewey	1703020P08
Oceans	Investigating the Sensitivity of the Drag Coefficient under Hurricane Conditions in Spectral Wave Models	Shangfei	Lin	1703020P09
Oceans	Effect of asymmetries in ripple shape and currents on two-dimensional oscillatory flow over ripples.	Subasha	Wickramarachchi	1703020P10
Oceans	High frequency observations of temperature and oxygen in a large Canadian lake over two winters reveal the role of solar radiation and ice cover in the development of the mixed layer	Bernard	Yang	1703020P11
Oceans	Simulation of Interannual Circulation Variability in Placentia Bay	Ying	Xie	1703020P12
Oceans	Heat transport from northern rivers to Canadian Arctic coasts	Daqing	Yang	1703020P13
Oceans	Algal bloom transport in the Great Lakes using remote sensing and hydrodynamic modelling	Nancy	Soontiens	1703030P01
Oceans	Characterizing fronts in a whale habitat	Tara	Howatt	1703030P02
Oceans	Model simulated variations of the California	Chengyi	Yuan	1703030P02

	Undercurrent off the Vancouver Island during 2013-2015			
Oceans	Origin of seasonal variation of salinity in Bering Strait	Xiaofan	Luo	1703030P03
Oceans	Evaluation of ocean variability simulated by the high-resolution CONCEPTS regional model of the Arctic and North Atlantic oceans	Simon	Higginson	1703030P04
Oceans	The setup and testing of a new model of a southern channel in the Arctic Archipelago	David	Greenberg	1703030P05
Oceans	Predictability of inter-annual variations of bottom temperature and salinity on the Scotian Shelf	Shiliang	Shan	1703030P06
Oceans	Variability and Wind Forcing of Ocean Temperature and Thermal Fronts in the Slope Water Region of the Northwest Atlantic	Ingrid	Peterson	1703060P01
Climate	When will we reach 1.5 of global warming?	Damon	Matthews	1704030P01
Atmosphere	GOES-R Data Access for Canada	Wayne	MacKenzie	1705010P01
Atmosphere	GOES-R Data Requirements in the Area of Weather Forecast and Science Applications	Hong	Lin	1705010P02
Atmosphere	Low and High Level Cloud Fraction Feedback over Tropical Oceans	Toni	Mitovski	1705020P01
Atmosphere	Evaluating the radiative effects of fog and cloud properties in the Arctic	Joelle	Dionne	1705020P02
Atmosphere	Oxidative processing studies on biological ice nucleating particles	Ellen	Gute	1705020P03
Atmosphere	Terrestrial Cloud Microstructure Analysis Utilizing the DSCOVR-EPIC Spacecraft	Rachel	Modestino	1705020P04
Atmosphere	The statistical characteristics on impacts of aerosol and cloud distributions between two Eastern China regions based on CloudSat/CALIPSO data	Yujun	Qiu	1705020P05
Atmosphere	Incorporation of a Four-Stream Solar Radiative Transfer Model into CanAM4.2	Jason	Cole	1705020P06
Atmosphere	Estimate and Analysis of Planetary Boundary Layer Height (PBLH) using a Mobile Lidar Vehicle system.	Hyounggu	Nam	1705030P01
Atmosphere	The Re-analysis of a Historical Atmospheric High Resolution Infrared Spectral Data-set Recorded at 80N	Pierre	Fogal	1705030P02
Atmosphere	Impact assessment of assimilating satellite-derived	Louis	Garand	1705030P03

	land surface skin temperature observations in the Canadian Land Data Assimilation System (CALDAS)			
Atmosphere	Polarimetric Retrievals of Cloud Droplet Number Concentrations: Evaluation of Measurements and Correlations with Aerosol Properties	Kenneth	Sinclair	1705030P04
Atmosphere	First retrievals of methane isotopologues from FTIR ground-based observations in the High Arctic	Whitney	Bader	1705040P01
Atmosphere	Long-term monitoring of the Arctic atmosphere using UV-visible spectrometers at Eureka, Nunavut	Kristof	Bognar	1705040P02
Atmosphere	Parallel warming-induced photosynthesis and respiration increases make the CO2 and 13C/12C seasonality stable under changing climate and vegetation activity	Alemu	Gonsamo	1705040P03
Atmosphere	Diagnostic of Arctic atmosphere energy budget during the polar night	Housseyni	Sankare	1705040P04
Atmosphere	High Arctic atmospheric water vapour measurements at PEARL	Dan	Weaver	1705040P06
Atmosphere	A Compact Cavity Ring-Down Spectroscopy Analyzer for in Situ measurements of Carbon Dioxide, Methane, and Water Vapor	Milos	Markovic	1705050P01
Atmosphere	Remote Sensing of Greenhouse Gases at East Trout Lake	Joseph	Mendonca	1705050P03
Interdisciplinary and others	Orientation and Spacing of Small-scale Surface Features in Mars' North Polar Cap: Preliminary Results	T. Giang	Nguyen	1707050P01
Interdisciplinary and others	Using a Laser and Camera to Determine the Depth and Turbidity of Water	Elisabeth	Smith	1707050P02


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Introduction

The following are the accepted abstracts for oral and poster presentations for the 2017 CMOS Congress held in Toronto, Ontario June 4-8, 2017. Where possible, all withdrawn abstracts have been removed. Abstracts are searchable and sorted in ascending order by session number. The abstracts are reproduced here in the format and language in which they were submitted.

Introduction

Voici les résumés acceptés pour les présentations orales et d'affiches pour 2017 Congrès SCMO tenue à Toronto au Ontario le 4 au 8 juin 2017. Si possible, tous les résumés retirés ont été supprimés. Les résumés sont consultables et triés par ordre croissant par numéro de session. Les résumés sont reproduits ici dans le format et la langue dans laquelle elles ont été soumises.

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PART 1 - ORAL PRESENTATIONS

1701010 Plenary

The Future of the Weather Enterprise with a Look Back over the Past

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The Government of Canada has been providing weather, water, climate and air quality services to Canadians, their governments, and public and private sector institutions for almost 150 years. Since its beginnings in 1871, Environment and Climate Change Canada's Meteorological Service provides high-quality and timely warnings and forecasts, services and information to reduce risks to health & safety and to help the public and private sector benefit from opportunities related to related to environmental changes. A strong research foundation and high performance computing capacity are essential to deliver on this unique federal mandate. Today, in Canada and around the world, national meteorological and hydrological services provide more than basic weather, water and climate information; weather enterprises strive to provide information on the anticipated impacts of expected events in order to help citizens and other stakeholders to make informed decisions and adapt their behaviour. With growing public concerns about changes in weather and climate, demands are growing from the public for faster, more comprehensive information delivered in a wider range of ways, including social media. The weather enterprise is also being called upon to provide the essential science-based foundations to support the global agenda and societal needs in areas such as sustainable development, disaster risk reduction, and climate change, including the Paris Agreement and domestic action under the Pan Canadian Framework on Clean Growth and Climate Change.

This talk will take a look back at the history of the Meteorological Service of Canada, and the vast improvements in the science and technology of weather predictions and services over the past century. It will provide an overview of the future priorities of the weather enterprise, not only in Canada but around the world, from the current President of the World Meteorological Organization, considering the opportunities and challenges facing the weather enterprise such as Big Data, crowdsourcing, advances in modeling, and the growing engagement with partners in the private and academic sector.

1701010 Plenary

Water Futures in Changing Cold Regions

Wheater, Howard - University of Saskatchewan
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Canada is experiencing some of the world's most rapid rates of climate warming; with a water environment dominated by snow, ice and frozen soils, Canada is losing her cold. Climate and landscapes are changing, and historical patterns of water availability are no longer a reliable guide to the future. Adaptation to change requires new science to understand the changing earth system, new monitoring systems to warn of critical environmental change, new modelling tools that can represent non-stationary and tipping points, and more effective methods to translate new scientific knowledge into societal action. We report on two major Canadian research programs that aim to prepare Canada to meet these challenges. The Changing Cold Regions Network (2012-2018) focusses on monitoring and modelling environmental change in western Canada. Global Water Futures (2016-2023) aims to deliver transdisciplinary science, working with users to address the question 'How can we best forecast, prepare for and manage water futures in the face of rapid change and increasing water-related risks?'

1701011 Plenary

An Introduction to the GOES-R Satellite Series

Goodman, Steven - NOAA/NESDIS
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NOAA's Geostationary Operational Environmental Satellites (GOES) have been a mainstay of weather forecasts and environmental monitoring for the past 40+ years. The next generation of GOES satellites, known as the GOES-R Series, will usher in a new era in geostationary environmental satellites. It has been 22 years since the last major instrument advance with the GOES I-M series. The first satellite in the GOES-R series, now GOES-16, was launched in November 2016 and is producing stunning imagery and undergoing on-orbit post launch testing for approximately 12 months before being placed into operations replacing either the GOES-E or GOES-W satellite. The GOES-R satellites will continue to provide continuous imagery and atmospheric measurements of Earth's Western Hemisphere that will foster a host of improved and new environmental products and services. GOES-R's primary instrument, the Advanced Baseline Imager (ABI), will provide three times the spectral resolution and four times the spatial resolution while scanning the Earth nearly five times faster than the current GOES. GOES-R will also host a new instrument, the Geostationary Lightning Mapper (GLM) that is designed to continuously map in-cloud and cloud-to-ground lightning with 8 km spatial resolution over the Western Hemisphere. It will provide information to improve storm monitoring and warnings and contribute to improved aircraft safety and efficient flight route planning. GOES-R's space weather instruments will provide improved observations of the sun and space environment with more timely dissemination and early warning to a diverse user community. This presentation will provide an overview and status update of the GOES-R program and the activities leading to an operational GOES-R system. The new observations will provide dramatically improved weather, water, and space environmental services in the coming decades, enhancing public safety and providing economic benefits to the U.S.and our international partners.

1701011 Plenary

"OK Granny, listen up.."

Martin, Claire - Environment and Climate Change Canada
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Apparently Albert Einstein once said that "you really don't understand something unless you can explain it to your grandmother". This quote, though not referring to my Granny who obtained 5 bachelor degrees in her life, should be tattooed on the forehead of any professional meteorologist currently trying to communicate their work in the highly politicalized rabbit-warren world of alternative-facts strewn science.

At best it is a challenge; at worst it can be career-ending.

So how does a good scientist learn to become a good communicator? Furthermore what makes a good science story? And most importantly, why bother?

Simply put: for informed decision making we need great science communicators.

The good news is that there is a consummate thirst for our particular niche of scientific information.

Arguably in fact, weather and climate are the most important science topics talked about today..

But, this then places a great deal of responsibility on the shoulders of those scientists who personally volunteer to help get their message out. Poorly devised communication, with unclear or a badly executed delivery can backfire on the subject matter, the scientist under the spotlight, and sometimes even the meteorological community as a whole.

Good science communication is an art.

The first hurdle is overcoming the very nature of the subject matter – it's complicated!

Learning to deliver the tricky nuanced details about the fluid-in-motion we call the atmosphere, is tough. But if it was easy, well, as they say, "everyone would do it".

The biggest hurdle though, is in the delivery. And that's where scientists can and (in my mind) should be given more training. An enthusiastic and willing scientist can be taught the tools to master any type of interview. Genuinely authentic scientists (read: nerdy) are widely recognized as credible, trustworthy

promoters of our profession – something we desperately need in these times of cleverly concealed "fake news".
So, listen up grandmothers, and grandfathers, and indeed everyone else – let's start embracing good science communication.

1701012 Plenary
Canada – The Last Ice Area?
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Observations and model predictions suggest that the Arctic will become free of sea ice during summer within the next 30 to 100 years. These changes will have huge climatic, ecologic, and socio-economic consequences. It is also expected that the Canadian Arctic will be the last region where sea ice will survive before disappearing completely. The region could become a last refuge for Arctic animals like Polar Bears. Supporting observations include satellite data of ice concentration, ice age, and ice thickness. I will summarize this evidence and complement it with results from airborne and snowmobile ice thickness surveys from various regions in the Canadian Arctic carried out in the past ten years. These provide more insights into thickness changes and regional and local variability than satellite observations can do. Results confirm that the thickest sea ice of the Arctic still resides in Canada, and that multiyear ice may not have thinned as strongly as first-year ice. This implies that ice conditions in the Beaufort Sea and Northwest Passage still have to be considered hazardous where the ice survives summer melt. Our measurements also show the ubiquitous occurrence of local thin ice in narrow straits or over shoals where ocean heat flux can be increased. With warmer conditions, these thin ice regions may become open polynyas throughout the winter, changing local weather and contributing to more rapid ice disintegration during spring. While the presented results support the notion of Canada as the Last Ice Area, they also imply that future ice conditions may not be the same as presently, changing its importance for local climate, ecosystem, and northern residents.

1701012 Plenary
Biogeochemical Trends and Their Ecosystem Impacts in Atlantic Canada
Fennel, Katja - Dalhousie University
Rutherford, Krysten - Dalhousie University
Kuhn, Angela - Dalhousie University
Zhang, Wenxia - Dalhousie University
Brickman, David - DFO
Brennan, Katie - Dalhousie University, DFO
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In the ocean, coastal ecosystems are the most vulnerable to the combined stressors of warming, deoxygenation, acidification, eutrophication and fishing while being the most relevant for human activities. The representation of coastal oceans in global climate models is difficult, making projections of future coastal trends and their ecosystem impacts challenging. These regions also have large air-sea fluxes of carbon dioxide, making them an important but poorly quantified component of the global carbon cycle. Regional model applications that are nested within large-scale or global models are necessary for detailed studies of coastal regions. We present results from such a regional biogeochemical model for the continental shelves and adjacent deep ocean of Atlantic Canada. The model is an implementation of the Regional Ocean Modeling System (ROMS) and includes a lower trophic level ecosystem model with explicit representation of dissolved oxygen and inorganic carbon. The region is at the confluence of the Gulf Stream and Labrador Current making it highly dynamic, a challenge for analysis and prediction, and prone to large changes. Historically a rich fishing ground, coastal ecosystems in Atlantic Canada have undergone dramatic changes including the collapse of several economically important fish stocks and the listing of many species as threatened or endangered. It is unclear whether the region is a net source or sink of atmospheric carbon

dioxide with estimates of the size and direction of the net air-sea flux of carbon dioxide remaining controversial. We will discuss simulated patterns of primary production, inorganic carbon fluxes and oxygen trends in the context of circulation features and shelf residence times for the present ocean state and present future projections.

1701013 Plenary

Regional climate downscaling: Achievements, challenges and prospects

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Since the pioneering work initiated at the National Center for Atmospheric Research (NCAR) three decades ago, dynamical downscaling with limited-area models has become increasingly used to achieve unprecedented high-resolution climate simulations and projections over regions of interest.
A recent World Climate Research Programme (WCRP) major project, the Coordinated Regional Downscaling Experiment (CORDEX), provides a common framework to assess and compare regional climate models (RCM) simulations over 14 continental-scale domains. CORDEX provides datasets to stakeholders for climate vulnerability, impact and adaptation studies, and will eventually contribute regional-scale projections ensembles that could be used in the Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC), as the Coupled Model Intercomparison Project (CMIP) does at global scale.
The presentation will give an overview of the added value afforded by high-resolution regional climate model (RCM) hindcast simulations driven by reanalyses for various regional and local climate processes. Some examples of the inherent limitations of dynamical downscaling will also be illustrated when ocean surface and atmospheric lateral boundary conditions driving datasets are imperfect. Finally prospects offered by on-going RCM developments such as convection-permitting resolution, coupling ocean-atmosphere, climate-vegetation, climate-aerosols, and others, will be discussed.

1701013 Plenary

Facing Climate Change

Saxe, Dianne - Environmental Commissioner of Ontario
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Dianne Saxe, the Environmental Commissioner of Ontario, will explain her role and introduce her report to the Ontario Legislature, Facing Climate Change. The presentation will focus on why the Commissioner considers climate change to be the most important and most urgent problem facing humanity, and how much it is already affecting Canada.

1702010 High-Impact Weather and Climate - Part 1

Spatial Verification of Lightning Forecasts Made During the Toronto 2015 Pan Am Games

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Lightning is a significant weather hazard that is prevalent in the summer months in southern Canada. Improved lightning prediction accuracy would lead to increased safety for Canadians.
During the Toronto 2015 Pan Am Games, several lightning forecasts were produced for the Greater Toronto Area and surrounding regions: two probabilistic forecasts using calibrated post-processing of output from the Canadian Regional Deterministic Prediction System (RPDS), the Kain-Fritsch deterministic convective precipitation forecast (also from RDPS) which can be used as a thunderstorm proxy, a calibrated thunderstorm forecast from the Canadian Regional Ensemble Prediction System (REPS), a nested (2.5 km to 1 km to 250 m) lightning intensity forecast using the High-Resolution RDPS (HRDPS), as well as a manual forecast done by human forecasters on the Research Support Desk (RSD).

Two sources of lightning observations were available: the operational Canadian Lightning Detection Network (CLDN) and the experimental high-resolution Southern Ontario Lightning Mapping Array (SOLMA).
In this talk, we summarize recent work that has been done for the inter-comparison of deterministic and probabilistic lightning forecasts. Going beyond contingency-based scores, we introduce spatio-temporal measures of forecasting error.
Answers to the following questions are presented. What is the average time lag and spatial error for each lightning forecast? What degree of smoothing of lightning forecasts best represents the forecast uncertainty? How can deterministic and probabilistic forecasts be compared when defined on different grids? How can broad categorical forecasts generated by human forecasters be compared with detailed continuous forecasts from numerical weather predictions? Does increasing the resolution of numerical weather predictions necessarily lead to a better lightning forecast?

1702010 High-Impact Weather and Climate - Part 1
Without Warning: An Ingredients-Based Investigation of the 2016 Windsor Ontario Tornado
Atallah, Eyad - McGill University
Gyakum, John - McGill University
Milrad, Shawn - Embry-Riddle Aeronautical University
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On the early evening of 24 August 2016, two high-impact (one EF-2 and one EF-1) tornadoes hit the Windsor, Ontario region, destroying structures, uprooting trees, and causing several injuries. The tornadoes were produced by a rapidly-developing and fast-moving supercell that crossed the Detroit River, and were notable not only for the damage they caused, but for the lack of watches and warnings in place at the time. Using an ingredients-based approach to severe convection (lift, moisture, instability, and vertical wind shear), an investigation of the synoptic- and mesoscale precursors and conditions that caused the tornadoes will be completed. The analysis will be conducted using a combination of high-resolution reanalysis data and observations, including proximity soundings. In addition, the investigation will examine whether upstream convection that resulted in more than 40 tornado reports earlier that day over Indiana and Ohio played a role in enhancing the downstream environment for supercells. Finally, there will be a discussion of why this event was such a large forecasting challenge in both the U.S. and Canada.

1702010 High-Impact Weather and Climate - Part 1
Signatures of Tornadoes seen with VHF Windprofiler Radars
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Studies of 31 tornadoes in Ontario and Quebec over an 11-year period show unique signatures on Windprofiler radars located less than 100 km from the tornado. These signatures show strong turbulence, strong winds, and, most notably, a column of highly reflective air extending to heights well within the stratosphere. It appears that this column of air has greater-than-normal humidity, resulting in strong radar backscatter, often up to 20dB above normal values. The column can often be seen before the tornado touches down, providing some possibility of touch-down warning in the area around the detecting radar. Examples will be shown and implications will be discussed.

1702010 High-Impact Weather and Climate - Part 1
"The Future of High-Impact Weather Forecasting" the human forecaster versus computer modelling
Shields, Jerry - Ontario Ministry of Natural Resources and Forestry
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Some of the world's largest supercomputers are now tasked with forecasting the weather and the science of how to use the information coming from these computers is happening at a breakneck speed. With so much

of this raw weather information available publicly through the internet, it can be enticing for decision makers to mistake this information as an operational product to improve efficiency and save money. There are however both benefits and pitfalls that should be considered as this technology is considered for implemented into future operations.

In this presentation, we will examine the evolution of fire weather forecasting and provide real examples of how computer weather products can both help and hurt an organization dealing with high-impact events. An examination will be done of how various forecast agencies and fire weather offices operate and lessons learned that can be used building the weather office of the future. Statistical evidence will be provided to establish where the human forecaster can add value and where the computer-generated forecasts can be used without a degradation of forecast quality.

The Ontario Fire Weather Forecast Office will be used as a backdrop to illustrate the evolution from hand generated forecast products to the struggles with computer automation over the past two decades. With the availability of internet weather resources, there is pressure for high-impact weather forecasters to provide more than static numbers for the creation of fire indices. A more comprehensive approach to weather services will be demonstrated that will help facilitate successful fire management outcomes, strategies, tactics and practices to cope with increasing expectations during extreme events.

The presenter will draw upon a diverse and unorthodox background of management experiences and operational roles in both emergency management and meteorology to create a fresh new perspective on the future on High-Impact Weather Forecasting.

1702010 High-Impact Weather and Climate - Part 1

The Severe Weather Outbreak of the Summer: 2 August 2015

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Knott, Steve -
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The summer of 2015 was an unusually quiet one for severe storms across Ontario. One notable exception was August 2nd when a significant severe weather outbreak targeted Southern Ontario with two rounds of thunderstorms. The primary convective mode was linear with both lines producing numerous reports of strong winds and damage, accompanied by some 47,000 customers without power. Several bowing segments were apparent in the second quasi-linear convective system, as well as four brief tornadoes. An overview of the event will be presented, accompanied by a detailed look at the significant features of the outbreak.

1702011 High-Impact Weather and Climate - Part 2

High-resolution wind fields using an optical flow technique for GOES-R/ABI

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"Significant improvements in spatiotemporal image resolution that will routinely be provided by the Advanced Baseline Imager (ABI) on GOES-R should lead to increased precision and accuracy of derived products such as atmospheric motion vectors (AMVs). Especially for mesoscale applications, these improvements will lead to more detailed 4-dimensional datasets that can more accurately describe rapidly evolving weather events, and better identify severe storm hazards potential.

1702011 High-Impact Weather and Climate - Part 2

Size Matters with Hurricanes: A New Component for a Hurricane Scale

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The Saffir-Simpson Scale was introduced in 1973 and included three components to assess the intensity of a hurricane: wind, storm surge, and barometric pressure. The National Hurricane Center eliminated pressure

and storm surge in 2009 and transformed the Saffir-Simpson Scale into a pure wind scale, dropping the components of pressure and storm surge.
Wind is not the major threat with every hurricane. Frequently water is the main threat. The size of a hurricane links directly to the components currently found in the Saffir-Simpson Scale. Due to the massive size and extensive cloud cover, a large storm is considered to be a water storm with the main hazards including flooding, storm surge, and excessive rainfall. Generally, a smaller storm has a greater angular velocity and will produce more wind damage.
This research focused on measuring hurricanes in the North Atlantic from 1978 to 2009 using enhanced infrared radiation satellite images taken at the time a hurricane reached its peak strength (lowest barometric pressure). Warm and cold core radial and area measurements were recorded for each cyclone formed based on cloud temperatures. Short and long radial distances were recorded along with area measurements to determine the approximate size of a cyclone and the shortest/longest side to a storm.
A case study of Hurricane Matthew and the change in the storm's area and radial distances are explored to gain a better understanding of how size played a key role in the destruction across Florida and the Carolinas.
Saffir and Simpson created their scale specifically for the public, to help save lives. All meteorologists share this common goal. We want to be ready for the next severe weather event. Hurricanes are a threat every year - it is time to step up and analyze ways to protect society and improve the Saffir-Simpson Scale. Deleting components is not the answer. Let's start by observing the size, because it does matter.

1702011 High-Impact Weather and Climate - Part 2

The 2013 Billion Dollar Flash Flood in Toronto – Challenges for Operational Forecasting and Nowcasting

Sills, David - ECCC
Ashton, Arnold - ECCC
Knott, Steve - ECCC
Boodoo, Sudesh - ECCC
Klaassen, Joan - ECCC (Retired)
Belair, Stephane - ECCC
Yang, Helen - ECCC
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July 8th 2013 seemed like a typical summer day in southern Ontario – warm and humid with a chance of thunderstorms in the afternoon. Forecasters expected storms to be accompanied by heavy rain and gusty winds with only a 'slight risk' of storms becoming severe. However, despite the lack of typical meteorological ingredients for a significant flash flood event, copious amounts of rain fell over the Greater Toronto Area (GTA) over a period of several hours with up to 138 mm observed. While only minor injuries were reported with the event, there were approximately \$850M CDN in insured losses and at least \$150M CDN more in uninsured losses, making it a 'billion dollar storm'.
The interaction between the Lake Ontario lake-breeze front and an outflow boundary generated by an initial area of storms north of the GTA appeared to play a critical role in the event, causing unexpected storm development along the lake-breeze front toward the Lake and directly over the GTA. Large and rapid increases in total lightning preceded the flash flooding by more than 20 minutes, and occurred more than an hour before a warning was issued.
Real-time NWP output and post-event, very high-resolution simulations both significantly under-predicted precipitation amounts. Rainfall accumulations from Canadian radars were significantly underestimated as well. However, algorithms using dual-polarization products from the King City radar post event were able to mostly correct for attenuation problems and gave accumulations exceeding 150 mm. Social media provided some of the first and only real-time indications that an historic flash flooding event might be underway.
We will discuss the evolution of what is now Ontario's costliest natural disaster, the operational challenges associated with forecasting and nowcasting for this event, and key indicators that could help improve prediction for this type of flash flooding.

1702011 High-Impact Weather and Climate - Part 2
Automated Forecast Products for Arctic Blizzard Conditions
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Mooney, Curtis - ECCC/MSC
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Blizzards in the Arctic are major high impact weather event in the fall, winter, and spring months. Blizzard conditions can last from a few hours to several days. The MSC criterion for issuing a blizzard warning are wind ? 40 kph and visibility ? ¼ SM in snow, blowing snow, or concurrent snow and blowing snow for at least 4 hours south of the treeline and 6 hours north of the treeline. Environment factors important for blizzard conditions are: temperature below freezing; strong wind for a few thousand feet above the ground; snowpack depth at least 1 cm; a source of snow, either precipitation or lifted from the ground locally or advected from upstream. Secondary factors are: the age of the snowpack, the temperature, and the degree of convective instability near the ground (caused by sublimation). More than half the occurrences of blizzard conditions in the Arctic are "clear sky" events caused by blowing snow. In the MSC National Lab in Edmonton we run 3 automated forecast guidance products in real time for forecasting a favourable environment for blizzard conditions, driven by CMC's RDPS hourly output from 1-48 hr and GDPS 3-hourly output from 51-120hr. Forecasts are shown on an internal MSC website accessible across Canada. These forecasts are: 1) an expert-system set of rules (the Blizzard Potential); 2) a perfect-prog forecast of the probability of visibility < ½ SM derived by analysis of many years of radiosonde profiles (Baggaley-Hanesiak); 3) a model-output-statistics forecast derived by applying a powerful machine-learning method (RandomForest) to a data-base of observations matched with a set of 43 physically-related predictors derived from RDPS output. In this presentation we will outline the modelling methods with examples and show verification results for the 2016-7 winter.

1702011 High-Impact Weather and Climate - Part 2
Applying New Satellite Techniques and Products for Forecasting Rapid Cyclogenesis and Extratropical Transition of Tropical Cyclones
Folmer, Michael - University of Maryland/ESSIC/CICS
Berndt, Emily - NASA/SPoRT
Sienkiewicz, Joseph - NOAA/NWS/NCEP/OPC
Clark, James - NOAA/NWS/NCEP/OPC
Cobb, Hugh - NOAA/NWS/NCEP/NHC/TAFB
Ramos, Nelsie - NOAA/NWS/NCEP/NHC/TAFB
Goodman, Steve - GOES-R Program Office
Goldberg, Mitch - JPSS Program Office
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The advent of advanced satellite sensors such as the Geostationary Operational Environmental Satellite-R (GOES-R) series Advanced Baseline Imager (ABI) and Himawari-8 Advanced Himawari Imager (AHI) are beginning to provide a broader spectrum of data compared to legacy satellite sensors. In addition, the Joint Polar Satellite System – first edition (JPSS-1), which is the follow-on to the Suomi National Polar-orbiting Partnership (S-NPP) satellite, offers up unique ways to combine datasets and further analyze significant weather events. More bands and products, not commonly used in operations will be available to forecasters to analyze high impact weather events. The use of multispectral composite imagery is one method to take advantage of the increased data volume and allow forecasters to analyze multiple satellite bands at once. The European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) led the development of multispectral composites in conjunction with the launch of Meteosat Second Generation with the Spinning Enhanced Visible and Infrared Imager (SEVIRI) instrument onboard. The Air Mass multispectral composite, or Red, Green, Blue (RGB) imagery, was designed to enhance regions of warm, dry, ozone rich stratospheric air to anticipate rapid cyclogenesis. Identification of stratospheric intrusions and tropopause folding events are an important factor in anticipating rapid cyclogenesis. In addition, large, deep extratropical cyclones are

capable of producing damaging surface winds which can be driven by tropopause folding events. Since the Air Mass RGB is qualitative in nature, ozone products derived from hyperspectral infrared sounders such as the Atmospheric Infrared Sounder (AIRS), Cross-track Infrared Sounder/Advanced Technology Microwave Sounder (CrIS/ATMS), and Infrared Atmospheric Sounding Interferometer (IASI) are compared to the RGB. The CrIS/ATMS atmospheric profiles processed though the NOAA Unique Combined Atmospheric Processing System (NUCAPS) add a significant advantage in analyzing the synoptic and mesoscale environments of these storms due to the ability to diagnose the vertical distribution of thermodynamic variables. This presentation will focus on highlighting how these products are being used to analyze hurricane-force extratropical cyclones as well as tropical-extratropical transition of tropical cyclones in both the North Atlantic and North Pacific. These techniques are also being introduced to forecasters in Alaska Region in collaboration with work done at the NOAA Satellite Proving Ground for Marine, Precipitation, and Satellite Analysis.

1702011 High-Impact Weather and Climate - Part 2

A Case Study on Snow Squall Lines in comparison with Warm Season Squall Lines

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On 1 February 2017, a “snow squall line” impacted the Greater Toronto Area, bringing reduced visibilities and several centimetres of snow in under an hour. On the afternoon of 1st, cellular lake-effect snow showers were being generated due to NW flow over the Georgian bay. Towards late afternoon, they began to congeal, forming a squall line along a weak surface trough. At this point, the line began to exhibit features that a typical warm season squall line would have, with a marked ""bowing"" of the line in the direction of propagation and the formation of a mesoscale convective vortex on the northern end of the line. This project seeks to understand the dynamics which allowed such a line to sustain strength and propagate at such distance away from the lake (>100km) in the absence of synoptic scale forcing, and relate existing warm season deep convective squall line theory to shallow convective cold season squalls. A synthesis of radar data, surface observations, and high-resolution model data will be used to elucidate the low-level kinematic and thermodynamic structure of this case, a warm season case, and any other pertinent cases.

1702012 High-Impact Weather and Climate - Part 3

""2016"" The Costliest Year in Canadian History- An Update on Canadian Catastrophe Trends

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Managing risk in a changing climate requires observational data on extreme weather events. Recent natural and man-made disasters which cause significant insured property losses, called “catastrophes” by the insurance industry, are catalouged in CatIQ’s platform including over 162 events since 2008 (as at February 2017). Catastrophes in Canada have caused insured losses of over $11 billion between 2008 and 2015 averaging $1.4 billion a year. However, in 2016, insured losses reached over an unprecedented $5 billion dollars (in part due to the Fort McMurray Wildfire). This presentation will provide an analysis of meteorological and geographic data associated with catastrophes, with a focus on 2016. Trends will be identified such as where events occur, what type of events are most frequent and provide insight into mitigating damage in high-risk areas.

1702012 High-Impact Weather and Climate - Part 3

Extreme Levels of Temperatures, Wind Speeds and Precipitation over British Columbia, Canada

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West, Gregory - University of British Columbia
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The extreme weather events of greatest concern in British Columbia include heavy precipitation, drought, unseasonably hot and cold periods, and wind storms. These weather events directly impact the general population as well as British Columbia's primary utility company, BC Hydro. To gauge the severity of an extreme weather event, a historical dataset is needed. However, weather station data over British Columbia is sparse outside of far southwestern BC. This paucity of data motivates research to determine the best reanalysis, and how well it represents extreme weather events.

Seasonal bias and spread of extreme values of 2-m temperatures, 10-m wind speeds and precipitation are evaluated at daily time scales over the complex terrain of British Columbia for the period 1980–2010, from the ERA-Interim, the Climate Forecast System Reanalysis (CFSR), the 55-year Japanese Reanalysis (JRA-55), and the latest Modern-Era Retrospective Analysis for Research and Applications (MERRA-2). Reanalysis data are compared with observations at 27 meteorological stations in disparate climatological zones. They cover the vast majority of BC's population centres as well as mountainous terrain to the extent possible. Finally, changes in extreme temperatures, wind speeds and precipitation due to nonstationarity are evaluated over the same period.

For temperature, JRA-55 and ERA-Interim are the better reanalyses. They represent well the distributions of daily maximum and minimum temperatures, and of extreme values. There is, however, significant bias for valley stations, likely due to poor terrain representation.

1702012 High-Impact Weather and Climate - Part 3

A Synoptic Climatology of Long-Duration Freezing Rain Events over North America

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While even short periods of freezing rain can be hazardous, the most severe impacts tend to occur when it persists for many hours. Predicting the precise and often fragile temperature stratification necessary for freezing rain to persist remains an important forecast challenge. To better elucidate the conditions responsible for the most severe impacts, we concentrate on surface observations of long-duration (6 or more hours) freezing rain events over North America from 1979-2015. Furthermore, we analyze cases in which multiple stations observe long-duration events simultaneously. Following these cases over successive days allows us to generate maps of freezing rain "tracks" which are then categorized by their geographic distributions. We then analyze the conditions that lead to the occurrence of freezing rain for each of these categories.

The climatology of long-duration freezing rain events is largely controlled by a combination of synoptic patterns and local terrain effects, which help to maintain or replenish cold air at the surface. As with freezing rain in general, long-duration events occur most frequently from southeastern Canada into the northeastern United States, though they have occurred in many warmer regions of the US. Classification of individual events highlights a recurring pattern with freezing rain falling over a broad southwest-northeast swath from Oklahoma into the northeastern US and eastern Canada. These storms regularly affect some of Canada's largest metropolitan areas, and include the January 1998 and December 2013 ice storms. The combination of the large geographic extent and particularly long durations associated with this pattern make it an especially impactful one. Through an analysis of the planetary-, synoptic-, and mesoscale patterns associated with this and several other categories of events, we hope to improve forecasters' understanding of and ability to forecast long-duration freezing rain events and better communicate their potential impacts to the public.

1702012 High-Impact Weather and Climate - Part 3

Future Changes in Convective Precipitation and Severe Weather Environment in Western Canada

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Severe convective storms are a common atmospheric phenomenon in North America that can produce high impact weather like hail, tornadoes, and torrential rainfall. As concern has increased over the impact of global climate change on the earth system, the question has arisen of how severe convective storms will be influenced by a changing climate. Though they still have too coarse a spatial resolution to directly resolve severe convective storms, climate researchers have turned to regional climate models (RCMs) forced by global climate model (GCM) outputs to study severe weather environments. The North American Regional Climate Change Assessment Program (NARCCAP) provides such RCM simulations at a 50 km resolution for the 1971 to 2000 and 2041 to 2070 periods. As its first objective, this research uses convective and total precipitation data provided by three NARCCAP model pairings to characterize future change in these variables over the domain, western Canada and the central U.S. Plains. Statistics are calculated and frequency distributions are produced over monthly, seasonal, and annual time scales using this data. Future change is assessed by examining the difference in statistics and frequency distributions between the two time periods. The second objective of this research is to determine why changes in convective and total precipitation are occurring by examining a number of severe weather variables to characterize future change in severe weather environment over the domain. This examination is done using the NARCCAP output for the same three model pairings as well as the 4 km Weather Research and Forecasting (WRF) model. The NARCCAP model pairings use convective parameterization schemes to simulate convection whereas WRF resolves convection directly. By using the NARCCAP model pairings and WRF to assess future changes, a comparison can be made between RCMs that simulate the severe weather environment and an RCM that directly simulates convection.

1702012 High-Impact Weather and Climate - Part 3

Increasing economic impacts due to cold/wet extremes in Canada, with particular reference to western Canada

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The new millennium (2000-2016) has brought an increased frequency of cold/wet extremes to western Canada. The Calgary floods of 2005 and 2013 brought insurance claims of $275 million and $1.7 billion dollars respectively. The 2009 growing season over the Canadian prairies was the coldest in 65 years coinciding with the deepest solar minimum in 95 years that affected crop development and quality. The 2011 flood in Manitoba, rated the fourth worst in Canadian history, saw the Assiniboine River reach its highest levels since 1923. More recently the extremely cold winter of 2013/14 described as the 'Winter from Hell' disrupted rail service in moving a record grain harvest to export position resulting in huge demurrage claims. The 2016 growing season brought rainfall that approached or exceeded 200% normal in four of six months in the Palliser Brown soil zone causing significant crop disease and harvest delays.

During the period 2005-2015 insurance claims in Saskatchewan and Manitoba for flood losses have dominated those for drought by a ratio of 3:1 such that flooding has become the newest threat to prairie crops. The decade of 2005-2014 brought the wettest May-Julys in forty years to the Canadian prairies during which May-July temperatures also cooled.

The research investigates the economic value of such cold/wet climatic impacts and identifies several climatic drivers that appear to be behind the trend. Finally, a suggestion is made as to how these drivers are expected to behave through 2020.

1702012 High-Impact Weather and Climate - Part 3

The importance of wave break events for synoptic-scale buildups of Northern Hemisphere zonal available potential energy

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Zonal available potential energy (ZAPE) is an estimate of the amount of potential energy in the atmosphere available for conversion to kinetic energy, providing a good proxy for the overall strength of the general circulation. Previous studies have estimated total hemispheric ZAPE, ZAPE generation, and conversion to kinetic energy, and proposed physical mechanisms to describe the annual ZAPE cycle as well as short term (sub-seasonal to synoptic) APE depletion events. Large, short term modulations of ZAPE have been shown to be associated with impactful weather events in the mid- and high-latitudes, including severe cyclones and high-amplitude ridging and blocking events

In this study, we examine the association of significant synoptic time-scale increases in ZAPE with dynamic tropopause wave break events. ZAPE buildup events are determined using a 1979-2011 daily Northern Hemisphere (20°-85° N) ZAPE climatology calculated from the National Centers for Environmental Prediction (NCEP) Department of Energy (DOE) Reanalysis 2 global reanalysis dataset in an isobaric framework. To diagnose the importance of wave breaks in the troposphere, we objectively identify wave breaks using potential temperature on the dynamic tropopause, identifying and tracking both anti-cyclonic (LC1) and cyclonic (LC2) wave breaks during the 1979-2011 period. Our results indicate that LC1 wave break events in the equatorward jet exit regions appear to play an important role in ZAPE buildup events. The formation of these anti-cyclonic wave break events result in the development of statistically significant warm-core high pressure anomalies in these regions, acting to reduce baroclinic conversions. We will further demonstrate that changes in LC2 wave break activity in the climatological storm track during ZAPE buildup events are indicative of notable changes to the regions of significant cyclone activity, which are occurring in response to shifts and elongations of the jet stream.

1702020 Coupled Environmental Prediction

Subseasonal Forecast of Arctic Sea Ice Concentration

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Subseasonal forecast of Arctic sea ice has been received less attention than the seasonal counterpart, as prediction skill of numerical models generally drops below the damped anomaly persistence for the extended range (>two weeks). A statistical model is evaluated for predicting the 1979-2014 weekly Arctic sea ice concentration (SIC) anomalies at the subseasonal time scale, using combined information from the sea ice, atmosphere and ocean. The cross-validated forecast skill of the statistical model is found to be superior to both the anomaly persistence and damped anomaly persistence at lead times > 3 weeks. Surface air and ocean temperatures can be included to further improve the forecast skill for lead times > 4 weeks. The long term trends in SIC due to global warming and its polar amplification contribute significantly to the subseasonal sea ice predictability in summer and fall.

1702020 Coupled Environmental Prediction

Variational Computation of Sensible and Latent Heat Flux over Lake Superior

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A variational approach with a Bowen ratio constraint is employed to compute sensible and latent heat fluxes over Lake Superior using 7-year high temporal resolution (half-hourly) observations of hydro-meteorological variables over the lake. Different from our previous work focusing on sensible heat flux, in this work computations of latent heat flux are required so that a new physical constraint of the Bowen ratio is introduced. Verifications are made possible for the first time for fluxes predicted by a Canadian coupled atmosphere-ocean model due to recent availabilities of observed and model predicted fluxes over Lake Superior. The observed flux data with longer time periods and higher temporal resolution than those used in our previous studies allow us to examine detailed performances in computing these fluxes.
Evaluations utilizing direct eddy-covariance measurements over Lake Superior show that the variational method yields higher correlations between computed and measured sensible and latent heat fluxes than a flux-gradient method. The variational method is more accurate than the flux-gradient method in computing these fluxes at annual, monthly, daily and hourly time scales. Under both unstable and stable conditions, the variational method considerably reduces mean absolute errors produced by the flux-gradient approach in computing the fluxes.
It is demonstrated that the variational method obtains higher correlation coefficients between the observed and the computed sensible and latent heat fluxes than the coupled model predicted, and yields lower mean absolute errors than the coupled model. As a result, the variational method may be useful as a complementary means of computing these fluxes in support of the coupled model.

1702020 Coupled Environmental Prediction

Developing a dynamical-statistical observation operator for SST data assimilation

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The diurnal cycle of sea surface temperature (SST) is a fundamental signal of the climate system. Although vertical resolution in ocean general circulation models has been reduced to about a metre at the near surface most models do not properly resolve near-surface thermo-dynamical processes. In low wind and/or high insolation conditions the diurnal cycle in skin SST can be large, thus degrading the accuracy of the ocean surface analysis and prediction. Furthermore, this also presents challenges in assimilating satellite SST observations because infrared sensors (e.g. AVHRR, SEVIRI) measure the skin SST (10 ?m depth) and microwave sensors (e.g. AMSR-2) measure a sub-skin temperature (1 mm depth). There is therefore a need for a dynamically-based observation operator for the assimilation of SST observations that can account for near-surface thermo-dynamical processes. In this paper we present results from an ocean column model that explicitly resolves the diurnal cycle of SST. The model is used to estimate the diurnal variability of SST over the Mediterranean Sea for 2013-2015. The modelled diurnal SSTs are validated against SEVIRI measurements. A canonical correlation analysis (CCA) is performed on the model output in various categories of meteorological conditions. The cross correlations, between the high resolution profile data

from the ocean column model and the satellite skin SST measurements, are used to derive a statistical-dynamical observation operator. This operator can be used for assimilating SST observations, at appropriate depth and time, and is designed to be easily implemented in any operational data assimilation system.

1702020 Coupled Environmental Prediction
Skillful regional prediction of Arctic sea ice on seasonal timescales
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Recent Arctic sea ice seasonal prediction efforts and forecast skill assessments have primarily focused on pan-Arctic sea-ice extent (SIE). In this work, we move towards stakeholder-relevant spatial scales, investigating the regional forecast skill of Arctic sea ice in a coupled dynamical prediction system. The regional skill assessment is based on a suite of retrospective initialized forecasts spanning 1981-2015 made with an atmosphere-ocean-sea ice-land model. Regional prediction skill for detrended SIE is highly region and target month dependent, and generically exceeds the skill of an anomaly persistence forecast. Prediction skill is notably high for winter and spring SIE in the Barents and Labrador Seas, which is partially attributable to the prediction system's initialization and dynamical evolution of surface and subsurface ocean temperature anomalies. The prediction system also skillfully forecasts regional summer SIE in the East Siberian, Laptev, and Beaufort Seas. These regions display prediction skill barriers, in which forecast skill drops off sharply in particular initialization months (May, May, and June, respectively). Both the prediction skill and the prediction skill barriers in these regions are partially attributable to the initialization and persistence of sea-ice thickness anomalies. These results suggest that improved subsurface ocean and sea-ice thickness initial conditions represent a promising route to improved regional sea-ice predictions.

1702020 Coupled Environmental Prediction
The New Coupled Global Deterministic Prediction System: Sensitivity of Operational NWP Forecasts to Coupling with an Ice-Ocean Model
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The importance of coupling between the atmosphere and the ocean for forecasting on timescales of hours to weeks has been demonstrated for a range of physical processes. Here, we provide a systematic demonstration

of the positive impact of an interactive air-sea coupling between an operational global deterministic medium-range forecasting system and an ice-ocean forecasting system. This system was developed in the context of an experimental forecasting system that is now running in operations at the Canadian Centre for Meteorological and Environmental Prediction since July 2016. We show that while the largest impact is found to be associated with reduced intensification of cyclones, the impact of this effect is felt over large spatial scales with positive global implications for forecast skill.

1702020 Coupled Environmental Prediction

Validation of the operational Regional Model Prediction System of the Gulf of St. Lawrence with in situ temperature and salinity data from an autonomous profiler.

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A freely-drifting and profiling float designed for the open ocean Argo program was deployed in the semi-enclosed Gulf of St. Lawrence (GSL) from June 24, 2015 to January 17, 2016. The float performed over 200 daily vertical profiles of temperature and salinity between 200 m depth and the sea surface, and reported its data in real-time on the Global Telecommunications System (GTS). Its water temperature data allowed us to perform real-time validation of a July 20-24 upwelling event north of the Gasp\'{e} peninsula that was correctly simulated by the operational Regional Model Prediction System of the Gulf of St. Lawrence (RMPS-GSL). We also used the float's near surface temperature data to help validate an operational global sea surface temperature analysis product over the spatial domain of the GSL.

1702030 Monitoring - Renewal and Modernization

MSC - Atmospheric Monitoring – Training Needs Assessment

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This presentation will summarize the process and recommendations of the Training Needs Assessment recently completed for the Monitoring and Data Services Directorate (MDSD) of the Meteorological Service of Canada (MSC). The MSC operates and maintains a number of atmospheric and marine monitoring networks, including; surface weather, climate, radar, fixed buoys, drifting buoys, AVOS, CLDN, and upper air, with lingering responsibilities for aviation weather and the HRPT satellite reception. To ensure that all platforms within these networks are operated and maintained in a safe, professional and cost effective manner, the MSC has committed to update or develop training programs consistent with the evolving role of its atmospheric monitoring technologists. To do so, the MSC has developed a competency-driven training framework matched to tasks required of its monitoring technologists for each of these networks. The MSC has also created an inventory of available training courses (private and government) and training elements, which have been mapped against the required competencies, to create a training-gap analysis. This Training Needs Analysis will be used by MSC management to define and prioritize training within the Directorate in the coming years.

1702030 Monitoring - Renewal and Modernization

Designing Monitoring Networks to Better Understand the Past and Predict the future: The Meteorological Service of Canada's Needs Index Decision Support Model and the Collaborative Monitoring Initiative

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In order to quantify users' needs in an objective way and to study the spatial variations of High Impact Weather (HIW) risks and their potential socio-economic impacts, the Network Design Unit (NDU) has developed a GIS-based Multi-Criteria "Needs Index (NI)" methodology to spatially characterise and differentiate the needs for monitoring, and to identify and prioritize spatial gaps by integrating scientific and socio-economic drivers. Needs Index (NI) scenarios can be created based on the relative ranking and weighing of various factors and considerations (e.g. program drivers, weather/climate-related risks and potential socio-economic impacts) for hydrometeorological monitoring. These integrated NI scenarios are important sources of information that can be used to help inform network decision making. The network design approach has been successfully applied to review both the Weather Radar and Surface Weather and Climate Weather Networks over the past two years.

The Network Design approach also considers the multitude of monitoring networks owned and operated by other public and private organizations. Coordinating these multiple data sources into a coherent national system so that the information is useable and beneficial for the community at large is a primary objective of the Canadian Network of Networks Initiative.

This talk will present an overview of the network design's needs index model and recent applications; and as well as provide an update on progress towards improving collaborative weather and climate monitoring in Canada.

1702030 Monitoring - Renewal and Modernization

Upper Air Automation

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The Meteorological Service of Canada (MSC) operates 31 upper air sites in Canada, and eleven of these are in the Canadian arctic and on other remote locations, where the access is exclusively by plane or by sea lift. For that reason the only feasible option for lifting gas is the local generation of hydrogen.

Over the last 5 years, several of the more southern sites have been retrofitted with new hydrogen generation system based on the HOGEN generator manufactured by Proton Energy Systems. The next milestone is to expand the deployment of Hogen based systems on the arctic and remote sites. These stations are generally located in smaller communities where the access to specialised equipment and resources is limited; for this reason, a project has been initiated to develop a modular hydrogen generation systems based on the HOGEN, which would be built centrally, and deployed for field integration, on the existing operational sites.

In conjunction with this project a second initiative has been launched consisting in the operational integration of systems providing the automatic launching of balloons and radiosondes (autolaunchers). Given the specific conditions, the expected solution is an integrated system for performing automatic launching of upper air soundings using locally produced hydrogen, as the lifting gas for balloons.

While feasible automatic sounding balloon launching systems (autolaunchers) are commercially available, the integration between an autolauncher and an on-site hydrogen generation facility, as a reliable and safe system, requires careful consideration and design. The MSC project is intended to result in the design of a safe and reliable integrated autolauncher and hydrogen generation system, capable of operating reliably in the Canadian Arctic. The presentation will present the concepts and plans for achieving these goals, a status report on the project underway and discuss future plans for automation within the Canadian Upper Air Network.

1702030 Monitoring - Renewal and Modernization
Data Management Systems
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MSC data management systems are providing known quality, additional data types / products and enhanced data access mechanisms in response to monitoring renewal and modernization. This presentation will provide an update in the evolution of monitoring data management in support of MSC service delivery, Open Data, the WMO Information System and beyond.

1702030 Monitoring - Renewal and Modernization
Replacement of the Canadian Weather Radar Network
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Canada's weather radar network has 31 radars, including two radars operated in partnership with the Department of National Defence and one owned by McGill University. The Meteorological Service of Canada is modernizing its existing mixed national network of aging and obsolete single-polarized radars with new and modern dual-polarized radar systems. Accurate weather information is critical to the health, safety and economic prosperity of Canadians as well as to security, defense, emergency management and search and rescue. A new modernized radar network is a central element of Environment and Climate Chance Canada's monitoring infrastructure and in ensuring its long-term sustainability and reliability.
The approach used in designing the modernization considers many factors - such as climatology, qualitative and quantitative user requirements and lessons learned from the operation and support of the existing network. We will present an overview of the process as well as progress to date.

1702030 Monitoring - Renewal and Modernization
Marine Transformation
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As of 2016, the Marine Observation Network has grown to a network of 9 moored buoys of the Atlantic Coast, 17 off the Pacific Coast and 20 seasonal moored buoys located in-land. In addition, the network also managers ~50 Canadian Automatic Volunteer Observing Ships (AVOS) and ~30 drifter buoys in the high Arctic which are a major contributor toward international efforts to monitor data sparse areas and produce quality weather models. Together observations taken from Marine Observation Network are important for marine transportation, marine forecasting, and climate modeling.
The increasing operating costs of the Marine Observation Network have contributed to the unsustainability of the network. Because of these reasons, the Marine Observation network initiated the Marine Transformation project, with the vision of designing a modern, sustainable and collaborative core national moored weather buoy Marine Observation Network that is integrated with other atmospheric and marine ocean observing systems that will strengthen our national capacity to monitor sever weather and climate change.

1702040 Weather forecasting applications

Snowfall Rate Estimation Using C-Band Polarimetric Radars

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Radar Quantitative Precipitation Estimation (QPE) plays an important role in weather forecasting, nowcasting, and hydrological models. This study evaluates the Sekhon and Srivastava (1970) Snow Water Equivalent (SWE) algorithm currently implemented by the Canadian Radar Network of Environment and Climate Change Canada (ECCC), suggests an improved algorithm, and also evaluates the ability of polarimetric radars in estimating SWE. The radar data were collected from the dual polarimetric King City radar (CWKR) near Toronto, Ontario, and the Doppler Holyrood radar (CWTP) in Newfoundland. SWE data were collected at Oakville, Ontario, at Pearson International Airport (CYYZ), Toronto, Ontario, and at Mount Pearl, Newfoundland.

The ground observations show that the polarimetric variables could be used to infer a few of the microphysical processes during snowfall. It is suggested that the co-polar correlation coefficient (?hv) could be sensitive to the size ranges of different snow habits. Also, higher differential reflectivity (Zdr) values were measured with large aggregates.

The results show a severe underestimation of SWE rates by the Sekhon and Srivastava (1970) algorithm. One hour accumulations from each site were used to develop SWE(ZeH) and SWE(ZeH, ZDR) algorithms (ZeH and ZDR are reflectivity factor and differential reflectivity, respectively). Similarly, algorithms were developed using SWE at 10 min intervals from CYYZ and Mount Pearl but these algorithms appeared to overestimate SWE. The hourly SWE accumulation from the three sites were combined to produce an additional SWE(ZeH) algorithm which showed better statistical results. A modest difference was found between the conventional and polarimetric algorithms for estimating snowfall amounts (SWE).

1702040 Weather forecasting applications

Notes on ICAO cold temperature correction procedures for aircraft barometric altimeters

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Most aviation authorities' procedures and regulations require or recommend that pilots apply corrections to minimum instrument approach altitudes during periods of very cold weather conditions, or cold weather conditions in combination with terrain. The purpose of these notes is to improve aviation safety by providing pilots with novel practical methods and tools to apply the cold temperature altitude corrections recommended by International Civil Aviation Organization (ICAO) in document PANS OPS Doc 8168 [1].

The concept of cold temperature altitude correction is often not well known and understood by pilots. A correctly calibrated pressure altimeter indicates true altitude above mean sea level (MSL) only when operating within the International Standard Atmosphere (ISA) parameters of pressure and temperature. The non-standard pressure conditions are corrected by applying the correct local area altimeter setting (QNH), but temperature differences from ISA are not usually considered. Conditions that may endanger aviation safety occur when temperatures are colder than ISA, as true altitudes could be lower than indicated altitudes causing the risk of inadequate obstacle clearance.

Currently, besides advanced avionics providing temperature compensation, the method pilots use to determine the required corrections is based on the "ICAO Cold Temperature Correction Table" [1][2][3]. Throughout the document the altitude correction formulas provided in ICAO document PANS OPS Doc 8168 [1] are discussed and utilized. They are used in various examples and to produce improved tables as well as to devise a novel type of parametric plot that help simplify the altitude correction process for pilots. Altitude corrections in an Off-ISA atmosphere are evaluated and both absolute and percentage errors are determined.

The improved correction tables and the new parametric plots provide pilots with new tools to better comply with obstacle clearance requirements.
Furthermore, spreadsheet software tools based on MS Excel and Google Sheets have been developed and made available to pilots for producing customized tables and plots for specific locations. A smartphone app has been developed to provide a straightforward tool for pilots to calculate and store airport's approach procedures information and altitude corrections.
Correction tables and plots are made available for download for the several airports in Canada and the United States.

[1] International Civil Aviation Organization (ICAO), ""ICAO PANS OPS Doc 8168 - Procedures for Air Navigation Services"".
[2] Transport Canada, ""Aeronautical Information Manual"".
[3] Federal Aviation Administration, ""Aeronautical Information Manual"".

1702040 Weather forecasting applications

Open Access to Canadian Weather Data via Geospatial Web Services

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MSC GeoMet is a public data dissemination service offering from the Meteorological Service of Canada providing dynamic, just-in-time access to real time weather conditions, forecasts, observations and alerts. Initially released in 2009, GeoMet enables the public to integrate weather data directly into their mobile/web application, GIS and other decision support tools. Recent enhancements provide a foundational platform for additional MSC data available via additional international standards in alignment with GoC Open Data, the WMO Information System and beyond.
Amongst its capabilities, MSC GeoMet enables users to interactively display and animate weather layers with their own symbology and download raw data for their specific geographic extent.
This presentation will provide an overview of GeoMet, current status and future implementation.

1702040 Weather forecasting applications

How Graphic Design can be used to change audience perception of weather data and improve it's communicative capacity

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The discipline of graphic design has an important role to play in developing how information is conveyed and consumed. Based on my thesis research, this oral presentation will focus on how weather content can be displayed alternatively, both graphically and visually, and ultimately allow richer data interpretations from users.
As explained by Dr. Jeffrey T. Nealon, professor of English and philosophy at Penn State University, the weather often functions as a privileged figure for banality itself; the lingua franca of everyday speech (Nealon, 2013, 109).
The research of T. Nealon provides a framework for observing weather content as something that is:
banal, due to excessive visibility; necessary, as it allows viewers them to make informed decisions within their daily lives; and socially relevant, as it allows us to connect due to its universal acceptability.
Adding to these characteristics, the typical way of displaying weather data—the inclusion of mass amounts of information with low metric variation in a static neutral visual structure preconceived for a specific media—participates in reinforcing its perception as banal information. It is thus fundamental to start observing that content from a different angle in order to highlight the critical impact it has on our lives.
Through the analysis of visual projects focused on alternative representation of weather data conducted in the context of my Master of Design at York University, Toronto, Canada, I will discuss how design can be used to change the perception of weather data through the use of alternative forms of visual representation. As

such, my presentation will demonstrate not only how weather data can be communicated and perceived differently through non-traditional forms of data visualization, but also the importance of orienting the visual representation of such a quantitative content towards a more qualitative and individualized form.
As a professional designer and a design educator, I strongly believe that graphic design has the potential to participate in establishing an original relationship between the weather content and its visual display, counter-acting the perceived banality of weather data by fostering a rich, engaging, and surprising experience. In the context of the Canadian Meteorological and Oceanographic Society's annual meeting, I aim to stimulate an open dialogue and initiate questioning surrounding the ways in which the representation of weather content can draw the public's attention and participate in improving its comprehension of the subject.

1702040 Weather forecasting applications

Transformation of the 24/7 Operations in Canadian Meteorological Centre

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"The Analysis and Prognosis Section (A&P) is the 24/7 Operations of the Canadian Meteorological Centre (CMC). It plays an important role as the face of the Meteorological Service of Canada (MSC), in the first-order scrutiny of forecast products which aides in the identification of errors in prediction systems and future innovation, and as the primary access point to MSC's products. It contributes to the CMC Operations Division in many areas, in particular the following:
1. Program monitoring: real-time management of the CMC operational meteorological program;
2. Synoptic-scale vigilance of high impact weather over Canada and strategic response;
3. Being an authority on the verification of the performance of automated operational forecast systems; and
4. Being a key component of the technological transfer process.
Currently, a transformation project is underway in A&P in order to improve our work in these four areas. In this presentation, the developments of this project and future direction of A&P will be presented. In addition, examples of the new products developed in A&P and its performance will be shown.

1703010 Physical Oceanography - Part 1

A conceptual model of the ocean overturning circulation with two closed basins and a reentrant channel.

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The ocean meridional overturning circulation (MOC) plays a key role in the climate system: it controls the amount of heat stored in the deep ocean and helps regulate the exchange of CO_2 with the atmosphere. Despite its global importance, there still exists a wide gap between the idealized theoretical studies that attempt to understand the dynamics of the overturning circulation and the observations of the MOC. For example, theories of the MOC have largely focused on the zonally averaged perspective and ignored zonal inter-basin exchanges. Here, we extend these previous theories and present a simple dynamical model that captures the key inter-basin exchanges. A central result of our analysis is that the exchange of waters between the Atlantic to the Indo-Pacific Ocean is inversely related to the strength of the overturning circulation in the Southern Ocean. In the limit of compensation in the Southern Ocean, the MOC is composed of a single overturning loop spanning both basins and closed by an inter-basin-exchange driven by a geostrophic flow at the southern end of the basins.

1703010 Physical Oceanography - Part 1
Surface tides in the Strait of Georgia near the Fraser River plume
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A harmonic tidal analysis of surface currents measured by HF radar near the Fraser River outflow in the Strait of Georgia reveals that the surface tidal currents are more complex than previously thought. For example, most of the large semidiurnal and diurnal constituents are substantially weaker at the surface than the barotropic tide, although the shallow water constituents (especially MK3), are larger. Spectral lines at tidal frequencies are flanked by larger cusps at the surface than at depth or in the barotropic tide. Furthermore, the Greenwich phase of M2 varies by nearly 3 hours within the HF radar domain, whereas the barotropic phase varies by 10 minutes or less.

In this talk, we summarize the HF radar surface observations and compare them to the observed and modelled barotropic tide, focusing mostly on the largest constituent, M2. We then explore various hypotheses to account for the differences. Most explanations can be traced back to the Fraser River, which is embedded in an otherwise tidally unremarkable region.

The relatively wide spectral peaks indicate a significant leakage of energy from the astronomical frequencies into neighbouring bands, presumably the result of low frequency modulation of the tidal currents. This is particularly acute in the highly stratified surface layer where low frequency energy is enhanced by direct wind and river forcing. Overtides further deplete the main tidal lines, particularly near the shallow mudflats. Finally, the variable GMT phase is hypothesized to be caused by the presence of the river channel and mudflats, which alter the sea level/velocity phase relationship from a standing wave (i.e. the rest of the Strait) to a more progressive relationship such as might be found in frictional rivers.

1703010 Physical Oceanography - Part 1
Instability properties under a model mode-1 internal tide.
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The instability properties of the bottom boundary layer (BBL) under a model mode-1 internal tide in linearly stratified finite-depth water are studied, using 2-D direct numerical simulations (DNS) based on a spectral multidomain penalty method model. This model internal tide is a proxy for its lower-mode oceanic counterpart which is generated when stratified water is forced over topography by barotropic tidal currents. Such low-mode internal tidal waves tend to propagate long distances from the point of generation, carrying with them large amounts of energy. One mechanism through which this energy is dissipated is through wave-BBL interactions, where strong shear layers develop along the bed, leading to focused instabilities which are precursors for localized turbulent events. Such events in the BBL can cause sediment resuspension and drive benthic nutrient fluxes, playing a crucial role in ecosystem balances. In the model problem, the stability response of the time-dependent BBL is examined by introducing low-amplitude perturbations near the bed. The corresponding time-evolving BBL-integrated perturbation energy growth rates are then computed, by comparing both the perturbed and unperturbed cases. When an instability actually occurs, its vorticity structure and preferred location is identified. Ultimately, a stability boundary is constructed as a function of perturbation amplitude and internal wave steepness, aspect ration and Reynolds number.

1703010 Physical Oceanography - Part 1
Conservation laws and inertial-symmetric instability
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Submesoscale oceanic density fronts are structures in geostrophic and hydrostatic balance, but are more prone to instabilities than mesoscale flows. We here present two-dimensional (x, z) Boussinesq numerical experiments of submesoscale baroclinic fronts on the f-plane. Mixed inertial-symmetric instabilities (ISI) (the actual name varies across the literature) develop, with the absence of along-front variations prohibiting baroclinic instabilities. Two new salient facts emerge. First, contrary to pure inertial or pure symmetric instability, the potential energy budget is significantly affected, ISI extracting significant available potential energy from the front. Second, in the submesoscale regime, the growth rate of ISI is sufficiently large that significant radiation of near-inertial internal waves occurs. Although energetically small compared to e.g. local dissipation within the front, this process might be a significant source of near-inertial energy in the ocean.

1703010 Physical Oceanography - Part 1
Ekman boundary layers in a large-scale gravity current experiment
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Coriolis forces can strongly influence oceanic density currents such as contourite and turbidity currents, or in dense overflows from marginal seas. These forces lead to Ekman boundary layers, which result in transverse secondary flows of as much as 10% of the primary flow Ekman boundary layers in sinuous channels can either act with, or against, the secondary flows driven by centrifugal forces. These secondary near-bed flows are responsible for many of the details of sediment erosion and deposition in contourites, as well as in larger channels formed by turbidity currentsThe magnitude and direction of flows in the Ekman boundary layers can be defined by a Rossby number, $RoW = U/Wf$, where U is the mean downstream velocity, W is the width of the channel and f is the Coriolis parameter. Flows with Rossby numbers less than 1 are dominated by Coriolis forces and have strong Ekman boundary layers dominating secondary circulation. A new finding is that even when the Rossby number is of order 10, there is an appreciable influence of Coriolis forces, supporting empirical observations of straighter turbidite channels when $|RoW| < 10$ A series of laboratory experiments were conducted by releasing a very large gravity current on the world's largest rotating platform (Coriolis platform) in Grenoble, France. New results will present changes within the velocity structure in such a large-scale gravity current. Our observations of secondary circulations clearly confirm the existence of Ekman boundary layer and the effect of Coriolis forces on this layer. Furthermore, we will show the effect Coriolis forces on the turbulence components of the flow as a function of different Rossby numbers.

1703010 Physical Oceanography - Part 1

Convective instabilities in internal solitary waves of depression shoaling over gentle slopes

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The shoaling of an internal solitary wave (ISW) of depression over gentle slopes is explored through fully nonlinear and non-hydrostatic numerical simulations based on a high resolution/accuracy deformed spectral multidomain penalty method model. As recently observed in the South China Sea, in high-amplitude shoaling ISWs, the along-wave current can exceed the wave celerity resulting in convective instabilities. If the slope is less than 3%, the wave does not disintegrate as in the case of steeper slope shoaling but, instead, maintains its symmetric shape; the above convective instability may drive the formation of a turbulent recirculating core. In this presentation, the sensitivity of convective instabilities in an ISW is examined as a function of the bathymetric slope and background stratification properties. ISWs are simulated propagating over realistic bathymetry, obtained from field measurements. Emphasis is placed on the structure of the above instabilities, the persistence of trapped cores and their potential for particle entrainment and transport. Additionally, the role of the vertical structure of the baroclinic background current on the development of convective instabilities and trapped cores is explored from preliminary 3D simulations. As such, a preliminary understanding is obtained of the transition to turbulence within a high-amplitude ISW shoaling over progressively varying bathymetry.

1703011 Physical Oceanography - Part 2

Interannual to decadal variability of the upper ocean over the northeast Pacific

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Owing to the deployment in recent years of a large number of Argo floats in the northeast Pacific and a NOAA Ocean Climate Station mooring at Station P, there has been great increase in the volume of data available to characterize oceanic variability over the central Gulf of Alaska. These time series data, particularly from Argo, are now of sufficient duration to examine variability at interannual to decadal times scales. An analysis will be presented of the long-period variability in the depth of the pycnocline over the northeast Pacific based on Argo data, focusing on the relation to Ekman pumping over the region. Low frequency variability of conditions at Station P and along Line P also will be discussed.

1703011 Physical Oceanography - Part 2

Dynamics of Quasi-Geostrophic Meddy-Type Vortices

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The stability of lens-shaped vortices, which are reflective of Mediterranean eddies (Meddies), is revisited in the context of an idealized, Quasi-Geostrophic model. First, we compute the linear stability characteristics more accurately than before and for a wider range of Burger numbers (Bu), and compare these results with previous stability analyses. Second, we push forward in a novel direction and study the non-linear evolution of lens-shaped vortices in the context of this model using high-resolution, three-dimensional, pseudo-spectral numerical simulations. The growth rates predicted by the linear stability calculations are compared with the non-linear simulations and found to differ for azimuthal mode one. Our investigation shows that lens-shaped vortices with a horizontal length scale equal to that of the Rossby radius of deformation tend to be stable. Moreover, the eddies with a horizontal length scale less than the radius of deformation ($Bu>1$) develop a

wobble due to an essentially barotropic instability, whereas those with a larger horizontal length scale (Bu<1) break up through baroclinic instability. Spectral transfers of the non-linear simulations reveal the energetics signature of the instabilities.

1703011 Physical Oceanography - Part 2

The variations of the Atlantic Meridional Overturning Circulation from an eddy-resolving North Atlantic model

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The variations of the AMOC from 1990 to 2015 were investigated using model results from a 1/12 degree resolution North Atlantic model. The modelled AMOCs at 26 N and 41 N were compared with the observations from the RAPID and those derived from ARGO based hydrographic and altimeter data, and the model shows a decent skill in representing the means and variations of the AMOC at these two latitudes. This study confirms that the Ekman transport plays an important role in the variations of the AMOC at all latitudes, and the Ekman transport variations dominate the seasonality of the AMOC. At inter-annual time scale, the strong anomalies in 1995, 2001 and 2010 were resulted from the strong Ekman anomalies. This study indicates a probable existence of two-stage regime of the AMOC, a strong AMOC regime from 1990 to 2001, and a weak AMOC regime after 2001. In the first regime, the strong convection events in early 1990s appear to contribute to the strong AMOC, on the contrary, in the second regime, the strong convection events of 2008, 2012, 2014 and 2015 do not reverse the deceasing AMOC trend. The sea level variations along the 50W from altimeter data for the period from 1993 to 2015 resemble the variations of the AMOC for the same period, suggesting the observed sea level changes at the high and low latitudes would be indicating the weakening of AMOC in the North Atlantic Ocean.

1703011 Physical Oceanography - Part 2

Interannual Variability of Global Overturning Circulation Dominated by Pacific Variability

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The view prevails that the global meridional overturning circulation (GMOC) is primarily reflective of the Atlantic meridional overturning circulation (AMOC). While this is true in the mean, this is likely not true when considering interannual variability. This paper shows that interannual variability of the GMOC in nine coupled climate models and one ocean reanalysis is heavily dominated by variability in the Pacific meridional overturning circulation (PMOC). This is apparent not just near the surface, but down to depths exceeding 4km. Furthermore, interannual PMOC variations are the dominant contributor to interannual variations of oceanic meridional heat transport. This PMOC variability has large scale organization. For example, in the Canadian Earth System Model version 2 (CanESM2), the first EOF of the PMOC streamfunction between 0-20N is an overturning cell that explains 78% of the total variability. Idealized experiments with CanESM2 show that PMOC variations are almost entirely driven by interannual variations in surface wind stress. This behaviour is partially expected from linear theories which predict that off-equatorial baroclinic Rossby waves take more than a year to propagate across the Pacific basin, whereas such disturbances cross the Atlantic basin in less than a year. Analysis of meridional velocity anomalies suggests that these waves are excited by variations in the deep boundary currents, and so PMOC variations are not constrained to remain above the thermocline.

1703011 Physical Oceanography - Part 2

Long-term versus decadal-scale variability in deep-water ventilation in the Labrador Sea

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Formation of Labrador Sea Water (LSW) through winter convection in the subpolar North Atlantic is a primary driver of the Atlantic Meridional Overturning Circulation (AMOC) which has been projected to weaken under global warming and reduce the ocean's capacity to transfer greenhouse gases to its abyssal depths. However, observations of the production of LSW over the past 75 years suggest a prevalence of decadal variability over a long-term trend.

Argo floats, ship surveys, and moored measurements are providing an unprecedented view of important seasonal, interannual, and longer-term LSW variability in the Labrador Sea region. There has been a progressive deepening of winter convection since 2012, with the individual profile maximum depth exceeding 1800?m since 2014 and reaching 2100?m in 2016. The resulting 2012–2016 LSW class is one of the deepest and most persistent ever observed since 1938, and its 2016 density and volume are the highest since the mid-1990s. This increase in winter convection and LSW production, during repeated positive phases of the winter North Atlantic Oscillation (NAO), resembles that observed during the formation of the record depth (2500?m) LSW in 1987–1994, which has been attributed to repeated positive NAO forcing having provided critical preconditioning.

This intermittently recurrent deep convection is contributing to predominant decadal-scale variations in intermediate-depth temperature, salinity, and density, with implications for decadal-scale variability across the subpolar North Atlantic and potentially in the AMOC.

These findings should help international observation programs and numerical model studies investigating LSW influences on the subpolar North Atlantic and AMOC.

1703011 Physical Oceanography - Part 2

The Stability of the Gulf of Oman Current

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Recently, there have been several campaigns that have measured a slope current in the Gulf of Oman. These observations show that the undercurrent changes significantly as it flows along the coastline. The life-cycle of this slope current is rather interesting in that there are some phases where it is strongly influenced by the coastlines and there are others that suggest it is strongly influenced by the topography beneath. There are four sections that were obtained that enable us to approximate the features of the current at the times they were observed.

Based on these observations, we develop two- and three-layer Shallow Water approximations to the observed current in the different sections. This allows us to determine the linear stability characteristics of the slope current in its various phases, and ascertain the influence of the coastline and topography in these different sections. Furthermore, we can determine whether barotropic or baroclinic instabilities dominate in each phase and make some predictions as to the eddy field that is generated in these different sections of the Gulf of Oman.

1703012 Physical Oceanography - Part 3
Midlatitude-equatorial dynamics of a grounded deep western boundary current
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A theoretical study of the nonlinear hemispheric-scale midlatitude and cross-equatorial steady-state dynamics of a grounded deep western boundary current (DWBC) is described. The domain considered is an idealized differentially rotating meridionally aligned basin with zonally varying parabolic bottom topography so that the model ocean shallows on the western and eastern sides of the basin. In mid-latitudes, the equatorward flow is governed by nonlinear planetary-geostrophic dynamics on sloping topography. As the flow enters the equatorial region, it speeds up, becomes increasingly nonlinear, and passes through two distinguished inertial regions referred to as the "intermediate" and "inner" inertial equatorial regions, respectively. The flow in the intermediate equatorial region is shown to continue accelerating and turn eastward forming a narrow equatorial jet. The large-scale inviscid structure of the flow within the inner equatorial region corresponds to a zonally aligned nonlinear stationary planetary wave that meanders about the equator in which the flow exits the equatorial region on the eastern side of the basin. Within localized zones located in the trough and crest regions of the equatorial wave, the inviscid streamlines begin to cross each other. It is in these zones of intersecting characteristics that dissipation makes a leading order contribution to the dynamics and induces the requisite potential vorticity adjustment permitting the cross-equatorial flow of a DWBC that is in planetary-geostrophic dynamical balance in mid-latitudes.

1703012 Physical Oceanography - Part 3
Impacts of the IOD-associated temperature and salinity anomalies on the intermittent Equatorial Undercurrent anomalies
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The study of Equatorial Undercurrent (EUC) has attracted a broad attention in recent years due to its strong response and feedback to the Indian Ocean Dipole. In this paper, we first produce a high-quality simulation of three-dimensional temperature, salinity and zonal current simulation from 1982 to 2014, using a high-resolution ocean general circulation model. On this basis, with two sensitivity experiments, we investigate the role of temperature and salinity anomalies in driving and enhancing the EUC during the positive IOD events by examining the variation of the EUC seasonal cycle and diagnosing the zonal momentum budget along the equatorial Indian Ocean. Our results show that during January-March, the EUC can appear along the entire equatorial Indian Ocean in all years, but during August-November, the EUC can appear and reach the eastern Indian Ocean only during the positive IOD events.
The zonal momentum budget analysis indicates that the pressure gradient force contributes most to the variation of the eastward acceleration of zonal currents in the subsurface. During the positive IOD events, strong negative subsurface temperature anomalies exist in the eastern Indian Ocean, with negative surface salinity anomalies in the central and eastern Indian Ocean, resulting in a large pressure gradient force to drive EUC during the August-November. Further, the results of two sensitivity experiments indicate that the temperature anomalies significantly impact the pressure gradient force and advection in the subsurface, playing a leading role in driving the EUC, while the surface salinity anomalies can also intensify the eastward EUC.

1703012 Physical Oceanography - Part 3

Real-time buoy observations for typhoons in the South China Sea

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As part of the program that was initiated to provide oceanographic and meteorological data sets for marine engineering operations in March 2008, several sets of real-time observation buoys were deployed on the continental shelf of the northern South China Sea (SCS). The buoy recorded several meteorological elements, including: air temperature, humidity, dew point, barometric pressure, surface wind, and wave elements (wave height, period and direction), and also several hydrographical elements: temperature, salinity and ocean currents in the upper ocean 70-340 m.

The measurements were obtained at 10-min interval and processed in CR1000 (a kind of data acquisition sensor) in the buoy, then transmitted to a terrestrial laboratory via Iridium hourly. We can study the exchanges of mass, heat and energy between the ocean and atmosphere as the passages of typhoons in the SCS.

1703012 Physical Oceanography - Part 3

Underwater Glider Measurements and Simulations of Storm-Induced Abrupt Upper Ocean Mixing

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As part of the Ocean Tracking Network (OTN), a glider captured the ocean temperature and salinity responses to fast-moving hurricane Arthur (2014), as the storm moved across the Northwest Atlantic and made landfall in New Brunswick. The high-resolution glider data provides a unique opportunity to investigate the ocean processes, for example current shear and wave-induced turbulence, under hurricane forcing. We used the General Ocean Turbulence Model (GOTM) to make one-dimensional analyses of these physical processes. Based on the GOTM k-epsilon equations, which incorporate the effects of wave breaking, the Coriolis-Stokes force (CSF) and Langmuir turbulence, represented as Stokes shear in the Turbulent Kinetic Energy (TKE). Simulations of temperature and salinity with GOTM are compared with glider observations. We found that wave breaking and Langmuir turbulence play an essential role in GOTM simulations. In particular, Langmuir turbulence dominates the surface wave impacts in the upper ocean cooling and the upper thermocline water warming in the developing-stage of the storm. Without inclusion of the Langmuir turbulence, the sea surface temperature (SST) cooling is underestimated by 0.7?; temperature is overestimated by an average of 0.5? in the upper 25 meters; whereas it is underestimated by an average of 0.7? in depths from 25 to 40 meters. The surface wave breaking is parameterized as a source of TKE flux at the surface and a body force. It is shown that the body force scheme is more effective than the TKE flux, which has limited effect in the upper ocean. The simulation results also indicate that the CSF effect might be relatively negligible in severe hurricanes, since it takes more time to affect the underwater currents. This study provides a rare opportunity to investigate the processes occurring in the ocean response to fast-moving storms, particularly the role of surface waves.

1703013 Physical Oceanography - Part 4

Pacific Water Pathway in the Arctic Ocean Revealed by Online Passive Tracer in NEMO Simulations

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Pacific Water inflow through the Bering Strait plays an important role in the Arctic Ocean. Besides the Atlantic Water, Pacific Water is the other major source water that mixes and forms the water masses in the Arctic Ocean. As the Pacific Water brings a large amount of heat and freshwater into the Arctic Ocean, its pathway is essential for understanding the Arctic Ocean sea ice condition, stratification (particularly within the upper layer), and circulation as well as biochemistry tracers distribution.
ANHA (Arctic and North Hemisphere Atlantic Ocean), a regional configuration of coupled ocean-sea ice model, base on the Nucleus for European Modelling of the Ocean (NEMO, version 3.4) framework, is utilized in this study. Two different horizontal resolution (1/4 and 1/12 degree) simulations were conducted as twin experiments to study the impact of model resolution. Driven with high temporal (hourly) and spatial (33km) resolution atmospheric forcings (CGRF) provided by Canadian Meteorological Center (CMC) global deterministic prediction system (GDPS) as well as carefully remapped inter-annual monthly runoff including meltwater from the Greenland, both the base simulations reproduce Arctic Ocean outflows that compare well with available observations. To tag and track the Pacific Water through the Bering Strait, an online passive tracer is designed to be proportional to the volume transport through the strait, and updated every model time step since January 1st, 2002. Both the pathway and vertical structure revealed by the passive tracer from the two base simulations will be presented in this talk.

1703013 Physical Oceanography - Part 4

Dissipation of low frequency wind-driven ocean flow by forced near-inertial motion: a modelling study

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We consider flow in a primitive equation eddy-resolving channel forced with a combination of steady and near-inertial winds. The high frequency forcing generates near-inertial waves, and we examine their interaction with the underlying geostrophic flow. Reynolds stresses exerted by the high frequencies on the low frequency motion account for up to 20% of the kinetic energy budget. This transfer extracts energy from a wide band of sub-inertial frequencies and from mesoscale wavenumbers. We also consider the potential energy budget, again focusing on how the near-inertial portion of the flow interacts with the balanced, slowly evolving flow. Similar to our results for kinetic energy, we find that near-inertial motion acts extract potential energy from low frequencies and transfer it to unbalanced, near-inertial frequencies. Finally, we attempt to situate these results with a number of other recent studies that also focus on how forced (or stimulated) near-inertial motion can damp balanced flow; that is, we situate our work within the broader context of ""Stimulated Loss Of Balance"", or SLOB.

1703013 Physical Oceanography - Part 4

Turbulent Dissipation Rates, Mixing, and Heat Fluxes in the Canadian Arctic from Glider-based Microstructure Measurements

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Understanding mixing rates in the Arctic Ocean allows us to estimate vertical heat fluxes through the water-column which have the potential to significantly impact heat budgets as well as ocean-sea ice and ocean-atmosphere interactions. We present new observations consisting of 340 quasi-vertical microstructure profiles of shear and temperature variance alongside profiles of finescale temperature and salinity in the Amundsen Gulf region of the Canadian Arctic. We use these to characterize the variability of turbulent

mixing rates in both space and time, and to begin identifying the dominant physical processes responsible for mixing in this region. The measurements were collected over two weeks by an autonomous glider in August 2015, and they represent one of the most dense microstructure sampling schemes in the Arctic to date. Profiles encompass the most prominent features of the Arctic water column, including the warm Atlantic water layer at depths below 250 m, the halocline between the Pacific and Atlantic water layers, and the surface mixed layer which exhibits a strongly stratified base. From the microstructure measurements, we calculate ? and ?, the dissipation rates of turbulent kinetic energy and thermal variance. Dissipation rates very across four orders of magnitude but are generally very low; mixing between Atlantic- and Pacific-origin water tends to be inhibited by the strong stratification.

1703013 Physical Oceanography - Part 4

Mapping platelet ice and ocean heat flux under Antarctic landfast sea ice

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Under thick Antarctic ice shelves, basal melting leads to the formation of supercooled Ice Shelf Water. As this water spreads under the landfast sea ice adjacent to ice shelves, large platelet ice crystals form to comprise an unconsolidated, porous sub-ice platelet layer. The occurrence and thickness of this meters thick layer, and the thickness of the overlying consolidated sea ice bear information about the location and reach of currents spreading from under the ice shelf, and of the degree of supercooling of Ice Shelf Water and therefore negative heat flux from the sea ice into the water.
Here we show that the occurrence and thickness of the sub-ice platelet layer can be continuously mapped with snowmobile and airborne electromagnetic (EM) induction measurements. The method takes advantage of the contrasting electrical conductivities of sea ice, the porous sub-ice platelet layer, and seawater underneath. Measurements were carried out over McMurdo Sound in the Southern Ross Sea in 2009, 2011, 2013, and 2016. Results are in good agreement with similar but much slower mapping efforts using hydrographic surveys or ice core analyses. Repeat surveys of the same profiles show hithero unknown, recurring small-scale variability of the sub-ice platelet layer, and little interannual variability.

1703013 Physical Oceanography - Part 4

Impact of ice strength parametrization and ice thickness distribution on the Canadian 1/12th degree resolution Arctic-North Atlantic ice-ocean prediction system

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The Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) has developed a 5km Regional Ice-Ocean Prediction System (RIOPS) based on NEMO-CICE. The system, run operationally, produces four 48h ice–ocean forecasts per day and provides hazard warnings in ice-infested

regions. RIOPS includes in particular explicit tides and a landfast ice parametrization based on the effect of grounded ice ridges (Lemieux et al. 2015) and on an increased resistance to tension and shear in the ice rheology (Lemieux et al. 2016). We reported already about the impact on thickness of switching from the Rothrock's (1975) ice strength parametrization to the simpler Hibler (1979) approach. This time, we will conduct a series of idealized experiments to understand the impact of the number of ice thickness categories and the ice strength parametrization on the ice strength and thickness

1703013 Physical Oceanography - Part 4

Modelling Greenland icebergs: pathways and freshwater contribution

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Icebergs are an important freshwater source to the ocean and a threat to navigation. Considering that the Greenland ice sheet has been melting faster in recent years, and also that the number of ships navigating the Canadian Arctic has increased significantly since 2002, understanding the pathways of Greenland icebergs has become essential. These paths, however, are scarcely documented and observations using remote sensing is limited by sea ice cover and the size of icebergs. Our study aims to evaluate the trajectories of icebergs that calve from Greenland – and their importance to the North Atlantic as a source of freshwater – using an interactive iceberg module coupled with the Nucleus for European Modelling of the Ocean (NEMO v3.4). The results show that Baffin Bay is preferentially occupied by icebergs calved from western Greenland. Numerous icebergs were found in Hudson Strait but only a few enter Hudson Bay and Foxe Basin. Smaller icebergs originating from the northwest tip of Greenland penetrate Lancaster Sound and follow the Somerset Island east coast. We will also present maps with the number of icebergs in the Canadian Arctic between 2002-2015, the size and lifetime of those icebergs, and the amount of freshwater released compared to other sources.

1703020 Coastal Oceanography and Inland Waters- Part 1

Assessing the Performance of Formulations for Nonlinear Feedback of Surface Gravity Waves on Ocean Currents over Coastal Waters

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This study presents applications of a two-way coupled wave-circulation modelling system over coastal waters, with a special emphasis of performance assessments of two commonly-used methods for nonlinear feedback of ocean surface gravity waves on three-dimensional (3D) ocean currents. These two methods are a vortex force (VF) formulation suggested by Bennis et al. (2011) and a latest version of radiation stress (RS) formulation suggested by Mellor (2015). The coupled modelling system is first applied to two idealized test cases of surf-zone scales. Model results in the two test cases demonstrate that the VF-based coupled system produces a more reasonable vertical structure for the cross-shore currents with strong offshore-directed flow near the bottom than the RS-based model. The coupled system is then applied to Lunenburg Bay (LB) of Nova Scotia during Hurricane Juan (2003). The coupled system using both the VF and RS formulations generates much stronger and more realistic 3D circulation in the Bay during Hurricane Juan than the circulation-only model, demonstrating the importance of surface wave forces to the 3D ocean circulation over coastal waters. Furthermore, in comparison with the RS formulation, the VF formulation performs better in simulating currents at two observation sites in LB, and produces a more coherent spatial structure of coastal currents with complex topography. Our results also demonstrate that the VF formulation is a relatively better approach for applications over the surf zone or complex topography where wave nonlinear effects are important.

1703020 Coastal Oceanography and Inland Waters- Part 1
Modelling the baroclinic response of Placentia Bay to Hurricane Leslie
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We use a three-dimensional, baroclinic finite-volume community ocean model (FVCOM) to examine oceanic responses of Placentia Bay to Hurricane Leslie in September 2012. Hurricane Leslie made landfall at the south coast of Newfoundland on September 11, 2012. The FVCOM model is forced by reconstructed winds during the storm period. The modelled storm surge magnitude and timing agree well with tide-gauge observations. The sea surface cooling in the outer Bay is well reproduced by the model. The model results show strong near-inertial oscillation, consistent with observations.

1703020 Coastal Oceanography and Inland Waters- Part 1
Development and applications of a next-generation coastal ocean forecast system for the eastern Canadian seaboard
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During the last several years, Dalhousie University, in collaboration with various stakeholders including Fisheries and Oceans Canada and Environment Canada, developed a nested-grid coastal ocean forecast system for the Gulf of St. Lawrence, the Scotian Shelf, and the Gulf of Maine, with a focus on the Scotian Shelf and adjacent coastal waters. Significant efforts have recently been made on upgrading this forecast system using the Regional Ocean Modeling System (ROMS). ROMS was chosen due to the availability of user-friendly modules such as a sea ice model and the option of coupling with a wave model. ROMS was set up with a domain covering the northwest Atlantic Ocean from Cape Cod to the southern tip of Greenland. Inputs for ROMS at the sea surface include wind stress, atmospheric pressure, and heat flux derived from atmospheric model simulations, and inputs at the model's lateral open boundaries include tides and values of current velocity, temperature, and salinity that were simulated by another ocean circulation model. In this talk, we will present preliminary model results produced by ROMS on time scales ranging from tidal to seasonal, and assess the model performance through comparisons between model simulations and observations. In the future, we plan to complete the update of the nested-grid coastal forecast system by setting up ocean models, also using ROMS, with smaller domains and finer spatial resolutions nested within this model.

1703020 Coastal Oceanography and Inland Waters- Part 1
Simulation of wave-current interactions under hurricane conditions using unstructured grid model FVCOM: The impact on wave and current fields
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The effect of wave-current interactions on both the wave and current fields under hurricane conditions is investigated through the application of the unstructured-grid finite-volume community ocean model (FVCOM) coupled with the unstructured-grid surface wave model (SWAVE) in the North Atlantic Ocean. The model domain ranges from 20N to 70N and from 80W to 30W, which provides a large enough area to study the progression of wave-current interactions during hurricanes Juan (2003) and Bill (2009), in both deep and shallow waters. Simulations of ocean and wave parameters in each hurricane are shown to compare well with buoy and satellite altimeter observations, in terms of winds, significant wave heights, wave energy spectra and wave directions. Significant modulations of wave-current interactions on significant wave heights show a dipole-like positive and negative alternative pattern. The effect of currents on significant wave heights

is shown to reach 0.4 m for hurricane Juan and 1.0 m for hurricane Bill. The effects of waves on currents is shown to reach 0.5 m/s. Simulation of wave-current interactions is also shown to improve the wave energy spectrum simulation at the peak of the storm, through the comparison with the buoy observations. The conventional default bulk formula for the drag coefficient and wind stress in the FVCOM-SWAVE coupled model give increasing values for the drag coefficient with increasing wind speed and overestimates in wave heights. However, the setting of a limiting cap following Soloviev et al. (2014) for the drag coefficient clearly reduces the overestimation of the maximum significant wave heights at the spectral peak and improves the simulation. Reference: Soloviev et al., 2014: The air-sea interface and surface stress under tropical cyclones Scientific Reports, 4: 5306.doi:10.1038/srep05306

1703020 Coastal Oceanography and Inland Waters- Part 1

Development and Applications of Shelf Circulation Models for the Eastern Canadian Shelf

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Significant progress has been made by the regional ocean modelling group at Dalhousie University in the development and applications of numerical shelf ocean circulation models with different levels of complexity for coastal and shelf waters over the eastern Canadian sea board. As part of research projects for multi-agency research networks including the Ocean Track Network (OTN) and the Marine Environmental Prediction, Observation and Response (MEOPAR), four different ocean general circulation models have been used in the group, including NEMO (Nucleus for European Modelling of the Ocean, POM (Princeton Ocean Model), CANDIE (Canadian Version of DieCast) and ROMS (Regional Ocean Modelling System). In this presentation, three-dimensional (3D) circulation and hydrography over the eastern Canadian shelf produced by different models will be compared and analyzed. A brief discussion will be made on the implication of the semi-prognostic method and spectral nudging method in the models. These two methods are very simple and effective data assimilation schemes to reduce the systematic seasonal drift in the model by assimilating monthly hydrographic climatology into the model. A brief discussion will also be made on applications of model-calculated 3D, time-varying currents and hydrography in examining how distributions and migration of marine animals such as American eels and Atlantic salmon are affected by physical oceanographic conditions over the study region.

1703020 Coastal Oceanography and Inland Waters- Part 1

The Mean Tilt of Coastal Sea Level in Shallow, Tidally-Dominated Regions

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The alongshore tilt of mean dynamic topography (MDT) along the coast can be used to make inferences about both nearshore and regional circulation. The present generation of high-resolution ocean models is providing more accurate predictions of the tilt of MDT along coastal boundaries. This will be demonstrated using a regional-scale configuration of the NEMO ocean model with a grid spacing of 1/36° applied to the Gulf of Maine and Scotian Shelf. The accuracy of the model predictions of tilt will be assessed through comparison with coastal tide gauge observations referenced to the most recent version of the Canadian Gravimetric Geoid model (CGG2013).

There are however regions where the model predictions exhibit a surprisingly strong sensitivity to certain aspects of the numerics. In this presentation we focus on the sensitivity of the mean tilt, circulation and vorticity in shallow, tidally-dominated regions to the model's formulation of the free surface. Reasons for the discrepancies in tilt based on the different formulations will be given and implications for modelling the circulation and transport in this dynamic environment will be discussed.

1703021 Coastal Oceanography and Inland Waters - Part 2
Patterns of SST variability along the west coast of North America
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Analysis of sea surface temperature variability for British Columbia tends to be very local (considering 1 or 2 locations) or basin-scale (e.g. the Pacific Decadal Oscillation and the North Pacific Gyre Oscillation). Here we take an intermediate approach and consider the sea surface temperature along the west coast of North America from California to Alaska. An EOF analysis of the satellite sea surface temperature data along the 1000 m isobaths was conducted for the years 1982 to 2016. The dominant mode is a (largely) uniform temperature fluctuation from California to Alaska which explains 57% of the variance. The second model is a north-south gradient with a nodal point at Queen Charlotte Sound, which explains 14% of the variance. Finally we consider whether these modes are useful for interpreting British Columbia coastal temperature time series.

1703021 Coastal Oceanography and Inland Waters - Part 2
Dispersion and transport in the Fraser River plume: Insight from drifting buoy trajectories
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Where does the fresh water of the Fraser river go once it enters the Strait of Georgia? Although we know in general that it eventually flows out to the Pacific in the estuarine circulation of the Salish Sea, the details of how this occurs are less clear. However, the details are important because a) contaminants dissolved within this fresh water (e.g., those introduced from sewage outfalls) will travel with the fresh water, and b) river particulate, which may itself have contaminants absorbed to it, will remain in this fresh water until it sinks out somewhere in the Strait.

Previously we have used indirect methods to determine the residence time of fresh water in various regions of the Strait. However, it is also possible to approach this more directly by deploying GPS-tracked drifting buoys near the river outflow. In this talk we present and discuss dozens of drifter tracks measured over a range of river, tide, and wind conditions. The tracks highlight the importance of wind stress on the surface layer, which is largely decoupled from deeper waters by stratification. Tides are important, but only near the river mouth and on short time scales. Finally, comparing the drifter trajectories and speeds to high frequency radar measurements of the currents suggests different conceptual models of the plume -- is it a swift, tidally-pulsed, narrow jet or a slow geostrophic trickle of buoyant water?

1703021 Coastal Oceanography and Inland Waters - Part 2
Barotropic to baroclinic energy conversion in a modelling study of the Salish Sea
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The Salish Sea is a semi-enclosed body of water between Vancouver Island and the mainland of British Columbia and Washington State. It is composed of several waterways separated by complicated bathymetry and coastlines. We present results from a baroclinic model of this region, focusing on barotropic and baroclinic currents. The model's barotropic tidal currents agree with observations and other modelling studies.The baroclinic tidal currents vary with stratification. Below the surface, they agree reasonably well with observation. However, the surface baroclinic tidal currents have proven difficult to evaluate, particularly in regions of strong fresh water influence. We provide estimates of barotopic and baroclinic energy dissipation and quantify the barotropic to baroclinic energy conversion to identify regions of internal tide generation.

1703021 Coastal Oceanography and Inland Waters - Part 2
Tidal propagation in Fraser River Estuary
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Information of tidal propagation in estuaries is of scientific and engineering importance for tidal prediction, offshore engineering design, marine navigation, sediment transport, and estuarine ecosystem. In the present study, propagation of tides in the Fraser River has been investigated using water level data along the estuary and a 3-D hydrodynamic model based on FVCOM, which covers from the estuary to about 100 km upstream of the river from the river outlet with a variable mesh with a horizontal resolution as high as 10 m. The model was validated with observational data including the water elevations and currents, and good agreement was obtained. Both the observations and model results show that tides significantly change in amplitude and phases along the river channel due to the presence of river discharge, which modifies bottom friction and pressure gradient.

1703021 Coastal Oceanography and Inland Waters - Part 2
A modelling study of the wind-driven and estuarine circulation of the Kitimat Fjord System
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A high-resolution unstructured-grid model based on the Finite Volume Community Ocean Model (FVCOM) is used to quantify the wind-driven and estuarine circulation in the Kitimat Fjord System, which is composed of channels, islands and estuaries. The horizontal resolution of the model varies from 1 km in the open ocean to about 100 m to resolve the complex circulation structures in the channel network. The model is forced by tides, winds, river discharges, and heat/freshwater fluxes. The model results compare favorably with the observations made by tide gauges and current-meters. Model results demonstrate that the mean circulation in the region is characterized by a seasonally varying multi-layer estuarine circulation. The effect of wind forcing on the estuarine exchange is discussed.

1703021 Coastal Oceanography and Inland Waters - Part 2
Wind-driven currents in the Strait of Georgia from recent model hindcasts
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Wind is often a dominant forcing of circulation and currents in coastal seas. Wind-driven circulation is well-understood in the open ocean and along continental margins, however, most literature on enclosed basins focuses on small, shallow or well-mixed lakes and estuaries, leaving many unanswered questions in deep, stratified, tidal basins. Here we examine wind-driven circulation in a semi-enclosed fjord basin on the BC coast (Strait of Georgia) under several distinct wind regimes using recent hindcasts from an operational model (NEMO) of the Salish Sea (SalishSeaCast). Along-strait winds dominate the region, blowing from the

southeast in winter and from the northwest in summer. Gap winds through the Fraser and Squamish Valleys exert significant influence over the southern Strait in the winter. Several persistent circulation patterns arise including right-bounded near-surface coastal currents and surface (Ekman) transport to the right of the mean wind field. Since near-surface net transport during sustained, along-strait wind events is generally downwind, we identify potential pathways for return circulation at deeper depths.

1703022 Coastal Oceanography and Inland Waters - Part 3

Sub-tidal circulation in a deep-silled fjord: Douglas Channel, British Columbia

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Douglas Channel, a deep fjord on the west coast of British Columbia, Canada, is the main waterway in the fjord system that connects the town of Kitimat to Queen Charlotte Sound and Hecate Strait. A 200 m depth sill divides Douglas Channel into an outer and an inner basin. This study examines the low-frequency (from seasonal to meteorological bands) circulation in Douglas Channel from data collected at three moorings deployed during 2013 -- 2015. The deep flows are dominated by a yearly renewal that takes place from May/June to early September. A dense bottom layer with a thickness of 100 m that cascades through the system at the speed of 0.1 -- 0.2 m/s, which is consistent with gravity currents. Estuarine flow dominates the circulation above the sill-depth, and the observed landward net volume flux suggests that it is necessary to include the entire complex channel network to fully understand the estuarine circulation in the system. The influence of the wind forcing on the sub-tidal circulation is not only at the surface, but also at mid-depth. The along-channel wind dominates the surface current velocity fluctuations and the sealevel response to the wind produces a velocity signal at 100 -- 120 m in the counter-wind direction. These wind-driven responses are modelled using ROMS. Overall, the circulation in the seasonal and the meteorological bands is a mix of estuarine flow, direct wind driven flow, and the barotropic and baroclinic responses to changes to the surface pressure gradient caused by the wind stress.

1703022 Coastal Oceanography and Inland Waters - Part 3

Physical Controls on Extremes of Carbon and Oxygen in Coastal Upwelling Regions

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Acidic and low- oxygen water occurs episodically in coastal upwelling regions and affects organisms at various trophic levels. Understanding these episodic events requires a combination of observational and modelling approach. Our approach is to characterize the physical, chemical, and biological processes that result in these extreme conditions in coastal upwelling regions using a biogeochemical model.

The current study uses a quasi 2D biogeochemical model to diagnose extreme oceanic carbon and oxygen conditions off the west coast of Canada. For this purpose, we added an oxygen cycle to the model of Ianson and Allen, [2002]. Reanalysis wind products were used to study the effects of local and remote forcing on biogeochemical fluxes through mixing and upwelling/downwelling in the region. The model performance was assessed using multiple cruise measurements taken between 1999 and 2016 and moored data obtained from the Ocean Networks Canada.

The simple configuration of the model allows multiple sensitivity analyses, the results of which will be discussed in detail. Preliminary results of simulations for the period 1995-2001 suggest remote influences on local biogeochemical processes in the region are stronger than previously thought.

Time permitting, the effects of future upwelling winds in the California Current System on carbon and oxygen extremes in the region will be discussed.

1703022 Coastal Oceanography and Inland Waters - Part 3

Drifter dispersion in a multiply connected fjord system in the context of estimating oil spill extents

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We analyzed the absolute dispersion of ocean surface drifters in a multiply connected system of fjords in northwestern British Columbia, in the context of estimating likely extents of potential oil spills. The novel, inexpensive drifters used in this study are biodegradable and were deployed indefinitely. The majority of drifters generated data for one to three weeks. To the best of our knowledge the resulting set of drifter data is the most extensive collected in a fjord system to date. Comparison of the drifter tracks with observed extents of diesel sheen from a spill in the study region in 2006 indicates that the drifters are a suitable proxy for spilled oil. The comparison also shows that trajectories starting in a confluence of two or more channels are quite sensitive to initial location. To accommodate this sensitivity we one-dimensionalize the problem and consider only landward and seaward along-channel displacements. Displacements are found to be normally distributed around a mean seaward motion after 6 days. Prior to this the distributions around the mean are more peaked than a normal distribution and positively skewed, consistent with transport by coherent flow structures favouring large down-channel displacements. A Gaussian distribution is found to be an acceptable model for the largest displacements to 95% confidence.

1703022 Coastal Oceanography and Inland Waters - Part 3

Observations of enhanced mixing and dissipation in the central Canadian Arctic Archipelago

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Detailed observations of flow through a major pathway of Arctic water towards the Atlantic show strong mixing due to internal wave breaking. Above a shallow sill where tidal currents often exceed 0.5 m/s, internal wave activity is evident from isopycnal displacements of 10-20 m over horizontal scales of order 1 km. Larger displacements occur at the downstream end of the sill as dense water plunges downward and forms an internal hydraulic jump, a feature consistently observed in repeat transects over the sill. Overturn-derived turbulent dissipation rates are elevated over the sill with typical values of 10^-8–10^-7 W/kg, similar to past estimates in nearby Barrow Strait. This dissipation amounts to 10-20% of the divergence of tidal energy flux in the region derived from a barotropic tidal model. We expect topographically induced eddies and internal tides to also play significant roles in the energy budget. Indeed, internal tides are apparent in our observations but their interpretation is complicated by their generation north of the critical latitude. To elucidate these various observations, high-resolution modelling experiments, both realistic and idealised, are being undertaken.

1703022 Coastal Oceanography and Inland Waters - Part 3

A Data Science Approach to Understanding Coastal Primary Productivity Dynamics

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The large effect of phytoplankton primary productivity on atmospheric oxygen, carbon cycling, and marine food webs motivates the understanding of drivers of phytoplankton distribution in the coastal ocean. Here, we analyze the primary productivity dynamics of the Salish Sea using the output of a newly-developed biophysical model based on the NEMO (Nucleus for European Modelling of the Ocean) framework (Olson et

al, in preparation). The biophysical model estimates four discrete organismal classes - small phytoplankton, diatoms, Mesodinium rubrum, and microzooplankton. Here, daily depth-integrated biomass signals for all four organismal classes are extracted from the model domain over the course of one year. This output is then analyzed using a normalized hierarchical clustering approach which utilizes Ward's Euclidean distance metric. Other data science techniques, such as neural nets, may be explored. This result is then considered in the context of the modelled ocean physics (mixed layer depth, wind intensity). The analysis shows that biomass volumes vary greatly (~2 orders of magnitude) throughout the model domain, and that clear spatial patterns, corresponding to regions dominated by different water masses and rivers, can be discerned. The study represents the first attempt at a large-scale statistical analysis of the newly-developed model, and demonstrates the potential utility of this approach in identifying discrete regions governed by various primary productivity regimes.

1703022 Coastal Oceanography and Inland Waters - Part 3

Nine Years of Extremely Large Internal Waves in the Strait of Georgia

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It is well-known that near-surface internal waves are often present in the Strait of Georgia in summer, but many aspects of waves in this area still remain unknown. Here we investigate the temporal variation of internal wave properties and energetics using a 9-year long time series of Acoustic Doppler Current Profiler (ADCP) and echosounder data collected at nodes of the Ocean Networks Canada coastal observatory.

Hundreds of large nonlinear internal wave packets were identified over a nine year period. The timing of these packets suggests a very strong correlation with daily tides. Other wave characteristics showed seasonal variations. Previous studies of the Strait's internal waves, conducted mainly in summer when the stratification is stronger, have found that large internal waves are generated near southern boundary passages and propagate northward. However, our analysis of the complete time series shows that in winter, when the pycnocline is weaker, both the spatial and temporal scales of internal waves are an order of magnitude larger than in summer (wave amplitudes can approach 30m), and that these waves can sometimes propagate in other directions as well. Also, wintertime internal waves are large enough vertically but small enough horizontally that standard ADCP processing algorithms can present a strongly distorted view of wave shape and features. A specialized reprocessing of the beam velocities must be used to study these waves.

1703023 Coastal Oceanography and Inland Waters - Part 4

Observations of surface drift in a very shallow embayment: Part I instrument design

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The drinking water for 70,000 Ontarians supplied by a local embayment is negatively impacted by seasonal bacterial contamination and algal blooms. Understanding the circulation in the embayment is essential for managing the ecosystem but there are only a small number of existing current measurements. The shallowness and complex shoreline of the bay along with the abundant public usage makes it difficult to install arrays of bottom mounted ADCPs and therefore a number of surface tracked GPS drifters that could be deployed and retrieved were designed to gather Lagrangian current observations. This talk will present the design of a small low-cost surface drift instrument that can be deployed in a shallow embayment for periods of a few hours to a few months. We will look at velocity estimates and the issues of deployments in these types of domains.

1703023 Coastal Oceanography and Inland Waters - Part 4
Investigating the flushing dynamics of Parry Sound
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Parry Sound is a large (Area ~ 77m2) embayment off Georgian Bay, Lake Huron. As a popular destination for recreational fishing and other water sports, along with supporting a thriving aquaculture industry, it is important to understand the physical processes that control water quality. Due to the narrow channel connecting the embayment to the main body of Georgian Bay, long residence times have been assumed for the water quality of the Parry Sound. However, to date there have not been any investigations into the flushing rate of Parry Sound which has stimulated the current research.
Using data collected from temperature strings, ADCP and salinity profiles in Parry Sound in 2016, along with water level and wind data collected by Environment Canada, we will analyze the relative importance of surface and internal waves on flushing the embayment. Due to the limited material flux across the thermocline, it can act as a bellows, similar to the surface water level, pumping water into and out of Parry Sound. Preliminary results indicate that thermocline fluctuations dominate surface water level fluctuations in flushing the sound, with an estimated retention time due to thermocline movements of ~45 days (retention time for surface water level movements is ~300 days). Analysis of the salinity profiles will provide an independent estimate of flushing rates in Parry Sound, allowing us to validate our results.
Due to the large size of Parry Sound (Area ~77 km2, max depth 108 m) and connection to the very large Georgian Bay (~15,000 km2) of Lake Huron, many features of circulation and flushing of this system are reminiscent of fjord systems. There are many long, deep embayments in the Great Lakes resulting in our investigations into the flushing dynamics of Parry Sound having generality to many other systems in the largest bodies of freshwater in North America.

1703023 Coastal Oceanography and Inland Waters - Part 4
Modelling environmental uncertainty in acoustic transmission loss and comparison to measurements in the Capraia Basin, Mediterranean Sea
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Imperfect knowledge of the environment drives uncertainty in acoustic propagation calculations which underlie sonar performance predictions that are of interest to the Royal Canadian Navy. Acoustic transmission loss (TL) was measured in the Capraia Basin in the Mediterranean Sea between 25 Aug and 09 Sep 2015 during a sea trial led by the North Atlantic Treaty Organization (NATO) Centre for Maritime Research and Experimentation (CMRE). A source transmitted waveforms at frequencies between 300 Hz and 5000 Hz and source-receiver ranges up to 15 km, remaining stationary for each five-minute transmit period. The waveforms were received on a fixed 32-channel vertical line array receiver spanning the water column from 48 m to 95 m depth in 115-m deep water. At the same time, a variety of techniques were used to measure ocean bottom properties while a fleet of underwater gliders measured sound speed profiles across the study area. Uncertainty in environmental parameters is transformed into TL variability using a Monte Carlo approach in which multiple realizations of the environment are used as inputs into the Bellhop acoustic propagation model. The original approach assumed Gaussian distributions for all the input environmental parameters; however, other distributions may be more realistic for such parameters as the wind speed (Weibull distribution), the sound speed profile (depth-dependent variance or empirical orthogonal functions), and the bottom loss (layering). The resulting modelled TL variability is compared with measured TL in order to provide insight into the validity of the individual models of environmental parameters.

1703023 Coastal Oceanography and Inland Waters - Part 4

Linkage between the flushing mechanisms and water quality patterns in the nearshore of South-eastern Georgian Bay

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Flushing mechanisms - driven by the natural circulation - play a dominant role in understanding the impact of land-based phosphorus on the nearshore water quality of South-eastern Georgian Bay, Ontario. Georgian Bay is located east of the main body of Lake Huron and has a surface area of 15,000 km², and contains approximately 30,000 islands. Generally the water quality is very good, but there are concerns about the impact of ongoing development upon the many inlets and bays along the eastern shore. Detailed observations of nearshore water quality (e.g. conductivity, phosphorous, chlorophyll) from Shwanaga and Moon River Island regions show pronounced gradients, presumably driven by water circulation patterns. This region experiences seasonal thermal stratification and a significant barotropic variability in currents that is tied to variability in surface water levels. Here is a strong signal of tides at diurnal and semidurnal periods, but water movements appear to be driven by the diurnal tides at these locations. This suggests a well-mixed estuarine like circulation that controls the water quality gradients. FVCOM (Finite Volume Community Ocean Model) will be run to simulate dispersion of river water where circulation is driven by diurnal winds.

1703023 Coastal Oceanography and Inland Waters - Part 4

Frequent hypoxic upwelling events in Hamilton Harbour driven by wind forcing

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A thermocline deflection model based on the Lake Number approach was created to predict the effects of wind driven upwelling events upon physical environment changes in temperature and dissolved oxygen concentration (DO). Historical wind data, bathymetry, and high frequency measurements of thermal stratification were used to model thermocline deflection for 2011. Desirable fish like Cisco have very specific temperature and DO range requirements for suitable habitat and are likely to be very susceptible to sudden changes in temperature and DO. The spatial distribution of fish habitat suitability is consequently influenced by the frequency, magnitude, and duration of thermocline deflection events predicted by this model. Based on the high dependence of upwelling events on windspeed direction and duration, we expected upwelling events to occur most frequently in the southwest and northeast and have the largest magnitude predominantly in the north and northeast areas of Hamilton Harbour. Our expectations were supported by both observed results from a measuring station and our model which predicted ~100 complete upwelling events over the summer stratified period - thus there is an almost diurnal cycle to the upwelling. Detailed acoustic fish telemetry data from 2016 finds that fish appear to move quickly in response to the diurnal upwelling of anoxic waters. This upwelling of the hypoxic hypolimnion up to the lake surface must be taken into account for fish habitat restoration efforts in the West, North and East areas of Hamilton Harbour.

1703023 Coastal Oceanography and Inland Waters - Part 4
Circulation and thermal regime in shallow embayments of a coastal lagoon: Combining field observations and hydrodynamic modelling
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We show that in a shallow harbour connected to a large lake, frequent water level oscillations can drive significant exchange in shallow embayments that is reminiscent of tidal flows. The analysis of water currents, water levels and temperatures demonstrate that strong water-level fluctuations with a period of one-hour drive most of the exchange flows in the shallow embayments of the harbour. Water velocities in these oscillating flows were as high as 0.6 m/s and determined flushing times of order of days for most embayments of the harbour, and thus the temperature differences between the shallow embayments and the colder and deeper harbour result from differences in thermal inertia. During summer, benthic water temperature differences between the embayments and similar depths in Lake Ontario were as high as 15°C. In in contrast to the prevailing paradigm that water level fluctuations in the Great Lakes are too small to drive significant currents, our observation and modelling efforts show that the exchange in these shallow embayments is dominated by water level fluctuations. Our observations and modelling results can be used to optimize the creation of warm water fish habitat in shallow embayments located next to large, cold lakes.

1703030 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1
Effects of Arctic sea ice retreat on primary production and emissions of climatically important trace gas dimethylsulfide (DMS): a model study
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Mortenson, Eric - University of Victoria
Sou, Tessa - Institude of Ocean Sciences
Hu, Xianmin - University of Alberta
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In polar regions, sea ice provides an important habitat for microalgae. During the spring melt season, primary production at the base of Arctic sea ice plays key roles in marine ecosystems, although quantification of these roles at pan-Arctic scale is challenging due to scarcity in observations. In this study, we tackle this challenge by developing a module for sea ice biogeochemistry, which has been implemented into a coupled 3-D regional sea ice-ocean physical-biogeochemical model. The model coverage includes the Arctic Ocean, the Canadian Arctic Archipelago, the northern Bering Sea, the northern North Atlantic Ocean, and the Nordic Seas. In this presentation, we plan to discuss the results of model simulations conducted for the recent historical period (1984-2007). The topics for these discussions include: 1) the relative contributions of ice algae and phytoplankton to primary production and emissions of climatically important gas dimethylsulfide (DMS); 2) the impacts of incorporating/neglecting the sea ice biogeochemical module in the pan-Arctic estimates for these quantities; and 3) the model sensitivity to parameter uncertainty. Additionally, we plan to present the projected changes in those biogeochemical quantities mentioned above by the end of this century.

1703030 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1

A model approach to carbon exchange in the air, sea, and ice of the marine Arctic

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Traditionally, models of seasonally ice-covered ocean have treated the ice cover as an inert barrier to the air-sea exchange of gases. However, recent field research indicates that chemical and biological processes in the sea ice contribute to the carbon transport within and below the ice. We have developed a coupled sea ice and pelagic ecosystem in a 1D model that simulates carbon exchange in the seasonally ice-covered marine Arctic. Carbon sinks and sources due to pelagic and sympagic biological production, and sea-ice carbon fluxes due to ice growth and melt have been included, as well as ikaite precipitation (within the ice) and dissolution (in the water column). The model has been set up for a location near Resolute Bay in the Canadian Arctic Archipelago. Sensitivity analyses, focusing on the relative importance of the ice algal bloom, DIC-rich brine rejection during ice growth, and low-DIC meltwater release during ice melt, provide insight into the impacts of these processes on the air-sea exchange of carbon during the ice-free season. These carbon fluxes are presently being implemented in a 3D regional coupled ice-ocean biogeochemical model for the Arctic, and preliminary results from the 3D regional model will be presented as well.

1703030 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1

Coupling a regional climate model to a lake tile model for prediction dissolved oxygen profiles in lakes

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Lake Trout live within narrow temperature and dissolved oxygen (DO) boundaries in the hypolimnia of stratified lakes. This species is vulnerable to environmental stressors including climate warming, that may deepen the thermocline and increase the duration and strength of thermal stratification. These processes exacerbate hypolimnetic hypoxia; therefore, there is a need to model future DO concentrations in lakes to aid fishery management. In this study, a simple DO sub-model has been embedded in the one-dimensional bulk mixed-layer thermodynamic Canadian Small Lake Model that is being incorporated into the land surface component of the Canadian Regional Climate Model (CRCM). Given the lack of monitoring data in many Canadian lakes, a simple oxygen budget model has been developed, with respiration, photosynthetic production and sediment oxygen demand parameterized as functions of light intensity, water temperature and

DO concentration. Vertical mixing, below the surface mixed layer is computed from Fick's Law using data from measured turbulent diffusion profiles. The model has been validated using 30 years of historical data from two Canadian Shield lakes and predicts the temperature and DO profiles with RMS error <1.5 °C and <3 mg/L, respectively. This talk will present ongoing work that compares model predictions, when forced with the CRCM, to reconstructions of past DO concentrations in the lakes from sediment cores.

1703030 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1
Exploring the Relationship Between Vertical Mixing, Overturning Circulation, and AABW Volume During the Last Glacial Maximum
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During the Last Glacial Maximum (LGM), the deep ocean is understood to have stored roughly 70-90ppm of atmospheric CO2, with ocean circulation changes contributing to enhanced carbon uptake. In the Atlantic Ocean, paleoceanographic evidence suggests that North Atlantic Deep Water (NADW) likely shoaled by at least 1000m while Antarctic Bottom Water (AABW) expanded below 2000m. AABW may have become poorly ventilated during the LGM, increasing the deep ocean carbon reservoir. Paleo-environmental data and arguments for a strengthening of the biological pump during glacial periods support a weakening of overturning circulation, yet few modelling efforts show reduced overturning when simulating AABW volume growth. One possible explanation for this discrepancy is that simulated mixing between AABW and NADW should decrease as the boundary between the two water masses shoals, either from increased stratification or increased distance from bottom topography. If so, upwelling would be reduced, allowing AABW to increase in volume without the need for increased overturning. This research addresses the relationship between vertical mixing, AABW volume, and overturning circulation using the UVic Earth System Climate Model with four mixing parameterizations: constant vertical diffusivity, a standard Bryan and Lewis scheme and a custom linearized version, and tidal mixing. The linearized Bryan and Lewis scheme is inspired by a topographically based mixing scheme of De Boer and Hogg (2014), which increased AABW volume and residence time while decreasing overturning circulation in a 3-box model. All simulations show an increase in AABW volume during the LGM relative to modern times. However, no significant difference in overturning circulation between mixing schemes is apparent. Therefore, the results of these simulations do not support the hypothesis that topography-dependent mixing schemes better represent the relationship between overturning and AABW volume compared to other mixing schemes.

1703030 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1
Impact of turbidity from the Fraser River plume on modelled primary production in the Strait of Georgia
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Turbidity in the Fraser River plume represents an important contribution to light attenuation in the southern Strait of Georgia. On short timescales, turbidity varies approximately linearly with salinity in the plume region (A. Sastri, personal communication), indicating that on these timescales turbidity is approximately conserved as plume and Strait water mix. Previous phytoplankton models for the Strait (Peña et al., 2016, Collins et al., 2009) have leveraged this relationship to represent plume turbidity through time-independent parameterizations of PAR attenuation as a function of salinity or freshwater flux. However, on longer

timescales (days to seasons), the parameters of the fits vary. We demonstrate that slope and intercept of the turbidity-salinity relationship over the plume region correlate with Fraser River turbidity measured in the Main Arm with R of approximately -0.44 and 0.36, respectively, at zero lag ($p<0.01$), becoming decorrelated on timescales of approximately 2 days. We will discuss the impact of the representation of river turbidity on primary production in a 3-d coupled physical-biological model for the Salish Sea, comparing cases with 1) no river turbidity 2) a time-independent relationship between k and S and 3) the use of a passive tracer initialized based on real-time Fraser River data to simulate turbidity in the plume.

1703030 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 1
Pan-Arctic Exchange, the Labrador Sea and the AMOC
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We use several different regional configurations of the NEMO model (including AGRIF nests) to look at Arctic-Atlantic exchange. The role of river runoff, melt from the Greenland Ice sheet (as well as its iceberg discharge) and high-frequency atmospheric forcing is examined to evaluate the model in terms of exchanges at the Arctic Gateways, water formation in the Labrador Sea and the North Atlantic overturning. Water mass pathways are examined through the use of passive tracers. Additionally, a simplified biogeochemical model, BLING, is coupled to NEMO and used to look at questions of productivity.

1703031 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2
Developing CanNEMO – the ocean component of the Canadian Earth System Model
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The Canadian Earth System Model (CanESM) is a global Earth System Model used for climate studies on timescales from seasons to centuries. The joint ocean, biogeochemistry and sea-ice components – together called CanNEMO – are built off the NEMO modelling framework, and developed collaboratively across several government and university labs. Here I briefly describe customizations to the physical ocean model used in CanNEMO, the two locally developed ocean biogeochemistry models: the Canadian Model of Ocean Carbon (CMOC) and the Canadian Ocean Ecosystem (CanOE), as well as development work on sea-ice biogeochemistry. Collaboratively developing, testing and deploying CanNEMO for operational use in the ESM is a major feat of software engineering. I outline the model development process, which is designed to harness industry standard tools and practices to facilitate collaborative development, and ultimately to ensure scientific reproducibility. Specifically we use a git based version control system, following a customized workflow, which is used to track and merge changes. Leveraging the version control system to run the model

across various high performance computing platforms is achieved by a range of specialized tools developed in-house, which are outlined. Formal tests of the model code, aspiring to continuous integration, and a suite of plotting and visualization tools to deliver evaluation metrics easily to developers are a key aspect of the development paradigm. This evaluation system will be presented with specific examples. The workflow used to develop CanNEMO has been successful in making development more systematic and open, facilitating collaboration, enhancing code portability, and ensuring reproducibility of simulations. Following successful testing in the ocean, the approach is now being rolled out to all components of the CanESM, and it may serve as an example workflow for scientific model development elsewhere.

1703031 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2

Evaluation of a high-resolution model of the Northeast Pacific based on NEMO

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The realism of the 1/36-degree (in longitude/latitude) model for the Northeast Pacific Ocean, based on the Nucleus for European Modelling of the Ocean (NEMO), is evaluated with a variety of in situ and satellite remote sensing observations. The evaluation is carried out for a hindcast simulation from 2014 to 2016, and specific test cases for March-April and October-November of 2015 involving “spectral nudging” to a data assimilative global ocean analysis at 1/12-degree horizontal resolution. The comparison demonstrates the effectiveness of “spectral nudging” in keeping the structure of large meso-scale eddies in the deep ocean, while allowing the sharpening of fronts. In the Hecate Strait region, the model reproduces the observed seasonal and inter-annual variation of temperature, and provides evidence of shelf-deep ocean exchange.

1703031 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2

Discussion on development, evaluation and analysis of physical and coupled biogeochemical ocean models

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This presentation aims to stimulate discussions on potential coordination and collaboration between Canadian government laboratories and universities in the development, evaluation and analysis of ocean models for hindcast and forecast at various time scales. The model components include ocean physics, sea-ice, and biogeochemistry. Specific topics may include: 1) model code development and improvement; 2) configurations and simulations; 3) model inter-comparison; 4) sources of input data; 5) evaluation datasets; 6) model analysis methods; 7) data presentation and visualization tools; 8) transfer to operations; etc.

1703031 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2

Diagnosing the dynamics of the barotropic transport in the North Atlantic Ocean with a high-resolution circulation model

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The main objective of this study is to examine the main physical processes affecting the Gulf Stream and its extensions over the North Atlantic Ocean, based on the model results produced by the VIKING20, which is a high-resolution coupled ocean-ice model covering the North Atlantic with a horizontal resolution of 1/20°. The VIKING20 captures reasonably well the Gulf Stream, North Atlantic Current (NAC) and their associated recirculation gyres without data assimilation. To obtain the barotropic transport associated with different dynamics, we calculate annual means in period 1960-2009 of the three vertically integrated forcing terms in the horizontal momentum equations: eddy momentum fluxes, mean-flow advections, and the JEBAR (Joint Effect of Baroclinicity And Relief). We then run a linear shallow water equation model with a horizontal resolution of 1/20° driven by only one of four forcing terms (three vertically integrated terms and sea surface wind stresses) in each run until the model reaches an equilibrium state. The results indicate that the JEBAR term is the primary forcing in driving the barotropic transport in the North Atlantic Ocean. The eddy momentum fluxes and mean-flow advections also play important roles in the Gulf Stream and NAC regions. Wind stresses play a minor role in general, but are the primary forcing in driving the barotropic transport on eastern side of the Mid-Atlantic Ridge. Correlations of the barotropic transport driven by each term to the North Atlantic Oscillation (NAO) are discussed.

1703031 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2

Development of a coastal circulation model in support of the Manolis-L operation

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We have developed a three-dimensional coastal circulation model off eastern Newfoundland for input into an Environment Canada and Climate Change oil spill model to support the Canadian Coast Guard Manolis-L operation. The circulation model is based on the finite-volume community ocean model (FVCOM), with very high resolution in the surrounding waters of the Manolis-L ship wreck site. A one-way nesting method is implemented with a transition zone of five unstructured grids for the open boundary. The impacts of different meteorological forcing datasets and different open boundary conditions on the circulation model results are examined, by comparison with tide-gauge data and Acoustic Doppler current profiler data.

1703031 Collaboration in development, evaluation and analysis of physical and coupled-biogeochemical ocean models - Part 2

NEMO_Nowcast: A Software Automation Framework for Research-Operational Deployments of NEMO

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NEMO_Nowcast is a software automation framework package that has been developed to assist in the creation of systems that run the NEMO ocean model in research-operational mode.

It has been used to implement such systems for the 1/36° resolution Gulf of Maine and Scotian Shelf (GoMSS),
and the ~500m resolution Salish Sea configurations of NEMO-3.6.
Both of these systems execute daily NEMO runs using as recent as possible atmospheric forcing, river runoffs, and boundary conditions fields from larger scale operational models. The runs are fully automated and cover the current day and up to 2 days forward, limited by the availability of high resolution atmospheric forcing forecasts. We will discuss the architecture and components of the NEMO_Nowcast framework. Systems like the GoMSS and Salish Sea model deployments provide ""worker"" modules that the framework calls to prepare, execute, and post-process the daily NEMO runs. Finally, we will present instances of how these operational results have been used for scientific investigations of charismatic events.

1703040 Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans
Quantifying the impact of internal tide mixing on shelf-basin exchange in a numerical model of the Arctic Ocean
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Dense water overflows off the Arctic shelves are important to maintaining and replenishing the Arctic Ocean cold halocline, contribute to the formation of Arctic Intermediate Water, and facilitate shelf-basin exchange. They are impacted by a number of mixing processes in the region. The local breaking of internal wanes generated by the lunar and solar tides is one such process, expected to lead to enhanced mixing in regions of large barotropic tidal speeds and rough topography. The magnitude and spatial patterns of this mixing can have important impacts on dense water formation on the shelves, and thus dense water overflows and shelf-basin exchange.
In this study we consider the impact of enhanced mixing due to the breaking of internal tides on shelf-basin exchange in the Arctic region. Specifically, we quantify the impact of including an additional parameterization of mixing due to the breaking of internal tides on shelf-basin dense water exchange, in a regional Arctic and Northern Hemisphere Atlantic (ANHA) configuration of the NEMO model at ¼ degree resolution. The impact is evaluated by comparing the mass exchange of waters as a function of density class in the model outputs from multiple simulations, two including an enhanced tidal mixing parameterization each with different vertical dissipation profiles based on Polzin (2009) and St Laurent et al. (2001) respectively, as well as a control run without the additional parameterization. Implications of the additional mixing and resultant changes to dense water formation and shelf-basin exchange for the larger Arctic circulation are further considered.

1703040 Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans
Labrador Sea Water formation rate and its impact on the meridional overturning circulation
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The meridional overturning circulation (MOC) is a key component of the Earth's climate system as it contributes to the redistribution of heat, salt and anthropogenic carbon in the world ocean. The lower limb of the MOC is associated with dense water formation driven by buoyancy forcing and is carried by a vigorous deep western boundary current (DWBC). The main water mass in the subpolar North Atlantic is the North Atlantic Deep Water (NADW) and its lightest contribution is the Labrador Sea Water (LSW). The LSW is formed in the Labrador Sea through deep wintertime ocean convection. After its formation, the LSW is exported out of the basin via the DWBC. Changes in the deep water formation have direct consequences for

the ventilation of the deep ocean and its capability to store anthropogenic carbon, as well as for the strength of the MOC and the associated heat transport. Many numerical studies have shown a link between the LSW formation rate and the strength of the MOC. However, the impact of the formation of the LSW on the MOC remains unclear and is still under debate. In this study, we will analyze the change in the fate of the LSW formation and how it impacts the MOC. Change in the DWBC associated with change in the LSW formation rate will be investigated. The formation rate of the LSW will be computed using an instantaneous kinematic subduction approach by analyzing the vertical transport of a water mass through the base of the instantaneous mixed layer. We will address the impact of the Labrador Sea Water on the MOC over the time period from 2002 to 2015 using simulations from the DRAKKAR project, especially a 1?4 degree Arctic and Northern Hemisphere Atlantic (ANHA) configuration and an eddy-permitting 1/12 degree ANHA configuration.

1703040 Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans
Spatial and temporal variability of internal wave energy and its potential effect on mixing in the Canadian Arctic Ocean

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To better assess the risks associated with evolving Arctic Ocean energy and heat budgets, we aim to complete a widespread survey of internal wave energy and evaluate its potential for generating turbulent mixing in the Canadian Arctic Ocean. Traditionally, the Arctic Ocean's unique density structure has acted as a barrier to vertical heat transport, preventing the upward mixing of heat contained in deep, warm Atlantic-sourced water and isolating the surface sea-ice pack. However, there are growing concerns that increasing internal wave energy arising from the intensification of storms and decreases in sea ice cover could enhance vertical mixing rates and erode this stratified barrier. Using over 3000 geographically distributed vertical profiles of ocean temperature and salinity collected by ArcticNet between 2002 and 2015, we calculate snapshots of isopycnal displacements in the region and use these to map the potential energy associated with the internal wave field as a function of space and time. We further consider the potential of the wave field to drive mixing by using a finescale parameterization to estimate the turbulent diffusivity associated with internal wave breaking. Since stratification is a key control on wave energies and mixing rates, we additionally investigate variability in stratification strength and evaluate its role in suppressing or enhancing potential mixing hot spots. We believe the large scope of the analysis promises a more complete quantification of internal wave field energetics and mixing patterns that exist in the Canadian Arctic Ocean. It will further contribute to collaborative Arctic Ocean modelling efforts that are central to our ability to forecast and prepare for the ongoing evolution of the Arctic environment.

1703040 Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans
The Arctic hydrosphere-cryosphere complex: a dynamic nexus of biogenic dimethysulfide production during summer.

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Sea-ice dynamics exert a strong influence on arctic microbial communities and their production and emission of the climate-active gas dimethylsulfide (DMS) in the Arctic. High-frequency measurements made in summer 2016 using a novel automated instrument (ACT-MIMS) during a 6-week oceanographic campaign in the Canadian Arctic Archipelago corroborate the hypothesis suggesting that the Arctic Ocean is a nexus of biogenic DMS production associated, in part, with diversified niches linked with dynamic sea-ice during the

productive season. Results reveal that microbial communities thriving in marginal ice zones contribute significantly to reservoirs of DMS. Furthermore, waters underlying sea-ice are as rich in DMS as their ice-free counterparts suggesting potentially important pulsed effluxes of DMS during ice break-up and the establishment of leads and cracks. Brackish melt ponds harbour DMS-producing communities and thus represent an additional source of DMS in direct contact with the atmosphere. The anticipated proliferation of arctic melt ponds may play a relevant role in spring-summer dynamics of DMS in the future and warmer Arctic. An unexpected outcome of the 2016 campaign was the detection of high DMS under a giant decaying ice floe, a difficult medium to sample from traditional ice camps in view of its high instability. Preliminary results suggest that strong haline stratification under melting floes may result in the entrapment of microbial communities within highly irradiated under-ice waters and a resulting up-regulation of photo-protective mechanisms including DMS production. Large variability in DMS and strong near-surface DMS gradients were detected across hydrographic fronts and transitional areas between open water and oceanic inlets and fjords. Near-terrestrial sources of DMS had never been surveyed at such fine scale thus far in the Canadian Arctic Archipelago and the high concentrations measured (up to 30 nmol L-1) warrant further investigation and monitoring of these regions as significant emitters of DMS during summer.

1703040 Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans
Role of Increasing Barents Sea Flux on the Intermediate Circulation in the Canada Basin
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Warm Atlantic water flows into the Arctic Ocean through Fram Strait and across the Barents Sea. This water forms an intermediate layer throughout the Arctic Ocean including in the Canada Basin. Classically it flows cyclonically in a set of interlocked gyres, one in each basin. However, recent measurements of ²³⁰Th, a water mass tracer, in the Canada Basin show very high values that could only have come from the Alpha Ridge region. As the Alpha Ridge is downstream in the classic cyclonic circulation, that circulation has clearly changed.

We present results from a three-dimensional, Arctic ²³⁰Th model based on a reversible scavenging model driven offline by a coupled ocean-sea ice model. The model reproduces the observed spatial variations of ²³⁰Th concentrations and the observed temporal increase in the Canada Basin. Sensitivity experiments indicate the increase is caused by a change in the intermediate circulation from cyclonic to anticyclonic throughout the Amerasian Basin. This shift in circulation results in a transport of high dissolved ²³⁰Th concentration from the Alpha Ridge to the south Canada Basin. The model circulation and density suggest that the change in the flow is caused by increased dense water flux into the Arctic Ocean, primarily through the Barents Sea route. The change in the intermediate layer circulation is achieved through the propagation of boundary trapped internal Kelvin waves that are triggered by the increased dense water flux.

1703040 Canada's Three Oceans: Evolving Science in the Arctic, Atlantic and Pacific Oceans

Modelled Arctic Freshwater Components from Dissolved Barium and ?¹⁸O

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Arctic Ocean freshwater is both affected by and affects climate. To predict future freshwater variations we need to tease apart the different components of the freshwater in the Arctic. Dissolved barium and the oxygen isotope ratio of water are water mass tracers that provide information on river runoff and sea-ice melt, respectively. In this research, an off-line tracer model was developed and driven with a three-dimensional coupled ocean-ice model of the Arctic Ocean. The simulation results show reasonable tracer climatology and seasonal cycles, and agree well with field observations. This model was applied to investigate the atmospheric drivers of freshwater variability in the upper 130 m of the water column through linear trend and Empirical Orthogonal Function analysis. We will discuss the impact of the Arctic Oscillation, the dipole anomaly, the North Atlantic Oscillation and the strength of the Beaufort High. As an example, we will present the sequential seasonal anomalies that led to the very high freshwater content of the Beaufort Gyre in 2007 and show where the freshwater originated.

1703050 Strategies for Arctic Ocean Observing

Real-time ocean/ice observations from the Northwest Passage: Past successes and recent developments

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The DFO Real-Time Arctic Observatory operated in Barrow Strait between 2011 and 2016, returning measurements of currents and water properties every two hours throughout the year. The combination of a cabled ""hub"" station and acoustically-connected ""nodes"" allows for maximum measurement flexibility and minimizes deployment logistics. The under-ice measurements of temperature and salinity have led to regression models for the prediction of freeze- and break-up, a valuable tool in the Northwest Passage particularly as increased shipping becomes a concern. New plans for re-deploying the system in summer 2017 have afforded the opportunity to expand the sensor suite to include ice draft measurements, and a local test location in the Strait of Canso is being used to demonstrate the new functionality. In this talk we will give an overview of the Arctic Observatory system, past results, and future plans.

1703050 Strategies for Arctic Ocean Observing

ROV SUPPORT TO ARCTIC OCEAN CABLED OBSERVATORIES

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The Canadian Scientific Submersible Facility is a national not-for-profit corporation established in 1995 by academics to operate Remotely Operated Vehicles (ROVs).
Since its inception, CSSF has made it possible for ocean scientists to conduct research on the ecology of hydrothermal vents, sponge reefs and cold-water corals, and the geochemistry and economic potential of sulphide mineral and gas hydrate deposits, and to perform pioneering work on cabled deep-sea observatories. For over two decades, CSSF has provided Canadian and international scientists with a state-of-the-art ROV intervention capabilities to conduct science and engineering in the submarine environment at a realistic cost.

The history of the CSSF flagship ROV the Remotely Operated Platform for Ocean Sciences (ROPOS) will be reviewed. It is the product of over 25 years of collaboration with world leading ocean scientists, engineers, and students who continue to push its limits through innovative and ambitious projects. From deep-sea hydrothermal vent exploration to the deployment and maintenance of ocean observatories, ROPOS has become known as the world's most capable scientific submersible for its capabilities, versatility, efficiency, and the skill and professionalism of its operators.

Additionally, CSSF has also built up years of experience operating the Arcticnet Super Mohawk (SUMO) ROV in the CCGS AMUNDSENSUM. Highlights from these Arctic missions will be reviewed.

The work to date of CSSF and ROPOS since the beginning of ocean observatories, as a key partner in the development, installation, and maintenance of the world's leading cabled ocean observatories will then be reviewed. This will include the development of unparalleled technology, experience, and efficiency in the installation and maintenance of observatory systems from primary nodes to delicate instruments. Highlights will include the safe and precise placement and recovery of instruments and multi-instrumented "platforms" from the seafloor, with substantial through-frame lift and meter accuracy subsea navigation capacities. The ROPOS team also develops and designs custom instruments for scientists allowing them to achieve their objectives of creating a lab on the seafloor. Interventions supporting geology, biology, ocean chemistry, acoustic data, video or still photo mosaics, are some of the disciplines ROPOS has executed at the highest level.

Building and maintaining a cabled ocean observatory in Baffin Bay will be a huge challenge. Large semidiurnal tides with high current speeds with rapidly changing directions are common; resulting in the collision and crushing of fresh, old, and pack sea ice. Even in the summer, winds and associated sea states can intensify quickly, and weather forecasts are much less reliable than those at mid latitudes. With ship time at a premium, the ability to safely launch and recover in higher sea states is critical. ROPOS has long experience operating in sea states that shut down other ROV systems.

1703050 Strategies for Arctic Ocean Observing

Ocean Networks Canada - Cabled Observatories and Community Monitoring in Canada's Arctic

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Ocean Networks Canada (ONC) has developed world-leading expertise in the deployment and operation of cabled ocean observatories, the archiving and delivery of ocean Big Data, the support of ocean observatory research, and community-based outreach and ocean literacy initiatives.

The Cambridge Bay Observatory (CBO) Instrument Platform was first deployed in September of 2012 and has since been recovered, serviced, upgraded, and re-deployed every consecutive summer. The CBO permits continuous, high resolution monitoring of the coastal Arctic, providing unprecedented insight into environmental events and longer-term trends. The observatory's growing, high-resolution data time series is supporting process-oriented and long- term studies of oceanographic processes in Cambridge Bay that range from the direct observation of benthic ecosystems responses to seasonal events, to the modeling of current and future sea ice dynamics. CBO has become an arctic test bed for Canadian instrument manufacturers and continues to support secondary and post-secondary learning opportunities. More recently, Cambridge Bay residents have been participating directly in the research success of the observatory by collecting critical, winter-time data on snow depth and ice thickness. These successes have helped to inspire and guide the implementation of ONC's "Smart Oceans" BC program which includes infrastructure for marine safety, public safety, environmental protection, and science-based decision making. Furthermore, ONC's "Community Fishers" mobile application was developed in collaboration with DFO's arctic "CROW" program and has been allowing remote communities along the BC Coast, which are part of the Pacific Salmon Foundation's "Citizen Science" Project, to transmit data directly back to ONC's data management system. The app is now ready more than ever to help serve monitoring efforts in Canada's North.

This presentation will showcase ONC's current monitoring solutions and discuss how they can best be implemented as part of a larger integrated network of monitoring techniques and initiatives across the Canadian Arctic.

1703050 Strategies for Arctic Ocean Observing
Spatial Variability of Sea Ice Velocity in the Continental Margin of the Canadian Beaufort Sea from a Dense Array of Moored Upward Looking Sonar Instruments
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An array of 7-8 upward looking sonar (ULS) operating from subsurface moorings provided accurate (± 0.015 m/s) and continuous measurements of ice velocity during two full years: 2009-2011 using Acoustic Doppler Current Profiler instruments with the "bottom track" mode enabled. Very high resolution measurements of sea ice draft (proportional to thickness) were also continuously measured to an accuracy of ± 0.1 m at 1-2 m horizontal spacing. The moorings were placed in water between 70 and 1010 m depth on the shelf and continental slope of the Canadian Beaufort Sea thereby spanning several topographic regimes between the middle slope and the middle shelf. The separation of moorings ranged between 4 and more than 100 km. Large seasonal variations were noted for all locations with the largest velocities occurring in the late summer to fall and smallest velocities from mid-winter to early spring. The ice speeds were generally larger for the deep offshore sites than for the shallower inner slope and outer shelf region. At weather-related synoptic time scales, the spatial correlations of ice velocity were generally high although differences are noted for specific events.
Of particular interest are episodes of very slow motion events which are often associated with the development of internal stress in the ice pack, which impedes the response of wind-driven ice motion. Generally, the very low motion ice episodes occur more frequently in reduced water depths.
These very slow motion ice speed episodes are known to occur more frequently under convergent wind forcing patterns when the ice velocity has a shoreward component. Their prevalence during the two winters of study was similar, with no-motion events occurring even in early winter at mid-shelf locations but present later at more offshore locations. The zero motion events were most common in both areas in February and March. There are notable differences in the timing and location of the slow-motion ice speed episodes between the two years and with location. A more general spatial correlation analysis of ice velocities reveals that ice velocities have a higher degree of spatial variability than is the case for ice drafts over the extended study area.

1703060 General Session - Oceans
Biogeochemical Argo – an extension of the Argo array
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Biogeochemical-Argo (BGC-Argo) is the extension of the core Argo array of profiling floats (measuring ocean temperature and salinity) to include floats that are equipped with biogeochemical sensors for pH, oxygen, nitrate, chlorophyll, suspended particles, and downwelling irradiance. Newly developed sensors now allow profiling floats to also observe biogeochemical properties with sufficient accuracy for climate studies. This extension of Argo will enable an observing system that can determine the seasonal to decadal-scale variability in biological productivity, nutrient supply, ocean acidification, hypoxia, and ocean uptake of CO_2. BGC-Argo has the potential to transform our ability to observe and predict the effects of climate change on ocean metabolism, carbon uptake, and living marine resource management. We will present a summary of a Canadian BGC-Argo workshop held in January 2017.

1703060 General Session - Oceans

Operational Wave Prediction System at Environment and Climate Change Canada: Going Global to Improve Regional Forecast Skill

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A global deterministic wave prediction system (GDWPS) was implemented in June 2015 in order to improve regional forecasts of waves off the Canadian coastline and help support the practice of safe marine activities in Canadian waters. The wave model has a grid spacing of 1/4 degree with spectral resolution of 36 frequency bins and 36 directional bins. The wave model is driven with hourly 10-m winds generated by the operational global atmospheric prediction system. Ice conditions are updated every three hours using the ice concentration forecasts generated by the global ice-ocean prediction system. The wave forecasts are evaluated over two periods: 15 August 2014 to 1 November 2014, and 15 December 2014 to 1 March 2015, and over select cases from the fall of 2012. The GDWPS is shown to result in gains of at least 12 hours of lead time. It is also shown to improve wave forecast skill over regions where operational forecasts were previously produced using limited area models only. The usefulness of the expansion to a global domain is demonstrated for large swell events affecting the north-east Pacific. The first validation of a Canadian operational wave forecast system in the Arctic is presented. Improvements in the representation of forecast wave fields associated with tropical cyclones is also demonstrated.

1703060 General Session - Oceans

Great Lakes Wave Prediction Systems: Offering Guidance over Lead Times of Hours to Three Days drawing from Locally Refined Forecasts to Lakes wide Ensemble Forecasts.

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In 2015 Toronto hosted the Pan American and Parapan American Games, which included on-lake events such as sailing. The operational Great Lakes prediction system available for wave guidance had not been updated for several years. In light of the upcoming games, the development and implementation of improved marine forecasts was deemed a priority. An important aspect of this improvement is the capacity to provide earlier warning of significant events. The primary objective of this study was thus to develop a wave forecast suite to increase the forecast lead time, provide better guidance from hours to days, and provide a realistic estimate of forecast uncertainty. The resulting deterministic (250 m and 1 km grid spacing) and 21 member ensemble (2.5 km grid spacing) Great Lakes prediction system is described. Results of their validation since their experimental implementation in June 2015 are presented, and selected cases are discussed. Methods of visualizing the results and addressing forecast uncertainty using the ensemble wave forecast are proposed.

1703060 General Session - Oceans

Advancing oceanographic habitat ecology with in-situ remote-sensing from autonomous gliders

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The proliferation of mobile autonomous profiling gliders as ocean observing systems worldwide provides opportunity to gain new insight into marine animal-habitat relationships. Mobile gliders can be equipped with a variety of sensors to monitor both animals and the features of their underwater habitat; including passive acoustic monitoring devices that record whale and fish sounds, water mass sensors to monitor physical oceanographic habitat features that indicate areas of high biomass, and echosounders to obtain acoustic biomass estimates. The goal of this study was to use gliders and their sensors to characterize spatiotemporal variability in the ecology of migratory whales across variable oceanographic conditions on the Scotian Shelf, Canada. The study found that the distributions of different baleen whale species, whose presence was derived from glider passive acoustic monitoring, were associated with different oceanographic and bathymetric features that were variable in time and space. For example, endangered right whales were found in colder coastal waters, while fin and sei whales were found in deep basins and along sloped bathymetry. Species that are thought to share more similar feeding niches were not always associated with the same habitat conditions, suggesting there is much still to learn about whales and their oceanographic habitat use. Acoustic monitoring of whales was masked at times by the presence of ambient noise from vessels and other sound sources. The challenges of using gliders to address whale-habitat associations across various scales is discussed.

1703060 General Session - Oceans

VITALS - Ventilation, Interactions and Transports Across the Labrador Sea

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The VITALS (Ventilation, Interactions and Transports Across the Labrador Sea) research network is a funded NSERC CCAR project that has now been ongoing for 4 years. Our goal is to answer fundamental questions about how the deep ocean exchanges carbon dioxide, oxygen, and heat with the atmosphere through the Labrador Sea. Our working hypothesis is that deep convection in the Labrador Sea, which allows for exchange of oxygen and natural and anthropogenic carbon to the deep ocean, is sensitive to the warming that is taking place at high latitudes. Validating and quantifying this sensitivity is central to our research network and also the broader community of climate change researchers and policy makers interested in characterizing, and possibly minimizing, the effects of global climate change. New observations, including biogeochemical, will include those collected from a SeaCycler moored in the interior of the Labrador Sea, additional moorings, gliders and floats as well as ship-board measurements and remote sensing). Combined with numerical modelling at a variety of scales and resolutions, we will determine what controls these exchanges and how they interact with varying climate, in order to resolve the role of deep convection regions in the Carbon Cyle and Earth System. VITALs is a pan-Canadian initiative involving scientists from 11 Canadian universities as well as multiple federal government laboratories (Fisheries and Oceans Canada, as

well as Environment Canada), industrial and foreign partners. This presentation will provide an update on the status of the project, as well as highlight some of the more interesting preliminary findings.

1704010 Climate Change Resiliency
Updating CWEEDS Weather Files used for Building and Solar Energy System Simulation and Design
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CWEEDS (Canadian Weather Energy and Engineering Data Sets) are long-term (at least 10 years) hourly weather files comprising elements such as temperature, humidity, wind and solar irradiance for simulation and design of building and solar energy systems. Their corresponding TMY (typical meteorological year) CWEC (Canadian Weather year for Energy Calculations) files are a condensed and standardized one-year file most commonly used for this purpose. The set of files made publicly available by Environment Canada includes data up to 2006 for 244 (CWEEDS) and 80 (CWEC) Canadian locations. A recent project updated and expanded these files resulting in CWEEDS and CWEC files for 492 locations with at least 10 complete years from the period 1998-2014.
This presentation describes the procedures used to update these data sets and their characteristics. Previous versions were based on observational data from weather stations supplemented at most locations by estimates of solar irradiance from a cloud layer-based model since solar observations are sparse (especially in the recent decade or so). Changes in network observing programs and advances in processing remotely sensed and reanalysis data sets have resulted in differences in the updated files. For instance, for locations south of 58N, the solar fields are based on GOES satellite-derived hourly solar irradiance values using a model developed and implemented at SUNY (State University of New York). Also, gaps in the observational data are filled with times series data from reanalysis and other gridded data sets. Other informational products were also generated including solar irradiance maps, new TMY files based only on direct normal solar irradiance for simulation of concentrating solar energy systems, and "first estimate" CWEEDS files comprised of SUNY solar data merged with reanalysis time series for all SUNY grid points over land in Canada. Finally, implications of a changing climate are discussed.

1704010 Climate Change Resiliency
Impacts of Climate Change on Building Envelope Energy Efficiency
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Current energy efficiency requirements for new buildings reference historic climate data, and a building designed to those requirements may lose energy efficiency as local temperatures rise due to climate change. Well-intended efforts to improve building energy efficiency as a means to reduce energy use and greenhouse gas (GHG) emissions may not yield the expected results if future projected climate data is not considered during the building design phase. Using statistical methods and publicly available global climate models to generate projected regional climate data for New York and Toronto in 2050, the energy use and GHG emissions of various building types in current and future projected climates were simulated using whole building energy modeling software.
Statistical methods of generating future projected regional climate data were compared with high resolution regional weather modeling to understand the advantages and disadvantages of using each method, and determine if more accurate publicly available climate data is required to inform building designers' decisions. A sensitivity analysis was done for different building envelope energy efficiency parameters; including thermal transmittance, solar heat gain coefficient, window to wall ratio and air tightness; to find the most effective ways to counteract efficiency losses resulting from climate change. The results of the energy

modeling and sensitivity analysis can guide design decisions that maintain building envelope energy efficiency as the climate changes over a building's life cycle.

1704010 Climate Change Resiliency
Establishing a Climate Change Resiliency Assessment Framework for Buildings
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While mitigation efforts are being undertaken to slow climate change, some adverse impacts are now unavoidable and this makes resiliency strategies an essential component of our collective response to climate change. Recognizing this, the City of Toronto added a Climate Change and Building Resiliency Assessment component to their Building Condition Assessment procedure. These resiliency assessments identify building components that are most at risk of failure, damage and/or deterioration from severe weather events, and make recommendations on what actions may be necessary to appropriately respond to current and future climate risks.
By conducting over 60 resiliency assessments to date, RWDI has been able to apply lessons learned to incrementally improve their resiliency assessment framework and methodology. However, several other resiliency assessment frameworks have also become available in recent months, and which of these frameworks will gain traction as the preferred standard for conducting resiliency assessments on buildings in North America is yet to be determined.
This paper will identify the best attributes from each of these frameworks to establish a formal protocol that fits within the context of buildings, that allows practitioners to more accurately and consistently quantify climate risks, and that helps practitioners identify priority and actionable recommendations that building designers and owners can implement to reduce risks.

1704010 Climate Change Resiliency
Climate Data for Building Design: Advances in Understanding and Future Needs
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Climate data has been used for many years in the design of buildings and infrastructure. Parameters such as wind speeds and directionality have obvious use for wind load calculations, however other parameters such as precipitation rates, diurnal temperature cycles and cloud cover are also important. Sometimes the data is used in raw format, and other times it is filtered by recognized authorities to make it easier to use.
The measured historical meteorological data that has been used by the design community is under pressure - this is a result of internal and external factors. For example, the need to drive building energy demand down means that climate data needs to be 'more local' to the building site. The use of Toronto data for a building in Barrie can lead to the wrong decision. Also climate change means that the historical norms are changing and future buildings need to respond to weather that has not been measured yet.
This presentation will present a history of the use of climate data in building design and make predictions for its future use. Through a series of short examples, the importance of quality data will be presented along with examples where poor data results in different design decisions. This historical review will cover a variety of climate parameters. We will then discuss the pressures facing the design community. Examples exploring the use of advanced climate modelling will be presented that show means by which the meteorological community can assist in the design of better and more resilient buildings and infrastructure.

1704010 Climate Change Resiliency
Application of Temperature to Augment Precipitation Projections in Ontario
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As Ontario's climate changes, it is important to quantify the potential impact on infrastructure. A recent Ontario Ministry of Transportation (MTO) project quantified small upward trends of approximately 1% per decade in the distribution of rainfall intensity for Ontario locations between 1960 and 2010. While the identification of historic trends helped refine current extremes, the extrapolation of these trends allowed for preliminary estimates of future Intensity-Duration-Frequency (IDF) curve parameters in the MTO's IDF curve lookup tool.
Subsequent research, sponsored by Ontario's Ministry of the Environment and Climate Change (MOECC) with MTO support, went beyond the preliminary extrapolation estimates. The research also explores a possible improvement for precipitation estimates. The MOECC research focused on the correlation between historical temperature and precipitation. Where earlier phases of the research were time-dependant, the MOECC project uses temperature as a covariate. This allows for the incorporation of temperature projections from different GCMs and their climate change scenarios, such as the Pacific Climate Impacts Consortium (PCIC) issued MPI-ESM-LR-r3 RCP2.6. The MOECC research uses the historic temperatures in the climate change scenarios, correlates them with historic precipitation records, and creates advanced probabilistic extreme rainfall projections for the climate change scenarios. This flexibility reflects the uncertainty in future climatic characteristics, and allows engineers and planners to identify the range of scenarios which are most appropriate for their needs. The results of the MOECC research are compared to historical rainfall data and other projections of extreme precipitation to determine the viability of the techniques. The research develops and tests a new technique for the establishment of extreme rainfall projections.

1704020 Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 1
High-resolution dynamical downscaling of precipitation and temperature over western Canada by Pseudo-Global Warming method using WRF model
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One of the fundamental challenges in climate science is the scale mismatch between climate information provided by Earth System Models (ESMs) and the needs of impact researchers, stakeholders, and policy makers who often desire high resolution outputs at finer regional to local scales than simulated by ESMs. This demand is especially evident for assessing the occurrence of weather and climate extremes for various purposes (e.g. water resources and infrastructure planning), as these are often caused by sub-grid scale processes (e.g. deep convection, orography fields, extreme events) typically not resolved by the current generation of ESMs which still operate at horizontal grid spacing larger than 50?km. Regional climate modelling using convection-permitting models (CPMs; horizontal grid spacing <= 4?km) has emerged as a promising framework to provide more reliable climate information on regional to local scales compared to traditionally used large-scale ESMs. CPMs no longer rely on convection parameterization schemes, which had been identified as a major source of errors and uncertainties in ESMs. Results from a pseudo-global warming (PGW) high resolution simulation (that permits convection and resolves mesoscale orography at 4-km horizontal grid spacing) of future changes in precipitation and temperature characteristics over much of western Canada using the Weather Research and Forecasting (WRF) model are presented in this study. Two 13-year simulations were made, consisting of a baseline (October 2000–September 2013) with initial and

boundary conditions from ERA-interim and a future climate sensitivity simulation with modified reanalysis-derived initial and boundary conditions through adding the CMIP5 ensemble-mean RCP8.5 emission scenario. The PGW simulation forced with high green-house gas perturbed boundary conditions enhances summer, fall, winter, and spring seasonal precipitation climatology and extremes over all of western Canada. Seasonal mean temperatures and extremes are also found to increase with global warming. This study should enable more informed application of high-resolution ESMs for the investigation of current and future changes in many applications of climate change, including impacts on surface hydrology, water resources, and ecosystems over this topographically complex region of western Canada.

1704020 Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 1

The diurnal cycle of summertime precipitation over Alberta using a convection-permitting model

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Simulation of mesoscale processes that modulate convective precipitation has been rapidly improving in regional climate models. This capacity allows us to better understand and predict severe precipitation events. The convective-permitting models has been a great step forward on this, however they are only recently been running in continental scale to better evaluate their benefits and drawbacks.
In this work we analyzed how accurate the simulation of diurnal cycle of summer precipitation over North America. The simulaton was performed using the Weather and Forecast Research (WRF) regional climate model in a convection permitting scale (4 km horizontal grid spacing). The analysis includes a historical run from 2001 to 2011, and a pseudo global warming simulation using a future ensemble projection (RCP8.5) equivalent to 2071-2100.
The phase and the amplitude of the first harmonic (diurnal cycle) are adequately simulated. The main error is evidenced on the later stage of the eastern propagating summer rainstorms (in the US Midwest). The potential warmer climate increases the frequency and decreases the intensity of the storms throughout the domain. In Alberta the amplitude of the storms are greatly increased in early summer.

1704020 Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 1

Very high-resolution (1-km) dynamical downscaling of continental scale 4-km WRF regional climate simulation and its evaluation in Central U.S.

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Very high spatial and temporal resolution regional simulations are required to provide information for local hydrology and agriculture study. Two sets of dynamical downscaling have been performed upon the 13-year continental scale 4-km WRF (CONUS) simulation, focusing on the central U.S. corn-belt in an extraordinary heat wave in the summer of 2006. The ""ndown"" technique is applied in these two seasonal simulations with the initial and boundary condition created from the CONUS run. The first simulation is considered as a control run with the exact same model configuration as that of the CONUS run except the spatial resolution changed from 4-km to 1-km. The land surface module is modified in the second simulation (Z0H) which is to balance the obvious warm bias occurred in the central U.S. The precipitation and temperature were evaluated for both 1-km simulations and the original 4-km CONUS simulation against gridded observation data PRISM and station data METAR. Compared to PRISM gridded data, the monthly mean temperature of the 4-km CONUS run is within 2 degrees C bias from April to June. However, the bias is greatly amplified over the entire domain in July. The situation for the 1-km control run is the same with the warm bias initiated even earlier in May. While the modified land surface Z0H 1-km simulation shows some cold bias from April to

June, but less warm bias as seen in the previous control simulation and the original CONUS simulation in July. The two 1-km simulations show more precipitation in April and May while less precipitation in June and July, with the 1-km Z0H simulation also produces better precipitation pattern than that of the 4-km CONUS simulation. When compared to METAR station observation, the two 1-km simulations show reasonable daily minimum temperature but overestimate the daily maximum temperature. The heat wave happened in mid-July was analyzed. It shows that the downscaled simulations underestimate precipitation, therefore amplify the extreme heat event. These two simulations are good examples for further high-resolution model study and inspire modification in land surface scheme for long term regional climate simulation.

1704020 Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 1

The representation of extreme orographic precipitation events in an intermediate complexity atmospheric model

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Accurate projection of future hydro-climatic extremes is critically important for flood assessments, water management, and infrastructure design. Such information can inform the construction of infrastructure ranging from dam spillway size to roof load-bearing capacity. However, the most extreme events, particularly in the mountains, are not well represented in current climate models due to their low-resolution spatial and consequently smoothed representation of mountain topography. As a result, end users turn to spatially downscaled data sets that have had the first order biases removed using either statistical methods, or complex regional climate models. Statistical methods rely on having an accurate knowledge of those extremes in current climate, and assume a stationary statistical relationship between those extremes and a few atmospheric variables. In contrast, regional climate models do not require knowledge of the current climate extreme events, nor do they impose strong stationarity assumptions; however, the computational cost of such models exceeds the available computing capacity, at least for high spatial resolutions (~6 km), long time periods (~100 years), and large numbers of ensembles (~20-100 members). We have developed the Intermediate Complexity Atmospheric Research model (ICAR) to enable a quasi-dynamical downscaling that satisfies both the computational and data resolution requirements without the reliance on statistical relationships. Here we analyze the changes in extreme orographic precipitation events using ICAR to downscale 35 ensemble members from the Community Earth System Model's Large Ensemble project. These changes are compared to the changes projected for 6 of these same ensemble members simulated using a state-of-the-art regional climate model, the Weather Research and Forecasting model (WRF), over a small spatial domain.

1704021 Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 2

Probabilistic Projections of Regional Climatic Changes Through an Ensemble Modeling Approach

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Planning of adaptation strategies against the changing climate requires a thorough assessment of the potential impacts of climate change at local scales. However, climate change impact assessment is usually subject to a number of challenges, such as the lack of high-resolution climate scenarios and the uncertainty in climate model projections, which may pose barriers to impact researchers and decision makers. To tackle these challenges, we will develop high-resolution regional climate scenarios using multiple regional climate models (e.g., PRECIS, WRF, and RegCM) driven by different global climate models (e.g., HadGEM2-ES, CanESM2, GFDL-ESM2M, and CCSM4) under RCP4.5 and RCP8.5 scenarios. A Bayesian hierarchical model will be proposed to help quantify the uncertainties associated with the regional climate ensemble simulations. Results on model evaluation and probabilistic projections of temperature and precipitation changes over Ontario, Canada will be analyzed and presented. The probabilistic projections can provide useful information for assessing the risks and costs associated with climatic changes at regional and local scales.

1704021 Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 2

Evaluation of the added value of high resolution in the Canadian Regional Climate Model for freezing rain

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Freezing rain is listed as one of the most important hazard occurring during the winter season. Major events endanger the aviation and transport industries and can cause significant damage to infrastructure and power networks. A better simulation of freezing rain events would definitely help in our adaptation to future climate. Several studies on the added value of high resolution as already concluded that global climate models (GCMs) are too coarse to predict and assess past, present and future freezing rain events. The used of regional climate models (RCMs) at higher resolution should be, however, considerate. The goal of this study is to determine the gain of using higher resolution for the simulation of freezing rain using the fifth version of the Canadian Regional Climate Model (CRCM5). The method used to diagnose the type of precipitation is Bourgouin (2000). To address this issue, three CRCM5 simulations driven by ERA-interim reanalysis over Eastern North-America at 0.44°, 0.22° and 0.11° are used. They were conducted over a 35 year period, from 1980 to 2014. In addition to a climatology study, freezing rain seasonal average accumulation and median annual hours will be investigated. We will also evaluate the ability of the three simulations to reproduce individual freezing rain events. Our analysis includes frequency, partition of different precipitation type and comparison with observations. The results point out that the simulations reproduced well the climatology of freezing rain and can identified important past event. The evolution of precipitation types during these events, however, seemed to be better replicated by the 0.22° and 0.11° simulations. The needs of higher resolution to simulate freezing rain climatology with the CRCM5 will be discussed.

1704021 Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 2

Multivariate quantile mapping bias correction: An N-dimensional probability density function transform for climate model simulations of multiple variables

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Most bias correction algorithms used in climate downscaling, for example quantile mapping methods, are applied to univariate time series. They neglect the dependence between different variables. Those that are multivariate often correct only limited measures of joint dependence, such as Pearson or Spearman rank correlation. Here, an image processing technique designed to transfer colour information from one image to another – the N-dimensional probability density function transform – is adapted for use as a multivariate bias correction algorithm (MBCn) for climate model projections/predictions of multiple climate variables. MBCn is a multivariate generalization of quantile mapping that transfers all aspects of an observed continuous multivariate distribution to the corresponding multivariate distribution of variables from a climate model. When applied to climate model projections, changes in quantiles of each variable between the historical and projection period are also preserved. The MBCn algorithm is demonstrated on three case studies. First, the method is applied to an image processing example with characteristics that mimic a climate projection

problem. Second, MBCn is used to correct a suite of 3-hourly surface meteorological variables from the Canadian Centre for Climate Modelling and Analysis Regional Climate Model (CanRCM4) across a North American domain. Components of the Canadian Forest Fire Weather Index (FWI) System, a complicated set of multivariate indices that characterizes the risk of wildfire, are then calculated and verified against observed values. Third, MBCn is used to correct biases in the spatial dependence structure of CanRCM4 precipitation fields. Results are compared against a univariate quantile mapping algorithm, which neglects the dependence between variables, and two multivariate bias correction algorithms, each of which corrects a different form of inter-variable correlation structure. MBCn outperforms these alternatives, often by a large margin, particularly for annual maxima of the FWI distribution and spatiotemporal autocorrelation of precipitation fields.

1704021 Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 2

A 50-member ensemble from a regional climate model at 12-km resolution to address local impacts from natural variability and extreme events under climate change

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Over the last years, large initial conditions ensembles using a single Global Climate Model (GCM) became increasingly popular for studying impacts from natural variability, extreme events and climate change. Due to the high computational cost involved for producing these ensembles, such rare opportunities are generally characterized by coarse grid resolutions, which make them inadequate for direct use in most real-world impact studies. Large ensembles using a high-resolution Regional Climate Model (RCM) instead of a GCM are even less common because a GCM large ensemble purposely designed to serve as boundary conditions to an RCM is required. The ClimEx project (www.climex-project.org), a Québec-Bavaria collaboration, investigates the dynamics and effects of climate change on hydrometeorological extreme events and their implications for water management. It consists of an unprecedented framework for studying the effect of natural climate variability, extreme events and climate change on local hydrological impacts by providing a large ensemble of high resolution RCM simulations as an input to the hydrological modeling chain. The Canadian Regional Climate Model (CRCM5) Large Ensemble (CRCM5-LE) consists of a dynamically downscaled high-resolution (~12 km) version of a coarse-resolution (~280 km) 50-member ensemble produced with the Canadian Earth System Model (CanESM2). In the CanESM2 large ensemble, slight differences were applied to the GCM's initial conditions to trigger internal climate variability. It was downscaled over two regions of interest, Europe and Eastern North America, and covers the period from 1955 to 2100 under forcing from the RCP8.5 scenario of greenhouse gases emissions. Here we provide an overview of the CRCM5-LE, including the validation with observational reference data and comparison with other ensembles. Some applications of the ensemble will also be discussed, and first findings from the application of CRCM5-LE as an input to the hydrological modeling chain will be presented.

1704021 Hydro-meteorological extremes in a changing climate: improved tools for downscaling - Part 2

The Added Value of Convection-permitting Simulations for Dynamically Downscaling Precipitation Extremes

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Changes in precipitation extremes are a major research topic and of great interest to policy makers. In order to bring coarse-resolution climate projections from GCMs down to a scale relevant for impact assessment, statistical and dynamical downscaling techniques have been developed. Statistical techniques, however, rely on the assumption of stationarity in some aspects of the climate. In this presentation areas are highlighted in which very high resolution dynamical downscaling can add value to climate projections and were statistical methods may suffice.
Dynamically downscaled climate projections are presented utilizing the WRF model with different physics configurations and initial/boundary conditions and ranging in resolution down to 3km. Downscaling was performed over western Canada, which is characterized by a highly heterogeneous climate and complex topography. Extreme value theory is employed for this analysis in conjunction with a novel approach to pooling data from climatologically similar locations, in order to facilitate the statistical analysis.
Comparison against historical station observations reveals that precipitation extremes are consistently underestimated at all scales. Nevertheless, during the cold season the statistical distribution of precipitation extremes is clearly better reproduced at higher resolution. However, the climate change response during the cold season appears to be relatively insensitive to resolution and model configuration.
The opposite is the case for summer precipitation extremes: compared to historical observations the added value of higher resolution is small, even at convection-permitting scales. However, it is demonstrated that the convective scheme represents a major uncertainty in climate projections, which can be reduced through the use of convection-permitting climate simulations. It is further shown that a relative increase in convective precipitation over stratiform precipitation causes a change in the distribution of summer precipitation extremes that may not be captured by statistical downscaling methods.

1704030 The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation

Observationally-constrained carbon budgets consistent with 1.5°C warming

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Carbon budgets consistent with remaining below 1.5 °C global warming reported in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5), are directly based on responses from comprehensive Earth System Models (CMIP5), which, on average, tend to warm more than observations for the current amount of carbon emitted. These models indicate a median remaining 1.5 °C carbon budget in 2015 of 69 PgC, which can be compared with annual emissions of 10.6 PgC/yr in 2015. Models that warm too strongly in response to historical CO2 emissions might also be expected to warm too strongly in response to future CO2 emissions. Here, we screen available CMIP5 models based on whether or not they simulate consistent fossil fuel emissions with those which have occurred for the observed level of present warming. The 1.5 °C carbon budgets based on the CMIP5 models which are consistent with observations, show a higher median remaining carbon budget than those based on all available models. Thus, while limiting median projected global warming to below 1.5 °C is undoubtedly challenging, our results indicate it is not impossible as might be inferred from the IPCC carbon budgets.

1704030 The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation

Effect of carbon-cycle uncertainty on estimates of the 1.5 °C carbon budget

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In December 2015, the participants of the COP21 agreed to pursue efforts to limit global temperature increase to 1.5 ºC relative to the preindustrial level. It is therefore important to provide robust estimates of the total allowable emissions that would be consistent with the temperature goal. The concept of a linear relationship between cumulative carbon emissions and global mean temperature increase enables us to give an estimate of the remaining future carbon budget for the 1.5 °C temperature target. These estimates, however, depend on Earth system models and need to account for inherent model uncertainty. Here, we quantify the effect of carbon cycle uncertainty using an intermediate complexity Earth system model to simulate a parameter perturbation ensemble focussed on uncertain land and ocean carbon cycle parameters. We use a Bayesian inversion approach to estimate the likelihood of the model results given observational constraints, so as to estimate a probability density function of allowable future carbon emissions given a prescribed guardrail of a 1.5 ºC at the year 2100. This will provide important probabilistic insight into the likelihood that a given carbon budget will succeed in maintaining temperatures below 1.5 °C given fundamental uncertainties in the carbon cycle response to CO2 emissions and climate changes.

1704030 The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation

The impact of anthropogenic aerosol emission reductions on achieving the 1.5-degree target

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The goal of the Paris agreement is “holding the increase in the global average temperature to well below 2?°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5?°C above pre-industrial levels”. It is necessary to quickly reduce carbon dioxide (CO2) emissions to zero to achieve these ambitious temperature goals. However, non-CO2 emissions should also be taken into account when assessing the allowable carbon emissions.

Here, we studied the role of aerosols emission reductions affect limiting the temperature increase to 1.5 °C by the end of the century under different future scenarios of anthropogenic aerosol emissions. We used climate-carbon-cycle model MAGICC and a combination of aerosol-climate model ECHAM-HAMMOZ and the University of Victoria Earth System Climate Model (UVic ESCM) to simulate two different greenhouse gas (GHG) emission scenarios: The RCP2.6 and a CO2 reduction leading to a 1.5 °C increase in global mean temperature (T1.5). Each GHG emission scenario included two alternative aerosol emission control cases denoted with CLE (current legislation) and MFR (maximum feasible reduction).

The main result is that the stronger the aerosol emission reduction was, the more significant was the temperature increase by 2100 relative to pre-industrial, making it harder to limit the warming below 1.5°C. According to preliminary results, the temperature differences between aerosol emission scenarios were larger in RCP2.6 than in T1.5. By the end of the 21st century, the differences between aerosol emission pathways were negligible for both GHG emission scenarios. In conclusion, choices on aerosol emission controls affected peak temperatures, but long-term differences were small when comparing only aggressive aerosol mitigation scenarios.

1704030 The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation

Can differences between 1.5 and 2.0°C of global warming be detected locally?

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The 21st Congress of the Parties in Paris culminated in the call for additional information on the consequences of 1.5 and 2°C of global warming over and above pre-industrial levels. The global and regional impacts of of 1.5 and 2°C are not well quantified given the origin of these targets outside of the climate science community, and the lack of any dedicated scenarios to examine these specific levels of change in recent global climate modelling exercises. Whether the locally realized impacts at 1.5 versus 2°C can be clearly differentiated from each other remains unclear, but would be valuable knowledge for making an informed decision between the two targets. At large averaging scales differences between the targets may be apparent, but at the local and regional scales relevant to policy makers the differences between the two targets could be masked by background internal variability for decades or even centuries. Here I use the large ensemble of 50 historical-Representative Concentration Pathway 8.5 simulations from the Canadian Earth System model to quantify the regional temperature and precipitation impacts of 1.5 and 2°C of global warming. I examine whether significant differences between these two targets are statistically detectable at the regional level, and how many years after stabilization these differences would take to emerge. According to these calculations, differences in temperature would be detectable at the local scale almost everywhere within a few years, but differences in precipitation between the two targets are only significant in a few isolated locations and take decades to centuries to emerge. While it is well known that significant differences do exist between the 1.5 and 2.0°C of global warming for variables such as sea-level, these results illustrate that for other variables of practical interest to policy makers, there may be effectively no significant differences between the two targets.

1704030 The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation

Exploring the reversibility of changes in ocean conditions under net-negative CO2 emissions

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Artificial carbon dioxide removal (CDR) from the atmosphere, also referred to as “negative CO2 emissions”, has been proposed as a measure of mitigating climate change and restoring the climate system to a state that avoids ‘dangerous’ impacts. Previous studies have demonstrated that the changes in surface air temperature due to anthropogenic CO2 emissions can be reversed through net-negative emissions, while some oceanic properties, for example thermosteric sea level rise, show a delay in their response to net-negative emissions. This research aims to investigate the reversibility of ocean conditions after the implementation of CDR on centennial timescales with a focus on ocean biogeochemical properties. We use RCP2.6 and its extension until year 2300 as the reference scenario and design a set of “overshoot” emission scenarios based on other RCPs. The University of Victoria Earth System Climate Model (UVic ESCM), a climate model of intermediate complexity, is forced with these emission scenarios. We compare the response of select ocean variables (seawater temperature, pH, dissolved oxygen) in the overshoot emission scenarios to that in the reference scenario at the time the same amount of cumulative emissions is achieved. Our results suggest that the overshoot and subsequent return to a reference CO2 cumulative emissions level would leave substantial impacts on the marine environment. Although the changes in global average sea surface variables (temperature, pH and dissolved oxygen) are largely reversible, global mean ocean temperature and dissolved oxygen differ significantly from those in the reference scenario. Large ocean areas exhibit temperature increase and dissolved oxygen decrease relative to the reference scenario without cumulative CO2 emissions overshoot. Furthermore, our results show that the higher the level of overshoot, the lower the reversibility of changes in the marine environment.

Key words: ocean biogeochemistry, Earth System modeling, negative emissions, cumulative emissions, climate change

1704030 The 1.5-degree Celsius Climate Target: Impacts and Implications for Greenhouse Gas Mitigation

North2Warm: The Impact of 1.5°C or Greater Global Warming on Canada's North

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The United Nations Framework Convention on Climate Change (UNFCC) has invited the Intergovernmental Panel on Climate Change (IPCC) to produce a Special Report to consider the impacts of 1.5°C global warming above pre-industrial levels. The Special Report will cover a range of topics including observed warming and its impacts since the pre-industrial era, climate modelling and projections, observed and projected extreme events, projections of impacts, and risk assessment. Noting that warming in Canada's north has proceeded at more than double the global mean rate (and such amplification is projected to continue), an activity has been convened to focus on the implications of 1.5 degrees Celsius or larger global warming for Canada's North. This activity aims to submit and publish a peer-reviewed paper on this topic that will provide highly relevant reference material for the IPCC Special Report and will provide valuable information to the Canadian public, policy makers, and the research community concerned with this critical topic.

In this talk, we will review the outcomes of a workshop scheduled for March 3, 2017, and follow on work, discussing observed changes, projected changes under different warming scenarios, and impacts and adaptations underway and anticipated, in the context of the 1.5 degree target. We will review the responses to the following questions asked of participants:

1. What does the Paris agreement's 1.5 degree or 2.0 degree target actually mean to you in a practical sense, and for Canada's North and cold regions?
2. In the context of the Paris targets, what adaptation measures are you aware of that are underway or anticipated in Canada's North and cold regions?
3. What metrics or diagnostics of environmental parameters would be most useful for adaptation and planning in Canada's North and cold regions in the context of the Paris targets?

1704040 Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades

Sources of uncertainty and variability in historical trends and future projections of snow cover extent and snow water equivalent

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Measures of the terrestrial cryosphere such as snow cover fraction (SCF) and snow water equivalent (SWE) are challenging to characterize with coarse-resolution gridded data sets due to significant subgrid heterogeneity in snow pack properties and spatial and temporal variability of snowfall. This variability leads to large uncertainties over the long term historical record. This presentation examines recent historical trends in snow-related variables exploiting the use of multiple observation-based data sets. While the climate modeling community has long recognized the strength in using output from a large number of climate models, such an ""ensemble-based"" approach has been less commonly adopted by the observational community. Several examples will be presented where this ensemble-based approach has enabled the detection of outlier SCF and SWE data sets containing spurious trends. Results that summarize the current understanding of how differing physical sources of uncertainty influence our confidence in both historical trends and future projections of terrestrial snow cover and snow mass are also discussed.

1704040 Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades
Simulation of FMCW radar returns over Arctic sea ice
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Current pan-Arctic observations of sea ice by satellite and airborne sensors have indicated a trend towards an ice pack that is younger, thinner, more mobile and that experiences significant inter-annual variability. Our ability to estimate sea ice thickness using altimeters and to derive snow depth using Frequency-Modulated Continuous-Wave (FMCW) radar systems is impacted by the morphology of snow and ice features on the sea ice surface. The effect of these features is to contribute an as yet unquantified uncertainty to radar derived snow depths, sea ice freeboard, and hence ice thickness.
The simulation of radar returns, and the comparison with real radar data, can help us to quantify uncertainty; as the different factors contributing to the uncertainties can be isolated and independently investigated. To develop the radar simulator we make use of a comprehensive set of in situ measurements collected in April 2016 in Eureka Sound, Nunavut by Environment and Climate Change Canada (ECCC), and data from a contemporaneous overflight by the NASA Operation IceBridge (OIB) aircraft. The in situ data will be used to parameterize the scattering properties of the sea ice surface, including the use of novel 2D wavelet techniques on terrestrial lidar data to constrain surface roughness. We will then compare simulated and real OIB snow radar waveforms to validate the simulator; then generate synthetic sea ice surface terrain to test the radar sensitivity to different topographic configurations. By comparing simulated and real radar returns, and through the use of synthetic terrain, the uncertainty relating to snow and ice morphology will be investigated and quantified yielding more accurate estimates of snow depth and sea ice thickness.

1704040 Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades
Reassessing the Role of Sea Ice Drift in Arctic Sea Ice Loss
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Earlier studies have claimed that sea ice drift in climate models is highly unrealistic, and this undermines confidence in model projections of Arctic sea ice loss. Here we show that, when appropriate time sampling is used, Arctic average sea ice drift speed in models and observations agree well with each other. Observations suggest that sea ice drift speed increases as sea ice melts, and 10 of the 22 climate models we analyze exhibit such behaviour when simulating a high emission global warming scenario. This motivates a reassessment of the role of sea ice drift in trends of Arctic sea ice loss. We find that models that exhibit drift acceleration do not systematically exhibit more rapid ice loss. The intermodel spread of ice loss trends is more systematically related to differences in initial climatology of ice volume. However, perturbed initial condition ensembles point to a more systematic influence of internal variability: for a particular model, realizations producing more ice loss also produce more ice drift acceleration. This is demonstrated in three climate models with multiple realizations, including a large ensemble of the Community Earth System Model version 1 (CESM1). Additional analysis of these ensembles shows that the degree of coupling between ice drift and ice volume is systematically related to the rate of ice loss. This gives support to previous claims that sea ice drift acceleration provides a key positive feedback that enhances the rate of Arctic sea ice loss. However, in contrast to assumptions in earlier studies, this drift acceleration feedback does not have any clear relationship to Arctic sea ice export, and it appears to be a dynamic-thermodynamic coupling process that acts mostly within the Arctic basin.

1704040 Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades
Recent Variability and Trends in Arctic Snow and Sea Ice Thickness
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Sea ice and its snow cover are important components of the polar climate system. Due to its high albedo sea ice regulates the Earth's energy budget, reflecting incoming solar radiation. It is also a driver of the global thermohaline circulation and controls the flux of heat and momentum between the atmosphere and polar oceans. As a strong insulator snow, sitting atop sea ice, influences both the growth and, later, the decay of sea ice throughout the year. Routine monitoring of sea ice thickness and snow depth in the Arctic is required for improved sea ice forecasting, to enable Arctic stakeholders to make safe and timely decisions, and to improve our overall understanding of polar climate change.
We present contemporaneous measurements of sea ice thickness obtained from a suite of remote sensing instruments carried on board NASA Operation IceBridge aircraft, and compare these with independent estimates of ice thickness from the CryoSat-2 mission. We discuss the variability in the ice thickness distribution, with respect to ice type, over the last decade. We also describe novel remote-sensing techniques for the retrieval of snow depth on sea ice that provide high-resolution measurements, across basin scales. Snow depths have been validated across a range of ice types and surface morphologies via comparison with measurements collected in situ during targeted field campaigns. We present pan-Arctic snow depth distributions on first- and multi-year sea ice for the period 2009 – 2015. We discuss the implications of our results for current and future monitoring of sea ice thickness from space.

1704040 Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades
Assessment of Canadian Snow and Sea Ice: Trends (1981-2016) and Projections (2020-2050)
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Studies undertaken during the International Polar Year (IPY, 2007-2008) enabled a comprehensive observation-based assessment of the state of the Canadian cryosphere in that epoch in relation to mean conditions and variability across preceding decades. This talk will present highlights from a report that will update the IPY findings to present day and will extrapolate them with climate simulations into the coming decades for snow and sea ice for Canada's North and cold regions, as well as for the pan-Arctic regions. This assessment, which represents Deliverable 2 of the Canadian Sea Ice and Snow Evolution Network, is part of an effort to improve Canada's capacity to predict sea ice, snow, and related climate variability.

1704040 Assessment of Canadian Snow and Sea Ice for the Recent Past and the Coming Decades
Influences of temperature and precipitation on historical and future snowpack variablity over North America in the Fourth-Generation Canadian Regional Climate Model (CanRCM4)
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I will examine the changing roles of temperature and precipitation on snowpack variability in the Second-Generation Canadian Earth System Model (CanESM2) historical and future climate simulations (1951-2050) downscaled with the Fourth-Generation Canadian Regional Climate Model (CanRCM4) over North America. The strength of the linear relationship between monthly snow water equivalent (SWE) in January-April and precipitation (P) or temperature (T) predictors is a sigmoidal function of the mean temperature over the snow season up to the indicated month. For P-predictors, the strength of this linear relationship increases for colder snow seasons, whereas for T-predictors it increases for warmer snow seasons. These behaviours are largely explained by the daily temperature percentiles below freezing during the snow accumulation period. There is

a threshold temperature Tth, approximately equal to -5 degree Celsius and largely independent of time and emission scenario, that represents a crossover point below which snow seasons are sufficiently cold that P is the primary driver of snowpack amounts, and above which T is the primary driver. This isotherm delineates the snow-climate regions and elevation zones in which snow cover amounts are more vulnerable to a warming climate. As climate projections indicate that seasonal isotherms shift northward and toward higher elevations, regions where snowpack amounts are mainly driven by precipitation recede, whereas temperature-sensitive snow covered areas extend to higher latitudes and/or elevations, with resulting impacts on ecosystems and society.

1704050 Extreme climatic and weather events
Case studies of winter storms over eastern Canada in a climate change context
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Winter storms have a major impact on society in many ways, especially in Canada and United States. Damages of those events lead mainly to power outages as well as air and ground transport disruption, but they can also be harmful for forests and sometimes humans. The damages are intimately linked with occurrences of precipitation when the temperature is near 0°C. Knowing that freezing rain can lead to an accumulation of ice on the surface and how difficult it is to forecast, it is imperative to improve the understanding of their formation mechanisms to better anticipate changes in their occurrences in the context of global warming. In this work, we investigate the effect of a warmer climate on a big snowstorm that hit the Montréal area on December 27, 2012 as well as the ice pellets storm in Toronto in December 2004. To do so, we are using continental-scale 4 km convection-permitting WRF simulations performed by Liu et al. (2016) over a 13-year period (2000–2013). They used a pseudo-global warming (PGW) algorithm to emulate a climate projection with the RCP8.5 emission scenario. First, the large-scale conditions of the historical (CTRL) simulation will be investigated and compared with observations. We will mainly look at the accumulated precipitation and pressure fields. Second, temperature, humidity and hydrometeor profiles will be used to study the vertical structure of the atmosphere during the storm. Finally, we will compare this event with the same storm within the PGW experiment. A comparison of the precipitation types, timing, location and characteristics will be investigated. This study constitutes the first of many steps towards a better understanding of the mechanisms leading to winter precipitation types at near 0 °C in the context of a warmer climate.

1704050 Extreme climatic and weather events
Characterizing extreme impact compound events emerging from natural climate variability and their dependence to climate change using a 50-member ensemble of high-resolution simulations
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There is an increasing demand for better assessing the impacts resulting from extreme weather conditions, as well as on how these could be modulated by future climate change. When referring to extremes, one generally means a single meteorological variable (e.g. surface air temperature) being in an extreme state for a certain amount of time in a given location. However, many severe weather conditions are the product of multiple variables under particular states (i.e. not necessarily extremes individually) occurring in a synchronous manner. Heat waves, droughts, floods and other extreme events may lead to highly damaging

impacts in different sectors like human health, agriculture, energy, infrastructure. Here we present a framework for characterizing the impacts from extreme events that are compounds of multiple variables. For example, the Heat Index translates the effect of warm temperature combined with high relative humidity into an increase of the perceived temperature by the human body. Another example is the Wind Chill Index that quantifies stress on the human body occurring from cold temperature along with strong wind. Univariate extremes being rare by definition, addressing the concurrence of multiple extreme variables is at the least challenging. Moreover, unlike in the univariate framework, there is no general definition of multivariate extremes. The benefit of the proposed approach relies on the fact that the impact function values can be studied in the univariate framework while the corresponding states in the underlying variables are also known. The scarcity of such events in observational datasets combined with the role of natural climate variability and climate change highlight the need for large ensembles of high-resolution climate model simulations. This analysis is based on the output from the Canadian Regional Climate Model (CRCM5) that was driven by 50 initial conditions members from the Canadian Earth System Model (CanESM2) to obtain 12-km resolution simulations from 1955 to 2100 (under RCP8.5) over Eastern North America and Europe in the context of the ClimEx project.

1704050 Extreme climatic and weather events

Understanding Regional Projections of Extreme Precipitation

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Under global warming, coupled climate models project that there will be increased extreme precipitation over most of the globe. This projection generally results from the thermodynamic increase of atmospheric moisture (i.e., Clausius-Clapeyron scaling) cancelled in part by the reduction of the moist adiabatic lapse rate (O'Gorman and Schneider, 2009). In particular regions, however, extreme precipitation projections are strongly influenced by changes in extreme updrafts. This paper explores the mechanisms driving changes in extreme updrafts using output from large ensembles of the Community Earth System Model version 1 (CESM1) and the Canadian Earth System Model version 2 (CanESM2) simulating the historical and RCP8.5 climate change scenarios. Despite their different spatial resolutions and convection schemes, CESM1 and CanESM2 produce large scale patterns of extreme updraft change that have much in common. For example, both models project weakening of extreme updrafts throughout the subtropical dry zones, and these are regions where extreme precipitation decreases significantly. We show that the common patterns of extreme updraft change are related to changes in mean moist stability (the vertical gradient of moist static energy) combined with changes in mean boundary layer height. Increases in boundary layer height are large enough to produce decreases in extreme precipitation over most land regions during boreal summer. Recent idealized studies provide additional insight into why mean moist stability and boundary layer height change the way they do. These physical processes are general enough that we expect them to be at work in the real world and in climate models with different resolutions and convection schemes.

1704050 Extreme climatic and weather events

Improving the representation of historical Climate Precipitation Indices using Optimal Interpolation methods

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Defining a reference climate is an important issue for the development of climate change impact and adaptation strategies. It remains a challenge in regions that were poorly covered by meteorological stations such as Northern Canada. Reanalyses represent interesting options to define such reference climate. However considering the bias and inaccuracies of the various reanalyses actually available, some validation and post-

processing are still needed before they could be used. In this paper, two data assimilation methods were used to improve the reference climate fields over Canada. Optimal Interpolation (OI) and Ensemble Optimal interpolation (EnOI) methods were used to combine four reanalysis datasets (CFSR, Era-Interim, JRA55 and MERRA) with two observational datasets. A total of 2160 meteorological stations, with minimally 10-year precipitation records, and Natural Resources Canada (NRCan) gridded dataset were used. Annual values of ten Climate Precipitations Indices (CPI) covering a 30-year period (1980-2009) were estimated for each dataset and were then combined (reanalysis + observations) to provide a realistic representation of each climate index across Canada. A cross-validation strategy was finally applied and suggested that the proposed reference dataset improved our ability to estimate index values at points where no recorded precipitations are available. The developed datasets by the ensemble approach was also compared to the NRCan gridded dataset. Results showed that NRCan dataset should be used with caution in northern regions where network density was low and especially for extreme CPI analysis.

1704050 Extreme climatic and weather events

Attributing Extreme Fire Risk in Western Canada to Human Emissions

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Extreme wildland fire events, such as the fire that affected Fort McMurray in 2016, can be devastating to the communities affected, and inevitably provoke the question of whether human induced climate change was a factor. Understanding the role of human emissions in the occurrence of such extreme fire events can also lend insight into how these events might change in the future. An event attribution framework is used to quantify the influence of anthropogenic forcings on extreme fire risk in the current climate of a western Canada region. Numerous metrics from the Canadian Forest Fire Danger Rating System are used to define the extreme events of interest. It is shown that the combined effect of anthropogenic and natural forcing has increased the probability of occurrence for all metrics of extreme fire risk, compared to a climate that would have been with natural forcings alone.

1704050 Extreme climatic and weather events

Past and future evolution of streamflow in three watersheds in southern Ontario

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Major flooding events have occurred in Canada in recent years as a consequence of global warming. Floods disaster occurrences have increased in Canada in the last few decades. Southern Ontario, which houses 1/3 of Canadian population, is an area of high vulnerability for floods. This region is important for agricultural and industrial production in Canada and the Greater Toronto Area is the largest urbanized zone in Canada. Understanding floods and their relationships with climate variability is very relevant in this region. The aim of this research is to understand the hydrological processes in southern Ontario and to assess the future evolution of streamflow and flooding. In this work we are using GS FLOW hydrological model, a coupled soil and subsoil conceptual semi-distributed model, in 3 watersheds across southern Ontario; urban dominated Credit river, the agricultural Bigcreek river watershed and the Thames river a semi-urban watershed. Past observed and Future climate data, simulated by different General climate models (GCM) for two IPCC greenhouse gases emissions scenarios (RCP4.5 and 8.5), are used as input in the model. The results show an increase in runoff in winter due to more rainfall events but a decrease in early spring as a consequence of early snowmelt in the last decades. Future runoff projections for both climate scenarios indicate also an increase in winter and a decrease in early spring.

1704060 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1
A practical scheme of the sigma-point Kalman filter for high-dimensional systems
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While applying a sigma-point Kalman filter (SPKF) to a high-dimensional system such as the oceanic general circulation model (OGCM), a major challenge is to reduce its heavy burden of storage memory and costly computation. In this study, we propose a new scheme for SPKF to address these issues. First, a reduced rank SPKF was introduced on the high-dimensional model state space using the truncated single value decomposition (TSVD) method (T-SPKF). Second, the relationship of SVDs between the model state space and a low-dimensional ensemble space is used to construct sigma points on the ensemble space (ET-SPKF). As such, this new scheme greatly reduces the demand of memory storage and computational cost and makes the SPKF method applicable to high-dimensional systems. Two numerical models are used to test and validate the ET-SPKF algorithm. The first model is the 40-variable Lorenz model, which has been a test bed of new assimilation algorithms. The second model is a realistic OGCM for the assimilation of actual observations, including Argo and in situ observations over the Pacific Ocean. The experiments show that ET-SPKF is computationally feasible for high-dimensional systems and capable of precise analyses. In particular, for realistic oceanic assimilations, the ET-SPKF algorithm can significantly improve oceanic analysis and improve ENSO prediction. A comparison between the ET-SPKF algorithm and EnKF (ensemble Kalman filter) is also tribally conducted using the OGCM and actual observations.

1704060 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1
Key observing locations for advancing beyond the winter predictability barrier of Indian Ocean dipole events
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In this paper, we explored the key observing locations (i.e., sensitive areas for targeted observations) of positive Indian Ocean dipole (IOD) events to advance beyond the winter predictability barrier (WPB) using the Geophysical Fluid Dynamics Laboratory Climate Model version 2p1 (GFDL CM2p1). The sensitivity analysis is conducted through perfect model predictability experiments, in which the model is assumed to be perfect and so any prediction errors are caused by initial errors. The results show that the initial errors with an east-west dipole pattern are more likely to result in a significant WPB than random initial errors; the areas where the large values of the dipole pattern initial errors are located have great effects on prediction uncertainties in winter and provide useful information regarding the sensitive areas. Further, the prediction uncertainties in winter are more sensitive to the initial errors in the subsurface large value areas than to those in the surface large value areas. The results indicate that the subsurface large value areas are sensitive areas for targeting and if we carry out intensive observations across these areas, the prediction errors in winter may be largely reduced. This will lead to large improvements in the skill of wintertime IOD event forecasts.

1704060 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1

Determining the spectrum of the nonlinear local Lyapunov exponents in a multidimensional chaotic system

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For an n-dimensional chaotic system, the authors recently extended the definition of the nonlinear local Lyapunov exponent (NLLE) from one- to n-dimensional spectra, and presented a method of computing the NLLE spectrum. The method was tested on three chaotic systems with different complexity. The results indicate that the NLLE spectrum realistically characterizes the growth rates of initial error vectors along different directions from the linear to nonlinear phases of error growth, which is an improvement over the traditional Lyapunov exponent spectrum that only characterizes the error growth rates during the linear phase of error growth. In addition, because the NLLE spectrum can effectively separate the slowly and rapidly growing perturbations, it has been shown to be more suitable for estimating the predictability of chaotic systems compared to the traditional Lyapunov exponent spectrum.

1704060 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1

Study of Nonlinear Forcing Singular Vector on Tropical Cyclone predictability

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How to improve tropical cyclone (TC) intensity forecast skill is urgent, especially that of TC track forecast has been upgraded greatly during these several decades. Therefore, identifying the sources of TC intensity forecast errors is essential.

Nonlinear forcing singular vector (NFSV) accounts for the processes that are not explicitly or correctly described by the nonlinear model equations. Based upon the WRF-ARW and its adjoint model, this study uses NFSV to investigate the impacts of model errors on TC intensity forecasts, which is represented by minimum sea level pressure (MSLP). The results show that (1) model error is the important source for TC intensity forecast error, which is O (102) hPa for 1-2 day forecast generally; (2) the inaccurate description of model output to both potential temperature and the mixing ratio can lead to large TC intensity forecast errors; (3) above inaccurate descriptions firstly produce abnormal vertical motion, which cause abrupt variation of vertical eta coordinate within very short period, and finally lead to large MSLP forecast errors. These results infer that WRF-ARW model should be adjusted first for a more accurate TC intensity forecast.

1704060 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1

Depicting the Predictable Patterns of Asian and Western Pacific Climate on Seasonal and Subseasonal Time Scales

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The predictable patterns of Asian and western Pacific climate are depicted using a maximized signal-to-noise empirical orthogonal function analysis based on results from the U.S. NCEP Climate Prediction System. On seasonal time scale, ENSO contributes to the most predictable patterns in all seasons, especially in the developing and mature phases of ENSO. However, the relations of the second most predictable mode (SMPM) to the effects of ENSO, monsoon, and the Indian Ocean SST vary with seasons. In winter and spring, the SMPM occurs associated with the decaying phase of ENSO and can be predicted 5 months ahead.

In summer, the SMPM is a mode of the East Asian – western Pacific monsoon and can be predicted with high skills of 4 months in advance. In autumn, the SMPM is related to the effect of the tropical Indian Ocean dipole and the lead time for predicting this mode with skills is about 3 months.
For subseasonal prediction, we focus on the time scales of 30-60 days and 10-20 days. The most predictable patterns for the 30-60-day time scale can be predicted by 32 days ahead in summer, with much lower skills in spring. Relatively, the skills of prediction for the time scale of 10-20 days are lower, with a skillful lead time of 12 days only in winter and even lower skills in autumn.

1704060 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 1
Verification of convective-scale ensemble forecasts system during the OLYMPEX (Olympics Experiment) field campaign in Washington State during December 2015
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Evolution of NWP models towards convective-scale, probabilistic forecasts requires increasing computation time and power. Such prediction is typically realized through forecast ensembles at O(1 km) horizontal grid spacing, which can be particularly expensive when they include frequent cycling of high-resolution data assimilation on their finest grids. A cheaper approach for convective-scale ensembles involves downscaling from coarser-resolution ensembles without high-resolution data assimilation, which can provide acceptable performance in some situations (e.g., Cookson-Hills et al, 2017 submitted). Environment and Climate Change Canada (ECCC) has experimented with such a downscaling forecasting system, using the Regional Ensemble Kalman Filter (REnKF) as the parent model and a horizontal grid spacing of 2.5 km on the finest mesh. Ensemble downscaling experiments have been performed for a 12-day period during the Olympics Experiment (OLYMPEX) field campaign in Washington State (03-14 December 2015). The OLYMPEX observations provide a unique opportunity to intensively verify the high-resolution ensembles against dense precipitation observations in an area of very complex terrain. These observations include numerous rain/snow gauges as well as both operational radars and research profiling and scanning radars. The verification uses several spatial verification techniques, including the Fractions Skill Score (Roberts and Lean, 2008) and the intensity-scaled technique developed by Casati et al (2010). Through an analysis of 40-member ensembles of 48-hr forecasts launched at 6 hour intervals, an assessment of model skill is characterized as a function of both spatial differences as well as temporal spread and model lag time, respectively. Casati, B. (2010). New Developments of the Intensity-Scale Technique within the Spatial Verification Methods Intercomparison Project. Weather and Forecasting, 25(1), 113–143.
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1704061 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2
The formulation of vector weights in localized particle filter
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Particle filter (PF) is a sequential data assimilation method based on the Monte Carlo approximation of Bayesian estimation theory. Standard PFs use scalar weights derived from the likelihood of observations to approximate posterior probability density functions (PDFs), and use resampling schemes to generate posterior particles, which is very easy to result in filter degeneracy and make it invalid.

Recently, a localized particle filter (LPF) was developed by extending the scalar weights of PF to vectors, which produces various (local) posterior PDFs for different model grids and variables. With a sampling and merging approach in resampling, the LPF can effectively solve the filter degeneracy and offer a practically efficient algorithm for localization.
In this work, we have analyzed the possible concerns of the current LPF, particularly in determining the vector weights. We argued that the current LPF algorithm inherently assumes the weights are continuous about spatial variables, which is a controversial assumption. On this basis, we propose a new algorithm of producing vector weights of PF. Numerical experiments with Lorenz '96 model show that our new localized particle filter performs better than the existing LPF algorithm, indicating the advantage and potential application of this new algorithm of vector weights in data assimilation.

1704061 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2
A study of predictability of a heavy rainfall event in steep domains by using BVs and ESVs
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In this study, BV and ESV methods are used to find out what would have large impact on the rainfall forecasts in the steep domains in southwest of China.
From the studies of BVs, it seems that the position around the trough is the sensitive areas. Besides, the structure and the location of the perturbation are very important. The locations of the perturbations determine whether it would have large impact on the forecasts, while the structure of the perturbations determine it would strengthen the event or weaken the event.
The investigation of ESVs shows that it is hard to adopt linear approximations in the rainfall cases especially for those occurred in the steep domains. Besides, it was found that both the variations of moist energy and the variations of moisture could be taken as indicators of the rainfall variations. Thus choosing the norms as moist energy or moisture is meaningful when considering precipitations. Moreover, it was found that the size of ESV maybe different, thus although the first ESV has the largest growth rate, but it may has less impact on the final items due to its small initial size, so rescaling the ESVs into the same size is very important.

1704061 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2
An improved 2015 El Niño hindcast using the CNOP approach to optimize initial conditions and model parameters in a coupled model
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Large uncertainties exist in real-time predictions of the 2015 El Niño event with systematic intensity biases that are strongly model dependent. It is critically important to characterize bias sources so that they can be reduced preferably. Here, the conditional nonlinear optimal perturbation (CNOP) approach is applied to an intermediate coupled model (ICM) which is equipped with a 4-dimensional variational (4-D Var) data assimilation technique. The CNOP approach is used to characterize prediction errors that can be attributed to initial conditions (ICs) and model parameters (MPs); then, a correction derived optimally can be made to errors in the ICs and MPs when making hindcasts. Two key model parameters are considered, which represent intensities of the thermocline effect and ocean-atmosphere coupling, respectively. Two types of hindcast experiments are performed, with these errors being optimally corrected or not. When errors in ICs and MPs are optimally corrected, it is shown that the 2015 El Nino event can be effectively improved for hindcasts made throughout 2015. In particular, the El Nino intensity in late 2015 can be adequately captured when hindcasts are started from early 2015. The feasibility and effectiveness are clearly demonstrated for improved El Nino hindcasts using the CNOP-derived optimal corrections to ICs and MPs. Further applications of and the limitations with the approach are also discussed.

1704061 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2

Role of sensitive physical parameter combinations in reducing simulation and forecast errors of sensible heat flux and latent heat flux in China

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Surface turbulent fluxes (sensible heat flux (SH) and latent heat flux (LH)) are recognized as key components of energy exchanges at the surface-atmosphere interface. It is important to improve the ability to simulate SH and LH by reducing parameter errors in the model .Since there exist quite a few parameters and related physical processes are nonlinear , it is crucial to investigate the nonlinear combinational effects of multiple-parameter uncertainty on the simulate or (and) forecast results .A new approach based on conditional nonlinear optimal perturbation related to parameters (CNOP-P) is employed within the Common Land Surface Model (CoLM). The results by the new approach is compared to that using the traditional method (such as the one-at-a-time (OAT) approach). The latter method ranks parameters one by one according to the sensitivity of each parameter and could fail to judge the sensitivity of the parameter combination.Numerical results show differences between the sensitivity of the parameter combinations using the new approach and the top ranked sensitive parameter using the OAT approach in dry and wet regions of China for SH and LH. By reducing the parameter error within the sensitive parameter combination, prediction is improved in China. Elevated extents of SH (84.3%) and LH (78.3%) calculated from the sensitive parameter combination using the new approach are higher than those of SH (57.2%) and LH (48.5%) using the OAT approach in semi-arid regions. This result suggests that it is essential to investigate the sensitivity of the parameter combination to lower simulation and prediction errors. The new approach for determining parameter combinations based on the CNOP-P is a promising method.

1704061 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2

Improved ensemble-mean forecasting of ENSO events by a zero-mean stochastic error model of an intermediate coupled model

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How to design a reliable ensemble prediction strategy with considering the major uncertainties of a forecasting system is a crucial issue for performing an ensemble forecast. In this study, a new stochastic perturbation technique is developed to improve the prediction skills of El Niño–Southern Oscillation (ENSO) through using an intermediate coupled model. We first estimate and analyze the model uncertainties from the ensemble Kalman filter analysis results through assimilating the observed sea surface temperatures. Then, based on the pre-analyzed properties of model errors, we develop a zero-mean stochastic model-error model to characterize the model uncertainties mainly induced by the missed physical processes of the original model (e.g., stochastic atmospheric forcing, extra-tropical effects, Indian Ocean Dipole). Finally, we perturb each member of an ensemble forecast at each step by the developed stochastic model-error model during the 12-month forecasting process, and add the zero-mean perturbations into the physical fields to mimic the presence of missing processes and high-frequency stochastic noises.

The impacts of stochastic model-error perturbations on ENSO deterministic predictions are examined by performing two sets of 21-yr hindcast experiments, which are initialized from the same initial conditions and differentiated by whether they consider the stochastic perturbations. The comparison results show that the stochastic perturbations have a significant effect on improving the ensemble-mean prediction skills during the entire 12-month forecasting process. This improvement occurs mainly because the nonlinear terms in the model can form a positive ensemble-mean from a series of zero-mean perturbations, which reduces the forecasting biases and then corrects the forecast through this nonlinear heating mechanism.

1704061 Data Assimilation, Ensemble Prediction, and Intrinsic Predictability - Part 2
Developing a 2D Hybrid Data Assimilation System for Surface Analysis
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This study looks to investigate the development of a 2D Hybrid Data Assimilation System, by implementing flow dependent error covariance with 2D Variational Data Assimilation system. Current 2D data assimilation systems, such as Real-Time Mesoscale Analysis (RTMA) utilizes terrain-following error covariance to produce hourly near-surface analysis. This 2D Variational approach is based on Gridpoint Statistical System (GSI). However, it lacks the ability to represent flow-dependent errors that are associated with synoptic and mesoscale systems. By developing a 2D Hybrid Data Assimilation System, it can take advantage of both the terrain-following error covariance that is currently employed in RTMA and flow dependent error covariance adopted from ensemble-based assimilation and forecast.
In the early stage, work has been done to identify spatial and temporal error distribution for a 2D Variational model, such as RTMA and ensemble products from Short Range Ensemble Forecast (SREF). High correlations are found between the analysis errors and the ensemble spreads in the vicinity of significant weather systems. The finding motivates to develop a 2D hybrid system, under GSI to assimilate conventional surface observations and utilize ensemble information. Current GSI system includes the configurations for the 3D hybrid system, but a 2D hybrid system has yet to be developed. Therefore, experiments will focus on adapting the GSI's 3D hybrid framework to develop a 2D hybrid system. It is expected that the 2D hybrid data assimilation system that uses dynamic flow-dependent and static terrain-following error covariance to give a more accurate hourly analysis of near-surface weather.

1704070 Climate Variability and Predictability - Part 1
Variations of Mid-Oceanic Troughs and Associated Atmospheric Teleconnection Patterns: Roles of Tropical SST and Arctic Sea Ice
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The mid-Pacific trough (MPT), occurring in the upper troposphere during boreal summer, acts as an atmospheric bridge connecting the climate over Asia, the Pacific, and North America. The first (second) EOF mode of the MPT reflects a change in its intensity on the western (eastern) portion of the trough. Both modes are significantly correlated with the variability of tropical Pacific SST. Moreover, the first mode is affected by the Atlantic SST and the second mode is influenced by the Arctic sea ice near the Bering Strait.
A stronger MPT shown in the first mode is significantly linked to drier and warmer conditions in the Yangtze-River basin, southern Japan and northern U.S. and a wetter condition in South Asia and northern China, while a stronger MPT shown in the second mode is associated with drier and warmer southwestern U.S. The relationships between MPT and the climate over Asia (North America) are modulated by ENSO (Atlantic SST and Arctic sea ice). Moreover, the dominant modes of MPT are closely related to Pacific tropical cyclone (TC) genesis during summer. Overall, an intensified MPT corresponds to more TCs over the western North Pacific and less TCs over the eastern Pacific.
A nearly parallel analysis has also been applied to the variations of the mid-Atlantic trough and associated teleconnection.

1704070 Climate Variability and Predictability - Part 1

Pacific-Atlantic interactions heat up: Evidence from El Nino and Mid-latitude Blobs

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In this talk, evidence will be presented to demonstrate that interactions between the Pacific and Atlantic Oceans have increased in the past two decades resulting in a greater number of synchronized occurrences of marine heatwave and cold spell events (aka. warm and cold blobs, respectively) in North Pacific and Atlantic and also more frequent occurrences of the Central Pacific (CP) El Nino.
Most previous studies have emphasized processes within the tropical Pacific for the generation of El Niño. We will show that after a change in the phase (from negative to positive) of the Atlantic Multi-decadal Oscillation (AMO) in the early 1990s, the Atlantic Ocean has been more capable of influencing El Niño dynamics. As a result of the stronger Pacific-Atlantic interactions, El Niño has changed from being predominantly of the Eastern Pacific (EP) type to being predominantly of the Central Pacific (CP) type and has become more biennial. The sequence of the physical processes that involved in this interaction will be presented.
We will also show evidence that during this same time period unusually prolonged North Pacific heatwaves (i.e., Pacific warm blobs) have a tendency to occur together with prolonged North Atlantic cold spells (i.e., Atlantic cold blobs). These synchronized extreme events are accompanied by a unique circulation pattern in the atmosphere, which exhibits a unique cross-basin structure. We will discuss how this pattern can serve as an atmospheric conducting pattern to induce co-variability in the North Pacific-Atlantic Oceans and why it has occurred more often recently.

1704070 Climate Variability and Predictability - Part 1

Changing association of Northern Hemisphere teleconnection patterns with ENSO

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El Niño is a major driver for atmospheric variability in the Northern Hemisphere extratropics. Two such associated teleconnection patterns are the Pacific-North American pattern (PNA), and the Tropical Northern Hemisphere pattern (TNH). The PNA and TNH pattern have been linked to El Niño related sea-surface temperature (SST) variability. However, with the changing climate and nonlinearities within the atmosphere-ocean system, the relationships between these teleconnection patterns and El Niño SST variability is ever changing. We will show that while the PNA has a fairly stable relationship with El Niño, there is some variation in their relationship. Furthermore, the TNH, which has been shown to be similar to the extratropical response to El Niño, has only been statistically significantly anti-correlated with it over the past few decades, and as recently as the 1950s, the sign of this correlation was reversed. This raises the questions of the possible mechanisms behind the recent anti-correlation between the TNH and El Niño, and whether or not the TNH occurs in the absence of it. Finally we will examine what role the Pacific-Decadal Oscillation plays in the relationships between both the PNA and TNH, with El Niño.

1704070 Climate Variability and Predictability - Part 1

Impact of cloud radiative effects on midlatitude jet variability in an aquaplanet GCM

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Meridional shifting of the eddy-driven jet in the extratropics is a leading mode of variability in both hemispheres. A variety of external forcings are known to project strongly onto this internal mode of variability, which is often called the annular mode. Furthermore, the sensitivity of this mode to external forcing may be related to its natural timescale: the more persistent, the more sensitive. Finally, modern

climate models are known to exhibit large positive biases in the annular mode timescale during certain seasons. Understanding the causes of these biases is an ongoing topic of study. In particular, recent observational work has suggested that clouds may act as a negative feedback on annular mode variability [Li and Thompson, 2016].

This study demonstrates the impact of cloud radiative effects on annular mode variability in a numerical model using the Clouds On-Off Klimate Intercomparison Experiment (COOKIE) framework [Stevens et al., 2012]. In this type of experiment, simulations are run in which the radiative transfer scheme is modified to ignore the presence of clouds. These runs can then be compared to control simulations performed with the normal radiative transfer scheme to isolate the impacts of cloud radiative effects in modifying the simulated atmosphere. Performing this type of experiment with the GFDL AM2.1 model in a specified SST aquaplanet mode, it is shown that clouds can act to significantly increase the amplitude of meridional shifts of the eddy-driven jet. The causes for this change are explored. Eddy variability in the extratropics is shown to be strongly amplified by cloud radiative effects. Due to the well-known positive feedback between eddy activity and zonal mean flow [Lorenz and Hartmann, 2001], this is suggested to explain the stronger meridional shifts of the eddy-driven jet in the “clouds-on” model run.

1704070 Climate Variability and Predictability - Part 1

Teleconnection over Afro-eurasia and Influence of Tropical Sea Surface Temperature on It

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Winter half-year teleconnection on intermediate time scales (10-30 day periods) over Afro-eurasia is studied. Years with anomalous intensity of the teleconnection are chosen as the positive and negative years. Composite maps show the anomalous teleconnection is associated with tropical sea surface temperature and anomalous Rossby wave propagation which creates the anomalous geopotential height. The geopotential height anomaly accompanies local precipitation anomaly.

1704071 Climate Variability and Predictability - Part 2

Coupled modes of large-scale features and hydroclimate variables in western Canada during the warm season

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The variability of warm-season hydroclimate variables in western Canada and their relationships to the large-scale atmospheric and oceanic variability are assessed by using gridded observations and NCEP-NCAR reanalysis. Modes of coupled variability between regional precipitation, temperatures and Standardized Precipitation and Evapotranspiration Index (SPEI) and large-scale circulations and sea surface temperatures are established by using singular value decomposition (SVD) analysis. Analysis of the leading modes suggests the tropical forcing of some larger-scale circulation features which govern the warm-season hydroclimate variability, trends and extremes (e.g., droughts and floods) in the region. The extent to which the coupled modes are reproduced in coupled general circulation models will also be examined.

1704071 Climate Variability and Predictability - Part 2

The Asian-Bering-North American teleconnection: Seasonality, maintenance, and climate impact on North America

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The Asian-Bering-North American (ABNA) teleconnection index is constructed from the normalized 500-hPa geopotential field by excluding the Pacific-North American (PNA) pattern contribution. The ABNA pattern features a zonally elongated wavetrain originating from North Asia and flowing downstream across Bering Sea and Strait towards North America. The large-scale teleconnection is a year-round phenomenon that displays strong seasonality with the peak variability in winter. North American surface temperature and temperature extremes, including warm days and nights as well as cold days and nights, are significantly controlled by this teleconnection.
The ABNA pattern has an equivalent barotropic structure in the troposphere and is supported by synoptic-scale eddy forcing in the upper troposphere. Its associated sea surface temperature anomalies exhibit a horseshoe-shaped structure in the North Pacific, most prominent in winter, which is driven by atmospheric circulation anomalies. The snow cover anomalies over the West Siberian plain and Central Siberian Plateau in autumn and spring and over southern Siberia in winter may act as a forcing influence on the ABNA pattern. The snow forcing influence in winter and spring can be traced back to the preceding season, which provides a predictability source for this teleconnection and for North American temperature variability. The ABNA associated energy budget is dominated by surface longwave radiation anomalies year-round, with the temperature anomalies supported by anomalous downward longwave radiation and damped by upward longwave radiation at the surface, as the consequence of the atmospheric anomalies imposed by anomalous thermal advection.

1704071 Climate Variability and Predictability - Part 2

The Dynamical Influence of Separate Teleconnections from the Pacific and Indian Oceans on the Northern Annular Mode

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This study uses simulations with a coupled ocean-atmosphere GCM to examine the influence of quasi-stationary wave teleconnections from the tropical oceans on the sign and amplitude of wintertime variability of the Northern Annular Mode (NAM). Composites constructed from a 1000-yr pre-industrial control simulation show that increased precipitation in the central/eastern Pacific drives a negative NAM response. In contrast, when isolated from ENSO variability, increased precipitation over the western-central Indian Ocean drives a strong and persistent positive NAM response. The sign and amplitude of the NAM responses are largely explained by opposite linear interference of the wave teleconnections propagating from the tropics. This mechanism is confirmed using a new set of experiments where the tropical ocean is nudged separately over the Pacific and Indian Oceans toward the large amplitude 1997/98 -- 1998/99 ENSO cycle. The phase of the quasi-stationary wave and NAM responses in these two cases are of opposite sign, providing strong evidence that precipitation changes over the Indian Ocean, driven by internal variability and/or in response to climate change, can induce teleconnections that affect the northern extratropics independent of--and with opposite-sign to--those associated with ENSO.

1704071 Climate Variability and Predictability - Part 2

A Decadal-scale Air-sea Interaction Theory for North Atlantic Multidecadal Variability: the NAT-NAO-AMOC-AMO Coupled Mode and Its Remote Influences

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North Atlantic region shows prominent multidecadal variability. Observational analysis shows that the North Atlantic Oscillation (NAO) leads the oceanic Atlantic Multidecadal Oscillation (AMO) by 15-20 years and the latter also leads the former by around 15 years. The mechanisms are investigated using simulations from a fully coupled model, and a NATNAO- AMOC-AMO Coupled Mode is proposed to explain the multidecadal variability in North Atlantic region. The NAT-NAO-AMOC-AMO coupled mode has important remote influences on regional climates. Observational analysis identifies a significant in-phase relationship between the AMV and Siberian warm season (May to October) precipitation. The physical mechanism for this relationship is investigated using both observations and numerical simulations. North Atlantic sea surface temperature (SST) warming associated with the positive AMV phase can excite an eastward propagating wave train response across the entire Eurasian continent, which includes an east–west dipole structure over Siberia. The dipole then leads to anomalous southerly winds bringing moisture northward to Siberia; the precipitation increases correspondingly. Furthermore, a prominent teleconnection pattern of multidecadal variability of cold season (November to April) upper-level atmospheric circulation over North Africa and Eurasia (NA–EA) is revealed by empirical orthogonal function analysis of the Twentieth Century Reanalysis data, and this teleconnection pattern is referred to as the Africa–Asia multidecadal teleconnection pattern (AAMT). A strong inphase relationship is observed between the AAMT and Atlantic multidecadal variability (AMV) and this connection is mainly due to Rossby wave dynamics. The AAMT acts as an atmospheric bridge conveying the influence of AMV onto the downstream multidecadal climate variability.

1704071 Climate Variability and Predictability - Part 2

The Impact of Natural Climate Variability and Bias-correction on Hydrological Simulations of Climate Change

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The impact of climate change on water resources is of great interest to researchers, policy makers and stake holders. Here an ensemble of high-resolution dynamically downscaled climate projections are used to drive a hydrologic model of the Grand River watershed in southern Ontario and assess the range of possible climate change impacts.

The hydrologic model is the fully integrated, physically-based surface-subsurface model HydroGeoSphere, which has been forced with high-resolution climate projections from the state-of-the-art WRF model. The latter has been extended with an interactive lake model (FLake) to represent the effect of the lakes on the regional climate in a physically consistent way under a changing climate.

Hydro-climatological projections will only be presented for the RCP8.5 GHG scenario (end-century). Nevertheless, a range of climate scenarios has been employed, based on different RCM configurations and resolutions, as well as different initial and boundary conditions, to represent natural climate variability. This approach enables us to quantify the impact of climate change on the hydrologic simulations relative to expected variations due to natural climate variability and uncertainty due to model error.

Despite the superior performance of the RCM compared to GCMs, the climate projections are still subject to significant biases and variability. So much so, that some members of the ensemble of climate projections lead to hydrologic responses of opposite sign. The reasons for the different hydrologic responses are discussed. Furthermore, the extend to which bias correction can mitigate the uncertainty due to model bias will be investigated.

1704071 Climate Variability and Predictability - Part 2

Connections linking the Spring Pacific-Arctic Dipole and Summer Sea Ice in the Beaufort-Chukchi Seas

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We identified an atmospheric circulation dipole anomaly in the Pacific-Arctic sector and showed that it is related to the sea ice in the Beaufort-Chukchi Sea, in the following September. These results are obtained using sea ice observations and model-generated data from PIOMAS (Pan-Arctic Ice-Ocean Modeling and Assimilation System), and the ERA-Interim re-analysis data. This dipole anomaly (hereafter, the Pacific-Arctic Dipole, PAD), is the second leading EOF mode of spring (April-June) sea level pressure (SLP) in the Pacific-Arctic (600N-900N, 1200E-1200W) and accounts for 21.6% of the variance. The PAD anomaly has a positive anomaly in the Beaufort Sea and a negative anomaly extending from East Siberia to Northwest America, and exhibits co-variance with the Beaufort High and the Aleutian Low. The dipole mode reflects the re-distribution of cyclones in the Pacific-Arctic sector, modulated by the co-variance between the Arctic Part of North Pacific Trough and the northwestern America ridge of the upper atmospheric steering flows. We found that the spring PAD accounts for about 20% of the interannual variance of the following summer sea ice concentration (SIC) in the Beaufort-Chukchi Sea. A positive PAD has an enhanced Beaufort high and an intensified, northward extended Aleutian Low; the resulting intensified eastern winds in the Beaufort Sea lead to enhanced ice advection and weakened sea ice thickness. Moreover, less cyclone activity leads to less mid-tropospheric level cloud cover and less water content in the atmospheric column above the Beaufort Sea and Central Arctic, causing a net surface heat flux gain and reductions in sea ice. With climate change, the tendency for increased sea ice thinning and intensified easterly winds, lead to earlier spring ice melt and open water formations along the coast; in turn, these processes foster a stronger summer ice-albedo feedback, resulting in accelerated sea ice reductions in following melting summer seasons

1704072 Climate Variability and Predictability - Part 3

Seasonal Predictability of North American Coastal Storm Activity during the Cold Months in the Canadian Seasonal to Interannual Prediction System (CanSIPS)

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Extratropical cyclones (ETCs) often produce hazardous weather conditions, such as high winds, heavy precipitation, and blizzard conditions, all of which can have detrimental socio-economic impacts. The North American east and west coastal regions are both strongly influenced by ETCs and, subsequently, land-based, coastal, and maritime economic sectors in Canada and the USA all experience strong adverse impacts from extratropical storm activity from time to time. Society would therefore benefit if ETC storm activity variability could be reliably predicted for the upcoming season. Skilful prediction would enable affected sectors to better anticipate, prepare for, manage, and respond to ETC storm activity and the associated risks and impacts. In this study, the seasonal predictability of North American coastal storm activity during the cold months (October-March) is investigated using Environment and Climate Change Canada's operational Canadian Seasonal to Interannual Prediction System (CanSIPS). Categorical deterministic and probabilistic seasonal forecasts are constructed from CanSIPS multi-model ensemble mean hindcasts (1981-2010). Forecasts are developed using the three equiprobable category framework (below-, near-, and above-normal conditions) and the parametric Gaussian method for determining probabilities. The CanSIPS forecasts are then evaluated against ERA-Interim, representative of observations, using leave-one-out cross-validation to determine forecast skill and whether that skill is sufficiently high (i.e., exceeding the climatological forecast) to be useful to end-users. The percent correct score is used to evaluate deterministic forecast skill while the

Brier skill score is used to evaluate probabilistic forecast skill. Seasonal predictability is investigated for the cold seasons (OND, NDJ, DJF, JFM), using mean sea level pressure, absolute pressure tendency, and 10-m wind speeds as proxies for extratropical storm activity. Seasonal forecasts of mean sea level pressure provide information on storm activity frequency while forecasts of absolute pressure tendency and 10-m wind speeds provide information on storm activity intensity.

1704072 Climate Variability and Predictability - Part 3
A robust empirical seasonal prediction of winter NAO and surface climate
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A robust empirical seasonal prediction of winter NAO and surface climate.
A key determinant of winter weather and climate in Europe and North America is the North Atlantic Oscillation (NAO). Skilful seasonal forecasting of the surface climate in both Europe and North America is reflected largely in how accurately models can predict the NAO. Most dynamical models, however, have limited skill in seasonal forecasts of the winter NAO. A new empirical model is proposed for the seasonal forecast of the December-January-February (DJF) mean NAO index using a multiple linear regression (MLR) technique with autumn conditions of sea-ice concentration, stratospheric circulation, and sea-surface temperature. This model's cross-validated forecast skill of 1980-2015 NAO index reaches as high as 0.76. This MLR model also provides skilful seasonal outlooks of winter surface temperature and precipitation over many regions of Eurasia and eastern North America.

1704072 Climate Variability and Predictability - Part 3
Seasonal hindcasts with the GEM-NEMO global coupled model
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The CMC numerical weather prediction model, GEM, is coupled with the NEMO ocean model. The objective is to develop a global atmosphere-ocean-sea ice coupled model for climate study and subseasonal and seasonal predictions. A set of hindcast experiments are performed starting from the first of each month for the 30 years of 1981-2010, with 10 members of 12-month integrations. Seasonal forecast skill is assessed for surface air temperature and precipitation, as well as for the Pacific-North American Pattern (PNA) and the North Atlantic Oscillation (NAO). The forecast skill of the Madden-Julian Oscillation (MJO) is also calculated to evaluate its performance on the subseasonal time scale. Comparison is made with the operational Canadian Seasonal and Interannual Prediction System (CanSIPS). It is found that the GEM-NEMO coupled model outperforms the two CanSIPS coupled models in many aspects.

1704072 Climate Variability and Predictability - Part 3
Surface Current in "Hotspot" Serves as a New and Effective Precursor for El Niño Prediction
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The El Niño and Southern Oscillation (ENSO) is the most prominent sources of inter-annual climate variability. Related to the seasonal phase-locking, ENSO's prediction traversing the low-persistence barrier in the boreal spring remains a challenge. Here we identify regions of surface current variability that influence the short-lead predictions of the July Niño 3.4 index by applying a regression analysis. A highly influential region, related to the distribution of wind-stress curl and sea surface temperature, is located near the dateline

and the southern edge of the South Equatorial Current. During El Niño years, a westward current anomaly in the identified high-influence region favours the accumulation of warm water in the western Pacific. The opposite occurs during La Niña years. This process can be regarded as the “goal shot” for ENSO development, which provides an effective precursor for the prediction of the July Niño 3.4 index with a lead time of 2-4 months. The skill of prediction based on surface current precursor beats that based on the warm water volume and persistence in the subsequent months after July. In particular, prediction based on surface current precursor shows skill in all years, while predictions based on other precursors show reduced skill after 2002.

1704072 Climate Variability and Predictability - Part 3
Multivariate analysis of extreme Net Basin Supplies in the Great Lakes
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This study focuses on the Great lakes Net Basin Supply Residuals (NBSR), which are defined as the difference between monthly values of NBS and their interannual mean. In this study, NBSR of all five Great Lakes from August to October were modelled statistically in relation with a number of hydro-climatic indices calculated with data issued from regional climate models covering different climatic scenarios (warm/warm-wet/warm-dry/cold/wet/cold-dry).
Non stationary frequency analysis was the main tool used for this project. The non-stationary Generalized Extreme Value (GEV) was fitted to NBSR with the shape and scale parameters allowed to vary as a function of hydro-climatic variables. For instance, for Lake Superior, the covariates are Degree Days of maximum temperature exceeding 20°C (from June to November) and total precipitation (from December to February). The indices are calculated using the climate model outputs from (1971-2000) and (2041-2070).
The results are promising since they allow comparing the effect of future simulations and historical ones on observed NBSR variations. Non-stationary quantiles were compared to stationary values, which permitted to highlight some important differences for a number of lakes and covariates.

1704072 Climate Variability and Predictability - Part 3
Cloud feedback during ENSO
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There exists a prominent discrepancy between climate models and observations on the sign and magnitude of cloud radiative feedback during ENSO. Previous works showed that global climate models show a very strong, positive cloud feedback in the central Pacific which is not present in observations. To better understand this discrepancy and the role of radiation in ENSO cycle, we use the radiation data from the CERES satellite dataset and atmospheric data from the ERA-interim reanalysis dataset to diagnose the radiative energy budget. We extend the previous works by analyzing not only the TOA but by also the surface and atmospheric radiation budgets, using a set of radiation kernels we developed. We find that cloud radiative feedback plays an interesting role during the ENSO cycle, helping the thermal anomalies to develop and sustain. It is important for the global models to properly simulate the radiative energetic effects in order to improve their simulations of ENSO.

1704080 Atmospheric Convection: Physics, Dynamics, and Roles in Climate
Cases of Elevated Convection Initiation on Frontal Surfaces in 2015
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Predicting the initiation of elevated deep moist convection is one of the most difficult forecasting challenges for operational meteorologists. In 2015, the Plains Elevated Convection at Night (PECAN) field project was the first comprehensive field campaign undertaken in the central United States to address these challenges. One of the scientific foci of PECAN was to better understand the initiation of elevated convection. In this study, two cases of elevated convection initiation above warm frontal surfaces were investigated, one during PECAN and another in southern Manitoba in 2015. These case studies revealed how the nocturnal low-level jet produced kinematic convergence and increased moisture transport in the vicinity of elevated convection. Convergence within the exit region of the low-level jet dramatically increased frontogenesis in the southern Manitoba case, but only caused minor frontogenesis in the PECAN case. However, in both cases the low-level jet convergence increased vorticity through vortex stretching. The increase in vorticity associated with vortex stretching aided in the development of lower-tropospheric potential vorticity anomalies when coincident with high static stability. An increase in both isentropic and kinematic vertical velocities also occurred in both cases from the development of the nocturnal low-level jet. These processes were found to aid in elevated convection initiation due to the lifting of the low-level jet along warm frontal surfaces. By moving the low-level jet out of the stable boundary layer and into the free atmosphere, convective inhibition was reduced, allowing free convection to occur when co-located with forcing for ascent.

1704080 Atmospheric Convection: Physics, Dynamics, and Roles in Climate
A population dynamics approach to parameterizing fractional areas for shallow and deep moist convection
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A new parameterization of the combined effects of deep and shallow moist convection as been developed for use in the 4th generation global atmospheric model (CANAM4) of the Canadian Centre for Climate Modelling and Analysis (CCCma). This parameterization employs coupled prognostic equations of the Lotka-Volterra type to model the temporal evolution of the fractional areas corresponding to shallow/congestus and deep moist convection. The maximum fractional area that can be occupied by combined populations of deep and shallow/congestus cumulus clouds is determined through a closure condition. The new parameterization scheme has been tested in single-column (SCM) simulations. It has also been implemented in CANAM4 and tested using in multi-year global simulations. The basic formulation and selected results from SCM and CANAM4 simulations will be presented.

1704080 Atmospheric Convection: Physics, Dynamics, and Roles in Climate
Topographic Impacts on the Spatial Distribution of Deep Convection over Southern Quebec
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Observations and numerical simulations reveal pronounced mesoscale variability in deep-convection occurrence over southern Quebec. A 22-yr climatology from the McGill radar just west of Montreal shows that deep-convection maxima exist (i) within the St. Lawrence valley surrounding Ottawa; (ii) within the Champlain valley of upstate New York, extending north to just east of Montreal; and (iii) in the lee of the Laurentian Mountains northeast of Trois-Rivières. These features are sensitive to the background low-to-midlevel geostrophic wind direction, shifting northward as the southerly wind component increases. A

meridional axis of suppressed convection also extends from Lake Ontario and the Adirondacks of New York north through Montreal and into the Laurentians. To physically interpret these features, a suite of quasi-idealized convection-permitting simulations is conducted. Analysis of the simulations, which broadly reproduce the observed extrema in convection occurrence, reveals that the maxima develop within pockets of moisture and mass convergence at the junctions of major river valleys and in the lee of prominent mountain ridges. In these locations, enhanced boundary layer humidity and convective available potential energy (CAPE) coincides with minimal convective inhibition (CIN). The minima occur over and downwind of water bodies, where limited surface heat fluxes reduce CAPE and increase CIN, and over the higher terrain, where reduced low-level moisture limits storm intensity.

1704080 Atmospheric Convection: Physics, Dynamics, and Roles in Climate
Evaluating cumulus entrainment retrieval methods using large-eddy simulation
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Cumulus entrainment regulates the internal cloud properties of cumuli and the interaction of cumuli with the larger scales. Due to the critical importance of cumulus entrainment on weather and climate processes, a thorough quantitative understanding of it is essential. However, such an understanding remains elusive, in part due to the difficulty of directly observing cumulus entrainment rates. Multiple approaches to retrieving bulk fractional entrainment rates within cumuli using ground-based in situ and remote data at the Department of Energy's Atmospheric Radiation Measurement (ARM) climate research sites have been developed recently. However, these retrievals have not been verified against ground truth and thus remain highly uncertain. To quantify the performance of such methods, we use large-eddy simulations (LES) of shallow cumulus convection as Observing System Simulation Experiments (OSSEs). From these simulations, we perform simulated entrainment retrievals and compare them directly to bulk diagnosed entrainment rates. These OSSEs include a broad range of continental and maritime simulated cloud fields. Two retrieval methods are considered, including one existing method based on an entraining parcel model and a new retrieval based on turbulent-kinetic-energy (TKE) similarity theory that we have developed. As a first step in the verification, we assume that all quantities used in the retrievals are perfectly observable, and evaluate these quantities over the full LES model grid. Subsequent experiments relax the latter assumption by restricting the observations to fixed vertical profiles within the model domain, to better represent the data available from ARM climate research sites. In particular, we assess the extent to which entrainment rates retrieved from time-height sections at one or more grid points (each representing observations from a profiling lidar or cloud radar) match the original retrievals over the full LES model grid.

1704080 Atmospheric Convection: Physics, Dynamics, and Roles in Climate
Accurate simulation of the temperature profile in actively convecting regions of the tropics using a convective parameterization
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The mean temperature profile of strongly convecting regions is a fundamental property of the tropics, but represents a challenge for convective parameterizations to accurately simulate. Most climate models have a 1-2 cold bias in the lower troposphere. Convective parameterizations require some mechanism for moistening the lower troposphere to bring modeled relative humidity profiles into agreement with observations. This can be done by some combination of evaporation, shallow detrainment, or downdrafts. Each has differing effects on the moist static energy budget of the lower troposphere. We argue that downdrafts are the most effective way to moisten the lower troposphere in a way that is most consistent with observed temperatures in the lower troposphere.

1704090 General Session - Climate

Terrestrial rock weathering and the carbon cycle in the UVic Earth System Climate Model (ESCM): Applications to past and future climates

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The importance of the rock weathering feedback during the last deglacial period is investigated using the UVic ESCM with four box-model (zero-D) parameterizations of terrestrial weathering. The deglacial cooling is driven by prescribed changes in orbital parameters, atmospheric CO2 and continental ice sheets. Over the course of the simulation (16000 to 4000 BCE), increases in weathering slowly remove CO2 from the atmosphere, in opposition to the observed increase. Weathering transfers both carbon and alkalinity to the ocean, resulting in a 1000 Pg C increase in the total carbon, relative to a control run with constant weathering. A second set of simulations is used to estimate the impact of increasing weathering rates on atmospheric CO2 when the latter is allowed to vary according to model carbon cycle dynamics. It is found that the CO2 concentration is reduced by about 16 ppm over 8000 years as a result of increasing weathering alkalinity and carbon fluxes from LGM to 10000 BCE values.

A spatially-explicit (2-D) weathering scheme which takes into account the worldwide distribution of rock types is also presented and applied to future carbon emission scenarios. Overall, the 2-D weathering model is more efficient than the zero-D model at restoring the carbon cycle to its pre-industrial state following pulse emissions. The model results show that the largest contributions to future changes in weathering rates come from the expansion of tropical and mid-latitude vegetation in grid cells dominated by weathering-vulnerable rock types. The results also confirm that only silicate rock weathering can lead to a full recovery of the carbon cycle on multi-millennial timescales.

1704090 General Session - Climate

CCDP: GIS-Based Data Portal for Climate Change Impact Assessment

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While mitigating climate change would require substantial and sustained reductions in greenhouse gas emissions through worldwide consensus and collaborations, adapting to climate change has become a major focus of local policy makers and development practitioners. Sound decisions rely on impact-based modeling, but the coarse-resolution outputs of global climate models (GCMs) are unsuitable for driving impact models, which usually require finer resolution projections at both spatial and temporal scales. Effective downscaling of GCMs projections is thus required, but it is practically difficult due to the lack of computational resources and/or long-term reference data. Such difficulty has become a major barrier preventing informed climate change adaptation planning at regional scales. To address this challenge, a web-based and user-friendly public data portal with integration of advanced geographic information system (GIS) technology, named Ontario Climate Change Data Portal (CCDP, http://ontarioccdp.ca), has been established to allow intuitive and open access to high-resolution regional climate scenarios for Ontario, Canada. Ontario CCDP offers functions of visual representation through geospatial maps and data downloading for a variety of climate variables (e.g., temperature, precipitation, relative humidity, solar radiation, and wind) at multiple temporal resolutions (i.e., annual, seasonal, monthly, daily, and hourly). The vast amount of information this portal encompasses can provide a crucial basis for assessing impacts of climate change on local communities and ecosystems and for supporting better decision making under a changing climate.

1704090 General Session - Climate
Oceanic origin of the transient climate response to cumulative CO2 emissions
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Virtually all Earth system models (ESM) show a near proportional relationship between cumulative emissions of CO2 and change in global mean temperature, a relationship which is independent of the emissions pathway taken to reach a cumulative emissions total. The relationship, which has been named the Transient Climate Response to Cumulative CO2 Emissions (TCRE), gives rise to the concept of a `carbon budget'. That is, a finite amount of carbon that can be burnt whilst remaining below some chosen global temperature change threshold, such as the 1.5 and 2.0 oC targets set by the Paris Agreement. In this presentation I will show that the path-independence of TCRE arises from two effects: (1) the ocean heat and carbon uptake being governed by a similar mechanism, which at the global average is consistent with diffusion. (2) The partitioning ratio of anthropogenic carbon between the ocean and the atmosphere being almost the same as the partitioning ratio of enhanced radiative forcing between the ocean and space. That these ratios are so close in value is a coincidence unique to CO2. I show that the compensation mechanism that generates path-independence works for a range of CO2 emission rates which largely envelops historical emission rates and emission rates from future emission scenarios. The results place TCRE and carbon budgets on a firmer physical foundation and therefore help validate the use of these metrics for climate policy.

1704090 General Session - Climate
Analyzing the future climate change on winter road systems in Ontario's Far North, Canada, using climate model projections
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Understanding climate change impacts on winter road systems in Ontario's Far North (OFN) is particularly critical due to the high dependence on such seasonal corridors by local residences, particularly among remote First Nations communities. In recent years, a warmer climate has resulted in a shorter winter road season and an increase in unreliable road conditions; thus, limiting access among remote communities. This study focused specifically on examining the future freezing degree-days (FDDs) accumulations during the preconditioning period of the winter roads at five locations throughout OFN using recent climate model projections from the multi-model ensembles of General Circulation Models (GCMs) and dynamical downscaling of Regional Climate Models (RCMs), under the Representative Concentration Pathway (RCP) scenarios. The Statistical DownScaling Model (SDSM) was applied to validate the baseline climate. The results from the CMIP5 ensemble and CanRCM4 models showed that by 2100 the CanRCM4 model projected the largest decreasing rates of the FDD accumulations under RCP4.5 while the CMIP5 ensemble simulated the greatest declines of the FDD accumulations under RCP8.5, relative to the baseline period of 1981–2010. Results of the FDD threshold measure indicated that climate conditions would possibly be unfavourable during the winter road construction period by mid-century for Moosonee and Kapuskasing, and for Red Lake by the end of century. For Big Trout Lake and Lansdowne House, on the other hand, climate conditions are expected to remain favourable for winter road construction through the end of 2100.

1704090 General Session - Climate

The Canadian Earth System Model version 5

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The Canadian Earth System Model, CanESM, is a global coupled Earth System Model developed to study past and future changes in climate, on timescales from seasons to centuries.
Developed at the Canadian Centre for Climate Modelling and Analysis (CCCma) with inputs from other government and university stakeholders, previous versions of CanESM have been used widely used for climate studies both internationally and within Canada, for example, as part of the Coupled Model Intercomparison Project (CMIP). A significant update to the model, named CanESM5, has been developed for inclusion in the upcoming sixth phase of CMIP, which will feed into the sixth Assessment Report of the Intergovenmental Panel on Climate Change. CanESM5 consists of the Canadian atmospheric model (CanAM) with an embedded land surface scheme and terrestrial biogeochemistry (CLASS-CTEM); an off-the-shelf but customized ocean model (CanNEMO), which includes sea-ice and Canadian- developed ocean biogeochemistry modules. The components communicate through a new custom coupler, CanCPL. Relative to CanESM2, the last widely-used version, major changes in the new model are the move towards a NEMO-based ocean, and the development of the new coupler and ocean-biogeochemistry. The atmospheric and land components, by contrast, are incremental improvements on the versions used in CanESM2. Here we briefly describe these model components, how they interact, and some basic characteristics of the new model which will be deployed during 2017. Beyond CMIP6, the new version of the model will also likely integrate into the operational Canadian Seasonal to Interseasonal Prediction System (CanSIPS) and will in general provide an updated tool for climate science applications at CCCma and within Canada.

1704090 General Session - Climate

Impact of Arctic Sea Ice loss on large-scale atmospheric circulation based on fully-coupled sensitivity experiments

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Arctic sea ice decline in the recent decades has been reported in observational studies. Modeling studies have confirmed that this downward trend in Arctic sea ice is mainly caused by increasing Greenhouse Gases (GHGs) concentrations into the atmosphere. The IPCC-AR5 report concluded that Arctic sea ice will continue to decrease and is projected to disappear in the middle of the 21st century, yielding to an ice-free region during boreal summer season. Arctic sea ice loss is expected to strongly impact the climate system. Recently, the climate community has conducted a number of studies to evaluate and understand the Arctic sea ice loss implications on climate.
While some studies have shown that Arctic sea ice decline can significantly affect the large-scale atmospheric dynamics at high and mid-latitudes of the Northern Hemisphere, by altering the storm-tracks, the jet stream (position and strength) and the planetary waves, large uncertainties remain due to a low signal-to-noise ratio and experimental protocol differences leading to a large inter-model spread.
In this work, we investigate the respective roles of Arctic sea ice loss and GHGs increase on the atmospheric dynamics by means of an idealized experimental set-up that uses the coupled model CNRM-CM5. The experimental set-up, based on a flux correction technique, will allow separating the contributions of Arctic sea ice loss from the GHGs increasing. We will focus mainly on the atmospheric circulation response in the Northern Hemisphere and on the associated synoptic variability, represented by the storm-tracks. We show that Arctic sea ice loss is responsible for an equatorward shift of the northern hemisphere jet, which is opposed to the GHGs effect. Finally, we show that these shifts are consistent with the storm-tracks response.

1705010 GOES-R Readiness in Canada - Part 1
Early GOES-R image examples over Canada
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Environment and Climate Change Canada / Meteorological Service of Canada (MSC) will be acquiring and disseminating data from the new GOES-16 satellite to operational forecast offices during the latter half of 2017. This presentation focuses on GOES-16 imagery over Canada to highlight the new capabilities arising from the increased number of channels and spatial / temporal resolution. Examples will be shown which compare the physical differences between channels and how they can be combined to create new products to help discern both atmospheric and surface features. As well, how the imagery will appear within the MSC operational meteorological workstation, NinJo, will be briefly shown.

1705010 GOES-R Readiness in Canada - Part 1
The Advanced Baseline Imager (ABI) on GOES-16
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Lindsey, Dan - NOAA NESDIS STAR
Bachmeier, Scott - CIMSS
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The Advanced Baseline Imager (ABI) on Geostationary Operational Environmental Satellite (GOES)-R was launched on November 19, 2016 and became GOES-16 when it reached geostationary orbit (29 November, 2016). This is the first satellite is a series of four. The ABI is a state-of-the-art 16-band radiometer, with spectral bands covering the visible, near-infrared and infrared portions of the electro-magnetic spectrum. Many attributes are improved on the ABI from the current GOES imagers, such as those relating to: spectral, spatial, temporal, radiometric and image navigation/registration. From these data, many derived products can be generated, for either direct use or in numerical weather prediction models. This talk will showcase ABI’s improved temporal, spectral and spatial attributes, with special emphasis on the rapid scan (1-minute refresh) capabilities, using data during the post-launch test phase. The information from the ABI on the GOES-R series will be used for many applications including severe weather, tropical cyclones and hurricanes, aviation, natural hazards, the atmosphere, oceans, and the cryosphere.

1705010 GOES-R Readiness in Canada - Part 1
GOES-R Product Readiness: Post-Launch Product Testing Status of the L2+ Algorithms
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The first satellite in the NOAA Geostationary Operational Environmental Satellite R-Series, now GOES-16, launched in November 2016. GOES-16 ABI provides enhanced spectral, temporal, and spatial information and with deployment of a new system with new capabilities, user readiness becomes an increasingly important activity. The GOES-R Product Readiness and Operations (PRO) team is tasked to work with our partners at the National Weather Service and within NESDIS to ensure products (both Level 1 and Level 2) are ready for operations and the user community is ready and are receiving and disseminating the various products to serve their needs and requirements.

With the launch of GOES-16, the GOES-R PRO team worked with our algorithm developers to develop comprehensive plans for testing during Post Launch Product Testing (PLPT) for Level 2 products. During this presentation, we will provide a high-level overview of the status of the PLPT for L2+ algorithms along with an update on L2+ system performance.

1705010 GOES-R Readiness in Canada - Part 1
Preparing the Meteorological Service of Canada for GOES-R
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The Meteorological Service of Canada (MSC) operates and maintains a satellite reception network to receive and process data which is broadcast directly from the geostationary GOES satellites, in order to provide near real-time imagery for the MSC weather and environmental forecasting programs.
GOES-R is program name for the next generation of the U.S. geostationary weather satellites, with the first satellite scheduled having launch in November 2016. The second satellite is called GOES-S and will launch in 2018. With GOES-R there will be a major leap forward in terms of technology, observations, data delivery and derived products – thus requiring a level of preparation not experienced in over 20 years.
To prepare for the transition to the next-generation GOES-R satellites, in 2016 the MSC initiated a project to coordinate, develop and implement the activities necessary to ensure program readiness. The details of the overall 'MSC GOES-R Readiness Project' will be presented, with a focus on data access and data processing.

1705011 GOES-R Readiness in Canada - Part 2
Anticipating GOES-R impact in weather prediction using HIMAWARI-8 and METEOSAT-10 data
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HIMAWARI-8 and GOES-R meteorological imagers are nearly identical, consisting of 16 channels. Therefore, the evaluation of HIMAWARI-8 data impact in assimilation cycles provides a good indication of what to expect from GOES-R. In a recent implementation at the Canadian Meteorological Center, wind observations from HIMARAWI-8 were assimilated in replacement of equivalent products from MTSAT-2. The superiority of the newly available winds was demonstrated along with their positive impact in forecasts. This is due to improved image quality in terms of spatial and temporal resolution as well as calibration. Similarly the HIMAWARI 6.2 micron water vapor channel replaced the equivalent channel from MTSAT-2. The next step is to assimilate three water vapor channels instead of one from HIMAWARI-8 and two from METEOSAT-10. Results from that experiment will be presented at the conference. At that time, we also hope to present first results on an offline evaluation of GOES-R wind and radiance products based on comparisons between observations and short term forecasts.

1705011 GOES-R Readiness in Canada - Part 2
GOES-R and Himawari-8 Training using SIFT
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The Satellite Information Familiarization Tool (SIFT) is a python-based tool developed at the Space Science and Engineering Center (SSEC) at the University of WIsconsin-Madison; it uses the GPU of laptop

computers to provide fast animation, reprojection, and pan and zoom capability of multi-spectral satellite data. Software tools include probing and density diagrams. SIFT has been used to educate forecasters in the US National Weather Service to better understand the multispectral capabilities of the AHI and ABI imagers and SIFT is available in all forecast offices. This talk will use examples from training to showcase how the software can illustrate to forecasters important new capabilities available with the latest geostationary imagers on GOES-16 and Himawari.

1705011 GOES-R Readiness in Canada - Part 2
Validation of the GOES-R Geostationary Lightning Mapper over Canada
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The new NOAA GOES-R/S satellites have a Geostationary Lightning Mapper (GLM) included as part of the instrument suite. The GLM will provide total lightning (cloud-ground + in-cloud) data over southern Canada at a nominal resolution near 10 km. Data from ECCC's Southern Ontario Lightning Mapping Array (SOLMA) centred over the Toronto area will be used by NOAA for systematic GOES-R GLM validation purposes over the period March to November, 2017. In addition, at four locations across Canada (central AB, southern MB, southern ON, eastern NL), ECCC will undertake 'deep dive' comparisons between GLM and Canadian Lightning Detection Network (CLDN) data for individual storm cases over that same period. A three-way comparison between GLM, CLDN and SOLMA will be undertaken in the Toronto area. In all cases, particular attention will be paid to differences in detection efficiency, the impact of GLM resolution, and GLM geolocation errors associated with satellite parallax issues. Detailed information related to the validation project will be presented.

1705011 GOES-R Readiness in Canada - Part 2
Use of GOES-16 High Resolution Data to Nowcast Thunderstorms
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The GOES-16 satellite was launched on Nov 19, 2016 and the data will soon become available to Meteorological Service of Canada (MSC) forecasters for use on the operational desk. GOES-16 is the first of a series of new geostationary weather satellites to be launched over the next 10 years. The Advanced Baseline Imager (ABI) aboard the GOSE-16 delivers 16 spectral channels with higher spatial and temporal resolutions than the legacy series. This high quality satellite data can help operational forecasters improve short-range weather forecasts and warnings. In addition, it helps researchers develop a better nowcasting system.

1705011 GOES-R Readiness in Canada - Part 2
GOES-R Training in the Meteorological Service of Canada (MSC)
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The first satellite in the GOES-R Series was launched on November 19th, 2016. Once it reached its checkout orbit it was renamed GOES 16. MSC's Training and Career Development Division's (TCDD) GOES-R training team has created bilingual training material on the mission, the two primary meteorological

instruments and their products. This foundational material is designed with a Canadian flavour and resides on the TCDD's Moodle learning management system. The training emphasizes a thorough knowledge of the Advanced Baseline Imager (ABI) and the Geostationary Lightning Mapper (GLM), and an understanding of the data reduction methods. This talk will describe the existing training material and outline plans for hands-on training which will make use of ABI and GLM test and evaluation data.

1705011 GOES-R Readiness in Canada - Part 2
Geostationary Fire Detection Using the GOES-R Series Advanced Baseline Imager
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Geostationary fire detection and characterization has been available 24/7 since 2002 when the Wildfire Automated Biomass Burning Algorithm (WFABBA) was made an operational product by NOAA/NESDIS (National Oceanic and Atmospheric Administration/National Environmental Satellite, Data, and Information Service). The WFABBA produces fire location and characterization data for all data received from current GOES, as well as Meteosat Second Generation, COMS, and the Advanced Himawari Imager (AHI) on Himawari-8. The experience with current generation geostationary platforms informed the requirements for the Advanced Baseline Imager (ABI) on GOES-R, and the WFABBA was adapted to the instrument and is a baseline product (under the name Fire Detection and Characterization Algorithm [FDCA]). The WFABBA's legacy as an algorithm for multiple instruments allows for excellent continuity as we transition to the new generation of geostationary imagers represented by ABI and its fraternal twin, AHI. While considered experimental until the end of extended validation in early 2018, the FDCA is available for examination today. ABI and AHI have 2 km pixels and scan rates as fast as every minute, though typically fires are available from ABI at five minute intervals. Cases from current GOES, GOES-16 ABI, and Himawari-8 AHI, including a case with one minute GOES-14 data from the Fort McMurray fire, will be presented to illustrate the performance and utility of geostationary fire detection in Canada (from current GOES and ABI) and in Asian locations at similar latitudes (from AHI).

1705020 Clouds: Microphysics, Aerosols, and Radiation
Internal Mixing of Black Carbon Aerosols and Its impact on Climate
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Black carbon (BC), a strong absorber of solar flux in the atmosphere, can have contributions to the direct and indirect radiative forcing. In the real atmosphere, BC is usually mixing with sulfate aerosol. However, most of the current climate models treat the two kinds of aerosol separately. A partly internal mixing (PIM) treatment of BC and sulfate is introduced. The influences of PIM treatment on effective radiative forcing of aerosol-radiative interaction (ERFari) and global temperature was studied and compared to those of external mixing (EM) treatment by using an aerosol-climate online coupled model. ERFari due to the three anthropogenic aerosols since pre-industrial era was thus obtained to be -0.34 W m-2 for EM case and -0.23 W m-2 for PIM case, respectively. Consequently, the global aerosol radiative effect is reduced.

1705020 Clouds: Microphysics, Aerosols, and Radiation

A sensibility study of the impacts of ice multiplication process in predicting high ice water content condition by Canadian high-resolution NWP model

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Knowledge of the existence, and the locations, of high ice water content (HIWC) conditions within mesoscale convective systems would benefit safety of operation of commercial aviation. One way of attempting to predict HIWC conditions is with high-resolution numerical weather prediction (NWP) models. This study explored the potential role of ice multiplication processes on formation and maintenance of HIWC conditions by Environment and Climate Change Canada's Global Environmental Multiscale (GEM) model. GEM's inner-domain was set to (~250 km)2 at 0.25 km horizontal grid-spacing. Simulations were for 16-May-2015 over French Guiana and included an ascending A-Train satellite track. Data from CloudSat's cloud-profiling radar, CALIPSO's cloud-aerosol lidar, and MODIS's spectroradiometer on Aqua were compared to data either simulated directly by GEM or produced via application of the COSP instrument simulator to GEM data. Observations made from the Canadian NRC Convair-580 and French SAFIRE Falcon-20 aircraft, which flew along CloudSat's path, were also used. Both aircraft were equipped with a suite of remote sensing and in situ cloud microphysical instruments. Results will be shown using GEM's conventional, and regularly used, cloud microphysical scheme, as well as a modified GEM version with a different approach in modeling the ice multiplication process.

1705020 Clouds: Microphysics, Aerosols, and Radiation

Sensitivity of Tropical Cyclone Intensification to Axisymmetric Heat Sources: The Role of Different Microphysical Properties

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Latent heat release from condensational heating has been recognized as one of the dominating energy sources of a tropical cyclone. Here we argue that other microphysical processes may also be of importance. Through the use of a real case WRF simulation of Hurricane Katrina we first identify some microphysical processes that are of similar magnitude as the condensational heating. From this we found that evaporational cooling and melting of some frozen hydrometeors radially outside of the eyewall region are commonly seen throughout the simulation. Idealized experiments are then performed using a heating and cooling function that is motivated from the Hurricane Katrina run. It is seen that the addition of cooling enhances the lower level inward radial winds which results in an acceleration of the lower level tangential winds through the enhanced advection of absolute vorticity. Sensitivity tests to the location of the heating and cooling function in addition to the background state of the vortex (such as changes to the inertial and static stability, as well as the baroclinicity) are performed.

1705020 Clouds: Microphysics, Aerosols, and Radiation

Impact of Saharan dust aerosols on radiation and cloud microphysics over the tropical east Atlantic Ocean

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Aerosols affect the atmospheric processes by interacting with shortwave and longwave radiations and also by modifying the cloud microphysics (direct and indirect effects respectively). This study examined the direct and indirect effects of the Saharan dust plumes through numerical simulation experiments. Simulations were conducted for July 1-31, 2010 using the Weather Research and Forecasting model coupled with Chemistry module (WRF-Chem). The model domain is located in the downstream of the Sahara desert covering the tropical east Atlantic Ocean. Simulation results show that the net direct radiative effect of dust without any cloud feedback is warming inside the atmosphere and cooling at the top of the atmosphere and at the surface. When the dust indirect effects were included in the simulations, presence of dust as a Cloud Cloud Condensation Nuclei (CCN) increased the cloud droplet concentration while reducing their sizes. Low level cumulus clouds below the maximum dust layer were reduced while the domain wide deeper cumulus clouds were enhanced. The accumulated precipitation rate at the surface showed time lag indicating a delay in precipitation start with the presence of dust particles.

1705020 Clouds: Microphysics, Aerosols, and Radiation

Measuring and Modeling Nonlinear Diffusion in Single Aerosol Particles

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Understanding hygroscopic properties of secondary organic aerosols can significantly contribute to their accurate parameterization and representation in air quality and climate modeling. In the present study, we model nonlinear water sorption of single viscous aerosol particles. We analyze the changes in the composition of a particle during the condensation process under varying relative humidities. Results indicate that at higher RHs, a sharp boundary or a diffusion front exists between the inner core and outer shell that moves towards the center of particle during the sorption. This finding suggests the existence of core-shell morphology in the viscous particles which can strongly impact the diffusion kinetics. Specifically, we observe that diffusion lifetime can change several orders of magnitudes from low to high RHs. Another goal of this work is to better understand how the gradients in composition and the core-shell morphology can change the scattering of electromagnetic radiation by a single particle. It is noticed that the morphology-dependent resonances (MDRs) mode positions shift to higher wavelengths in condensation process. From simulation data, the most sensitive region to refractive index gradient is found to be very close to the particle surface. We also develop an optical model to track diffusion in viscous particles using their modes in scattered MDRs. The mode peaks from common multi-layered coupled diffusion-scattering model can be well presented using our single core-shell model. This allows lifting up the complexity associated with traditionally numerical calculations of scattering coefficients of a non-homogeneous particle. The result of this study will help understanding the composition dependency of resonance waves from non-homogeneous particle light scattering.

1705020 Clouds: Microphysics, Aerosols, and Radiation

Turbulence effect on cloud droplet collision: how does the droplet size distribution evolve in cumulus clouds?

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As a major feature in warm cumulus clouds, turbulence has long been postulated to accelerate the droplet collision-coalescence process to shorten the time for warm rain initiation. In both stochastic models and direct numerical simulation (DNS) experiments, significant turbulent enhancement of the geometric collision kernel has been observed. However, the inclusion of hydrodynamic effects, which affect the collision efficiency, are relatively rare in DNS studies. As a result, there are few definitive results on the evolution of droplet size distribution (DSD) in warm cumulus from DNS experiments.

We developed a DNS model to simulate the droplet collision-coalescence process inside adiabatic cloud cores where turbulence is assumed homogeneous and isotropic. The model explicitly resolves the droplet disturbance flow by applying the Stokes flow solution around the droplet using an improved superposition method proposed by Wang et al. (2005). Cloud droplets of radii from 5 to 25 microns are investigated.

In this presentation, I will share with you our recent model result on droplet collision efficiency and how it changes with different turbulence environments. Possible DSD broadening mechanism by turbulence is proposed. In the end, case studies on DSD evolution initiated with realistic cloud conditions will be shown to testify our proposed theory.

1705030 Recent Advances in Remote Sensing of the Atmosphere - Part 1

An intercomparison of simultaneous island and aircraft overflight observations of aerosols and trace gases as part of the NASA North Atlantic Aerosols and Marine Ecosystems Study (NAAMES).

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Moore, Richard - NASA
Wilson, Alan - Environment and Climate Change Canada
Barnett, Thomas - Dalhousie University
Qadoumi, Haya - Dalhousie University
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Volatile organic compounds (VOCs) emitted by phytoplankton, and associated secondary cloud condensation nuclei (CCN), play an important role in the formation of clouds that mediate climate. However, they are not well quantified due to a lack of long-term sampling platforms in the marine environment. Meteorology, VOCs, criteria gases and size-resolved particle number, mass and chemistry measurements have been ongoing on Sable Island since 2013. Sable Island is a sand bar 300 km east of Nova Scotia, Canada. In 2015, this study was absorbed into the NASA North Atlantic Aerosols and Marine Ecosystems Study (NAAMES). NAAMES is an interdisciplinary investigation resolving key processes controlling marine ecosystems and aerosols that are essential to our understanding of Earth system function and future change. NAAMES utilizes a C-130 airborne laboratory equipped to characterize aerosols and measure trace gases, as well as measurements from the R/V Atlantis and satellite measurements. The GEOS-Chem chemical transport model is also utilized to provide 2D horizontal and 2D curtain estimates of various atmospheric components, e.g., sea salt and SO_4. During May 2016, the NAAMES C-130 conducted 12 overflights of Sable Island. The mean (min : max) metric observations from Sable Island during the overflight were as follows: VOC = 1871.3 (0 : 20,029) ppbv, Ultrafines 268 (0 : 35,441) #/cm3, PM10 13.0 (0 : 127) µg/m3. A comparison of the observations on Sable Island with the aircraft laboratory measurements will be presented, together with

associated ocean colour and meteorological features. The measurements on Sable Island are important for providing a long-term data set that can fill in the gaps between the four NAAMES missions. Collectively these data will provide new insights into seasonal ocean phytoplankton dynamics, fluxes of VOCs from the ocean, CCN, fog and cloud formation and ultimately a finger on the pulse of climate change.

1705030 Recent Advances in Remote Sensing of the Atmosphere - Part 1

Spatiotemporal Variability of Ammonia over North America from CrIS Satellite Observations

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Ammonia (NH3) is essential for agricultural activities and is one of the most important reactive nitrogen species in any ecosystem. Ammonia reacts quickly in the atmosphere with acidic species (i.e. nitric acid and sulfuric acid from NOx and SOx) to produce a significant fraction of fine mode particulate matter (PM2.5), which is associated with negative health impacts. Emissions of NH3 from anthropogenic activities have largely been unregulated globally and have increased ~4x since pre-industrial times; they are also the only sources of PM2.5 emissions that are projected to continue increasing throughout the next century. Despite its current and future there are still large uncertainties in our knowledge of the sources and spatiotemporal distributions of ammonia. However, recent satellite observations are providing a greater understanding of its emission sources, atmospheric transport, and deposition. Presented are initial results from our recently developed CrIS Fast Physical Retrieval (CFPR) NH3 satellite algorithm, which uses an optimal estimation approach that along with the retrieved profile provides a measurement of vertical sensitivity (averaging kernels) and an estimate of the retrieval errors. These results include spatiotemporal maps of ammonia across North America that highlight the emissions from agriculture practices and forest fire. Also provided are examples of using the spatiotemporal coverage of these CrIS satellite observations to constrain and evaluate Chemical Transport Models ammonia processes (e.g. bi-directional flux) and their input emissions (e.g. temporal profiles).

1705030 Recent Advances in Remote Sensing of the Atmosphere - Part 1

Impact of far infrared measurements on analyses of temperature and humidity

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Data assimilation optimally combines numerical weather predictions and large amounts of observations to obtain the analysis which is the best linear unbiased estimate of the state of the atmosphere. In this context, current observations comes mostly from satellites instruments and many of which comes from infrared sounders in the thermal infrared, such as AIRS and IASI. However, the thermal infrared only constitutes half of the Earth's emitted radiance, the other half being the far infrared, ranging from 15 to 100 ?m. Measurements in the far infrared from space were taken more than 40 years ago by Russian and American spacecrafts. However, in recent years, some theoretical studies have shown the added-value of far infrared observations for remote sensing of water vapor and clouds, especially in dry and cold regions. Furthermore, other studies based on radiative transfer models have investigated hyperspectral infrared sounders similar to

AIRS and IASI but with an extended spectral coverage to include the far infrared. They concluded that the added-value depends on the sensitivity of the sensors, which is beyond what current technology can offer. However, radiometers can provide measurements in the far infrared over broader bands which increases the signal-to-noise ratio. This study serves as a basis for the development of the future satellite mission TICFIRE (Thin Ice Clouds in Far IR Experiment). The added value of different configurations of this instrument can be measured through information content they bring to the analysis for temperature and humidity. In this presentation, configurations have been evaluated which differ in terms the number of bands and their positioning.

1705031 Recent Advances in Remote Sensing of the Atmosphere - Part 2

CO2 profile retrieval from near-infrared spectra

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The Total Carbon Column Observing Network (TCCON) is composed of high resolution ground-based Fourier transform spectrometers. Their spectra can be used to retrieve the column-averaged dry-air mole fraction of CO_2 (XCO_2), and other trace gases. TCCON measurements are used to validate satellite observations.

Variations in XCO_2 are partly driven by local surface fluxes of CO_2, and partly by transport from remote locations. Even though XCO_2 observations are precise, they lack information about the vertical distribution of CO_2 in the atmosphere, which is of interest for the validation of satellite measurements and model simulations.

The GFIT non-linear least-squares spectral fitting program is used for TCCON retrievals. A forward model computes an atmospheric transmittance spectrum using a priori knowledge of atmospheric conditions. An inverse method then compares the measured spectrum with the resulting calculation, and adjusts the retrieved parameters to obtain the best fit. In GFIT, the parameters include volume mixing ratio (VMR) scale factors for the different fitted gases. A single scale factor scales the a priori concentration profile of a given trace gas. GFIT2 is an algorithm being developed to compute CO_2 profile retrievals on TCCON spectra. GFIT2 allows the profile shape to vary during the retrieval process. The algorithm has thus more freedom to fit the observed spectra, but it is also more sensitive to uncertainties in the forward model calculations caused by spectroscopic errors and instrument misalignment, for example.

Steps to improve CO_2 profile retrievals will be presented. A more complex forward model including a speed-dependent Voigt line shape with line mixing is used, and a method to combine CO_2 retrieved in spectral bands of various opacities is being tested.

1705031 Recent Advances in Remote Sensing of the Atmosphere - Part 2

Calibrating Water Vapour Mixing Ratio Measurements from the MeteoSwiss RAman Lidar for Meteorological Observations (RALMO) using a Radiosonde Trajectory Method

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Water vapour is the dominant greenhouse gas in our atmosphere and plays a prominent role in atmospheric chemistry and dynamics. With only 50% downtime from 2007-2016, the RALMO is the only lidar with

almost 9 years of nearly continuous water vapour measurements. These measurements will be processed into a multi-year water vapour climatology using the OEM method introduced by Sica and Haefele 2016. The OEM requires a precise knowledge of the water vapour calibration factor. However, the RALMO water vapour calibration factor has shown a measurable drift over the course of the operational period (Dinoev et al., 2013). We present an improved method of finding the calibration factor as well as its evolution.
This improved lidar calibration method is based on the radiosonde tracking methods presented in Whiteman et al. 2006 and Adam et al. 2010. However, unlike Whiteman et al. and Adam et al., the wind speed and direction are considered for each altitude bin. This calibration technique systematically accounts for the displacement of the Vaisala RS92 radiosonde from the lidar, thereby increasing the validity of the calibration when other instruments such as a microwave radiometer are not available. We compare this new "trajectory method" with the standard water vapour lidar calibration technique of integrating a 30 minute profile from the time of radiosonde launch. Unlike the standard method, the trajectory method considers the wind speed and direction as well as the radiosonde position to determine an appropriate integration time as a function of altitude. A preliminary comparison of the two methods shows that the difference between the two calibration coefficients is statistically significant by a factor of 7 sigma. The traditional method produces a larger fitting region due to larger SNR values at higher altitudes; however, the trajectory method produces a profile closer to the radiosonde.

1705031 Recent Advances in Remote Sensing of the Atmosphere - Part 2

The Purple Crow Lidar Middle Atmospheric Temperature Climatology Using the Optimal Estimation Method

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Rayleigh measurements from the Purple Crow Lidar (PCL) facility located near The University of Western Ontario have been used to develop the atmospheric temperature climatology from 1994.
Temperature retrievals from Rayleigh-scattering lidar measurements have been performed using the algorithm given by Hauchecorne and Chanin (1980; henceforth HC) for the last 3 decades. The HC method integrates temperatures downward, and requires the assumption of a "seed" pressure at the highest altitude, taken from a model. Geophysical variation in the lower thermosphere is sufficiently large to cause temperature retrievals to be unreliable for the top 10 or more km. Uncertainties due to this pressure assumption make it prudent, without ancillary measurements, to remove the top two scale heights of temperatures from each profile to be discarded. Recently Sica and Haefele (2015) have presented an Optimal Estimation Method (OEM) to retrieve atmospheric temperature profiles and they found that it had many advantages over the other technique. Unlike the HC method, which included estimates of random uncertainty, the OEM produces a complete uncertainty budget for all effective parameters in the retrieval procedure. Also, the OEM determines a valid cut-off height in the retrieval procedure missing in the traditional analysis. The PCL consists of two Rayleigh channels to measure temperature from 24 km to 110 km. These channels overlap with each other. To create a single temperature profile from different lidar channels' measurements using the HC method, their profiles had to be merged. The OEM provides an easy way to incorporate data from multiple sources, such as combining lidar measurements from different channels.
This presentation will show the PCL temperature climatology using the OEM for the 500+ nights Rayleigh measurements, including the quantitative determination of the top altitude of the retrieval and the evaluation of the various systematic and random uncertainties.

1705031 Recent Advances in Remote Sensing of the Atmosphere - Part 2

The Application of the Optimal Estimation Method (OEM) for Tropospheric Rotational Raman Temperature Retrieval

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We present the first application of the Optimal Estimation Method (OEM) to directly retrieve atmospheric temperature from the raw pure rotational Raman (PRR) backscatter lidar measurements. The OEM is an inverse method that requires specifying a forward model capable of reproducing the measurements. The OEM provides an estimate of both random and systematic uncertainties on a profile by profile basis. Unlike in the traditional Raman temperature retrieval method introduced by Cooney (1972), we do not require an approximation for the lidar calibration function consists of two or more calibration coefficients to determine the temperature. We have developed a forward model to apply the OEM and used this model to successfully retrieve temperatures from the synthetic lidar profiles based on, lidar measurements from the Raman Lidar for Meteorological Observations (RALMO) located in Payerne, Switzerland. The OEM temperature retrievals for day and nighttime measurements agreed to the true temperature profiles provided to the simulations within 1 K and 3 K standard deviations respectively. Currently background noise and the lidar calibration constant can also be retrieved using the OEM with less than 1% uncertainty. We have begun applying the method to the actual RALMO measurements and are including the ability to retrieve the lidar's overlap function. In the future we will apply the OEM to the PRR lidar measurements from other lidars, including the CANDAC Rayleigh - Mie- Raman Lidar (CRL).

1705031 Recent Advances in Remote Sensing of the Atmosphere - Part 2

Far InfraRed Radiometer Arctic campaign

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More than 50% of the earth emission occurs in the Far infrared spectrum. Even so there is currently no space base instrument doing spectrally resolved measurement in those wavelengths. Theoretical work has shown the added-value of such measurement on various applications such as water-vapour retrieval and optical properties of ice clouds.

Through the polar night most of the radiative balance is driven by the IR and FIR and a small variation of water vapour content can lead to a strong cooling effect of the surface and the atmosphere. Furthermore, remote sensing observations from CALIPSO and CloudSat satellites over the Arctic have enlighten the existence and properties of thin ice clouds (TIC). Those clouds act as an effective radiator over the whole troposphere and are still misunderstood. Water cycle in the Arctic and longwave radiative flux are strongly entangle.

FIR measurements could fill a lack of observations during arctic winter and help enhancing current observations of TIC. To allow further studies, a new passive remote sensing is in development. The TICFIRE satellite project aims to better understand the formation processes of ice clouds as well as the water cycle at the pole.

In this presentation, we show the results of the first ground experiment using a new instrument prototype, the Far InfraRed Radiometer (FIRR) located at Eureka, NU (79°59?20?N 085°56?27?W). The FIRR is an uncooled micro-bolometer measuring radiance in 9 broad bands channels spanning from 8 to 50 micron. This spectral region is really sensitive to the water vapour content and the effective diameter of ice crystals. By comparing these measurements with the E-AERI and other collocated instruments, we aim to assess the radiative accuracy of this technology as well as is sensitivity to the state of the atmosphere.

1705031 Recent Advances in Remote Sensing of the Atmosphere - Part 2

Balloon demonstrator imaging Fourier transform spectrometer for the measurement of methane and carbon dioxide

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The Arctic multi-year ice cover is disappearing more rapidly than climate models estimate and the arctic climate is also changing. With declining ice cover, the Arctic Ocean will be subject to increased shipping traffic and exploration activity for natural resources with a concomitant increase in air pollution. Thus, there is a multifaceted need to monitor the polar region. A number of Canadian government departments, led by the Canadian Space Agency (CSA), are proposing the Polar Communications and Weather (PCW) satellite mission to provide improved communications and critically important meteorological and air quality information for the Arctic using an operational meteorological Imager. This paper will focus on the development of a demonstrator Imaging Fourier Transform Spectrometer (IFTS) to be flown on a high-altitude balloon to demonstrate the capacity to measure atmospheric mixing ratios of methane and carbon dioxide and the Oxygen A-band in near space conditions. The interferometer has two individual channels centred at 762 nm and 1650 nm. The Laboratory for Atmospheric Remote Sounding from Space (LARSS) at York University is developing the IFTS payload and ABB of Quebec City has developed the core of the interferometer.

Funding is now in place to develop the demonstrator IFTS to show that images of methane and carbon dioxide can be collected from space. The characteristics of the instrument and plans for the balloon flight will be discussed. The author wishes to acknowledge support of the PHEOS-WCA science team.

1705040 The Changing Arctic Atmosphere from IPY to YOPP - Part 1

Seasonality of the Arctic temperature inversion and its dependence on sea ice

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The Arctic atmosphere is characterized by a pervasive low-level temperature inversion, resulting from the balance of surface heat fluxes, as well as upper-level atmospheric heat fluxes from the mid-latitudes. With a diminishing sea ice cover, surface heat fluxes are modified, with potential impacts on stability related climate processes and feedbacks. Using reanalysis and GCM data, we find a strong seasonal signal in projected inversion changes, with significant decreases and increases during the winter and summertime, respectively. Wintertime decreases are shown to be linked to a decrease in sea ice thickness, whereas summertime increases are related to atmospheric warming in regions of ongoing sea-ice melt. While these results show the importance of sea ice for the strength of Arctic inversions, a large part of the variability at short temporal and spatial scales is left unquantified. Preliminary analysis of the atnospheric contribution to inversion variability show large spatial variability in their frequency and life-time, and suggests an important link with the location and frequency of synoptic scale systems.

1705040 The Changing Arctic Atmosphere from IPY to YOPP - Part 1
Aerosols as Arctic Climate Forcers
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The Arctic climate has undergone rapid changes in recent decades and is widely expected to continue to change in the near future. Aerosols have contributed to multi-decadal Arctic climate variability in various ways. In particular, a positive radiative forcing of black carbon aerosols at the top of the atmosphere provides opportunities for mitigation actions aimed at reducing Arctic warming. Politically, action on black carbon may be particularly promising because the benefits of mitigation are seen more quickly than for mitigation of CO2 and there are co-benefits in terms of improved air quality. The Arctic Monitoring and Assessment Programme recently assessed impacts of black carbon emissions on Arctic climate based on several models, including a new version of the Canadian atmospheric global climate model with improved aerosol modeling capabilities. It was determined that black carbon emissions within Asian nations represent a large source of Arctic warming. On the other hand, the Arctic is most sensitive, per unit mass emitted, to emissions from Arctic nations themselves. However, considerable uncertainties still exist with regard to impacts of aerosols on Arctic climate given that key atmospheric and aerosol processes both within and outside of the Arctic are still poorly understood.

1705040 The Changing Arctic Atmosphere from IPY to YOPP - Part 1
Far IR Spectral Measurements Applied to Atmospheric Water Cycle and Links to Arctic Aerosols
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The water cycle in the dry and cold Arctic is not well understood, yet it is by far the dominant factor controlling polar climate with strong implications on the midlatitude weather. In particular, optically thin ice clouds (TIC) processes are still poorly represented in atmospheric models. Furthermore, it is now recognized that anthropogenic aerosol can alter cloud microphysics and precipitation. In addition to filling a gap in cloud observation at high latitudes since IPY, the deployment of CALIPSO and CloudSat satellites also highlighted the ubiquity of TIC and aerosol during the polar night. These clouds, sensitive to aerosols via ice nucleation, can significantly modulate the amount of far infrared radiation escaping the Earth, and consequently the temperatures in the upper troposphere. Since their signature in the far infrared is also very sensitive to their microphysical properties (crystals size and shape) and optical depth, these quantities can be retrieved from ground-based and satellite observations. Such measurements in the far infrared (particularly beyond 20 ?m), were until recently constrained by technical limitations, but recent advancements in microbolometers technology at Institut National d'Optique (Québec) has allowed to study this under-explored spectral region. Theoretical calculations demonstrate that the far infrared spectrum of the atmosphere could provide valuable information for weather forecast data assimilation and climate simulations, about its water vapour content, the microphysical characteristics of ice clouds and common light precipitation, especially in dry and cold regions. In view of YOPP, with the Canadian Space Agency and in collaboration with NETCARE, PAHA and AVATAR, we have initiated new measurements in the mid and far IR range (8-50µm) to advance our knowledge of the water cycle in the High Arctic with the deployment of the Far IR Radiometer (FIRR). We present here the first results from the FIRR, which is meant for the airborne and surface measurements of ice clouds in view of validating the users' requirements for a future satellite instrument. The results of new ground-based measurements with potential applications to Canadian Arctic stations are also presented.

1705040 The Changing Arctic Atmosphere from IPY to YOPP - Part 1
Land-atmosphere interactions of thawing boreal forest-wetland landscapes in northwestern Canada
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Boreal landscapes in the Taiga Plains of northwestern Canada store large amounts of soil organic carbon (C) and play an important role in the regional and global climate system. Warming-induced permafrost thaw in organic-rich lowlands causes expansion of permafrost-free wetlands at the expense of boreal forests. To better understand how these land cover changes affect land-atmosphere interactions, we combine nested eddy covariance measurements of water, energy, CO2 and CH4 fluxes from a thawing boreal forest-wetland landscape with flux footprint and planetary boundary layer modeling, remote sensing data, paleoecological records, and climate projections.
Thaw-induced forest loss modifies land-atmosphere energy fluxes through changes in aerodynamic and ecophysiological surface properties. Increasing albedo decreases available energy, while decreasing surface roughness and increasing wetness enhance latent heat at the expense of sensible heat fluxes. These energy flux changes indicate a regional cooling while enhancing atmospheric humidity.
Thaw-induced wetland expansion increases landscape CH4 emissions inducing a positive net radiative greenhouse gas forcing. The current wetland expansion rate (0.26±0.05 % yr-1) increases landscape CH4 emissions by 0.034±0.007 g CH4 m-2 yr-1. Long-term net CO2 uptake typical of these landscapes (50 – 150 g CO2 m-2 yr-1) are too small to compensate the associated climate warming effect until the end of the 21st century.
The thawing landscape acts as net annual CO2 sink (73±22 g CO2 m-2 yr-1, 2015-2016). Landscape net CO2 uptake does not change with wetland expansion, as enhanced gross primary productivity (GPP) is compensated by increased ecosystem respiration (ER). In contrast, direct impacts of increasing air temperatures and decreasing incoming shortwave radiation on net CO2 fluxes appear to be larger. For a high warming scenario, modeled increases in ER exceed increases in GPP significantly, inducing a net annual CO2 release. For a moderate warming scenario, ER and GPP increases are of similar magnitude.

1705041 The Changing Arctic Atmosphere from IPY to YOPP - Part 2
Characterization of the chemical, physical and optical properties of atmospheric aerosols in the Canadian High Arctic
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Atmospheric aerosols, i.e. particulate matter (PM), are a major source of uncertainty in climate models. Due to this uncertainty, it is important to analyze the correlation between the composition, the physical properties (e.g. particle size) and the optical properties of atmospheric aerosols using different instruments. In the Arctic, climate change is much more rapid than the global mean, highlighting the important need for atmospheric measurements in this region. To this end, field measurements of the composition of atmospheric aerosol are currently being performed at the Polar Atmospheric Environment Research Station (PEARL) in Eureka, Nunavut (80N, 86W) to characterize aerosols in the Canadian High Artic. The instruments deployed include two PAXs (Photoacoustic Extinctiometers) that measure aerosol light scattering and absorption at 870 nm and at 405 nm, an AMS (Aerosol Mass Spectrometer), an OPC (Optical Particle Counter) and a SMPS (Scanning Mobility Particle Sizer). Using the data obtained from these instruments, which have been operational since August 2015 until today, it is possible to observe changes in aerosol size distributions and aerosol concentrations as well as concomitant changes in the optical characteristics of aerosols.

1705041 The Changing Arctic Atmosphere from IPY to YOPP - Part 2

Sources and sinks of ammonia in the summertime arctic boundary layer: spatial and temporal variability

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Ammonia (NH3) is the primary alkaline trace gas in the troposphere and knowing its sources and sinks is essential for understanding the role of NH3 in aerosol formation. Especially in remote areas, such as the Arctic, data on NH3 is sparse and even small sources of NH3 may have a significant impact on the NH4+ aerosol abundance. Known regional sources of NH3 in the Arctic summertime include migratory seabird colonies and northern wildfires, whereas the Arctic Ocean is a net sink. Motivated by the lack of in situ NH3 measurements in the Arctic, NH3 measurements were collected using online ion chromatography (AIM-IC) and laser spectroscopy (QC-TILDAS) techniques in both marine and terrestrial environments. The marine atmosphere in the eastern Canadian Arctic was investigated onboard the CCGS Amundsen in summer 2014 and 2016. Median NH3 mixing ratios measured from the ship were 0.22 ppbv in 2014 and 0.14 ppbv in 2016. High time resolution measurements in 2016 revealed short episodes of significantly higher NH3 levels reaching up to a few ppbv, suggesting a local source of atmospheric NH3, which might be emissions from seabird colonies. Ocean-atmosphere exchange of NH3 was quantified using measurements of sea surface water NH4+ concentrations, showing uptake of NH3 by the Arctic Ocean in both years. In summer 2016, NH3 was measured at a tundra site in Alert, NU, revealing a median NH3 mixing ratio of 0.22 ppbv. Measurements of soil NH4+ content and pH showed that the tundra can also act as a source for atmospheric NH3 under certain conditions. The loss of atmospheric NH3 through wet deposition was quantified in both 2016 campaigns. Finally, GEOS-Chem model results and back trajectories are used to discuss the sources and sinks of NH3 and the spatial and temporal variability between the three measurement campaigns.

1705041 The Changing Arctic Atmosphere from IPY to YOPP - Part 2

Identifying long-range transport of wildfire emissions to the Arctic using a network of ground-based FTIR spectrometers, satellite observations, and transport models

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We present a multi-year time series of the total column amounts of carbon monoxide (CO), hydrogen cyanide (HCN) and ethane (C2H6) obtained by Fourier Transform Infrared (FTIR) spectrometer measurements at ten sites. Six are high-latitude sites: Eureka, Nunavut (80.05°N, 86.42°W); Ny Alesund, Norway (78.92°N, 11.93°E); Thule, Greenland (76.53°N, 68.74°W); Kiruna, Sweden (67.84°N, 20.41°E); Poker Flat, Alaska (65.11°N, 147.42°W); St. Petersburg, Russia (59.88°N, 29.83°E) and four are mid-latitude sites: Bremen,

Germany (53.1°N, 8.8°E); Zugspitze, Germany (47.42°N, 10.98°E); Jungfraujoch, Switzerland (46.55°N, 7.98°E) and Toronto, Ontario (43.66°N, 79.40°W).
For each site, enhancements of total column amounts above seasonal means are identified and attributed to wildfire events using HYSPLIT and FLEXPART back-trajectories. Wildfire source locations are identified using the Moderate Resolution Imaging Spectroradiometer (MODIS) fire hot spot dataset while satellite measurements of CO total columns from the Infrared Atmospheric Sounding Interferometer (IASI) illustrate transport of the smoke plume and allow for further confirmation of the observed enhancement. Using the multi-year time series, inter-annual variability of wildfire events is observed. Differences in travel times of the smoke plume between sites allow for ageing of the plume to be determined, providing a means to infer the physical and chemical processes affecting the loss of each species during transport. The varying lifetimes of the species and independent measurements at all sites, along with sensitivities to various source regions given by FLEXPART allow for the transport pathways to the Arctic to be investigated. By accounting for the effect of the ageing of the smoke plumes, the measured FTIR enhancement ratios are corrected to obtain emission ratios and emission factors, which are needed to improve the simulation of fire emissions in chemical transport models.

1705041 The Changing Arctic Atmosphere from IPY to YOPP - Part 2
Using the Optimal Estimation Method (OEM) for Retrieval of Stratospheric Ozone Profiles from DIAL lidar measurements
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The Optimal Estimation Method (OEM) is an inverse method that allows the retrieval of parameters based on measurements and a forward model of the measurement. A complete uncertainty budget on a profile to profile basis, plus the vertical resolution of the measurements as a function of height can be found by this method. We use OEM for the first time to retrieval ozone profiles from a DIAL ozone lidar. The retrievals will be used on measurements from the CANDAC Stratospheric Ozone Differential Absorption Lidar located in Eureka, Canada. We will show results for simulated measurements using one Rayleigh channel. The synthetic pro?les are similar to 3 hours of the real measurements. The ozone is retrieved at 900 m vertical resolution from 7 km to 55 km altitude. The averaging kernel shows essentially no contribution from the a priori below 40 km; above this altitude the response of the averaging kernel drops to 0.8 around 45 km; above which height the retrieval becomes less sensitive to the measurements. The percentage error between the true and retrieved profiles varies between 0.5% to 2% in the region where the retrieval is valid and is less than the statistical uncertainties. In this pilot study background counts are also retrieved. A constant background was used to make synthetic measurements, however, due to the Signal Induced Noise (SIN), the background counts are not constant. We will include the effect of SIN offset on the background counts in the near future. The retrieval is currently being extended to use both of the lidar data channels. Using the two channels, we are planning to retrieve the ozone density profile, the aerosol extinction coefficient, deadtime of the detectors, and the lidar constants. We will then validate the method using measurements of ozone from other instruments, as well as against the traditional DIAL ozone analysis.

1705041 The Changing Arctic Atmosphere from IPY to YOPP - Part 2

A decade of atmospheric composition measurements at the Polar Environment Atmospheric Research Laboratory

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The Polar Environment Atmospheric Research Laboratory (PEARL) is located in the Canadian High Arctic at Eureka, Nunavut (80N, 86W) and is operated by the Canadian Network for the Detection of Atmospheric Change. It has been equipped with a suite of instrumentation to investigate chemical and physical processes in the atmosphere from the ground to 100 km. Research at PEARL is currently being carried out under the Probing the Atmosphere of the High Arctic (PAHA) program. One of three PAHA research themes is that of Composition Measurements, which includes projects investigating greenhouse gases related to the carbon cycle, ozone and related species, and biomass burning and continental influence on the Arctic. Accurate time series of trace gas concentrations are crucial to understanding the processes that determine atmospheric composition and drive atmospheric change. The complementary capabilities of Fourier transform infrared spectrometers and UV-visible grating spectrometers installed at PEARL make it possible to measure many chemical constituents. This presentation will provide an overview of the PAHA CM theme, including highlights from more than a decade of atmospheric composition measurements at PEARL.

1705050 General Session - Atmosphere

The May 4, 2016 Fort McMurray Pyrocumulonimbus

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Data from a variety of sources including weather stations, weather radar, the Canadian Lightning Detection Network (CLDN) and numerical weather prediction data are used to examine a pyrocumulonimbus (pyroCb) event that occurred on May 4, 2016 during the extreme Fort McMurray wildfire in northeastern Alberta. A cold front passage, which destabilized the atmosphere at mid-levels, combined with abundant heat and moisture from the burning vegetation, created conditions favourable for the development of the pyroCb that extended well above the smoke deck. Several hours later, a 15 ms-1 low-level jet at 850 hPa, combined with unstable conditions in the boundary layer, allowed abundant oxygen injection to further fuel the fire and sustain the pyroCb. At 2150 UTC May 4, a radar echo, related to the pyroCb, about 20 km east of Fort McMurray was detected at the Jimmy Lake radar facility. It reached a maximum vertical extent of 12 km by 0020 UTC May 5 before dissipating several hours later. Several episodes of cloud-to-ground lightning flashes associated with this pyroCb were detected by the CLDN. Provincial fire officials subsequently identified four new fire ignitions in the vicinity of this lightning activity. PyroCBs have been observed to produce lightning over many wildfires around the world however, to our knowledge, this is the first reported case of a PyroCb subsequently igniting more fires.

1705050 General Session - Atmosphere

Synoptic controls on orographic precipitation distributions during OLYMPEX

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During the OLYMPEX field campaign in Washington State in winter 2015-16, intensive precipitation and upper-air measurements were obtained within frontal systems crossing the Olympic mountains (a quasi-axisymmetric mountain range of height ~2500 m and radius 50 km). Here, an analysis and interpretation of the observed precipitation distributions during OLYMPEX, as a function of synoptic conditions, is undertaken. The synoptic conditions are categorized as warm-frontal (ahead of a surface warm front), warm sector (between the surface warm and cold fronts), and post-frontal (behind the surface cold front). Six events of each type are selected, for which observed precipitation distributions are retrieved using a combination of operational S-band radars a regional rain-gauge network. Not surprisingly, far greater orographic precipitation amounts are observed during warm-frontal and warm-sector events than during post-frontal events. The warm-sector and warm-frontal events differ in that the former exhibits much greater orographic enhancement, with a maximum shifting closer to the ridge crest. While some of these differences follow directly from differences in upstream flow properties, others are less straightforward. To enhance the physical interpretation, quasi-idealized simulations with the WRF model are conducted. The simulations use the real Olympics terrain, idealized soundings based on the upper-air observations, and a large-scale lifting parameterization to produce realistic background precipitation rates. This latter element represents a significant advancement over past idealized studies of orographic precipitation. Simulations of warm-frontal, warm sector, and post-frontal conditions reproduce the key differences in precipitation distributions between these events. The model data is then intensively analyzed to gain insight into the dynamical and microphysical mechanisms that underlie the observed precipitation distributions.

1705050 General Session - Atmosphere

Source apportionment of aerosols on Sable Island, Nova Scotia, Canada

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Atmospheric particulate matter has been shown to have acute and chronic health impacts, potential to negatively affect ecosystems, and plays an important role in climate forcing through its role in the formation of cloud condensation nuclei. Particle size, morphology, and chemical composition are key in determining the extent of the impacts on populations and the planet. In this study, particulate mass concentration and number counts were measured on Sable Island, Nova Scotia, Canada from October 1, 2015 – December 31, 2016. The United States Environmental Protection Agency Positive Matrix Factorization v5.0 program was used to apportion the particulate matter sources with further evidence provided by air mass back trajectories and satellite observations. It was found that sea spray contributed 43.4% of particulate matter, long range transport from the continent contributed 30.9% of particulate matter, aged biogenic marine emissions/non sea salt sulphate contributed 24.3% of particulate matter, and fresh biogenic marine emissions contributed 1.4% of particulate matter.

1706010 Climate Change, Air Quality and Interconnections to Human Health

Quantifying Environmental Damages from Pavement Management Activities

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This study aims to quantify the health and environmental damages caused by emissions released by pavement management activities in Ontario. The construction, maintenance, and rehabilitation of pavement emits greenhouse gases such as carbon dioxide and pollutants such as particulate matter and sulphur dioxide (SO2) which have significant impacts on human health and the environment. Traditional lifecycle costing methods used in pavement management systems do not account for the cost of these impacts. Improved emissions estimates and estimates of the damages from these emissions were combined with an existing sustainable pavement management framework to calculate the economic cost of health and environmental impacts of

pollutants and emissions from pavement management activities in Ontario. Preliminary estimates of damages caused by particular maintenance strategies may total over $1 million CAD with SO_2 being the largest contributor to damages. These estimates will be combined with lifecycle costs to improve existing pavement management systems. Further uncertainty analyses will be conducted on emission factors and cost data used in the study as well as on calculated damages to improve these results.

1706010 Climate Change, Air Quality and Interconnections to Human Health
Coordinating Climate and Air Quality Policies through Inclusion of Air Quality Co-benefits of GHG Reduction
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Ambitious climate policies have been adopted or are being drafted by the federal government and various provinces across Canada. At the same time, improving air quality to protect public health has been another important policy driver at the provincial and federal levels. While major sources of CO_2 and air pollutants such as particulate matter and ozone are the same, climate and air quality policies have so far been considered independently from each other. A lack of coordination between air quality and climate policies is likely to result in lower cost-effectiveness of the proposed measures to reduce air pollution or CO_2 emissions. One straightforward approach to coordinate climate and air quality policies is to account for air quality "co-benefits" of CO_2 reduction, i.e., to include the ancillary air quality benefits of CO_2 control from combustion sources in the overall benefit-cost analysis potential measures. We use reverse (adjoint) sensitivity analysis within a state-of-the-art chemical transport model (USEPA's CMAQ) to estimate health benefits associated with reduced emissions of CO_2 on a source-by-source basis in Canada and the U.S. Our preliminary results in the U.S. indicate that these co-benefits range from $300/ton-$CO_2$ to $1500/ton-$CO_2$ for heavy-duty diesel vehicles, a number significantly larger than the social cost of carbon or its price in various cap-and-trade markets. By comparison, co-benefits associated with upstream oil and gas industry in Texas is mostly below $100/ton-$CO_2$. This suggests that targeting emissions from both these source sectors without consideration of air quality co-benefits would miss a great opportunity for reducing the health impacts of air pollution.

1706010 Climate Change, Air Quality and Interconnections to Human Health
Air Quality Forecasting in Canada and worldwide: past, present and future
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Air quality forecasting has been a specific area of research, development and services for the past 20 years. It addresses the need for information in real-time on the levels of outdoor air pollution in order to mitigate population exposure and associated health impacts ranging from discomfort to premature deaths. The ability to forecast air quality emerged from combining air pollution modelling in a regulatory context with new capacity and technologies in numerical weather prediction. Around the world, air quality and atmospheric composition modelling is now part of the service provided by the main meteorological centres; it includes analyses and re-analyses of atmospheric composition on a daily basis, operational air quality forecasts from the global to the mesoscale as well as dynamic atmospheric composition representation within global numerical forecasts. The presentation will review the evolution of air quality forecasting in Canada and worldwide and present some perspective about its future directions.

1706010 Climate Change, Air Quality and Interconnections to Human Health

Mitigating climate change's impact on human health through photocatalytic air pollution control

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Climate change has and will continue to alter the atmosphere of the earth, resulting in elevated ambient temperature. On a local to regional scale, human impact on the atmospheric environment can be seen through the formation of smog, which is a combination of ground level ozone and fine particulate matter (PM2.5 or less). Smog is typically observed during summer months as a result of warm ambient temperatures and increased sunlight fuelling ozone production. Severe health implications have been linked to ground level ozone and other harmful air pollutants, including cancer, respiratory disease, and premature death. Due to climate changes, anticipated elevated air temperatures will exacerbate smog production and heighten health problems worldwide. While it may be difficult to mitigate smog production by moderating atmospheric temperatures, an avenue to reduce smog is to mitigate the concentration of oxides of nitrogen (NOx) at ground level to reduce the subsequent formation of ozone. The Envison SQ SmogStop Barrier is designed to remove NOx produced by vehiclular traffic through photocatalytic reduction. This new version of a highway sound barrier uses a patented coating to break down NOx into harmless environmentally benign by-products. The overall implications will be reduced NOx and better air quality resulting in fewer public health concerns in spite of climate change and global warming.

1706030 Measurements and modeling of air pollution - Part 1

INVESTIGATING AIRCRAFT-BASED EMISSIONS ESTIMATES USING GEM-MACH WITH THE TOP-DOWN EMISSION RATE RETRIEVAL ALGORITHM (TERRA)

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During a summer intensive field campaign in the August and September of 2013, aircraft-based measurements of air pollutants were collected in support of the Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring (JOSM). The Top-down Emission Rate Retrieval Algorithm (TERRA) was developed by Environment and Climate Change Canada to estimate facility emission rates based on the aircraft measurements (Gordon et al, 2015). TERRA as applied to date uses aircraft observations of emitted pollutants, wind speed and direction, to create two-dimensional screens surrounding an emitting facility; the transport through these screens and the divergence theorem is used to generate observation-based emissions estimates. Here, as part of a larger effort on TERRA improvement, Environment and Climate Change Canada's air quality model, Global Environmental Multiscale-Modeling Air-quality and CHemistry (GEM-MACH), was used as a surrogate source of concentration and meteorology data. We investigate the potential of this approach for improving the known uncertainties in the TERRA schemes of extrapolation to the surface from the lowest flight altitudes of ?150 meters above ground, and as a check on the accuracy of GEM-MACH. Linear interpolation in time and space of GEM-MACH's 2.5km-resolution/2-minute time-step output fields to the aircraft's observed locations were used as TERRA inputs. The TERRA-calculated emission rates are compared with those input into GEM-MACH, for different TERRA configurations. The work evaluates the combination of TERRA and GEM-MACH as a proxy for testing the downward

extrapolation schemes within TERRA and identifies possible avenues for GEM-MACH and/or TERRA improvements. Outcomes from this work can provide useful suggestions for future flight plans for top-down emission rate estimations.

Reference: M. Gordon, S.-M. Li, R. Staebler, A. Darlington, K. Hayden, J. O'Brien, M. Wolde, Determining air pollutant emission rates based on mass balance using airborne measurement data over the Alberta oil sands operations, Atmos. Meas., Tech., 8, 3745-3765, 2015.

1706030 Measurements and modeling of air pollution - Part 1

Carbon Monoxide Over Canada as Seen from the MOPITT instrument

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Carbon monoxide (CO) is a pollutant gas with a major source in uncontrolled combustion and similar processes. Since it has a moderate lifetime of about a month in the atmosphere, it can be transported over great distances especially if lofted into the mid and upper tropopshere.

Within Canada there are some significant sources of CO, with forest fires being one of the most unpredictable. However, there is also considerable transport of CO into Canada from the West and transport out of Canada to the East.

Since 2000 the Measurements Of Pollution In The Troposphere (MOPITT) instrument has been measuring CO over the entire globe including Canada, and these long-term dense measurements permit us to see the evolution of CO over Canada at the continental and global scale. There have been many atmospheric events over the lifetime of the satellite, but in 2016 there was clear evidence of considerable transport of CO into Northern Canada including the Canadian Arctic leading to detection of CO anomalies as far North as Eureka (80N). These intrusions appear to be at least comparable to CO sources within Canada and so are significant contributors to the CO above the country.

This talk will focus on what we can learn about the internal/external sources of CO for Canada using satellite measurements.

MOPITT was built in Canada by COMDEV of Cambridge, ON and the instrument and operations are funded by the Canadian Space Agency.

1706030 Measurements and modeling of air pollution - Part 1

Quantifying emissions of CO and NO_x using satellite observations of multiple chemical species

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GEOS-Chem Four-dimensional variational (4D-var) data assimilation system is used to assimilate satellite observations of multiple chemical species to estimate emissions of CO and NO_x, as well as the tropospheric concentrations of O₃. We utilize CO retrievals from The Measurements of Pollution In The Troposphere (MOPITT), O₃ retrievals from the Tropospheric Emission Spectrometer (TES) , O₃ retrievals from the Optical Spectrograph and InfraRed Imager System (OSIRIS), NO₂ and HCHO columns from the Ozone Monitoring Instrument (OMI), and

HNO₃ columns from the Microwave Limb Sounder (MLS). We find that we are able to reduce the impact of discrepancies in the model chemistry on the source estimates by combining these observational constraints on tropospheric O₃-NO_x-CO-OH chemistry. Our use of a 4D-Var data assimilation scheme for the multiple-species assimilation produces a modeled state that is consistent with all of the observations over the assimilation period, providing a strong constraint on the chemical state of the system. However, there are still uncertainties on the CO and NO_x emission estimates due to limitations of the assimilation approach.

1706030 Measurements and modeling of air pollution - Part 1
Long-term trend of ground-level ozone in Windsor, Canada
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In Ontario, Canada, emissions of NOx (nitrogen oxides) and VOC (volatile organic compounds) had decreased by 41% and 30% from 2004 to 2013, respectively. However, annul mean ozone concentrations had increased by 8% across Ontario during the same time period. In this study, ambient ozone concentrations in Windsor, Ontario during 1996-2015 are analyzed with statistical approaches and back trajectories. Annual mean ozone concentration has increased with a rate of 0.52 ppb/year, or approximately 10 ppb during the past 20 years. The increasing rate was greater in non-smog season (October to April, 0.72 ppb/year) than smog season (May-September, 0.37 ppb/year) suggesting an increase of background concentrations. The elevated background concentration is evident by the increased 25th percentile concentrations. The peak values, represented by the 95th percentile, however, deceased during the study period, resulting from less in situ photochemical production of ozone due to declining NOx and VOC emissions. Weekend concentrations (33 ppb) were significantly higher ($p<0.05$) than those on weekdays (30 ppb) in spite of less vehicular and industrial NOx emissions, suggesting a decreased NO (nitric oxide) titration. Analysis of backward trajectories found that the high 8-hour max ozone concentrations in Windsor were associated with transboundary air mass from the south where industrial states of Ohio and Indiana are located. Additional analysis is undertaken to quantify the effect of reduced NO titration on the long-term ozone trend.

1706030 Measurements and modeling of air pollution - Part 1
Canadian Air Quality Modelling Platform for Policy Emission Reduction scenarios
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The REQA unit (unité de Réponse aux Enjeux de Qualité de l'Air), within the Air Quality Modeling and Application Section (AQMAS) of Environment and Climate Change Canada (ECCC), is responsible for providing air quality regulatory guidance to policy-makers. The REQA team is involved in many science and policy development studies both nationally and internationally. In order to provide such guidance, air-quality model scenarios analysis are the most common means used to estimate the impact of emission changes on atmospheric pollutant concentrations. This presentation will give an overview of the methodologies used in air quality emission scenario analysis, updates on the REQA modelling platform used to create baselines and projected scenarios as well as an overview of recent published regulatory work and on-going projects.

1706031 Measurements and modeling of air pollution - Part 2
Improving site selection for tower-based deposition measurements with multiple sources in complex topography
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Installing a flux tower to measure deposition of pollutants in regions with multiple sources and complex topography requires preliminary analysis of source locations, wind fields, topography, and canopy/sub-canopy coupling and dynamics. Here we present a procedure intended to optimize the probability of measurements of all sources (and the clean background) within a limited timeframe.
Given a limited set of locations to install a tower, as often occurs in areas with commercial interests and limited accessibility, we can make use of meteorological data to inform our selection. Using historic wind direction data and HYSPLIT model trajectories, we can establish the suitability of a location for flux measurements by analysing if protracted periods of polluted or clean air are likely to occur. This is important in regions with complex terrain, as winds there can be far from isotropic, especially in a given short timeframe. Each trajectory is analysed with historic air quality data to verify that our presumptive pollutant source locations are indeed linked with aerosol emissions. This is done in iteration to fine-tune the final site selection.
Additionally, to characterize deposition, we investigate coupling between the sub-canopy layer and the free atmosphere. Sub-canopy flows can be systemically different from above canopy flows, so coupling and decoupling can be important in the process of deposition. This can be done with a passive scalar like pollutants, water vapour, or, if those are unavailable at multiple heights, potential temperature.
This procedure has been implemented in the selection of a site in the oil sands region of Alberta for a flux tower in the Summer of 2017. Our selection demonstrates the applicability of our procedure, which can be tested for other diverse locations.

1706031 Measurements and modeling of air pollution - Part 2
Validation of CrIS Satellite Ammonia Retrieval
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Ammonia is one of Canada's six main criteria air contaminants (CACs) (https://www.ec.gc.ca/air/default.asp?lang=En&n=7C43740B-1) and an important component of reactive nitrogen in the atmosphere, where it reacts with acidic species (i.e. nitric acid and sulfuric acid from NOx and SOx) to produce a significant fraction of fine mode particulate matter (PM2.5), which is linked to various harmful health impacts. Excess deposition of ammonia into ecosystems can lead to soil acidification and water eutrophication. Thus monitoring of ammonia is important; however, due to its 'sticky' and highly reactive nature it would be difficult to measure. Furthermore, it is difficult and expensive to measure ammonia with a dense network across Canada using active in-situ surface methods. Therefore we have developed a satellite-based NH3 retrieval and processing algorithm using the Cross-Track Infrared Sounder (CrIS) instrument. CrIS was launched on 28 October 2011 on USA NOAA/NASA/DoD the polar-orbiting Suomi National Polar-orbiting Partnership (NPP) satellite, which provides twice daily (~01:30 and 13:30 standard local time) global observations. Combining these satellite observations with available ground-based

observations helps fill the monitoring gap, and improves our knowledge of NH3 emission sources, ambient concentrations, and deposition across Canada. Ultimately it is envisioned that it will lead to improvements in the Canadian air quality forecast model and its input emission inventory. In order to evaluate the uncertainties in the CrIS Fast Physical Retrieval (CFPR) NH3 satellite observations we compare them against other available observation sources. Presented are validation studies comparing the CrIS satellite data against ground-based profiles and column measurements from FTIR sites in the Network for the Detection of Atmospheric Composition Change (NDACC) around the globe, and surface passive sampler Ammonia Monitoring Network (AMoN) observations across North America, including 3 Canadian Air and Precipitation Monitoring Network (CAPMON) sites.

1706031 Measurements and modeling of air pollution - Part 2

Estimation of nitrogen dioxide (NO2), sulfur dioxide (SO2) and ammonia (NH3) dry deposition over North America from satellite observations

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Atmospheric deposition of pollutant species such as nitrogen dioxide (NO2), sulphur dioxide (SO2) and ammonia (NH3) can lead to acidification of soil and water, and adversely affect sensitive ecosystems. Ammonia also contributes to eutrophication (i.e. algal blooms) of surface waters. The comprehensive monitoring provided by the spatiotemporal satellite mapping of dry deposition flux is essential in assessing these various effects, and particularly useful for filling in gaps where in situ measurements are not available. In this study, an inferential method was used to estimate dry deposition flux of NO2, SO2, and NH3 over North America by combining satellite concentration observations and modelled dry deposition velocities. NO2 and SO2 concentrations were derived from the Ozone Monitoring Instrument (OMI), and NH3 concentrations from the Cross-track Infrared Sounder (CrIS) satellite instrument. The satellite derived concentrations for these three species are in good agreement with measurements from surface networks. The magnitude and spatial-temporal characteristics of the deposition products were explored with a focus on acid-sensitive lakes, urban areas, and regions downwind of emission sources. Preliminary analysis shows strong decreasing trends in NO2 and SO2 dry deposition fluxes over much of North America and the role of forest fires in the dry deposition of NH3, especially over northern Canada during summer. Our deposition estimates are consistent with other existing estimates, but provide a much larger spatial and a longer temporal coverage.

1706031 Measurements and modeling of air pollution - Part 2

What measurements tell us about the sources and sinks of atmospheric ammonia

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While industrial production of ammonia over the last century has supported the intensification of agriculture and our planet's ability to feed billions of people, it has also left a lasting imprint on the environment. As the dominant base in the atmosphere, ammonia can impact particle formation, growth and hygroscopicity. Furthermore, the deposition of ammonia can influence the nutrient status of unmanaged ecosystems, with consequences for biodiversity. The emissions of ammonia are typically poorly characterized, contributing to large biases in the magnitude and timing of ammonia concentrations in models. In this talk, I will summarize measurements made by my group of both gas phase ammonia and the composition of fine model particles across a range of environments in Ontario, Alberta, California and Colorado. In many cases, these observations indicate that area-wide bi-directional surface exchange is required to explain the observed ammonia levels. This has important implications for regional and global scale ammonia budgets, and the formation of particle nitrate.

1706031 Measurements and modeling of air pollution - Part 2

Characterization of biomass burning emissions of two wildfires through dispersion modeling and OP-FTIR measurements during summer 2016 in Halifax, NS.

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The Tropospheric Remote Sensing Laboratory (TRSL) at Saint Mary's University characterizes atmospheric trace gas concentrations in and around Halifax, Nova Scotia. A ground-based open-path Fourier transform infrared spectrometer (OP-FTIR) was used to collect broadband, low-resolution (0.5 cm-1) spectral data during the summer of 2016. This field study characterized biomass burning emissions from one nearby (~150 km) and one more distant wildfire source as captured in ground level air in Halifax. Initially, HYSPLIT model trajectories were used to characterize the dispersion of emission plumes from the wildfire sources during the study period while trace gas data was being collected continuously (day and night, 1 measurement per minute) using the active-source OP-FTIR for two weeks during the peak of the wildfires. HYSPLIT trajectories then guided the interpretation of measurements, identifying likely times of increased biomass burning emissions in Halifax surface air. OP-FTIR spectra were analyzed to determine trace gas concentrations in the vicinity of wildfire emissions by using carbon monoxide as the main tracer, among other gases. We detected CO enhancements and compared our derived trace gas data with independently measured in situ CO sensor data from a Nova Scotia Environment (NSE) National Air Pollution Surveillance Network (NAPS) measurement station, also located in Halifax. The full results of this analysis will be presented.

1706032 Measurements and modeling of air pollution - Part 3

Improving plume rise algorithms within the GEM-MACH model: a comparison to stack plume measurements in the Athabasca oil sands

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The plume rise algorithm of the GEM-MACH model is based on the Briggs parameterizations, which were developed in the 1970's. We have tested these equations independently of the GEM-MACH model by means of a comparison with measurements of plume location made in the Athabasca oil sands region as part of the Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring in August and September of 2013. Wind and temperature data used to drive the algorithm were measured in the region of emissions from various platforms, including two meteorological towers, a radio-acoustic profiler, and a research aircraft. These measurement platforms were compared to determine the degree of spatial representation for the area and the uncertainty of the measurements. Other meteorological variables used to drive the algorithm include friction velocity, boundary-layer height (H), and the Monin-Obhukov length. These variables were parameterized from wind and temperature data. Various parameterizations of H were compared to aircraft measurements of the moist to dry air transition height to determine the most accurate parameterization. Stack emission information reported by Cumulative Environmental Management Association (CEMA), including stack height, emission temperature, and flow rate, were used to drive the plume rise algorithm. The calculated plume heights were then mapped to interpolated aircraft SO_2 measurements in order to compare the measured plume locations with the predicted plume rise. The results demonstrate that the Briggs equations significantly underestimate plume rise in this region, with the majority (60%) of the measured plume rise values more than twice the predicted value.

1706032 Measurements and modeling of air pollution - Part 3

Air Quality Monitoring - What the Future Holds

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We live in one of the most exciting periods in human history. Although there remains much to be done with respect to literacy, nutrition and health care, modern communication and technological advances are making it possible to live and thrive in harmony with our environment. We do have to deal with the byproducts of the energy and materials required to build this new world. Most people seem not to be paying attention to air pollution issues unless they directly impact their well-being. If we accept that our priority is looking after number one, then the ability for a modest cost to assess and/or protect one`s health in real-time is an excellent investment.

Many studies have confirmed that there are multiple pathways for substances of concern to enter the human body and that the major pathways are already known as are the most important sources.

To-day there are almost 6 billion cell phones in the world. In the more developed countries, there is more than one cell for each person. Accompanying this is an incredible increase in applications that can be run on these devices. Almost any task, is doable by just about anybody, anywhere anytime.

In many parts of the developing world, the cell phone is the most important component of the daily health regime. Medication availability and location, usage, time of consumption as well as implications and complications, potential antagonisms and synergies is all available on-line.

On the one hand, the threat of new agents of potentially adverse health impact and on the other hand a means of keeping us protected from, or at least alerted to, the potential threat and possible remedies.

A new approach to future air quality monitoring will be discussed in this paper.

1706032 Measurements and modeling of air pollution - Part 3
Air pollution emissions from satellite observations: methods and applications
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Model forecasts of air pollution are ultimately limited by the quality of the emissions inventories that go into them. And yet, despite this critical link, large uncertainties remain on emissions. Here we present examples of satellite observations of criteria air contaminant (CACs; e.g., NOx, SO2, NH3, aerosol), and the corresponding derived emissions using a new general methodology for locating and quantifying emissions from a combination of satellite observations and meteorological reanalyses. In addition to this general methodology, we present some recent research highlights including: the first global satellite-derived inventory for SO2 (and the identification of many missing sources), assessment of the consistency between pollutant distributions from satellite and those derived from emissions, a novel gridded-emissions retrieval approach, a multi-pollutant view of wildfire emissions, and applications to the Canadian oil sands region.

1706032 Measurements and modeling of air pollution - Part 3
Analysis of Air Quality across the Windsor Area (Canada) based on Satellite and Ground Level Observations
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In order to mitigate impact of air pollution on human health and our environment, knowledge of geospatial distribution of air pollutants is essential. Ground level air quality monitoring networks provide accurate and frequent point measurements, however their spatial coverage remains sparse due to resource limitations. The past decade has seen a rapid development and application of satellite remote sensing technology in air quality management. This project presents a case study in Windsor area, Ontario, Canada, using an air quality analysis system. The system consists of acquisition of relevant ground level air quality readings and satellite data, interpretation of satellite data, incorporation of regional/local demography, land use, infrastructure and point source locations, overviews and analyses of historical data in graphical and mapping formats, and graphical user interfaces enabling fast access and manipulation of the data inputs and outputs. The developed system was used for geospatial analysis of air quality across the Windsor area during the period 2013 - 2015. Air quality indicators analyzed include nitrogen dioxide, ozone, and fine particulate matter. The study domain is 100 km by 100 km with a grid size of 5 km.

1706032 Measurements and modeling of air pollution - Part 3
The prediction of aerosol size and composition in the regional particulate pollution, analyses and sensitivity simulations
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To study the impact of particulate pollution on the regional-scale air quality, and assess the source-receptor relations between precursors and pollutants, a comprehensive performance of CMAQ-MADRID (CMAQ coupled with the Model of Aerosol Dynamics, Reaction, Ionization, and Dissolution (MADRID)) was

implemented during the summer of 2001 across Southern Ontario. The link of the emission of primary PM and precursors of secondary PM to the formation mechanism underlying ambient PM concentrations were correspondingly assessed using a combination of observed and predicted data. Furthermore, for the importance of the model precision and performance evaluation, two modeling approaches (CMAQ and CMAQ-MADRID) were presented by different representations of particulate matter properties and details in the gas-phase and aerosol-phase processes. The comparison of the modeling performances signifies the differences in the reliability of CMAQ-MADRID and CMAQ in the prediction of the atmospheric pollutant distribution by the PM precursors emissions sensitivity simulations and the formation of gas phase inorganic species. A diagnostic evaluation against speciated aerosol field measurements and the source investigation of transported aerosol with the back trajectory analysis was also carried out as a part of the performance consistency. The assessments ultimately allow us to address possible causes of the model biases including the uncertainties related to the model structure, numerical solution, and even the selection of input data and parameters.

1707010 The Year of Polar Prediction

The Year of Polar Prediction: Environment and Climate Change Canada's objectives and planned activities.

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The Year of Polar Prediction (YOPP) will run from mid-2017 to mid-2019 as the core phase of the ten year (2013-2022) Polar Prediction Project (PPP), an initiative of the WMO's World Weather Research Programme (WWRP). The evidence of rapid changes in the Arctic following the International Polar Year (IPY) have motivated the WWRP-PPP to look beyond weather and focus on wider environmental factors such as the ocean, sea ice and the climate. YOPP's goal is to enable a significant improvement in environmental prediction capabilities for the Polar Regions and beyond, by coordinating a period of intensive observation, modelling, verification, user-engagement and educational activities. To this end Special Observing Periods (SOPs) have been scheduled at both Poles during YOPP when the international monitoring and environmental modeling communities will concentrate their efforts to evaluate the impact of enhanced observations on environmental forecasts at the poles as well as globally, and to engage users to explore how this information can be of greater value.

This is particularly timely for Canada with close to a third of its land mass north of the Arctic Circle. The fast warming of the region allowing for economical exploitation of natural resources, the recent opening of new shipping routes, the increased number of flights over the Arctic, have all contributed to a widespread economic and population growth in the Arctic region. At the same time the fast changes in climate are creating new challenges for First Nations as their traditional environmental references are also changing. YOPP presents an opportunity for Canada to leverage its assets in the Arctic with the international community to accelerate the development of a reliable and relevant environmental monitoring and prediction systems to better serve the needs of the North. This presentation will describe the current plans and expected outcomes of YOPP and PPP as well as how ECCC is contributing along with its national and international partners as a world leader in Data Assimilation and Coupled Sea-Ice-Atmosphere Numerical Modeling.

1707010 The Year of Polar Prediction

MEOPAR's Contribution to the Year of Polar Prediction

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"MEOPAR (www.meopar.ca) is a Network of Centres of Excellence initiated in 2012, which seeks to reduce risk and strengthen economic opportunity in Canada's marine sector.

MEOPAR's Cycle II (2017-2022) focuses on four main challenge areas –
marine observation; improvement of forecasting and prediction, especially in the North; the vulnerability and resilience of coastal communities; risk and efficiency of marine transportation and offshore operations.
In accordance with this strategic direction and following discussion with Environment and Climate Change Canada (ECCC), MEOPAR decided to support Canadian involvement in the international Year of Polar Prediction (YOPP).
Subsequently a joint research initiative was developed with Polar Knowledge Canada (POLAR) and the Arctic Research Foundation (ARF). The focus of this initiative is a partnered research call, with a total funding envelope of $2.3 mil CAD.
In October 2016, MEOPAR in cooperation with the Polar Prediction Project (PPP), ECCC, POLAR and ARF hosted an Expert Forum to engage various stakeholders in the Canadian approach to YOPP. The workshop focused on the overall YOPP objectives and specification of research objectives that should be emphasised in the joint call for proposals, including a strong focus on end-user engagement and benefit.
Three overarching classes of objectives emerged from the discussions:
1. Observing systems and data assimilation (including satellite data)
2. Process representation, prediction systems and model verification
3. Benefits to users, outreach and training
These objectives were expressed in the YOPP Call for Proposals, which was released on December 13, 2016. Projects will be selected and approved for funding in April 2017. The presentation will include short synopses of each of the funded projects.

1707010 The Year of Polar Prediction
The Cambridge Bay Observatory: A Laboratory for Thermodynamic Sea-Ice Modelling
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In 2012, Ocean Networks Canada installed a cabled ocean observatory in the northwest passage, near Cambridge Bay, Nunavut. The shallow water system includes shore-based weather stations and in-water sensors to monitor the coastal marine conditions. Successful servicing of the observatory each summer has resulted in 5-year high-resolution suite of marine time series. The data include standard meteorological measurements (air temperature, wind speed and direction, and solar radiation), and near bottom measurements of seawater temperature, salinity, dissolved Oxygen, chlorophyll, pCO2, and ice draft thickness. A one-dimensional thermodynamic sea-ice model based on these observations is helping to improve sea-ice thermodynamic simulations. Recent improvements include adding layered snow and ice slabs, which permits more realistic heat flux, and in situ snow depth measurements from community observers. The observatory represents an in situ laboratory for testing and evaluating sea-ice model parameterizations. The present modelling effort is to incorporate 7 to 14 day weather forecasts and push the model to improve near-term forecasts of sea-ice during the freeze-up and melts periods. Future research will focus on improving surface albedo parameterizations during the melt season, when surface water and melt ponds dramatically affect forecast skill. These critical periods impact safe transportation on the water (fishing) and ice (hunting) and are the events most likely to evolve and shift under the influence of climate change.

1707020 Atmosphere, Ocean and Climate Dynamics - Part 1

The Fully Nonlinear Stratified Geostrophic Adjustment Problem

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The study of the adjustment to equilibrium by a stratified fluid in a rotating reference frame is a classical problem in geophysical fluid dynamics. We consider the fully nonlinear, stratified adjustment problem from a numerical point of view. We present results of smoothed dam break simulations based on experiments in the published literature, with a focus on both the wave trains that propagate away from the nascent geostrophic state and the geostrophic state itself. We demonstrate that for Rossby numbers in excess of roughly 2 the wave train cannot be interpreted in terms of linear theory. This wave train consists of a leading solitary-like packet and a trailing tail of dispersive waves. However, it is found that the leading wave packet never completely separates from the trailing tail. Somewhat surprisingly, the inertial oscillations associated with the geostrophic state exhibit evidence of nonlinearity even when the Rossby number falls below 1. We vary the width of the initial disturbance and the rotation rate so as to keep the Rossby number fixed, and find that while the qualitative response remains consistent, the Froude number varies and these variations are manifested in the form of the emanating wave train. For wider initial disturbances we find clear evidence of a wave train that initially propagates toward the near wall, reflects and propagates away from the geostrophic state behind the leading wave train. We compare kinetic energy inside and outside of the geostrophic state, finding that for long times a Rossby number of around one quarter yields an equal split between the two, with lower (higher) Rossby numbers yielding more energy in the geostrophic state (wave train). Finally, we compare the energetics of the geostrophic state as the Rossby number varies finding long-lived inertial oscillations in the majority of cases, and a general agreement with past literature that employed either hydrostatic, shallow water equation-based theory or stratified Navier-Stokes equations with a linear stratification.

1707020 Atmosphere, Ocean and Climate Dynamics - Part 1

Scaling estimates of tracer flux though a submarine canyon

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The exchange of water and solutes between the coastal area and the open ocean is of great importance to biogeochemical fluxes, nutrient budgets and their response to climate change and human activities. On a regional scale, submarine canyons are known to enhance physical processes such as shelf-slope mass exchange and mixing. There is good understanding of the flow around upwelling submarine canyons; however, the flux of biologically relevant tracers is less understood. The objective of this work is to develop scaling estimates for tracer transport onto the shelf through a submarine canyon taking into account the impact of locally-enhanced mixing within the canyon. For that purpose, numerical experiments simulating an upwelling event near an idealized canyon were performed adding a passive tracer with an linear, initial profile.

This work presents scaling estimates for tracer and water upwelling fluxes based on results from numerical experiments using the community model MITgcm when varying the geographic distribution of vertical eddy diffusivity and its magnitude, initial stratification, Coriolis parameter, and the strength of the incoming flow. We find that locally-enhanced vertical diffusivity slightly increases (?10%) the depth of upwelling compared to a case with uniform vertical diffusivity. In such a case, previous scaling schemes underestimate the depth of upwelling by about the same amount because enhanced diffusivity weakens the vertical density gradient within the canyon, reducing the stratification and allowing more water to upwell. This also has a positive effect on the tracer flux that is advected by the upwelling flow. Additionally, locally-enhanced mixing drives a higher diffusive transport of tracer, while the lower background diffusivity allows relatively unmixed water onto the shelf, near the bottom. In conclusion, although tracer fluxes are mainly dominated by advection, the spatial pattern of diffusivity plays a major role on their final distribution.

1707020 Atmosphere, Ocean and Climate Dynamics - Part 1
Internal Solitary Wave Generation: Effects of a Mean Background Current
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Tide-topography interactions are the source of most of the worlds internal solitary waves. Here we use two-dimensional numerical simulations to investigate the generation of these waves by tide-topography interactions with a symmetric sill in the presence of a surface trapped background current. This introduces asymmetries in the upstream and downstream energy fluxes and in the form of the solitary waves, with broader waves forming in the downstream direction. In extreme cases internal solitary waves in the downstream direction can be waves of elevation while internal solitary waves in the upstream direction are waves of depression.

1707020 Atmosphere, Ocean and Climate Dynamics - Part 1
Upper ocean physical and biological response to Typhoon Cimaron (2006) in the South China Sea
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The physical dynamic and biological response processes to Typhoon Cimaron (2006) in the South China Sea are investigated through application of the three-dimensional Regional Ocean Modeling System (ROMS). For sea surface temperatures, ROMS achieves a correlation of more than 0.84, with respect to satellite observations, indicating a generally high level of skill for simulating the sea surface temperature variations during Typhoon Cimaron (2006). However, detailed analysis shows that ROMS underestimates the sea surface temperature cooling and mixed layer deepening because of insufficient mixing in the model simulations. We show that the simulation accuracy can be enhanced by adding a wave-induced mixing term (BV) to the nonlocal K-Profile Parameterization (KPP) scheme. Simulation accuracy is needed to investigate nutrients, which are deeply entrained to the oligotrophic sea surface layer by upwelling induced by Typhoon Cimaron, which plays a remarkable role in the subsequent phytoplankton bloom. Simulations show that the phytoplankton bloom was triggered five days after the passage of the storm. The surface ocean was restored to its equilibrium ocean state by about 10 to 20 days after the typhoon's passage. However, on this time-scale, the resulting concentrations of nitrate and chlorophyll a remained higher than those in the pre-typhoon equilibrium. Reference: Sun, Pan and Perrie, 2016: Upper Ocean Physical and Biological Response to Typhoon Cimaron (2006) in the South China Sea. Published in "Recent Developments in Tropical Cyclone Dynamics, Prediction, and Detection", Chaper 4, 17pp. Edit. Anthony R. Lupo, ISBN 978-953-51-2702-4, 256 pages, InTech, DOI: 10.5772/61455

1707021 Atmosphere, Ocean and Climate Dynamics - Part 2
Spectral analysis of in situ measurements from Honeoye lake: episodic events and dimension reduction
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Honeoye is one of the finger lakes in New York state. It is relatively small (717 ha in area) and shallow, with a deep portion that has a maximum depth of roughly 9 meters and two broad, shallow shelf regions on the north and south ends. The lake is roughly oriented north-south, with a length of 7 km and a maximum width of 1.3 km. Two thermistor chains were used to gather high time resolution temperature data: one in the deep portion of the lake, and one on the southern, shallow shelf. We will review the relevant attributes of Lake

Honeoye and discuss the general features of the measurements, with a particular focus on the late spring period. We will then present an overview of the EOF and wavelet methods employed in the analysis of the data acquired from this lake. The strengths of these spectral methods and their resulting outputs will be compared. We will also discuss the problem of how to interpret these results as evidence of dynamic events in the hydrodynamics of the lake, given that data was sampled at only two locations. Time permitting we will discuss some reduced dimension, or toy, models.

1707021 Atmosphere, Ocean and Climate Dynamics - Part 2
Cross-boundary layer transport due to shoaling mode-2 internal waves
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It is generally agreed that large amplitude internal waves transport a substantial amount of energy throughout the coastal ocean. Much of the literature has focused on the first mode in which isopycnals move vertically in tandem. Nevertheless, there has lately been an increase in observations of the second mode which has led to an uptick in numerical and experimental studies. However, most of these studies have ignored the effects of topography. We present experimental and numerical results of mode-2 internal solitary waves traveling over smooth, isolated topography. For narrow topography (maximum slope of 0.86), we focus upon vorticity generation and its role in transport across the bottom boundary layer. We find that cross boundary layer transport is quite easy to induce, occurring even in cases where minimal vorticity is produced. For broad topography (maximum slope of 0.14), we focus on the evolution of the primary waveform, and on the issue of mode-mode coupling that leads to the generation of mode-1 wavetrains from the primary mode-2 wave.

1707021 Atmosphere, Ocean and Climate Dynamics - Part 2
Scaling up experimental scale DNS
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With today's computer resources it is reasonable to perform fully resolved, three dimensional, direct numerical simulations of many experimental scale stratified fluid phenomena (e.g. gravity currents, internal waves) on the experimental scale . I will briefly review the pros and cons of the various methodologies available, and discuss a few sore points which may trouble certain configurations. However, the main message here is a positive one, and I will show instances of excellent agreement between simulation and experiment. I will then turn to discussions of how we scale up to the field scale. Here the twin focus will be on emergent phenomena that are not observed on the lab scale, and the necessary compromises one must make in ensuring the numerics remains tractable. Examples will include scale up of internal wave induced instability in the bottom boundary layer, and buoyancy driven flows around the four degree temperature maximum. I will end with some speculation for what is necessary for next generation code development.

1707021 Atmosphere, Ocean and Climate Dynamics - Part 2
Internal Gravity Wave Fluxes Radiated by a Stably Stratified Turbulent Wake
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The study of the turbulent wake generated by a bluff body moving through a stably stratified fluid has important applications for naval hydrodynamics as well as geophysical flows around topography. Significant progress has been made in terms of investigating the structure and dynamics of the turbulent wake core and the associated near and far-field spectral properties of the wake-radiated internal gravity wave (IGW) fields, namely in the context of high Reynolds stratified turbulence within the wake itself. Nevertheless, little has been done to quantify the amount of energy and momentum radiated away by the IGWs generated by the wake. Through analysis of a broad Large Eddy Simulation dataset, spanning values of body-based Reynolds

$Re=~5\times 10^3,~10^5$, and 4×10^5, and Froude numbers $Fr=~4,~16$ and 64, we compute the energy and momentum fluxes of IGWs radiated by the stratified turbulent wake of a towed sphere and explore the relevant parametric dependence. The analysis further aims to determine the potential of the IGWs as a sink for energy and momentum relative to the dissipation of turbulent kinetic energy in the wake itself. Finally, we discuss the implications that for our findings for wake mean-flow self-similarity and turbulence subgrid scale models.

1707021 Atmosphere, Ocean and Climate Dynamics - Part 2
Large Eddy Simulation of Turbulence under an Internal Solitary Wave of Depression
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Internal solitary waves (ISWs) are O(1km) long internal waves that are ubiquitous in the shelf regions of the coastal ocean and lakes. ISWs interact with the sea/lake-floor by impressing significant pressure and shear stress fields on the bed. These wave-driven fields give rise to a highly vigorous turbulent bottom boundary layer which, along with the accompanying particulate resuspension, is of great importance to shelf energetics, ecology, water-quality, acoustics and optics. Our driving hypothesis is that the turbulence under ISWs results from a transition founded in the global instability of the separated near-bed vortex wake occurring in the lee (front) of a wave of depression (elevation).

This talk will review relevant field observations and the physical underpinnings of the above hypothesis. In addition, past, theoretical, numerical and laboratory work on ISW-bottom boundary layer (BBL) interaction will be summarized. The presentation will then focus on our most recent results on well-resolved massively parallel spectral multidomain-based Large Eddy Simulations (LES) of the turbulent BBL under a mode-1 ISW of depression at Reynolds numbers typical of the laboratory. An ISW propagating into quiescent waters is first considered where, perplexing disagreements between laboratory and LES observations emerge. The latter component of the results discussion will focus on the structure of primary and more complex subsequent instabilities and the transition and fully developed turbulence, all of which drive a self-sustained near-bed wake under an ISW propagating against a background current. The talk will conclude with first, limited, results on BBL turbulence diagnostics in the along-wave direction.

1707021 Atmosphere, Ocean and Climate Dynamics - Part 2
Subsurface Cores in Internal Solitary Waves
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It has been known for some time that internal solitary waves may have trapped cores at the surface under conditions in which the stratification is strong at the surface of there is a background current with sufficiently large vorticity at the surface of the same sign as the wave induced vorticity (i.e., a surface current in the direction of propagation of waves of depression). Recent observations in the South China Sea have shown the existence of large internal solitary waves with subsurface trapped cores. These waves can exist under appropriate conditions if the background current has near surface vorticity of the opposite sign as that induced by the waves. In this talk we discuss the conditions under which such waves can exist using solutions of the DJL equation and fully nonlinear numerical solutions of the incompressible Euler equations.

1707022 Atmosphere, Ocean and Climate Dynamics - Part 3

On Boussinesq turbulence near the tropopause

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The Global Atmospheric Sampling Program provided data on the horizontal kinetic and potential energy spectra near the tropopause (Nastrom and Gage, 1985). While the steep synoptic-scale part of the energy spectrum agrees well with Charney's theory of geostrophic turbulence, its break to a shallower -5/3 slope in the mesoscale remains a subject of controversy.

Several homogeneous turbulence studies have addressed the issue. In particular, Bartello (2010) presented numerical simulations of decaying triply-periodic rotating-stratified Boussinesq turbulence. It was found that the steep geostrophic spectrum eventually crosses a shallower ageostrophic spectrum at large-enough Rossby numbers. The total energy spectrum thus exhibits a slope break similar to that observed. The assumption of vertical periodicity limits this study to case of constant stratification. Near the tropopause, however, stratification undergoes a rapid change.

A similar slope break can also occur within the quasigeostrophic (QG) framework when vertical boundaries are taken into account (Tulloch and Smith, 2006). A discontinuous jump in stratification generates a delta sheet of QG potential vorticity acting like rigid lid on which buoyancy is materially conserved. This leads to a forward cascade of buoyancy variance and is associated with a shallower, approximate -5/3 spectrum (Held et al. 1995). In this surface quasigeostrophic (SQG) model, the stratification jump at the tropopause plays a crucial role in the slope break and ageostrophic motion is ignored. In the homogeneous turbulence model, it is the other way round.

In this contribution, we aim to reconcile these two mutually exclusive perspectives. To do so, we model the near-tropopause flow in the framework of Boussinesq dynamics. The tropopause is modeled as a continuous yet rapid change in background stratification. A companion QG model is used to produce control runs with identical initial conditions. Implications for the interpretation of the atmospheric spectrum will be discussed.

1707022 Atmosphere, Ocean and Climate Dynamics - Part 3

Normal Mode Decomposition of Mesoscale Simulations

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The kinetic energy spectrum of the atmosphere has been well observed to exhibit a -3 power law at synoptic scales with a transition to a shallower -5/3 power law at the mesoscale. To better understand the mesoscale kinetic energy spectrum, the spectrum can be decomposed into the two dominant modes at this scale: quasi-horizontal vortex motion and inertia-gravity wave motion. A commonly used technique for this is a Helmholtz decomposition of the horizontal velocity into rotational and divergent components, representing the geostrophically balanced and inertia-gravity wave modes, respectively. This decomposition is an approximation, since geostrophically balanced flows have small but non-zero divergence and inertia-gravity waves can have non-zero rotational energy. We investigate the mesoscale spectrum generated in a high resolution, doubly-periodic, non-hydrostatic simulation of a baroclinically unstable jet. A three-dimensional normal mode decomposition is used to decompose the kinetic energy into geostrophic and ageostrophic components. We compare the results with the Helmholtz decomposition and find they are qualitatively similar, but ageostrophic modes increasingly dominate with increasing vertical wave number.

1707022 Atmosphere, Ocean and Climate Dynamics - Part 3

Stimulated imbalance of barotropic flow by large amplitude Poincarre waves in a two layer shallow water setting

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We consider the wave-vortex decomposition in the context of a two layer rigid lid shallow water model. Unlike in the shallow water case, the linear modes do not form a complete basis. This is because the linear approximation to the depth-integrated flow is divergent, so that a velocity potential is need to to describe the barotropic mode. The velocity potential, however, can be thought of as given by quadratic interactions between the linear baroclinic modes, that is, it includes wave-wave, wave-vortex, and vortex-vortex parts. Taking this into account, it is shown that the net effect of all wave-wave interactions on the barotropic vortical mode is identically zero. With this in mind, numerical simulations are carried out to examine energy transfers between barotrophic (balanced) and unbalanced baroclinic modes in settings where wave energy is large. We show that the barotropic mode can loose energy to wave modes in association with a vortex-(wave-vortex) interaction, where the terms in parentheses are baroclinic. While this interaction is normally considered off-resonant, the baroclinic vortical modes can also contain high frequencies. These are responsible for the transfers and can be understood as related to quadratic interactions between baroclinic waves and barotropic vortical modes. That is, the transfer we describe can be thought of as a quartic interaction between two baroclinic wave and to barotropic vortical modes.

1707022 Atmosphere, Ocean and Climate Dynamics - Part 3

A Minimum Diffusive Model for the Bipolar Seesaw

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An alternate form of a minimal model of the interhemispheric bipolar seesaw is proposed. A previous minimal model of the bipolar seesaw proposed that the Southern Hemisphere signal is the result of a Southern Ocean heat reservoir that convolves Northern Hemisphere time signals with a characteristic timescale. However, no satisfying physical interpretation of the model was proposed. By interpreting the results from a global coupled climate model simulation, a new simple model is proposed to represent the interhemispheric diffusion of momentum and tracer by parameterized mesoscale eddies in the Atlantic with a characteristic timescale that is based upon a horizontal mesoscale eddy diffusion. This “diffusive bipolar seesaw” describes how millennial scale climate variability in the Southern Hemisphere responds to rapid changes in the Northern Hemisphere during Dansgaard-Oeschger (D-O) oscillations. While this model produces a similar response to the previous model in the Southern Hemisphere, this new model has a characteristic timescale that is dependent on both a characteristic meridional length scale and a horizontal diffusion timescale, rather than being solely dependent on a thermodynamic timescale. The new model also differs with respect to the previous model in that there is a time lag between the Northern and Southern Hemisphere signals that is not present in the original model. Isotopic data from Greenland and Antarctic ice cores as well as data from a coupled climate model simulation of the D-O oscillation are employed as input to the simple model to reveal a much more satisfying physical basis for the observed interhemispheric variability.

1707022 Atmosphere, Ocean and Climate Dynamics - Part 3
Hot spots of atmospheric warming under climate change
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Radiatively forced atmospheric warming has a distinctive pattern with warming ""hot spots"" in the tropical upper troposphere and the Arctic lower troposphere. Mechanistic descriptions to account for the distinctive warming in these two regions are rather distinct: moist convection is central to the hot spot in the tropical upper troposphere, while destabilizing radiative feedbacks (e.g., surface albedo feedback) and increased meridional energy transport are typically invoked in the Arctic. Here, we describe our research to put these warming hot spots into a common framework, where we can compare the relative roles of energy transport and radiative processes in the vertical and horizontal directions.

1707022 Atmosphere, Ocean and Climate Dynamics - Part 3
A nonlinear model for dynamical-chemical processes in the atmosphere
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Internal gravity waves affect the general circulation, chemical composition and energy budget of the atmosphere. These effects are investigated using a two-dimensional dynamical-chemical model involving nonlinear reaction-diffusion equations for chemical transport coupled with the conservation equations that describe dynamical processes in the atmosphere, including wave-mean-flow interactions. Numerical simulations indicate that the internal gravity wave saturation and breaking and the resulting momentum deposition affect the distribution of the chemical species, which in turn affects the gravity waves.

1707030 Remote Sensing of the Atmosphere and Surface from Space - Part 1
Overview and Validation Results from the Canadian Atmospheric Chemistry Experiment (ACE) Satellite Mission
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In February 2017, the Canadian-led Atmospheric Chemistry Experiment (ACE) mission will mark its thirteenth year of measurements on board the SCISAT satellite. SCISAT/ACE uses infrared and UV-visible spectroscopy to investigate the chemistry and dynamics of the Earth's atmosphere. The long lifetime of ACE has provided a valuable time series of composition measurements that contribute to our understanding of ozone recovery, climate change and pollutant transport.
The primary instrument on board, the ACE Fourier Transform Spectrometer (ACE-FTS) is a high-resolution (0.02 cm-1) infrared FTS operating between 750 and 4400 cm-1. It also contains two filtered imagers (0.525 and 1.02 microns) to measure atmospheric extinction by clouds and aerosols. The second instrument is a dual UV-visible-NIR spectrophotometer called ACE-MAESTRO (Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation) which was designed to extend the ACE wavelength coverage to the 280-1030 nm spectral region. From these solar occultation measurements, altitude profiles of atmospheric trace gas species, temperature and pressure are obtained. In addition to the mission status, a review of validation and science results from the ACE mission will be presented.
For information about the Atmospheric Chemistry Experiment including publications, climatological data sets and publicly available profiles, please visit the ACE website: http://www.ace.uwaterloo.ca/.

1707030 Remote Sensing of the Atmosphere and Surface from Space - Part 1

A Summary of Canadian Progress in Spatial Heterodyne Spectroscopy (SHS)

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This summary covers the development of Spatial Heterodyne Spectroscopy (SHS) in Canada and some areas of its application. Briefly stated, SHS is an offshoot of the Michelson interferometer, most commonly described as Fourier Transform Spectroscopy (FTS) in which the mirrors in the two arms are replaced by diffraction gratings which diffract different wavelengths at different angles so that their combined beams produce sinusoidal patterns with spatial wavelengths directly related to the optical wavelengths. Thus a single image can be Fourier transformed to recover the spectrum as in FTS. This can be accomplished only for a narrow range of wavelengths around the Littrow wavelength (the one for which both beams are parallel) which can be chosen as required for each application. The SHS design lends itself to field-widening so that a small compact instrument is possible. The first application at York University was for measurement of water vapour, called SHOW (Spatial Heterodyne Observations of Water), and it has been flown on a stratospheric balloon. This summer, in collaboration with the University of Saskatchewan and ABB, SHOW will be flown on the NASA ER-2 aircraft. A similar instrument was flown on an aircraft for the observations of methane. A Stratospheric Wind Interferometer For Transport studies – Doppler Asymmetric Spatial Heterodyne (SWIFT-DASH) was developed at York University but did not proceed to mission. More recently York University has collaborated with Juelich Research Centre in developing an SHS called Atmospheric Heterodyne Interferometer Test (AtmoHIT) for the measurement of rotational temperature from the airglow O2 Atmospheric Band, which will first be flown on a rocket from Kiruna. The development of a satellite version called Atmospheric Spatial Heterodyne Interferometer Next Exploration (AtmoSHINE) is currently underway.

1707030 Remote Sensing of the Atmosphere and Surface from Space - Part 1

The Orbiting Carbon Observatory-2

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The carbon cycle describes the flow of carbon, typically in the form of carbon dioxide, between the atmosphere, oceans and land. It is influenced by changes in the sources and sinks of carbon, including anthropogenic releases (fossil fuel burning), changes in land use, the respiration and photosynthesis of plants, and the uptake and release by oceans. Atmospheric measurements of carbon dioxide are required to quantify the sources and sinks and monitor their long-term trends. NASA's Orbiting Carbon Observatory-2 (OCO-2) satellite was launched in July 2014, and has been providing high quality measurements of carbon dioxide for over two years. Its measurements represent a significant improvement over previous generations of carbon dioxide monitoring satellites. We will present the first comprehensive comparisons between the OCO-2 data and the established ground-based validation network, the Total Carbon Column Observing Network (TCCON). With these promising and informative results, we will provide an outlook for future refinements of the OCO-2 data.

1707030 Remote Sensing of the Atmosphere and Surface from Space - Part 1
ACE-FTS satellite measurements of HCN in the upper troposphere to N_2O in the lower thermosphere
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Two recent discoveries from the Canadian ACE-FTS (Atmospheric Chemistry Experiment – Fourier Transfer Spectrometer) satellite instrument will be discussed. The first is the production of N2O in the lower thermosphere, and the second is a global enhancement of HCN in the upper troposphere – lower stratosphere throughout 2016. ACE-FTS has the only available satellite measurements of vertically resolved HCN in the upper troposphere - lower stratosphere and N_2O in the lower thermosphere.
The N_2O measurements show that there is a consistent lower thermospheric source of N_2O via energetic particle precipitation (EPP). This leads to average polar winter concentrations on the order of ~20-40 ppbv near 90 km. In the polar winter, N_2O -rich air descends into the lower mesosphere, and especially during sudden stratospheric warmings ACE-FTS observes N2O being transported as far down as ~45 km.
In late 2015, a large amount of HCN was emitted from Southeast Asia into the upper troposphere and lower stratosphere. The emitted HCN was then transported by the general circulation from the tropics to polar latitudes. By early 2016, the daily mean concentrations of HCN in the lower stratosphere at all latitudes, as measured by the ACE-FTS instrument, were consistently the largest on record for the region, on the order of 50-90% greater than the climatological mean, and ~30% greater than the 2007 El Niño-driven values.

1707030 Remote Sensing of the Atmosphere and Surface from Space - Part 1
Long-Term, Episodic and Quasi-periodic CO Events as Seen in the MOPITT Dataset.
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Launched in 1999, the Measurements Of Pollution In The Troposphere (MOPITT) instrument is one of several Canadian satellite instruments still operating long after their design life has expired. The 17 year dataset of carbon monoxide over the planet is the longest global dataset that we have and shows many long-term trends and short-term events in the atmosphere. Since much CO production is associated with uncontrolled burning, it is episodic and the 4-week lifetime of the gas in the atmosphere allows the mapping of transport of the pollution from these events across the globe.
This talk will look at the long-term trends associated with CO, including the long-term global reductions recently identified and will also look at some of the episodic and quasi-periodic events such as the burning in Indonesia associated with El Nino events.
MOPITT was built in Canada by COMDEV of Cambridge, ON and the instrument and operations are funded by the Canadian Space Agency.

1707030 Remote Sensing of the Atmosphere and Surface from Space - Part 1
Studies in support of greenhouse gas observations in the Arctic and boreal regions from a highly elliptical orbit (HEO) mission
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Sioris, Chris E. - Environment and Climate Change Canada
McLinden, Chris - Environment and Climate Change Canada
Garand, Louis - Environment and Climate Change Canada
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Continuous space-based observations of atmospheric CO2 and CH4 are desirable for studies of the carbon cycle. Multiple geostationary (GEO) mission concepts are under consideration by international space agencies, with one recently being selected by NASA for launch in the 2020s. GEO missions will greatly improve observational capabilities; however, the high viewing angles from GEO poleward of approximately 55°N/S prohibit coverage of the Arctic and much of the boreal region. The Canadian Space Agency has recently funded new studies to explore the feasibility of a mission optimized for observing northern high latitudes (~50-90°N). Two satellites with shortwave infrared (SWIR) imaging capability in a highly elliptical orbit (HEO) configuration offer the potential for quasi-geostationary observational coverage of CO2 and CH4 in the high latitude regions. Such observations are more challenging at high latitudes than at lower latitudes due to large solar zenith angles and reduced albedo over snow in SWIR bands compared to other land surfaces. In spite of these challenges, earlier work has demonstrated that HEO observations would yield improved constraints on regional-scale Arctic and boreal CO2 fluxes, where permafrost and other components of the carbon cycle will be important to monitor over the coming years. This paper will provide an overview of recent progress on the mission concept study and on CO2 retrievals in high latitude regions using observed spectra from NASA's Orbiting Carbon Observatory 2 (OCO-2).

1707031 Remote Sensing of the Atmosphere and Surface from Space - Part 2
Cloud-assisted retrieval of stratospheric water vapor from nadir view satellite measurements
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Water vapor in dry atmospheric environments is of great importance for weather and climate. However, the retrieval of stratospheric water vapor is known to be challenging. Satellite nadir view radiance measurements usually do not have sufficient sensitivity to the low concentration of stratospheric water vapor while limb view measurements have large sampling footprints, making small scale water vapor hard to be detected. This study examines the feasibility of retrieving stratospheric water vapor using a nadir infrared hyper spectrometer, with a focus on the detectability of small-scalar water vapor variability. Based on optimal estimation method [Rodgers 2000], this investigation iteratively retrieves the stratospheric temperature and humidity from synthetic satellite radiance using MODTRAN 5.0 as the forward model. The feasibility of the retrieval is assessed using simulation experiments under a variety of instrument settings. A hypothetical case with ideal instrument setting shows the theoretical limits of this retrieval, while a suite of additional cases shows the performance that can be expected from current satellite instruments, as well as improvements that can be achieved under different instrumentation conditions.
These experiments show that the infrared spectra, measured with sufficient spectral coverage, resolution and noise level, contain considerable information content that can be used to retrieve lower stratospheric water vapor with. Very interestingly, it is found that the presence of an opaque cloud layer at the tropopause level can substantially improve the retrieval performance, as it helps remove the degeneracy in the retrieval problem. Under this condition, elevated lower stratospheric water vapor concentration, for instance, caused by convective moistening, can be detected with an accuracy of 0.13 g/m2 using improved space-born hyper spectrometers.

1707031 Remote Sensing of the Atmosphere and Surface from Space - Part 2

Using O2 bands to improve MAESTRO tangent height profiles

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MAESTRO (Measurement of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation) is part of Atmospheric Chemistry Experiment (ACE) mission flying along with a Fourier Transform Spectrometer (the ACE-FTS) since 2003 on-board the Canadian satellite SCISAT. It measures a wide range of solar spectra in Occultation mode from 400 nm in UV region up to 1000 nm in Visible with a spectral resolution between 1.5 and 2.5 nm. The primary goal of MASTRO instrument in the ACE mission is the measurement of aerosol extinction. However, the MAESTRO retrieval is able to determine the pressure and temperature profiles using the A- and B- band of the O_2 molecule. The retrieval fits the entire spectra from a single occultation simultaneously to determine the density profile, which is then used to retrieve the pressure and temperature profiles. Current tangent heights used by MAESTRO's algorithm are provided by the ACE-FTS measurements based on CO_2 profiles. Recent improvements to the O_2 spectroscopic parameters led to an improvement of MAESTRO pressure profiles which could be used for the MAESTRO tangent height determination. In this study, the influence of improved O_2 parameters on MAESTRO p-T profiles as well as the potential of using the MAESTRO pressure profiles to determine more accurate tangent height profiles for MAESTRO measurements will be discussed.

1707031 Remote Sensing of the Atmosphere and Surface from Space - Part 2

EarthCARE radiative transfer algorithms and products: A summary and application to A-train data

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The EarthCARE mission, expected to launch in late 2018, will use a combination of passive, a multispectral imager, and active instruments, lidar and cloud radar, to retrieve profiles of cloud and aerosol properties. In addition to these instruments a radiometer will measure broadband solar and thermal radiances at nadir and along track at 53 degrees in the fore and aft directions. The retrievals are used as input for 1D and 3D broadband radiative transfer calculations with the latter computing radiances and fluxes that will be used to evaluate retrievals through continuous comparison to broadband radiometer observations. In advance of launch, the algorithm is being applied to A-Train observations and synthetic observations generated using high resolution numerical weather prediction model output and instrument simulators. We provide a brief description of the radiative transfer algorithms and products as well as results of applying the algorithm to the two sources of input data.

1707031 Remote Sensing of the Atmosphere and Surface from Space - Part 2

Characterizing Wheat Yield Sensitivity to the Timing and Duration of Soil Moisture Extremes Observed from Microwave Satellites

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Crop yield predictions are extremely important across the Canadian Prairies (Manitoba, Saskatchewan and Alberta), where roughly 80% of Canada's total cropland area is found, as they are essential in identifying potential and actual food losses that can help guide export-import policies, food security policies, and land management practices. However, as climate variability intensifies and the global demand for food increases, there is a growing need to develop a greater understanding of the relationships between climatic variables and yields in order to facilitate the development of more robust and accurate large-scale crop yield prediction methodologies and to assess the impacts of current and future extremes. Soil moisture is widely regarded as one of the main determinants of yield, particularly in arid regions such as the Canadian Prairies. While in-situ measurements of soil moisture are sparsely-distributed, recent developments in remote sensing platforms, such as the Soil Moisture Ocean Salinity Mission (SMOS) satellite, have allowed for accurate observations of global soil moisture at frequent temporal resolutions. However, a challenge exists in determining the thresholds of satellite soil moisture that are indicative of reduced yields at the end of the season, since satellite soil moisture differs in scale (in both support and extent) to more traditional measures of soil moisture or climate that have been used to study such relationships at the field plot scale. Moreover, defining extremes over the short record of satellite data is challenging, since extreme events are by definition, rare. The aim of this study is to investigate the utility of remotely-sensed satellite observations of soil moisture extremes in regional wheat yield predictions.

To complete this analysis SMOS weekly volumetric soil moisture data for North America, gridded to a 0.25 degree resolution, and township-level wheat yield data provided by Agriculture and Agri-Food Canada was acquired for 2010-2016 for a study region in Central Saskatchewan. Determination of the relationships among soil moisture and wheat yield anomalies was completed using an iterative chi-square analysis to identify the phenological stages in which crop yields exhibit the greatest sensitivity to soil moisture extremes. In order to account for the short satellite temporal record, spatial aggregation will be used to "trade space for time", increasing the number of observations in the data record. An analysis of the sensitivity of the spatial aggregation grids to be included in the chi-square approach was required. Several spatial aggregation windows were evaluated to illustrate the changes in associations among yield and SMOS soil moisture. Optimization of the aggregation window will have significant implications for the development of more reliable crop yield prediction methodologies and for facilitating further research into the use of remotely-sensed soil moisture observations in predicting crop yields.

1707031 Remote Sensing of the Atmosphere and Surface from Space - Part 2

Moving towards Operational Drought Monitoring Using the Vegetation Drought Response Index

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Agriculture and Agri-Food Canada, through the National Agroclimate Informaiton Service, provides timely information on weather and climate conditions and impacts throughout Canada at national and regional scales. These are distributed as maps and reports to help inform the agricultural sector about potential and ongoing risks to agricultural production in Canada, and includes many commonly used indicators of drought, such as the Palmer Drought Severity Index (PDSI). Traditional drought indicators use precipitation and

temperature measurements from meteorological stations that collect long term measurements. These indicators are limited by the number of long-term stations that are available, limiting the spatial resolution of these indicators in areas where stations are sparse. The Vegetation Drought Response Index (VegDRI) was developed in the United States as a drought monitoring indicator that can be used to map drought conditions at a higher spatial resolution using remote sensing data and station-based weather data as inputs. The model developed in the United States was adapted and validated for use in monitoring agricultural regions in Canada (Tadesse et al, 2017). The model combines remotely sensed vegetation condition using the Normalized Difference Vegetation Index, remotely sensed land cover and irrigation along with soil properties and weather station information to categorize drought severity at a 1km resolution. This paper will discuss existing drought monitoring tools in Canada and how the VegDRI remote sensing index can help supplement these for providing a unique perspective on drought in Canada

1707031 Remote Sensing of the Atmosphere and Surface from Space - Part 2

Evaluating the relationship between C-band SAR backscatter and sea ice thickness in the Beaufort Sea

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The Beaufort Sea is a region of significant interest for both climate science and marine operations as summer sea ice extent and ice age have shown strong declines in recent years, while interest in oil and gas activities have increased. As a result, there is high demand for improved sea ice observations in this region. In particular, routine observations of ice thickness are desired at regional scales for the initialization, parameterization and validation of seasonal and long-term ice forecasts, and at local scales for ensuring safe marine operations. We present ice thickness measurements acquired in April 2009-2016 by an airborne electromagnetic induction system (AEM). The AEM data are compared to RADARSAT-2 (RS2) synthetic aperture radar (SAR) imagery to determine if ice thickness can be inverted from C-band SAR data. The RS2 data include ScanSAR dual-pol (HH/HV) and high-resolution quad-pol images. Ice drift is accounted for by utilizing ice motion vectors from the Canadian Ice Service Automated Sea Ice Tracking System, which tracks ice motion between sequential SAR images. The AEM measurements indicate that there is high interannual variability in the modal multi-year ice thickness in the Beaufort Sea, and that significant areas of thin first-year ice were present in 2015 and 2016 due to strong divergent ice motion and westward advection in February-April. The AEM data were averaged in 1 to 10 km intervals and compared to SAR backscatter and polarimetric parameters. Correlations between ice thickness and SAR backscatter were generally strong, especially for data averaged over 5 km or longer intervals ($r > 0.7$). However, the root-mean-squared error of ice thickness estimates inverted from SAR backscatter was high (> 0.5 m). Work is ongoing to conduct detailed analysis of polarimetric parameters and to compare the AEM and SAR data at the floe scale instead of fixed distance intervals.

1707040 Numerical Methods and Model Development

A higher-order finite volume method for quasi-uniform spherical grids

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As resolution and computational resources increase with new supercomputing environments, the polar singularities and uneven grid spacing of traditional latitude/longitude grids limit the maximum permissible timestep and parallel scaling of the dynamical cores of global weather models. Quasi-uniform grids alleviate these problems by maintaining a fixed area ratio between the grid's smallest and largest cells, but they lack the coordinate orthogonality and regular structure of latitude/longitude grids.

This work develops a non-staggered finite volume method for these quasi-uniform grids capable of at least third-order convergence, reconstructing scalar and vector quantities at cell edges from their cell-average values. Results are demonstrated for the global shallow water equations, as a precursor to a three-dimensional dynamical core.

1707040 Numerical Methods and Model Development
How to choose the filter in pseudospecral DNS simulations?
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Since the 1970s when Gottlieb and Orszag wrote their monograph on spectral methods, these methods have been an important tool used within the computational fluid dynamics community. One aspect of spectral methods that has been under-examined in the literature is the filter. Though many spectral schemes exist, most do not discuss the details of the impact of the filter. We will use high resolution DNS of stratified flows to examine how certain filters fail, and how that motivates the choice of correct filter. Different filters will be analyzed for the Burgers equation, shallow water equations, and the full Navier-Stokes equations under the Boussinesq approximation. The differences between the necessary filter strengths for each equation will be presented. Applicability of filters used in idealized models to the full Navier-Stokes equations will discussed.

1707040 Numerical Methods and Model Development
The evolution of Environment Canada's numerical prediction systems over the past 50 years
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To mark the first 50 years of CMOS, the Operations division of the Canadian Meteorological Centre (CMC) will present an overview of Canadian numerical prediction systems over the past half century. Over this period, we have witnessed an evolution from two atmospheric deterministic models (the Global and Regional models) to a world-class suite of ensemble, coupled-oceanic, environmental, and seasonal prediction systems. The wide breadth of high quality prediction systems of today is a testament to the scientific and technological foresight of our researchers, developers, computer scientists, and meteorologists over the years. In many respects, these were true pioneers in their fields, and they built a lasting foundation for a strong weather and environmental service for the benefit of Canadians.

1707040 Numerical Methods and Model Development
Three dimensional graphics as a tool for studying dynamics
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Three-dimensional simulations are now a regular feature of the computational fluid dynamics literature. Just as there is a wide variety of models, there is a wide variety of visualization tools. Climate models (e.g. the NCAR CESM) and weather models (e.g. WRF) tend to have well developed tools that are maintained by organizations on an ongoing basis. Models for dynamics tend to employ more ad hoc methods, often developed, at least in part, in house. In this talk we report on efforts to use the open source software VisIt as a tool for a variety of dynamics simulations in our group. The central point of this effort is to make visually pleasing images, but also to go beyond this to facilitate novel insight into the fluid dynamics that may not be possible to visualize in two dimensions. We will discuss tools ranging from enhancing portions of the colorbar in volume plots, to plotting different variables together, to the hierarchy of variables from primary variables output by the model (e.g. velocity), to secondary variables computed via differentiation (e.g. enstrophy), to tertiary variables computed from decompositions of the rate of strain tensor (e.g. Q and lambda_2).

1707040 Numerical Methods and Model Development

A projected model for internal wave propagation

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We consider the propagation of low-mode internal tides through quasi-geostrophic turbulence in the open ocean. Fully non-linear simulations reveal that the tides are both distorted and scattered to smaller scales by the time-varying quasi-geostrophic flow. We derive a linearized, vertical-mode projected model that captures these two effects. An analysis of the non-linear model outputs shows that the fields satisfy the projected model equations. Lastly, we evaluate the projected model's predictive performance, and consider perspectives for leveraging this computationally lightweight model.

1707040 Numerical Methods and Model Development

A post-processing technique for stabilizing the discontinuous pressure projection operator in marginally-resolved incompressible inviscid flow

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A method for post-processing the velocity after a pressure projection is developed that helps to maintain stability in an under-resolved, inviscid, discontinuous element-based simulation for use in environmental fluid mechanics process studies. The post-processing method is needed because of spurious divergence growth at element interfaces due to the discontinuous nature of the discretization used. This spurious divergence eventually leads to a numerical instability. Previous work has shown that a discontinuous element-local projection onto the space of divergence-free basis functions is capable of stabilizing the projection method, but the discontinuity inherent in this technique may lead to instability in under-resolved simulations. By enforcing inter-element discontinuity and requiring a divergence-free result in the weak sense only, a new post-processing technique is developed that simultaneously improves smoothness and reduces divergence in the pressure-projected velocity field at the same time. The refined post-processing is applied to an environmental fluid mechanics benchmark problem, the inviscid propagation of an internal solitary wave in a uniform depth channel with a two layer stratification. When compared against a non-post-processed velocity field, the post-processed velocity field remains stable far longer and exhibits better smoothness and conservation properties.

1707050 Planetary Atmospheres, Oceans and Ice - Part 1

Characterizations of Martian Water-Ice Cloud Crystal Geometries From Phase Functions Derived Using MARCI Image Data

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The Mars Color Imager (MARCI) was launched aboard the Mars Reconnaissance Orbiter (MRO) in early August of 2005. During the orbiter’s primary science phase (PSP), MRO was locked in a 3am-3pm sun-synchronous orbit, allowing MARCI to capture 12 to 13 images per Martian day in 5 visible and 2 ultraviolet wavelengths. These filters were permanently mounted on top of MARCI’s 180° field of view (FOV) charge coupled device (CCD), operating as a ‘pushbroom’ imager capturing frames every few seconds. Our work seeks to derive the phase function of Martian water-ice clouds through the analysis of MARCI images taken during the PSP. We will then use the phase function data to deduce the dominant geometries of water-ice

crystals in Martian clouds by comparing the phase functions to their corresponding scattering angles over the course of the entire PSP. We take into account the angles at which the clouds were observed by MARCI and the angles at which they received incident solar radiation, to have a thorough understanding of how the ice crystals in any image pixel scatter light. Furthermore, we hope to observe how the dominant ice crystal types change over the course of a Martian year, and over Martian longitude.
With a more concrete understanding of the types of ice crystals that exist in Martian water-ice clouds, we can better understand the global climate impact of these clouds, as their particulate geometries affect how solar radiation is distributed in the atmosphere. It can also dictate whether optical phenomena such as haloes could be observed on Mars.

1707050 Planetary Atmospheres, Oceans and Ice - Part 1
Dust within Gale Crater, Mars: Observations from the Mars Science Laboratory
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It is well known that Mars is a dusty place. Telescopic, orbital and ground observations have confirmed this time and again. Shortly after the Mars Science Laboratory landed in August of 2012, it appeared that dust devil activity might be minimal within Gale Crater, Mars. Up until recently, over two hundred dust devil survey movies (DDSM) have been collected with only one marginal sighting of a dust devil and one dust-lifting event. Convective vortices, e.g. dustless devils, have been inferred from pressure dips as seen with the Rover Environmental Monitoring Station, leading to the thought that wind speeds in Gale Crater may be subdued, which would be in agreement with predictions of a suppressed planetary boundary layer that ultimately curbs wind speed.
The DDSM observations have however shown cloud activity and have been repurposed to study the dust-loading environment in northern Gale Crater. Seasonal trends in dust loading are observed, with higher line-of-sight extinction coefficients in southern spring and summer and are repeatable over the two Mars years in which data exists. Additionally, the amount of dust per kilometer outward horizontally from the rover is lower than that of the vertical column averaged dust per kilometer. Similar values for the line-of-sight and the column-averaged extinction do occur throughout the dataset, specifically during mid-winter (Ls 135) and mid-summer (Ls 300-315) in the southern hemisphere.
Recently, non-DDSM images appear to show dust devils and dust-lifting events. Dust devils may have been occurring all along, but due to the northward pointing of the DDSMs none were found. A new campaign to search and study dust devils is underway surveying different times of day and a more diverse geographical area adding to the story of dust on Mars.

1707050 Planetary Atmospheres, Oceans and Ice - Part 1
Inter-annual and diurnal variability in clouds observed from MSL over two Martian years
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We report on cloud observations conducted using the Navigation Camera (Navcam) onboard the Mars Science Laboratory rover Curiosity over a two Martian year period between Ls = 150° of MY 32 to Ls = 160° of MY 33. During this two-year period, over 500 cloud observations have been returned which have revealed tenuous water-ice and dust clouds in the skies above the landing site. The equatorial latitude of

Curiosity’s landing site, Gale Crater, has enabled consistent imaging of the aphelion cloud belt (ACB) to be made during the aphelion seasons (centered around Ls = 71°) of MY 32 and 33. We examine the inter-annual variation of the ACB between these two Mars years using opacity measurements obtained from the Navcam images. Increased cloud opacity is found in MY 33, which is increased by 38% compared to MY 32, however this unexpectedly large inter-annual variation is likely attributed to a statistical bias in the diurnal distribution of the ZMs and SHMs. When this bias is accounted for, <5% variation in cloud opacity is seen in the ZM data set between the two Mars years studied, which is expected given the low degree of inter-annual variability of the ACB observed using orbital data sets. Additionally, the diurnal behavior of the ACB is examined between Ls = 42°-146° of MY 33. Increased opacity occurs in the morning hours between 07:00-09:00. The opacity appears lowest near midday, although the diminished coverage between 09:00-13:00 limits the analysis that can be made. Cloud opacity is found to steadily increase as the day progresses, reaching another maximum in the late afternoon between 15:00-17:00.

1707050 Planetary Atmospheres, Oceans and Ice - Part 1

Estimating the Altitude of Martian Clouds at the Mars Science Laboratory Rover Landing Site

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Clouds on Mars have been observed through movies taken from the NavCam on the Mars Science Laboratory (MSL) Rover, also known as Curiosity, located at Gale Crater. These movies are called “zenith movies” (ZMs) and consist of eight images taken at an elevation of 85° with a 45° field of view. These movies are acquired every 3-4 sols and have been taken consistently since the beginning of the mission. The altitude of the observed clouds has yet to be determined due to the absence of a LiDAR sensor on board. To estimate this altitude, the Mars Regional Atmospheric Modeling System (MRAMS) will be used to compare observations with numerical predictions to correlate wind direction and speed.

Due to the low optical depth of the clouds, the raw images must be processed using the mean-frame subtraction technique before the wind speed and direction can be correlated. The ZM is created by putting the processed images together to form a movie which allows the cloud evolution to be more easily observed. The angular wind speed can then be calculated by finding the average distance the clouds move across the frame whilst the wind direction can be found by following the cloud’s direction of motion. After finding these parameters, they will be compared to the wind speed and direction through the MRAMS model data to pinpoint an altitude between 0 and 50 km above Curiosity.

The goal of this research is to simulate and compare and entire Martian year to find the height of the clouds above Curiosity’s location over an entire Martian year. Although to start, the altitude corresponding to the ZMs and MRAMS data for the first solar longitude (LS) 90° will be presented in this work.

1707050 Planetary Atmospheres, Oceans and Ice - Part 1

Trace gas retrievals for the ExoMars Trace Gas Orbiter Atmospheric Chemistry Suite mid-infrared channel

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The ESA's ExoMars Trace Gas Orbiter (TGO) entered a nominal Martian orbit in October 2016 and its primary science operations will commence in fall 2017 after an aerobraking phase is complete. The TGO carries two spectrometer suites, a neutron detector and a camera. The Atmospheric Chemistry Suite has three spectrometers, and this presentation focuses on the mid-infrared channel (ACS-MIR). ACS-MIR is a cross-dispersion echelle spectrometer combining an echelle grating with a wide blaze angle and a secondary grating to separate the spectral orders. The secondary grating operates in several positions, resulting in spectra between 100 - 300 nm wide, over a spectral range of 2.3 - 4.2 ?m. The MIR channel operates in solar occultation mode, and has a resolving power of ~50,000. Since the launch of TGO, the instruments have been operated three time: mid-cruise, after Mars orbit insertion, with a 4-day elliptic orbit, and prior to aerobraking, with a 1-day elliptic orbit. There are two data analysis streams for ACS-MIR, the first at the Space Research Institute (IKI) in Moscow, based on Spectroscopy for Investigation of Characteristics of the Atmosphere of Mars/Venus (SPICAM/V), and the other from Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS) in Paris and based on terrestrial retrieval software, the GGG software suite from NASA's Jet Propulsion Laboratory. We will present preliminary results from the in-flight instrument operations, introduce the trace gas volume mixing ratio (VMR) retrieval strategy, target trace gas species, their expected abundance and detection limits, and simulated ACS-MIR spectra and trace gas retrievals made in preparation for the first solar occultation measurements at the end of 2017.

1707050 Planetary Atmospheres, Oceans and Ice - Part 1

The GEM-Mars General Circulation Model for Mars

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In addition to an increasing observational dataset, it is vital to have powerful and flexible atmospheric modeling capabilities to enhance our understanding of the processes taking place in the Martian atmosphere. The GEM-Mars three-dimensional general circulation model uses the operational framework and dynamical core of the Global Environmental Multiscale (GEM) model from the Recherche Prévision Numérique (RPN) division of Environment Canada (Côté et al., 1998a, 1998b; Yeh et al., 2002). The current version available to the community (under the Gnu Lesser General Public Licence v2.1) is GEM 4.2.0, and this has been converted from the terrestrial application for the simulation of the Mars atmosphere. Physical processes have been included such as condensation and sublimation of carbon dioxide, dust lifting, radiatively active water ice clouds and gas-phase chemistry.

We will present the current state and performance of the model now that the ESA-Roskosmos ExoMars Trace Gas Orbiter (TGO) mission is underway and in orbit around Mars. GEM-Mars will play an integral part in the analysis of data that is received by the NOMAD instrument (Vandaele et al., 2015) on board the TGO.

1707051 Planetary Atmospheres, Oceans and Ice - Part 2

Penitentes at Tartarus Dorsa, Pluto

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Actively sublimating surfaces often form complex morphologies on Earth such as penitentes, in which deep hollows separate regular spires or ridges. We apply the theory of how these features form on Earth to the much larger regular and possibly self-organizing sublimation features observed at Tartarus Dorsa (TD) on Pluto. Referred to as 'bladed' or 'snakeskin' terrain we find that these features are well described by the theoretical penitente models of Claudin et al (2015) with spacing, orientation and growth rates matching well with observations for the methane ices observed by New Horizons (NH) on Pluto. Nitrogen ices, by contrast, are not anticipated to form penitentes under the same model, also matching with observations that the bladed terrain is restricted to TD.

One active period is observed for the atmosphere per orbit occurring at either the vernal or autumnal equinox, depending upon Pluto's orbital state. This active period for the atmosphere leads to two peaks in the limiting friction velocity towards the start and end of the atmospheric active period. As such, over Ma timescales, there are four separate periods when the formation of penitentes is favored. This leads to three different predicted orientations for growing penitentes that align with the observation of three different orientations at TD on Pluto. At the times of formation, PlutoWRF predictions of atmospheric conditions support the observed scale of the features. Finally, if the initial topography is assumed to be similar in scale to Pluto's youngest terrains, a formation timescale of several 10s of Ma is derived from deepening rates of approximately 1 cm/orbit in the current era, consistent with crater-ages estimates for TD which are intermediate between Sputnik Planum (<10 Ma) and eastern Tombaugh Reggio (~1Ga). Taken together, these three lines of evidence collectively suggest that the bladed terrain is composed of penitentes.

1707051 Planetary Atmospheres, Oceans and Ice - Part 2

Surface shielding of UV radiation on Mars from idealized spacecraft components

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Martian surface chemistry and habitability are affected by the levels of UV radiation incident on the surface. In the Martian atmosphere, UV radiation undergoes lower levels of attenuation than in Earth's atmosphere due to lower abundances of ozone and lower atmospheric pressure. Spacecraft on the surface can cause shielding in a similar fashion to surface features such as pits or ridges. In this work we simulate the effects of shielding from idealised spacecraft components on the Martian surface using a combination of the Doubling and Adding (D&A) radiative transfer code and an original geometric code.

The D&A code includes optical depth contributions from Rayleigh scattering, mie scattering and gaseous absorption and outputs radiances as a function of azimuth and zenith angle. The model has been validated against literature models and the outputs are in good agreement. The shadowing from idealised spacecraft components is calculated from the outputted radiance maps of the D&A code, assuming each point in the radiance map emits a parallel vector field. Regions not in shadow receive a proportion of the incident energy corrected for the incidence angle. Reflection from spacecraft components is included, assuming that each point on the spacecraft in light absorbs a proportion of the incident energy, according to the albedo of the spacecraft material, and radiates the remaining energy uniformly. This is repeated for every point in the radiance map and the received energy summed. This is repeated for a number of time intervals, to build up a map of UV energy received by the ground in the vicinity of specific spacecraft components over the course of a sol, a season or a year.

1707051 Planetary Atmospheres, Oceans and Ice - Part 2

Laboratory Studies of Deliquescence and Adsorption at the Surface of Mars with Raman Scattering

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Laboratory chamber experiments have been carried out to investigate the exchange of water between the atmosphere and surface on Mars. Raman spectroscopy was applied to detect water uptake by samples of magnesium perchlorate hexahydrate. When exposed to the water vapour pressure and temperatures found at the Phoenix landing site, magnesium perchlorate hexahydrate samples of the size found on Mars began to undergo deliquescence at temperatures above the frost point temperature for pure water ice. Significant water uptake from the atmosphere began to occur within minutes, indicating that bulk deliquescence is likely to occur on present-day Mars. This demonstrates that perchlorates in the surface material can contribute to the hydrological cycle on Mars by absorbing water directly from the atmosphere.

Chamber experiments have also been conducted to study the adsorption of water on regolith grains. Raman spectroscopy has been applied to study the adsorption properties of zeolites under conditions found at the Phoenix landing site on Mars. Experimental results indicate that zeolites on the surface of Mars are capable of simultaneously adsorbing water and carbon dioxide from the atmosphere on diurnal time scales and that Raman spectroscopy provides a promising method for detecting this process during a landed mission. Additional experiments were carried out using a mixture of magnesium perchlorate and zeolite. The sample of mixed surface material remained visually unchanged during water adsorption, but was found to darken during deliquescence.

1707051 Planetary Atmospheres, Oceans and Ice - Part 2

An Investigation into how Water is Transported to the Moon's Polar Regions

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Cabeus crater, and other low lying areas near the southern pole of the Moon are known to be permanently shadowed regions (PSRs) where water ice can be trapped. These PSRs receive no direct solar radiation and thus fall over 60 K below water's volatility threshold. Signals of water ice near the lunar poles have been observed through different methods.

Recently, it has been proposed that the almost antipodal, 5° offset between the water ice signals from the north and south poles of the Moon are due to True Polar Wander. This would imply that the subsurface ices of Cabeus crater are several Gyr old and that new delivery of ice to polar PSRs is relatively insignificant. It has been shown that the cold temperatures of the poles create potential energy barriers for incoming particles, which in turn allow lower latitude craters to have higher concentrations than their poleward neighbours. During this work, the trapping of water molecules was further explored using a combination of numerical models of ballistic transport of water vapour on the present-day lunar surface, including both a validated Monte Carlo model and a full lunar exospheric model, which had not previously been explored poleward of 85°S. All the accumulated fractional concentrations of water ice in PSRs, taken with respect to that of Cabeus Crater, were similar to those reported by Moores (2016).

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1707060 A Transdisciplinary Approach to Future Earth
Toward seamless weather-climate and environmental prediction
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Over the last decade or so, predicting the weather, climate and atmospheric composition has emerged as one of the most important areas of scientific endeavor. This is partly because the remarkable increase in skill of current weather forecasts has made society more and more dependent on them day to day for a whole range of decision making. And it is partly because climate change is now widely accepted and the realization is growing rapidly that it will affect every person in the world profoundly, either directly or indirectly.
One of the important endeavors of our societies is to remain at the cutting-edge of modelling and predicting the evolution of the fully coupled environmental system: atmosphere (weather and composition), oceans, land surface (physical and biological), and cryosphere. This effort will provide an increasingly accurate and reliable service across all the socio-economic sectors that are vulnerable to the effects of adverse weather and climatic conditions, whether now or in the future. This emerging challenge was at the center of the World Weather Open Science Conference (Montreal, 2014).The outcomes of the conference are described in the World Meteorological Organization (WMO) book: Seamless Prediction of the Earth System: from Minutes to Months, (G. Brunet, S. Jones, P. Ruti Eds., WMO-No. 1156, 2015). It is freely available on line at the WMO website.
We will discuss some of the outcomes of the conference for the WMO World Weather Research Programme (WWRP) and Global Atmospheric Watch (GAW) long term goals and provide examples of seamless modelling and prediction across a range of timescales at convective and sub-kilometer scales for regional coupled forecasting applications.

1707060 A Transdisciplinary Approach to Future Earth
Addressing the Transdisciplinary Approach through Global Research Programs
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As we look ahead to the future climate and global ecosystems, we need to examine how the interactions between natural and social sciences – and other disciplines – can contribute to a sustainable future. There are now several international research programs undertaking this research and the connections with Canadian research, and policy, communities needs to be enhanced. This will also enable the injection of Canadian concerns and issues into this broader scientific agenda for mutual benefits.

1707060 A Transdisciplinary Approach to Future Earth
Transdisciplinary approaches of the Future Earth Ocean Knowledge-Action Network
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Cook, Christina - Future Earth
Starger, Craig - Future Earth
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The ocean forms a globally connected ecosystem and highly dynamic environment of physical, chemical, and biological interaction. It maintains a great diversity of life, exchanges mass and heat with the atmosphere and modulates our climate. The ocean, including coastal and nearshore areas, thus provide services essential for life on earth and to the history, culture and livelihoods of people across the globe.
The overarching goal of Future Earth Ocean Knowledge-Action Network is to enable a solution-oriented, transdisciplinary approach to ocean research that will provide critical knowledge regarding how the ocean is changing, how these changes impact the diversity of life, human systems and governance of the ocean and beyond, and societies may prepare for and respond to these changes.
High-level key questions thus include:
- How do human activities, combined with natural variability, affect the health of the ocean and coasts and their environmental and socio-economic services?
- How can detrimental effects on ocean health be avoided?

- How can ocean health and services to people be preserved or restored?
Engagement of a broad range of researchers and societal partners is central to the work of the Future Earth Ocean Knowledge-Action Network. As such, Future Earth will facilitate transdisciplinary research that can be used by policy-makers, businesses and communities to achieve sustainable interactions of humans with the ocean at large. We will also work to build scientific capacity to empower researchers and societal partners worldwide to assess the state of the oceanic and coastal domains and improve their management and governance.

1707060 A Transdisciplinary Approach to Future Earth
Future Earth, Future Transport
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Transportation underpins much of the economic activity and social well-being in Canada and is highly sensitive to weather and climate conditions across a wide range of system users, managers, decisions and time scales. The mobility benefits afforded by the transport system come with significant environmental, social and economic costs, including its significant and growing role in emissions of greenhouse gases and other air pollutants. Much effort and resources are spent managing these costs and taking actions to reduce or ameliorate weather-related risks and impacts in order to maintain adequate mobility and acceptable levels of safety and performance. Many of these actions are informed by weather and climate-related knowledge. As performance requirements become more demanding, driven in part by advances in transportation technology and expectations of a just-in-time, high-speed, global economy, the need for both integrated prediction systems and actionable weather information and climate services has never been greater. This presentation explores current challenges; emerging trends, sensitivities, and opportunities; and future scenarios of the transportation sector, particularly as they pertain to Canada – and how these intersect with weather, climate and climate change.

1707060 A Transdisciplinary Approach to Future Earth
Weather Extremes and Human Health: Adaptation to Protect Canadians in a Changing Climate
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Current emissions of greenhouse gases put the world on track for warming of more than 2oC, a level that increases the risk of potentially catastrophic climate change. The World Health Organization has identified a number of key health risks from climate change and has called on health authorities in all countries to take actions to reduce impacts. Recent research suggests that climate change is increasing risks to the health of Canadians. In addition to impacts from greater air pollution (e.g., pollens, ground level ozone, particulate matter, mould), impacts on water- and food-borne diseases, and the spread of vector-borne diseases (e.g., Lyme disease), many weather hazards such as wildfires, droughts, extreme heat events and ice storms continue to impact communities in Canada and are expected to increase in frequency and severity due to climate change.
Canadian health authorities, in collaboration with meteorologists and climatologists, are beginning to prepare for climate change. Officials at federal, provincial, territorial and local levels are gaining new knowledge about climate change risks to health, weather and climate trends, vulnerable populations and the capacity of individuals and organizations to take protective actions. The Climate Change and Innovation Bureau at Health Canada is fostering new partnerships and has developed new information and tools to facilitate the use of weather and climate services information in efforts to protect the health of Canadians from climate change impacts. Dr. Berry will provide examples of these activities and discuss the need for continued collaboration to integrate evidence-based research findings into health and emergency management decision making to help Canadians prepare for the health risks of climate change and reduce future impacts.

1707060 A Transdisciplinary Approach to Future Earth
The economics of disaster management
Part of a proposed session lead by Gordon McBean on a transdisciplinary approach to future earth
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Over several decades there has been an alarming increase in the economic damage in Canada due to extreme weather. The session will review the major factors contributing to this increase, and prospects for better managing the risk of disasters. Risk management options that will be explored include investments to better understand the evolving risk of damage from severe weather, options for risk reduction including land use planning and building codes, and mechanisms to finance severe weather risk management like insurance.

1707070 Boundary-Layer Studies
Idealized Simulations of Sea Breezes over Mountainous Islands
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High-resolution simulations of diurnally heated airflows over mountainous islands are conducted to study the impacts of island terrain on sea-breeze circulations. As the simulated island terrain height increases, the sea-breeze front (SBF) propagates inland faster but its frontal circulation weakens dramatically, as does the sea-breeze flow behind it. This sensitivity is interpreted through the frontogenesis budget in a SBF-relative reference frame. The dominant frontogenetic term (the cross-frontal convergence) weakens over taller islands, but this trend is offset by a similar weakening of the dominant frontolytic term (the front-relative advection) to yield minimal sensitivity of the SBF baroclinicity to island terrain height. At first glimpse, this finding appears inconsistent with the systematic reduction in SBF circulation strength over taller islands. However, as the island height is increased, baroclinicity at the SBF becomes increasingly associated with not the front itself but with the ``background'' baroclinicity associated with elevated heating over steeper island slopes. When this latter contribution is removed, a clear weakening of the SBF baroclinicity is recovered over the taller islands. Analysis of the cross-frontal convergence budget indicates that this reduction in cross-frontal convergence, and hence the SBF baroclinicity, is caused by an increased slope-parallel buoyancy gradient. As the SBF migrates inland, this gradient preferentially accelerates the air ahead of the SBF up the slope, which weakens the convergence along the front. Finally, as shown by a simple scaling of the slope-parallel momentum equation, the weakened sea-breeze flow over taller islands is associated with a weaker onshore perturbation pressure gradient force, owing to the protrusion of the convective boundary layer into the stable free troposphere.

1707070 Boundary-Layer Studies
A New Diagnostic Turbulence Scheme in CanAm4 Climate Models
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A new semi-empirical turbulent kinetic energy (TKE) scheme has been developed to represent turbulent transfer processes for both clear and cloudy conditions. It has been compared with the default parameterization in the CanAM4 using three single-column modeling cases (Cabauw, ARM2X, and DYCOMS). In general, the new scheme performs comparably well in all boundary layer conditions. In the case of a stable boundary layer, it is capable of reproducing the observed multiple regimes of turbulence, winds, and near surface temperature inversion under nighttime clear-sky conditions, and it reproduces a more realistic fraction of very shallow SBL than that of the default one in the CanAM4 models. A delayed non-local mixing parameterization has been incorporated. It has contributed to improved simulation of diurnal varying winds and temperature during transition period between stable and unstable surface. The new scheme is currently implemented and tested in the CanAM4, results from the recent simulations will be presented.

1707070 Boundary-Layer Studies

Measurements of Aerosol, Trace Gas and Turbulent Fluxes and Vehicle-Induced Turbulence (VIT) from a Mobile Car Platform on the Highway

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Motor vehicles generate vehicle-induced turbulence (VIT) while in motion, which affects the mixing and transport of emitted aerosols, trace gases, heat and momentum. During July 2016, a 40Hz sonic anemometer (ATI), a 20Hz open path CO_2/H_2O gas analyzer (LICOR) and an ultra-high sensitivity aerosol spectrometer were secured to a 2-m height measurement platform and driven on highways in the Greater Toronto Area. Co-located sampling was employed to calculate fluxes using eddy-covariance method. A similar highway study was completed by Environment Canada during the Pan Am games in July 2015, utilizing a 20Hz sonic anemometer (ATI) with a measurement height of 3-m. Both field campaigns utilized a video camera with a GPS system to assess the surrounding features while chasing a specific vehicle type. Video processing then allowed the following distance of each chased vehicle to be calculated as a function of pixel location, with the vehicle location identified as the initial contrast between the vehicle's shadow and the roadway.

To quantify VIT, turbulent kinetic energy (TKE) is calculated using a 10-s averaging period. Analysis of TKE demonstrates a power law decay with increasing following distance, particularly for heavy-duty trucks. The results from both studies are compared to assess variations of TKE with height (i.e. 2-m versus 3-m) for different vehicle classes. Additionally fluxes of aerosols, trace gases, heat and momentum are explored using statistical and spectral analysis and compared to stationary roadside measurements (taken upwind and downwind) to assess their validity. Underestimation of these fluxes due to under-sampling will be also be explored.

1707070 Boundary-Layer Studies

Mesoscale numerical modeling of surface turbulent fluxes in the littoral environment

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Doyle, James - U.S. Naval Research Laboratory
Chen, Sue - U.S. Naval Research Laboratory
Schmidt, Jerome - U.S. Naval Research Laboratory
Piotr, Flatau - Scripps Institution of Oceanography, University of San Diego
Hans, Graber - Rosenstiel School of Marine and Atmospheric Science
Haus, Brian - Rosenstiel School of Marine and Atmospheric Science
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Quantifying turbulent fluxes at the air-surface interface remains an outstanding challenge in high-resolution numerical modeling of littoral environments. Sub-grid scale variability in ocean wave conditions and model terrain representation can generate substantial error in surface wind stress prediction, yielding model error in atmospheric surface layer wind speed, wind direction and additional fields and posing an acute threat to seaborne vessels in transit or near port. The Coastal Land-Air-Sea Interaction (CLASI) project conducted a field campaign during two weeks in summer 2016 around Monterey Bay, California, USA, to collect in-situ and remote measurements of meteorological and oceanographic quantities on-shore, off-shore and slightly inland to capture the cross-shore gradient of key atmospheric fields and turbulent fluxes in a variety of conditions. The region was modeled using the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®) at horizontal resolutions of 1 km (coupled with ocean and wave models) and 333 m (atmosphere only).

Observations from flux tower stations assembled along the Bay just above the high-tide line show a distinct sensitivity of wind stress to wind direction not found at stations positioned several kilometers inland. Inter-station wind stress variability is also seen during on-shore high wind speed conditions. Observations over water suggest a departure of atmospheric surface layer profiles from those expected by Monin-Obukhov similarity theory. Model results show a broad overestimation of predicted wind stress at the shoreline stations. The root-mean-square error of predicted near-surface wind direction at the inland stations is approximately half that at shoreline stations and suggests potential benefit of wind direction-dependence in model wind stress formulations. Model momentum and scalar flux biases further demonstrate the importance of very high resolution terrain representation in high-resolution littoral modeling.

1707070 Boundary-Layer Studies

The Role of Coherent Structures and Coupling Between the Atmosphere and Forest Canopy on Atmospheric Chemistry

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Coherent structures are known to play an important role in the turbulent exchange of mass and momentum above forested canopies. Greater uncertainties exist in the role that these coherent structures play in the regulation of trace gas chemistry, but they are potentially significant as coherent events occur on time scales relevant to in-canopy chemical reactions. We investigate the transport of trace gases by coherent turbulent structures in a temperate forest. Turbulence data were collected during a five-week intensive atmospheric chemistry campaign, PROPHET-AMOS, conducted in a temperate forest located at the University of Michigan Biological Station in July of 2016. The instrumentation included 5 sonic anemometers mounted at different heights on a 34m tall tower ($z = 1.5h$) coincident with a suite of gas-phase chemical measurements. Coherent structures are identified using a wavelet analysis technique and coupling of air masses above and within the canopy are studied and compared to measurements of trace gas species. A 1-D chemistry-including canopy model with an observationally constrained turbulence parametrization is used to quantify the relative contribution of turbulence, photochemistry, emissions, and deposition to modelled chemical concentrations.

1707070 Boundary-Layer Studies

The effects of forest sheltering on peatland evapotranspiration in the Boreal Plains, Alberta, Canada

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Peatlands comprise approximately 50% of the total landscape of the Western Boreal Forest, including the sub-humid Boreal Plains (BP) zone. The BP experiences persistent water deficit conditions, prohibiting anaerobic conditions, which has the potential to increase decomposition, transforming the peatlands from carbon sinks to carbon sources. With evapotranspiration (ET) being the dominant source of water loss in the BP, it is necessary to understand the dynamics and controls on ET within these wetlands. Peatlands often experience turbulent sheltering from their surrounding upland forests, which results in spatially variable ET rates inside the peatlands, produced by zones of flow separation which suppress ET losses. Understanding the dynamics of peatlands and upland forests will allow us to assess the resiliency of hydrologic conditions under future climatic and land use scenarios. The use of the Regional Atmospheric Forest Large Eddy Simulation (RAFLES) allows for various wetland and upland forest configurations to be simulated at a high temporal and spatial resolution. Results have shown that wetlands with the same area and shape, but a different orientation to the dominant wind direction experience significantly different ET loss and spatial patterns of ET.

1707080 Harsh Marine Environments
Explosive cyclogenesis over the North Atlantic: progress, challenges and new research opportunities
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Rapidly intensifying extratropical cyclones, or meteorological "bombs" have been studied comprehensively in the refereed literature for nearly four decades. Nevertheless, operational forecasters have been well aware of this phenomenon for much longer. We focus our discussion on our research and operational progress in understanding explosive cyclogenesis. Much of this progress is linked to our improved knowledge of physical processes that drive rapid intensification. This knowledge, in turn, has led to significant improvements in operational numerical weather predictions. Nevertheless, there are significant, continuing gaps in our knowledge of explosive cyclogenesis. These gaps include explosive secondary cyclogenesis on time scales of a day, and the regime-based "clustering" of rapid cyclogenesis on time scales of weeks. An example of the latter phenomenon is that of the extremely active North Atlantic storm track during the winter of 2013-2014. A strategy for addressing these knowledge gaps will be discussed.

1707080 Harsh Marine Environments
An ocean surface current analysis (GlobCurrent) calibration and validation
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Rio, Marie-Hélène - Collecte Localisation Satellites
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Observations of extreme conditions, characterized by high heat flux, rapidly changing surface wind, or strong ocean current, are rare. Although analyses provide estimates of these conditions, because there are few observations to begin with, it is difficult to calibrate and validate an analysis using independent observations. This requirement of independence may not be so dire, however, if we acknowledge that analyses are designed to localize the impact of observations. We thus propose that extrapolation from outside the impact (in space or time) of an observation provides great freedom to improve an analysis using a framework provided by triple collocation (Stoffelen 1998). In other words, we seek not only to assess performance, but also to suggest that a more complete analysis or retrieval is one that includes downstream calibration and validation against another high quality reference. The ESA GlobCurrent analysis calibration is given with reference to drifting buoys. Some consideration of appropriate physical quantity to gauge measures of performance across an entire range (including both weak and extreme conditions) is given.

1707080 Harsh Marine Environments
The Characteristics of Fog Offshore Newfoundland
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Observations have been made offshore Newfoundland in fog for the past several years and this is leading to a better understanding of its climatology, fog formation mechanisms, and its characteristics. Instruments have been placed on offshore rigs and buoys allowing a unique data set to be collected on open ocean fog. A fog climatology using MANMAR measurements has shown a peak probability near 50% in July with winds from the southwest. No diurnal variation in fog frequency is observed. The early work of Taylor (1917) showed that most of Grand Banks fog is formed as warm air flows over colder water. The more recent observations

confirm this finding. Generally, throughout the year, 80% of the fogs are formed by warm advection with the sea surface temperature being colder than the air. Recent buoy measurements, supplemented by satellite observations show the sea surface temperature gradients during fog events. The fog appears as a bank at the offshore observation site implying formation upwind. The visibilities near the surface at the buoy are similar to those measured on the offshore platforms. The cloud droplet size distribution peaks near 6 microns with droplet concentrations less than 100 cm-3 and liquid water contents less than 0.1 g m-3. These distributions are different that those measured in clouds over the ocean. Some reasons for these differences will be given. How these observations will help in developing improved forecast techniques will be described. Future suggested and planned work will also be outlined.

1707090 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1
Sea ice concentration from SAR imagery using a convolutional neural network and comparison with a passive microwave retrieval

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Synthetic aperture radar (SAR) imagery is widely used for operational monitoring of sea ice conditions. It is challenging to estimate sea ice concentration from these images using automated methods due to sensitivity of the SAR backscatter to the imaging geometry and surface conditions. This task is typically carried out manually by expert analysts, who use their knowledge of visual cues in the images and environmental conditions to estimate sea ice concentration and ice type for a given region.

Convolutional neural networks (CNNs) are a supervised learning method commonly used for image classification tasks. CNNs are able to learn features directly from images, and have been proven capable of outperforming comparable methods. We have used this method to estimate sea ice concentration from SAR scenes acquired during freeze-up in the Gulf of St. Lawrence on the east coast of Canada. The ice concentration estimates from the CNN are compared to those from two additional methods i) a neural network (NN) that uses hand-crafted features, and ii) ice concentration estimated from passive microwave (PM) brightness temperatures. All methods use image analysis charts generated manually as training data. The ice concentration from the CNN is less noisy than that from the MLP due to the deep structure of the CNN. The CNN is also able to capture the small scale details of the ice cover better than the PM data due to the higher spatial resolution of the data. Under significant wind roughening, the CNN ice does produce noisy results over open water, which less of a problem for the ice concentration from PM data. Future steps toward using the CNN-based SAR ice concentration operationally will be discussed

1707090 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1
Automated Detection of Mesoscale Boundaries from Multiple Sensors: a Bayesian Framework

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Mesoscale boundaries are often a key ingredient in thunderstorm and severe weather initiation. Environment and Climate Change Canada's (ECCC) iCAST thunderstorm nowcasting systems allow manual identification of these mesoscale boundaries. However, to date, there exists no system that reliably automates the detection and tracking of mesoscale boundaries.

In this talk, we present preliminary work on the detection and tracking of lake-breeze fronts in the Great Lakes region. A Bayesian framework for the probabilistic description of the evolution of the location of lake-breeze fronts over time is described. This framework has two main components: (i) a prior distribution for the location of boundaries and (ii) an edge detection algorithm for each type of observation.

A prior distribution for the location of lake-breeze fronts is computed from climatology (i.e. manually detected lake-breeze fronts from previous years). This prior is then updated using a conditional climatology of lake-breeze front location given their previous position.
For each type of observation, we then compute the likelihood (probability) of this observation given a boundary at some location. This is combined with the prior probability of the boundary to obtain a posterior probability via Bayes' Theorem. If we want a deterministic answer, the Maximum A Posteriori (MAP) estimator can then be computed.
We concentrate on three types of observations: cumulus cloud detected by satellite imagery, dry convection detected by low-level radar scans and surface station measurements of wind direction, temperature and dew point temperature.
Preliminary results will be presented. Mesoscale boundaries that were manually identified using iCAST between 2004 and 2014 will form the training set, whereas the quality-controlled Toronto 2015 Pan Am dataset of manually detected hourly lake-breeze fronts will be used for validation.

1707090 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1
Towards nonlinear updatable model outputs statistics via machine learning
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While nonlinear machine learning methods have been widely used in environmental forecasting, in situations where new data arrive continually, the need to make frequent model updates can become cumbersome and computationally costly. To alleviate this problem, the online sequential extreme learning machine (OSELM), an online learning algorithm for the one-hidden-layer feedforward neural network model (with random weights in the hidden layer), is automatically updated inexpensively as new data arrive. OSELM was applied to forecast daily streamflow at two small watersheds in British Columbia, Canada, at lead times of 1-3 days and to forecast temperature and probability of precipitation over 13 stations across Canada for forecast hours 3-48. Using the online sequential multiple linear regression (OSMLR) as benchmark, we found that the nonlinear OSELM outperformed OSMLR in forecast accuracy.
OSELM does have a major limitation, namely the number of hidden nodes (HN), which controls the model complexity, cannot be changed from the initial model as online learning proceeds. Usually, as more data become available, the longer time-scale behaviour can be learned by using more HN in the model. A new variable complexity online sequential extreme learning machine (VC-OSELM) is proposed, which automatically adds or removes HN as the online learning proceeds, so the model complexity self-adapts to the growing available data. The performance of VC-OSELM was compared with OSELM in daily streamflow predictions at a lead time of one day, where VC-OSELM outperformed OSELM when the number of initial HN turned out to be smaller or larger than optimal. OSELM and VC-OSELM can be used to provide nonlinear updatable model output statistics in the post-processing of numerical weather prediction model output.

1707090 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1
Comparative Study of Machine Learning Algorithms and the Future of Weather Forecasts
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Machine learning algorithms generate weather forecasts with various strengths and weaknesses. This project compares the optimization and outputs of seven machine learning techniques including, boosted decision tree, decision forest regression, fast forest quantile, neural network regression and others. Weather systems are found to be optimally forecasted by boosted decision trees. Tree structures allow for the mapping and weighting of trends at various scales (seasons versus months versus days etc). Understanding these high-level abstractions of weather systems and applying them to optimization for machine learning generates high accuracy. The data modeled is from NOAA, KAPC, and Arable Inc. The results of this project reveal the

limitations of top end machine learning suites, such as Microsoft Azure, and the methodologic direction that property geophysical machine learning methods should head.

1707090 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1
Use of artificial neural network for fecal indicator nowcasting in a sewage impacted recreational water source

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While the popularity of recreational water-related activities in urban areas is rapidly increasing, the safety of urban waters for such activities is an important concern for citizens and city officials. An important source of uncertainty for the city of Montreal is that during and after heavy rainfall, fecal contamination is highly variable due to the cumulated impact of combined sewer overflow (CSO) discharges in recreational water sources. More specifically, as the city of Montreal is planning to open several beaches along the shore of the Saint Lawrence River, knowing the daily risk of microbial contamination is crucial. Therefore, a "safe" criterion level based on the result of a fecal coliform test that is only available 24 hours after sampling is not appropriate for a day-to-day management . To reduce temporal uncertainty around fecal contamination , we developed an artificial neural network (ANN) model nowcasting concentrations of fecal coliforms.
To predict fecal coliforms, we trained a multi-layer feed-forward ANN with a Levenberg-Marquardt algorithm using the following data: cumulative rainfall, cumulative dry days, volumes of CSO discharges, river flow rate and water temperature, and weekly sampling of from May to September for 2003 to 2015 as the response variable. Our preliminary work shows, using daily rainfall and river flow rates at three sites for a level of 200 CFU/100 ml, that false negative identification fecal contamination by the ANN ranged between 3% to 16%. To improve estimations during peak events, we plan to use local CSO discharges and local flows as supplemental predictors for a second model. More specific information on the microbial risk in a sewage impacted source derived by an ANN model could provide insight, directly transferable to management actions.

1707090 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 1
High Resolution Forecast Prediction using Machine Learning

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Improvements to existing weather forecasting models can be elucidated using the power of machine learning. Current forecasting models such as the Global Ensemble Forecasting System (GEFS) are capable of producing fairly accurate 15-day weather forecasts including temperature and precipitation at resolutions that exceed their daily input dataset. This project uses the output of the GEFS model, and attempts to model true temperature and precipitation for a given location over a time period of t+1 days to t+10 days. In order to achieve these, we trained several machine learning algorithms on GEFS data for a number of test locations, then predicted a forecast for the given time interval. Results are compared to weather station data for test locations to test how accurately our model could produce weather predictions.

1707091 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2
Use of climate and satellite data in crop yield forecasting and early-warning for decision support
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Predicting crop yield ahead of the harvest date provides early warning information for markets, policy and program activities. Agriculture and Agri-Food Canada (AAFC) developed a functional model, the Canadian Crop Yield Forecaster -CCYF, to sequentially forecast crop yield during the growing season and using a monthly time step to provide the much needed early warning functionality. The method utilizes robust least angle regression to reduce the influence of outlier predictors and heteroscedasticity on the variance. Predictor variables are selected from a suite of primary weather, value added, and vegetation health. The smallest predictive unit is the Census Agricultural Region (CAR). For each CAR, the model is 'trained' using all the available predictor variables (climate and satellite) and cross-validated against the neighbouring CARs in order to incorporate those variables which have the largest influence on the variance of predicted yields. In near real-time, the observed predictor variables from seeding to the date of forecasting are updated and variables from the forecasting date to the end of the season are generated using a random forest algorithm. Generating predictor variables is done in this manner due to the lack of skill beyond one week from conventional weather forecasting tools. Crop yield prediction results (examples include, spring wheat, canola, corn for grain and soybeans) from 2013 to the 2016 growing seasons showed consistent agreement between the predicted and survey results gathered by Statistics Canada at the end of the growing season (December). Most significant from a preparedness perspective, the predicted crop yield values had a lead time of 1 to 3 months. Cross validation experiments indicated that forecast results in years with extreme weather were however, less skillful. To improve the skill of the tool further, additional data sets such as El-Nino Southern Oscillation (ENSO) variability, crop phenology-based indices, and CanSIPS forecast model outputs and alternative AI/machine-learning prediction algorithms are being tested.

1707091 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2
Scalable machine learning on big climate data with Scispark
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Scispark is a robust big Data framework that extends Apache Spark for scaling scientific computation in a parallel computing environment by emphasizing in-memory computation. Scispark processes data stored in NetCDF and HDF files by partitioning them across time or space and distributing along a cluster of computer nodes. Central to Spark is the Resilient Distributed Dataset (RDD), an in-memory distributed data structure that extends the functional paradigm provided by the Scala programming language. The SciSpark project introduces the Scientific Resilient Distributed Dataset (sRDD), a distributed-computing array structure which supports iterative scientific algorithms for multidimensional data.
We will show the usability and extensibility of SciSpark by implementing distributed processing and algorithms on a geospatial grid of multidimensional daily data from the ""Customized Spatial Climate Models for North America"" (McKenney, D. et al., 2011). We will then create a massive amount of geolocalized time series for a wide variety of variables.
Finally, the geolocations will be clustered by their time series features using Spark's Machine Learning algorithms such as K-means and latent Dirichlet allocation.

1707091 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2
Toward improved estimates of snow water equivalent in a mixed alpine region: data fusion of gridded data products via machine learning
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Accurate estimates of regional snow water equivalent (SWE) are critical for hydrologic planning, particularly areas with hydrologic regimes dominated by spring melt. While numerous gridded data products provide such estimates, accurate representations are particularly challenging under conditions of mountainous terrain, heavy forest cover and large snow accumulations, contexts which in many ways define the province of British Columbia (BC), Canada. One promising avenue of improving SWE estimates is a data fusion approach which combines field observations with gridded SWE products and relevant covariates. A base artificial neural network (ANN) was constructed using three of the best performing gridded SWE products over BC (ERA-Interim/Land, MERRA and GLDAS-2) and simple location and time covariates. This base ANN was then enhanced to include terrain covariates (slope, aspect and Terrain Roughness Index, TRI) as well as a simple 1-layer energy balance snow model driven by gridded bias-corrected ANUSPLIN temperature and precipitation values. While the ANN enhanced with all these covariates did perform better than the base ANN, it was found that slope and aspect did not contribute to skill improvement in a meaningful way. The enhanced ANN improved station mean absolute error (MAE) by 55% and interannual peak SWE correlation by 14% to 44% relative to the composing gridded products over the province. This nonlinear approach outperformed a comparable multiple linear regression (MLR) model by 20% in MAE and 7% in correlation. The enhanced ANN has also been shown to estimate better than the Variable Infiltration Capacity (VIC) hydrologic model calibrated and run for four BC watersheds, improving MAE by 29% and correlation by 9%. The performance improvements of the enhanced ANN are statistically significant across the province and in most of its five physiographic regions.

1707091 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2
PAVICS : A platform for multidisciplinary climate analysis
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Climate modeling and remote earth sensing are generating volumes of data so large that they cannot be easily replicated on local machines for exploration and analysis. For their products to remain useful and relevant, large data providers not only need to give access to files, but also algorithms and computing resources. For example, the Earth System Grid Federation is currently developing subsetting, regridding and averaging services, so that users of CMIP6 data are able to reduce the volume of data requested for download. In the same spirit, Ouranos is developing the PAVICS platform, a web portal offering climate-related data analysis services through OGC standards. The primary objective of the platform is to streamline climate research and the delivery of climate services by making available both the data and the analysis services required to turn bytes into information. These services include data acquisition, empirical downscaling methods, climate indices computation, spatial analogs, mapping and visualization. The long term vision driving this initiative is an ecosystem of climate data analytics algorithms, developed by researchers and maintained by climate service providers, such that non-experts can integrate state-of-the-art science into their own workflows. In a time where science is increasingly done by large multi-disciplinary teams, there is potential for this approach to reduce the logistical and technological overhead associated with such collaborations.

1707091 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2
High-Resolution Meteorological Surface Analysis using 2D-Variational Method
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"In many applications, it is necessary to provide the optimal estimation of the present meteorological information at the surface level. The Weather Network (TWN) developed an observation engine, which is an operational system to generate the present surface-level meteorological observations. This observation engine statistically adjusts the background (i.e., the model forecast) value at the target location through applying the influence of all the observations within the defined radius of each target location. The method using 2D-variational (2D-Var) data assimilation has been implemented to produce the meteorological surface analysis in operational applications. Compared to TWN's observation engine, this 2D-Var method has two major advantages:
1. Due to the feature of the global optimization in the 2D-Var analysis, the influence of more observations can be adopted for a certain target location;
2. The 2D-Var surface analysis is done for all grid points at once, so the surface data at any location inside the domain can be easily obtained through the interpolation from the 2D-gridded surface product.
In this research project, York University and TWN collaborate to develop a new generation of the observation engine through implementing the 2D-Var method with the aim of satisfying various needs at TWN. Using the latest version 3.5 of community Gridpoint Statistical Interpolation (GSI) system, the GSI internal function of the 2D-Var surface analysis has been applied over the CONUS domain with 3-km horizontal grid spacing. The system updates the surface analysis hourly by assimilating the METAR observations with the background field from the surface-level model data from the High Resolution Rapid Refresh (HRRR) 1-hour forecasts. The analysis variables include surface pressure, 2-m temperature, 2-m specific humidity, 2-m dewpoint temperature, 10-m wind speed, 10-m wind direction, 10-m wind gust, and surface visibility. Our system results, such as surface temperature, wind speed, and visibility, are validated through comparing the verification statistics with the National Centers for Environmental Prediction's operational product of Real-Time Mesoscale Analysis (RTMA), which uses the same method and similar configurations. An ongoing data denial experiment is being conducted to compare the verification statistics between TWN's observation engine and the 2D-Var analysis system.
Various improvement options will be considered for this meteorological surface analysis system, such as including more analysis variables (e.g., cloud amount) and implementing the hybrid method (i.e., combining the methods of ensemble and variational data assimilation) for the surface analysis. Moreover, we will couple the 2D-Var surface analysis system with the Unified Nowcasting technology, which is being developed at TWN, so that TWN can have consistent current conditions and nowcasting information for consumers.

1707091 Artificial Intelligence and Big Data in meteorological and environmental applications - Part 2
Forecasting crop heat stress with Bayesian learning networks
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The agricultural sector is highly vulnerable to a wide range of weather-related risks. Heat and drought act concurrently in many agricultural regions around the globe, causing severe declines in crop yields and longer-term food insecurity. While drought is a prolonged, intensifying period of abnormal moisture deficiency; heat waves are episodic, and far more abrupt and difficult to predict. Yet, heat waves are projected to increase in duration, intensity, and extent (IPCC Fifth Assessment Report (AR5), Working Group II, Chapter 19 on Emergent Risks and Key Vulnerabilities, and Working Group I, Chapter 11 on Near-term Climate Change:

Projections and Predictability). High-humidity heat waves (i.e., persistence extremes in night-time temperature) are occurring more frequently than in the past and impacting larger land areas. Extreme heat stress during the crop reproductive period (anthesis) is critical for crops, especially wheat, which faces heat stress at lower critical temperatures. Further improvements in modeling are needed to more reliably forecast crop heat stress response in time and space – for different crops/cultivars, landscapes and climate zones, especially during anthesis. Also, models need to better track the critical trade-off between beneficial CO_2 fertilization and detrimental extreme heat stress (e.g., reduction of leaf photosynthesis and enhancement of leaf senescence rates). We present an overview of our investigation underway to identify and characterize heat waves, and utilize machine-learning (e.g., random-forest and Bayesian learning networks) to build a flexible, multi-variate index of crop heat stress. We explore the forecast accuracy of this index and discuss how this index could be coupled to weather forecast data (e.g., CanSIPS) to generate monthly risk/peril maps through the growing season, potentially useful for weather index-based crop insurance.

PART 2 – POSTER SESSIONS

1708010 POSTER SESSION - PART 1

The spontaneous radiation of spiral inertia-gravity waves and the imbalance in tropical cyclone-like vortices - Evidence from fully nonlinear simulations.

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Tropical cyclones (TCs) may experience various asymmetric instabilities as they evolve over time. One possible outcome is the development of an elliptical or polygonal eyewall. Moreover, asymmetric instabilities can influence track and intensity.
Despite an extensive body of literature in TC instabilities, the role of spiral inertia-gravity waves spontaneously emitted from the vortex core is usually overlooked or tacitly assumed to be inconsequential. In this study we present evidence of inertia-gravity wave radiation being the main cause of instability in a number of nonlinear numerical simulations that are configured in a parameter regime appropriate for tropical cyclone perturbations. The sensitivity of this instability mechanism to various properties of the initial vortex will be briefly addressed.

1708010 POSTER SESSION - PART 1

Nocturnal Relative Humidity Maxima above the Boundary Layer in the American Midwest

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Diurnal cycles of relative humidity (RH) over the Midwest U.S. are constructed using observations from the Aircraft Communications Addressing and Reporting System (ACARS). A maximum in RH is observed above the planetary boundary layer (PBL) in the early morning hours at various locations across the Midwest U.S. The maxima are strongest during the summer months. We believe these RH maxima are related to the formation of upper potential vorticity (PV) anomalies near the Rocky Mountains, as a result of daytime heating. Upward motion associated with these PV anomalies is likely a primary mechanism for nocturnal convective rainfall east of the Rockies during the summer. Longitude-time plots of rainfall rate data from the Tropical Rainfall Measuring Mission (TRMM) suggest that the PV anomalies are advected eastward at about 20 m/s in the upper flow. This eastward-moving rainfall reaches longitude 95W near 0400 LST, which is consistent with the time that the RH maxima appear in areas along this meridian.

1708010 POSTER SESSION - PART 1

Reductions in carbon budgets due to non-CO2 greenhouse gases

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Limiting the global mean warming to well below 2.0 °C in accordance with the Paris Agreement requires rapid reductions in global emissions, and a cap on the total amount of carbon emitted. Non-CO2 greenhouse gases have a net warming effect, thereby reducing carbon budgets, or the allowable total carbon emissions consistent with limiting anthropogenic warming to below a specific temperature threshold, and are also expected to reduce the carbon uptake by the terrestrial and marine carbon sinks. Here, using simulations from comprehensive Earth System Models (CMIP5), we compare carbon budgets consistent with not exceeding

1.5 °C and 2.0 °C warming due to CO_2 alone, and in simulations that also include non-CO_2 forcings, where the median allowable carbon budgets are reduced by 257 PgC and 418 PgC, respectively, compared with the CO_2-only carbon budgets.

1708010 POSTER SESSION - PART 1

A particle swarm optimizer based on directions and its application to the four dimensional variational data assimilation

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This study uses a variant particle swarm optimizer based on directions (PSOBD) to solve optimization problems related to the non-smooth and large-size four dimensional variational data assimilation (4D-VAR). In PSOBD update process, not only the historical optimal positions of the particle swarm and the current particle are utilized. While for each direction of particles, the historical optimal directions of both the particle swarm and the current particle are also used. To verify the performance of PSOBD in the non-smooth 4DVar, an idealized simple model with "on-off" oscillations is employed as the governing equation. Three assimilation schemes are performed as well. One is the 4DVar based on the traditional adjoint method (ADJ_4DVar), the second is based on the classic particle swarm optimizer (PSO_4DVar) and the last is based on the PSOBD (PSOBD_4DVar). 200 identical twin numerical experiments are performed for each assimilation scheme. Results show that both the classical particle swarm optimizer (PSO) and PSOBD can overcome the influences of the "on-off" switches and present satisfied assimilation retrievals with large probability. While compared with the PSO_4DVar, the PSOBD_4DVar only takes its 1/30 optimization time in average and much less evolution generations to obtain good assimilation retrievals. Furthermore, PSOBD is applied to the shallow-water equation (SWE) 4DVar to test its effectiveness for complex models. Identical twin numerical experiments for five different observations show that PSOBD keeps its strong search ability and can yield good assimilation retrievals with 99% probability. Considering the actual requirement for computation time, the parallel PSOBD is designed and applied to the SWE 4DVar. Results show that, in average, the assimilation time consumed by the parallel PSOBD_4DVar can be shorten to 1/13 of the one taken by the serial PSOBD_4DVar, which demonstrates that the parallel PSOBD is an alternative optimization algorithm to the 4D-Var of real models.

1708010 POSTER SESSION - PART 1

A novel convective scheme for the CAM4 AGCM and impacts on the tropical circulation.

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The simulation of tropical convection (which drives the tropical circulation) in climate models has been problematic due to the need for parameterization. The intensity of the tropical circulation is affected by the tropical mean profile of temperature (static stability) and the strength of tropical diabatic heating. Here we investigate the relationship between moist convection and the tropical general circulation using a modified version of the NCAR-CAM4 AGCM with an alternate convective scheme developed at Dalhousie University (CAM4-IF). This scheme was developed in part to remove the known lower tropospheric cold bias seen in the NCAR-CAM4 and employs a "leaky pipe" model of convective detrainment, among other changes from the default scheme.

Simulations with CAM4 using the IF scheme (CAM4-IF) in place of the default shallow and deep convective schemes reveal a strengthening of the climatological mean tropical Walker and Hadley circulations. Furthermore, idealized sensitivity experiments with imposed SST warming

in CAM4-IF produce stronger weakening of the tropical circulation than the default CAM4. Results show that the increased amount of modeled cloud ice in CAM4-IF simulations in deep convecting regions increases the strength of the tropical circulation as it increases the diabatic heating in the upper troposphere. Under a uniform SST warming the size of ice crystals increases and there is a large decrease in upper tropospheric diabatic heating compared to the default CAM4. This is believed to be at least partially responsible for the stronger weakening of the tropical circulation seen in the CAM4-IF under an imposed SST warming. These results provide strong additional support that climate models' convective schemes play a critical role in the simulation of the tropical circulations.

1708010 POSTER SESSION - PART 1

Extended range forecast over East Asia during boreal summer using the ECCC monthly forecasting system

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A useful extended range forecast is of great societal and economical value in the highly populated East Asian region, especially during boreal summer when frequent extreme events such as heat waves and persistent heavy rainfalls occur. Despite recent interest and development in extended range forecast, it is still unclear how skillful dynamical forecasting systems are in East Asia beyond two weeks. In this study we evaluate the extended range forecast over East Asia during boreal summer in the operational monthly forecasting system of Environment and Climate Change Canada (ECCC). Results show that the climatological intra-seasonal oscillation (CISO) of East Asian summer monsoonis reasonably well captured. Statistically significant forecast skill of 2-meter air temperature (T2m) is achieved for all lead times up to week 4 (days 26-32) over East China and Northeast Asia, which is consistent with the skill in 500 hPa geopotential height (Z500). Significant forecast skill of precipitation, however, is limited to the week of days 5-11. Possible sources of predictability on the extended range time scale are analyzed. The weekly mean T2m anomaly over East China is found to be linked to an eastward propagating extratropical Rossby wave from the North Atlantic across Europe to East Asia. The Madden-Julian Oscillation (MJO) and El Nino-Southern Oscillation (ENSO) are also likely to influence the forecast skill of T2m at the extended range timescale over East Asia.

1708010 POSTER SESSION - PART 1

Carbon cycle feedbacks in the context of negative CO2 emissions

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Feedbacks between the carbon cycle and the physical climate system have been extensively studied in the past two decades based on future scenarios of continued CO2 emissions into the atmosphere. However, current discussions in climate change science and policy communities highlight the need for technologies to remove CO2 from the atmosphere in the future, as part of mitigation strategies for aiming at the 1.5°C or 2°C warming target. Our research applies the University of Victoria Earth System Climate Model (UVic ESCM) to investigate the response of the natural CO2 sinks (land and ocean) to the eventual artificial CO2 removal from the atmosphere, also known as negative CO2 emissions. To this end, the UVic ESCM is forced with atmospheric CO2 concentration prescribed to increase at 1% per year from pre-industrial levels to 2x, 3x and 4x the pre-industrial CO2 concentration, and then decline at the same rate back to pre-industrial levels. For each scenario, three model simulations are performed in order to characterize the carbon-concentration feedback and the carbon-climate feedback: a fully coupled simulation, a biogeochemically coupled simulation, and a radiatively coupled simulation. The results will provide insights into the simulated response of the natural CO2 sinks under negative CO2 emissions, as well as the prospects of restoring atmospheric CO2 concentration to pre-industrial levels by means of artificial CO2 removal.

1708010 POSTER SESSION - PART 1
Grand Banks fog - a tale of cold air advection, turbulent mixing and radiative fluxes.
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The condensation of water vapour into droplets and the formation of fog in the Earth's atmospheric boundary layer involves a complex balance between horizontal advection and vertical turbulent mixing of heat and water vapour, cloud microphysical processes involving the numbers and size of available condensation nucleii and radiative transfers of heat, plus the impact of water droplets, and sometimes ice crystals, on visibility. It is a phenomenon which has been studied for many years in a variety of contexts. Over the waters offshore from Newfoundland a key factor is the advection of moist air from over warm gulf stream waters to colder Labrador current water - an internal boundary-layer problem, modified by radiative heating and cooling. Some basic properties can be learned from a steady state 2-D (x-z) model. These may help define the conditions under which fog will occur.

1708010 POSTER SESSION - PART 1
From DNS of shear instability to cross-layer transport
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All models of dynamics at basin-scales are forced to parametrize a host of unresolved sub-grid scale processes. From a hydrodynamics point of view, chief amongst these is irreversible mixing. In particular, for layered models when shear between layers is sufficiently large, mixing will occur and lead to mass flux between layers and the creation of intermediate density layers. Using high--resolution spectral simulations of the stratified, incompressible Navier--Stokes equations, we discuss the evolution of large amplitude seiches that break down due to the presence of high vertical shear. We quantify the effect of overturning events and demonstrate that enhanced mixing and stirring occurs during events such as Kelvin-Helmholtz instability. As a result, the initial pycnocline becomes thicker as time passes. We discuss how the interface thickening varies in parameter space, as well as ways in which this thickening could be rationally integrated into layered models.

1708010 POSTER SESSION - PART 1
Subseasonal Predictability over the United States assessed from Two Operational Ensemble Prediction Systems
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The subseasonal predictability of surface temperature and precipitation is examined for two global ensemble prediction systems (ECMWF and CFSv2), with an emphasis on the week-3&4 forecast skill in the domain of the United States. Although the ECMWF system exhibits slightly higher skill for both temperature and precipitation in general, these two systems show very similar geographical variations in the week-3&4 skill and encouraging skill in certain regions. The high skill in these regions is generally realized through large scale teleconnections and often linked to long persistence in the tropics. In particular, the monsoon system leads to higher skill in the spring and summer precipitation and surface temperature in the southwest US. On the other hand, the high skill over northern California in spring is associated with the seasonal variability of the AO. Furthermore, the week-3&4 predictability can be largely improved during extreme phases of ENSO and AO/NAO.

1708010 POSTER SESSION - PART 1

A New Targeted Observing Strategy based on Particle Filter and Its Application

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El Niño-Southern Oscillation (ENSO) has been widely accepted that there are two distinct types of El Niño events over the tropical Pacific: one is the traditional Eastern-Pacific El Niño (EP-El Niño) and the other is the Central-Pacific El Niño (CP-El Niño) which occurs more frequently during the past twenty years. In this paper, we focus on the predictability study of the two types of El Niño and propose a new targeted observing strategy based on the impact of assimilated observations on the ensemble forecast skill of El Niño. Using this new strategy, the sensitive areas of sea surface temperature (SST), sea surface height (SSH) and zonal wind speed regarding the targeted observing of the two types of El Niño are investigated and the validity of these sensitive areas in improving El Niño forecast skill is verified. We then determine the potential sensitive variable(s), for which assimilating observations in its(their) sensitive areas yields the ensemble with highest forecast skill. It then provides useful ideas for improving the predictability of the diversity of ENSO events.

1708010 POSTER SESSION - PART 1

A Fast and Accurate Scheme for Sea Ice Dynamics with Pseudo Subgrid Resolution

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Sea ice physics is a very complex process occurring over a wide range of scales; such as local melting or large scale drift. At current grid resolutions of about 20 km, used in Global Climate Models (GCMs), we are able to resolve the bulk of the large-scale dynamics but uncertainty remains due to subgrid physics and potential dynamic feedback. Recent research shows that realistic representation of sea-ice rheology necessitates very fine grids on the order of 1 km or so, especially, in the formation of linear kinematic features that greatly impact the large-scale processes. Moreover, recent work in atmospheric science has shown success in the use of stochastic subgrid models to account for unresolved, subgrid physics and there is a push to implement these methods in other components of the Earth System. In order to test and develop similar models for the cryosphere, it is important to use better numerical methods to accurately capture the large scale dynamics.

As a first step forward, we present a second order accurate scheme, in both time and space, for the sea ice momentum equation (SIME) with a Jacobian-Free Newton-Krylov (JFNK) solver, gaining subgrid resolution through the use of the signed distance function, a common method used in engineering to track interfaces in multiphase flows. The SIME is highly nonlinear due to the rheology terms appearing in the stress tensor, which has motivated the use of implicit methods for the SIME and a JFNK solver was recently introduced to gain efficiency. However, the method used so far is only first order in time. We expand on this approach and, with no increase in computational cost, use a Crank-Nicholson discretization of the SIME to produce a fully second order approximation. Internal to the JFNK solver, a distance function solver is implemented to better track the ice boundary. The distance function provides a continuum like representation near the ice edge, which is used to better account for boundary conditions, particularly at land boundaries. At a future time, the distance function may also be used to improve the representation of processes such as lead formation or wave induced deformation.

1708010 POSTER SESSION - PART 1

A New Index representing Circumglobal Variability

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The circumglobal teleconnection pattern (CGT) has been brought to light by the work of Branstator (2002). This pattern of variability describes waves trapped within the Jet stream as they circumscribe the globe. This work presents a new point-based index and its skill at capturing CGT related variability. Points were chosen along the South Asian Jet region where the CGT seems to emanate from. Furthermore, these points were chosen to so that they do not coincide with locations explicitly related to either the PNA or NAO; the goal being to avoid any spurious relationships based on point selection. We will show that this new index captures the majority of CGT variability not only in the stream function field (where the CGT is defined) but also in the surface fields such as near-surface air temperature, and outgoing longwave radiation, etc.

1708010 POSTER SESSION - PART 1

Risk Forecasting in Harsh Offshore Environments

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In order to make effective operational decisions in a harsh environments, we need to know more than just the expected sea height. We need to know the probability, or risk, that the seas will exceed some operational limit. Presently, the standard method of generating such a risk forecast is to run a weather model repeatedly and examine the fraction of simulated seas that exceeded some threshold. However, running a high resolution regional weather model is expensive. Running it twenty times to generate a risk forecast is very expensive. In this presentation we will outline an alternative risk forecast technique that makes use of multiple data sources instead of multiple model runs to deliver an accurate and cost effective risk forecast. We will illustrate the application of this approach with examples in forecasting wind and sea risks in a marine environment as well as look ahead to future work to further improve our risk forecasting accuracy.

1708010 POSTER SESSION - PART 1

Uncertainty quantification of snow-related parameters in the Canadian Land Surface Scheme (CLASS)

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Snow parameterization in land surface models (LSM) is an important source of uncertainty in climate simulations. However, quantifying this uncertainty is challenging due to the high-dimensional parameter space as well as parameter interaction. In this study, we investigate the sensitivity of varying thirteen snow microphysical parameters in the Canadian Land Surface Scheme (CLASS) using an uncertainty quantification (UQ) approach commonly applied to atmospheric models. In a large ensemble of O(10^3) simulations defined through Latin hypercube sampling (LHS), the parameters are perturbed across their full range of empirical uncertainty determined from available observations and expert elicitation. A statistical model using support vector regression (SVR) is then constructed to efficiently emulate the dynamical CLASS simulations over a much larger O(10^6) set of cases, from which the impact of the parameters on the snow simulation can be fully quantified. The implementation and results of this study will be presented and discussed in detail. Quantifying the importance of snow-related parameters, and their uncertainties, is an important step toward better understanding and quantification of uncertainty within integrated earth system models.

1708010 POSTER SESSION - PART 1

Monitoring trace gases in downtown Toronto using open-path Fourier transform infrared spectroscopy

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In-situ measurements are commonly used to monitor trace gas concentrations in urban settings, however, it is unclear how representative these measurements are in inhomogeneous urban environments. Open-Path Fourier Transform Infrared Spectroscopy (OP-FTIR) measurements offer spatial averaging and continuous measurements of several trace gases simultaneously in the same airmass. We have set up an open-path system in downtown Toronto to monitor trace gases in the urban boundary layer. Our system consists of a globar source, retroreflector, telescope, and Bruker 125M FTIR spectrometer. Trace gas concentrations are derived from atmospheric absorption spectra recorded over a two-way atmospheric open path of 300 m using non-linear least squares fitting. This presentation will describe the open-path system and report some initial measurements, including comparisons of these data with co-located total column measurements obtained using solar absorption FTIR spectroscopy.

1708010 POSTER SESSION - PART 1

Evaluate the surface coupling strength of a continental scale 4-km WRF regional climate simulation

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Uncertainties in representing land-atmosphere interactions can substantially influence regional climate simulations. Among these uncertainties, the surface exchange coefficient, Ch, is a critical parameter controlling the total energy transported from the land surface to the atmosphere and directly impacts the land-atmospheric coupling strength. Yet it has not been properly evaluated for regional climate models. This study assesses the representation of surface coupling strength in 4-km WRF simulations through comparing Ch derived from WRF simulations, from offline Noah-MP simulations, and from data collected at eight FLUXNET sites, which were then categorized into four ecoclimate regions. The seasonal variations of Ch for different land-cover types in Canada calculated by using 10-year half-hourly FLUXNET data are used to evaluate surface coupling strength in WRF. Also, Ch calculated from offline Noah-MP simulations is used to contract to these from WRF to understand the impacts of uncertainties in coupled WRF simulations and in offline Noah-MP simulations on Ch. Such analysis is used to evaluate 4-km WRF simulated surface heat fluxes.

1708010 POSTER SESSION - PART 1

Impact of climate change on climate indices in latitudes across Canada

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Extreme events such as floods, droughts, heat waves and freezing rains have serious impacts on communities and vulnerable populations. In recent years many indices have been developed to describe and characterize extreme weather events. In this study, we analyze the impacts of the past and future climate change on extreme weather events for southern parts of Canada. A set of precipitation and temperature based indices has been computed using the CMIP5 multimodel ensemble projections (Coupled Model Intercomparison Project

Phase 5) of the 21st century for two Representative Concentration Pathways scenarios (RCP 4.5 and 8.5). Results showed a stronger warming and an increase in precipitation extremes in the region. Generally, changes and variability in temperature and precipitation indices are most pronounced under RCP8.5 than RCP 4.5. Overall, projected changes in indices based on minimum temperature were greater than changes in indices based on maximum temperature. We also observe a decrease in frost days and an increase in warm nights. By the year 2100, annual global mean changes in minimum and maximum temperature relative to the reference period 1981-2000 are 4°C and 2°C, respectively under RCP4.5 scenario. For the same time frame, annual total precipitation is expected to increase by about 10%.

1708010 POSTER SESSION - PART 1

Interpreting Changes in the Eddy Moist Isentropic Circulation to Surface Perturbations in a Relatively Simple Model

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Diagnosing meridional heat and mass transport in midlatitudes is complicated by the diabatic heating caused by the condensation of water vapor, which is associated with the raising of warm moist air parcels from the surface by cyclonic systems. In order to gain insight into the transport of heat and mass through the midlatitudes by the eddies we utilise the Statistical Transformed Eulerian Mean (STEM). The STEM approximates the eddy-driven overturning streamfunction on moist potential temperature surfaces by parameterizing it in terms of second order zonal mean statistics. Since the moist potential temperature is conserved during condensation, the streamfunction on these surfaces separates the warm poleward moving air parcels from the cold equatorward moving air parcels, a separation which is usually obscured by an averaging on pressure surfaces.

In order to study the sensitivity of the eddy moist isentropic circulation to midlatitude surface perturbations, we impose switch-on surface thermal perturbations in a relatively simple general circulation model that incorporates the dynamical impacts of latent heating but does not include any radiative coupling to water vapour. By using the STEM parametrization we can (to a good degree) approximately decompose the variation of the streamfunction into variations in the zonal mean moist potential temperature and variations in the eddy covariance. By utilising the relatively simple nature of the STEM parametrization we also calculate analytic sensitive kernels to calculate changes in the eddy streamfunction and use these to explain the changes in the perturbation experiments.

In response to surface warming we find that the streamfunction is moved to higher moist potential temperature surfaces in the midlatitudes and the maximum mass transport is shifted further poleward, related to the changes in the eddy covariance. By decomposing the poleward energy transport using the same method, it is found that the eddy covariance has the dominant impact.

1708010 POSTER SESSION - PART 1

Projecting yield change of canola on the Canadian Prairies under climate scenarios of the 1.5°C climate target

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Canada shares 22% of the global cultivation area for canola/rapeseed, and exports 90% of its production. Canola cultivation area in Canada, more than 95% on the Canadian Prairies, has been expanded from 2.5 million ha in late 1980s to 8.5 million ha in recent years. Meeting the increasing demand for canola may be a challenge, especially in the face of climate change as the projected warmer future climate is suspected to be unfavorable to cool-season crops such as canola. Therefore, different climate targets may have different implications to canola yield and production on the Canadian Prairies. In this study, we used a dynamic crop model to simulate canola yield changes under climate scenarios associated with the targets of 1.5°C and 2°C above pre-industrial levels. Climate scenarios used to drive the crop model were developed with a bias correction method of multivariate quantile mapping, based on climate projections from 20 climate models under RCP8.5. The preliminary results showed that seeding could occur earlier by 5 and 8 days accompanied with an increase in the potential yield by 23% and 31%, respectively, under the 1.5°C and the 2°C targets, compared with the baseline of 1971-2000. However, the simulated yield increase under water-limited conditions would be only 4.9% and 4.4% for the two targets because of the increased water stress.

1708010 POSTER SESSION - PART 1

Updating the Canadian Historical Snow Survey Dataset

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Bi-weekly snow survey programs are carried out across Canada by a number of provincial agencies and hydro-electric utilities in support of water resource management activities. During the 1955-1985 period, Environment and Climate Change Canada (ECCC) ran an extensive snow survey program and provided national coordination of snow survey activities through the publication of annual summaries of observations, and through standardization of instrumentation and observing practices. In 2000, an ECCC data rescue project resulted in the publication of the first digital snow survey dataset for Canada based on digitized paper records and contributions of data from provincial agencies. This dataset included data back to 1935 with the bulk of the observations contained in the 1965-1985 period. The dataset was subsequently updated to 2003/2004 snow season. These data have been used extensively in hydrological studies, for climate monitoring, for evaluations of climate and hydrological models, and for applied studies such as snow loads on buildings, and there was a clear need to bring the dataset up to date. This poster will present an overview of recent efforts to update the historical snow survey dataset to the 2015/2016 snow season. The poster will also present a preliminary analysis of trends and variability in snow depth, snow water equivalent and snow density over Canada over the past 40-50 years.

1708010 POSTER SESSION - PART 1

Effects of moisture and precipitation in a simple model of baroclinic beta-plane turbulence.

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We consider moisture effects on baroclinic, forced-dissipative beta-plane turbulence using a two-layer shallow water equation channel designed as idealized model of the midlatitude storm tracks. Moisture is input via evaporation and triggers precipitation when supersaturation occurs. The related latent heat release is modelled as a mass transfer between the two layers and, as such, feeds back on to the dynamics. This excites both gravity waves and geostrophic modes, and our focus is on i) how this `forcing' alters the equilibrium dynamics compared to dry baroclinic turbulence and ii) how sensitive these dynamical effects are to changes in moisture content, which are analogous to the projected intensification of the hydrological cycle under climate change.

1708010 POSTER SESSION - PART 1

Separating linear and nonlinear interference effects in stratosphere-troposphere interactions

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The wintertime northern annular mode (NAM) associated with the strength of the polar stratospheric jet is negatively correlated to the upward propagating planetary waves consisting primarily of zonal wavenumbers 1 and 2. Recent observational and modeling studies have demonstrated that such negative correlation is dominated by the linear interference effect in the wave activity flux anomalies. A constructive (destructive) linear interference occurs when the vertical component of wave anomalies is in phase (out of phase) with the climatological stationary wave, such that the climatological stationary wave is amplified (attenuated) and the stratospheric jet is weakened (strengthened). While the linear interference effect is associated with the amplitude of the upward propagating wave anomalies, the nonlinear interference effect is primarily related to the tilt of wave anomalies and hence is also an important contribution to the wave activity flux anomalies. However, the majority of past literature has focused on the linear interference effect in initiating stratosphere-troposphere interactions, whereas the role played by the nonlinear interference effect is less well understood. In this work, we attempt to separate the linear and nonlinear interference effects by examining both observational and modeling data. We also examine NAM anomaly associated with tropical-extratropical teleconnection events, in particular the two opposite phases of El Nino-Southern Oscillation (ENSO). We found that there are two components contributing to the nonlinear interference effect. The first one, associated with the ensemble mean of a certain ENSO phase, is small but non-zero, whereas the other one, associated with perturbations, has a larger variance and fluctuates on the synoptic time scale.

1708010 POSTER SESSION - PART 1

Central U.S. WRF composite radar verification using MODE-Time Domain

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A 4-km convection-allowing Weather Research and Forecasting (WRF) model was ran for the contiguous United States from October 2000 to September 2013 (Liu et al. 2016). Downscaling to a higher resolution of 4-km permits the model to simulate deep convection without parameterization. Here, a verification of the model’s simulated composite radar reflectivity in comparison to the Weather Surveillance Radar-1988 Dopplers (WSR-88Ds) national mosaic is performed using the Method for Object-Based Diagnostic

Evaluation (MODE) with the included Time Domain (MODE-TD). The comparison focuses on the Central Plains of the U.S. for convective systems from April through September. Using MODE-TD allows additional features of a storm systems lifetime to be analyzed such as initiation, development, and dissipation. MODE-TD compares each storm system identified based on the certain thresholds that are specified and compares different attributes such as object area, center, axis angle, and intensity. Pair attributes can also be defined such as area ratio, center distance, axis angle difference, and intensity ratio. Other biases that are examined include speed, shape, and storm track/duration. In a capsule summary of this model, it is described that the model is able to create realistic propagating convection, but the model underestimates the occurrence of storm systems in the central U.S. This study assesses the accuracy of the simulated composite radar data in the model.

1708010 POSTER SESSION - PART 1

Long-Term Variations of Tropospheric Ozone over Asia from 1980 to 2000

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Tropospheric ozone plays an important role in the atmospheric environment and radiative balance. In this study, we use a long-term ozone climatology dataset, namely the Trajectory-mapped Ozonesonde dataset for the Stratosphere and Troposphere (TOST), to assess the temporal variations of tropospheric ozone during 1980–2010 over Asia (25°E–180°E and 0°–85°N). TOST was derived from global ozonesonde records at more than 100 stations, using a unique domain-filling trajectory approach. TOST is 3-dimentionally resolved at resolution of 5°×5°×1 km in latitude, longitude and altitude.

The Tropospheric Emission Spectrometer (TES) instrument, onboard the Aura satellite, provides an unprecedented ozone dataset that is useful to evaluate TOST data. As TES data in the middle troposphere are least biased, TES data in nadir view at middle tropospheric altitudes are selected to compare with TOST data at 4-5 km. We find that the correlation between the TOST and TES data is over 0.5, and the mean bias is 6.82 ppbv. In addition, TOST is evaluated against a subset of ozonesonde profile data, and shows good agreement with a correlation coefficient of 0.86 and mean bias of 1.1 ppbv.

Our analysis of TOST suggests an increasing ozone trend from 1980 to 2000 in the middle troposphere over Asia. Using the Mann-Kendall (M-K) test, we find a significant trend of 0.68 ppbv/year ($p <0.001$) and an abrupt change in 1994.

1708010 POSTER SESSION - PART 1

Projected changes of mixed precipitation over southern Quebec using high-resolution climate simulations.

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Freezing precipitation events can have major impacts on the society by causing power outages and disruptions to the transportation networks. These types of precipitation such as freezing rain and ice pellets are formed through complete or partially melting of snow as it falls through the atmosphere. Despite the catastrophic consequences associated with these precipitation types, very few studies have investigated how the occurrences will evolve under warmer climate scenarios. The goal of this study is to investigate the

evolution of the mixed precipitation region over southern Quebec with climate change using high-resolution climate simulations.
This study used 5 methods (Cantin and Bachand, Bourgouin, Ramer, Czys and Baldwin) to diagnose freezing rain, ice pellets and their combination, based on a simulation of the fifth-generation Canadian Regional Climate Model with a 0.11° grid mesh under scenario RCP 8.5. The analysis of the diagnosed precipitations is studied in past climate (1980-2009) and compared with future climate projection (2070-2099). Overall, our results show that the occurrences of mixed precipitation will decrease over southern Quebec, with the most pronounced reduction from December to February. This study contributes to better understanding how the distribution of precipitation types will change in a warmer climate and highlight the sensitivity of the type of precipitation reaching the surface to atmospheric conditions.

1708010 POSTER SESSION - PART 1

Path Independence of Climate-Carbon Cycle Response Over a Broad Range of Cumulative Emissions

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Previous studies have identified a nearly linear relationship between cumulative carbon emissions and global mean temperature (e.g. Matthews et al. 2009; Gillett et al. 2013) and that for century to millennial timescales, the response of global mean temperature is independent of the emissions pathway followed (e.g. Zickfeld et al. 2012). We use the University of Victoria Earth System Climate Model (UVic ESCM) to assess the Transient Climate Response to Cumulative Emissions (TCRE) over a broad range of cumulative carbon emissions. Using 24 idealized emission scenarios with cumulative fossil fuel emissions ranging between 1000 and 5000 gigatonnes of carbon (GtC), and a cumulative 275 GtC of land use change emissions (all together totalling 1275 – 5275 GtC), we assess whether or not the TCRE relationship is robust at high levels of cumulative emissions (above 2500 GtC for example). A variety of emission scenarios are tested, including peak and decline, instantaneous pulse, and overshoot cases in order to assess whether the response is path dependent. Across the 24 emission scenarios, we found an average TCRE of 1.8°C per trillion tonnes of carbon (TtC) at the time of CO? doubling, and a range between 1.3°C TtC?¹ and 2.0°C TtC?¹. The TCRE was found to be slightly path dependent, with faster emission rates yielding slightly smaller TCRE values, and to decrease with increasing cumulative emissions (especially >2275 GtC). Using the TCRE at the time of CO? doubling, we estimate that cumulative carbon emissions must remain below 833 GtC (with a range between 750 GtC - 1154 GtC) in order to meet the 1.5°C temperature target, and remain below 1111 GtC (1000 GtC – 1538 GtC) in order to stay below 2°C.

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1708010 POSTER SESSION - PART 1

The importance of detritus in idealized models of planktonic ecosystems

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There are many different ways to idealize planktonic ecosystems. One simple model that has received considerable attention in the literature is a Nutrient-Phytoplankton-Zooplankton-Detritus (NPZD) population model. It neglects the spatial variations of each category and hence is sometimes referred to as a four box

model. An NPZD model can be coupled to a hydrodynamical model, such as General Circulation Models, or can be studied separately to focus on understanding the underlying dynamics of the biological model. In the latter case, the governing equations are a system of Ordinary Differential Equations and can be analyzed using a fairly accessible mathematical theory, to determine the consequences of the complex interplay of inter-variable coupling mechanisms.
Previously, Gentleman and Neuheimer (2008) used dynamical systems theory in a simpler three box model that neglects detritus to analyze the dynamics of their NPZ model. They determined that the functional form of the grazing was important in determining the nature of the solution; some choices tended to asymptotically approach the steady solution whereas others yielded oscillations. We have extended this analysis in the context of the aforementioned NPZD models. First, we compute the steady state solutions that are permitted and then compute their stability characteristics. This determines whether a given steady solution is realizable or not. We compare our results with previous studies and determine that for a remineralization rate sufficiently large, the NPZD model exhibits similar behaviour to the NPZ model. As the remineralization rate decreases, certain steady-states begin to exhibit oscillations that were not present in the model that ignored detritus. We briefly speculate on the importance of this result to spatially distributed models.

1708010 POSTER SESSION - PART 1

QG SPINS : A Spectral QG Model with Channel Geometry

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There are a variety of different numerical models that simulate the non-linear evolution of the continuously stratified Quasi-Geostrophic (QG) system. Many of these models are pseudo-spectral in order to achieve high-order accuracy in the spatial discretization and typically assume a doubly-periodic geometry. In this talk we present a new numerical model called QG SPINS that is also pseudo-spectral but allows for a channel geometry and correctly computes the evolution of the zonal transport while maintaining spectral accuracy.
QG SPINS is built using the framework provided by SPINS, a spectral and parallel model for simulating the 3D incompressible, non-hydrostatic, Boussinesq Navier-Stokes equations. This framework provides powerful MPI-based parallelization in order to efficiently perform large-scale simulations in high powered computing environments.
To validate this model, we present the results from various test cases, including: geostrophic turbulence, instability of a jet, instability of a vortex, and dipole-wall interactions.
The spectral accuracy allows for the total energy to be very well conserved as well as providing accurate calculations of power spectra, spectral fluxes, and anisotropy metrics.

1708010 POSTER SESSION - PART 1

Interannual variability of spring intraseasonal variability and Mei-Yu onset

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The Mei-yu onset over the middle-lower reaches of Yangtze River Basin from mid-June to Mid-July in China is associated with the transition of weather regimes with the evolution of the East Asia summer monsoon, and the Mei-Yu onset date is closely related to the amount of rainfall and the rainy season length as well as its intensity. In this study, we find that the Mei-Yu onset date is significantly associated with the strength of the intraseasonal oscillation (ISO) over the East Asia and the western Pacific (EAWNP) region in spring, and that a strong (weak) EAWNP ISO during the spring season leads to an early (late) onset of Mei-yu over the middle-lower reaches of Yangtze River Basin. The seasonal march of the rain belt in China matches well with the 8 phases of the EAWNP ISO referring to the convective center.

An examination of the precursory signals associated with early onsets of Mei-yu reveals that, during strong spring EAWNP ISO years, the abnormal sea surface temperature (SST) is presented as a conventional ENSO pattern from January to July. With the ENSO pattern, the negative SST anomalies in eastern Indian Ocean and the South China Sea in May lead to the early onset of the South China Sea monsoon?indicating the early Meiyu onset subsequently. Corresponding to the weak spring EAWNP ISO years, the abnormal SST pattern changes from CP-ENSO pattern to EP-ENSO pattern in May, and the positive SST anomalies appear in both eastern Indian Ocean and the South China Sea, and cause the late onset of the South China Sea monsoon suggesting the late onset of Meiyu too.
A statistical forecast model is established using the intensity of spring EAWNP ISO, CP-ENSO and EP-ENSO indices to assess the predictability of the onset dates of Mei-yu. Since all these predictors can be readily monitored in real time, this empirical model provides a real-time forecast tool to predict the Meiyu onset.

1708010 POSTER SESSION - PART 1
Optimally Growing Initial Errors of ENSO in CESM Model
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The optimally growing initial errors(OGE) of ENSO events are found in CESM models by the conditional nonlinear optimal perturbation(CNOP) method. On the character of low-dimensional attractor for ENSO system, we apply singular vector decomposition(SVD) to reduce the dimension of the model for ENSO and calculate CNOP of the truncated model. In CESM model, due to uncontinuity caused by the paramterization, the cost function is not diffrentiable and we apply the differential evolution (DE) algorithm. It is found that the CNOP in CESM model can develop remarkably and its spatial structure is physically meaningful.
we obtained two kinds of OGE, called Type-1 and Tyep-2 respectively. The structure of Type-1 is characterized by the same symbolized perturbation structure which is west-east slope from subsurface to surface in equatorial eastern Pacific. The structure of Type-2 is characterized by the dipole structure in the subsurface of equatorial Pacific. The Type-1 develops locally, similar to the development of some ENSO case. The Type-2 develops with propagation, similar to the decaying progress of some ENSO case and then development of the anti-phase case. Regarding to El Niño event, whether eastern Pacific (EP) El Niño or central Pacific (CP) El Niño, the OGEs induce significantly spring predictability barrier (SPB) phenomenon. However, for La Nina, the OGEs do not cause SPB. So, relative large prediction error is not always accompanied with SPB. The effect of OGEs for structure is case-dependent. For EP-El Niño events, most of the OGEs made the model predict the original events as a normal case mistakenly and one OGE for year 118 made the the model predict the origin event as a stronger EP-El Niño. For CP-El Niño events, all OGEs mistaked the original events as La Nina and for La Nina events, all OGEs mistaked the original events as EP-El Niño event.

1708010 POSTER SESSION - PART 1
PEARL and YOPP
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The Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Nunavut (80N, 86W) is currently a fully operational atmospheric observatory in Canada's High Arctic which has been operating since 2005. It houses upwards of 25 research instruments with considerable capacity for remote operations as well as on-site activities.
This talk will discuss the plans and aspirations of the PEARL team to support the observing phases of YOPP. PEARL is well-placed to provide a comprehensive set of atmospheric measurements to support YOPP and

since much of the instrumentation is mature with significantly long data records, the data gathered in the YOPP time frame can be placed into a longer-term context.
PEARL is currently supported by the Natural Sciences and Engineering Research Council, Environment and Climate Change Canada and the Canadian Space Agency.

1708010 POSTER SESSION - PART 1

The Lagrangian identification of moisture sources for precipitation over Western Canada

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The McKenzie and Saskatchewan River basins are agriculturally dominant river basins in the western Canada where agriculture is heavily dependent on the natural weather system and large network of rivers. It is important to detect the moisture sources that contribute to the precipitation over Saskatchewan and McKenzie River basins (SRB and MRB resp). Based on ANUSPLINE precipitation data the locations of the daily maximum precipitation areas has been identified in both the river basins for warm seasons between 2001-2013. The Lagrangian approach has been used to identify the sources of moisture for each precipitation day happened for the 12-year period. The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model has been used to trace back the moisture transport and to identify the remote moisture source outside the western Canada. The methodology employed in the study computes the moisture uptake through the calculation of the evaporation minus precipitation as well as the changes in the specific humidity along 7-day backward trajectories. The results indicate that the moisture released in the SRB and MRB region in warm season is substantially originated from the east or the south especially US Great Plains and Midwest. The moisture uptake from the western Pacific Ocean also made considerable contribution. Special attention has been paid to extreme drought/wet years over SRB.

1708010 POSTER SESSION - PART 1

Nitrogen availability dampens optimism for the positive impacts of CO2 fertilization on carbon/water cycles

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The terrestrial ecosystem carbon sink is expected to partially offset fossil-fuel emissions as a result of the raising atmospheric CO2 concentration. However, the magnitude and variation of global terrestrial carbon sink remain uncertain partly due to limited information on the ecosystem nutrition (N) cycles. In this study, satellite observed chlorophyll content over the 2003-2011 period provide an evidence that the terrestrial carbon sink is constrained by the N cycle in many unmanaged forests. In most tropical and boreal forests, reduced photosynthetic capacity, as indicated by reduced leaf chlorophyll, progressively suppresses the positive response of vegetation to enhanced CO2 fertilization. Deforestation in tropical forests also causes N loss and therefore significantly reduced ecosystem productivity. Using an ecosystem model with consideration of N limitation, the global gross primary productivity (GPP) is estimated to have increased during 2000-2015 at a rate of 0.2 Pg C yr-1, which is only two thirds of the estimate (0.3 Pg C yr-1) without N constraint. Based on our carbon-water coupled simulations, enhanced CO2 concentration decreased stomatal conductance and hence increased water use efficiency (WUE) by 10% globally from 1982 to 2015. Owing to increased N application and deposition by human activities, GPP in croplands continues to grow and offset the weak negative trend in forests due to the N limitation. However, the improved WUE is unlikely to ease the regional drought in croplands because of the increase in evapotranspiration associated with enhanced GPP from N fertilizer use. Our study suggests the importance in monitoring of ecosystem chlorophyll to enable more accurate projection of the interaction between carbon and water cycles and climate change in the future.

1708010 POSTER SESSION - PART 1

Statistical Homogenization of Undocumented Monthly Temperature Data in British Columbia for Trend Analysis

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Non-climatic variations (such as changes of instrument, station relocation, changes in observing time and procedure, etc.) in climate data can lead to discontinuities, causing the inaccurate analysis of the climatic characteristics for a given location. Thus, data quality control and homogenization is the crucial first step before properly analyzing climate trend and extremes. In Canada, the most recent Adjusted and Homogenized Canadian Climate Data (AHCCD) from Environment and Climate Change Canada have been produced for four climate variables at various temporal resolution, such as adjusted surface air temperature for 338 locations (Vincent et al., 2012), adjusted precipitation dataset for over 450 locations (Mekis and Vincent, 2011). In British Columbia (B.C.), thousands of stations from non-ECCC networks are available for quality control and homogenization.

In this project, homogenization of monthly temperature data for 797 stations from three networks (BCHydro, Ministry of Forests Lands and Natural Resource Operations Wildfire Management Branch and the Ministry of Transportation and Infrastructure) is based on a penalized maximum t-test with Quantile-Matching (QM) algorithm to detect inhomogeneities and make adjustments to the data (Wang et al. 2007, Wang 2008a, Wang 2008b). The homogenized product from the project will be made available to climate researchers through the Pacific Climate Impacts Consortium's (PCIC) data portal. Climate trends in the studied region B.C. will be presented from the homogenized dataset and will be compared to those calculated from datasets without homogenization and the AHCCD data. After such evaluation, the preliminary results are expected to suggest an improvement in the ability of characterizing climate change with the homogenized datasets.

1708010 POSTER SESSION - PART 1

Trace gas measurements by Open-path Fourier Transform Infrared (OP-FTIR) spectroscopy at Halifax, Canada: vehicles and ships emissions

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A mobile open path Fourier Transform Infrared (OP-FTIR) spectrometer system has been set up at different locations of Halifax, Canada over the past 2 years to record mid-infrared spectra with high temporal resolution (typically 1 minute). Trace gas concentrations are derived from spectra using a nonlinear least squares spectral fitting technique and suite of data processing tools. The uninterrupted measurement time ranged from a few hours to few weeks. Halifax is a medium size coastal city in Atlantic Canada, which has high population density, busy vehicles and regular commercial and military ships calls at the Halifax Peninsula water front. Concentrations of derived trace gases included NOx, NH3, HCHO, CH3OH and other species, some of which were emitted by vehicles and ships in the harbour. The concentration variations of the above gases are analyzed in this presentation, with some special events showing strong man-made emissions of NOx and NH3 being highlighted. A detailed characterization of observed trace gases as a function of time of day and also season will be presented. This is helpful for investigations of exhaust gases from different types of engines and fuels, and the potential effect of traffic and shipping on air quality in urban and coastal areas.

1708010 POSTER SESSION - PART 1

Response of convection to large-scale forcings in spCAM5 and CanAM4

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Within global climate models parameterizations are used to model subgrid scale deep convection, including precipitation, and its effect on the large-scale (grid-scale) environment. In turn, the interaction of convection with the large-scale environment will affect the amount and the variability of convective precipitation. To examine convective parameterization in the Canadian Atmospheric Model version 4 (CanAM4) we use results from version 5.0 of the super-parameterized Community Atmosphere Model (spCAM5). Particularly, we study the relation between precipitation initiation and convective available potential energy (CAPE) tendencies generated by large-scale free troposphere and boundary layer forcings.

1708010 POSTER SESSION - PART 1

Satellite validation of CFCs over the High Arctic

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Atmospheric satellite data plays an important role in monitoring and surveying trace gas concentrations in the atmosphere, including ozone depleting substances. These datasets have to be validated thoroughly to show their reliability and to encourage their application in atmospheric research.

Ground-based measurements at the Canadian Arctic research station PEARL (Polar Environment Atmospheric Research Laboratory) provide a high-quality, if localized, view of the atmosphere within the High Arctic.

I will present comparison results for ozone depleting substances obtained from two satellite instruments. The first is the CFC-11, CFC-12, and HCFC-22 dataset from the ACE-FTS instrument (Atmospheric Chemistry Experiment Fourier Transform Spectrometer) on SCISAT. The second instrument is HIRDLS (High Resolution Dynamics Limb Sounder) on Aura, which obtained profiles for CFC-11 and CFC-12.

1708010 POSTER SESSION - PART 1

Non-linear interactions between internal wave beams: beyond the traditional approximation

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Internal wave beams have been observed numerical simulations and experiments. Interacting internal gravity waves is an area of current research due largely to their contribution to ocean mixing. When wave beams interact they can produce higher harmonics whose frequencies are integer multiple of the frequency of the incident wave, these higher harmonics are generated at the region of interaction of the incident and reflected waves. It is common place in the study of internal waves to assume the rotation vector is parallel to gravity so that the effect of rotation is along the vertical. This is widely known as the Traditional Approximation. If we jettison this assumption, a horizontal component of the Earth's angular velocity, becomes relevant which causes some adjustment in the Coriolis force. This horizontal component of the Coriolis force is important for low-frequency internal waves in weakly stratified fluids. An important consequence of the non-traditional approximation is that waves now exist at slightly sub-inertial frequencies. That is, the range of allowable frequencies for internal wave propagation is increased. In the first part of the talk, I report the differences between the traditional and non-traditional approximations based on research done earlier in this field of study. In the second part of the talk I report our recent time series analysis of data obtained from moorings situated in the flow field of a wave beam reflecting off a sloping bottom.

1708010 POSTER SESSION - PART 1

Modeling the impact of marine fugitive VOC emissions from the transport and handling of petroleum products on summertime ground level ozone in southwestern British Columbia.

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Fugitive emissions of volatile organic compounds (VOCs) from the marine loading and transport of petroleum products could potentially be an important source of ozone precursors in maritime locations. The current Environment and Climate Change Canada (ECCC) marine emission inventory includes combustion emissions and fugitive VOC emissions from some crude petroleum loading, but is missing fugitives from non-crude marine transport and from tanker barges. We developed an activity based marine emission inventory that includes both combustion and fugitive emissions over the part of the Salish Sea in southern British Columbia and coastal Washington State.

Using this inventory, we examined the impact of various levels of fugitive emission control strategies and marine transport activity levels on ground level ozone over the Lower Fraser Valley (LFV) B.C. using the AURAMS photochemical model. AURAMS was run at a 4km resolution and driven by meteorological fields generated using ECCC's GEM numerical weather prediction model.

Emissions for all non-marine sources were based on ECCC's 2010 national emission inventory (NEI) and the US EPA's 2008 NEI. Marine emissions were based on archived Automated Identification System (AIS) reports from vessels movements within part of the Salish Sea. We used the AIS data along with vessel characteristics to compute main engine, auxiliary engine, and boiler combustion emissions. Fugitive emissions from the loading of petroleum products were calculated based on loading volume estimates from the various terminals in the Salish Sea. Fugitive transit emissions were calculated using the estimated loaded volume and observed transit times. To test the marine inventory accuracy, we compared monthly round trip fuel consumption based on fuel sales versus fuel consumption based on calculated CO_2 emissions from a number of passenger ferries within the Salish Sea.

1708010 POSTER SESSION - PART 1

Atmosphere-Biosphere Interaction: A Quantitative Study of Ozone Dynamics over a Mixed Forest

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Atmospheric ozone and terrestrial ecosystem interact in complicated ways. At the forefront of this atmosphere-biosphere interaction is the stoma, a major gas exchange site on plants that regulates the passage of carbon dioxide and water. It is through these stomata that ozone's interaction with the biosphere occurs. Early research has hypothesized that moisture availability plays an important role in this relationship. With less moisture, plants will experience drought stress and close their stomata, which reduces the passage of ozone diffusion into the plant. Up to now, very few studies examined the effects of forests on ground-level ozone quantitatively. This study aims to address this issue and also further the knowledge in this field.

The study site is the Borden Forest Research Station located at Borden, Ontario in an area dominated by mixed forests. The datasets used consist of hourly meteorological and environmental observations, half-hourly gas concentrations (including ozone) sampled by the flux tower at six different heights (1 m, 5.3 m,

16.5 m, 25.7 m, 33 m, and 41.5 m), and daily leaf-area index (LAI) interpolated from measurements. A process model that simulates stomatal conductance and environmental influences, namely Boreal Ecosystem Productivity Simulator (BEPS), is used to help untangle these interactions and pin down the processes that affect ozone variation above the forest canopy.
Our analyses suggest a strong link between soil moisture and above canopy ozone concentrations. Canopy stomatal conductance (gst) appears to be at the centre of this link. However, this relationship is only present during the day, and canopy non-stomatal conductance (gns) dominates at night (the gst:gns ratio is rougly 1:1 during the day and 1:5 at night). Furthermore, we find that precipitation also plays a role by affecting the wetness of the cuticle, which influences ozone diffusion through the stomata.

1708010 POSTER SESSION - PART 1

Charactersitics of Smog in Ontario

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Smog, with two major components of ozone (O3) and fine particulate matters (PM2.5), is harmful to human health. In this study, air quality measurements from the Ontario Ministry of Environment and Climate Change are analyzed to characterize spatial and seasonal variations of smog in Ontario, and their trends between 2003 and 2014.
For PM2.5, high concentrations are observed from May to August. Southern cities (Toronto, Hamilton, and Sarnia) have higher concentrations than northern cities (Sault Ste. Marie, Sudbury, and North Bay). Annual PM2.5 concentrations decreased from 2003 to 2009, but increased from 2010 to 2014 for all cities except Sarnia where PM2.5 concentrations decreased continuously during 2003-2014.
Ground-level O3 concentrations in Ontario are the lowest in winter, but the highest in spring. Northern cities have high O3 concentrations from March to May. From 2003 to 2014, Sarnia has the largest drop in O3 annual means, followed by Sault Ste. Marie, Toronto, and North Bay. Annual mean O3 concentrations have increased in Hamilton and Sudbury.
The temporal variation of smog in Ontario has been affected by different seasonalities of PM2.5 and O3. For example, Toronto has the highest number of smog advisory days in June (46 days), followed by July, August, May, September, October, and February from 2003 to 2014. During warmer seasons (April to September), smog advisories were mostly due to high PM2.5 concentrations with monthly values of 32 - 41 µg/m3, and low O3 concentrations with monthly means of 21-27 ppbv. However, during colder seasons from October to February, monthly PM2.5 concentrations dropped significantly to 6-18 µg/m3, while monthly ozone concentrations increased to 28-34 ppbv. The number of smog advisories varied over years with peaks in 2005, 2007, and 2012.

1708010 POSTER SESSION - PART 1

Spectral analysis of large-scale meteorological patterns preceding summer ozone episodes and heat waves in North America

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Ozone pollution episodes and heat waves have negative impacts on human health and can damage vegetation. These two types of event are linked by their occurrence during stagnant conditions and the influence of temperature on emissions of biogenic precursors to ozone formation. Subseasonal forecasting skill and predictions of the frequency and intensity of these extreme events under climate change could be improved by characterizing large-scale meteorological patterns (LSMP) that typically occur in advance. Ozone episodes and heat waves are identified in records from North American ozone and temperature monitoring stations. Statistical clustering methods are used to divide stations into large regions (e.g. West Coast, Northeast United States) according to their likelihood to simultaneously experience extreme temperatures or ozone concentrations. These divisions are useful because the characteristic LSMPs for extreme events differ by region. Upper troposphere composite circulations are calculated from reanalysis data for heat waves and ozone episodes in each region. Wavenumber-frequency analysis is used to decompose these patterns into standing and traveling zonal wave components. Persistent planetary-scale standing wave patterns are found to precede both ozone episodes and heat waves in most regions. It is argued that because these patterns evolve more slowly than typical weather patterns, they may be used to better predict future ozone and temperature extremes.

1708010 POSTER SESSION - PART 1

A comparison of the atmospheric response to sea ice loss in isolation among coupled climate models

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Arctic sea ice loss amplifies greenhouse warming, but it's difficult to determine how specific changes in the climate system are attributed to sea ice loss or to other drivers like low-latitude warming. The atmospheric response to sea ice loss in isolation is studied in two sets of experiments using a coupled modelling framework. The first set of experiments uses the Community Earth System Model (CESM1) and isolates sea ice loss by keeping radiative forcing constant at year 2000 levels while melting sea ice globally by altering its albedo. The atmospheric response is compared to a set of experiments done with the Canadian Earth System Model (CanESM2) where sea ice is melted in the Arctic only by nudging the ice cover toward doubled CO_2 conditions while keeping the radiative forcing at preindustrial levels. Using a pattern scaling approach, the full response pattern (i.e., to both radiative forcing and sea ice loss) in the Northern Hemisphere is separated into a part that scales with sea ice loss and a part that scales with low latitude warming. Despite the differences in experimental design and model differences, the part that scales with sea ice loss is surprisingly robust. The differences in the response scale with low-latitude warming, suggesting that they arise from the extratropical response to tropical forcing.

1708010 POSTER SESSION - PART 1

Propagation and Directional Scattering of Ocean Waves in the Marginal Ice Zone and Neighbouring Seas

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A recent field experiment was conducted in the Beaufort Sea in the autumn of 2015, for the project: Sea State and Boundary Layer Physics of the Emerging Arctic Ocean, as described http://www.apl.washington.edu/project/project.php?id=arctic_sea_state. The objectives include to improve forecasting of waves on the open ocean and in the marginal ice zone (MIZ), and improve the theory of wave attenuation/scattering in the MIZ. Here, we describe the field data collected for waves in MIZ storms, during the field experiment and report model results for wave-ice interactions. WAVEWATCHIII (WW3) is adapted for wave scattering in the marginal ice zone (MIZ) following recent studies in the literature. Presently, no practical methodology has been developed to directly incorporate a detailed model for wave attenuation and wave scattering for the MIZ region, accounting for wave-ice interactions, in WW3. We show that this can be achieved by construction of a large look-up database that captures the essential characteristics of the linear Boltzmann integral for the wave attenuation and scattering integral in the action density conservation equation. This makes for efficient, accurate integration of the wave-ice interactions. Other features include

properties that allow for non-rigid floes, ice floe flexure, which can dominate large floes. The resulting model for wave attenuation and scattering is able to model observed measurements such as the strong dependence of wave scattering on wave period, and the roll over effect, whereby attenuation increases with increasing frequencies until reaching the spectral peak region, and then begin to diminish, as frequencies increase into the equilibrium range and the high frequency region of the spectrum. Similar results occur for differing values in sea ice concentration, thickness, and floe sizes. The resulting model system is shown to compare reasonably well with in situ and satellite remotely sensed data collected during the field experiment.

1708010 POSTER SESSION - PART 1

Application of CanESM2 to Project Future Soil Temperature at a Northern Quebec Location with Statistical Downscaling Model (SDSM) software

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Northern infrastructure such as transportation and housing frequently rely on the frozen ground to provide structural strength. We seek to project how future soil temperature will increase by with SDSM software. We gathered 27 years of historical soil temperature data at various depths (5cm to 150cm) at Kuujjuaq airport in Quebec. CanESM2 predictor variables ceshtempgl (mean temperature at 2m), ceshumgl (surface specific humidity), ceshs850gl (specific humidity at 850 hPa) and ceshp850gl (850 hPa geopotential height) performed well in the validation exercise for mean soil temperature at those depths. The model tends to predict warmer maximum temperature and colder minimum temperature than observed in winter. Variance in the data were reproduced reasonably well, which demonstrated that the software was able to reasonably reproduce data points deviating from the mean, such as extreme events. As soil temperature is not one of the downscaled variable for CanESM2, we used surface air temperature at 2m as a proxy for future projections. Projections are divided into three 30-year periods. In RCP 2.6 and RCP 4.5 scenarios, the projected annual mean soil temperature would stay below 0°C at all depths in this location by 2090s. However, annual soil temperature will rise to above 0.5°C in RCP 8.5 scenario. In conclusion, we successfully demonstrated that the SDSM software can be utilized for site-specific soil temperature projection.

1708010 POSTER SESSION - PART 1

Trend analysis of long-term hydrometeorological time series in the Great Lakes Basin, with an emphasis in the Lake Huron-Michigan System.

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The North American Great Lakes are an important resource for Canada and United States. It holds 20% of the world's available freshwater and spans over 10,000 miles of coastline, with over 33 million population residing within the basin. Understanding impacts of climate change on large hydrologic systems such as the Great Lakes are of great importance to the North American and global economies. In light of this, trends in meteorological (mean, minimum and maximum air temperature, cloud cover, wind speed) and hydrological (precipitation, runoff, evaporation, net basin supply, water temperature, and connecting channel flows) variables over each of the Great Lakes during the 20th century are analyzed using the updated hydrometeorological database from the Great Lakes Environmental Research Laboratory.

Trends were computed using the non-parametric pre-whitening method described in Zhang et al. (2000). Long-term trends were computed for precipitation (1900-2015), runoff (1916-2015) and flows (1900-2011). Trends for the other parameters are computed from the late 1940s to 2015, due to insufficient data prior to the 1950s. A separate analysis using data starting from 1970 were computed for all parameters to assess for trends in the recent decades where the climate change and global annual temperature trend was more pronounced.
Preliminary results showed significant decrease in cloud cover in Lake Erie, Lake Michigan, Lake Huron but not Georgian Bay. Minimum air temperature had increased over most of the Great Lakes and their basin. Increase in evaporation was significant during the warm season in the recent 45 year period in Lake Michigan and the Great Lakes as a whole. Wind Speed over Lake Superior also showed a small but significant increase. The improved understanding of the hydrometeorological trends should fill a critical gap in Great Lakes climate change research.

1708010 POSTER SESSION - PART 1

Modeling the Interannual Variability of Tornado Occurrences In North America: Influence of Madden-Julian Oscillation and El-Nino/Southern Oscillation

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Previously we have introduced a Bayesian hierarchical framework to depict the causal linkages between seasonal tornado occurrence and large-scale environmental predictors over the contiguous United States and Canada. Under this framework, the problem of modeling tornado occurrence is dissected into levels (hierarchies) which address both the limitations in tornado reports and the assumption of a constant large-scale tornadic environment over the course of the year and in different regions. Allowing for seasonal and regional influences (e.g., High-Shear, Low-CAPE environment in the cool season) could improve our ability to tease out the significant drivers in time and space and ultimately our predictive capacity. In this study, we present the application of this framework in the characterization of the inter-annual variability of monthly tornado occurrence using monthly average large-scale environment predictors, and we examine the influences of large-scale climate oscillations such as the Madden-Julian Oscillation (MJO) and El-Nino/Southern Oscillation (ENSO) on the frequency of tornado occurrences and their associated tornadic environments in various regions in North America.
In addition to presenting different methods in defining hierarchies, from a static approach to dynamic hierarchies that evolve based on thresholds of large-scale environmental predictors, we showed that the hierarchical approach resulted in a more spatially balanced model performance than a non-hierarchical modeling approach. In turn, we were about to better elucidate the influence of MJO and ENSO on tornado occurrence in various regions in North America. For example, tornado occurrence in the west region of the U.S. during the spring are significantly associated with ENSO, and tornado occurrence in the Great Lakes region during the summer are significantly associated with one of the MJO phases. The findings of this research should have major implications to the understanding of the influence of large-scale climate oscillations on the occurrence of severe convective storms and tornadoes.

1708010 POSTER SESSION - PART 1

New blended sea ice thickness dataset

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We present the development of a new dataset of Arctic sea ice thickness comprised of several observational sources within the context of the Canadian Sea Ice and Snow Evolution (CanSISE) network. We combined

measurements from satellite-borne, in-situ, and aircraft-based instruments from 2000 and onwards to build a climatology of sea ice thickness. This dataset is meant to improve our knowledge of the sea ice thickness climatology, its spatial and temporal distribution, and its evolution. It is also a tool to be used for hindcast and short-term forecast simulations. The project also served to compare the different sources of measurements, assess the consistencies and the differences between the different instruments and retrieval algorithms.

1708010 POSTER SESSION - PART 1

Health risk assessment of PM2.5 bound compounds in Windsor, Canada

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Exposure to ambient fine particulate matter (PM2.5) has been linked to a number of adverse human health effects including cancer. This study estimates lifetime health risk of ambient PM2.5 bound elements and polycyclic aromatic hydrocarbons (PAHs) during 2013 to 2015 in Windsor, Ontario, Canada. Risk assessment methods of US Environment Protection Agency (USEPA) were employed to the following PM2.5 components: six elements (Cr, Co, Ni, As, Cd, Pb) and 16 USEPA priority PAHs for carcinogenic risk, and 11 elements (Al, Ba, Cr, Ni, As, Cd, Pb, Co, V, Cl, Se) for non-carcinogenic risk expressed as hazard quotient (HQ). In Windsor, the three-year average PM2.5 mass concentration was 9.6 µg/m3, slightly lower than the Canadian Ambient Air Quality Standard of 10 µg/m3 proposed for 2015. Among the four seasons, summer and winter had higher PM2.5 levels (11.0 µg/m3), followed by spring (8.7 µg/m3), and fall (8.0 µg/m3). The estimated lifetime non-cancer HQ due to exposure to ambient PM2.5 was 0.16. According to USEPA, HQs less than 1.0 indicate no appreciable or adverse risk. However, a HQ greater than 0.2 suggests a risk to human health potentially exists. The HQ values were higher in summer (0.19) and fall (0.18) but lower in spring (0.16) and winter (0.12). The lifetime cancer risk was 9.33E-04. This cancer risk level is much higher than the USEPA's threshold of 1.00E-04 for sufficiently large risks. Contributions of PM2.5 carcinogenic components to cancer risk are in the order of Cr > As >> PAHs > Pb > Cd > Co > Ni. Summer accounted for 29% of total lifetime cancer risk, followed by fall (27%), spring (23%), and winter (21%). Overall, lifetime cancer risks in Windsor were higher than the corresponding USEPA threshold. Consequently, remediation measures are desirable.

1708010 POSTER SESSION - PART 1

Long term trends of sulphur dioxide emissions and ambient concentrations in Ontario, Canada

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A comprehensive trend analysis of atmospheric sulphur dioxide (SO2) over the period of 2002-2015 in Ontario, Canada is conducted using emission and concentration data in relation to environmental policies. The following monitoring stations were selected: Windsor Downtown, Sarnia, Hamilton Downtown, Toronto West, Ottawa, Sault Ste. Marie, and Sudbury. The respective facilities that report SO2 emissions to National Pollutant Release Inventory (NPRI) database were utilized to obtain annual SO2 emissions from each of the seven cities during 2002-2015. These seven cities together account for approximately 30% of the total SO2 emissions in Ontario over the study period, half of which were from Sarnia. From 2002 to 2015, the provincial SO2 emissions have decreased by 56%. Ambient SO2 concentrations at all cities were found to be decreasing over the study period. The seven-city average SO2 concentration in 2015 was 2 ppb, less than half of the 2002 level of 4.3 ppb. SO2 concentration was reduced by 69% in Sarnia, an industrial city, as the result of 76% drop in emissions. However, Hamilton, another industrial city, only saw a 13% reduction in concentrations due to a 24% increase in SO2 emissions. Consequently, since 2012 Hamilton has replaced Sarnia to record the highest annual SO2 concentrations in Ontario. At urban centres, including Windsor, Ottawa and Toronto, SO2 concentrations had decreased by 66-86%. The long term SO2 concentration and emission trends, as well as the association between emission and concentration will be further assessed using statistical tools. The environmental policies regulating emissions and influencing fuel choices will be taken into consideration to derive the concentration-emission relationship.

1708010 POSTER SESSION - PART 1

Assessing land-surface initialization in CanSIPS using bias-corrected operational GEM analysis.

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Seasonal to interannual hydrological forecasts are very sensitive to the accuracy of the land surface initialization, in particular soil moisture and snow. Climate model output typically needs to be bias corrected before it can be applied to hydrological models such as Canadian Land Surface Scheme (CLASS), which is the land component of Canadian Seasonal and Interannual Predicition System (CanSIPS). In recent years substantial progress have been made in developing advanced bias correction methods (Pierce et al. 2015; Cannon 2016). In this study we evaluate advanced bias correction techniques such as multivariate bias correction (MBC, Cannon 2016) and equidistant quantile matching (EDCDFm, Pierce et al. 2015) for bias correcting Global Environmental Multiscale Model (GEM), which is the operational weather forecast model of Environment and Climate Change Canada, analysis, to initialize the land component of CanSIPS. The impact of bias corrected GEM analysis on CanSIPS hydrological forecasts are assessed using observational data from in-situ monitoring networks over an agricultural site in southern Saskatchewan, and Manitoba.

1708010 POSTER SESSION - PART 1

Long Term Forecast and Modelling of South Athabasca Oil Sands and Provincial Emissions in Alberta

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In situ oil sands development is expected to dominate bitumen production in the coming decades and much of it will be located in the south Athabasca oil sands area (SAOS). Meanwhile, shale gas development in Upper Peace River area may also be projected to increase in production. In order to assess impact of environmental footprints of oil sands production and other energy development under the new Alberta Climate Leadership Plan (CLP), future Alberta province-wide emissions are developed based on 2010 baseline year and forecasted future development scenarios for two separate periods: 2030 and 2045. The year 2030 was selected to capture a major milestone of Alberta's CLP that will phase out emissions from coal-burning electricity generation by 2030. The study selected year 2045 by taking into account available activity data for the oil and gas industry as well as the limitation of mobile emission projection tools.

This study introduces the method of building a comprehensive database for point source and non-point air emissions inventory and model inputs for long-term forecasting in regions of Alberta province. Particularly, the future-year inventory in the SAOS region were developed based on Alberta energy projection from 2010 to 2045 and focused on in-situ oil and gas and shale gas production. Coal-fired power plants will be all phased out by 2030. This study also applies CMAQ model to simulate the ground level concentrations of ozone, PM2.5, PM10, NO2, SO2, CO, and acid deposition in SAOS and Upper Peace region for baseline case in year 2010, future development scenarios of high production level in year 2030, and future development scenarios of high production level in year 2045. The outcome of this study can assist future air quality and health impact researches in the province of Alberta.

1708010 POSTER SESSION - PART 1
Atmospheric Pollution in Coastal Environments: A Nova Scotia Perspective
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Air Quality (AQ) in Nova Scotia, is good when compared to highly polluted regions, e.g., megacities (> 10 million residents) in the developing world. In an absolute sense, too, the Canadian Ambient Air Quality Standards (CAAQS) for PM2.5 and O3 have been achieved in the 2014 base year in all Nova Scotia Air Zones. However, management actions are necessary for preventing either future AQ deterioration or CAAQS exceedances. On a day to day basis, Nova Scotia does experience days when National Ambient Air Quality Objectives (NAAQO) are not met for some species, especially in terms of maximum desirable concentration levels. Moreover, the CAAQS metrics are currently being expanded to include SO2 and NO2, at the same time as fuel sulphur content regulations in marine transport are being reduced within Emission Control Areas. This talk will examine long-term trends in SO2 and other air pollutant concentrations in Halifax and other locations in the context of changing emission sources and regulations.

1708010 POSTER SESSION - PART 1
Barrier Effect of the Maritime Continent on the MJO in the in the Superparameterized CAM
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The space–time structures of the Madden–Julian oscillation (MJO) as simulated by the superparameterized Community Atmosphere Model (SPCAM) are analyzed. SPCAM implements a 2D cloud resolving model (CRM) in CAM to replace its conventional parameterization for moist convection and large-scale condensation. Compared to the CAM that implement conventional parameterizations, the SP-CAM displays robust atmospheric variability on intraseasonal space and time scales and more MJO events that generate over the Indian Ocean can overcome the barrier effect of the maritime continent. These differences are likely due to better moist environment and stronger deep convection in the SPCAM.

1708010 POSTER SESSION - PART 1
Forecasting Outdoor Residential Water Consumption using Ensembles of Regression Trees
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Short-term predictions of water consumption are used by water utilities for day-to-day management, and, if necessary, to enact water use restrictions. We focus on outdoor consumption in particular, because it is more able to be reduced at short notice than indoor usage, which is largely based on household appliance stock and the number of occupants. In addition, there is more variability in outdoor usage, based both on both time of year and weather conditions, than there is in indoor usage. Also, because outdoor consumption comprises a much greater percentage of peak usage than it does average-day usage, identifying and reducing this consumption is useful for reducing infrastructure strain. We estimate the outdoor water usage based on an hourly threshold past which it is unlikely all of the consumption is indoor use, and based on this estimate we build a model to predict outdoor consumption.
Our dataset consists of hourly water consumption recordings for approximately 8,000 single-family households in Abbotsford, British Columbia taken over a 12-month period. Our model uses an ensemble of regression trees for prediction, to maintain some interpretability. We predict consumption for census dissemination areas at a daily timescale, using demographic and property information, outdoor consumption on previous days, and weather data. There are three variations on the model which take into account potential

variations in the accuracy of weather forecasts available: i) no weather information, ii) complete actual weather information to simulate a perfect forecast, iii) only actual previous-day weather to simulate the realistic scenario. Future work could include longer-term consumption forecasts in combination with climate models to predict the effects of climate change on water demand.

1708010 POSTER SESSION - PART 1

High Resolution Regional Climate Change Projections for Ontario

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Taylor, Peter - Department of Earth and Space Science and Engineering, York University
Zhou, Xiaolan - Department of Mathematics and Statistics, York University
Madras, Neal - Department of Mathematics and Statistics, York University
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Practitioners need to know what future climate conditions to adapt to at the right scale. In response to this demand, the LAMPS group at York University has developed high resolution (~10km x 10km) regional climate data (both historical data from 1900 to 2016 and future projections from 2017 to 2100) over Ontario using state-of-the science combined downscaling method. These projections are based on an ensemble of over two hundred simulations from CMIP5 GCM daily output and were bias-corrected using the ERA-Interim daily data. Period averages of four basic variables and over forty extreme climate indices were developed. These terabytes of climate data has been disseminated to the general public for free via the York University climate change data portal at http://yorku.ca/occp. This data portal provide both intuitive visualization for general public and policy makers and extensive data downloading for more advanced practitioners. It also published reports on special topics for decision maker, climate change pictures and videos. Since its launch in 2015, the data portal now has many registered users and received numerous data downloading requests. These data have been used in climate change impact assessments on vector-borne diseases, agricultural practices, etc. To improve the data dissemination efficiency of the data portal, a single-page application (SPA) using new web application development technology is currently being developed at LAMPS. A cloud service was also created to provide raw climate data (7~8 TBs). This paper will provide an overview and live demonstration of the data portal.

1708010 POSTER SESSION - PART 1

On the linearity of Arctic sea ice loss and doubled CO2 in a coupled system

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Fyfe, John - Canadian Centre for Climate Modelling and Analysis
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Arctic sea ice loss has an important effect on local climate through increases in ocean to atmosphere heat flux and associated feedbacks, and may influence midlatitude climate through changes in large-scale circulation that amplify or damp changes that are due to greenhouse gases. The extent to which climate change in a warming world can be understood as changes due to greenhouse gases that are modulated in some way by Arctic sea ice loss depends on how linear the responses to the separate influences are. Here we use a novel sea ice nudging methodology in the Canadian Earth System Model, which has a fully coupled ocean, to isolate the distinct effects of Arctic sea ice loss and doubled atmospheric carbon dioxide (CO_2) concentrations in order to determine their linearity and sensitivity to mean state. We find that the climate

response to isolated Arctic sea ice loss and isolated doubled CO2 is remarkably additive in winter, even at small spatial scales, with sea ice loss in some locations amplifying and some locations dampening the response to CO2. In this model, Arctic sea ice loss amplifies the change in surface air temperature from doubled CO2 nearly everywhere except over the gulf stream and over Southeast Asia, whereas Arctic sea ice loss dampens the changes in sea level pressure nearly everywhere except over the central Arctic and North Pacific. The degree of linearity is highest for thermodynamic variables and is generally higher in winter and summer for all variables, suggesting a role for the changing sea ice edge in setting the degree of linearity. Our results suggest that a robust response to Arctic sea ice loss can be identified as distinct from the response to doubled CO2, and may provide guidance for how to interpret the diverse array of Arctic and midlatitude changes found in the CMIP5 archive.

1708010 POSTER SESSION - PART 1

Stratospheric polar vortex characteristics and winter temperature cold anomalies in North America

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Stratospheric polar vortex characteristics and circulation indices in the lower troposphere and lower boundary are used to study the coupling between these parameters and their impacts on weather over North America. The relationship between stratospheric polar vortex and extreme cold temperature anomalies in different ENSO phases and circulation indices is investigated through comparing sudden stratospheric warming (SSW) events and vortex status and tropospheric circulation. Statistical analyses of the connection between polar vortex distortion and displacement, circulation anomalies and lower troposphere conditions for extreme cold events are conducted to find the precursors of extreme cold events.

1708010 POSTER SESSION - PART 1

On the variability of upper-level winds over southern Ontario

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Climate change is not uniform across the globe and ""Arctic Amplification"" may well be a cause of increased variability, and extremes, in northern hemisphere mid-latitude weather. While we primarily experience this variability at ground level, within the atmospheric boundary layer, the broad scale atmospheric dynamics are mainly driven from above, where measured data are relatively scarce but winds are relatively predictable. Weather prediction models can provide reliable information and NARR (NCEP North American Regional Reanalysis) model data are a valuable source.of historical data. Our first step was a comparison of upper level (surface to 15 km height) winds with those measured by our Ontario-Quebec Network of VHF wind profilers. The comparisons were satisfactory and gave us confidence to use NARR winds to analyse variability and trends.

Analyses of upper air winds from NARR data for southern Ontario for the past 36 years are presented. Annual averages show a slight weakening of 500 hPa zonal wind and a slight increase in the mean of the absolute value of the Meridional Circulation Index (|MCI|). These trends are expected as a result of Arctic Amplification of tropospheric temperature increases but are weak in comparison to inter-annual variability. There are seasonal variations in monthly averaged wind speed and April and October maxima in monthly averaged |MCI|.

1708010 POSTER SESSION - PART 1

How much half a degree in global warming may affect the extreme precipitation change in China?

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Paris Agreement recognized a “long-term goal” was to hold the increase in global average warming to well below 2?C and to pursue efforts to limit the temperature increase to 1.5?C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change. However, the future climate risks in those two levels show significantly regionally difference. This article aims to study the magnitude and frequency of extreme precipitation change over China between two global warming levels at 1.5?C and 2?C relative to present period (1986-2005) and how much the additional half degree affect the extreme precipitation changes using CMIP5 models under RCP4.5 experiment. The results show that the change relative to reference period in extreme precipitation averaged over China is 6.2% and 10.9% when the global temperature increases 1.5?C and 2?C, respectively. The increases in the magnitude of extreme precipitation are more significantly notably under 2 ?C condition compared to the 1.5 ?C. The additional 0.5 increase makes the magnitude of extreme precipitation averaged China increasing by 4%, the prominent significant increase areas are located over parts of southwestern and southeastern China, where the model consistency is relative high. The 20-years events in present period are projected to occur more frequently in large parts of the China with the global warming. The present 20 years return level is 2 times more likely to occur at 2?C warming over most parts of western China. The future return period of the historical 20 years events under 1.5?C warming and 2?C warming are estimated to decrease about 14 years and 11 years, respectively. Additional half degree makes the region averaged return period reduce 3 years, especially over southwestern China and regions surrounding Tibetan Plateau, where the recurrence time reduces from 20 years to 12-15 years. All those results indicate that a warming 1.5?C level will be a “safe” threshold for impact of climate change over China.

1708011 POSTER SESSION - PART 2

Oxidative processing studies on biological ice nucleating particles

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Ice nucleating particles (INPs), such as mineral dust, soot, and biological particles, play an important role in cloud formation as they have the ability to form ice crystals in the atmosphere. These ice crystals contribute to the overall impact clouds have on the Earth’s climate, by affecting precipitation and the radiation budget of the atmosphere.

Chemical exposure to oxidants such as OH or ozone may impact the ice nucleation ability of INPs. Besides inorganic particles, it is known that biological particles, such as bacteria, fungi and pollen can act as INPs. There is evidence that biological particles represent a major part of atmospheric particles. However, little is known about their change of ice nucleation ability due to chemical processing.

In this project, we studied the effect of aqueous OH oxidation on the ice nucleation activity of two types of pollen: Silver Birch and Sycamore Maple. The ice nucleation activity of the biological material was compared to Arizona Test Dust (ATD) as a typical non-biological material that is known to efficiently nucleate ice.

The ice nucleation activity was measured using a flow diffusion chamber. Pollen and ATD particles were exposed to OH in the liquid phase inside an atomizer bottle. The material was then atomized and dried with a diffusion drier before being size selected using a Differential Mobility Analyzer and injected to the University of Toronto – Continuous Flow Diffusion Chamber (UT-CFDC). The ice nucleation activity was measured for 233 K. It was found that only the Silver Birch pollen exhibited ice nucleation activity in the deposition freezing mode. This ice nucleation activity could be altered through exposure to OH. In contrast,

ATD did not show any loss of ice nucleation activity due to exposure to OH. Potential impacts on the atmosphere will be discussed.

1708011 POSTER SESSION - PART 2

Orientation and Spacing of Small-scale Surface Features in Mars' North Polar Cap: Preliminary Results

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The Northern Polar Layered Deposit (NPLD) of Mars contains many small-scale surface features that may hold information on various Martian atmospheric processes. Images from the High Resolution Imaging Science Experiment (HiRISE) taken around the NPLD are used to find patterns of surface features ranging approximately 20-40 m in size. Prominent patterns are analyzed by measuring the spacing between the features as well as determining whether the patterns follow a specific orientation. Many features were observed on the NPLD but the features' spacing did not have a general tendency to increase or decrease with respect to latitude; the orientations of the features also showed no trend moving northward or southward. However, the variety of patterns observed may offer insight into the potential origins of theses surface features. Features that orient east-west, found near the pole, suggest that sublimation features are possible on Northern Mars. There were also small-scale features observed to have a different orientation than the surrounding large-scale sastrugis, which are mainly driven by katabatic winds, suggesting that other processes may affect the formation of small-scale features on the NPLD.

1708011 POSTER SESSION - PART 2

Impact assessment of assimilating satellite-derived land surface skin temperature observations in the Canadian Land Data Assimilation System (CALDAS)

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The Canadian Land Surface Analysis System (CALDAS) is used to evaluate the impact in forecasts of assimilating GOES-derived surface skin temperature observations over land . A 1D-var approach is used for the retrieval using four infrared channels. The advantage of using geostationary observations is that these are available at fixed times with high spatial resolution (~4 km). GOES-E and GOES-W retrievals are assimilated at 3-h interval over a two-month summer period. The impact in forecasts up to 48-h is evaluated by adding the skin temperature observations to the operational system which assimilates SMAP brightness temperatures and 2-m temperature and humidity observations using an ensemble Kalman filter approach.

1708011 POSTER SESSION - PART 2

A Compact Cavity Ring-Down Spectroscopy Analyzer for in Situ measurements of Carbon Dioxide, Methane, and Water Vapor

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High quality measurements of greenhouse gases in remote locations require instruments that are precise, versatile, robust, and most importantly have power requirements that are as not limited by location, i.e. low enough power consumption to run off of batteries or even solar array. Here we present a battery-operated, full greenhouse gas analyzer that utilizes a novel method of Cavity Ring-Down Spectroscopy (CRDS) to measure carbon dioxide, methane and water vapor. The instrument consumes only 25 W and still maintains long term

stability to allow for averaging time of over 3 hours. Measurements have a 1-? precision of 30 ppb for CO_2 and 300 ppt of CH_4 with 5 minutes of averaging; and with measurements of 3 hour averages reaching precision down to 40 ppt of methane. Additionally this new flavor of CRDS has allowed for an overall increase in
measurement dynamic range from traditional CW-CRDS measuring methane up to 1000 ppm and carbon dioxide up to several percent. We will present supplemental data acquired using this <11 kg analyzer, including soil respiration using closed static chambers and ambient measurements from different remote locations.

1708011 POSTER SESSION - PART 2

Predicting Heavy Snowfall Along the Eastern Rocky Mountains: An Examination Into Hydrometeor Drift

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Hydrometeor drift, or “lee side spillover precipitation” [Kaplan et. Al 2009], in Alberta is a winter weather phenomenon that has a high impact on highways and local communities, and is difficult to forecast accurately within the Rocky Mountains. The occurrence is generally spatially limited and oftentimes leaves meteorologists struggling to determine how much precipitation will drift over from the windward side of a mountain range.

For the last two winters, a small group of forecasters in the Prairie and Arctic Storm Prediction Centre have worked diligently to capture data and generate case studies pertaining to hydrometeor drift with the goal of improving forecast accuracy within these data sparse regions.

The presentation will include a case study of the upper air and surface patterns potentially associated with warning level (hydrometeor drift) snow for the mountain park regions of Alberta, and the various model outputs for an event from November 2015. The poster will also feature a preliminary checklist for meteorologists to utilize while on the forecast desk, an overview of forecast verification techniques, and a discussion of the model(s) generally utilized for such cases.

1708011 POSTER SESSION - PART 2

Evaluating the radiative effects of fog and cloud properties in the Arctic

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Uncertainty in the radiative effects of clouds and fog contributes to large uncertainties in global climate models. This is especially important in the Arctic where the summer radiation balance is highly sensitive to the presence of clouds. In this preliminary study, we use version 18 of the CCCma radiative transfer model to explore the importance of liquid water path, cloud fraction, effective radius, and other liquid water clouds parameters on radiative fluxes. Inputs are based on observations collected during the 2014 flight campaign conducted by the Network on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments (NETCARE) near Resolute Bay, Nunavut combined with reanalysis data from the European Centre for Medium-Range Weather Forecasts (ECMWF). Simulated radiative fluxes will be compared to observations and sensitivity studies will determine the most important parameters affecting radiation. These results will inform improvements to cloud, fog and their microphysics in models, e.g., single-column models.

1708011 POSTER SESSION - PART 2
Using a Laser and Camera to Determine the Depth and Turbidity of Water
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This poster presentation will detail the experimental procedures and analysis of data obtained for using a camera and a laser in conjunction to determine the depth and turbidity of liquid water. The purpose of this experiment is to develop a device suitable for use on potential future missions to Saturn's moon Titan to collect data on its methane-rich lakes. Experiments were conducted by using an SBIG ST9-XE camera with a 4mm Tamron CCTV lens to acquire images of a Laserglow laser's beam (4.5W at 532 nm). The laser was aimed at an angle of approximately 77 degrees down a 178 L aquarium filled with water simulating an optical path length of 737 mm. Multiple image series were taken for these experiments where the turbidity of the water being increased by adding increments of 0.25 g of SiO2, for a change in particle density of approximately 1.9 g/m3 between each series. Images were calibrated using an averaged dark field and flat field image. The images were then analyzed in Matlab by examining the intensity of the light reflected back to the camera along the beam's length, and measuring the change in extinction as the turbidity of the water increased. From these analyses, an algorithm will be created to determine turbidity as a function of depth in water based on the angle of the laser relative to the camera and the pixel brightness of the images. The experiment will be repeated using a 7 foot black PVC tube, with a 100 mm lens attached to the SBIG camera and 532nm laser aimed down its length to increase the length of the optical path under investigation.

1708011 POSTER SESSION - PART 2
Frequency analysis of wind forcing over ocean gyres
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Ocean circulation is driven primarily by low frequency large scale wind stress patterns. It has been noted, however, that i) high frequency atmospheric winds and ii) smaller spatial scale surface ocean velocities both contribute to the low frequency stress. The former serves mainly to increase the low frequency stress and, with it, the wind power input to ocean circulation. The latter acts mainly as an energy sink. Here we use near-surface wind data and assume a quadratic drag law for the stress. Focusing on midlatitude storm tracks, we analyze which frequencies of the wind field contribute most to which frequencies of the wind stress. Based on these results and using a simple model, we also comment on how synoptic frequency winds and an ocean surface velocity dependence in the stress formulation might combine to produce near-inertial forcing over strong ocean currents such as the Gulf Stream.

1708011 POSTER SESSION - PART 2
Conversion of Pressure to Depth for Moored Instruments Using a Reference Bottom Mounted Pressure Sensor
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A new method is proposed to convert pressure measured by an instrument to water depth using an additional available bottom-moored pressure sensor. A perturbation analysis is used in this analysis, which leads to a simple formula for calculating water depth (defined as one from the mean sea surface to the instrument) from the pressure data. In field experiments, this method is easier to apply than existing methods. Based on the theoretical derivation, the error associated with the method comes from two sources when the instrument depth is known at the beginning of the measurement: temporal variation of deep water density at depths deeper than the instrument and variation in the gravitational acceleration with instrument displacement. These

two sources contribute up to 4% of the error relative to the vertical displacement of the instrument, assuming the pressure sensor is accurate. With the vertical displacement of the instrument being on the order of 10 m, the absolute error is on the order of 0.4 m, which is expected and acceptable in oceanic measurements. The method is applied to data from a field experiment that took place along the Myanmar coast in December 2012.

1708011 POSTER SESSION - PART 2
Algal bloom transport in the Great Lakes using remote sensing and hydrodynamic modelling
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Harmful algal blooms are a pressing concern for Lake Erie, which supplies drinking water to millions of people in the United States and Ontario. We discuss preliminary results from a hydrodynamic model of the Great Lakes combined with remotely sensed surface Chlorophyll-A concentration to simulate algal bloom transport. The hydrodynamic model is a component of a full water cycle model, called the Water Cycle Prediction System for the Great Lakes and Gulf of St. Lawrence (WCPS-GLS), which couples models of the atmosphere, lake dynamics, land-surface processes, and river runoff. Remotely sensed images are used to initialize a tracer field, Chlorophyll-A, which is advected by the lake model (NEMO). We discuss the advantages, disadvantages and challenges of this strategy, as well as our progress with respect to integrating these techniques into an operational version of the WCPS-GLS.

1708011 POSTER SESSION - PART 2
CONCEPTS Coupled Environmental Prediction Systems
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As numerical weather prediction (NWP) systems become further refined, the interactions across the Air-Ice-Ocean (AIO) interface are becoming increasingly important. This is giving rise to the development of a new generation of fully-integrated environmental prediction systems composed of atmosphere, ice, ocean, and wave modeling and analysis systems.
Within the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS), a fully-coupled AIO forecasting system for the Gulf of St. Lawrence (GSL) has been developed and has been running operationally at the Canadian Centre for Meteorological and Environmental Prediction (CCMEP) since June 2011. Here we present an overview of recent system developments in CONCEPTS.
Recent real-time evaluations of the GSL system demonstrate its smaller errors compared to the uncoupled atmospheric Regional Deterministic Prediction System (RDPS), especially over water and at coastal locations in cases of cold-air outbreaks. The GSL system is also being run at higher resolution over the Laurentian Great Lakes, with the same objective of improving forecasts both for the atmosphere and the water bodies. Illustrations of the high resolution modelling capabilities from this application will be shown.
A Global Ice-Ocean Prediction System (GIOPS) has been running in real-time at CCMEP since January 2013, upgraded in June 2014, and running operationally since August 2015. Improvements in ice forecast skill compared to persistence are demonstrated by the original system and even more by the upgraded system. GIOPS is being coupled atmospheric Global Deterministic Prediction System (GDPS) for improved medium-range forecasts, which will be discussed in more detail in a companion presentation.
We also outline the higher resolution Regional Ice-Ocean Prediction System (RIOPS) and its coupling with a higher resolution version of the RDPS.
Plans for the use and further development of these systems within the Ocean Protection Plan will be mentioned.
This presentation will be made on behalf of our many colleagues in CONCEPTS.

1708011 POSTER SESSION - PART 2

The role of Antarctic sea ice on the meridional overturning circulation.

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The Meridional Overturning Circulation (MOC) represents the global pathways of tracers such as heat and CO_2 and thus plays a key role in the climate system. In the past decade, major progress has been made in theorizing the internal dynamics of this circulation. However, it remains unclear how the ocean's global MOC is constrained by its various boundary conditions. For example, little is known on how sea ice controls deep-water formation on the Antarctic continental shelf and how this process affects the MOC. It has been suggested that Antarctic sea ice may also control the surface outcrop latitude dividing the mid-depth cell and an abyssal cell of the MOC and thus control the partitioning of carbon between the atmosphere and the ocean. Here, an ocean general circulation model in an idealized single basin setup is used to study the influence of the Antarctic sea ice cover on the global MOC. Sensitivity experiments are performed on various surface atmospheric forcing to disentangle the role of the temperature seasonal cycle, precipitation patterns, sea ice and katabatic winds on the equilibrium MOC as well as its multi-centennial internal variability. The influence of other geometric parameters such as the latitudinal extent of the Antarctic Peninsula and the atmospheric wind stress profile are also investigated.

1708011 POSTER SESSION - PART 2

Model simulated variations of the California Undercurrent off the Vancouver Island during 2013-2015

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We investigate spatial and temporal variations of the California Undercurrent (CUC) during 2013-2015 using the simulation results obtained from the high-resolution global ocean forecasting system of Mercator-Ocean, France. To the west of Vancouver Island (VI), British Columbia, the CUC derived from model is less continuous and extends offshore under the significant influence of energetic meso-scale motions in winter, while presents as a narrow continuous flow close to the continental slope in summer. For the upper (0 -100 m) and subsurface (100 - 300 m) layers, the seasonal and year-to-year variations of kinetic energy (KE) representing the strength of the CUC and meso-scale eddies are primarily controlled by those of the wind power input (WPI) at the sea surface. The year-to-year variations of WPI and corresponding KE off the VI agree with those of the North Pacific Index that represents the strength of the Aleutian Low, and the Northern Oscillation Index that represents the strength of the Pacific High, in winter and summer, respectively. The strongest CUC and meso-scale eddies occurred in the winter of 2015, and this can be linked to the most intensive Aleutian Low during 2013-2015.

1708011 POSTER SESSION - PART 2

Long-term monitoring of the Arctic atmosphere using UV-visible spectrometers at Eureka, Nunavut

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The Polar Environment Atmospheric Research Laboratory (PEARL) and the Environment and Climate Change Canada weather station at Eureka, Nunavut (80°N, 86.4°W) host an array of instruments that observe the polar atmosphere. Among these instruments, the University of Toronto and PEARL Ground-Based Spectrometers (GBSs) have been monitoring stratospheric ozone and NO2 columns since 1999 and 2006, respectively. I will present the full time series of stratospheric measurements from the GBSs, focusing on trends and on some highlights throughout the years. With the implementation of new measurement techniques, the GBSs are now also capable of observing tropospheric trace gases. BrO, an indicator of near-surface ozone depletion events, has been measured since 2010. I will outline a case study of an observed bromine enhancement, and highlight interesting opportunities in light of the increasing measurement capabilities at Eureka.

1708011 POSTER SESSION - PART 2

Estimate and Analysis of Planetary Boundary Layer Height (PBLH) using a Mobile Lidar Vehicle system.

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Planetary Boundary Layer Height (PBLH) is a major input parameter for weather forecasting and atmosphere diffusion models. In order to estimate the sub-grid scale variability of PBLH, we need to monitor PBLH data with high spatio-temporal resolution. Accordingly, we introduce a LIdar observation VEhicle (LIVE), and analyze PBLH derived from the lidar loaded in LIVE. PBLH estimated from LIVE shows high correlations with those estimated from both WRF model (R2=0.68) and radiosonde (R2=0.72). However, PBLH from lidar tend to be is overestimated in comparison with those from both WRF and radiosonde because lidar appears to detect height of Residual Layer (RL) as PBLH which is overall below near the overlap height (< 300 m). PBLH from lidar with 10 min time resolution shows typical diurnal variation since it grows up after sunrise and reaches the maximum after 2 hours of sun culmination. The average growth rate of PBLH during the analysis period (2014/06/26 ~ 30) is 1.79 (-2.9 ~ 5.7) m min-1. In addition, the lidar signal measured from moving LIVE shows that there is very low noise in comparison with that from the stationary observation. The PBLH from LIVE is 1065 m, similar to the value (1150 m) derived from the radiosonde launched at Sokcho. This study suggests that LIVE can observe continuous and reliable PBLH with high resolution in both stationary and mobile systems.

1708011 POSTER SESSION - PART 2

Terrestrial Cloud Microstructure Analysis Utilizing the DSCOVR-EPIC Spacecraft

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In order to achieve an evaluation of Earth's atmosphere and cloud particle habit more efficiently, we suggest a method for acquiring this globally: by utilizing the Earth Polychromatic Imaging Camera (EPIC) data on board the Deep Space Climate Observatory (DSCOVR) spacecraft. At the present, most atmospheric data of Earth is obtained using localized weather stations, observation stations and location specific LEO and GEO orbiting satellites. In addition, cloud particle habit is an assumed parameter in a majority of mesoscale models and GCMs; retrieval of this parameter on a global basis will reduce the uncertainties in cloud and

radiational modeling and ice water paths. An analysis of Earth's cloud microstructure, including ice crystal configurations, particle phase functions, and scattering angles, is currently underway with the use of calibration documents and Matlab data programming. Our extensive work using Matlab has created a code to read in image files, calibrate images as outlined in calibration documents and to solve numerous calculations such as: Phase Functions, Phase Angles, and Scattering Angles. In addition to this, graphs of phase function versus its corresponding scattering angle for the Terrestrial clouds have been generated for further comparisons and conclusions for the ice crystal habit. The goal of this study is to determine terrestrial cloud microstructures and to validate the accuracy for the ability to use DSCOVR-EPIC images, and our evaluation technique, as future comparable means to other planetary atmospheric processes. In addition, we hope to also learn useful characteristics about Earth's atmospheric processes, as the whole disc of the Earth has not been previously examined in this fashion.

1708011 POSTER SESSION - PART 2

Moored observation of abyssal flow and temperature near a hydrothermal vent on the Southwest Indian Ridge

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Four moorings were deployed near ''Dragon Flag,'' an active hydrothermal vent in the valley of the Southwest Indian Ridge. The goal was to examine the variability of currents and temperature, which will guide the trajectory of spreading plumes. The mean current was cross-isobath, and the circulation was characterized by a submesoscale circulation. Observed currents also showed fluctuations with periods of 1–15 days. The inferred phase speed and wavelength for the wave with a period of 4.4 day are 10.4 km d21 and 45.8km, respectively, which are consistent with the topographic Rossby wave theory. The persistent warming tendency with corresponding variation of salinity based on background h-S properties may be caused by background circulation and divergence of the water column. The warming or cooling episodes were most likely as signatures of isopycnal surface depression or uplifting induced by the moving of mesoscale eddies. Well-resolved rotary spectra exhibited important nonlinear interactions between inertial and semidiurnal tide in the velocity and temperature records. Amplification of near-inertial currents in the near bottom is also exposed. These discoveries provided new evidence for the nonlinear interaction and trapped near-inertial waves by the ridge, which occurred in the deep ocean of the Southern Hemisphere. Such nonlinear interaction may represent a significant energy loss pathway for the internal waves, and part of the decay of such motion would likely result in increased mixing to maintain the abyssal stratification. Enhanced near-inertial motions can play a major role for the local advection of hydrothermal plumes.

1708011 POSTER SESSION - PART 2

Ensemble-Based Forecast Verification of Typhoon Haikui (2012)

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On 8 August 2012, an extreme event induced by Typhoon Haikui has caused an average rainfall amount of 230mm in Ningbo, China. This study evaluates the prediction performance of the catastrophic rainfall induced by Typhoon Haikui based on the THORPEX interactive grand global ensemble (TIGGE) dataset against CMA hourly merged precipitation product. A series of verification metrics, including RMSE, Brier skill score (BSS), reliability diagram, ROC curve are used to evaluate the ensemble mean quantitative precipitation forecasts (QPFs) and probabilistic QPFs (PQPFs) of five operational global ensemble prediction systems (EPSs) at 0–8 days timescales. Results indicate that generally ECMWF ensemble mean QPF has the least RMSE and possesses higher probabilistic skill than other centers, especially in medium-range forecasting. CMA performs the worst in short-range forecasting due to larger displacement error. CMC is obviously overdispersive because of its multiphysics schemes, leading to an overestimate of total precipitation in terms of medium-range forecasting, but it possesses a better discrimination ability at heavy

precipitation thresholds. For different stages of Typhoon Haikui, the performance differences of the five EPSs are most remarkable in the developing period, suggesting that the prediction of torrential rainfall is greatly challenging in typhoon intensification with high uncertainties. Moreover, ensemble-based sensitivity analysis (ESA) method is used to investigate the causes of ensemble forecast errors and analyze the differences between good and poor ensemble members. It is found that low-level water vapor flux is a major factor that significantly impacts this typhoon precipitation event.
KEY WORDS: Ensemble forecast, Forecast verification, TIGGE, Typhoon Haikui

1708011 POSTER SESSION - PART 2

Origin of seasonal variation of salinity in Bering Strait

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A decade-long hindcast using an ocean and sea-ice model covering the Arctic and the adjoining North Atlantic and North Pacific Oceans is analyzed. The model has a nominal horizontal resolution of ¼-deg in longitude/latitude, achieving ~12 km in the shelf water adjacent Bering Strait. Here we present the evaluation of the time-mean, seasonal variations of ocean circulation and hydrography in the Chukchi and Bering Seas, through comparison with available observational data and results published in literature. The evaluation suggests that the model possesses reasonable skills in reproducing the key dynamic factors. Through analyzing seasonal variation of salinity, the Gulf of Anadyr (GA) is suggested to be a high-salinity source to the Bering Strait in winter. Based on quantifying the contributions of various influencing processes on salinity, the processe of ice freezing-melting acts as the dominant driver of the seasonal variation of salinity in GA. Future sea-ice loss in GA would result in a weaker seasonal variation of salinity in Bering Strait, and thus influences the freshwater flux through Bering Strait and stratification in the adjacent seas.

1708011 POSTER SESSION - PART 2

First retrievals of methane isotopologues from FTIR ground-based observations in the High Arctic

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Atmospheric methane concentrations have reached a new high at 1845 ± 2 ppb, accounting for an increase of 256 % since pre-industrial times (WMO, 2016). In the last ten years, methane has been on the rise again at rates of ~0.3%/year (e.g., Bader et al., 2016), after a period of stabilization of about 5 years. This recent increase is not fully understood due to remaining uncertainties in the methane budget, influenced by numerous anthropogenic and natural emission sources. In order to examine the cause(s) of this increase, we focus on the two main methane isotopologues, i.e. CH3D and 13CH4. Both isotopologues are emitted in the atmosphere with a different ratio depending on the emission processes involved. As heavier isotopologues will react more slowly than 12CH4, each isotopologue will be depleted from the atmosphere at a specific rate depending on the removal process. Methane isotopologues are therefore good tracers of the methane budget. In this contribution, the first development and optimization of the retrieval strategy of CH3D as well as the preliminary tests for 13CH4 will be presented and discussed , using FTIR (Fourier Transform infrared) solar spectra collected at the Polar Environment Atmospheric Research Laboratory, located at Eureka, Nunavut (80.05 °N, -86.42 °E, 610 m a.s.l.). Mixing ratio vertical profiles from a Whole Atmosphere Community Climate Model (WACCM v.4, Marsh et al., 2013) simulation developed by Buzan et al. (2016) are used as a

priori inputs. The uncertainties affecting the retrieved columns, as well as an evaluation of the information content, will be discussed in order to assess the best strategy to be employed based on the altitude sensitivity range and complete error budget.

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World Meteorological Organization, Greenhouse Gas Bulletin, N°12, October 2016.

1708011 POSTER SESSION - PART 2

GOES-R Data Requirements in the Area of Weather Forecast and Science Applications

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With the launch of the next generation GOES-R satellite, a wide range of GOES-R baseline products will be generated. It is important for ECCC (Environment and Climate Change Canada) to be ready for the reception and dissemination of these new products to the operational and research & development users across the department.

Beginning in 2015, the ECCC GOES-R project team conducted a department wide user requirements survey. The objective of the survey was to ask potential users about their expectations and needs on 25 baseline products (single channel imagery and 24 Level 2 products).

The feedback was collected, analyzed and compiled into a report which has been used by the project. The details of the report will be presented. Subject to availability, examples of some key GOES-R level 2 products identified in the survey will be shown.

1708011 POSTER SESSION - PART 2

Variability and Wind Forcing of Ocean Temperature and Thermal Fronts in the Slope Water Region of the Northwest Atlantic

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Subsurface temperatures in the Slope Water region of the Northwest Atlantic from Argo profiling floats and on the adjacent continental shelf from ship-based measurements are compared with the latitudinal position of the Shelf-Slope Front (SSF) and the Gulf Stream North Wall (GSNW). The Slope Water and shelf temperature anomalies at 200 m depth are in agreement for the period, 2002-2015. For the period 1978-2015, shelf temperatures are significantly correlated with the SSF position, and to a lesser extent with the GSNW position. Annual SSF position anomalies near the Grand Banks at 50-55°W lead anomalies to the west at 65-75°W by 1-2 years. Wind stress curl is compared with the annual change in the SSF and GSNW latitudinal positions, rather than with the positions directly. Changes in the mean position of the SSF are related to the wind stress curl pattern in the mid-Atlantic, with an 8-month lag. However changes in the GSNW position are related to an NAO-like wind stress curl pattern in the eastern Atlantic in the winter-spring period, in agreement with other studies. High sea surface temperatures in recent years can be largely attributed to positive local onshore wind anomalies.

1708011 POSTER SESSION - PART 2
GOES-R Data Access for Canada
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Seybold, Matthew - NOAA/NESDIS
Fulbright, Jon - Arctic Slope Technical Services, Inc
Kline, Elizabeth - Science and Technology Corp
Mozer, Kathryn - NOAA/NESDIS
Seymour, Paul - NOAA/NESDIS
Pogorzala, David - Integrity Applications, Inc.
Williams, Ryan - Stellar Solutions, Inc
McHugh, Maurice - Noblis, Inc
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GOES-16 ABI, GLM, and Space Wx science products have provided stunning early results throughout the past year. The Post-Launch Test (PLT) six-month phase has concluded and the subsequent Extended Validation six-month phase is nearing completion. Calibration and Validation activities have led to the declaration of Provisional Validation Maturity for the GOES-16 portfolio of science data products and they are ready for operational assignment in the GOES constellation.
Readiness for operational delivery of the portfolio to the user community via numerous direct readout and terrestrial paths has been strategically planned, rehearsed, and executed to ensure customers will have timely access to all products. On-orbit Post Launch Product Tests (PLPTs) have been executed to ensure systems, algorithms, procedures, tools, operators, notifications, and the user community are prepared to exploit the benefits of GOES-16.
This talk will outline all GOES-16 product distribution paths including direct readout services, review the validation maturity for the GOES-16 portfolio including in-progress algorithm and configuration updates, and finally describe the readiness of GOES-16 data operations to serve in the GOES constellation.

1708011 POSTER SESSION - PART 2
Impact of augmenting the quantity of assimilated surface observations in a regional forecast system
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Milewski, Thomas - Environment and Climate Change Canada
Caron, Jean-Francois - Environment and Climate Change Canada
St-James, Judy - Environment and Climate Change Canada
Pellerin, Simon - Environment and Climate Change Canada
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We present recent efforts to improve weather forecasts in the context of the Canadian Meteorological Centre's (CMC) Regional Deterministic Prediction System (RDPS). The currently-operational RDPS includes a four-dimensional Ensemble-Variational (4DEnVar) data assimilation scheme with a 6-hour assimilation window, and produces 48-hour forecasts four times per day. Forecasts are provided by the Global Environmental Multiscale (GEM) model over a domain which covers all of North America as well as the Arctic region, at a nominal resolution of 10 km. Operationally, the analysis scheme accepts observations of surface parameters from the synoptic observation (SYNOP) network, the majority of which are available at synoptic times. Here we demonstrate the impact of augmenting the spatial density and temporal frequency of observations by including SYNOP every 3 hours, Meteorological Aerodrome Report (METAR) and Meteorological Service of Canada (MSC) partner surface weather networks, generally available every hour. SYNOP and METAR measurements cover the entire North American continent while MSC partner reports are limited to the Canadian land mass. Previous data assimilation studies have shown that addition of METAR observations benefits short-term forecast quality near the surface, particularly in the context of rapid-refresh systems. The present work is a step in the same direction. The separate impacts of spatial density versus temporal frequency are also discussed.

1708011 POSTER SESSION - PART 2

Incorporation of a Four-Stream Solar Radiative Transfer Model into CanAM4.2

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A delta-four-stream approximation (FSA) of the 1D solar radiative transfer equation is used in the Monte Carlo Independent Column Approximation (McICA) framework which is in turn used within the fourth generation Canadian atmospheric general circulation model (CanAM4.2). Until now, only the two-stream approximation (TSA) has been used in McICA. Moreover, the few applications of FSAs in GCMs treated cloudy atmospheres with great simplicity. Pairing the FSA with McICA allows for straightforward realization of its superior treatment of radiative transfer, relative to the TSA, while using McICA to define arbitrarily complicated descriptions of clouds for scales unresolved by GCMs.
We present results from a pair of CanAM4.2 simulations, one using the TSA and the other FSA, for the period 2000-2009, highlighting the instantaneous differences between the two approaches as well as the impact on the simulated climate.

1708011 POSTER SESSION - PART 2

When will we reach 1.5 of global warming?

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Recent global temperature trends indicate that we may be rapidly approaching 1.5 degrees of global warming. However, rigorous estimates of when this target will be breached are rare, and are highly sensitive to small errors in observed and model-simulated historical warming, as well as widely-varying estimates of the allowable emissions for 1.5°C. Here, I present a proposed method to estimate the time remaining to 1.5°C using a new estimate of human-attributable warming, updated CO2 emissions trends, and the latest estimates of the 1.5°C carbon budget. The resulting calculation suggests that a continuation of recent CO2 emission trends would take us past 1.5°C in 2037, a little less than 20 years from now. Uncertainties in this calculation remain large, reflecting both fundamental scientific uncertainties associated with the climate response to emissions, as well as uncertainties associated with human mitigation decisions and their effect on future CO2 and non-CO2 greenhouse gas emissions. However, it is nevertheless important to provide a robust and widely-accepted best estimate of the time remaining before we breach the climate targets that have been adopted in the Paris climate agreement, so as to clearly communicate our scientific understanding to policy makers and the general public. To this end, in an effort to visualize and track our progress towards these target, we have develop an online and projectable climate clock, which shows a real-time countdown of the time remaining to 1.5 and 2°C of global warming (see www.climateclock.net). This clock will be updated annually in light of the most recent emissions and global temperature data, and accounting for improved estimates of the remaining carbon budget associated with these climate targets. As countries around the world move forward with climate mitigation efforts, this climate clock will be able to clearly mark our progress towards the objective of adding time to the countdown so as to ultimately avoid breaching these dangerous climate thresholds.

1708011 POSTER SESSION - PART 2

The setup and testing of a new model of a southern channel in the Arctic Archipelago

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The understanding of the oceanography of channels and adjacent bays south and southeast of Victoria Island in the Southern Arctic Archipelago is just beginning. Recently, localized areas of tidal polynyas have been

identified with apparent significant summer biological activity. We plan to use FVCOM in a high resolution model study of the area to help examine the local physical and biological processes. This talk focuses on the setting up and early testing of the model in an area with few observations and many areas of inadequate or no bathymetric observations.

1708011 POSTER SESSION - PART 2

High frequency observations of temperature and oxygen in a large Canadian lake over two winters reveal the role of solar radiation and ice cover in the development of the mixed layer

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High-frequency observations of the vertical thermal and oxygen structure under the ice of a large lake over the winter of 2015 and the winter of 2016 reveal the presence of large (10-20 m) overturning convection cells, driven by diurnal solar heating penetrating the ice cover. The most vigorous convection occurred near the end of winter, which our model suggest is the time that the ice melted, thinned and became transparent. This convection led to a deepening of the mixed layer over time. During the same period the dissolved oxygen had become super-saturated from the surface to 23 m below the surface, suggesting abundant algal growth. Thorpe scale analysis of our high frequency temperature measurements revealed that very large scale mixing occurred beneath the ice. This mixed layer depth increased during the melting period, and mixing was most active during the day. The lake experienced a persistent ice cover over the winter of 2015, but an intermittent ice cover over the winter of 2016 due to the warmer air temperatures. Comparing data from these two winters suggest that solar radiation and ice cover are critical for the mixed layer dynamics and oxygen budgets in the many northern ice covered lakes.

1708011 POSTER SESSION - PART 2

CTD dynamic corrections for an unpumped inductive conductivity cell on autonomous platforms

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On ocean conductivity/temperature/depth (CTD) instruments, unpumped inductive conductivity sensors are becoming increasingly common, owing to their robustness and low power consumption. The latter is particularly of benefit to long term autonomous monitoring platforms, such as profiling floats, where power savings from the sensors can translate into increased lifetimes and more data returned. Recent integration of RBR conductivity cells on Argo-like floats by a variety of manufacturers has highlighted the need for careful analysis of both the long term stability and the dynamic response of the sensors. This talk will focus on the dynamic response, specifically the need for accurate conductivity/temperature alignment and correction for thermal inertia errors induced in regions of vertical temperature gradients.

1708011 POSTER SESSION - PART 2

Internal Solitary Wave Reflection near Dongsha Atoll, the South China Sea

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Internal solitary wave (ISW) in the northern South China Sea (SCS) is one of the strongest and most energetic in the world. Compared to large number of satellite images showing the ISW fission and refraction patterns, fewer than five satellite images acquired by both visible (MODIS) and microwave synthetic aperture radar (SAR) have shown the ISW reflection pattern in the literature. Limited observations lead to our knowledge gap in ISW reflection. As reviewed by Alford et al. [2015, Nature], only diurnal internal tides are partially reflected, while steeper and highly nonlinear ISWs are transmitted [Klymak et al., 2011 JPO]. If so, how did those ISWs reflect in satellite images?

This study provides new evidence from space observation that ISWs also are reflected, although rarely, with strong nonlinearity. The recent visible satellite images show that the unusual reflection appears to be associated with large-amplitude ISWs generated by strong tidal currents. Therefore, influence of ISWs with different amplitudes on the reflection is tested in numerical simulations. Simulations indicate that large-amplitude ISW induce strong reflection, which also shows distinct imprints in surface. Distinct reflection appears in the form of mode-2 ISWs, after the trailing inertial-gravity wave impinges the bottom. As propagating away from the atoll, these reflected waves dissipate quickly. These properties of reflected waves, i.e. weak energy and strong dissipation, may explain why reflected waves are rarely appeared and observed in the SCS.

1708011 POSTER SESSION - PART 2

Low and High Level Cloud Fraction Feedback over Tropical Oceans

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The uncertainty in equilibrium climate sensitivity (ECS) simulated by global climate models (GCMs) has been attributed to uncertainties in cloud radiative feedbacks (CRF). To examine these feedbacks we use output from CMIP5 simulations in which CO2 was set at 1850 values or abruptly quadrupled from these values. Among the nine GCMs used, the largest disagreement in CRF is over the tropical eastern Pacific and is mainly due to low cloud CRF that largely stems from cloud fraction feedback. In this region low cloud fraction feedback is found to strongly anti-correlate with high cloud fraction feedback while high cloud fraction feedback strongly correlates with changes in the large-scale 500 hPa vertical moist static energy (MSE) advection. This suggests that high clouds could modulate low cloud radiative feedback.

Sensitivity tests using the Canadian Earth System Model version 2 (CanESM2) indicate model modifications affecting mid-level MSE advection also affect high cloud fraction, e.g., increased MSE advection change, increased high cloud fraction change. Increased large-scale vertical MSE advection leads to increased column instability and higher CAPE values. To reduce the increased column instability, deep convection responds with increased vertical mass flux and stronger tropospheric heating and drying. This suggests that deep convection is modifying high-level thermodynamic conditions which affects high clouds.

1708011 POSTER SESSION - PART 2

Evaluation of ocean variability simulated by the high-resolution CONCEPTS regional model of the Arctic and North Atlantic oceans

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High-resolution ocean and sea-ice forecast models for the Arctic and North Atlantic have been developed by the Canadian government inter-departmental CONCEPTS program. In situ and satellite observations of the ocean and sea ice have been collected in order to develop an evaluation package that can be used to assess the performance of the model and the impact of model improvements. In this presentation we will show some examples of this model evaluation, with a discussion of the agreement between the model and the observations.

1708011 POSTER SESSION - PART 2

Parallel warming-induced photosynthesis and respiration increases make the CO2 and 13C/12C seasonality stable under changing climate and vegetation activity

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Northern terrestrial ecosystems have shown global warming-induced advances in start, delays in end, and thus increased lengths of growing season and gross photosynthesis in recent decades. The tradeoffs between seasonal dynamics of two opposing fluxes, CO2 uptake through photosynthesis and release through respiration, determine the influence of the terrestrial ecosystem on the atmospheric CO2 and 13C/12C seasonality. Here we use four CO2 observation stations in the Northern Hemisphere, namely Alert, La Jolla, Point Barrow and Mauna Loa Observatory, to determine how changes in vegetation productivity and phenology, respiration, and air temperature affect both, the atmospheric CO2 and 13C/12C seasonality. Since the 1960s, the only significant long-term trend of CO2 and 13C/12C seasonality was observed at the northern most station, Alert, where the spring CO2 drawdown dates advanced by 0.65±0.55 days yr?1, contributing to a non-significant increase in length of the CO2 uptake period (0.74±0.67 days yr?1). For Point Barrow station, vegetation phenology changes in well-watered ecosystems such as the Canadian and western Siberian wetlands contributed the most to 13C/12C seasonality while the CO2 seasonality was primarily linked to non-tree vegetation. Our results indicate significant increase in the Northern Hemisphere soil respiration. This means, increased respiration of 13C depleted plant materials cancels out the 12C gain from enhanced vegetation activities during the start and end of growing season. These findings suggest, therefore, that parallel warming-induced increases both in photosynthesis and respiration contribute to the long-term stability of CO2 and 13C/12C seasonality under changing climate and vegetation activity. The summer photosynthesis and the soil respiration in the dormant seasons have become more vigorous which lead to increased peak-to-through CO2 amplitude. Since the relative magnitude of the increased photosynthesis in summer months is more than the increased respiration in dormant months, we have the increased overall carbon uptake rates in the northern ecosystems.

1708011 POSTER SESSION - PART 2

Synoptic-scale zonal available potential energy increases in the Northern Hemisphere

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Available potential energy (APE), a measure of the energy available for conversion to kinetic energy, has been previously applied to examine changes in baroclinic instability as well as seasonal changes in the general circulation. Here, pathways in which the troposphere can build the reservoir of zonal available potential energy (ZAPE) on synoptic (3-10 day) time scales are explored. A climatology of ZAPE and its associated generation and conversion terms are calculated from the National Centers for Environmental Prediction (NCEP) Department of Energy (DOE) Reanalysis 2 global reanalysis dataset from 1979 to 2011 for the Northern Hemisphere (20°-85° N). Applying a standardized-anomaly based identification technique, 160 ZAPE buildup events are identified during the 33-year period, which are grouped by meteorological season and the amplitude of the ZAPE anomaly at the conclusion of a buildup period.

Buildup events are analyzed from both an energetics framework and a dynamical framework to identify key processes contributing toward increases in ZAPE. Anomalously low conversion of ZAPE to eddy APE (Ca) and anomalously high generation of ZAPE (Gzape) contribute equally to the total rate of change of ZAPE, while conversion from ZAPE to zonal kinetic energy (Cz) contributes little across all seasons. Anomalously low Ca occurs for much of the Northern Hemisphere during buildup events with larger contributions from portions of the storm tracks, owing to changes in the jet location near high terrain, zonal elongations of the jet exit regions, and shifts in the jet stream in response to subtropical ridging. Examination of DJF buildup events reveals that the pathway toward ZAPE increase includes rapid high latitude cooling leading to increased Gzape, high-latitude cut-off anticyclones acting to reduce Ca, mid-latitude Rossby wave trains exciting transient ridges acting to reduce Ca, and sub-tropical ridging associated with anticyclonic wave breaks acting to increase Gzape and decrease Ca.

1708011 POSTER SESSION - PART 2

Diagnostic of Arctic atmosphere energy budget during the polar night

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The Arctic region is the most sensitive to climate change (Hassol, 2005). Over the last few decades, global warming has been twice more rapid in this region compared to average global warming (Hansen et al., 2010). Indeed, satellite observations show a warming trend since the 1970s, especially during winter. One of the main features of the Arctic environment is the absence of solar radiation (shortwave) for a significant portion of the year. The ability of climate models to simulate feedback between different components of the climate system depends on the degree to understand the processes that govern this system. However, most of those processes are still not yet understood over the Polar Regions. Energy budget approach appears to be one of the most efficient ways to improve functioning physical mechanisms in atmosphere. In this study, the energy cycle equations as formulated by Nikiéma and Laprise (2013) will be used to make the energy budget in the Arctic during the polar night. This set of equations based on available enthalpy and kinetic energy will serve to compute the Arctic atmospheric energy reservoirs with a particular focus on the assessment of the role of thin ice clouds (TIC) in the generation of available potential energy. To address this question, a reanalysis

driven application of the Canadian Regional Climate Model version5 (CRCM5) simulation is used to compare with satellite-based heating rate observations (CloudSat and CALIPSO). Overall, this study contributes to better understanding of the physical processes of the Polar Regions, to improve model simulations and aiming to evaluate the relative importance of polar clouds on the atmospheric energy balance.

1708011 POSTER SESSION - PART 2

Surface Seiching in Quesnel Lake, BC

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The effect of complex bathymetry and, in particular, multiple arms on the standing wave patterns, or seiches, present within a lake is not easy to predict. Typically, the dominant seiche pattern in simple basins coincides with the fundamental mode, but multi-armed lakes may favour the activation of modes that more closely match the spatial pattern of the wind forcing, which may also vary in time. Here, we seek to characterize surface (i.e. barotropic) seiching in Quesnel Lake, British Columbia, a deep, fjord-type lake with three distinct arms arranged in a “Y”-shape. Seiching in Quesnel Lake is studied through a combination of observational and numerical techniques. Pressure is measured at five moorings located in different regions of the lake over a two-year period. A 3D hydrodynamic model is used to characterize the mode shapes and periods for both a free and wind-forced response. Observations show low amplitude (typically 0.1m) surface oscillations present throughout the year with periods ranging from 10 to 80 minutes. These observations appear consistent with both the mode shapes and periods predicted by the 3D model. The pressure readings further suggest a seasonal pattern of dominant seiche modes with separate summer and winter regimes. During the summer, the dominant signal is attributed to a mode-1 wave with relatively high deflection in the West Basin. During the winter, an apparent mode-2 wave with high deflections along the North Arm becomes active. This seasonal variation corresponds very well to seasonal changes in the regional wind directions. Topographic channelization of the seasonally varying wind along the arms of the lake is consistent with the observed mode shapes and readily explains the seasonality in surface signal.

1708011 POSTER SESSION - PART 2

Investigating the Sensitivity of the Drag Coefficient under Hurricane Conditions in Spectral Wave Models

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Accurate estimation of the momentum flux across the air-sea interface is crucial in predicting ocean surface wave fields and ocean currents. One of main uncertainties in the momentum flux is the parameterization of the drag coefficient under extreme wind conditions. In this study, we propose a new parameterization for the drag coefficient based on field observations published in the literature. One of important characteristics of the new parameterization is a decrease of the drag coefficient with wind speeds under extreme wind conditions. This new parameterization is incorporated into a triply-nested wave model based on spectral wave models (WW3 and SWAN) to simulate the wave fields over the Gulf of Mexico under Hurricane Rita. The wave model is driven by the CFSR wind fields, in which the hurricane wind forcing from NOAA’s Hurricane Research Division (H*WIND) is additionally blended. The influences of surface elevations and ocean currents are considered in the wave model by using the HYCOM reanalysis data. In-situ buoy measurements and satellite altimeter data are used to access the performance of spectral wave model using different wind drag parameterizations. The analysis of model results shows that the conventional linear drag coefficient significantly overestimates the significant wave heights. The overestimation can be reduced by using the new drag coefficient parameterization. In addition, wind drag coefficients are shown to have limited effects on

wave evolution over shallow coastal areas due to depth-induced dissipation processes. The drag coefficient parameterizations with reduced values at high wind speeds generally perform better in both shallow and deep waters.

1708011 POSTER SESSION - PART 2

Characterization of the Flow Dynamics in a Wide, Arctic Canyon

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Submarine canyons are steep-walled topographical features that incise continental shelves and slopes. The enhanced upwelling and cross-shelf exchange associated with canyons supply nutrients to the upper layers of the ocean, thereby supporting diverse and abundant fauna. The local ocean dynamics have been examined by numerous observational, laboratory, and numerical studies. They describe upwelling events lasting several days and consisting of an initial transient response followed by a steady advection-driven stage. The steady stage is characterized by the generation of anti-cyclonic vorticity within the canyon, upwelling over the canyon rim on the downstream side of the current, and unperturbed flow near the surface of the ocean. Previous work also includes the development of a scale analysis that is based on the observed dynamics and provides a framework for understanding and predicting the basic response of other canyons. However, this scale analysis is restricted to narrow canyons, namely those whose widths are smaller than two Rossby radii of deformation.

This work describes a few attributes of the relatively unexplored flow dynamics in a wide canyon. Numerical simulations of the Mackenzie Canyon, located in the southern Beaufort Sea, were conducted using a regional configuration of the NEMO ocean model. The simulations include both realistic and idealized canyon bathymetries and a realistic Arctic stratification. The circulation around the canyon is described using non-dimensional numbers, such as the Rossby and Burger numbers. Moreover, the simulated dynamics are compared to the behaviours predicted by the scales established for narrow canyons. This analysis provides a valuable contribution to ongoing research regarding the effect of canyon geometry and ocean conditions on the resulting dynamics.

1708011 POSTER SESSION - PART 2

Characterizing fronts in a whale habitat

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High-traffic areas in Canadian coastal waters can be hazardous to whale populations due to vessel strikes and net entanglements. Previous work has been successful in identifying and protecting some critical zones containing locations of known whale habitats, but it has also revealed that there are many habitats left to be described, leaving endangered whales at risk of ship strike in many of their habitats. The Whale Habitat and Listening Experiment (WHaLE) strives to identify and examine key whale habitats on Canada’s coasts and work with the shipping fleet to protect them. Roseway Basin on the Scotian Shelf is a known habitat for the North Atlantic right whale, a baleen whale that feeds on diapausing copepods. The presence of density fronts is often associated with zooplankton aggregations and whale feeding grounds. In this study we use hydrographic data collected by gliders deployed as part of the WHaLE project to characterize the density structure of Roseway Basin. We quantify the density structure through isopycnal slopes and lateral density gradients in order to identify and characterize the density fronts present. We then examine the relationship between density structure with zooplankton biomass from glider-based echosounder data and whale presence from glider-based passive acoustic data. We observe amplified gradients on the southeast margin of Roseway Basin, where there was an enhanced whale presence. By examining the physical mechanisms that make Roseway Basin a biological hotspot and successful whale habitat we can start understanding the driving mechanisms that define baleen whale habitat.

1708011 POSTER SESSION - PART 2

Remote Sensing of Greenhouse Gases at East Trout Lake

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In the fall of 2016 a Bruker IFS 125HR Fourier transform spectrometer was installed at Environment and Climate Change Canada's East Trout Lake monitoring site in Saskatchewan. This will produce long?term, time?resolved, ground-based remote sensing measurements of atmospheric spectra that will be used to retrieve accurate and precise total column dry-¬air mole fractions (DMFs) of greenhouse gases and other trace gases in the boreal forest. These measurements will serve as the link between surface in situ measurements of atmospheric CO_2 and CH_4 in the region, and satellite-based measurements from OCO¬?2, GOSAT, and follow on missions. In the long term the interannual variability of the measured DMFs will allow us to investigate the impacts of seasonal effects which will provide insight into the boreal forest's response to climate change and its future role in the carbon cycle. The station is aiming to be a part of the Total Carbon Column Observing Network (TCCON), which is a network of ground-based Fourier transform spectrometers that measure total column DMFs of greenhouse gases. We will present the configuration of the FTS which allows simultaneous measurements of atmospheric spectra in the mid- and near-infrared spectral ranges, as well as, the retrieved total column DMFs of greenhouse gases and other atmospheric trace gases from the first six months of operation.

1708011 POSTER SESSION - PART 2

High Arctic atmospheric water vapour measurements at PEARL

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Strong, Kimberly - Department of Physics, University of Toronto
Schneider, Matthias - Institute of Meteorology and Climate Research (IMK-ASF), Karlsruhe Institute of Technology
Rowe, Penny - NorthWest Research Associates
Sioris, Chris - Department of Earth and Space Science and Engineering, York University
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Water vapour impacts the atmosphere in critical ways, including its role in the greenhouse effect, energy transport, and atmospheric chemistry. We present an overview of a variety of techniques employed at the Polar Environment Atmospheric Research Laboratory (PEARL) to measure atmospheric water vapour over the last decade. This includes recently developed datasets from the Bruker 125HR Fourier Transform Spectrometer (FTIR), Atmospheric Emitted Radiance Interferometer (AERI), and radiosondes, as well as coincident Atmospheric Chemistry Experiment (ACE) satellite measurements. The ongoing refinement and validation of these techniques will be discussed.

In particular, the Total Carbon Column Observing Network (TCCON) FTIR product is examined in reference to the well-validated MUSICA (MUlti-platform remote Sensing of Isotopologues for investigating the Cycle of Atmospheric water) FTIR product, at PEARL and at other sites globally. The MUSICA and TCCON

products are of specific interest because they offer information about water isotopologues, which can be used to infer details about the transport history of air.
These datasets promise to contribute valuable insights for studies of climate and the Arctic atmosphere.

1708011 POSTER SESSION - PART 2
Observations of the transport of organic material from the shelf to the abyssal sea off the west coast of Vancouver Island.
Mihaly, Steven - Ocean Networks Canada
Cabrera De Leo, Fabio - Ocean Networks Canada
Sastri, Akash - Ocean Networks Canada
Matabos, Marjolaine - Ifremer
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The continental slope off of Vancouver Island is incised by numerous canyons spaced about 20 to 30 km apart. Over the past 6 years observations obtained by video near the seafloor show a marked difference between locations in the axial valley of canyons and the less incised slope regions. Not surprisingly there is substantive increase in organic material such as Neocalanus spp. copepods and Nereocystis sp. kelp concentrated in the canyons. We use automated video imagery analysis along with measurements of currents and water properties at two sites on Ocean Networks Canada's NEPTUNE observatory, to describe and estimate the flux from the continental shelf to the Cascadia Basin Abyssal plain.

1708011 POSTER SESSION - PART 2
Long-term performance of the RBR conductivity sensor: Evaluation from an autonomous float
Halverson, Mark - RBR LTD
Richards, Clark - Department of Fisheries and Oceans, Bedford Institute of Oceanography
Johnson, Greg - RBR LTD
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Argo member institutions have been deploying floats since the inception of the program 17 years ago, and nearly every float has been equipped with Seabird conductivity and temperature sensors. Recently, RBR Ltd partnered with Argo and three float manufacturers to test RBR conductivity and temperature sensors. The power savings resulting from the lower power consumption of the inductive RBR cell can translate into more profiles or a longer float life cycle. Additionally, the lack of a pump means that profiles can be made to within 10 cm of the surface. Analysis and evaluation of data currently being returned from several RBR-equipped floats is underway to ensure that it meets Argo standards.
In this talk we present a study of the performance of an RBR-equipped float that has been drifting for 1.5 years in the Coral Sea along with a Seabird companion for reference. In particular, the stability of the salinity measured by the float is examined relative to: the companion float, climatology, and other nearby floats. Dynamic response (during profiling) of the sensor is briefly assessed, along with a discussion of sensor improvements to minimize C/T lag errors.

1708011 POSTER SESSION - PART 2
Decadal simulations of sea surface salinity in the Arctic Ocean
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Recent observations show significant decrease of sea surface salinity (SSS) in the Beaufort Sea in recent decades. The changes in the SSS can affect sea ice through its impact on surface mixing and associated heat flux (Long and Perrie, 2015). To understand the decadal variations in the SSS, we implemented NEMO in the

Arctic Ocean and conducted a 62-year simulation, forced with CORE-II surface fields (1948-2009). Compared to observations, NEMO can reliably reproduce sea ice, the Atlantic water layer in the central Arctic Ocean, and a fresh water content maximum in the Beaufort Sea. In addition, the NEMO simulation shows that the freshwater from the rivers in Siberia is transported to Fram Strait through the transpolar drift and to the Beaufort Sea through the Ekman convergence. In terms of the SSS, the first leading EOF mode is dominated by the SSS decrease in the central Arctic Ocean from 1990 to 2009, while the SSS near the Makenzie River and the Siberian coast tends to decrease, mostly due to the accelerated ice melting and enhanced Ekman convergence. The second EOF reflects the climate shift in the 1970s, whereby there is a SSS decrease in the Beaufort and Laptev Seas and an increase in the eastern Siberian Sea starting in 1976. The third EOF mode represents the impact of AO (Arctic Oscillation). During a positive AO, the SSS in the Laptev Sea tends to increase, while there is a negative anomaly in the eastern Siberian Sea, suggesting that the freshwater pathway associated with the transpolar drift shifts eastward. While the first mode is consistent with the change pattern under the climate change scenario, the second and third modes are mainly caused by atmospheric internal variability. Reference: Long and Perrie, 2015: Scenario Changes of Atlantic Water in the Arctic Ocean. J.Climate, 28, 5523-5548.

1708011 POSTER SESSION - PART 2

Understanding ocean temperature and salinity variability in the Coast of Bays Region, NL

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Environmental conditions play an important role in the finfish aquaculture activities. Anomalous temperature and/or salinity conditions were reported to cause stress to the farmed fish leading to high risk of disease and sometimes to loss by mortality. In Newfoundland, finfish aquaculture takes place in the Coast of Bays region of the South Coast of Newfoundland. The region is a set of fjord-like bays with complex bathymetric and topographic features and is subject to various oceanographic processes including changing freshwater run-offs, strong high and low frequency temperature and salinity variability, competing forcing processes to induce circulation (tidal, wind, and density driven), wind-driven upwelling, varying stratification and mixing depth.

We analyze temperature and salinity data to understand how the process of mixing and stratification works in our region of interest. We also look into how the presence of the cold and relatively fresh Labrador Current Water (LCW) mixed with winter cooled water found at depths between 25 and 175 m might affect surface layers. The later process might explain the occurrence of very cold surface water sometimes affecting farmed fish health at some locations in winter season.

Historical data shows geographic differences among bays with measured temperature between ~-2 to ~5 deg C in winter season and between ~2 to ~22 deg C in summer season for the upper 20 m. Short-term processes such as temperature variability of more than 10 deg in one day at specific depth as well as vertical mixing affecting layers as thick as 40 m at some locations have been observed.

The present study contributes to our understanding of the oceanographic conditions and their variability for the region of interest in order to develop an ocean circulation model to be used for aquaculture purposes.

1708011 POSTER SESSION - PART 2

The Re-analysis of a Historical Atmospheric High Resolution Infrared Spectral Data-set Recorded at 80N

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From 1993 to 2008 a Bomem DA8 high spectral resolution Fourier Transform Spectrometer (FTS) was located near Eureka, NU at 80 oN and operated as part of the Network for Detection of Atmospheric Composition Change (NDACC). In 2006, the instrument was replaced in the network by a newer Bruker

IFS125HR. Development of tools for analyzing infra red spectra also continued, providing enhanced functionality, including better physical and instrument models and the determination of atmospheric profiles through the application of inverse calculations. Current spectral analyses techniques are not automatically applicable to older data-sets due to file format differences as well as lacking ancillary meta data.
This data-set was used in the early validation of the ACE FTS instrument and the re-analysis is valuable in putting those initial measurements into the current context and bridging to the later Bruker data-set.

1708011 POSTER SESSION - PART 2
Use of Dorado as a Platform for the Validation of High Resolution Ocean Circulation Models
L'Esperance, Chris - Dalhousie University
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We describe the physical and operational characteristics of an autonomous platform for ocean observation which has considerable potential for validation of high resolution ocean circulation models. Dorado (International Submarine Engineering, Port Coquitlam, B.C.) is an 8.2 m long, 1.2 m in diameter, snorkelling, semi-submersible vehicle powered by a 315 kW Caterpillar marine diesel engine. Capable of cruising at 8 m/s (16 knots) for sustained periods of up to 28 hours, the vehicle's linear range is on the order 1000 km. The vehicle is equipped with a winched, tow body, bearing instrumentation payload, which can be actively flown while deployed to depths of 200 m at high speed. The vehicle's hull may be at the immediate surface or may dive down to maximum depth of 4 – 5 m. An interesting result owing to the vehicle's semi-submersible nature is the stability with which the platform is able to negotiate sea states up to moderate or rough. This stability is expected to enhance the quality of platform motion-sensitive measurements such as those involved in the eddy covariance technique for estimating fluxes. Dorado's relatively unobtrusive and streamlined mast/superstructure is highly amenable to this technique.
We describe the results of initial Sea trials of Dorado, carried-out in Indian Arm within the Burrard Inlet during June of 2016. We further describe plans for Dorado's maiden scientific voyage. The vehicle will be equipped with a novel, compact, unattended GC and membrane-based equilibrator, as well as, supporting instrumentation. The vehicle will be used to monitor the dispersion of the deliberate tracer, SF5CF3, following a surface injection in coastal waters. The analytical system will be tuned for the detection of the SF5CF3 and SF6.

1708011 POSTER SESSION - PART 2
Simulation of Interannual Circulation Variability in Placentia Bay
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In this paper, a three-dimensional, prognostic, baroclinic model based on the finite-volume community ocean model (FVCOM) was developed to simulate the interannual variability of circulation and stratification in Placentia Bay. The model was forced by NARR winds and heat fluxes on the seas surface. Tidal and non-tidal sea levels as well as temperature and salinity were specified on the open boundary. Overall, the model solution compares well with the observed monthly-mean water levels, surface currents and sea surface temperature (SST), except for the surface currents at a location near the head of the bay. The circulation patterns for December 2011 and December 2012 showed that the general monthly-mean circulation in the upper ocean in Placentia Bay was cyclonic and positively correlated with the remote water inflow associated with the inshore Labrador Current. When local wind forcing was relatively strong (October 2010), the wind effect on the surface circulation could be as important as the effect of the remote water inflow. The monthly-mean SST distributions for August 2010 and August 2014 showed distinct spatial and interannual variations positively correlated with air temperature, net heat flux and remote water inflow. The evolution of stratification also showed interannual variability associated with the changes in wind intensity, air temperature, and net heat flux.

1708011 POSTER SESSION - PART 2

Synoptic Forcing on Mesocale Circulations During Heat Waves at Vancouver, British Columbia.

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Heatwaves are a significant physical hazard in mid-latitude climates such as Canada. Although coastal areas like the Lower Fraser Valley of British Columbia are not traditional perceived as being vulnerable to such events, a heatwave during July 2009 resulted in an estimated 200 deaths in the region. Evidence based thresholds for heat-alert criteria proposed by Henderson and Kosatsky [Canadian Journal of Public Health, 103(3), 227 (2012)] were used to identify past occurrences of such extremes at Vancouver and Abbotsford, British Columbia. Empirical orthogonal function analysis and compositing of key meteorological variables were used to examine synoptic forcing on mesoscale circulations during heatwaves. Initial results reveal that due to the complex terrain in the region, considerable spatial variability exists in attaining proposed heat alert criteria in the region. Heatwave occurrences are influenced by a wide spectrum of synoptic forcing regimes on local circulations such as sea-breezes, onshore coastal surges, and thermally induced troughing. Temporal evolution of multi-day events is demonstrated as one source of the observed variability.

1708011 POSTER SESSION - PART 2

The statistical characteristics on impacts of aerosol and cloud distributions between two Eastern China regions based on CloudSat/CALIPSO data

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The interaction between aerosols and clouds has a complex feedback effect. By investigating the statistical characteristics of cloud and aerosol vertical distributions over two south and north regions in east China, with each region having a size of 4° latitude by 4° longitude, stronger correlation was found between water vapor condition and cloud occurrence probability (COP) than that between aerosol condition and COP in the warm cloud layer (WCL). The differences in COP between the two regions in the mixed cloud layer and ice cloud layer were highly correlated with those in the aerosol extinction coefficient. In addition, the highest cloud proportions in R1 and R2 appeared in the mixed cloud layer in all of the four seasons. High values of COP occurred in a cloud layer of 2 to 3 km thickness above the 0? layer in all the four seasons. The corresponding reflectivity factors were continuously distributed from -30 dBZ to 15 dBZ. The high values of COP in R2 in this layer were more continuous than those in R1. The clouds with high reflectivity factors mainly appeared in the mixed cloud layers and WCL. The mean values of the aerosol extinction coefficient were higher in R2 than in R1 in the layers above the 0? layer in all four seasons, indicating great influences of aerosols on mixed cloud formation.

1708011 POSTER SESSION - PART 2

Sea state indices for a coastal strait

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The Strait of Georgia is an enclosed coastal strait between British Columbia's mainland and Vancouver Island, about 250km long and 25 to 50 km wide, with great socio-economic importance. Regular freighter traffic, ferry services, commercial and sport fisheries, and recreational boating, makes the area one of the busiest marine areas in the world. Waves in the Strait of Georgia are generally small due to limited fetches, strait dimension and orientation, and the alignment of the prevailing winds, with the median value of the significant wave height Hs=0.3m. However, strong outflows off the BC coastal mountains, or storm winds aligned from the NW or SE can generate significant wave heights Hs > 2.5m, with high spatial and temporal variability. In addition, strong tidal currents and the Fraser River outflow generate localised regions of wave-

current interactions, with steep and breaking waves that are of particular concern. We have implemented the Wavewatch III model at 500m-resolution, forced by Environment Canada's high-resolution atmospheric model and currents from the UBC NEMO implementation of the Salish Sea. The final output will combine GIS layers of the predicted wave field (Hs, dominant wavelength and direction), the modelled wind and current fields, observed currents from a set of CODAR systems, and a sea state index that highlights regions of potentially steep and dangerous waves.

1708011 POSTER SESSION - PART 2

Predictability of inter-annual variations of bottom temperature and salinity on the Scotian Shelf

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Bottom temperature and salinity are believed to have an important influence on the abundance and distribution of ground fish, lobster, snow crab and other benthic species on the Scotian Shelf. In this study, the variability of bottom temperature and salinity on the Scotian Shelf is studied using observations and predictions from a regional ocean model. The primary observations were made by (i) a cross-shelf array of ten benthic pods deployed from 2011 to 2016 that recorded hourly values of temperature, salinity, and bottom pressure, and (ii) annual July ground fish surveys conducted by DFO leading to spatial maps of bottom temperature and salinity. The observations indicate significant inter-annual variability of bottom temperature and salinity over the six-year study period. The predictions were made by a high-resolution (1/36°) model of the Gulf of Maine and Scotian Shelf (GoMSS) based on the NEMO 3.6 (Nucleus for European Models of the Ocean) modelling framework. Overall the agreement between observations and model predictions is good over the inner third of the shelf but deteriorates as the shelf break is approached. An explanation for this loss of skill is given in terms of predictability of conditions at the shelf break with a particular focus of the strength of the shelf break current and the appearance of warm core eddies that spin off the nearby Gulf Stream. The main pathways, and origin, of bottom water on the Scotian Shelf are explored using numerical particle tracking experiments and the predictability of inter-annual changes in shelf-deep ocean exchange is discussed.

1708011 POSTER SESSION - PART 2

An investigation into Kamloops flash flooding events

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Kamloops is a city in the Thompson Valley of British Columbia, which is vulnerable to thunderstorm flash flooding. Historical data indicate that annual flooding events have increased during the recent years at Kamloops. Due to complex terrain and the localized nature of thunderstorms, it is a challenge for operational meteorologists to make forecast and warning decisions. One of the challenges is that for an approaching thunderstorm, how meteorologists judge ahead if the thunderstorm is one with the potential to produce flash flooding at the time it arrives at the city.

In this study, ten thunderstorm flooding events that occurred over the Kamloops area during the recent years were investigated. Through storm trajectory analysis, two clusters – southern track and western track – were identified, and each of them represents a unique weather pattern. Composite analysis for these two clusters provided useful information regarding synoptic patterns, flow structure and moisture transfer. An examination into radar echo evolutions and intensities for each event revealed that thunderstorms which produced flash flooding at Kamloops have much weaker echo intensities than those elsewhere in the BC interior. The results from the examination will help to set up unique radar criteria for thunderstorm warning specifically regarding to flash flooding over the Kamloops area. In addition, the features of precipitable water with these two patterns were also investigated. It is expected that the findings from this study can help operational meteorologists to make better thunderstorm warning decisions.

1708011 POSTER SESSION - PART 2

The study of the microphysical and dynamical processes of in-flight icing environments and icing intensity forecast at Cold Lake Alberta, Canada

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The purpose of this paper is to report on a study analyzing two years of data over the Cold Lake airport, Alberta, to further the understanding of microphysical and dynamical processes of icing environments with the goal of improving the icing detection system. In-flight icing occurs when the subfreezing liquid water droplets freeze on the surface of aircrafts, which degrades the aerodynamic performance of the aircraft and serve icing can cause the loose of control. Unfortunately, icing forecast is challenging since it relies on accurate prediction of several atmospheric parameters: temperature, wind, humidity, liquid water content (LWC) and vertical motion, and on the level on which the microphysics of icing can be represented in the numerical forecast models. Pilot reports (PIREPs) of in-flight icing for Cold Lake airport (CYOD), Alberta, are frequent in the fall and winter seasons. In 2013 the Meteorological Research Division of Environment and Climate Change Canada (ECCC), working in collaboration with the Department of National Defense (DND) within the Search and Rescue (SAR) framework commissioned a specialized observing platform Cold Lake to further the understanding on icing conditions. The ground based platform includes a Vaisala PWD22 present weather sensor, a multi-channel microwave profiling radiometer (MWRP), a Jenoptik CHM15k ceilometer and a K-band Micro Rain radar (MRR) which collect data continuously. In this paper we analyze 33 icing events which occurred during 2015-2016. In particular, the microphysical icing conditions are examined by integrating the ground based measurements with the Geostationary Operational Environmental Satellite (GOES) and the Canadian 2.5 km resolution NWP (HRDPS - High Resolution Deterministic Prediction System) model data. Three different icing intensity scales based on a cylindrical shape approximation of airfoil and LWC alone have been tested using the HDRDPS model data. The preliminary results show that the model based icing intensity prediction reasonably agreed with the PIREPs and MWRP observations, but using LWC alone over predicts the intensity.

1708011 POSTER SESSION - PART 2

Wind Rose Renewal Project

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Wind roses are extremely useful for weather forecasting. They provide a quick overview of the wind speeds and directions that are typically experienced at a given location, taking into account seasonal pressure patterns and topography, and can lead to more accurate forecasts when used as a reference. As weather patterns and site characteristics change through time, these wind roses should be updated with the most recent observations to reflect current climatology. This poster will review the process of updating the wind roses across Canada, the challenges encountered, and the differences observed between past and current wind roses.

1708011 POSTER SESSION - PART 2

Effect of asymmetries in ripple shape and currents on two-dimensional oscillatory flow over ripples.

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We investigate the effect of asymmetries on oscillatory flow over two dimensional ripples. The asymmetries in the flow is chosen to resemble those observed under progressive waves in shallow water. Asymmetry in the ripple shape resembles, in its direction of skewness, those formed under aforementioned asymmetric flows. Reynolds number of the flow is mostly limited to 1250 and occasionally increased to 5000. During the

first three cycles, it is observed that vortex pairs ejected at each flow reversal reach higher up in the water column as the flow or ripple asymmetry is increased. This is attributed to the difference in the strengths of vortices constituting the vortex pairs. After about 20 cycles, a quasi-steady state is reached and a pattern of organised vortex shedding give rise to a band of net negative current above the ripples in the presence of asymmetries, either in the ripple shape or the flow forcings. In the absence of asymmetries, a new current is generated above the ripples but without a preferred direction, undergoing slow but consistent oscillatory changes in the direction.

1708011 POSTER SESSION - PART 2

Polarimetric Retrievals of Cloud Droplet Number Concentrations: Evaluation of Measurements and Correlations with Aerosol Properties

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Cloud droplet number concentration (CDNC) is a key parameter of liquid clouds and is essential for the understanding of aerosol-cloud interaction. It couples surface aerosol composition and chemistry with cloud reflectivity. It impacts radiative forcing, cloud evolution, precipitation, global climate and, through observation, can be used to monitor the cloud albedo effect, or the first indirect effect.
With its unique combination of multi-wavelength, multi-angle, total and polarized reflectance measurements, the Research Scanning Polarimeter (RSP) is capable of retrieving CDNC. Here, we will show results from the North Atlantic and Marine Ecosystems Study (NAAMES), off the east coast of Newfoundland, and Observations of Aerosols Above Clouds and their Interactions (ORACLES) campaign, off the coast of Namibia. During NAAMES, variable low cloud decks and aerosols were observed, along with other variations in environmental conditions over a marine environment. The completed fall 2015 and spring 2016 deployments provide an excellent opportunity for the RSP to evaluate its approach of sensing CDNC over a range of concentrations and cloud types with the Langley Aerosol Research Group Experiment's (LARGE's) Cloud Droplet Probe (CDP). A correlation coefficient of 0.72 was found for daily mean value comparisons for the two instruments. Strong correlations are found between the RSP CDNC measurements and the LARGE in situ measured cloud condensation nuclei (CCN) and aerosol types from the Aerosol Mass Spectrometer (AMS). Links between the size and type of aerosols are explored. Initial RSP cloud and aerosol measurements made during the ORACLES campaign are also presented. Connections between geographical influences and aerosol concentrations and their effects on cloud droplet sizes and number concentrations are investigated.

1708011 POSTER SESSION - PART 2

December 23rd 2014 and January 4th 2015 Freezing Rain Events in Montreal Or Aiming at better assessing the duration of a freezing rain event in Montreal

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Two freezing rain events in the Greater Montreal Area (GMA), similar in appearance but significantly different in duration and impact, caused great concern to aviation and public forecasters. The first event, December 23rd 2014, was initially forecast to last the whole day (11 hours) but changed into rain after 3 hours, for a total freezing rain amount of only 1mm for the GMA. The second event, January 4th 2015, was expected to change into rain in the morning (7 hours duration) but instead lasted until early in the evening (14 hours), for a total freezing rain amount of 18mm. While the former event had no major consequences, the latter was responsible for power outages (~150 000 in the GMA) and major delays or accidents in transportations. An overview of the synoptic patterns for both events showed similarities, namely a fairly strong Colorado low, low-level jet, isobaric gradient perpendicular to the St Lawrence valley and a thickness gradient under 540dam to enhance cold air drainage. However, a thorough investigation has shown significant differences between these two events as to the stage of evolution of the Colorado low and the intensity of the low-level jet, the isobaric and thickness gradients over the St-Lawrence valley. The 2m-temperatures for Montreal given by the Updateable Model Output Statistics (UMOS), the most widely used data for temperature forecasting by Canadian meteorologists, showed some improvements when compared with the Regional Deterministic Prediction System version 4.0 (RDPS), but still increased temperatures above 0°C 4 hours late and 11 hours too early, respectively. As expected, RDPS showed great skill in predicting the beginning of both freezing rain events, but its ability to simulate realistic strong temperature gradients and drainage winds in the boundary layer seems limited. In conclusion, a simple calculation to guide the forecaster in better predicting the end of a freezing rain event in the GMA is suggested.

1708011 POSTER SESSION - PART 2

Heat transport from northern rivers to Canadian Arctic coasts

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Northern rivers transport large amount of freshwater and thermal/geochemistry fluxes to the polar ocean system. Many recent studies document significant variations and changes in discharge, water temperature, and geochemistry characteristics in the large arctic watersheds. Based on recent data analysis and literature review, this presentation aims to synthesize our knowledge of northern river heat flux into the Canadian Arctic Ocean. It will describe the seasonal cycles of discharge, water temperature, and heat flux from the northern rivers and compare their main features across the pan-Arctic domain. It will also discuss basin specific results, such as statistical analyses and model simulations of historical changes and future projections of heat transport processes due to climate variation and human impact, particularly the effects of reservoir regulation. These results are critical for a better understanding of climatic and hydrologic linkages and variations over the northern regions. They are also important for regional hydrology and climate change investigations, such as basin-scale energy balance calculations, and land-ocean interactions, particularly large-scale ocean heat budget and model analyses across the arctic regions.

1708011 POSTER SESSION - PART 2

Forecasting flood-producing water levels in the Ottawa River and Lake Ontario: May, 2017

Durnford, Dorothy - Environment and Climate Change Canada
Fortin, Vincent - Environment and Climate Change Canada
Smith, Gregory - Environment and Climate Change Canada
Archambault, Benoit - Environment and Climate Change Canada
Deacu, Daniel - Environment and Climate Change Canada
Dupont, Frederic - Environment and Climate Change Canada
Dyck, Sarah - Environment and Climate Change Canada
Martinez, Yosvany - Environment and Climate Change Canada
Klyskejko, Erika - Environment and Climate Change Canada
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Following a decade of research and development, the Water Cycle Prediction System was implemented in June 2016 on the Great Lakes and St. Lawrence River (WCPS-GLS) by Environment and Climate Change Canada (ECCC). WCPS-GLS links ECCC's coupled atmospheric and land-surface model GEM, the lake/ocean model NEMO, the marine ice model CICE, and the river routing model WATROUTE. GEM and NEMO exchange information every few minutes. GEM also provides hourly forcing fields to WATROUTE, which, in turn, provides boundary conditions to NEMO. This operational prediction system of the complete water cycle produces two forecasts per day for the next three days.

Managers of the dam on the Ottawa River upstream of Montreal and of the Moses-Saunders dam on the St. Lawrence River at Cornwall were provided with WCPS-GLS products during the flooding of May, 2017 in Quebec and Ontario. The WCPS-GLS forecasts of river flows and lake levels provided advance warning of the magnitude of expected increases during this period of historically high levels. In our presentation, we describe the multi-component Water Cycle Prediction System. We compare forecast, observed and historical water levels.

PART 3 – PUBLIC LECTURES

Public Lecture

Changing weather extremes – why it isn't an "alternative fact"

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Stories about extreme weather and climate events around the world often make media front-page headlines, alongside the recent upswing in "alternative fact", or fake, news. These stories about extremes draw our attention because of their immediacy and the devastating impacts, which often include deaths and up to billions of dollars in damage.

Two Canadian examples include the Fort McMurray wildfire (2016, >$3.6B in insured losses) or the Calgary floods (2013, $6.7B USD in total losses). In the aftermath of such devastation, media ask whether such extreme events are now more frequent or intense than in the past, whether they are caused by human influence on the climate and if they represent a harbinger of the future.

In most cases, climate science does find that human influence played a role, consistent with the overwhelming body of evidence indicating a human contribution to the observed changes in average climatic conditions over the past century.

Nevertheless, at a localized level, the effects of climate change can be hard to detect, leading to possible discrepancies between our own personal experience of climate change and the findings of climate science. In this new era of "alternative facts", it would be a fallacy to rely solely on personal experience, reject the findings of the climate science community and consequently fail to prepare for the climatic changes ahead.

Public Lecture

The Climate Clock

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As people arrive for the public lecture we will screen the Climate Clock, developed by Concordia University and the Human Impact Lab. Dr Mathews will give a brief history of its development.