49th CMOS CONGRESS
49ème CONGRÈS SCMO
13th AMS CONFERENCE ON POLAR METEOROLOGY AND OCEANOGRAPHY

Program

TROPICS TO POLES
DES TROPIQUES AUX POLES

ADVANCING SCIENCE IN HIGH LATITUDES
AVANCEMENT DE LA SCIENCE DES HAUTES LATITUDES

Programme

Editors / Éditeurs: Tim Ashman & Andres Soux

2015 WHISTLER

May 31 - June 4 | 31 mai - 4 juin | British Columbia, Canada

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

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Translators | Traducteurs – Matt MacDonald, Chantal McCartin

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BRITISH COLUMBIA

A Message from Premier Christy Clark

As Premier of the Province of British Columbia, I am pleased to welcome everyone to the Canadian Meteorological and Oceanographic Society's 49th Congress, here in beautiful Whistler.

I understand that this year's congress — *Tropics to Poles: Advancing Science in High Latitudes* — has brought together national and international experts to share their findings and recommendations, to ensure excellence in the field of high latitude science. Events like these are critical in understanding our own climate and environment, and I commend everyone here for their commitment to furthering environmental discussions.

I'd like to take this opportunity to thank the conference team for the time and effort that has been put into organizing this important gathering. Without your dedication, none of this would be possible.

I wish you all the best in your deliberations, and I hope everyone will also have an opportunity to enjoy some of the many sights and amenities Whistler has to offer.

Sincerely,

Christy Clark
Premier

WHISTLER

THE RESORT MUNICIPALITY OF WHISTLER
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April 7, 2015

GREETINGS FROM THE MAYOR

On behalf of the Resort Municipality of Whistler, I would like to extend a warm welcome to all participants at the 49th Congress of the Canadian Meteorological and Oceanographic Society (CMOS) and the 13th American Meteorological Society's (AMS) Conference on Polar Meteorology and Oceanography.

Thank you to the CMOS and the AMS for choosing Whistler when you organized this event. It sounds like you have an interesting itinerary arranged for your conference on the theme Tropics to Poles — Advancing Science in High Latitudes.

Whistler is an appropriate place to hold your conference. You will find that we have a dynamic mountain environment and climate, which we are passionate about and is very much part of our identity as a resort community. From the early pioneers to the energetic and innovative community of today, we all embrace Whistler's relationship with nature, and a built environment that matches the majesty of our mountains.

We hope you all have time to experience much of what Whistler has to offer—from the great variety of paved and single-track trails for biking and hiking, to the variety of spas, restaurants, pubs, shops and entertainment around the Village. Whistler was the proud Host Mountain Resort for the 2010 Olympic and Paralympic Winter Games and I encourage you to check out the venues including Whistler Olympic Plaza and the Whistler Sliding Centre.

Have a wonderful visit and we look forward to welcoming you again.

Regards,

Nancy Wilhelm-Morden

Nancy Wilhelm-Morden
Mayor
Resort Municipality of Whistler

About CMOS

The Canadian Meteorological and Oceanographic Society (CMOS) is the national society of individuals and organisations dedicated to advancing atmospheric and oceanic sciences and related environmental disciplines in Canada. The Society's aim is to promote meteorology and oceanography in Canada, and it is a major non-governmental organisation serving the interests of meteorologists, climatologists, oceanographers, limnologists, hydrologists and cryospheric scientists in Canada. CMOS was officially created in 1967 as the Canadian Meteorological Society and adopted its present name in 1977, following an invitation by the Canadian Meteorological Society to the oceanographic community in Canada to join the Society. However, CMOS has a rich history dating back to 1939 when it was known as the Canadian Branch of the Royal Meteorological Society.

The Society comprises some 1100 members and subscribers, including students, corporations, institutions, and others who are involved in the educational functions, communications, the private sector and government. Membership is open to all who share an interest in atmospheric and oceanic sciences, their related sciences and applications. The Society addresses a broad range of national and international meteorological and oceanographic concerns including weather and weather extremes, global warming, ozone depletion and surface air quality and their effects on all aspects of life in Canada including forestry, agriculture and fisheries. Special interest groups in the Society consider meteorological aspects of hydrology, agriculture, forestry, meso-scale meteorological phenomena and operational meteorology.

À propos de la SCMO

La Société canadienne de météorologie et d'océanographie (SCMO) est une société nationale de personnes et d'organisations vouées à l'avancement des sciences atmosphériques et océaniques liées aux disciplines environnementales au Canada. Un des principaux organismes non gouvernementaux à servir les intérêts des météorologues, océanographes, limnologues, hydrologues et scientifiques cryosphériques, la Société vise à promouvoir la météorologie et l'océanographie au Canada. La SCMO a vu le jour officiellement en 1967 et a adopté son nom actuel en 1977 après que la Société météorologique du Canada ait invité la communauté océanographique du Canada à se joindre à elle. Toutefois, la SCMO a une riche histoire qui remonte à 1939 alors qu'elle était connue sous le nom de Section canadienne de la Société royale des météorologues.

La Société compte 1 100 membres et adhérents, et parmi ceux-ci, des étudiants, des corporations, des institutions et d'autres groupes engagés dans l'éducation, les communications, le secteur privé et le gouvernement. Peut devenir membre de la SCMO toute personne qui a un intérêt dans les sciences atmosphériques et océaniques, ainsi que dans les disciplines connexes et leurs applications. La Société s'intéresse à une vaste gamme de questions nationales et internationales qui touchent la météorologie et l'océanographie, et en particulier, le temps et les conditions météorologiques exceptionnelles, le réchauffement de la planète, la diminution de l'ozone et la qualité de l'air à la surface, ainsi que leurs effets sur tous les aspects de la vie au Canada incluant la foresterie, l'agriculture et les pêches. Des groupes d'intérêts spéciaux de la Société étudient les questions météorologiques associées à l'hydrologie, à l'agriculture, à la foresterie, ainsi que les phénomènes météorologiques d'échelle moyenne et la météorologie opérationnelle.

Welcome from the President of the Canadian Meteorological and Oceanographic Society

On behalf of the Canadian Meteorological and Oceanographic Society (**CMOS**), I would like to welcome you to our 49th CMOS Congress in Whistler on **"Tropics to Poles: Advancing Science in High Latitudes"** which is a Joint Congress of the CMOS and the American Meteorological Society (**AMS**) whose partnership is greatly appreciated. Our congresses are an outstanding forum for networking and exchange of ideas between the government, academic and private sector scientists and practitioners working in the field of meteorology and oceanography. This year the partnership with AMS further enhances these opportunities. They provide us with a forum to present our scientific advances and learn about new scientific work of our peers. We also recognize the work of outstanding colleagues over their career as well as on special projects. More importantly we recognize the work of our youngsters, the future of our profession, through awards for outstanding work done by them.

We have also organized a student industry networking event in the Congress to encourage students to establish connections with industry.

In addition to the regular scientific program, we have also organized a special session on the "Future of CMOS" in which we would discuss where we would like to take this venerable organization. We invite all our members to attend our Annual General Meeting to vote on various important motions and to help select our new Council.

As usual there will be a Patterson-Parsons Luncheon and a Banquet where achievements of our colleagues and students will be recognized. We have also organized an interesting Exhibition in which various companies will display their products and services. We strongly encourage you to visit the booths to learn about new products and services and also encourage these companies so that they keep participating in these Exhibitions.

These Congresses require a lot of work to organize. We would like to strongly recognize the untiring work of the Chair of the Local Arrangements Committee Ken Kwok and the Chair of the Scientific Committee Bruce Ainslie and their teams for organizing this conference so well. In addition, we would like to recognize our sponsors whose generous contribution helps these congresses to succeed. We encourage other potential sponsors – especially larger users of meteorology to step up to the plate to help their organization – CMOS to grow and organize additional events.

Finally, our 50th Congress is planned to be held in Fredericton next year. We plan to hold some special events to celebrate this Golden Jubilee of our Congresses. We encourage you to provide additional ideas for this celebration and hope we can count on your attendance.

Our best wishes to all attendees for an interesting, fruitful and productive Congress in Whistler, BC.

Dr. Harinder Ahluwalia
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 tiens à vous souhaiter la bienvenue à notre 49ième congrès **SCMO** à Whistler intitulé "**Des tropiques aux pôles: Avancement de la science des hautes latitudes**". Le congrès est une collaboration entre la SCMO et la Société Américaine de Météorologie (**AMS**) dont le partenariat est grandement apprécié. Nos congrès sont un forum exceptionnel pour le réseautage et l'échange d'idées entre les différents gouvernements, les scientifiques ainsi que les praticiens académiques et privés travaillant dans le domaine de la météorologie et de l'océanographie. Cette année, le partenariat avec AMS accroit ces opportunités davantage. Le congrès nous fournit un forum pour présenter nos progrès scientifiques et en apprendre davantage sur les nouveaux travaux scientifiques de nos pairs. Nous reconnaissons également le travail de nos collègues au fil de leurs carrières ainsi qu'au cours de projets spéciaux. Encore plus important est la reconnaissance du travail accompli par nos jeunes, l'avenir de notre profession en les récompensant pour le travail remarquable qu'ils ont accompli.

Nous avons également organisé un événement de réseautage industrie-étudiant durant le Congrès afin d'encourager les élèves à établir des liens avec l'industrie.

En plus du programme scientifique régulier, nous avons aussi organisé une session spéciale sur « l'avenir de la SCMO » durant lequel nous discuterons de la direction de cette vénérable organisation. Nous invitons tous nos membres à assister à notre assemblée générale annuelle afin de voter sur diverses motions importantes et d'aider avec la sélection notre nouveau conseil.

Comme d'habitude, il y aura un diner Patterson-Parsons et un banquet où les accomplissements de nos collègues et des étudiants seront reconnus. Nous avons également organisé une exposition intéressante où différentes entreprises présenteront leurs produits et leurs services. Nous vous encourageons vivement à visiter leurs stands pour vous renseigner sur les nouveaux produits et services offerts et aussi pour encourager ces entreprises afin qu'elles continuent de participer à ces expositions.

Ces congrès exigent un travail organisationnel énorme. Nous tenons à souligner le travail inlassable du président du comité des arrangements locaux Ken Kwok ainsi que le président du comité scientifique Bruce Ainslie et leurs équipes pour l'excellente organisation de cette conférence. En outre, nous tenons à reconnaître nos commanditaires dont la contribution généreuse assure la réussite de ces congrès. Nous encourageons les autres commanditaires potentiels - en particulier les grands utilisateurs de la météorologie – d'aller de l'avant pour aider leur organisation à croître et d'organiser des événements supplémentaires.

Finalement, notre 50ième congrès est prévue être tenue à Fredericton l'année prochaine. Nous prévoyons d'organiser des événements spéciaux pour célébrer ce jubilé d'or de nos congrès. Nous vous encourageons à fournir des idées supplémentaires pour cette célébration et espérons que nous pouvons compter sur votre présence.

Nos meilleurs vœux à tous les participants pour un congrès intéressant, fructueux et productif à Whistler en Colombie-Britannique.

Dr. Harinder Ahluwalia
Président de la SCMO

Welcome Message from the Local Arrangements Committee and Scientific Program Committee

On behalf of the Scientific Program and Local Arrangements Committees, we welcome you to Whistler, B.C. for the joint 49th Canadian Meteorological and Oceanographic Society (CMOS) Congress and 13th American Meteorological Society (AMS) Conference on Polar Meteorology and Oceanography.

This year's congress theme of Tropics to Poles: Advancing Science in High Latitudes, reflects the heightened interest in the economic development and environmental impacts, both underway and projected for, the world's high latitude and polar regions. This year's congress features almost 400 abstracts to be presented in the 52 oral sessions and the Monday afternoon poster session. These submissions, along with eight internationally renowned plenary speakers, highlight top Canadian and international researchers in the fields of oceanography, meteorology, climatology, hydrology and the cryospheric sciences. At the Wednesday night public lecture, Captain Kurt Salchert, Royal Canadian Navy (retired), will draw on his experience as a senior NORAD delegate to the Canadian Arctic Security Working Group, to speak about policy issues arising as a consequence of the rapidly changing Arctic and polar regions.

The congress also features a number of events including the student pub night on Monday, afternoon social activities on Tuesday, and the traditional Banquet on Wednesday evening, with all of these events taking place against Whistler's beautiful vistas. Of course, none of this would have happened without the tireless effort of the Local Arrangements Committee (LAC) and Scientific Program Committee (SPC) members as well as all of the volunteers and CMOS staff.

The SPC and LAC recognize that it is a time of tight budgets and we are grateful for your participation at this year's congress. We hope the scientific sessions, workshops, public lecture and many social events will provide the opportunity to learn, exchange ideas, as well as make and renew acquaintances.

Welcome!

Ken Kwok
Chair – Local Arrangements Committee

Dr. Bruce Ainslie
Chair – Scientific Program Committee

Dr. Andrew Roberts
Chair - AMS Polar Meteorology and Oceanography Committee

Mot de bienvenue du Comité du programme scientifique et du Comité local des préparatifs

Au nom du Comité du programme scientifique et du Comité local des préparatifs, nous vous souhaitons la bienvenue à Whistler, en Colombie-Britannique pour le 49ème Congrès de la Société Canadienne de Météorologie et d'Océanographie (SCMO) joint avec la 13ième conférence de la Société Américaine de Météorologie (AMS) portant sur la météorologie et l'océanographie polaire.

Cette année, le thème du congrès est « Des tropiques aux pôles: Faire progresser la science dans les hautes latitudes » ce qui reflète l'intérêt accru dans le développement économique et des impacts environnementaux déjà amorcé dans les hautes latitudes et les régions polaires. Le congrès cette année met en vedette près de 400 résumés qui seront présentés dans l'une des 52 sessions orales et lors de la session d'affiches lundi après-midi. Jumelées aux huit conférenciers de renommée internationale, ces soumissions reflètent les meilleurs chercheurs canadiens et internationaux dans les domaines de l'océanographie, la météorologie, la climatologie, l'hydrologie et des sciences de la cryosphère. Durant la conférence publique mercredi soir, le capitaine marine récemment retraité Kurt Salchert tirera sur son expérience en tant que délégué principal NORAD du Groupe de travail sur la sécurité de l'Arctique canadien pour parler de questions de politique découlant de l'évolution rapide de l'Arctique et des régions polaires.

Le congrès comporte également un bon nombre d'événements sociaux, y compris la soirée pub pour étudiants lundi soir, les activités sociales mardi après-midi et le banquet traditionnel mercredi soir. Tous ces événements se dérouleront parmi la beauté exceptionnelle de Whistler. Bien sûr, rien de tout cela ne serait arrivé sans l'effort inlassable du Comité local des préparatifs (CLP) et des membres du Comité du programme scientifique (CPS) ainsi que tous les bénévoles et le personnel de la SCMO.

Le CPS et le CLP reconnaissent que nous sommes présentement dans une période de budgets serrés et nous sommes reconnaissants de votre participation au congrès cette année. Nous espérons que les sessions scientifiques, les ateliers, les conférences publiques et les nombreux événements sociaux vous offriront l'occasion d'apprendre, d'échanger des idées, ainsi que de renouveler et de créer des connaissances.

Bienvenue!

Ken Kwok
Président du Comité local des préparatifs

Dr. Bruce Ainslie
Président de la Comité du programme scientifique

Dr. Andrew Roberts
Président – Comité AMS de la météorologie et de l'océanographie polaire

Local Arrangements Committee
Comité des arrangements locaux

Tim Ashman
Alyssa Charbonneau
Chris Gibbons
William Hsieh
Oscar Koren
Ken Kwok
Matt MacDonald
Ross MacDonald
Chantal McCartin
Robert Nissen
Peter Scholefield
Andrew Snauffer
Brad Snyder
Andres Soux
Lisa Vitols
Cindy Yu

Scientific Program Committee
Comité du programme scientifique

Bruce Ainslie
Susan Allen
Phil Austin
Ryan Fogt
Mark Halverson
William Hsieh
Doug McCollor
Ron McTaggart-Cowan
Richard Pawlowicz
Andrew Roberts
Martin Taillefer

Volunteers | Bénévoles

Kevin Akaoka
Byeong Kim
Yimei Li
Dana Ehlert
Timothy Chui
Aranildo Lima
Robert Irwin
Fifine Peng
Jie (Catherine) Liu
Xiaoxin (Cindy) Yu
Evgeniya Snauffer
Morgen Shull
Mekdes Ayalew Tessema
Lea Zhecheva
Yingkai (Kyle) Sha
Jian Jin
Timothy Atkinson
Karina Musalem
Matthew Fung
Nils Koropatnisky
Jason Ross
Jake McQueen
Samantha Lee
Zach Boudreau
Jon Bau
David Jones
Lisa West
Colin Fong
Colin Tam
Mindy Brugman
Oscar Koren
Andrew Snauffer

CMOS 2015 Social Events

Whistler offers endless opportunities for all kinds of unique experiences and adventures. Play hard, rest easy, wine and dine, attend an event, explore the arts, shop non-stop, commune with nature, or find the ultimate adrenaline rush. The big question is where do you want to start?

The 2015 CMOS Organizing Committee is happy to offer reduced-rate activities to our delegates and their families during the congress. We worked with Tourism Whistler to select the three following activities.

Peak 2 Peak Gondola Enjoy stunning 360-degree views of Whistler Village, mountain peaks, lakes, glaciers and forests.

Zipline Tours Ziptrek Ecotours is the North American pioneer of zipline tours, with the most ziplines and tour options around! Ziptrek offers an entertaining combination of high-wire adventure and ecological exploration on a choice of 2 guided zipline tours.

Whistler Tasting Tours Experience the Best Whistler Restaurants all in One Night! During our guided walking tours, guests enjoy a fantastic multi-course dinner where each delicious course is provided by one of the different restaurants in Whistler. Monday June 1st starting at 5:45pm.

For more info and to register, please visit www.whistler.com/delegates/cmos

SOCIAL CALENDAR

	Sunday May 31	Monday June 1		Tuesday June 2	Wednesday June 3	Thursday June 4
	Peak 2 Peak sightseeing available all week					
What	**Icebreaker** Music by *The Splinters*	**Student Night** Sponsored by Howe Sound Brewery & Campbell Scientific	**Whistler Tasting Tour**	**Zipline Tours**	**CMOS Banquet** Music by *The Splinters*	It's a wrap!
Where	Whistler Conference Centre Lobby	*Dubh Linn Gate* Irish Pub	Various restaurants. Starts at Conference Centre	Carleton Lodge across from Whistler Gondola	Whistler Conference Centre	
When	6pm-10pm	8pm-10pm	Meet at 5:45pm	3pm	7pm-10pm	

Activités Sociaux durant le Congrès SCMO 2015

Whistler offre des possibilités infinies pour toutes sortes d'aventures et d'expériences exceptionnelles. Jouer dur, dormir tranquille, dégustations et vin, assister à un événement, les arts, magasiner sans arrêt, communier avec la nature, ou trouver l'ultime décharge d'adrénaline. La grande question est où voulez-vous commencer?

Le Comité d'organisation SCMO 2015 est heureux d'offrir des activités à taux réduit à nos délégués et à leurs familles durant le congrès. Nous avons travaillé avec Tourisme Whistler pour sélectionner les trois activités suivantes.

Gondole « Peak 2 Peak » Profitez d'une vue à 360 degrés imprenable sur le village de Whistler, des sommets montagneux, des lacs, des glaciers et des forêts.

Balade de tyrolienne Ziptrek Ecotours est le pionnier nord-américain des tournés tyroliennes avec le plus grand choix de tournés dans la région. Ziptrek vous offre une combinaison divertissante d'aventure haut-fil et l'exploration écologique sur un choix de 2 visites guidées de tyrolienne.

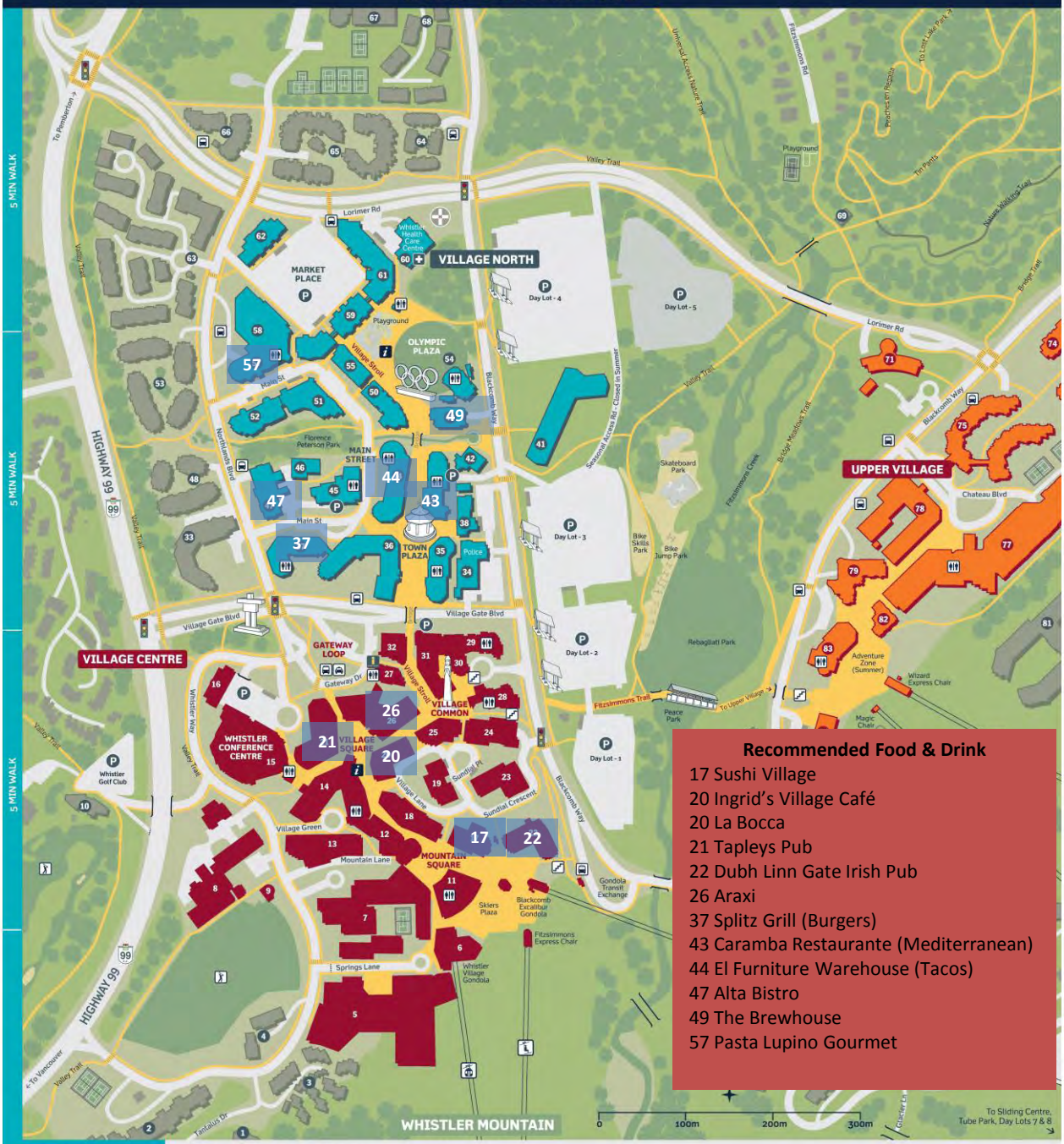
Tours « Whistler Tasting » Découvrez les meilleurs restaurants à Whistler en une nuit! Au cours de nos visites guidées à pied, les clients bénéficieront d'un souper de plusieurs plats délicieux fournis par l'un des différents restaurants à Whistler. Lundi 1er juin à partir de 17h45.

Pour plus d'information et pour vous inscrire, s'il vous plaît visitez www.whistler.com/delegates/cmos

CALENDRIER SOCIAL

	Dimanche 31 mai	Lundi 1er juin		Mardi 2 juin	Mercredi 3 juin	Jeudi 4 juin
	Tours de gondole « Peak 2 Peak » disponibles toute la semaine					
Quoi	**Brise-glace** Musique par *The Splinters*	**Nuit pour les Étudiants** Commandité par Howe Sound Brewery et Campbell Scientific	**Tours Whistler Tasting**	**Tournés Zipline**	**Banquet SCMO** Musique par *The Splinters*	C'est la fin du congrès!
Où	Le hall d'entrée du Centre de Conférence de Whistler	Pub Irlandais *Dubh Linn Gate*	Divers restaurants. Tournée débute au Centre de Conférence	Carleton Lodge en face de la gondole Whistler	Centre de Conférence de Whistler	
Quand	18-22h	20h-22h	17h45	15h	19-22h	

WHISTLER VILLAGE



Recommended Food & Drink

- 17 Sushi Village
- 20 Ingrid's Village Café
- 20 La Bocca
- 21 Tapleys Pub
- 22 Dubh Linn Gate Irish Pub
- 26 Araxi
- 37 Splitz Grill (Burgers)
- 43 Caramba Restaurante (Mediterranean)
- 44 El Furniture Warehouse (Tacos)
- 47 Alta Bistro
- 49 The Brewhouse
- 57 Pasta Lupino Gourmet

LEGEND

- Village North/ Neighbourhoods
  - Main Street
  - Market Place
  - Olympic Plaza
  - Town Plaza
- Village Centre/ Neighbourhoods
  - Conference Centre
  - Gateway Loop
  - Mountain Square
  - Skiers Plaza
  - Village Common
  - Village Square
- Upper Village
- Parking Area
- Accessible Parking
- Pedestrian Path
- Emergency Services
- Public Restrooms
- Visitor Centre
- Village Host
- Stairway
- Bus Stop
- Taxi
- Golf Course
- Gondola
- Chairlift

VILLAGE DIRECTORY

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Medical & Dental Services
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44 Town Plaza Medical Clinic
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60 Whistler Health Care Centre
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Accommodations
8 Aava Whistler Hotel
14 Adara Hotel
52 Alpenglow
26 Blackcomb Lodge
11 Carleton Lodge
33 Cascade Lodge
18 Clock Tower Hotel
75 Club Intrawest
12 Crystal Lodge
36,37 Delta Whistler Village Suites
18 Executive Inn
77 The Fairmont Chateau Whistler
20 Fitzsimmons Condos
86 Gables
78 Glacier Lodge
65 Glacier's Reach
64 Granite Court
21 Hearthstone Lodge
7 Hilton Whistler Resort & Spa
79 Le Chamois
13 Listel Whistler Hotel
57 Market Pavilion
59, 61 Marketplace Lodge
23 Mountainside Lodge
1 Northern Lights
22 Pan Pacific Whistler Mountainside
29 Pan Pacific Whistler Village Centre
7 Powder's Edge
21 Rainbow Building
16 Royal Suite
87 Snowy Creek
25 St. Andrews House
53 Stoney Creek
51 Summit Lodge & Spa
17 Sundial Boutique Hotel
66 Symphony at Whistler
2 Tantalus Lodge
35, 43, 44 Town Plaza Suites
50,55 Tyndall Stone Lodge
63 Valhalla /Twin Peaks Resorts/ North Star at Stoney Creek
32 Village Gate House
5 The Westin Resort & Spa
30 Whistler Peak Lodge
47 Whistler Pinnacle
19, 24 Whistler Village Inn & Suites
18 Whistlerview Condos
21 Windwhistle

Building Names
1 Northern Lights
2 Tantalus Lodge
3 Telemark Place
4 Mountain Edge
5 Westin Resort & Spa
6 Whistler Village Gondola & Whistler Blackcomb Guest Relations
7 Hilton Whistler Resort & Spa
8 Aava Whistler Hotel
9 Whistler Golf Club Driving Range
10 Whistler Golf Club
11 Carleton Lodge
12 Crystal Lodge
13 Listel Whistler Hotel
14 Adara Hotel
15 Whistler Conference Centre
16 Cornerstone Building
17 Sundial Boutique Hotel
18 Whistlerview Condos, Clock Tower Hotel & Executive Inn
19, 24 Whistler Village Inn & Suites
20 Fitzsimmons Condos
21 Hearthstone Lodge, Rainbow Suites, Windwhistle
22 Pan Pacific Whistler Mountainside
23 Mountainside Lodge
25 St. Andrews House
26 Blackcomb Lodge/Blackcomb Professional Building
27 Gatehouse Building
28, 30, 31 Whistler Village Centre
29 Pan Pacific Whistler Village Centre
32 Village Gate House
33 Cascade Lodge
34 Police, Fire Hall, Bylaw (Emergency 911)
35 Town Plaza Suites, Bear Lodge
36,37 Delta Whistler Village Suites
38 Municipal Hall
41 Future Audain Art Museum
42 Maurice Young Millennium Place
43 Town Plaza Suites, Eagle Lodge
44 Town Plaza Suites, Deer Lodge
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47 Whistler Pinnacle
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52 Alpenglow
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91 Cedar Ridge
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Exhibitors List

On behalf of the Canadian Meteorological and Oceanographic Society and the American Meteorological Society we would like to thank all the Congress Exhibitors.

Liste des exposants

Au nom de la Société Canadienne de Météorologie et d'Océanographie et de la Société Américaine de Météorologie, nous tenons à remercier tous les exposants du congrès.

Booth Kiosque	Exhibitor Exposant	Website Site web
1	---	---
2	ASL Environmental Sciences Inc.	http://www.aslenv.com
3	CMOS	http://www.cmos.ca
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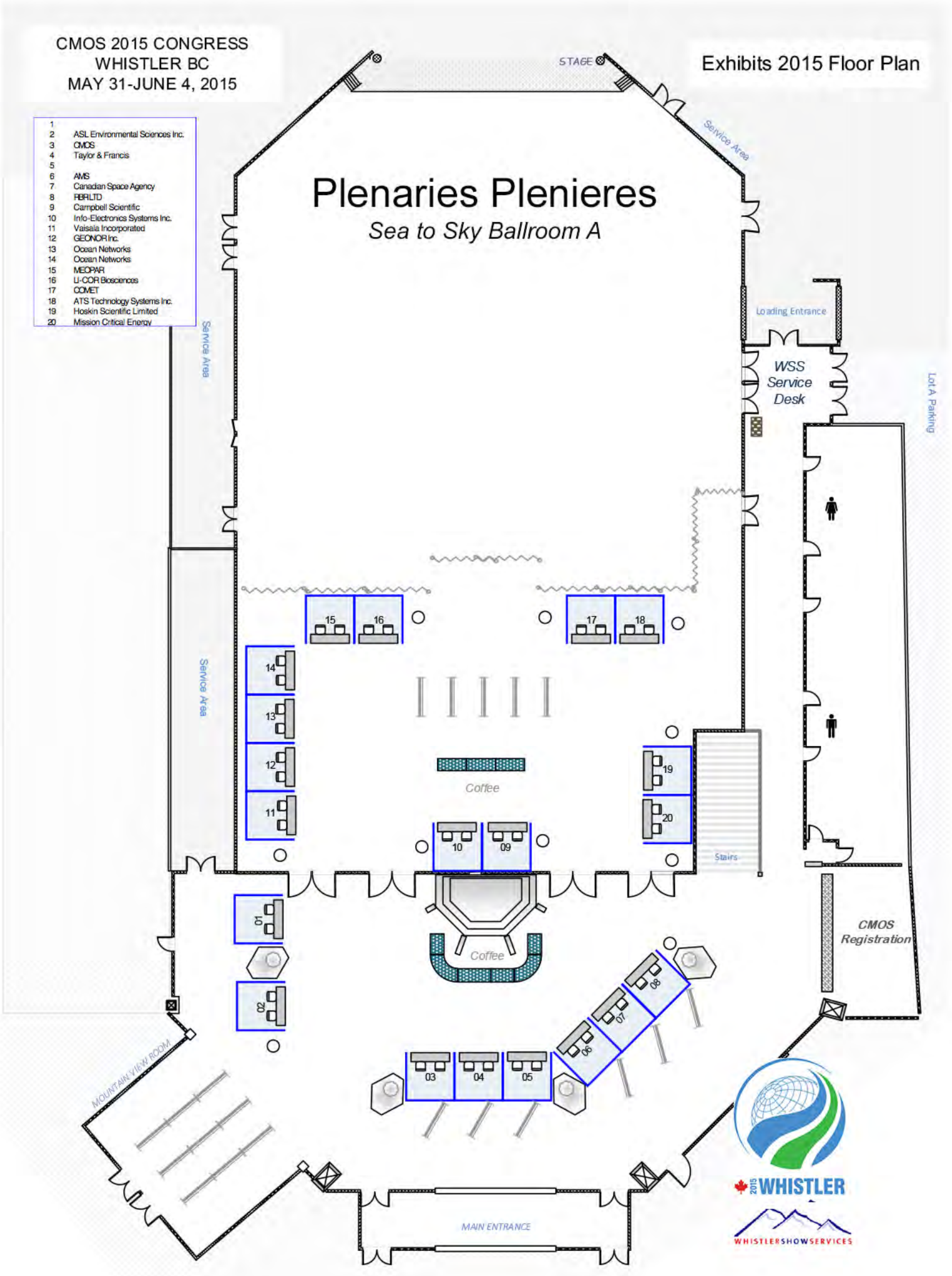

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Public Lecture| Conférence publique
Captain Kurt Salchert
Royal Canadian Navy (Retired)

Arctic Collaboration: challenges and opportunities in building global partnerships

Collaboration dans l'Arctique : défis et opportunités durant l'établissement des partenariats mondiaux

Tuesday, June 2 at 7:00 p.m. | Mardi, 2 juin, 19h00

Problem statement

In an increasingly inter-connected, inter-dependent and rapidly changing globalized world, there continues to be an absence of habitual and persistent relationships across the global maritime and Arctic communities of Interest, which is essential to developing a comprehensive shared understanding of the Maritime Domain, and in particular the Arctic region. The unprecedented changes which are occurring in the Maritime Domain as a direct or indirect result of changes which are occurring in the Arctic region are clear and unequivocal; however, without a comprehensive shared understanding of these unique domains, decision-makers from around the world are faced with the challenge of making and enforcing decisions of potentially geo-strategic significance on the basis of scanty, incomplete or wrong information.

Background

The Arctic community of interest and indeed the broader global maritime community of interest is made up of stakeholders representing international, national, regional, state and local government, academic and business communities, international organizations, non-governmental organizations, think tanks, special interest groups, as well as individual citizens.

The overall safety, security and health of the Arctic and maritime domains, as well as the efficiency and resilience of a global supply chain which is steadily becoming more reliant on ocean resources and maritime transportation routes, depends on both the physical flow of materials and goods as well as information flow from origin to destination. There is little benefit to the overall management of the Arctic and maritime domains (and those activities and interests which influence or are influenced by these domains) if certain links or stakeholders are maintaining habitual and persistent relationships while others are not, or if there are shortfalls in information sharing and collaboration among stakeholders.

It is the total performance of this highly complex system that is relevant. The world has become a system of systems in which people, cargo, conveyances, information, the physical environment, as well as real and virtual

infrastructure are linked into intricate patterns of dependency with other inter-modal transportation methods and facilities spread around the world; and, in fact, the Arctic and maritime domains cannot be looked at in isolation from the broader air, space, land and cyber domains due to the various dependencies and inter-dependencies of this complex system of systems.

Aim

To share unique insights into the challenges of relationship-building across key stakeholders of the global maritime and Arctic communities of interest and to propose a number of potential solutions, solution enablers and possible areas for further research to enhance Arctic and Maritime Domain Awareness in order to enable timely and well-informed decisions and actions related to this area of geo-strategic significance.

Methodology

This assessment will be based on my previous academic research and on my recent professional experiences while serving in Washington, D.C. as Commander North American Aerospace Defense Command (NORAD) and U.S. Northern Command's primary Canadian advisor in the U.S. national capital. With offices at the Embassy of Canada and various locations throughout the U.S. defence, intelligence and interagency communities, I was responsible for nurturing strong collaborative relationships with stakeholders from around the globe to facilitate dialogue between national security planners, political decision-makers, industry, and academic stakeholders with

actionable insights regarding the most significant global strategic challenges of the day; including understanding the various global interests in a rapidly changing Arctic.

In addition to sharing insights gathered from my time serving in Washington, I plan to present the findings of a study undertaken for a consortium of multinational clients to improve global security and domain awareness. This project identified 8 key Capability Focus Areas which form the foundation for building habitual and persistent relationships across the global maritime community of interest and developing a comprehensive shared understanding of the maritime environment in order to improve decision-making. The findings of this study are applicable to the Arctic and any other geographic location with ties to the Maritime Domain.

Participants will leave the conference with a deeper appreciation of the challenges of relationship-building across key stakeholders of the global Arctic and maritime communities of interest and better informed of potential solutions, solution enablers and areas for future study and research.

Énoncé du problème

Dans un contexte de mondialisation, d'interconnexion et d'interdépendance croissantes, il n'existe toujours pas de relations internationales routinières et durables entre les communautés s'intéressant à la mer et à l'Arctique. Relations qui s'avèrent essentielles au développement d'une compréhension totale et partagée du domaine maritime, en particulier la région arctique. Les changements sans précédent qui se manifestent dans le domaine maritime et qui découlent directement ou indirectement des changements que connaît la région arctique s'avèrent évidents et sans équivoque. Toutefois, sans une comprehension totale et partagée de ces domaines particuliers, les décideurs de tout pays devront prendre des décisions potentiellement stratégiques touchant la planète et les appliquer sur la base d'informations insuffisantes, incomplètes ou erronées.

Rappel des faits

La communauté s'intéressant à l'Arctique, tout comme la communauté mondiale des sciences de la mer en général, se compose d'intervenants représentant des gouvernements nationaux, régionaux et locaux, des organisations internationales et non gouvernementales, des universités et des communautés d'affaires, des groupes de réflexion, des groupes d'intérêts spéciaux, ainsi que des particuliers.

La sûreté, la sécurité et la vitalité des domaines arctique et maritime, ainsi que l'efficacité et la résilience de la chaîne mondiale d'approvisionnement, laquelle compte de plus en plus sur les ressources océaniques et les routes de transport maritime, dépendent à la fois de l'acheminement physique de matières et de biens, ainsi que de la transmission d'informations, de l'origine à la destination. La gestion globale des domaines arctique et maritime (y compris des activités et intérêts qui influent sur ces domaines ou sont influences par ceux-ci) offrira peu si certains intervenants maintiennent des relations routinières et durables, alors que d'autres ne le font pas, ou si le partage d'information et la collaboration entre parties intéressées restent insuffisants.

C'est l'efficacité globale de ce système hautement complexe qui compte. Le monde consiste en un système de systèmes dans lequel les gens, le fret, le transport, les informations, l'environnement physique, ainsi que les infrastructures réelles et virtuelles forment des réseaux complexes de dépendance avec le transport intermodal, et au sein duquel des installations s'implantent, partout sur la planète. De fait, on ne peut étudier les domains arctique et maritime isolément, sans inclure les domaines atmosphérique, spatial et terrestre, et le cyberespace, et ce, en raison des dépendances et interdépendances variées qui caractérisent ce système complexe de systèmes.

Objectif

Partager des idées inédites concernant le renforcement de liens entre les intervenants principaux internationaux des communautés d'intérêt visant les domaines arctique et maritime. Proposer des solutions possibles, des leviers et des champs de recherché prometteurs pour sensibiliser les collectivités à l'Arctique et au domaine maritime, de façon à faciliter la prise de décision et la mise en place de mesures utiles et fondées, en ce qui a trait à ce sujet d'importance géostratégique

Méthodologie

Cette évaluation s'appuiera sur mes recherches universitaires et sur l'expérience professionnelle récente que j'ai acquise à Washington D.C., en tant que commandant du Commandement de la défense aérospatiale de l'Amérique du Nord (NORAD) et conseiller principal aux affaires canadiennes au sein du Northern Command des États-Unis. En poste à divers bureaux au sein de l'ambassade du Canada et ailleurs dans des organismes américains militaires, de renseignements ou interorganisation, je m'occupais de renforcer la collaboration internationale des parties intéressées, afin de faciliter le dialogue entre les planificateurs de la sécurité, les décideurs politiques, l'industrie et les universités, et ce, en proposant des idées concrètes sur les enjeux stratégiques actuels les plus importants, y compris la compréhension des intérêts mondiaux variés que suscite l'évolution rapide de l'Arctique.

En plus de partager les idées approfondies durant ma période de travail à Washington, je présenterai les conclusions d'une étude entreprise pour un consortium de clients multinationaux, et visant à améliorer la sûreté mondiale et à éveiller l'intérêt pour le domaine maritime. Ce projet a mis au jour huit secteurs d'intervention privilégiés, qui forment la base de relations routinières et

durables au sein des communautés d'intérêt mondiales se préoccupant du domaine maritime, et qui favoriseraient le développement de connaissances complètes et partagées de l'environnement maritime, afin d'améliorer la prise de décision. Les conclusions de cette étude s'appliquent à l'Arctique et à toute zone géographique liée au domaine maritime.

Les participants retireront de cette conférence une compréhension approfondie des enjeux relatifs au renforcement des rapports entre les principaux intervenants des communautés d'intérêt concernées par l'Arctique et le domaine maritime. Ils prendront aussi conscience de pistes de solutions potentielles, de leviers, et de champs d'étude et de recherché prometteurs.

Biography

A recently retired naval officer and decorated combat veteran, Kurt Salchert now brings his extensive expertise and leadership in Arctic and Maritime affairs to the private sector.

Upon leaving public service in 2014, Kurt founded Beyond the Border Consulting Ltd. an executive-level professional services firm that provides tailored support to governments, NGOs and corporations to help them make sense of and respond to complex, cross-disciplinary challenges. Over the past year, he has provided customized services to a consortium of multinational clients to understand and mitigate gaps and seams in maritime global supply chain security and critical infrastructure resilience. He has been retained to support concept development, planning and execution of Canadian government national-level exercises as well as live/synthetic incident response and decision---support training through the use of state-of-the-art C4ISR systems. Recognized as an authority on the Arctic and remote sensing and advanced decision-support technologies, he was sought by name to provide specialist insights at the 2013 Canadian Symposium on Remote Sensing. He is currently focused on delivering leading-edge renewable energy and breakthrough icephobic materials to the North American marketplace.

Kurt spent his final years of public service in Washington, D.C. where he was handpicked as Commander North American Aerospace Defense Command (NORAD) and U.S. Northern Command's primary Canadian advisor in the U.S. national capital. With offices at the Embassy of Canada and various locations throughout the U.S. defence, intelligence and interagency communities, he was responsible for nurturing strong collaborative relationships with stakeholders from around the globe to facilitate dialogue between national security planners, political decision-makers, industry, and academic stakeholders with actionable insights regarding the most significant global strategic challenges of the day; including how to address competing interests in a changing Arctic. Drawing on his experience as the senior NORAD delegate to the Canadian Arctic Security Working Group, he shared unique Canadian insights with such distinguished fora as the Canada-United States Permanent Joint Board on Defence, the Military Operations Research Society, and the United States Navy Task Force Climate Change.

Over a distinguished 30-year career, Kurt has held command and senior leadership appointments in virtually every class of Canadian warship as well as United Nations riverine and coastal Patrol Vessels. His decades of sea experience have been complemented by diverse duties ranging from leading small multinational strategic advisory teams in Cambodia to managing large scale multi-disciplinary operations both at home and abroad. As a former Director of Operations at the Canadian Forces Joint Headquarters in Kingston, Ontario, he served on a rotational basis as the Commanding Officer of Canada's Disaster Assistance Response Team (DART) and Joint Task Force Theatre Activation Team; both maintained in readiness to deploy globally on extremely short notice. Major accomplishments included his appointment as Liaison Officer to Commander U.S. Central Command in Tampa and Qatar coordinating operational planning for Canadian contributions to the Global War on Terrorism and leading crisis-action planning for the deployment of highly specialized military capabilities to evacuate Canadian citizens from Haiti during the fall of ex-President Aristide – an extremely time-critical, high-stakes operation.

Kurt holds a Bachelor of Arts degree in Military and Strategic Studies from Royal Roads Military College and is a graduate from the Canadian Forces College. He earned his Master's Degree in Defence Studies from the Royal Military College of Canada authoring his thesis entitled Northern Apathy - The time has come for the Canadian government to take immediate and substantial actions to secure effective control over the sovereign waters of the Canadian Arctic Archipelago. Kurt is a veteran of numerous operational tours of duty including appointment with U.S. Central Command in Tampa and Qatar, two deployments with Multinational Forces in Haiti, a tour of duty as a United Nations Military Observer in Cambodia, and deployment on Operation Friction, Canada's contribution to the 1990 - 1991 Gulf War. He is the recipient of numerous honours and awards for his service in both peace and war including, most recently, the United States Meritorious Service Medal conferred by President Barack Obama for his role in disrupting a significant transnational security threat to North America.

Plenaries | Plénières

Monday, June 1, 8:30 a.m.
Lundi, 1 juin, 08h30

David Battisti

Recent decadal trends in the tropical Pacific and their impact on Antarctic and the Arctic

Tendances décennales récentes dans le Pacifique tropical et leurs impacts sur l'Arctique et l'Antarctique

ABSTRACT: The global average temperature increased rapidly from about 1980 to 2000, but it has not increased appreciably in the past 15 years or so – despite a significant increase in atmospheric carbon dioxide. The stall in the rise in global temperature, called the "hiatus", is due in large part to a decrease in the sea surface temperature in the eastern tropical and subtropical Pacific. In this talk, I will present results that demonstrate the decadal-scale trends in the tropical Pacific were likely responsible for the destabilization of the Pine Island Glacier and other ice shelves in West Antarctic in the 1990s, and for about half of the remarkable warming over Greenland and northeast Canada in the past 15 years.

Several hypotheses have been put forward to describe the global hiatus and the tropical Pacific temperature trends – ranging from natural variability to a regional response to human activity (increased carbon dioxide or atmospheric aerosols). I will review these ideas, argue that climate models used by the IPCC are incapable for evaluating these hypotheses, and suggest a way forward so that we can better understand the cause of past climate variability and improve the projections of future climate.

RÉSUMÉ: La moyenne mondiale de température a augmenté rapidement durant les années 1980 à 2000, mais n'a pas augmenté autant au cours des quelque quinze dernières années, malgré une hausse importante de dioxyde de carbone dans l'atmosphère. Cette discontinuité dans l'élévation des températures mondiales, appelée « hiatus », est surtout due à la baisse de la température superficielle de la mer dans la portion est du Pacifique tropical et subtropical.

La présentation portera sur les résultats démontrant que les tendances à l'échelle décennale dans le Pacifique tropical sont vraisemblablement responsables de la déstabilisation du glacier Pine Island et d'autres nappes glaciaires de l'Antarctique occidental dans les années 1990, et d'environ la moitié du remarquable réchauffement du Groenland et du nord- est du Canada durant les quinze dernières années.

Nombre d'hypothèses ont vu le jour pour décrire cet hiatus mondial et les tendances de températures dans le Pacifique tropical; hypothèses allant de la variabilité naturelle à une réaction régionale résultant de l'activité humaine (augmentation du dioxyde de carbone ou des aérosols atmosphériques). Je vais examiner ces idées, soutenir que les modèles de climat qu'utilise le GIEC sont incapables d'évaluer ces hypothèses et proposer une façon de progresser, afin de comprendre la cause de la variabilité passée du climat et d'améliorer les projections du climat futur.

BIO: David Battisti is The Tamaki Endowed Chair of Atmospheric Sciences at the University of Washington. His research is focused on understanding the natural variability of the climate system. He is especially interested in understanding how the interactions between the ocean, atmosphere, land and sea ice lead to variability in climate on time scales from seasonal to decades. His previous research includes coastal oceanography, the physics of the El Nino/Southern Oscillation (ENSO) phenomenon, midlatitude atmosphere/ocean variability and variability in the coupled atmosphere/sea ice system in the Arctic. Battisti is presently working to reduce the

uncertainty in the response of ENSO to external forcing, to understand the impact of major orographic features on climate for the past 50 Myr, and to better understand the monsoons. He is also working on the impacts of climate variability and climate change on global food production.

Battisti has served as the Director of the Joint Institute for the Study of the Atmosphere and Ocean at UW, the co-chair of the Science Steering Committee for the U.S. Program on Climate Variability (US CLIVAR), and on several Committees of the National Research Council. He has published over 100 papers in peer-review journals in atmospheric sciences and oceanography, and twice been awarded distinguished teaching awards.

BIO: David Battisti est titulaire de la chaire Tamaki pour les sciences atmosphériques de l'Université de Washington. Ses recherches visent à expliquer la variabilité naturelle du système climatique. D. Battisti cherche notamment à comprendre comment les interactions entre l'océan, l'atmosphère, la terre et la glace de mer régissent la variabilité du climat aux échelles saisonnières à décennales. Ses recherches précédentes portaient, entre autres, sur l'océanographie côtière, la physique du phénomène El Niño-oscillation australe (ENSO), la variabilité atmosphérique et océanique des latitudes moyennes, et la variabilité du système couplé atmosphère-glace marine dans l'Arctique. D. Battisti travaille actuellement à réduire l'incertitude pesant sur la réaction du phénomène ENSO au forçage externe, afin de comprendre l'impact de barrières orographiques majeures sur le climat des 50 derniers millions d'années, et de comprendre les moussons. Il étudie aussi les effets de l'évolution et de la variabilité du climat sur la production alimentaire mondiale.

Il a occupé le poste de directeur du Joint Institute for the Study of the Atmosphere and Ocean de l'Université de Washington et celui de coprésident du Science Steering Committee for the U.S. Program on Climate Variability (US CLIVAR). En outre, il a siégé à plusieurs comités du conseil national de recherche américain. D. Battisti a publié plus d'une centaine d'articles sur l'atmosphère et l'océanographie dans des revues avec comité de lecture, et a reçu à deux reprises un prix soulignant l'excellence de son enseignement.

Monday, June 1, 9:15 a.m.
Lundi, 1 juin, 09h15

Elizabeth Barnes

Assistant Professor, Professeure adjointe
Colorado State University

The impact of Arctic warming on the midlatitude jetstream: Can it? Has it? Will it?

La transformation du courant-jet des latitudes moyennes résultant du réchauffement de l'Arctique: est-ce possible? Est-ce fait? Est-ce à prévoir?

ABSTRACT: The Arctic region has warmed more rapidly than the globe as a whole, and this has been accompanied by unprecedented sea ice melt. Such large environmental changes are already having profound impacts on those that live in the Arctic region. An open question, however, is whether these Arctic changes have an effect on weather patterns farther south. This broad question has recently received a lot of scientific and media attention, but conclusions appear contradictory rather than consensual. We argue that one point of confusion has arisen due to ambiguities in the exact question being posed. Here we frame our inquiries around three clear and tractable questions: Can Arctic warming influenced the midlatitude jet stream? Has Arctic warming significantly influenced the midlatitude jetstream? Will future Arctic warming significantly influence the midlatitude jet stream? Here, we will frame a discussion of jetstream variability around these three questions: Can it?, Has it?, Will it?; however, we note that these three questions are still a long way from being fully answered.

RÉSUMÉ: La région arctique s'est réchauffée plus rapidement que l'ensemble de la planète. Cette situation a entraîné une fonte des glaces sans précédent. Cette importante modification de l'environnement a déjà profondément perturbé les habitants de la région arctique. Une question demeure, toutefois. Les changements touchant l'Arctique ont-ils une incidence sur les systèmes météorologiques au sud? Ce thème a récemment reçu une attention accrue de la part des scientifiques et des médias, mais les conclusions semblent se contredire plutôt que de s'accorder. Nous pensons que la confusion émane du fait que la question posée est ambiguë. Nous allons donc restreindre notre étude à trois questions claires et raisonnables.

Le réchauffement arctique peut-il transformer le courant-jet des latitudes moyennes? Le réchauffement arctique a-t-il transformé de manière significative le courant-jet des latitudes moyennes? Le réchauffement arctique transformera-t-il de manière significative le courant- jet des latitudes moyennes? Nous limiterons donc la discussion sur la transformation du courant-jet à ces trois questions ainsi reformulées : est-ce possible? Est-ce fait? Est-ce à prévoir? Toutefois, il est à noter que ces trois questions sont loin d'être entièrement résolues.

BIO: Elizabeth (Libby) Barnes is an Assistant Professor at Colorado State University. She received her PhD from the University of Washington in 2012 and then took a 1-year postdoc as a NOAA Climate and Global Change Fellow at the Lamont-Doherty Earth Observatory before starting her position at CSU. Prof. Barnes' research focuses on the midlatitude circulation in the past, present and future. Recently, she has done work on the response of the jet-streams and their variability to future climate warming as well as how atmospheric transport and mixing by synoptic systems may vary under different climate states.

BIO: Elizabeth (Libby) Barnes est professeure adjointe à la Colorado State University. Elle a obtenu un doctorat de l'Université de Washington en 2012 et une bourse de recherche postdoctorale (climat et évolution mondiale) de la NOAA, pour travailler à l'observatoire terrestre Lamont-Doherty, avant d'occuper son poste à l'université.

Ses recherches portent sur la circulation passée, présente et future dans les latitudes moyennes. Récemment, E. Barnes a étudié la réaction et la variabilité des courants-jets relativement au réchauffement climatique futur. Elle a aussi examiné comment varient le transport et le mélange atmosphériques que génèrent les systèmes synoptiques, et ce, suivant différentes situations climatiques.

Tuesday, June 2, 8:30 a.m.
Mardi, 2 juin, 08h30

Mary-Louise Timmermans
Assistant Professor, Professeure adjointe
Yale University

Arctic Ocean scales of variability and change

Échelles de variabilité et d'évolution de l'océan Arctique

ABSTRACT: This talk will review highlights of recent Arctic Ocean measurements, encompassing a wide range of temporal and spatial scales, in an exploration of ocean drivers of sea ice and climate change. Arctic freshwater dynamics, ocean heat and mixing processes, circulation and eddies, and atmosphere-ice-ocean interactions and their interrelationships will be surveyed. Observations indicate apparently rapid changes in the basin-scale freshwater distribution that have marked effects on Arctic stratification. Recent measurements support the idea that a strengthened stratification limits the vertical flux of deep-ocean heat. All ocean layers exhibit a rich mesoscale eddy field. Measurements further reveal an active submesoscale flow field that modifies heat, salt, and momentum fluxes between

the ocean and adjacent sea-ice cover. Pervasive double-diffusive structures link the smallest to the largest spatial scales of variability in the Arctic, and allow for constraints to be placed on the regional and temporal changes in the transfer of heat and salt.

RÉSUMÉ: Cette présentation résumera les récentes activités de mesure réalisées dans l'océan Arctique et couvrant une large gamme d'échelles temporelles et spatiales, afin d'explorer les changements climatiques et les facteurs océaniques régissant la glace de mer. Nous examinerons la dynamique des eaux douces de l'Arctique, la chaleur et le mélange dans l'océan, la circulation et les tourbillons, les interactions atmosphère-glace-océan, et leur interdépendance. Les observations laissent voir des changements rapides dans la répartition d'eau douce à l'échelle du bassin. Ceux-ci perturbent notablement la stratification de l'océan Arctique. Des mesures récentes étayent l'hypothèse qu'une stratification accrue limite le flux vertical de la chaleur de l'océan profond. Toutes les couches de l'océan montrent des courants tourbillonnaires considérables à l'échelle moyenne. Ces mesures révèlent aussi un écoulement actif à l'échelle sous-méso, lequel modifie les flux de chaleur, de sel et de quantité de mouvement entre l'océan et la couverture de glace marine adjacente. Des structures généralisées favorisant la diffusion double lient les plus petites échelles de variabilité spatiale aux plus grandes. Elles imposent donc certaines contraintes aux modifications régionales et temporelles du transfert de chaleur et de sel.

BIO: Mary-Louise Timmermans is an Assistant Professor in the Department of Geology & Geophysics at Yale University. Her principal research focus is investigating the dynamics and variability of the Arctic Ocean to better understand how the ocean impacts Arctic sea ice and climate. Her approach is to apply theoretical models to geophysical observations, including measurements from an ice-based network of drifting automated ocean-profiling instruments, and hydrographic measurements from icebreaker surveys. Her research includes investigations of ocean mixing, eddies, waves, double-diffusive heat transport, and freshwater and heat content in the upper Arctic Ocean. She received a B.S. in physics at the University of Victoria, and her PhD is in fluid mechanics from Cambridge University.

BIO: Mary-Louise Timmermans est professeure adjointe au département de géologie et de géophysique de l'Université Yale. Elle étudie principalement la dynamique et la variabilité de l'océan Arctique, afin de comprendre les impacts de l'océan sur la glace marine et le climat. Mary-Louise applique des modèles théoriques aux observations géophysiques, y compris des mesures issues d'un réseau de profileurs océaniques automatisés dérivant avec la glace et des mesures hydrographiques provenant de sondages réalisés à partir de brise-glaces. Ses recherches incluent des études sur le mélange, les tourbillons, les vagues, le transport de chaleur en diffusion double dans l'océan, et le contenu en eaux douces et en chaleur des couches supérieures de l'Arctique. Elle détient un baccalauréat en physique de l'Université de Victoria et un doctorat en mécanique des fluides de l'Université de Cambridge.

Tuesday, June 2, 9:15 a.m.
Mardi, 2 juin, 09h15

Marika Holland
National Center for Atmospheric Research

Factors influencing the surface albedo feedback in coupled climate models

Facteurs agissant sur la rétroaction liée à l'albédo de la surface dans les modèles climatiques couplés

ABSTRACT: Amplified Arctic surface warming in response to rising greenhouse gas concentrations, or

so called Arctic Amplification, is a ubiquitous feature of climate model simulations. However, the magnitude of this amplification varies considerably across models, in part due to differing strengths of the simulated surface albedo feedback. Numerous factors influence the surface albedo response to rising greenhouse gas concentrations. These include changes in sea ice surface properties, ice-covered area, and snow conditions. Here we assess a number of these factors using simulations from a large ensemble of the Community Earth System Model and simulations from other models participating in the Coupled Model Intercomparison Project 5 (CMIP5). This includes an analysis of aspects that contribute to the spread across models in projected albedo change and Arctic Amplification. The results provide insight on the uncertainty in future projections, possible methods to better constrain those projections, and model development needs.

RÉSUMÉ: L'amplification du réchauffement de la surface en Arctique, en réaction à la hausse des concentrations de gaz à effet de serre, est appelée amplification arctique et est une caractéristique omniprésente des modèles de simulation climatique. Toutefois, l'intensité de cette amplification varie considérablement d'un modèle à l'autre. Ces différences proviennent en partie de l'ampleur de la rétroaction liée à l'albédo simulé de la surface. De nombreux facteurs régissent la variation de l'albédo de la surface que provoquent les concentrations accrues de gaz à effet de serre. Ils comprennent la modification des propriétés de la surface de la glace marine, de l'étendue des zones de glace et des conditions nivales. Nous évaluerons certains de ces facteurs à l'aide de simulations provenant d'un large ensemble du Community Earth System Model (modèle communautaire du système terrestre) et des simulations issues d'autres modèles utilisés dans le cadre du Coupled Model Intercomparison Project 5 (projet d'intercomparaison de modèles couplés ou CMIP5). Ce qui inclut une analyse des facteurs qui contribuent à l'écart entre les valeurs prévues d'albédo et celles de l'amplification arctique, d'un modèle à l'autre. Les conclusions donnent un aperçu de l'incertitude des projections à venir, des méthodes possibles pour circonscrire ces projections et des besoins relatifs au développement de modèles.

BIO: Dr. Marika M. Holland is a Senior Scientist in the Climate and Global Dynamics Division at the National Center for Atmospheric Research. Her research interests are focused on the role of sea ice in the climate system, including secular sea ice change, sea ice predictability, and polar climate variability. Dr. Holland has extensive experience using coupled climate models to study polar climate variability and change and has been active in the development of improved sea ice models for climate simulations. She has served as co-chair for the Polar Climate Working Group of the Community Earth System Model and Chief Scientist for the Community Earth System Model project. She has been a contributing author on the Intergovernmental Panel on Climate Change third, fourth, and fifth assessment reports, contributed to numerous other national and international assessments on the changing Arctic climate, and is an author on over 70 peer-reviewed publications. Dr. Holland received her Ph.D. in Atmosphere and Ocean Sciences from the University of Colorado in 1997 and performed a Postdoctoral fellowship at the University of Victoria in British Columbia before joining the scientific staff of NCAR's Climate and Global Dynamic Division in 1999.

BIO: Marika M. Holland (Ph. D.) est scientifique principale à la division Climate and Global Dynamics du National Center for Atmospheric Research. Ses intérêts de recherche portent sur le rôle de la glace de mer relativement au système climatique, y compris les modifications séculaires et la prédictibilité de la glace de mer, et la variabilité du climat polaire. Madame Holland possède une très grande expérience des modèles climatiques couplés appliqués à l'étude de l'évolution et de la variabilité du climat polaire. Elle a participé activement au développement de modèles améliorés de glace marine, utiles à la simulation du climat. Elle a assumé la coprésidence du groupe de travail du Community Earth System Model (modèle communautaire du système terrestre) et occupé le poste de scientifique en chef du projet sur le Community Earth System Model. En outre, elle a été auteure collaboratrice des 3e, 4e et 5e rapports d'évaluation du Groupe d'experts intergouvernemental sur l'évolution du climat et a contribué à de nombreuses autres évaluations nationales et internationales sur l'évolution du climat arctique. Elle a rédigé ou corédigé plus de 70 articles révisés par des pairs. Marika Holland a obtenu son doctorat en sciences atmosphériques et océanographiques de l'Université du Colorado en

1997. Elle a occupé un poste de boursière de recherche postdoctorale à l'Université de Victoria (C.-B.) avant de se joindre au personnel scientifique de la division Climate and Global Dynamic du NCAR, en 1999.

Wednesday, June 3, 8:30 a.m.
Mercredi, 3 juin, 08h30

David B. Fissel
Chair and Senior Scientist
ASL Environmental Sciences Inc.

Canadian Arctic Oceanography: present and future research priorities based on lessons from the past

Océanographie de l'Arctique canadien : priorités de recherche présentes et futures selon les leçons apprises

ABSTRACT: Major advances have been realized over the past forty years in our scientific understandings of the physical oceanography and marine ice regime of the Canadian Arctic. These advances have been driven by the increased priority of Arctic research at the Canadian federal government level, albeit often uneven in its application, and more priority at the international level over the past two decades. A related impetus for Arctic oceanography and ice research has been the search for natural resources including offshore oil and gas and mining along with the increased awareness of environmental assessments for proposed industrial developments. Scientifically, the awareness of the importance of the Arctic to climate change and to the global ocean has also been an important driver for Arctic research. Over the past four decades, Canadian Arctic ocean and ice research has been challenged by the remoteness of the area including the high cost of accessing it by ship for short periods in summer. Key enablers of Arctic Ocean and ice research are technological advancements including: satellite and aircraft based remote sensing, advances in underwater instrument arrays to allow year-long observation measurement programs from subsurface moorings; satellite communications systems for allowing data collection from ice- and ocean-based drifting platforms; numerical modeling advances. While improved technology have benefited oceanographic research on a global basis, the benefits have been largest in remote areas of the planet such as the Canadian Arctic. Even with these advances, the Canadian Arctic remains less well understand than for the more temperate oceans adjoining Canada, especially in the long period of ice cover within each year. Scientific understandings must address the high degree of interannual variability in the Arctic, combined with the very large climate changes of the Arctic by comparison to other parts of the world. Key gaps in our present understandings will be presented leading to some proposed research priorities for the future.

RÉSUMÉ: Des progrès scientifiques majeurs ont été accomplis au cours des quarante dernières années en ce qui concerne la compréhension de l'océanographie physique et du régime des glaces marines dans l'océan Arctique. Ces progrès résultent de la priorité accrue, quoique souvent fluctuante, donnée à la recherche sur l'Arctique au sein du gouvernement fédéral canadien, ainsi qu'à la priorité accordée à ce sujet, à l'échelle internationale, au cours des vingt dernières années. La recherche de ressources naturelles au large, y compris le gaz, le pétrole et les minerais, a suscité un engouement supplémentaire pour la recherche liée à l'océanographie de l'Arctique et à la glace, parallèlement à l'intérêt accru soulevé par les évaluations environnementales associées à d'éventuels aménagements industriels. La sensibilisation à l'importance scientifique de l'Arctique relativement aux changements climatiques et aux océans mondiaux a aussi considérablement favorisé la recherche sur cette région polaire.

Au cours des quarante dernières années, la recherche sur l'océan Arctique canadien et sur la glace est demeurée difficile à cause de leur éloignement, qui entraîne des coûts élevés de déplacement par bateau pendant de courtes périodes estivales. Les progrès technologiques sont des outils clés de la recherche sur l'océan Arctique et sur la glace. Ils comprennent la télédétection par satellite et par avion; les séries d'instruments sous-marins qui permettent la mise en place de programme d'observation tout au long de l'année, à partir de mouillages installés sous la surface; les systèmes de communication par satellite qui permettent la collecte de données provenant de plateformes dérivant dans l'océan et avec la glace; les modèles numériques de dernière génération. Bien que ces améliorations technologiques aient profité à la recherche océanographique partout dans le monde, les gains se sont avérés les plus importants dans les régions éloignées de la planète, comme l'Arctique canadien.

Malgré ces avancées, l'Arctique canadien demeure moins bien compris que les océans tempérés qui touchent le pays, notamment en ce qui a trait aux longues périodes annuelles de couverture maximale de glace. Les scientifiques doivent se pencher sur le haut degré de variabilité interannuelle dans l'Arctique combiné aux changements climatiques plus importants dans cette région qu'ailleurs sur la planète. Des suggestions de recherches prioritaires pour le futur seront présentées à la suite d'informations sur les plus importantes lacunes minant notre compréhension.

BIO: After completing an M.Sc. in physical oceanography at the University of British Columbia in 1975, David worked as a research oceanographer at the Institute of Ocean Sciences of the Department of Fisheries and Oceans (DFO) in Sidney B.C. In 1977, he co-founded ASL Environmental Sciences Inc. (originally Arctic Sciences Ltd.), and has held a number of senior positions in the company as it has grown to become Canada's largest physical oceanographic company with a staff of more than 50 highly qualified personnel, mainly scientists and engineers.

Since founding ASL Environmental Sciences Inc. in 1977, David Fissel has managed hundreds of oceanographic projects, involving studies of ocean currents, waves, and sea-ice in various parts of all three oceans bordering Canada as well as overseas projects. Most of these projects involved Arctic research with many of them providing input to the design of offshore oil and gas facilities, port development, or environmental assessment and monitoring for coastal and deepwater developments. In 1996, he founded the Product Division of ASL with the launch of the ASL Ice Profiler. ASL sells underwater acoustic instruments on a global basis, with major markets in the United States, the European Community, Norway, Japan, Korea, and Australia. David has co-authored over 28 papers in peer-reviewed scientific journals and approximately 52 scientific conference papers as well as hundreds of technical reports.

David has served on the Board or local executives of several scientific organizations, industry associations and business community groups. He was the Vice-President, President and Past-President of the Canadian Meteorological and Oceanographic Society (CMOS) from 2009-2012 and is presently on the Boards of: Ocean Initiatives BC (since 2005); the Canadian Ocean Glider Foundation (since 2006); Ocean Networks Canada (Neptune Canada and Venus Ocean Observatories, since 2009) at the University of Victoria; and the Marine Environmental and Observation Prediction and Response (MEOPAR) National Centre of Excellence (NCE) at Dalhousie University (since 2012). He was a member of the Science Advisory Council for Fisheries and Oceans Canada (2005-2009) and he was a founding member of the Science, Technology and Innovation Council of Canada (2007-2010; which reports directly to the Canadian Minister of Industry). While CMOS President, he served as an ex-officio member of the Board of the Canadian Foundation for Atmospheric and Climate Sciences and on the Canadian National Committee for the Scientific Council on Ocean Research (CNC-SCOR). David chaired a Core Panel on the Leading Research Priorities for the Canadian Ocean Science for the Canadian Council of Academies in 2012. He is the CSA Working Group Chair for Metocean international standards (ISO 19901-1).

BIO: Après avoir obtenu une maîtrise en océanographie physique de l'Université de la Colombie-Britannique en 1975, David a travaillé comme chercheur en océanographie à l'Institut des sciences de la mer du ministère des Pêches et des Océans (MPO), à Sidney (C.-B.). En 1977, il a cofondé

ASL Environmental Sciences Inc. (anciennement Arctic Sciences Ltd.) et a occupé plusieurs postes de haut niveau au sein de cette société. Celle-ci constitue maintenant la plus grande entreprise d'océanographie physique au Canada. Elle emploie plus de cinquante personnes hautement qualifiées, pour la plupart des scientifiques ou des ingénieurs.

Depuis la fondation d'ASL Environmental Sciences Inc. en 1977, David Fissel a géré des centaines de projets liés à l'océanographie, comprenant l'étude de courants océaniques, de vagues et de glace marine, dans diverses parties des trois océans entourant le Canada, ainsi que des projets à l'étranger. La plupart de ces projets portaient sur l'Arctique. Certains ont mené à la conception d'installations gazières et pétrolières en mer, à l'aménagement de ports, ou à des évaluations et à de la surveillance environnementales visant des installations côtières et en eau profonde. En 1996, il a fondé la division « Product » d'ASL en lançant un profileur de glace (ASL Ice Profiler). ASL vend des instruments acoustiques sous-marins partout dans le monde. Ses principaux marchés se situent aux États-Unis, au sein de la Communauté européenne, en Norvège, au Japon, en Corée et en Australie. David a corédigé plus de 25 articles publiés dans des revues scientifiques avec comité de lecture, près de 50 communications scientifiques, ainsi que des centaines de rapports techniques.

Il a siégé au conseil ou à la direction locale de plusieurs organisations scientifiques, d'associations d'industries et de groupes d'affaires. Il a été vice-président, président et président sortant de la Société canadienne de météorologie et d'océanographie (SCMO) de 2009 à 2012, et siège actuellement au conseil des organismes suivants : Ocean Initiatives BC (depuis 2005); Canadian Ocean Glider Foundation (depuis 2006); Ocean Networks Canada (observatoires Neptune Canada et Venus Ocean, depuis 2009) de l'Université de Victoria; Marine Environmental and Observation Prediction and Response (MEOPAR) du Réseau de centres d'excellence (RCE) de l'Université Dalhousie (depuis 2012). Il était membre du Comité consultatif scientifique pour les pêches et les océans (2005 à 2009) et membre fondateur du Conseil des sciences, de la technologie et de l'innovation (2007 à 2010), qui relève directement du ministre canadien de l'Industrie. Tandis qu'il présidait la SCMO, David a été membre d'office de la Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA) et du Comité national canadien du Comité scientifique pour les recherches océaniques (CNC du SCOR). En 2012, il a assumé la présidence du groupe-cadre d'experts sur les questions de recherche prioritaires en océanographie canadienne relevant du Conseil canadien des académies. Il est président du groupe de travail de la CSA pour les normes internationales océano-météo (ISO 19901-1).

Wednesday, June 3, 9:15 a.m.
Mercredi, 3 juin, 09h15

Nadja Steiner

Marine biogeochemistry in the Arctic
Biogéochimie marine dans l'Arctique

ABSTRACT: Climate change forces multiple stressors on Arctic marine ecosystems, such as warming, sea-ice retreat, ocean acidification and enhanced stratification limiting food supply. Expanding economic development might cause additional stressors, e.g. pollution and potential oil spills. Many changes are faster and more profound in the Arctic than in any other region of the world ocean, hence the study of marine biogeochemical processes in high latitudes has received a boost of attention in the last two decades. With a variety of projects including intense measurement programs we somewhat belatedly struggle to establish some baseline before potentially irreversible system changes occur. Projecting future ecosystem responses to climate change and other potential stressors requires the application of numerical

ecosystem models. The 5th Coupled Model Intercomparison Project (CMIP5) includes for the first time a variety of Earth system models (ESMs, model systems with fully coupled atmosphere, ocean, sea ice and land components including interactive biogeochemical modules for all components), allowing the study of future projections of the marine carbon cycle and ecosystem behavior. However, the still fairly coarse horizontal and vertical resolution restricts the ability to resolve biological or chemical processes happening in the euphotic zone as well as small-scale physical processes important for biogeochemistry. Model skill for biogeochemical variables in global ESMs is still low, especially for the Arctic, where observational data are few and seasonally biased, and where shelf areas and narrow passages are common features. I will provide an update of results from ESM intercomparison studies in the Arctic which show both consistent trends (e.g. acidification) as well as differences (e.g. future primary production) among the models. I will discuss the shortcomings in ESMs and improvements obtained with the application of higher resolution regional models. In addition I will highlight the use of 1-D models in the development of model parameterizations, including biogeochemical, mixing, gas and radiative transfer processes. An example is the 1D General Ocean Turbulence Model (GOTM) plus sea ice which is used for physical forcing and coupled to biogeochemistry modules via the Framework for Aquatic Biogeochemical Models (FABM). Following a main focus on the pelagic ecosystem, I will then guide some attention to sea-ice biogeochemistry. Our knowledge of the role sea-ice biogeochemical processes play in local and global systems is severely limited by our poor confidence in numerical model parameterisations representing those processes. Improving those parameterisations requires communication between observationalists and modellers to both guide model development and improve the aquisition and presentation of observational results. In addition to more observations, we need conceptual and quantitative descriptions of the processes controlling e.g. the incorporation and release of sea ice algae, the magnitude and limits of primary production, and the release or absorption of radiatively active gases, such as CO2 and DMS. I will present some guidelines to help modellers, and observationalists improve the integration of measurements and modelling efforts and advance towards the common goal of understanding the biogeochemical processes involved and their impacts on environmental systems.

RÉSUMÉ: Les changements climatiques imposent de multiples facteurs de stress sur les écosystèmes marins de l'Arctique : réchauffement, recul de la glace de mer, acidification des océans et renforcement de la stratification limitant la disponibilité des aliments. Le développement économique pourrait ajouter des facteurs de stress supplémentaires, par exemple, la pollution et d'éventuels déversements d'hydrocarbures. Beaucoup de changements se manifestent plus rapidement et plus profondément dans l'Arctique que dans toute autre région océanique de la planète. Ainsi, l'étude des processus biogéochimiques marins dans les hautes latitudes a connu un regain d'intérêt au cours des vingt dernières années.

Grâce à divers projets comprenant des programmes de mesures intenses, nous nous sommes tardivement efforcés de déterminer un état de base avant que des modifications potentiellement irréversibles ne touchent le système. La prévision de la réaction future des écosystèmes suivant l'évolution du climat et d'autres facteurs de stress éventuels nécessite l'application de modèles numériques simulant ces écosystèmes.

Le cinquième projet d'intercomparaison des modèles couplés (CMIP5) comprend pour la première fois une série de modèles du système terrestre (Earth System Models ou ESM). Ces modèles entièrement couplés incluent des composantes pour l'atmosphère, la mer, la terre et la glace de mer, ainsi que des modules biogéochimiques pour toutes ces composantes. Ils permettent l'étude de l'évolution future du cycle du carbone marin et du comportement des écosystèmes. Toutefois, les résolutions horizontales et verticales plutôt grossières des simulations limitent la capacité de résoudre les processus biologiques et chimiques qui surviennent dans la zone euphotique, ainsi que la physique de petite échelle, qui influe grandement sur les processus biogéochimiques. La capacité des modèles du système terrestre à prévoir les variables biogéochimiques demeure inadéquate, notamment pour l'Arctique, où les observations sont rares et comportent un biais saisonnier, et où les plateaux et les passages étroits ne manquent pas.

Je présenterai une mise à jour des résultats de l'intercomparaison des modèles du système terrestre

pour l'Arctique, qui montrent d'un modèle à l'autre des tendances cohérentes (p. ex. pour l'acidification), ainsi que des différences (p. ex. pour la production primaire future). Je discuterai des faiblesses des modèles du système terrestre et des améliorations obtenues en utilisant des modèles régionaux de résolution supérieure. En outre, je discuterai de l'utilisation de modèles unidimensionnels dans le développement de paramétrisations décrivant les processus biogéochimiques, le mélange, et les transferts gazeux et radiatifs, entre autres. Le General Ocean Turbulence Model (modèle général de turbulence océanique) incluant la glace de mer en est un exemple. Il est utilisé pour les forçages physiques et est couplé aux modules biogéochimiques à l'aide du Framework for Aquatic Biogeochemical Models (cadre pour les modèles aquatiques biogéochimiques) ou FABM.

Après avoir discuté de l'écosystème pélagique, j'attirerai votre attention sur la biogéochimie de la glace marine. La fiabilité insuffisante des paramétrisations des modèles numériques représentant ces processus limite sérieusement nos connaissances sur le rôle que jouent les processus biogéochimiques de la glace marine au sein des systèmes locaux et mondiaux.
L'amélioration de ces paramétrisations nécessite une collaboration entre les spécialistes des observations et les modélisateurs, afin d'orienter le développement des modèles, et d'améliorer l'acquisition et la présentation des résultats d'observation. En plus d'observations supplémentaires, nous avons besoin de descriptions conceptuelles et quantitatives des processus régissant, par exemple, l'incorporation et la libération d'algues de glace, la magnitude et les limites de la production primaire, et le rejet et l'absorption de gaz agissant sur le rayonnement, comme le CO2 et le méthane. Je proposerai des pistes de solutions pour aider les modélisateurs et les spécialistes des observations à améliorer l'intégration des mesures et des activités de modélisation, afin de progresser vers un objectif commun : la compréhension des processus biogéochimiques pertinents et leur impact sur les systèmes environnementaux.

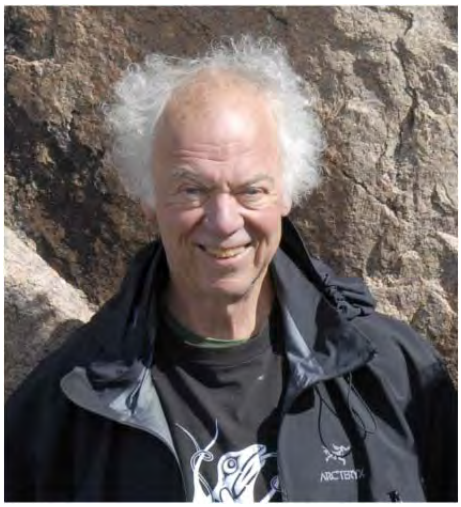
BIO: Nadja Steiner is a research scientist with Fisheries and Oceans Canada (DFO), located at the Institute of Ocean Sciences (IOS) in Sidney, BC, with a temporary assignment to the Canadian Centre for Climate Modelling and Analysis (CCCma). Nadja is originally from Germany. She did her PhD on modelling sea ice roughness at the Institute of Marine Research in Kiel and came to Canada in 2000 to work within the Arctic Ocean Model Intercomparison Project at IOS. She continued on as a PostDoc within Canadian SOLAS where she started modelling ecosystem and gas exchange processes. She now works on the development of coupled atmosphere-ocean ecosystem models to study the marine sulphur and carbon cycles in the North Pacific and Arctic. In collaboration with CCCma's Canadian Earth System Modelling group she is developing parameterizations for Arctic marine ecosystems and evaluates marine ecosystem responses to climate change. She is a contributing author of AMAP's recent and upcoming Arctic Ocean Acidification assessments as well as the AMAP Adaptation Actions for a Changing Arctic (AACA) assessment. She lead the Arctic trends and projections assessment of DFO's Aquatic Climate Change Adaptation Services Program and is co-chair of the SCOR-WG 140 on Biogeochemical Exchange Processes at Sea-Ice Interfaces (BEPSII). She is also an adjunct professor at the University of Victoria.

BIO: Nadja Steiner est chercheuse à l'Institut des sciences de la mer (ISM) du ministère des Pêches et des Océans (MPO), à Sidney (C.-B.) et profite actuellement d'une affectation temporaire au Centre canadien de la modélisation et de l'analyse climatique (CCmaC). Elle est originaire de l'Allemagne. Nadja a reçu un doctorat pour ses travaux sur la rugosité de l'océan, effectués à l'institut de recherche marine de Kiel. Elle est arrivée au Canada en 2000 pour se joindre au projet d'intercomparaison des modèles océaniques appliqués à l'Arctique, au sein de l'ISM. Elle a ensuite entrepris la modélisation d'écosystèmes et de processus d'échanges gazeux dans le cadre canadien du projet SOLAS, grâce à une bourse de recherche postdoctorale. Nadja travaille maintenant sur le développement de modèles couplés atmosphère-écosystème marin, afin d'étudier les cycles du soufre et du carbone marins dans le Pacifique Nord et dans l'Arctique. En collaboration avec le groupe canadien de modélisation du système terrestre du CCmaC, elle développe des paramétrisations simulant les écosystèmes marins arctiques et évalue leur réaction par rapport aux changements climatiques. Elle est auteure collaboratrice de la récente évaluation de l'acidification de l'océan Arctique du Programme de

surveillance et d'évaluation de l'Arctique (PSEA), ainsi que de l'évaluation des mesures d'adaptation relative à l'évolution de l'Arctique de ce même programme. Elle est responsable de l'évaluation des tendances et des projections, laquelle relève du Programme des services d'adaptation aux changements climatiques en milieu aquatique du MPO. Elle est coprésidente du groupe de travail 140 du SCOR, sur les processus d'échange biogéochimique à l'interface mer-glace (BEPSII). Nadja occupe aussi le poste de professeure auxiliaire à l'Université de Victoria.

Thursday, June 4, 8:30 a.m.
Jeudi, 4 juin, 08h30

Garry Clarke



Twenty-first century warming and the deglaciation of Western Canada

Le réchauffement au XXIe siècle et la déglaciation de l'ouest du Canada

ABSTRACT: Glaciers in mountainous parts of Alberta and British Columbia are faring badly in a warming climate. We project their future using a regional glaciation model (RGM): a coupled model of glacier dynamics and surface mass balance. The model is forced by an ensemble of global climate models, downscaled to the 200 m resolution of the RGM, and four climate scenarios (RCP2.6, RCP4.5, RCP6.0 and RCP8.5). Our results indicate that by 2100 the volume of glacier ice in western Canada will shrink by as much as 80% relative to 2005. Most mountain ranges become completely deglaciated, but glaciers near the Pacific coast, in particular those in northwestern British Columbia, will survive in a diminished state. The maximum rate of ice volume loss, corresponding to peak input of deglacial meltwater to streams and rivers, is projected to occur around 2020–2040.

RÉSUMÉ: Les glaciers des régions montagneuses de l'Alberta et de la Colombie-Britannique se portent mal en raison du réchauffement climatique. Nous prévoyons leur état futur à l'aide d'un modèle régional de glaciation (RGM), un modèle couplé simulant la dynamique des glaciers et le bilan massique en surface. Les forçages du modèle proviennent d'un ensemble de modèles globaux de climat, dont l'échelle est réduite à la résolution du RGM, soit 200 mètres, et de quatre scénarios climatiques (RCP2.6, RCP4.5, RCP6.0 et RCP8.5).

Les résultats montrent que d'ici 2100, le volume de glace de glaciers dans l'ouest du Canada fondra de 80 % par rapport au volume de 2005. La plupart des chaînes de montagnes seront complètement libres de glace. Les glaciers près de la côte du Pacifique, notamment ceux du nord-ouest de la Colombie-Britannique, persisteront, mais dans un état réduit. Le taux maximal de perte de volume de glace, qui correspond à l'apport maximal d'eau de fonte de déglaciation atteignant les cours d'eau, est censé se produire vers les années 2020 à 2040.

BIO: Garry Clarke received his doctorate in physics in 1967 from the University of Toronto and is currently Emeritus Professor of Geophysics in the Department of Earth, Ocean and Atmospheric Sciences at the University of British Columbia. His research speciality is glaciology and his particular expertise is in subglacial physical processes, subglacial hydrology, the stability of glaciers and ice sheets, and cryospheric agents of abrupt climate change. He has spearheaded a 35-year glaciological field study in the Yukon Territory, Canada, that involves drilling and extensive use of subglacial instrumentation and he is also active in the development of theory and computational models of glacier and ice sheet dynamics. Clarke has served as President of the International Glaciological Society and the Canadian Geophysical Union and received the highest scientific awards of both these organizations.* He was a lead author of the Third Assessment Report of the Intergovernmental Panel

on Climate Change and a contributing author to the Fourth Assessment. Clarke is a Fellow of the Royal Society of Canada, the American Geophysical Union, and the Arctic Institute of North America.

BIO: Garry Clarke a obtenu un doctorat en physique de l'Université de Toronto. Il est actuellement professeur émérite de géophysique au département des sciences de la Terre, des océans et de l'atmosphère à l'Université de la Colombie-Britannique. Il se spécialise en glaciologie. Ses compétences couvrent notamment les processus physiques et l'hydrologie sous-glaciaires, la stabilité des glaciers et des nappes glaciaires, et les facteurs cryosphériques générant d'abrupts changements climatiques. Il a été le fer de lance d'une étude in situ de 35 ans en glaciologie, au Yukon (Canada). Ses recherches comprenaient des forages et l'utilisation fréquente d'instruments sous-glaciaires. G. Clarke participe aussi activement au développement de théories et de modèles informatiques expliquant la dynamique de glaciers et de nappes glaciaires. Il a été président de la Société internationale de glaciologie et de l'Union géophysique canadienne. Il a en outre reçu les distinctions scientifiques les plus élevées qu'octroient ces deux organismes. Il est l'un des auteurs principaux du Troisième Rapport d'évaluation du Groupe d'experts intergouvernemental sur l'évolution du climat et auteur collaborateur du Quatrième Rapport d'évaluation. G. Clarke est membre de la Société royale du Canada, de l'American Geophysical Union et de l'Institut arctique de l'Amérique du Nord.

Thursday, June 4, 9:15 a.m.
Jeudi, 4 juin, 09h15

Chris McLinden

Eye in the sky: Monitoring air pollution from space

Du haut des airs : la surveillance de la pollution à partir de l'espace

ABSTRACT: Beginning in earnest around 2000, several satellite instruments have been launched that are designed primarily to quantify air pollution levels in the lowermost atmosphere. These "air quality" sensors measure either sunlight reflected by Earth and its atmosphere, or radiation emitted from them, and from this are able to provide global information on a wide range of compounds linked to smog and acid rain. These include ozone, nitrogen dioxide, sulphur dioxide, carbon monoxide, ammonia, particulate matter, and others. Beyond the more straightforward monitoring and trend applications, these measurements are being used in conjunction with atmospheric models to provide insight into current and near-future surface concentrations of these pollutants as well as their rates of emission and their environmental impacts. This talk will: (i) review what types of data are currently available along with their strengths and limitations, (ii) present examples of how these data are applied towards pollution monitoring, trend assessment, emissions, and impacts (including findings from the Alberta oil sands), (iii) discuss challenges unique to Canada and other nations at higher latitudes, (iv) examine what the future may

hold, and (v) touch on how these analyses and results are relevant for policy and decision-makers.

RÉSUMÉ: Concrètement, depuis à peu près 2000, plusieurs instruments embarqués sur des satellites ont été conçus principalement pour quantifier les niveaux de pollution de l'air dans la basse atmosphère. Ces capteurs de « qualité de l'air » mesurent soit la lumière solaire réfléchie par la Terre et l'atmosphère, soit le rayonnement émis par ceux-ci. À partir de ces mesures, il est possible d'obtenir des informations sur une large gamme de composés liés au smog et aux pluies acides, partout sur la planète. Ces substances comprennent l'ozone, le dioxyde d'azote, le dioxyde de soufre, le monoxyde de carbone, l'ammoniac, les matières particulaires et autres. Au-delà des applications habituelles de surveillance et de calculs de tendances, ces mesures sont utilisées avec des modèles atmosphériques, afin d'estimer en surface les concentrations actuelles et prochaines de ces polluants, ainsi que leurs taux d'émission et leurs incidences environnementales. Cette présentation permettra : i) d'examiner les types de données actuellement disponibles et de connaître leurs forces et leurs limitations; ii) de présenter des exemples d'applications de ces données à la surveillance, à l'évaluation des tendances, aux émissions et aux incidences de la pollution (incluant des résultats provenant des sables bitumineux de l'Alberta); iii) de discuter des enjeux particuliers au Canada et aux autres pays des hautes latitudes; iv) d'examiner ce que nous réserve le futur; v) de voir comment ces analyses et ces résultats influent sur les politiques et en quoi elles concernent les décideurs.

BIO: Dr. Chris McLinden, from Barrie, Ontario, completed his undergraduate in Engineering Physics at McMaster University in 1993 and his Ph.D. in Physics & Astronomy at York University in 1998. He joined Environment Canada in Toronto as a Research Scientist in 2001 following a post-doc at the University of California at Irvine. Chris' research is aimed at developing improved methods for measuring pollution from space, and using these to help understand its sources, distributions, trends, and impacts. He has authored or co-authored over 85 articles in the peer-reviewed literature, is a member of several satellite instrument science teams, and has developed models and algorithms used by research institutes internationally. Chris currently resides in Barrie with his wife, daughter, dog and cat. In his spare time he enjoys playing guitar and pouring over sports statistics.

BIO: Chris McLinden (Ph. D.), de Barrie en Ontario, a obtenu un diplôme de 1er cycle en génie physique de l'Université McMaster en 1993 et un doctorat en physique et astronomie de l'Université York en 1998. En 2001, il est entré comme chercheur au service d'Environnement Canada à Toronto, après avoir été boursier de recherche postdoctorale à l'Université de la Californie (Irvine). Ses recherches visent le développement de méthodes améliorées de mesure de la pollution à partir de l'espace, afin de comprendre les sources, la répartition, les tendances et les incidences des polluants. Il est l'auteur ou le coauteur de plus de 85 articles publiés dans des revues à comité de lecture. Il est membre de plusieurs équipes scientifiques s'intéressant aux instruments à bord de satellites et il a développé des modèles et des algorithmes qu'utilisent des instituts de recherche internationaux. Chris habite à Barrie avec sa conjointe, sa fille, un chien et un chat. Dans ses temps libres, il joue de la guitare et compulse les statistiques sportives.

Workshops and Special Sessions
Ateliers et sessions spéciales

Workshop on Communicating Uncertainty to Users of Weather Forecasts

Sunday, May 31 | 10:00 – 16:30
Room: Garibaldi

There can be a significant gap between what forecasters know and what users of weather forecasts ultimately receive. Most (government-issued) forecasts are comprised of deterministic textual information with few outlets for forecasters to express the inherent uncertainty that is associated with predicting the weather. In the last decade, there have been numerous studies related to communicating forecast uncertainty to different types of end-users. The findings support the notion that uncertainty information is wanted and can be used effectively by decision makers. Indeed, some weather services have made efforts to incorporate uncertainty information beyond basic probability of precipitation forecasts. For example, some offer expressions of forecasters' confidence while others provide output from Ensemble Prediction Systems (EPS) to indicate the probability of occurrence of events. Still, a deeper understanding is lacking about what type of forecast uncertainty information is most useful and how best to communicate it.

This workshop will include invited speakers along with facilitated discussions or breakout sessions. Invited speakers, panelists and participants will be asked to address topics related to uncertainty, including (but not limited to):

- Sources of forecast uncertainty
- Scales of uncertainty
- Using forecast uncertainty to aid in decision making
- The use of Ensemble Prediction Systems (EPS) to communicate uncertainty
- Effective Communication: Words – numbers – graphics

Atelier sur la communication des incertitudes aux utilisateurs de prévisions météorologiques

Dimanche, 31 mai | 10h00 – 16h30
Salle: Garibaldi

Il peut exister un écart considérable entre ce que les prévisionnistes savent et ce que les utilisateurs des prévisions météorologiques reçoivent. La plupart des prévisions (émises par le gouvernement) contiennent des informations textuelles prédéterminées, et ainsi très peu de façons pour le prévisionniste d'exprimer les incertitudes inhérentes à la prévision du temps. Au cours des dix dernières années, de nombreuses études ont traité de la communication des incertitudes des prévisions destinées à différents types d'utilisateurs. Les résultats confirment que les décideurs veulent des informations sur l'incertitude et peuvent les utiliser efficacement. En fait, des services météorologiques ont incorporé des informations sur l'incertitude qui vont au-delà des simples probabilités de précipitations. Par exemple, certains laissent le prévisionniste exprimer son niveau de confiance, tandis que d'autres fournissent les sorties de prévisions d'ensemble, afin d'indiquer la probabilité d'occurrence de phénomènes météorologiques. Toutefois, il faut encore comprendre quel type de prévision profiterait d'informations sur l'incertitude et la manière de la communiquer.

Cet atelier inclut des conférenciers, et des discussions dirigées ou en petits groupes. Nous demandons aux conférenciers, aux panélistes et aux participants de choisir des sujets liés à l'incertitude, y compris, sans s'y limiter :

- les sources des incertitudes minant la prévision

- les échelles d'incertitude
- l'utilisation de l'incertitude de la prévision comme aide à la prise de décision
- l'utilisation des prévisions d'ensemble pour communiquer l'incertitude
- la communication efficace : mots – nombres – graphiques

CMOS & AMS Student and Early Career Scientist Lunch 'n Learn
Monday, June 1 | 12:00 – 13:30
Room: Harmony

Are you a student or early career scientist (earned your degree in the last 5 years) looking to make your way in the industry? Interested in meeting and hearing perspectives from leaders in industry, government and academia? Usually hungry around lunch time? Come to the CMOS / AMS Student & ECS Lunch 'n Learn on Monday June 1 from 12 to 1:30. Representatives from top organizations and institutions will give their views on a host of issues facing our industry and then sit with you in a small group to hear your thoughts and questions. The event will be held in the Harmony room. Lunch will be provided to all conference attendees.

Dîner-causerie pour étudiants et chercheur en début de carrière présenté par SCMO et l'AMS
Lundi, 1 juin | 12h – 13h30
Salle : Harmony

Êtes-vous étudiant ou chercheur en début de carrière (diplômé au cours des 5 dernières années) qui désire débuter votre chemin dans l'industrie? Intéressé à rencontrer et d'entendre les perspectives des dirigeants de l'industrie, du gouvernement et du milieu universitaire? Et avez-vous habituellement faim autour de midi? Venez donc au dîner-causerie SCMO / AMS pour étudiant qui se tiendra le lundi 1er Juin de midi à 13h30. Des représentants de grandes organisations et d'institutions offriront leurs points de vue sur une panoplie de sujets auxquels font face notre industrie. Vous pourriez ensuite vous assoir avec ces professionnels en petit groupe pour partager vos pensées et vos questions. L'événement aura lieu dans la salle de l'Harmonie. Le dîner sera offert à tous les participants à la conférence.

A practical guide to using the Community Earth System Model and Regional Arctic System Model for polar climate research – One Hour American Meteorological Society Short Course
Tuesday, June 2 | 15:30 – 17:00
Room: Garibaldi A
Workshop Convenors: Edward Blanchard-Wrigglesworth,
Department of Atmospheric Sciences, University of Washington

Andrew Roberts
Department of Oceanography, Naval Postgraduate School

This short course is an introduction to running and using the latest versions of the Community Earth System Model (CESM) and the Regional Arctic System Model (RASM) for polar climate research. CESM is an open source fully coupled global model, one of the three national climate models supported federally in the U.S.. RASM is a regional counterpart to CESM that uses the same model infrastructure, as well as identical sea ice (CICE) and ocean models (POP), as well as flux coupler (CPL). During this practical one-hour guide, latest and upcoming polar enhancements to CESM and RASM will be explained, especially focusing on new physics available in Version 5 of the Los Alamos

Sea Ice Model (CICE) and their implementation in the CESM/RASM coupled framework. The one-hour session will also include a tutorial on downloading, setting up and running CESM and RASM, with tips and tricks for processing and analyzing model output. There will be time for questions during the short course.

NSERC Update Session
Tuesday, June 2 | 15:30 – 17:30
Room: Harmony

This is an opportunity to discuss and learn more about our NSERC's Discovery Grants programs and policies. The session will serve as a platform for NSERC to share the latest program news and the latest DG competition results with a focus on those from the Geosciences Evaluation Group.

Debrief from the Atmosphere-Related Research in Canadian Universities (ARRCU) workshop: The ARRCU Working Group will be holding its workshop in Montreal on May 8, 2015 with the main purpose of discussing the ARRCU white paper, which is an ad hoc effort to create a strategic plan for atmosphere-related research for Canadian universities. This session will allow those who were unable to attend the Montreal meeting to hear the outcomes and plans for the future of this initiative.

Session de mise-à-jour du CRSNG
Mardi, le 2 juin | 15h30 – 17h30
Salle : Harmony

Ce sera l'occasion de discuter et d'en apprendre davantage sur le Programme de subventions à la découverte du CRSNG et des politiques qui les entourent. La session servira de plate-forme pour le CRSNG de partager leurs dernières nouvelles reliées au Programme ainsi que les derniers résultats de la concurrence DG avec un accent sur ceux du Groupe d'évaluation des géosciences.

Compte rendu de l'atelier de la Recherche atmosphère-connexes dans les universités canadiennes (RACUC): Le Groupe de travail RACUC tiendra son atelier à Montréal, le 8 mai 2015, avec l'objectif principal de discuter le livre blanc RACUC, qui est un effort ad hoc de créer un plan stratégique pour la recherche sur l'atmosphère pour les universités canadiennes. Cette session permettra à ceux qui n'ont pu assister à la réunion de Montréal d'entendre les résultats et les plans pour l'avenir de cette initiative.

CMOS Special Session
Tuesday, June 2 | 15:30 – 17:30
Room: Rainbow

1. A summary of the "Future of Weather Enterprise" presentation that was made at the 2014 World Weather Open Science Conference in Montreal will be presented.
2. Next steps for the future of existing CMOS programs (Webinars, Mentoring Program, Recruiting Large Users, Media relationship, etc.) will be discussed.
3. CMOS volunteer recruitment discussion.
4. Audience feedback regarding the future of CMOS will be collected.

Session spécial de la SCMO
Mardi, le 2 juin | 15h30 – 17h30
Salle : Rainbow

1. Un résumé de la présentation sur «l'Avenir de l'entreprise météo" tenue lors de la Conférence Scientifique Publique Mondiale sur la Météorologie 2014 à Montréal sera livré.
2. Les prochaines étapes concernant l'avenir des programmes SCMO existants (Webinaires, Programme de mentorat, Recrutement des grands utilisateurs, Relations avec les médias, etc.) seront discutées.
3. Discussion sur le recrutement de bénévoles de la SCMO.
4. Commentaires des participants quant à l'avenir de la SCMO seront recueillis.

Special Session on the Intergovernmental Oceanographic Commission (IOC)
Wednesday, June 3 | 12:00 – 13:30
Room: Harmony

The IOC is the competent UN body that deals with Ocean Science internationally under the auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO). The Assembly of the IOC meets June 18 to 25, 2015 in Paris, France. Trevor Swerdfager, ADM of Ecosystem and Oceans Science at DFO will be Canada's Head of Delegation. As at the last couple of CMOS Congresses, you are invited to a discussion about the current issues that face IOC as well as Canada's position on them as Canada's delegation prepares for the meeting. Some issues that will be raised include:

- The future of the IOC
- Strengthening WMO-IOC cooperation, e.g. Joint Commission for Ocean and Marine Meterology (JCOMM), Climate Services, IOC-Blue Planet Cooperation
- Canadian input to the Global Ocean Science Report (GOSR)

The session will include a presentation about the current state of the IOC, followed by discussion.

Session spéciale sur la Commission Océanographique Intergouvernementale (COI)
Mardi, le 3 juin | 12h00 – 17h30
Salle : Harmony

La COI est l'organisation des Nations unies qui traite des sciences de la mer à l'échelle internationale sous les auspices de l'Organisation des Nations Unies pour l'éducation, la science et la culture (UNESCO). L'assemblée de la COI va se rencontrer le 18 au 25 juin 2015 à Paris, France. Trevor Swerdfager, le sous-ministre adjoint des Sciences de l'océan et des écosystèmes (SOE) du département de Pêches et Océans Canada, sera le chef de la délégation du Canada. Tous comme aux derniers congrès de la SCMO, vous êtes invités à une discussion sur les enjeux actuels de la CIO ainsi que la position du Canada envers ces enjeux lors de la préparation de la délégation du Canada pour la réunion.

Certaines questions qui seront soulevées incluent :

- L'avenir de la COI
- Renforcement de la coopération OMM-COI, ex. Commission conjointe sur l'océanographie et la météorologie marine (J-COMM)
- La contribution du Canada au rapport de la Commission Océan Mondial (GOSR)

La session comprendra une présentation sur l'état actuel de la COI, suivie d'une discussion.

Guidelines for Presenters

Poster Presentations Guidelines

- Posters will be displayed in the Grand Foyer and Ballroom B and C on the upper level of the Whistler Conference Centre.
- Posters will be on display throughout the meeting, but poster presenters should be present at their posters to answer questions during the main poster session scheduled Monday June 1st between 15:30-17:00. A second, informal poster session is scheduled for Tuesday June 2nd between 15:30 – 17:00.
- The maximum poster size is 42 inches by 42 inches (105 cm x 105 cm). Poster presenters are responsible for hanging and removing your own posters. Velcro fastener supports will be provided. Please hang your poster on the assigned numbered board to allow grouping by theme.
- Posters should be up by 10:30 on Monday June 1st and removed by 13:00 on Thursday June 4th in the afternoon. Posters not removed by this time will be discarded.
- Prizes will be awarded by CMOS for the best student poster in Oceanography, the best student poster in Meteorology and best overall poster.

Oral Presentations 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.

Uploading files onto the CMOS fileserver

To manage the oral presentations, CMOS has set up a file server specifically for the conference. The conference file server is an OwnCloud DropBox clone managed by the University of British Columbia (UBC). All presentations must be loaded onto this fileserver prior to the session. No presentations will be uploaded to computers in the session rooms.

Presentation files must be uploaded onto the congress fileserver either two hours prior to your presentation using on your own personal computer, or prior to 9:00 the morning of the presentation at the Registration area in the Grand Foyer, where volunteers will help to upload the files from a USB stick. These computers will not be able to load files from DVDs.

Uploading Presentations to the CMOS OwnCloud file server

1) You should have received an email from OwnCloud providing you with a userid and password

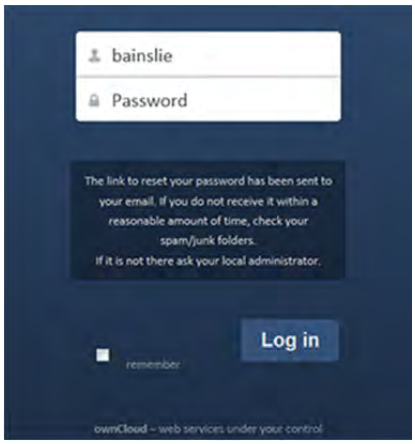
2) If you have not received such an email, please send a help request, with your name and abstract ID in the subject line, to:
→ cmostalks@eos.ubc.ca

3) Armed with your userid and password, open a browser and go to the CMOS 2015 OwnCloud server
→ https://roc.eos.ubc.ca:8443

4) Agree to the security exception

5) Enter the Username and Password you received via email

6) Click the "Log In" box

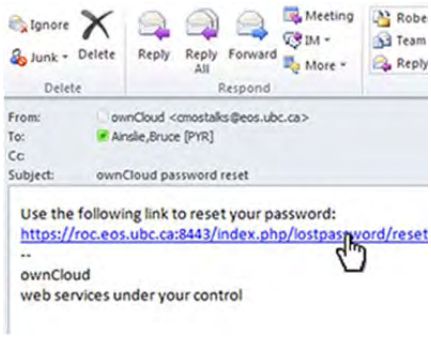


7) Your Login should fail, and you will be asked to reset your password

8) This has been done so that everyone is forced to change their password

9) Click on the"Reset it!" text to reset your password

10) This will trigger an email to be sent containing a link for reseting your password



11) After a few minutes an email should arrive from ownCloud (cmostalks@eos.ubc.ca)

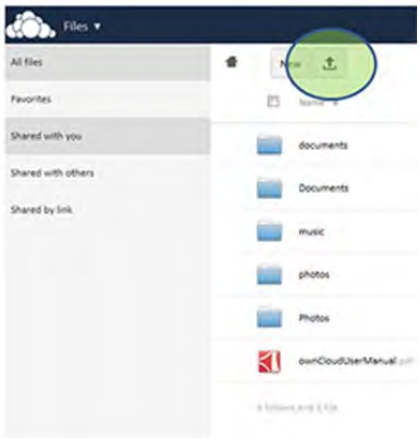
12) Open the email and click on the link

13) If after a few minutes you do not receive and email, check your spam or junk folders

14) If no email arrives, please send a help request, with your name and abstract ID in the subject line, to:
→ cmostalks@eos.ubc.ca

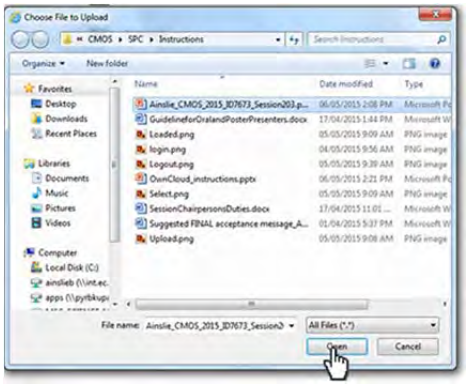
15) The link will re-direct you to an OwnCloud password reset page

16) Type in a new password and click "Reset password"



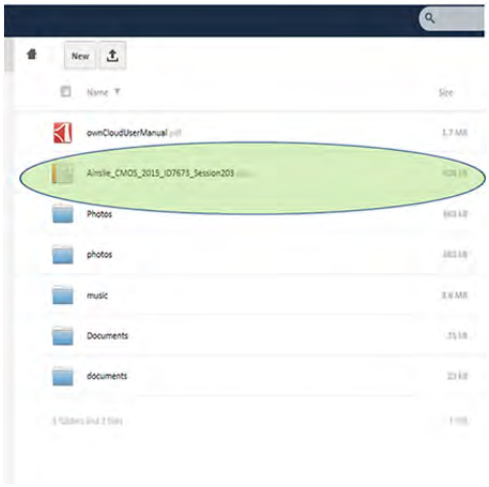
17) You should now see your Home folder where you must save your presentation

18) Click on the Upload icon at the top to upload your presentation



19) Use the popup box to select the file you want to upload

20) Click "Open" to start uploading your presentation file(s)



21) You should now see your file(s) on the OwnCloud server

22) Check the file size(s) to make sure everything loaded correctly

23) At anytime, right up to the morning of your presentation, you can upload newer versions of your presentation by simply logging on to the OwnCloud server (using your userid and your new password)

24) You are done !!

25) The OwnCloud file server will make sure that your talk will be accessible to the computer assigned to your session

26) As a result, you MUST upload your presentation prior to your session. Do NOT show up at your session expecting to be able to load your presentation onto the session computer

27) To Logout, click on your username (the upper right hand corner) From the pull-down menu, select "Log out"

Naming presentation files

All filenames and folders associated with each presentation must contain the 4-digit abstract ID, which is part of your owncloud user name.

File types

The following file types are 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 file to your ownCloud account. 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 7 based PC with MS Office 2010, QuickTime, VLC media player, Windows media play, 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 be available during your presentation. Each session room will be equipped with a screen, LCD projector, timer and laser pointer. Presentations will be automatically uploaded onto the session computer by the CMOS file server.

Les lignes directrices du présentateur

Lignes directrices pour les présentations d'affiche

- Les affiches seront exposées dans le Grand Foyer et la Salle de bal B et C sur le niveau supérieur du Centre de conférence Whistler.
- Les affiches seront exposées tout au long de la réunion, mais les présentateurs d'affiches devraient être présents à leur affiche pour répondre aux questions au cours de la session principale prévue le lundi 1er juin entre 15h30 et 17h 00. Une deuxième session informelle est prévue pour le mardi 2 juin entre 15h30 et 17h00.
- La taille maximale de l'affiche est de 42 pouces par 42 pouces (105 cm x 105 cm). Les présentateurs d'affiches sont responsables de suspendre et retirer leurs propres affiches. Des supports de velcro de fixation seront fournis. S'il vous plaît accrocher votre affiche sur le tableau numéroté qui vous a été assigné pour permettre le regroupement par thème.
- Les affiches devraient être en place avant 10h30 lundi 1er juin et enlevé par 13h00 le jeudi 4 juin en après-midi. Les affiches non retirées à ce moment seront jetées.
- Les prix seront décernés par la SCMO pour la meilleure affiche étudiante en océanographie, la meilleure affiche étudiante en météorologie et la meilleure affiche globale.

Lignes directrices pour les présentations orales

Chaque présentation orale a été allouée 15 minutes, dont 12 minutes pour la présentation et 3 minutes pour les questions et commentaires. Certains présentateurs invités ont été attribuées un total de 30 minutes.

Télécharger les fichiers sur le serveur de fichier de la SCMO

Pour gérer les présentations orales, la SCMO a mis en place un serveur de fichier spécifiquement pour la conférence. Le serveur de fichier de conférence est un clone de OwnCloud DropBox géré par l'Université de la Colombie-Britannique (UBC). Toutes les présentations doivent être chargées sur ce serveur de fichiers avant la session. Aucunes présentations ne seront téléchargées à partir d'ordinateurs dans les salles de session.
Les fichiers de présentation doivent être téléchargées sur le serveur de fichier de congrès soit deux heures avant votre présentation à l'aide de votre propre ordinateur personnel, ou avant 9h00 le matin de la présentation à la zone d'enregistrement dans le Grand Foyer, où les bénévoles aideront à télécharger les fichiers à partir d'une clé USB. Ces ordinateurs ne seront pas en mesure de télécharger à partir d'un DVD.

Téléchargement de présentations au serveur de fichier SCMO OwnCloud

1) Vous devriez avoir reçu un courriel de OwnCloud vous fournissant un nom d'utilisateur et un mot de passe

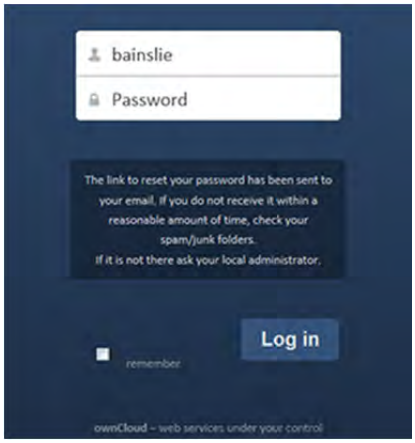
2) Si vous n'avez pas reçu un tel courriel, s'il vous plaît envoyer une demande d'aide, avec votre nom et votre numéro d'identification du résumé dans la ligne d'objet, à:
→ cmostalks@eos.ubc.ca

3) À l'aide de votre nom d'utilisateur et le mot de passe, ouvrez un navigateur et allez au serveur CMOS 2015 OwnCloud
→ https://roc.eos.ubc.ca:8443

4) Acceptez l'exception de la sécurité

5) Entrez le nom d'utilisateur et le mot de passe que vous avez reçu par courriel

6) Cliquez sur le bouton « Login »

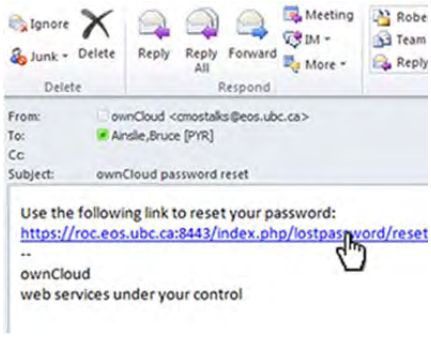


7) Votre connexion devrait échouer et vous sera demandé de réinitialiser votre mot de passe

8) Cela a été fait de sorte que tout le monde est obligé de changer leur mot de passe

9) Cliquez sur le texte « Reset it! » pour réinitialiser votre mot de passe

10) Cela déclenchera l'envoie d'un courriel contenant un lien pour réinitialiser votre mot de passe



11) Après quelques minutes un courriel devrait arriver de ownCloud (cmostalks@eos.ubc.ca)

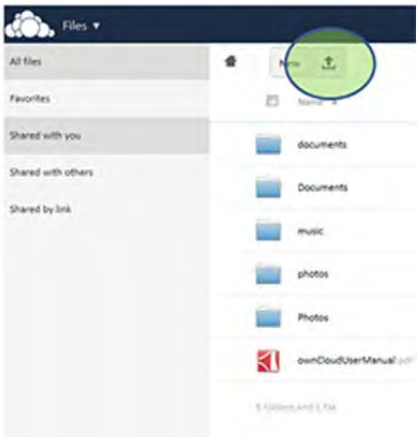
12) Ouvrez le courriel et cliquez sur le lien

13) Si, après quelques minutes, vous ne recevez pas de courriel, vérifiez vos dossiers de spam ou pourriel.

14) Si aucun courriel arrive, s'il vous plaît envoyer une demande d'aide, avec votre nom et votre numéro d'identification du résumé dans la ligne d'objet, à:
→ cmostalks@eos.ubc.ca

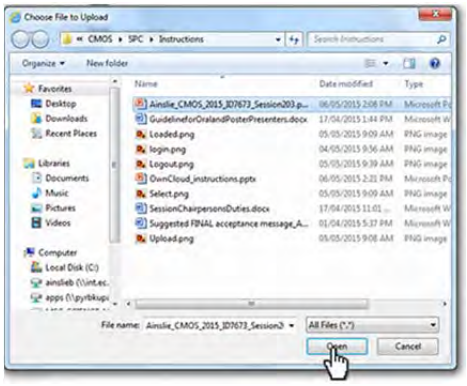
15) Le lien vous redirigera vers une page de réinitialisation de mot de passe OwnCloud

16) Entrez un nouveau mot de passe et cliquez sur « Reset password »



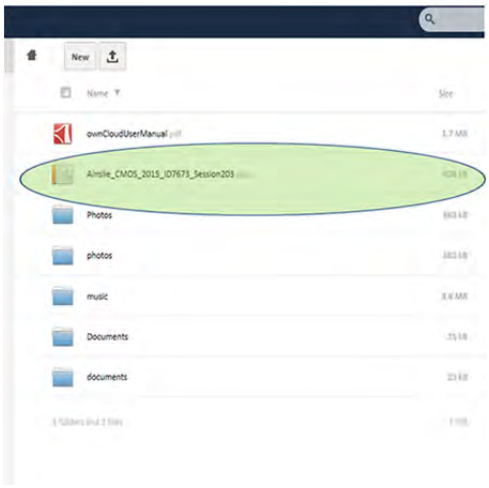
17) Vous devriez maintenant voir votre dossier d'accueil (Home) où vous devez enregistrer votre présentation

18) Cliquez sur l'icône de chargement au haut de la page afin de télécharger votre présentation



19) Utilisez la nouvelle fenêtre sur l'écran pour sélectionner le fichier que vous souhaitez télécharger

20) Cliquez sur « Open » pour démarrer le téléchargement de votre fichier de présentation



21) Vous devriez maintenant voir votre fichier sur le serveur OwnCloud

22) Vérifiez la taille du fichier pour vérifier que tout correctement téléchargé

23) À tout moment, jusqu'au matin de votre présentation, vous pouvez télécharger les nouvelles versions de votre présentation en vous connectant au serveur OwnCloud (en utilisant votre nom d'utilisateur et votre nouveau mot de passe)

24) C'est fait!

25) Le serveur de fichier OwnCloud assurera que votre présentation sera accessible sur l'ordinateur assigné pour votre présentation

26) Par conséquent, vous DEVEZ télécharger votre présentation avant votre session. NE VOUS PRÉSENTEZ PAS à votre session en espérant être capable de charger votre présentation sur l'ordinateur

27) Pour vous déconnecter, cliquez sur votre nom d'utilisateur (le coin supérieur droit). Dans le menu déroulant, sélectionnez « Logout »

Nommer les fichiers de présentation

Tous les noms de fichiers et dossiers associés à chaque présentation doivent contenir les 4 chiffres d'identification du résumé, qui font partie de votre nom d'utilisateur OwnCloud.

Types de fichier

Les types de fichiers suivants sont acceptés pour les présentations orales:

- PowerPoint (.ppt, .pptx)
- Adobe Reader (.pdf)
- QuickTime

PowerPoint intègre les fichiers d'image directement dans le document lorsque vous les enregistrez, tandis que les fichiers vidéo ne sont pas intégrés. Seul un lien est établi avec le fichier vidéo. Copiez les vidéos que vous voulez insérer dans le même dossier que le fichier PowerPoint avant de les relier dans votre présentation. Cela éliminera le problème de PowerPoint qui perd le lien vers le fichier. Assurez-vous de télécharger à la fois les fichiers vidéo et le fichier PowerPoint à votre compte OwnCloud. Vidéo / audio peut également être joué indépendamment de Powerpoint en utilisant le lecteur VLC media, qui supporte divers formats (par exemple, .wmv, .mpg, .avi, .mov, etc.). S'il vous plaît préparer vos fichiers en conséquence.

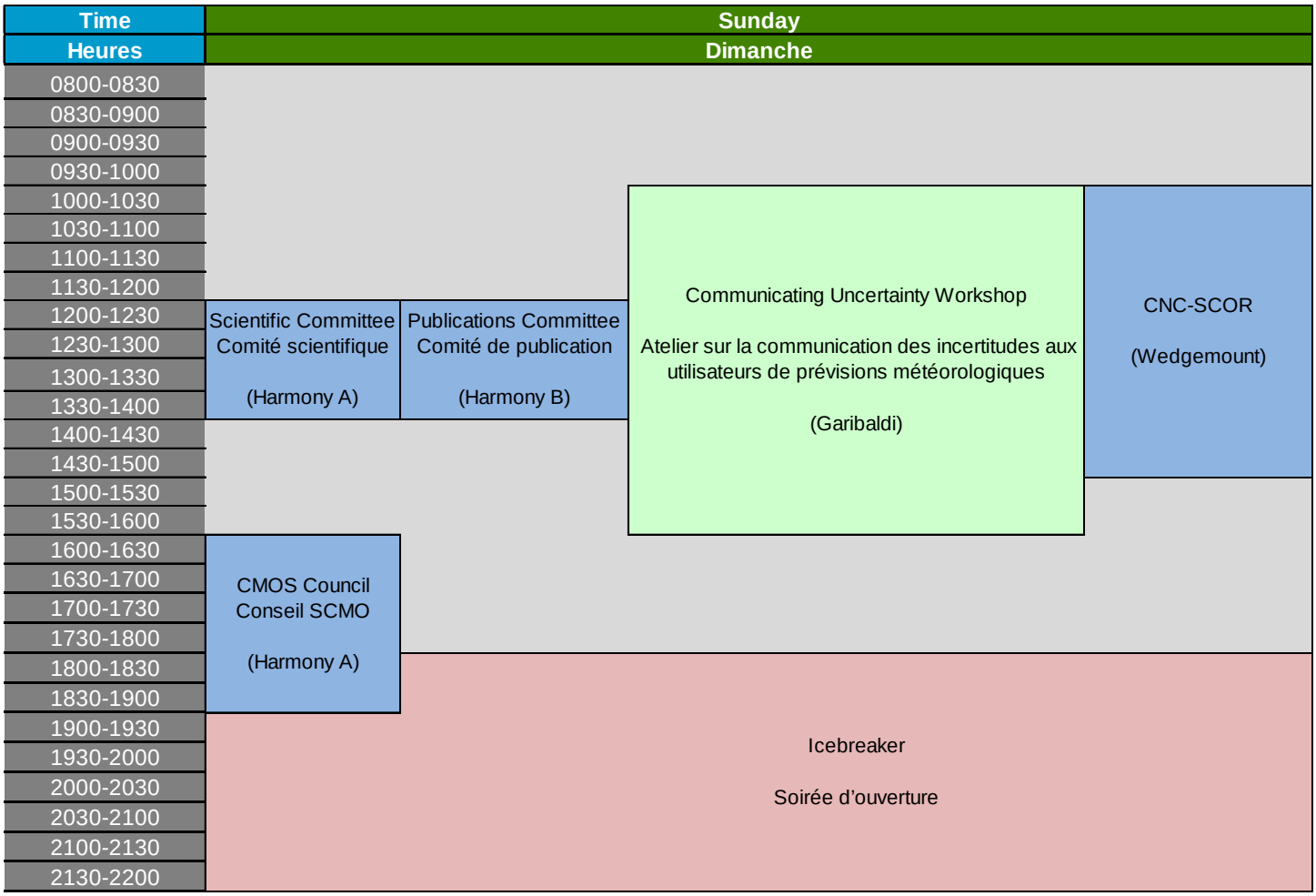
Ordinateur et équipement A/V

L'utilisation de votre propre ordinateur ne sera pas possible. Toutes les salles de réunion seront équipées d'un PC équipé de Windows 7 avec MS Office 2010, QuickTime, VLC media player, Windows media play, et Adobe Acrobat Reader. S'il vous plaît vérifier la bonne performance de votre présentation à l'avance, en particulier si elle inclut de l'audio, de la vidéo ou des fichiers d'animation. L'accès à Internet sera disponible lors de votre présentation. Chaque salle de présentation sera équipée d'un écran, un projecteur LCD, un minuteur et un pointeur laser. Les présentations seront automatiquement téléchargées sur l'ordinateur de session par le serveur de fichier de la SCMO.

Week at a Glance / La semaine en un coup d'oeil

Time / Heures	Sunday Dimanche	Monday Lundi	Tuesday Mardi	Wednesday Mercredi	Thursday Jeudi
0800 - 0830		Opening Remarks Cérémonie dèouverture			
0830 - 0900	Meetings & Workshops Réunions & ateliers	Plenaries 1&2 Plénières 1&2	Plenaries 3&4 Plénières 3&4	Plenaries 5&6 Plénières 5&6	Plenaries 7&8 Plénières 7&8
0900 - 0930					
0930 - 1000					
1000 - 1030		Coffee Break / Pause santé			
1030 - 1100		Parallel Sessions / Sessions parallèles			
1100 - 1130					
1130 - 1200					
1200 - 1230	Lunch Dîner	Lunch on-site Dîner sur place	Patterson - Parsons Luncheon Dîner Patterson - Parsons	Lunch on-site Dîner sur place	
1230 - 1300					
1300 - 1330					
1330 - 1400	Meetings & Workshops Réunions & ateliers	Parallel Sessions / Sessions parallèles			
1400 - 1430					
1430 - 1500					
1500 - 1530		Coffee Break / Pause santé			
1530 - 1600		Poster Session / Session d'affiches		Parallel Sessions Sessions parallèles	
1600 - 1630					
1630 - 1700					
1700 - 1730					
1730 - 1800		CMOS Annual Meeting Assemblée générale annuelle SCMO			
1800 - 1830	Ice Breaker Soirée d'ouverture				
1830 - 1900					
1900 - 1930			Public Lecture Soirée publique	CMOS Banquet Banquet SCMO	
1930 - 2000					
2000 - 2030		Student Night Soirée étudiante			
2030 - 2100					
2100 - 2130					
2130 - 2200					

Sunday Meetings and Workshops
Conférences et ateliers du dimanche



Meetings, Workshops, Special Sessions

Conférences, ateliers, sessions spéciales

Time / Heure	Monday / Lundi	Tuesday / Mardi	Wednesday / Mercredi	Thursday / Jeudi	Time / Heure
0800-0830	Educators Day Journée des enseignants (Black Tusk)				0800-0830
0830-0900					0830-0900
0900-0930					0900-0930
0930-1000					0930-1000
1000-1030					1000-1030
1030-1100					1030-1100
1100-1130					1100-1130
1130-1200					1130-1200
1200-1230	Student Lunch & Learn (Harmony)	Patterson-Parsons Luncheon Dîner Patterson-Parsons (Sea to Sky Ballroom A)	Centre Executives Committee (Black Tusk) / IOC Session (Harmony)		1200-1230
1230-1300					1230-1300
1300-1330				NEMO Ocean Modeling (Black Tusk)	1300-1330
1330-1400					1330-1400
1400-1430					1400-1430
1430-1500					1430-1500
1500-1530					1500-1530
1530-1600		AMS Modeling Workshop (Black Tusk) / CMOS Special Session (Rainbow) / NSERC Info Session (Harmony)			1530-1600
1600-1630					1600-1630
1630-1700					1630-1700
1700-1730	AMS Executives (Black Tusk) / CMOS AGM SCMO AGA (Rainbow)				1700-1730
1730-1800					1730-1800
1800-1830					1800-1830
1830-1900					1830-1900
1900-1930		Public Lecture Conférence publique (Rainbow)	Banquet (Sea to Sky Ballroom A)		1900-1930
1930-2000					1930-2000
2000-2030	Student Night Nuit pour les Étudiants				2000-2030
2030-2100					2030-2100
2100-2130					2100-2130
2130-2200					2130-2200
2200-2230					2200-2230
2230-2300					2230-2300

Session Schedule | Horaire du sessions

June 1

Time	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
0800-0830	**Opening Ceremony (Sea to Sky Ballroom A)**						
0830-0900 0900-0930 0930-1000	Plenaries (Sea to Sky Ballroom A) *Battisti and Barnes*						
1000-1030	Coffee Break (Grand Foyer / Sea to Sky Ballroom B&C)						
1030-1100 1100-1130 1130-1200	Polar Coupled Climate Modeling and Weather Prediction	Observations I	Climate Change and Extreme Events I	Mechanisms of Polar Change and Variability	Physical Oceanography I	Numerical Weather Prediction I	Education, Outreach and General Interdisciplinary Studies
1200-1230 1230-1300 1300-1330	Lunch on-site (Grand Foyer)						
1330-1400 1400-1430 1430-1500	Polar/Lower-Latitude Connections	The Changing Arctic Atmosphere	Climate Change and Extreme Events II	Innovation through Integration: Collaborative Science, Policy, and Environmental Management at High Latitudes	Physical Oceanography II	Numerical Weather Prediction II	
1500-1530	Coffee Break (Grand Foyer / Sea to Sky Ballroom B&C)						
1530-1600 1600-1630 1630-1700	Poster Session						

1 juin

Heures	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
0800-0830	**Cérémonie d'ouverture (Sea to Sky Ballroom A)**						
0830-0900 0900-0930 0930-1000	Plénieres (Sea to Sky Ballroom A) *Battisti and Barnes*						
1000-1030	Pause santé (Grand Foyer / Sea to Sky Ballroom B&C)						
1030-1100 1100-1130 1130-1200	Modélisation couplée du climat et de la prévision météorologique aux pôles	Observations-Partie 1	Changement climatique et événements extrêmes-Partie 1	Mécanismes sous-tendant la variabilité et les changements aux pôles	Océanographie physique-Partie 1	Prévision numérique du temps-Partie 1	Éducation, sensibilisation et travaux interdisciplinaires généraux
1200-1230 1230-1300 1300-1330	Déjeuner sur place (Grand Foyer)						
1330-1400 1400-1430 1430-1500	Relations entre les pôles et les latitudes inférieures	L'atmosphère arctique en évolution	Changement climatique et événements extrêmes-Partie 2	L'innovation fondée sur l'intégration : science, politique et gestion environnementale collaboratives dans les hautes latitudes	Océanographie physique-Partie 2	Prévision numérique du temps-Partie 2	
1500-1530	Pause santé (Grand Foyer / Sea to Sky Ballroom B&C)						
1530-1600 1600-1630 1630-1700	Affiches						

June 2

Time	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
0830-0900	Plenaries (Sea to Sky Ballroom A) *Timmermans and Holland*						
0900-0930							
0930-1000							
1000-1030	Coffee Break (Grand Foyer / Sea to Sky Ballroom B&C)						
1030-1100	Ocean-atmosphere interactions and sea ice I	Meteorology, Hydrology and Renewable Energy	From Carbon Emissions to Climate Change	Hydro-climatic Variability, Change and Extremes I: Climatic Drivers	Collaboration in development, application and analysis of ocean forecasting models I	Coordination of Ocean Science in Canada - An Update and Way Forward	Acoustics in Oceanography and marine sciences I
1100-1130							
1130-1200							
1200-1230	Patterson-Parsons Luncheon (Sea to Sky Ballroom A)						
1230-1300							
1300-1330							
1330-1400	Ocean-atmosphere interactions and sea ice II	Coupled Environmental Prediction: From hours to seasons.	Detection and attribution	Hydro-climatic Variability, Change and Extremes II: Modelling Snow and Land Surface Processes	Collaboration in development, application and analysis of ocean forecasting models II"	Synoptic and Mesoscale Dynamics	Acoustics in Oceanography and marine sciences II
1400-1430							
1430-1500							
1500-1530	Coffee Break (Grand Foyer / Sea to Sky Ballroom B&C)						
1530-1600	Poster Session continued / social time						
1600-1630							
1630-1700							

2 juin

Heures	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
0830-0900	Plénieres (Sea to Sky Ballroom A) *Timmermans and Holland*						
0900-0930							
0930-1000							
1000-1030	Pause santé (Grand Foyer / Sea to Sky Ballroom B&C)						
1030-1100	Interactions océan-atmosphère et glace de mer-Partie 1	Météorologie, hydrologie et énergie renouvelable	Des émissions de carbone aux changements climatiques	Variabilité, évolution et extrêmes hydroclimatiques -Partie 1 : facteurs climatiques	Collaboration dans le développement, l'application et l'analyse des modèles de prévision océanique - 1	Coordination des sciences de la mer au Canada : mise à jour et avenir	L'acoustique en océanographie et en sciences de la mer : des tropiques aux pôles- 1
1100-1130							
1130-1200							
1200-1230	Déjeuner Patterson-Parsons (Sea to Sky Ballroom A)						
1230-1300							
1300-1330							
1330-1400	Interactions océan-atmosphère et glace de mer-Partie 2	Prévision environnementale couplée: de quelques heures à saisons	Détection et causes des changements climatiques dans les hautes latitudes	Variabilité, évolution et extrêmes hydroclimatiques - 2 : modélisation de la neige et des processus de surface	Collaboration dans le développement, l'application et l'analyse des modèles de prévision océanique - 2	Dynamique synoptique et de mésoéchelle	L'acoustique en océanographie et en sciences de la mer : des tropiques aux pôles - 2
1400-1430							
1430-1500							
1500-1530	Pause santé (Grand Foyer / Sea to Sky Ballroom B&C)						
1530-1600	La session d'affiches se prolonges / Temps de rencontres						
1600-1630							
1630-1700							

June 3

Time	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
0830-0900 0900-0930 0930-1000	Plenaries (Sea to Sky Ballroom A) *Fissel and Steiner*						
1000-1030	Coffee Break (Grand Foyer / Sea to Sky Ballroom B&C)						
1030-1100 1100-1130 1130-1200	High-resolution sea ice-ocean modeling	Data Assimilation and Impact of Observations	Climate Variability and Predictability I		Coastal Oceanography and Inland Waters in a Changing Climate I	Atmospheric Physics	Ocean Biogeochemistry from Tropics to Poles – Synthesizing Observations and Model Results
1200-1230 1230-1300 1300-1330	Lunch on-site (Grand Foyer)						
1330-1400 1400-1430 1430-1500	Beaufort Sea Ocean-Ice-Atmosphere Dynamics	State of the Cryosphere	Climate Variability and Predictability II	The Labrador Sea as a Vital element of the climate system I	Coastal Oceanography and Inland Waters in a Changing Climate II	Atmospheric Chemistry and Air Quality	Land-atmosphere exchange of trace gases
1500-1530	Coffee Break (Grand Foyer / Sea to Sky Ballroom B&C)						
1530-1600 1600-1630 1630-1700	Two Ways of Knowing – Scientists and Inuit Knowledge Holders	Atmospheric Interfaces in the Arctic	Climate Variability and Predictability III	The Labrador Sea as a Vital element of the climate system II	Coastal Oceanography and Inland Waters in a Changing Climate III	Polar Clouds, Precipitation, and Aerosols	Atmosphere, Ocean, and Climate Dynamics

3 juin

Heures	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
0830-0900 0900-0930 0930-1000	Plénieres (Sea to Sky Ballroom A) *Fissel and Steiner*						
1000-1030	Pause santé (Grand Foyer / Sea to Sky Ballroom B&C)						
1030-1100 1100-1130 1130-1200	Modélisation glace de mer-océan à haute résolution	Assimilation des données et incidence des observations	Variabilité et prévisibilité du climat-Partie 1		Océanographie côtière et eaux intérieures dans un climat changeant-Partie 1	Physique atmosphérique	Biogéochimie de l'océan, des tropiques aux pôles - synthèse des observations et des résultats de modèles
1200-1230 1230-1300 1300-1330	Déjeuner sur place (Grand Foyer)						
1330-1400 1400-1430 1430-1500	Dynamique océan-glace-atmosphère dans la mer de Beaufort	État de la cryosphère	Variabilité et prévisibilité du climat-Partie 2	La mer du Labrador, un élément capital du système climatique-Partie 1	Océanographie côtière et eaux intérieures dans un climat changeant-Partie 2	Chimie atmosphérique et qualité de l'air	Échange sol-atmosphère de gaz traces
1500-1530	Pause santé (Grand Foyer / Sea to Sky Ballroom B&C)						
1530-1600 1600-1630 1630-1700	GIS ARCTIQUE: Deux perspectives du savoir : le savoir scientifique et le savoir autochtone	Interfaces atmosphèriques dans l'Arctique	Variabilité et prévisibilité du climat-Partie 3	La mer du Labrador, un élément capital du système climatique-Partie 2	Océanographie côtière et eaux intérieures dans un climat changeant-Partie 3	Nuages, précipitation et aérosols polaires	Dynamique de l'atmosphère, des océans et du climat

June 4

Time	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
0830-0900	Plenaries (Sea to Sky Ballroom A) *Clarke and McLinden*						
0900-0930							
0930-1000							
1000-1030	Coffee Break (Grand Foyer / Sea to Sky Ballroom B&C)						
1030-1100		Observations	New Approaches to Ocean Observing	Mixing in the Open and Coastal Oceans	High latitude glacier and ice sheet interaction with the atmosphere and ocean	Operational Forecasting	
1100-1130							
1130-1200							

Le 4 juin

Heures	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
0830-0900	Plénieres (Sea to Sky Ballroom A) *Clarke and McLinden*						
0900-0930							
0930-1000							
1000-1030	Pause santé (Grand Foyer / Sea to Sky Ballroom B&C)						
1030-1100		Observations-Partie 2	Nouvelles méthodes d'observation de l'océan	Mélange en pleine mer et près des côtes	Interaction des glaciers et des nappes glaciaires des hautes latitudes avec l'atmosphère et l'océan	Prévision opérationnelle	
1100-1130							
1130-1200							

Presentations Schedule | Horaire de presentations

Monday Morning - June 1 / Lundi matin - 1 juin

	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
	Polar Coupled Climate Modeling and Weather Prediction Modélisation couplée du climat et de la prévision météorologique aux pôles	Observations I Observations-Partie 1	Climate Change & Extreme Events I Changement climatique et événements extrèmes-Partie 1	Mechanisms of Polar Change & Variability / Mécanismes sous-tendant la variabilité et les changements aux pôles	Physical Oceanography I Océanographie physique-Partie 1	Numerical Weather Prediction I Prévision numérique du temps-Partie 1	Education, Outreach and General Inter-disciplinary Éducation, sensibilisation et travaux interdisciplinaires généraux
1030-1045	**Andrew Roberts** Sea Ice State in Version 1 of the Regional Arctic System Model	**David Mikolajczyk** The 2014-15 UW-Madison AWS Network Field Season: A Campaign to Divide and Conquer	**Trevor Murdock** Downscaling Extremes - a set of climate change projections for Canada	**Qinghua Ding** Temperature change on the Antarctic Peninsula linked to the tropical Pacific	**Yi Sui** Circulation, dispersion, and hydrodynamic connectivity over the Scotian Shelf, a numerical investigation using a nested-grid ocean circulation model	**Keith Hines** Real-time Numerical Weather Forecasts for Arctic Research Flights with Polar WRF	**Wendy Schreiber-Abshire** COMET's 25 Years of Education and Training: Where We've Been and Where We're Going
1045-1100	**Michael Sigmond** Seasonal forecasts of Arctic sea ice in a dynamical forecast system	**Andrew Leung** Fog Occurrence in Hudson Bay Region	**Carlos Gaitan Ospina** On the use of statistical downscaling time-invariant transfer functions and their effect on different historical and future metrics. Case study: daily maximum temperature in Montreal,		**Rich Pawlowicz** Salinity anomalies in coastal waters	**Andrew Orr** Assessment of numerical weather prediction for the Antarctic Peninsula using the UK Met Office Unified Model and AMPS	**Adam Monahan** Effects of Spatial and Temporal Averaging on Surface Irradiance
1100-1115	**Yi Jin** Numerical Modeling of Summer Arctic Boundary Layer during the Arctic Summer Cloud Ocean Study (ASCOS)	**Stephen Berg** Variable Precipitation Differences on Cypress Mountain during SNOW-V10	**Eva Mekis** Observed trends in severe weather conditions based on humidex, wind chill and heavy rainfall events in Canada for 1953	**Chad Goergens** Seasonal Antarctic station-based pressure reconstruction evaluation during the 20th century		**Jeff Lundgren** Predicting local climate changes due to reservoir impoundment using WRF	**Rick Fleetwood** CoCoRaHS Canada Update
1115-1130	**John Cassano** Simulation of Arctic climate with the Regional Arctic System Model (RASM): Sensitivity to atmospheric processes	**Wil Marsh** Optical Rain Gauge - An Alternative to Traditional Rain Gauges	**Vanessa Foord** Climate Change Impacts to Natural Disturbances in Northern British Columbia	**Till Wagner** How Climate Model Complexity Influences Sea Ice Stability	**Denis Lefaivre** Dynamics of the Position of the Transition from Freshwater to Salt Water in the St. Lawrence River	**Ron McTaggart-Cowan** Upcoming changes to the Canadian Global Deterministic Prediction System	**Roland Stull** Proposal to Eliminate DiffEQ as Requirement for a Bachelors in Atmospheric Science
1130-1145	**Keith Hines** ACCIMA: Regional Coupled Modeling of Antarctica for Sea Level Rise Studies	**Derek van der Kamp** Spatial and temporal variability of fuel moisture across a heterogenous landscape	**David Huard** The Delicate Undertaking of Making Climate Science Relevant to Decision-Making	**Cecilia Peralta-Ferriz** Inter-annual variability of Arctic mixed layer properties from 1979 to 2012	**Cedric Chavanne** Diagnosing the upper ocean 3D circulation from high-resolution observations at a submesoscale cold filament in the Lower St. Lawrence Estuary	**Simon Horton** Avalanche forecasting with high resolution NWP data	**Andrew Leung** Assessing the Impacts on Aviation by Analyzing Historical Surface Wind Patterns in Northern Quebec and Labrador Communities
1145-1200	**Pranab Deb** Validation of near-surface variables simulated by Polar WRF over West Antarctica	**Herb Winston** An Assessment of the Global Lightning Dataset (GLD360) over Canada		**Bunu Sharma** The changing contribution of Snow to Hudson Bay River Discharge.	**Louis-Philippe Nadeau** Instability and mixing of zonal jets along an idealized continental shelf break.	**Sylvie Leroyer** An Integrated Urban High-Resolution Numerical Weather Prediction System dedicated to the 2015 Pan-American Games in Toronto	

Monday Afternoon - June 1 / Lundi après-midi - 1 juin

	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount
	Polar/Lower-Latitude Connections Relations entre les pôles et les latitudes inférieures	The Changing Arctic Atmosphere L'atmosphère arctique en évolution	Climate Change and Extreme Events II Changement climatique et événements extrêmes-Partie 2	Innovation through Integration: Collaborative Science, Policy, and Environmental Management at High Latitudes L'innovation fondée sur l'intégration : science, politique et gestion environnementale collaboratives dans les hautes latitudes	Physical Oceanography II Océanographie physique-Partie 2	Numerical Weather Prediction II Prévision numérique du temps-Partie 2
1330-1345	**Ed Blockley** Seamless coupled forecasting across all time scales at the Met Office, UK: ocean-ice forecasting, seasonal prediction, climate projections and Earth system modelling.	**Aaron Donohoe** The interannual variability of the Arctic energy budget	**Emmanuel D. Poan** Variability and change in Storm Track characteristics over Canada from Regional Climate Model Perspective	**Sina Abadzadesahraei** Quantifying the water budget of Coles Lake, Northeastern British Columbia	**Nicolas Grisouard** Damping of Geostrophic Motions by Oceanic Internal Waves, Critically Reflecting off the Sea Surface.	**Hanneke Luijting** Forecasting Polar Lows with an on-demand EPS system
1345-1400	**Ryan Fogt** The Roles of the PDO and ENSO on Regional Antarctic Warming during Austral Spring, 1979-2012	**Banafsheh Afshar** High Resolution NWP for the Canadian Arctic	**Dominique Paquin** Evaluation of maximum precipitation changes and precipitable water from Regional Climate Models over Canadian watersheds	**Jennifer Spinney** The practice of producing and consuming flood warning information: an ethnographic exploration of working and living the weather		**Syed Zahid Husain** Improving Land-Surface Parameterization with the Multi-Budget Soil, Vegetation, and Snow (SVS) Scheme
1400-1415	**Kelly McCusker** Exploring the link between human-induced Arctic sea ice loss and cold Eurasian winters	**Sophie Tran** Trace gas measurements at two Arctic sites using infrared emission spectroscopy: Filling the polar night knowledge gap	**Kirien Whan** The impact of atmospheric blocking on extreme winter minimum temperatures in North America	**Amanda Lynch** Extremes, Remoteness and Adaptation in the Arctic	**Francis Poulin** A study of a surface trapped elliptical anticyclone at finite Rossby number	**Iain Russell** The Weather Network's Hourly NWP Precipitation Nowcasting Model
1415-1430	**Catrin Mills** The Temporal and Spatial Evolution of Atmospheric Responses to Changing Arctic Ice Cover in Present-Day CCSM4	**Patrick Sheese** Seasonal differences in Arctic N2O throughout the stratosphere to the lower thermosphere and its effect on stratospheric NO and O3	**Rick Fleetwood** Long Term Climate Records Generator and Data Base for Canada	**Paul LeBlond** A proposal for international scientific collaboration at the North Pole	**Renske Gelderloos** A simple model of ocean dynamics in Nares Strait	**Ron Chapman** Determining forecast skill in a numerical weather model: Case study – 1 year of daily WRF NWP results compared against observation data from the Wood Buffalo Environmental Agency Air monitoring network.
1430-1445	**Michael Sigmond** Pacific trade wind intensification and the recent prevalence of unusually cold North American winters	**Knut von Salzen** Simulations of Arctic Aerosols and Climate with CanAM		**Gabriela Ibarguchi** The Arctic Observing Summit 2013, 2014, 2016: Progress Towards an Integrated, Multipurpose, International Arctic Observing System	**David Straub** Meridional propagation of geostrophic jets in ocean circulation models	**Aranildo Lima** Postprocessing of Numerical Weather Forecasts Using Online Sequential Extreme Learning Machines
1445-1500	**Qinghua Ding** Tropical forcing of the recent rapid Arctic warming in northeastern Canada and Greenland	**Line Bourdages** A Pan-Arctic view of inversion formation and maintenance processes			**William Crawford** Decadal Trends of Oxygen in the Northeast Pacific Ocean	**Nacera Chergui** Les activites de post-traitement dans la section des elements du temps du Centre Meteorologique Canadien (CMC).

Tuesday Morning - June 2 / Mardi matin - 2 juin

	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
	Ocean-atmosphere interactions and sea ice I Interactions océan-atmosphère et glace de mer-Partie 1	Meteorology, Hydrology and Renewable Energy Météorologie, hydrologie et énergie renouvelable	From Carbon Emissions to Climate Change Des émissions de carbone aux changements climatiques	Hydro-climatic Variability, Change and Extremes I: Climatic Drivers Variabilité, évolution et extrêmes hydroclimatiques -Partie 1 : facteurs climatiques	Collaboration in development, application and analysis of ocean forecasting models I Collaboration dans le développement, l'application et l'analyse des modèles de prévision océanique - 1	Coordination of Ocean Science in Canada Coordination des sciences de la mer au Canada : mise à jour et avenir	Acoustics in Oceanography and marine sciences: from tropics to poles L'acoustique en océanographie et en sciences de la mer : des tropiques aux pôles- 1
1030-1045	**Jim Thomson** Sea State and Boundary Layer Physics of the Emerging Arctic Ocean	**Christian Reuten** Likelihood of Microclimate Changes Caused by a Large Hydro Power Project: Application of Bayesian Two-Sample Comparison to Site C	**Vivek Arora** Constraining the strength of the terrestrial CO2 fertilization effect in Earth system models	**Chris DeBeer** Recent Earth system change in the interior of western Canada – recent results from the Changing Cold Regions Network	**Jean-Francois Lemieux** The CONCEPTS Global Ice-Ocean Prediction System	Invited session with panelists discussing ocean science coordination in Canada. The panelists will include: • **David Fissel,** Chairman and Senior Scientist, ASL Environmental Science • **Sara Iverson,** Scientific Director, Ocean Tracking Network • **Kate Moran,** President and Chief Executive Officer, Ocean Networks Canada • **Douglas Wallace,** Scientific Director, MEOPAR (Marine Environmental Observations Predictions and Response) • **Carmel Lowe,** Regional Director Science – Pacific Region, Department of Fisheries and Oceans	**Harald Yurk** The Certainties and Uncertainties when assessing noise impact on marine mammals
1045-1100	**Johannes Gemmrich** Wind waves in arctic seas	**Joseph Bailey** Past and potential relationships between wind speed and runoff behaviour. Implications for renewable planning development in British Columbia.	**Martin Leduc** Extending the TCRE to regional climate changes	**Aseem Sharma** Elevational dependence of climate variability and trends in British Columbia's Cariboo Mountains, 1950-2010	**Youyu Lu** Circulation, meso-scale eddies and tides simulated with the high-resolution ocean models based on NEMO		**Tetjana Ross** Surveying right whale habitats using glider-mounted sonar
1100-1115	**Mathieu Plante** Observation-based large scale material properties of landfast sea ice	**Wolf Read** The Dose-Response of the Power Distribution Grid to Windstorms that Affect Southwest British Columbia, Canada	**Ines Dana Ehlert** The effect of ocean mixing on heat and carbon fluxes and the linearity between global warming and cumulative CO2 emissions	**Yanping Li** The June 2013 Alberta Catastrophic Flooding: Water vapor transport analysis by WRF simulation	**Fatemeh Chegini** A high-resolution baroclinic model of ocean circulation off southwest of Nova Scotia		**David Barclay** Three-dimensional noise modeling in shallow water environments
1115-1130	**Christian Haas** Mapping thin landfast ice in the Canadian Arctic	**Jeff Daines** Present and Future Wind Energy Resources in Western Canada.	**Kirsten Zickfeld** Exploring the proportional relationship between global warming and cumulative CO2 emissions for negative emission scenarios	**Charles Curry** Does increased resolution alone add value in RCM simulations of extreme climate events? A multi-scale study over Western Canada	**Susan Allen** Evaluation of Physics and Numerics of a Real-time Model of the Salish Sea		**Matthew Hatcher** Ambient noise from turbidity currents in Howe Sound
1130-1145	**Mathilde Jutras** Thermodynamics of snow-ice formation on sea ice	**Peter Taylor** Potential impacts of wind farms in Lake Erie: Some preliminary 1-D modelling using COHERENS	**Katarzyna** How much would five trillion tonnes of carbon warm the climate?	**Waqar Younas** Improving the Representation of Snow Processes in CLASS for Western Canadian regions	**Charles Hannah** Baroclinic circulation along the northern coast of British Columbia		**Kanachi Angadi** The spectrum levels of ambient noise sources in Folger Passage.
1145-1200	**Amy Solomon** Validating processes that impact sea-ice melt-back and freeze-up in coupled limited area model simulations of the marginal ice zone		**Wayne Evans** Methane Leaks from Canadian and American Gas Fields and Impacts on the UNFCCC	**Arelia Werner** Trends in Hydrological Extremes as Modelled Using Two Gridded-Climatological Datasets	**C. Harold Ritchie** A relocatable coupled atmosphere-ocean prediction system		**Jinshan Xu** An study of underwater sound propagation in Barrow Strait using the CONCEPTS GIOPS ocean prediction system

Tuesday Afternoon - June 2 / Mardi après-midi - 2 juin

	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
	Ocean-atmosphere interactions and sea ice II Interactions océan-atmosphère et glace de mer-Partie 2	Coupled Environmental Prediction: From hours to seasons Prévision environnementale couplée: de quelques heures à saisons	Detection and Attribution of High Latitude Climate Change Détection et causes des changements climatiques dans les hautes latitudes	Hydro-climatic Variability, Change and Extremes II: Modelling Snow and Land Surface Processes Variabilité, évolution et extrêmes hydroclimatiques - 2 : modélisation de la neige et des processus de surface	Collaboration in development, application and analysis of ocean forecasting models II Collaboration dans le développement, l'application et l'analyse des modèles de prévision océanique - 2	Synoptic and Mesoscale Dynamics Dynamique synoptique et de mésoéchelle	Acoustics in Oceanography and marine sciences: from tropics to poles II L'acoustique en océanographie et en sciences de la mer : des tropiques aux pôles - 2
1330-1345	**Rhiannon Davies** Modeling the atmospheric boundary-layer of the marginal ice zone: an ACCACIA case study.	**Ed Blockley** UK Environmental Prediction - integration and evaluation at the convective scale	**Seung-Ki** Detection and attribution of recent Arctic sea-ice melting patterns	**William Hsieh** Using artificial neural networks to emulate the VIC hydrological model: Application to streamflow and snow water equivalent projections	**David Greenberg** The pathways of long period and steady state barotropic flows through the Arctic Archipelago.	**John Gyakum** An analysis of extreme precipitation events in continental and coastal regions of North America: The relative roles of synoptic-scale triggers versus stratification	**Greg Wilson** A New Statistical Method for Acoustic Backscatter Amplitude Inversion
1345-1400	**Patricia DeRepentigny** Finding the source regions of sea ice melting in the marginal ice zone: a Lagrangian approach	**C. Harold Ritchie** Overview of an integrated marine Arctic prediction system for METAREAs		**Yonas Dibike** Potential Impacts of Projected Climate on Water Availability in the Western Canadian River Basins	**Jinshan Xu** Validation and inter-comparison against observations of GODAE Ocean View Ocean Prediction Systems for the Northwestern Atlantic	**Jiangnan Li** The Dissipation Structure of Extratropical Cyclones	**Akash Sastri** Zooplankton biomass estimates from acoustic backscatter in the Salish Sea, British Columbia, Canada
1400-1415	**Xiaojun Yuan** Arctic Sea Ice Seasonal Prediction by a Linear Markov Model	**Neil Barton** Insights in low-level polar temperature biases from atmospheric – sea ice coupling in the Navy's Global Coupled Modeling System	**Bennit Mueller** Application of the optimal fingerprinting method to detection and attribution of Arctic sea ice change	**Siraj ul Islam** Assessing climate change impacts on the snowpacks and water availability of the Fraser River Basin, British Columbia	**Len Zedel** Comparison between Doppler sonar observations from a seismic survey ship and ocean circulation analysis results from the CONCEPTS Global Ice Ocean Prediction System over the Grand Banks	**Ron Stewart** The June 2013 Alberta Catastrophic Flooding Event	**Richard Dewey** Four Co-located Doppler Systems for Monitoring the Coastal Bottom Boundary Layer
1415-1430	**Stephen Howell** Multi-year ice replenishment in the Canadian Arctic Archipelago: 1997-2013	**Shouping Wang** Regional Simulations of Summer Arctic Boundary Layers	**Marie-Eve Gagne** Comparison of observed and simulated sea ice extent in the Arctic and Antarctic prior to 1979	**Craig Smith** Intercomparison of snow depth and snow water equivalent measurements during WMO SPICE	**Doug Latornell** Automation Framework for a Regional Ocean Forecast Model	**Ali Asaadi** The importance of African easterly wave critical layer in developing tropical storms	**Len Zedel** Observing fish behavior using a bottom mounted Doppler velocity profiler at a proposed in-stream tidal site: Grand Passage Nova Scotia
1430-1445	**Wieslaw Maslowski** Air-Sea Interaction under a Diminishing Sea ice Cover in the Regional Arctic System Model (RASM)	**Keith Hines** The Year of Polar Prediction (2017-19)	**Francis Zwiers** Detection, Attribution and Extreme Climate and Weather Events	**Felix Ouellet** Spatialization of the SNOWPACK snow model in the Canadian Arctic for Peary caribou winter grazing conditions assessment	**Youyu Lu** Discussion on development, validation and application of high-resolution regional ocean models	**Georgina Paull** Sensitivity of Tropical Cyclone Intensifi cation to Axisymmetric Heat Sources	
1445-1500	**Will Perrie** Decadal variations of the Arctic water temperature and salinity simulated by NEMO	**Melanie Rochoux** Analysis of the subgrid-scale variability in a land surface/atmosphere coupled system	**Nathan Gillett** Observationally-constrained climate projections beyond the near term		**Youyu Lu** Discussion on development, validation and application of nearshore ocean models	**K Menelaou** Some aspects of the problem of secondary eyewall formation in idealized three-dimensional nonlinear simulations	

Wednesday Morning - June 3 / Mercredi matin - 3 juin

	Rainbow	Harmony	Fitzsimmons	Garibaldi B	Wedgemount	Spearhead
	High-resolution sea ice-ocean modeling Modélisation glace de mer-océan à haute résolution	Data Assimilation and Impact of Observations Assimilation des données et incidence des observations	Climate Variability and Predictability I Variabilité et prévisibilité du climat-Partie 1	Coastal Oceanography and Inland Waters in a Changing Climate I Océanographie côtière et eaux intérieures dans un climat changeant-Partie 1	Atmospheric Physics Physique atmosphérique	Ocean Biogeochemistry from Tropics to Poles – Synthesizing Observations and Model Results Biogéochimie de l'océan, des tropiques aux pôles - synthèse des observations et des résultats de modèles
1030-1045	**E. Joseph Metzger** Ice validation of the U.S. Navy's Global Ocean Forecast System 3.1	**Louis Garand** Assimilation of Cris, ATMS, and European ground-based GPS at Environment Canada	**Franco Molteni** Tropical-extratropical teleconnections in the ECMWF sub-seasonal and seasonal prediction systems	**Michael Foreman** A Circulation Model for Baynes Sound, British Columbia	**Caroline Jouan** Aerosols effects on Numerical Weather Prediction through impacts to the microphysics.	**Elise Olson** Physical Aggregation of Buoyant Trichodesmium spp. Colonies through Eddy/Wind Interaction: Observations and Modeling
1045-1100	**Axel Schweiger** Accuracy of short term Sea Ice Drift Forecasts using a coupled Ice-Ocean Model	**Ron McTaggart-Cowan** Comparison of EnKF and EnVar-based ensemble data assimilation methods	**Zhiwei Wu** Potential Influence of the November-December Southern Hemisphere Annular Mode on the East Asian Winter Precipitation: A New Mechanism	**Rich Pawlowicz** Horizontal circulation in the Strait of Georgia	**David Collins** A Stochastic Bulk Rate Parameterization Driven by a Turbulent Collision Kernel	**Akash Sastri** High resolution spatio-temporal patterns of surface CDOM in the Strait of Georgia, BC
1100-1115	**Clark Pennelly** Effect of grid resolution on ocean simulations in the sub-polar North Atlantic and Canadian Arctic using NEMO and AGRIF	**Keith Hines** Arctic System Reanalysis: 15 and 30 km Versions	**Nicholas Soulard** The spring link between the North Atlantic Oscillation and Pacific-North American pattern	**Di Wan** Physical Oceanographic Conditions in Douglas Channel, British Columbia	**Loren Oh** A comparison of direct and bulk calculations of entrainment and detrainment in a high resolution simulation of tropical convection.	**Joannie Charette** The Changing Arctic Ocean: new environments conducive to algal blooms
1115-1130	**Jean-Pierre Auclair** Solving the sea ice momentum equation using Newton's method: Non-linearity, numerics and convergence.	**Zhan Li** EnKF Data Assimilation of Canada Radar for a Lake-Effect Snowstorm in 2015	**Bin Yu** A physical analysis of the severe 2013/14 cold winter in North America	**Richard Dewey** The 2013-15 North East Pacific Surface Warming Comes Near Shore	**Philip Austin** Sub-cloud plumes and cloud-plume interactions in the marine boundary layer.	**Huixiang Xie** Origin of the subsurface anomaly of dissolved methane in seawater on the Baffin Bay and Labrador shelves
1130-1145	**Jean-Francois Lemieux** A basal stress parameterization for modeling landfast ice	**Natalia Hryniw** The Antarctic Radiosonde Network: Optimal Locations for Observation	**Sanjiv Kumar** The Soil Moisture Residence Time and Its Atmospheric Connectivity	**Yongsheng Wu** Representing kelp forests in a regional circulation model: the tidal circulation	**Eric Bazile** GABLS4: An Inter-Comparison Case to Study the Stable Boundary Layer on the Antarctic Plateau	**Nicole Jeffery** How does iron accumulate in Antarctic sea ice?
1145-1200	**Yukie Hata** An Anisotropic Sigma-Coordinate Sea-Ice Thermal Stress Model	**Keith Hines** Assimilating GPS RO in Polar WRF to improve surface pressure estimation over Antarctica	**Yiwen Mao** Predictive anisotropy of surface wind vectors	**Jennifer Shore** Modelling the Bay of Quinte in Lake Ontario using FVCOM	**George Isaac** Grand Banks Fog	

Wednesday Afternoon Part 1 - June 3 / Mercredi après-midi partie-1 - 3 juin

	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
	Beaufort Sea Ocean-Ice-Atmosphere Dynamics Dynamique océan-glace-atmosphère dans la mer de Beaufort	State of the Cryosphere État de la cryosphère	Climate Variability and Predictability II Variabilité et prévisibilité du climat-Partie 2	The Labrador Sea as a Vital element of the climate system I La mer du Labrador, un élément capital du système climatique-Partie 1	Coastal Oceanography and Inland Waters in a Changing Climate II Océanographie côtière et eaux intérieures dans un climat changeant-Partie 2	Chemistry and Air Quality Chimie atmosphérique et qualité de l'air	Land-atmosphere exchange of trace gases Échange sol-atmosphère de gaz traces
1330-1345	**Matthew Asplin** Variability in Wind Forcing Drives Winter Sea Ice Drift in the Southern Beaufort Sea	**Gary Corlett** Towards a combined surface temperature dataset for the Arctic from the Along-Track Scanning Radiometers (ATSRs)	**Jinhai He** Monitoring and Predicing the meridional Propagation of the 30-60-day Variability of Precipitation in the East Asian Subtropical Summer Monsoon Region	**Paul Myers** VITALS - Ventilation, Interactions and Transports Across the Labrador Sea	**Guoqi Han** Simulation of circulation and ice over the Newfoundland and Labrador Shelves	**Ray Nassar** Weather, Climate and Air Quality Observations of the Northern Latitudes from a Highly Elliptical Orbit	**Alison Cassidy** The effect of permafrost disturbances on carbon-dioxide exchange in a high arctic tundra ecosystem
1345-1400	**Jennifer Hutchings** The role of sea ice dynamic preconditioning in recent Beaufort Sea change	**Andrew Snauffer** Development of a Statistical Model for Snow Water Equivalent Estimates in British Columbia, Canada	**Boualem Khouider** Simulation of MJO and Monsoon ISO in an aquaplanet GCM with a stochastic multicloud parameterization	**Jean-Philippe Paquin** Modelled variations of deep convection in the Irminger Sea during 2003-2010	**Pascal Matte** Towards an operational 2D non-stationary hydrodynamic model of the St. Lawrence River and fluvial estuary	**James Drummond** MOPITT Measurements of Carbon Monoxide: What Else Can We Learn?	**Andreas Christen** Greenhouse gas fluxes from a disturbed bog in the Lower Fraser Valley undergoing restoration and rewetting
1400-1415	**Christian Haas** Thickness of sea ice and extreme ice features in the Beaufort Sea	**Chris Derksen** Impact of observational uncertainty in determining variability and change in Arctic snow cover and sea ice extent	**Lei Wang** Summer Arctic Sea Ice Intra-Seasonal Predictability Using a Vector Auto-Regressive Model	**Maggie Campbell** Pathways of Iceland-Scotland Overflow Water in the Sub-Polar North Atlantic Ocean based upon the NEMO ocean general circulation model	**Shiliang Shan** A Modelling Study of Coastal Upwelling on the Scotian Shelf	**Jiangnan Li** Cloud Semi-direct Effect and Its impact on Climate	**Vivek Arora** Potential future carbon uptake may overcome losses from a large insect outbreak in British Columbia, Canada
1415-1430	**Michael Steele** Seasonal Ice Loss in the Beaufort Sea: Toward Synchrony and Prediction	**Bruno Tremblay** Understanding the Interannual Variability of the September Sea Ice Minimum: a Dynamic Approach	**Yonghong Yao** Subseasonal variability of precipitation in China during boreal winter	**Nathan Grivault** Evolution of Baffin Bay water masses and transports in a climate change experiment including Greenland runoff	**Zhigang Xu** Using the All-Source Green's Functions to Specify Barotropic Open Water Boundary Conditions for A Regional Model		**Baozhang Chen** Satellite-observed changes in terrestrial photosynthetic activity trends across the Asia-Pacific region associated with land cover and climate from 1982 to 2011
1430-1445	**Alexandre Forest** Intense shelf-slope fluxes of particulate matter in the mid-water column of the Canadian Beaufort Sea: linkages with atmospheric, ice and ocean forcings	**Ian Eisenman** A spurious jump in the satellite record: has Antarctic sea ice expansion been overestimated?	**Vincent Cheng** A Bayesian Modeling Framework for Tornado Occurrences in North America	**Alex Fuller** Multiple steady solutions of the circulation in the Labrador and Irminger Seas	**Pengcheng Wang** Numerical Study of Wave-Current Interactions over the Eastern Canadian Shelf under Extreme Weather Conditions	**Nan Hu** Refining an Inverse Dispersion Method for Sources on Undulating Terrain	**John Wilson** Surface-layer dispersion: Project Prairie Grass, the turbulent Schmidt number and the flux footprint
1445-1500	**Jennifer Jackson** The seasonal modification of Canada Basin Halocline Water along the Canadian Beaufort slope, Arctic Ocean	**Stephen Howell** What can CMIP5 sea ice projections tell us about future navigability in Canadian Arctic Waters?	**Amanda Lynch** Is There An Economic Advantage to Increased North Slope Navigability?		**Guoqi Han** Modelling the response of Placentia Bay to hurricanes Igor and Leslie	**Huiping Peng** Air Quality Prediction using Machines Learning Methods	

Wednesday Afternoon Part 2 - June 3 / Mercredi après-midi partie-2 - 3 juin

	Rainbow	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount	Spearhead
	Two Ways of Knowing GIS ARCTIQUE: Deux perspectives du savoir : le savoir scientifique et le savoir autochtone	Atmospheric Interfaces in the Arctic Interfaces atmosphèriques dans l'Arctique	Climate Variability and Predictability III Variabilité et prévisibilité du climat-Partie 3	The Labrador Sea as a Vital element of the climate system II La mer du Labrador, un élément capital du système climatique-Partie 2	Coastal Oceanography and Inland Waters in a Changing Climate III Océanographie côtière et eaux intérieures dans un climat changeant-Partie 3	Polar Clouds, Precipitation, and Aerosols Nuages, précipitation et aérosols polaires	Atmosphere, Ocean, and Climate Dynamics Dynamique de l'atmosphère, des océans et du climat
1530-1545	The Session will examine the interactions between Inuit knowledge holders and northern researchers. Discussions will look at new and innovative ways of addressing communication between the "Two Ways of Knowing" by examining lessons learned and opportunities for scientists and Inuit knowledge holders to work better together in Arctic science. La session examinera les interactions entre les détenteurs de connaissances Inuits et les chercheurs du Nord. Les débats exammineront les façons nouvelles et novatrices d'aborder la communication entre les « Deux façons de savoir » en examinant les leçons apprises et les possibilités pour les scientifiques et les détenteurs de connaissances Inuits à mieux travailler ensemble dans le domaine de la science de l'Arctique. Notre débat de discussion comprend / Our discussion panel includes: * **Vic Gillman,** Fisheries Joint Management Committee, Inuvialuit Settlement Region, Inuvik, NWT • **Baba Pedersen,** Inuit Ranger and Resource Management Officer, Kugluktuk, Nunavut • **Hal Ritchie,** Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) Arctic Initiative • **Bill Williams,** Oceanographer, Fisheries and Oceans Canada,	**Mimi Hughes** The climatological distribution of extreme Arctic winds, and implications for ocean and sea ice processes.	**Song Yang** Extended-Range Forecast of Tropical Asian Summer Monsoon	**John Loder** Historical and Recent Hydrographic Variability in the Labrador Sea, and Larger-Scale Linkages	**Karina Ramos Musalem** The combined effect of mixing and advection for tracers within a submarine canyon	**Matthew Shupe** The interplay of Arctic surface fluxes, stratocumulus clouds, and cloud-driven mixed layers	**Stephanie Waterman** A Geometric Decomposition of Eddy-Mean Flow Interactions
1545-1600		**James Drummond** The Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Nunavut	**Edward Blanchard-Wrigglesworth** Model skill and sensitivity to initial conditions in a sea-ice prediction system	**Xianmin Hu** Impact of Greenland Melt on the East and West Greenland Currents and the North-West Labrador Sea	**Ram Rao Yerubandi** On the simulation of Algal Blooms in Lake Erie	**Tristan L'Ecuyer** Satellite Constraints on the Roles of Supercooled Liquid and Snowfall on Arctic Energy and Water Cycles	**David Straub** Dissipation of geostrophic flow by wind-driven near-inertial oscillations
1600-1615		**Ola Persson** Atmosphere-Ice-Ocean Interactions During Summer Melt and Early Autumn Freeze-up: Observations from the ACSE Field Program	**Youmin Tang** The Climatologically relevant singular vector and its application in climate predictions	**Yarisbel Garcia Quintana** Labrador Sea Water formation rate, 2002-2010, from a numerical model.	**Jennifer Jackson** Satellite Chlorophyll off the British Columbia Coast, 1997-2010	**Samuel LeBlanc** Changing arctic cloud properties at the sea-ice edge measured by airborne observations from Fall 2014	**Yavor Kostov** Southern Ocean cooling in a warming world: reassessing the role of westerly winds
1615-1630		**Glen Lesins** High Frequency Temperature and Pressure Measurements in Very Stable Winter Boundary Layers at the Eureka Flux Tower	**Zhiwei Wu** Interdecadal Variability of the mega-ENSO-NAO Synchronization in Winter	**Mitchell Wolf** Using Argo-O2 data to examine the impact of deep-water formation events on oxygen uptake in the Labrador Sea	**Roberta Hamme** The interplay of denitrification and deep-water renewal dynamics in Saanich Inlet	**Nathaniel Miller** Cloud influence on the surface energy budget of the Greenland Ice Sheet	**Amber Holdsworth** Modelling Near surface winds in the Nocturnal Boundary Layer
1630-1645		**Joseph Hamman** Evaluation of the Land Surface Climate in the Regional Arctic System Model (RASM)	**Ray Garnett** Determinants of Summer Weather Extremes over the Canadian Prairies: Implications for Long Lead Grain Forecasting	**John Loder** Recent Oceanographic Variability on the Scotian Slope and Rise, and Upstream Linkages	**Ben Moore-Maley** Long-term variability of pH and aragonite saturation state in the Strait of Georgia	**Lauren Zamora** Aircraft-measured indirect cloud effects from biomass burning smoke in the Arctic	**Oliver Watt-Meyer** The role of standing waves in driving persistent anomalies of upward wave activity flux
1645-1700		**William Ward** Coordinated observations of Dynamics in the Arctic Polar Mesosphere and Thermosphere: The Dynamics of the Neutral Thermosphere Project	**Hai Lin** GEM-NEMO global coupled model for subseasonal to seasonal predictions		**Debby Ianson** The vulnerability of the Strait of Georgia to Ocean Acidification and Hypoxia	**Norm O'Neill** Polar winter aerosol optical depth (AOD) : spectrally and temporally cloud-screened (starphotometer) AODs compared with CALIOP and GEOS-Chem estimates	**Colin Goldblatt** From Snowball Earth to the Runaway Greenhouse: multiple climate states of Earth now

Thursday Morning - June 4 / Jeudi matin - 4 juin

	Harmony	Fitzsimmons	Garibaldi A	Garibaldi B	Wedgemount
	Observations II Observations-Partie 2	New Approaches to Ocean Observing Nouvelles méthodes d'observation de l'océan	Mixing in the Open and Coastal Oceans Mélange en pleine mer et près des côtes	High latitude glacier and ice sheet interaction with the atmosphere and ocean Interaction des glaciers et des nappes glaciaires des hautes latitudes avec l'atmosphère et l'océan	Operational Forecasting Prévision opérationnelle
1030-1045	**Chris McLinden** The TEMPO geostationary air quality mission and what it means for Canada	**Steve Mihaly** The first year of autonomous water column measurements in Saanich Inlet: The Saanich Inlet Buoy Profiling System	**Stephanie Waterman** Rates and mechanisms of turbulent dissipation and mixing in the Southern Ocean	**Clark Richards** Dynamics of glacier calving in a West Greenland tidewater fjord	**Jim Abraham** The Future of the Weather Enterprise
1045-1100	**James Drummond** Carbon Monoxide Events and Trends over 15 Years from the MOPITT Space Instrument	**Charles Hannah** Surface drift in the Douglas Channel area: adventures with a low cost satellite tracked drifter.	**Jody Klymak** Mixing in the Canadian Arctic Archipelago	**Laura Gillard** Ocean Circulation and Marine Terminating Glaciers of the Canadian Arctic Archipelago and the Greenland Ice Sheet	**Renee Tatusko** The NOAA Arctic Test Bed
1100-1115	**Pierre Fogal** Re-investigation of a long term infrared spectral data set for ozone recorded at 80° N	**Kevin Bartlett** Operating Oceanographic HF Radar Systems in the Coastal Waters of BC	**Nancy Soontiens** Mixing and dissipation in a regional model of the Salish Sea	**Adrien Gilbert** Recent and future evolution of Barnes ice cap (Baffin Island, Canada)	**Uwe Gramann** Communicating and forecast uncertainty during the 2014 Lake Louise FIS Alpine Ski World Cup.
1115-1130	**Gerrit Holl** Cross-validation of methane retrievals from ACE-FTS, GOSAT, and ground-based solar absorption measurements, at Eureka, Nunavut.	**Mark Halverson** Drifter-based validation of the Ocean Networks Canada Strait of Georgia CODAR array	**Jody Klymak** Turbulence in low Froude number stratified flows	**Sam Pimentel** Modelling the dynamic response of Belcher Glacier (Devon Island, Nunavut) to seasonal surface melt	**Nan Miao** Access forecast uncertainties from a multi-model post-processing system
1130-1145	**Alexander Radkevich** Modeling of TOA radiance measured by CERES over the East Antarctic Plateau	**Cedric Chavanne** Hindcasts of surface drifter trajectories using high-frequency radars : skill sensitivity to drifter depth in a highly vertically-sheared environment	**Hesam Salehipour** Small scale shear stratified turbulent mixing and its inference for the global Oceans	**L. Mac Cathles** Surface roughness and other controls on the albedo of ice sheets	**Iain Russell** Verification of precipitation start/stop times derived from probabilistic nowcasting
1145-1200	**Marcelo Santos** Geodetic Applications of Ray-tracing through the neutral-atmosphere		**David Deepwell** Mass transport and mixing by mode-2 internal waves	**Shawn Marshall** A comparison of surface energy balance and degree day models for mass balance of Arctic icefields and the Greenland Ice Sheet	**Herb Winston** A Heavy Precipitation Event as Observed by King City's Upgraded Dual-Polarization C-Band Radar

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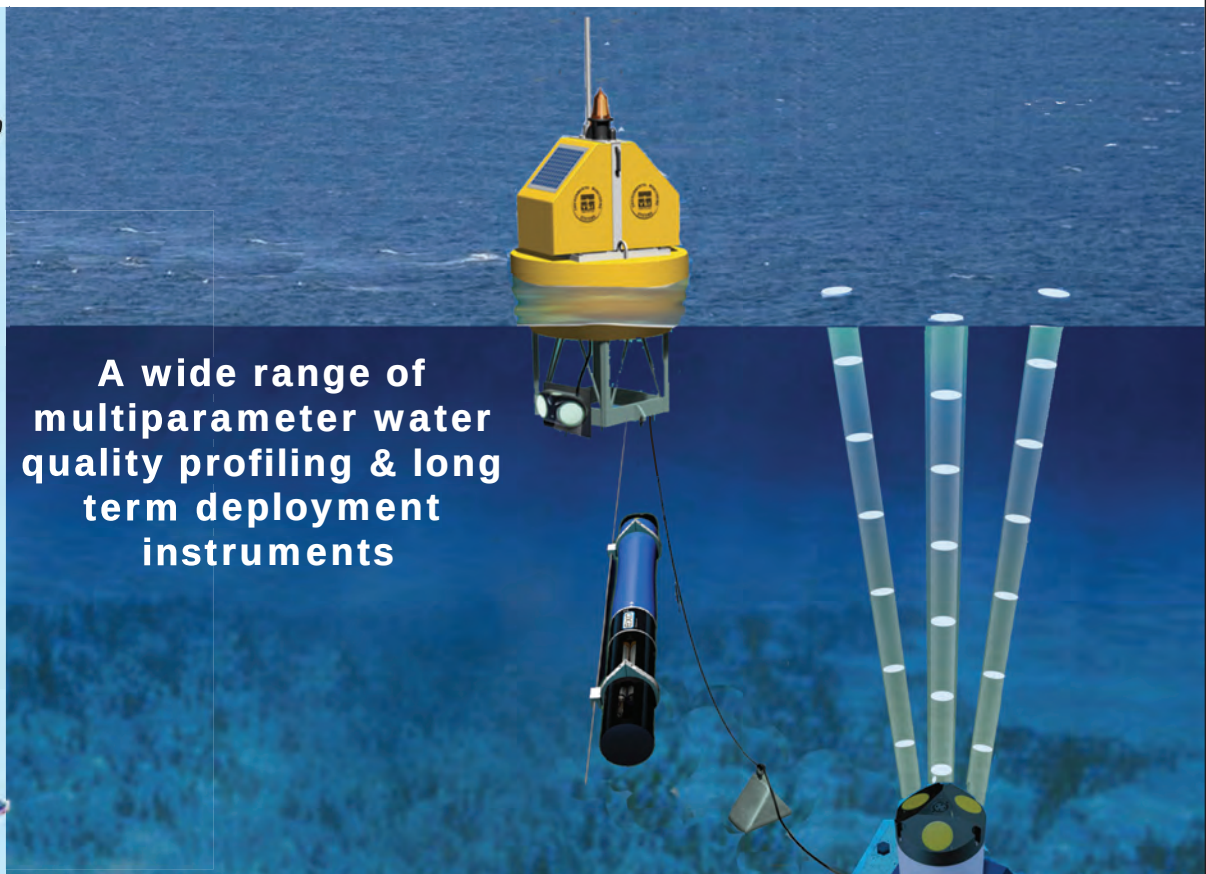

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Abstract Book

TROPICS TO POLES
DES TROPIQUES AUX POLES

ADVANCING SCIENCE IN HIGH LATITUDES
AVANCEMENT DE LA SCIENCE DES HAUTES LATITUDES

Recueil des résumés

Editors / Éditeurs: Bruce Ainslie, Tim Ashman, & Andres Soux

2015 WHISTLER

May 31 - June 4 | 31 mai - 4 juin | British Columbia, Canada

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

American Meteorological Society

49th CMOS Congress
13th AMS Conference on Polar Meteorology and Oceanography
Abstract book

Tropics To Poles:
Advancing science in high latitudes

49e congrès SCMO
13e conférence AMS sur la météorologie polaire et l'océanographie
Recueil des résumés

Des Tropiques Aux Poles :
Avancement de la science des hautes latitudes

Whistler 2015

May 31– June 4, 2015
31 mai – 4 juin 2015

Editoris / Éditeurs : Bruce Ainslie, Tim Ashman, Andres Soux

Canadian Meteorological and Oceanographic Society
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Introduction

This book contains the abstracts of all the oral communications and posters presented at the 49th Canadian Meteorological and Oceanographic Society (CMOS) Congress and the 13th American Meteorological Society's (AMS) Conference on Polar Meteorology and Oceanography in Whistler from May 31-June 4, 2015.

The abstracts are ordered chronologically by scientific sessions.

Some communications may have been removed from the program after the publication date of this book. For a final updated list, see the address below.

Introduction

Ce recueil rassemble les résumés de tous les communications orales et de tous les posters présentés au 49e congrès Société canadienne de météorologie et d'océanographie (SCMO) et 13e conférence American Meteorological Society (AMS) sur la météorologie polaire et l'océanographie à Whistler du 31 mai au 4 juin 2015.

Les résumés sont classés par ordre chronologique par des sessions scientifiques.

Quelques communications peuvent avoir été retirées du programme après la date de publication de ce recueil. Pour une liste définitive tenue à jour, voir l'adresse suivante.

https://www.cmos.ca

08:30

Recent decadal trends in the tropical Pacific and their impact on Antarctic and the Arctic

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The global average temperature increased rapidly from about 1980 to 2000, but it has not increased appreciably in the past 15 years or so - despite a significant increase in atmospheric carbon dioxide. The stall in the rise in global temperature, called the hiatus, is due in large part to a decrease in the sea surface temperature in the eastern tropical and subtropical Pacific. In this talk, I will present results that demonstrate the decadal-scale trends in the tropical Pacific were likely responsible for the destabilization of the Pine Island Glacier and other ice shelves in West Antarctic in the 1990s, and for about half of the remarkable warming over Greenland and northeast Canada in the past 15 years. Several hypotheses have been put forward to describe the global hiatus and the tropical Pacific temperature trends - ranging from natural variability to a regional response to human activity (increased carbon dioxide or atmospheric aerosols). I will review these ideas, argue that climate models used by the IPCC are incapable for evaluating these hypotheses, and suggest a way forward so that we can better understand the cause of past climate variability and improve the projections of future climate.

09:15

The impact of Arctic warming on the midlatitude jetstream: Can it? Has it? Will it?

Elizabeth Barnes[1]
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The Arctic region has warmed more rapidly than the globe as a whole, and this has been accompanied by unprecedented sea ice melt. Such large environmental changes are already having profound impacts on those that live in the Arctic region. An open question, however, is whether these Arctic changes have an effect on weather patterns farther south. This broad question has recently received a lot of scientific and media attention, but conclusions appear contradictory rather than consensual. We argue that one point of confusion has arisen due to ambiguities in the exact question being posed. Here we frame our inquiries around three clear and tractable questions: Can Arctic warming influenced the midlatitude jet stream? Has Arctic warming significantly influenced the midlatitude jetstream? Will future Arctic warming significantly influence the midlatitude jet stream? Here, we will frame a discussion of jetstream variability around these three questions: Can it?, Has it?, Will it?; however, we note that these three questions are still a long way from being fully answered.

08:30

Arctic Ocean scales of variability and change

Mary-Louise Timmermans[1]
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This talk will review highlights of recent Arctic Ocean measurements, encompassing a wide range of temporal and spatial scales, in an exploration of ocean drivers of sea ice and climate change. Arctic freshwater dynamics, ocean heat and mixing processes, circulation and eddies, and atmosphere-ice-ocean interactions and their interrelationships will be surveyed. Observations indicate apparently rapid changes in the basin-scale freshwater distribution that have marked effects on Arctic stratification. Recent measurements support the idea that a strengthened stratification limits the vertical flux of deep-ocean heat. All ocean layers exhibit a rich mesoscale eddy field. Measurements further reveal an active submesoscale flow field that modifies heat, salt, and momentum fluxes between the ocean and adjacent sea-ice cover. Pervasive double-diffusive structures link the smallest to the largest spatial scales of variability in the Arctic, and allow for constraints to be placed on the regional and temporal changes in the transfer of heat and salt.

09:15

Factors influencing the surface albedo feedback in coupled climate models

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Amplified Arctic surface warming in response to rising greenhouse gas concentrations, or so called Arctic Amplification, is a ubiquitous feature of climate model simulations. However, the magnitude of this amplification varies considerably across models, in part due to differing strengths of the simulated surface albedo feedback. Numerous factors influence the surface albedo response to rising greenhouse gas concentrations. These include changes in sea ice surface properties, ice-covered area, and snow conditions. Here we assess a number of these factors using simulations from a large ensemble of the Community Earth System Model and simulations from other models participating in the Coupled Model Intercomparison Project 5 (CMIP5). This includes an analysis of aspects that contribute to the spread across models in projected albedo change and Arctic Amplification. The results provide insight on the uncertainty in future projections, possible methods to better constrain those projections, and model development needs.

08:30

Canadian Arctic Oceanography: present and future research priorities based on lessons from the past

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Major advances have been realized over the past forty years in our scientific understandings of the physical oceanography and marine ice regime of the Canadian Arctic. These advances have been driven by the increased priority of Arctic research at the Canadian federal government level, albeit often uneven in its application, and more priority at the international level over the past two decades. A related impetus for Arctic oceanography and ice research has been the search for natural resources including offshore oil and gas and mining along with the increased awareness of environmental assessments for proposed industrial developments. Scientifically, the awareness of the importance of the Arctic to climate change and to the global ocean has also been an important driver for Arctic research. Over the past four decades, Canadian Arctic ocean and ice research has been challenged by the remoteness of the area including the high cost of accessing it by ship for short periods in summer. Key enablers of Arctic Ocean and ice research are technological advancements including: satellite and aircraft based remote sensing, advances in underwater instrument arrays to allow year-long observation measurement programs from subsurface moorings; satellite communications systems for allowing data collection from ice- and ocean-based drifting platforms; numerical modeling advances. While improved technology have benefited oceanographic research on a global basis, the benefits have been largest in remote areas of the planet such as the Canadian Arctic. Even with these advances, the Canadian Arctic remains less well understand than for the more temperate oceans adjoining Canada, especially in the long period of ice cover within each year. Scientific understandings must address the high degree of interannual variability in the Arctic, combined with the very large climate changes of the Arctic by comparison to other parts of the world. Key gaps in our present understandings will be presented leading to some proposed research priorities for the future.

09:15

Marine biogeochemistry in the Arctic

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Climate change forces multiple stressors on Arctic marine ecosystems, such as warming, sea-ice retreat, ocean acidification and enhanced stratification limiting food supply. Expanding economic development might cause additional stressors, e.g. pollution and potential oil spills. Many changes are faster and more profound in the Arctic than in any other region of the world ocean, hence the study of marine biogeochemical processes in high latitudes has received a boost of attention in the last two decades. With a variety of projects including intense measurement programs we somewhat belatedly struggle to establish some baseline before potentially irreversible system changes occur. Projecting future ecosystem responses to climate change and other potential stressors requires the application of numerical ecosystem models. The 5th Coupled Model Intercomparison Project (CMIP5) includes for the first time a variety of Earth system models (ESMs, model systems with fully coupled atmosphere, ocean, sea ice and land components including interactive biogeochemical modules for all components), allowing the study of future projections of the marine carbon cycle and ecosystem behavior. However, the still fairly coarse horizontal and vertical resolution restricts the ability to resolve biological or chemical processes happening in the euphotic zone as well as small-scale physical processes important for biogeochemistry. Model skill for biogeochemical variables in global ESMs is still low, especially for the Arctic, where observational data are few and seasonally biased, and where shelf areas and narrow passages are common features. I will provide an update of results from ESM intercomparison studies in the Arctic which show both consistent trends (e.g. acidification) as well as differences (e.g. future primary production) among the models. I will discuss the shortcomings in ESMs and improvements obtained with the application of higher resolution regional models. In addition I will highlight the use of 1-D models in the development of model parameterizations, including biogeochemical, mixing, gas and radiative transfer processes. An example is the 1D General Ocean Turbulence Model (GOTM) plus sea ice which is used for physical forcing and coupled to biogeochemistry modules via the Framework for Aquatic Biogeochemical Models (FABM). Following a main focus on the pelagic ecosystem, I will then guide some attention to sea-ice biogeochemistry. Our knowledge of the role sea-ice biogeochemical processes play in local and global systems is severely limited by our poor confidence in numerical model parameterisations representing those processes. Improving those parameterisations requires communication between observationalists and modellers to both guide model development and improve the aquisition and presentation of observational results. In addition to more observations, we need conceptual and quantitative descriptions of the processes controlling e.g. the incorporation and release of sea ice algae, the magnitude and limits of primary production, and the release or absorption of radiatively active gases, such as CO2 and DMS. I will present some guidelines to help modellers, and observationalists improve the integration of measurements and modelling efforts and advance towards the common goal of understanding the biogeochemical processes involved and their impacts on environmental systems.

08:30

Twenty-first century warming and the deglaciation of Western Canada

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Glaciers in mountainous parts of Alberta and British Columbia are faring badly in a warming climate. We project their future using a regional glaciation model (RGM): a coupled model of glacier dynamics and surface mass balance. The model is forced by an ensemble of global climate models, downscaled to the 200 m resolution of the RGM, and four climate scenarios (RCP2.6, RCP4.5, RCP6.0 and RCP8.5). Our results indicate that by 2100 the volume of glacier ice in western Canada will shrink by as much as 80% relative to 2005. Most mountain ranges become completely deglaciated, but glaciers near the Pacific coast, in particular those in northwestern British Columbia, will survive in a diminished state. The maximum rate of ice volume loss, corresponding to peak input of deglacial meltwater to streams and rivers, is projected to occur around 2020-2040.

09:15

Eye in the sky: Monitoring air pollution from space

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Beginning in earnest around 2000, several satellite instruments have been launched that are designed primarily to quantify air pollution levels in the lowermost atmosphere. These "air quality" sensors measure either sunlight reflected by Earth and its atmosphere, or radiation emitted from them, and from this are able to provide global information on a wide range of compounds linked to smog and acid rain. These include ozone, nitrogen dioxide, sulphur dioxide, carbon monoxide, ammonia, particulate matter, and others. Beyond the more straightforward monitoring and trend applications, these measurements are being used in conjunction with atmospheric models to provide insight into current and near-future surface concentrations of these pollutants as well as their rates of emission and their environmental impacts. This talk will: (i) review what types of data are currently available along with their strengths and limitations, (ii) present examples of how these data are applied towards pollution monitoring, trend assessment, emissions, and impacts (including findings from the Alberta oil sands), (iii) discuss challenges unique to Canada and other nations at higher latitudes, (iv) examine what the future may hold, and (v) touch on how these analyses and results are relevant for policy and decision-makers.

19:00

Arctic Collaboration: challenges and opportunities in building global partnerships

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Problem statement: In an increasingly inter-connected, inter-dependent and rapidly changing globalized world, there continues to be an absence of habitual and persistent relationships across the global maritime and Arctic communities of Interest, which is essential to developing a comprehensive shared understanding of the Maritime Domain, and in particular the Arctic region. The unprecedented changes which are occurring in the Maritime Domain as a direct or indirect result of changes which are occurring in the Arctic region are clear and unequivocal; however, without a comprehensive shared understanding of these unique domains, decision-makers from around the world are faced with the challenge of making and enforcing decisions of potentially geo-strategic significance on the basis of scanty, incomplete or wrong information. Background: The Arctic community of interest and indeed the broader global maritime community of interest is made up of stakeholders representing international, national, regional, state and local government, academic and business communities, international organizations, nongovernmental organizations, think tanks, special interest groups, as well as individual citizens. The overall safety, security and health of the Arctic and maritime domains, as well as the efficiency and resilience of a global supply chain which is steadily becoming more reliant on ocean resources and maritime transportation routes, depends on both the physical flow of materials and goods as well as information flow from origin to destination. There is little benefit to the overall management of the Arctic and maritime domains (and those activities and interests which influence or are influenced by these domains) if certain links or stakeholders are maintaining habitual and persistent relationships while others are not, or if there are shortfalls in information sharing and collaboration among stakeholders. It is the total performance of this highly complex system that is relevant. The world has become a system of systems in which people, cargo, conveyances, information, the physical environment, as well as real and virtual infrastructure are linked into intricate patterns of dependency with other inter-modal transportation methods and facilities spread around the world; and, in fact, the Arctic and maritime domains cannot be looked at in isolation from the broader air, space, land and cyber domains due to the various dependencies and interdependencies of this complex system of systems. Aim: To share unique insights into the challenges of relationship-building across key stakeholders of the global maritime and Arctic communities of interest and to propose a number of potential solutions, solution enablers and possible areas for further research to enhance Arctic and Maritime Domain Awareness in order to enable timely and well-informed decisions and actions related to this area of geo-strategic significance. Methodology: This assessment will be based on my previous academic research and on my recent professional experiences while serving in Washington, D.C. as Commander North American Aerospace Defense Command (NORAD) and U.S. Northern Command's primary Canadian advisor in the U.S. national capital. With offices at the Embassy of Canada and various locations throughout the U.S. defence, intelligence and interagency communities, I was responsible for nurturing strong collaborative relationships with stakeholders from around the globe to facili-

tate dialogue between national security planners, political decision-makers, industry, and academic stakeholders with actionable insights regarding the most significant global strategic challenges of the day; including understanding the various global interests in a rapidly changing Arctic.

10:30

Downscaling Extremes - a set of climate change projections for Canada

Trevor Murdock[1], *Alex Cannon*[1], *Steve Sobie*[1]
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Demand for projections of climate extreme events has arisen out of local infrastructure vulnerability assessments and adaptation planning. Global climate models (GCMs) are often too coarse in resolution to provide information specific to regional and local communities. To obtain the local data needed, statistical downscaling methods are frequently used to generate high resolution projections for individual assessments or areas. The skill of multiple statistical downscaling methods were compared using multiple measures of skill. Then, an ensemble of CMIP5 simulations was selected based on historical simulation of extremes and a clustering algorithm to ensure the ensemble represents a wide range of projected climate change. Finally, the effect that downscaling on the magnitude and distribution of changes in extreme events that are projected to occur in GCMs was then examined to assess whether the downscaling process preserves the large-scale GCM spatial patterns and precipitation distributions. Selected applications of the new dataset of downscaled climate projections, which are available at http://www.pacificclimate.org/data/statistically-downscaled-climate-scenarios, will be highlighted.

10:45

On the use of statistical downscaling time-invariant transfer functions and their effect on different historical and future metrics. Case study: daily maximum temperature in Montreal, Canada.

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Nowadays a wide community of users is interested in information about climate variables at a spatial scale not resolved by the current generation of global climate models (GCMs). Among the typical users of high resolution data we can find hydrologists, biologists, ecologists, economists, planning agencies, insurance companies, policy-makers and government agencies interested in providing local scale information relevant to their stakeholders. Statistical downscaling techniques are often used to generate finer scale projections of climate variables affected by local scale processes not resolved by the coarser resolution GCMs. Statistical downscaling models rely on several assumptions in order to produce finer/local scale projections of the variable of interest; one of these assumptions is the timeinvariance of the relationships between predictors (e.g. coarse resolution GCM output) and the local scale predictands (e.g. gridded observation based time-series or weather station observations). However, in the absence of future observations, statistical downscaling studies use historical data to evaluate their models and assume that these historical simulation skills will be retained in the future. Here we study the effect of this generally overlooked assumption when downscaling daily maximum temperatures and using the downscaled information to estimate historical and future metrics like return periods and heat waves durations over Montreal, Canada. To do so, we used regional climate model (RCM) output from the Canadian RCM 4.2, as proxies of historical and

future local climates, and daily maximum temperatures obtained from the Canadian GCM 3.1. The results show that the root mean squared errors (RMSEs) between the pseudo-observations and the statistically downscaled time-series (historical and future) varied over time, with higher errors in the future period. The results also show the effect of different post-processing techniques like randomization and variance-inflation on the tails of the statistically downscaled time-series.

11:00

Observed trends in severe weather conditions based on humidex, wind chill and heavy rainfall events in Canada for 1953

Eva Mekis[1], *Lucie A. Vincent*[1], *Mark W. Shephard*[1], *Xuebin Zhang*[1]
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Observed trends in severe weather conditions based on alert statements to the public are examined across Canada. Changes in extreme heat and extreme cold events represented by various humidex and wind chill indices are analyzed for 1953-2012 at 126 climatological stations. Changes in heavy rainfall events based on rainfall amounts provided by the Tipping Bucket Rainfall Gauges are analyzed for 1960-2012 at 285 stations. The results show that extreme heat events defined by days with at least one hourly humidex value above 30^oC have significantly increased at more than 36% of the stations mainly located south of 55^oN, and days with nighttime hourly humidex values remaining above 20^oC have significantly increased at more than 52% of the stations mainly located south of 50^oN. Extreme cold events represented by days with at least one hourly wind chill value below -30^oC have significantly decreased at more than 76% of the locations across the country. No consistent changes were found in heavy rainfall events. Since city residents are very much vulnerable to severe weather events, detailed results in extreme heat, extreme cold and heavy rainfall events are also provided for ten urban centres.

11:15

Climate Change Impacts to Natural Disturbances in Northern British Columbia

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Northern BC is experiencing significant changes to its climate and impacts are already occurring. Most notably, recent winter warming provided conditions for overwinter survival of the Mountain Pine Beetle which resulted in large-scale mortality of pine trees at epidemic levels. Other pests and some forest diseases are finding current climate conditions more favourable for their survival and spread. Loss of snow, ice, and mountain permafrost is creating conditions more suitable for landslides. Low elevation permafrost in northeastern BC is warm and at risk of melting and causing stability issues. Winters are becoming shorter and contributing to extended forest fires seasons. Hydrological regimes are changing and becoming more difficult to predict. This presentation will focus on current efforts in the Ministry of Forests, Lands, and Natural Resource Operations to monitor climate impacts in northern BC and risks to natural disturbances.

11:30

The Delicate Undertaking of Making Climate Science Relevant to Decision-Making

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In the few instances where climate scientists meet decision-makers, many hurdles hinder the exchange of information. On the science side, the wide array of results conditional on apparently arbitrary emission scenarios, climate models and natural variability makes the interpretation of results a daunting task. On the decision side, there are also myriad factors at play in any decision, some political, social or economic, and as climate scientists, we usually cannot tell how significant climate uncertainties are compared to other kinds of uncertainties. This focus on uncertainties and their sources required by standards of scientific integrity is obviously at odds with decision-makers needs for straight answers, yet is not something scientists are willing to give up. In a project targeting hydroelectric generation, we are testing an approach called Robust Decision Making with the aim of lowering perceptual barriers to the inclusion of climate projections into decision-making processes. This approach can be thought of as a sensitivity study to climate change as well as to the other factors affecting the decision process. Climate projections only enter the picture at the end of the analysis, where instead of conditioning the results as in typical impact studies, it is interpreted as an expert judgment about the likelihood of parameterized climate change scenarios.

10:30

Temperature change on the Antarctic Peninsula linked to the tropical Pacific

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Significant summer warming over the eastern Antarctic Peninsula in the last 50 years has been attributed to a strengthening of the circumpolar westerlies, widely believed to be anthropogenic in origin. On the western side of the Peninsula, significant warming has occurred mainly in austral winter and has been attributed to the reduction of sea ice. We show that austral fall is the only season in which spatially extensive warming has occurred on the Antarctic Peninsula. This is accompanied by a significant reduction of sea ice cover off the west coast. In winter and spring, warming is mainly observed on the west side of the Peninsula. The most important large-scale forcing of the significant wide-spread warming trend in fall is the extratropical Rossby wave train associated with tropical Pacific sea surface temperature anomalies. Winter and spring warming on the western Peninsula reflects the persistence of sea ice anomalies arising from the tropically forced atmospheric circulation changes in austral fall.

11:00

Seasonal Antarctic station-based pressure reconstruction evaluation during the 20th century

Chad Goergens[1], *Ryan Fogt*[1]
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A key component in understanding climate variations across Antarctica, whether from the Southern Annular Mode (SAM) or from tropical teleconnections, is understanding changes in the atmospheric circulation. Yet, as with much of Antarctic data, researchers are left with neither long-term point (station) measurements of pressure variations across Antarctica, nor gridded pressure data from reanalyses or models that can be deemed reliable, given very little in situ data to constrain the solution across the high southern latitudes. This presentation provides station-based reconstructions of 17 Antarctic manned stations by seasons. We employ principal component regression using midlatitude pressure observations as predictors individually for each Antarctic station. We are able to reconstruct the austral summer and winter pressure back until 1905 with fairly high skill, and modest skill in austral spring and autumn. The reconstruction skill along the Antarctic Peninsula is considerably higher in all seasons. A few reconstructions are used as examples to place the recent atmospheric circulation changes in a longer historical context, thereby highlighting the uniqueness of these recent changes. Future work includes conducting a spatial Antarctic-wide pressure reconstruction back until 1905.

11:15

How Climate Model Complexity Influences Sea Ice Stability

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Record lows in Arctic sea ice extent are making frequent headlines in recent years. The change in albedo when sea ice is replaced by open water introduces a nonlinearity that has sparked an ongoing debate about the stability of the Arctic sea ice cover and the possibility of Arctic "tipping points". Previous studies identified instabilities for a shrinking ice cover in two types of idealized climate models: (i) annual-mean latitudinally-varying diffusive energy balance models (EBMs) and (ii) seasonally-varying single-column models (SCMs). The instabilities in these low-order models stand in contrast with results from comprehensive global climate models (GCMs), which typically do not simulate any such instability. To help bridge the gap between low-order models and GCMs, we develop an idealized model that includes both latitudinal and seasonal variations. The model reduces to a standard EBM or SCM as limiting cases in the parameter space, thus reconciling the two previous lines of research. We find that the stability of the ice cover vastly increases with the inclusion of spatial communication via meridional heat transport or a seasonal cycle in solar forcing, being most stable when both are included. If the associated parameters are set to values that correspond to the current climate, the ice retreat is reversible and there is no instability when the climate is warmed. The two parameters have to be reduced by at least a factor of 3 for instability to occur. This implies that the sea ice cover may be substantially more stable than has been suggested in previous idealized modeling studies.

11:30

Inter-annual variability of Arctic mixed layer properties from 1979 to 2012

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As part of a recent observation-based assessment of the variability of pan-Arctic mixed layer properties (i.e., temperature, salinity and depth) we have quantified seasonal mixed layer depth change, and provided insight on the dominant contributors to mixed layer depth variability [Peralta-Ferriz and Woodgate, 2015]. This assessment shows that the seasonal variability of Arctic mixed layer depth may be largely explained by the seasonal cycle of sea ice growth and melt, and that the effectiveness of the wind to deepen the mixed layer depends on the strength of the underlying stratification. The study also shows that the underlying stratification exerts a dominant control (compared to wind) in determining the depths of the mixed layer. In this presentation, we focus on the inter-annual and multi-year trends in mixed layer properties from 1979 to 2012 in six regions of the Arctic Ocean (Chukchi Sea, Southern Beaufort Sea, Canada Basin, Makarov Basin, Eurasian Basin and Barents Sea). Despite an increase in the ice-free area of the Arctic Ocean (thus presumably increasing the Arctic's vulnerability to wind-stirring), we find that there is a small but significant and nearly pan-Arctic shoaling trend (about 1 m/yr), associated with a small - yet significant - freshening of the mixed layer. The only exceptions are during the winter in the Southern

Beaufort and Barents seas, where the trends are towards deepening and salinization of the mixed layer. We explore the possible causes of this nearly-ubiquitous Arctic mixed layer depth shoaling, and provide perspective of these changes in mixed layer properties as the Arctic Ocean transitions into a seasonally ice-free environment. Peralta-Ferriz, C. and R. A. Woodgate (2015), Seasonal and interanual variability of pan-Arctic Surface mixed layer properties from 1979 to 2012 from hydrographic data, and the dominance of stratification for multiyear mixed layer depth shoaling, Progress in Oceanography, in press.

11:45

The changing contribution of Snow to Hudson Bay River Discharge.

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Hudson Bay (HB) in northern Canada covers an area of 1.2 million km2 with a drainage basin spanning 3.8 million km2. Freshwater discharge into HB has historically averaged approximately 950 km3 yr-1, amounting to some 20% of total annual fluvial contributions to the Arctic Ocean. However, there have been indications that the volume and distribution of flows have changed in recent decades. These shifts may be due to changing snow accumulation and ablation regimes across central North America. This presentation will therefore quantify the changing contribution of snowmelt from eighteen major river basins draining into Hudson Bay (including James Bay) between 1980 and 2008. The analysis is based on daily snow water equivalent (SWE) data from GlobSnow, and daily streamflow data from the Water Survey of Canada and Le Centre d'Expertise Hydrique du Québec. The contribution of snowmelt to streamflow generation is estimated from the ratio of water year maximum SWE to runoff. Interannual and interdecadal trends of SWE and streamflow, and the ratio between these metrics, will also assessed using the Mann-Kendall Trend test. These findings suggest that changing climatic conditions are beginning to provoke shifts in hydrological patterns in the HB basin, which may in turn impact physiographic, ecological and socio-economic characteristics across much of Canada's North, and potentially throughout the Arctic Basin.

10:30

Circulation, dispersion, and hydrodynamic connectivity over the Scotian Shelf, a numerical investigation using a nested-grid ocean circulation model

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A nested-grid ocean circulation modelling system is used to simulate circulation and hydrography over the Scotian shelf. The modelling system consists of a coarse-resolution ($1/12^o$) barotropic storm surge outer model covering the eastern Canadian shelf, and fine-resolution ($1/16^o$) baroclinic inner modeling covering the Gulf of St. Lawrence, the Scotian Shelf and the Gulf of Marine. This nested-grid modelling system is driven by tides, atmospheric forcing, surface heat and freshwater fluxes, and large-scale oceanic currents specified at model open boundaries. The model performance is assessed by comparing models results with in-situ oceanographic observations and satellite remote sensing data. The simulated near-surface circulation on the Scotian Shelf features two strong currents flowing southwestward along the south coast and over the shelf break of the Scotian Shelf, influenced significantly by the extension of the bifurcation of the GSL low-salinity waters over the eastern Scotian Shelf. A particle-tracking model is used to track particle movements from hourly simulated ocean currents. Particle movements are then used to calculate dispersion, retention, and hydrodynamic connectivity of surface waters on the study region. The near-surface dispersion is higher on the shelf break and lower on the coastal waters and inner shelf regions. The upstream and downstream retention areas for several sensitive areas on the Scotia Shelf are also examined.

10:45

Salinity anomalies in coastal waters

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Electrical conductivity/Absolute Salinity relationships in the open ocean vary from place to place because the relative chemical composition of "sea salt" changes from place to place. Techniques to account for these changes are now part of the TEOS-10 seawater standard, incorporated into a "salinity anomaly". However, in coastal regions, relative chemical composition can also change due to the inflow of river salts, and local biogeochmical processes. Numerical modelling of river salt/seawater mixtures provides some estimates of what might happen. However, actual measurements of the salinity anomaly in the Salish Sea and on Line-P provide some surprises.

11:15

Dynamics of the Position of the Transition from Freshwater to Salt Water in the St. Lawrence River

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St. Lawrence estuary position of fresh water to salt water transition along the navigational channel is presented. Thegeographical position of the vertically well mixed waters of salinity 1 to 10 oscillates between the eastern end of Ile d'Orléans and 35 km downstream. The analysis combines observations in 2007 of water level and salinity at two tidal gauge stations, Saint-François ile d'Orléans and Rocher-Neptune, with continuous salinity record on-board ship le Cabot, as she transits twice a week from St-John's harbour to the port of Montreal. The two main driving forces, the tides and the fresh water runoff, drive the salt wedge along paths of similar amplitude. It is a challenge to separate the effects. Quantification of the effects of the semi-diurnal tides, of the spring-neap semimonthly oscillation of the tides, of the fresh water and of storm surges on the movement of the salt wedge will be presented.

11:30

Diagnosing the upper ocean 3D circulation from high-resolution observations at a submesoscale cold filament in the Lower St. Lawrence Estuary

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Vertical velocities associated with mesoscale O(100 km) and submesoscale O(10 km) processes in the upper ocean are important for vertical exchanges of heat, salinity, and tracers such as nutrients and dissolved organic and inorganic carbon, between the surface mixed layer (ML) and the ocean interior. These vertical velocities are 100 m/day (1 mm/s), and are therefore very difficult to measure directly. Instead, they have often been estimated indirectly from observations of density and horizontal velocity using the Omega equation, but such estimations require high-resolution in situ observations. A decade ago, a method based on surface quasi-geostrophic (SQG) dynamics was proposed to diagnose the three-dimensional (3D) motions in the upper ocean from a single snapshot of surface buoyancy or height anomalies, combined with a knowledge of the background stratification. However, the resulting diagnoses of vertical velocities were shown to degrade in the ML. Recently, a quasi-geostrophic model with a diabatic ML and adiabatic interior (MLQG model) has been developed and tested against high-resolution primitive-equation numerical simulations, yielding an improved diagnosis of vertical velocities in the ML. Here, we compare the diagnoses of the upper ocean 3D circulation provided by the SQG and MLQG models against high-resolution surface and in situ observations of a submesoscale cold filament in the Lower St. Lawrence Estuary. Results show that both diagnoses have similar skills for horizontal currents and buoyancy, provided that buoyancy anomalies below the ML rather than at the surface are used for solving the diagnostic models. In contrast, vertical gradients of vertical velocities diagnosed by the MLQG model compare better to surface divergence observed by high-frequency radars than those diagnosed by the SQG

model.

11:45

Instability and mixing of zonal jets along an idealized continental shelf break.

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The interaction between an Antarctic Circumpolar Current-like channel flow and an idealized continental shelf break is considered using eddy-permitting simulations of a quasi-geostrophic and primitive equation model. The experimental setup is motivated by the continental shelf break of the West Antarctica Peninsula. Numerical experiments are performed to study the effect of the width and slope of a zonally-symmetric hyperbolic tangent continental shelf topography. The main focus is on the regime where the shelf break width is slightly greater than the eddy scale. In this regime, a strong baroclinic jet develops on the shelf break due to the locally stabilizing effect of the topographic slope. The magnitude of the velocity of this jet is set at first order by the gradient of the geostrophic contours. At statistical equilibrium, an aperiodic cycle is observed. Initially, over a long stable period, an upper-layer jet develops over the shelf break. Once the vertical shear reaches the critical condition for baroclinic instability, the jet becomes unstable, drifts away from the shelf break, and is replaced by a new jet over the shelf break. The cross-shelf mixing is intrinsically linked with the jet drifting, as most of the meridional flux occurs during this instability period. Investigation of the zonal momentum budget reveals that a strong Reynolds stress divergence inversion across the jet is associated with a drifting event, accelerating one flank of the jet and decelerating the other. The hypothesis that the meridional drift of the shelf break jet may be due to the vertical shear on one flank of the jet being more baroclinically unstable compared to the other is then tested using topographic profiles with variable curvatures.

10:30

The 2014-15 UW-Madison AWS Network Field Season: A Campaign to Divide and Conquer

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The Automatic Weather Station (AWS) Program at the University of Wisconsin-Madison (UW) has maintained an AWS network on Antarctica since 1980. As of the beginning of the 2014-2015 field season, the UW AWS network consisted of 61 AWS, out of approximately 120 total on the continent. The UW AWS field team planned to visit 31 of their 61 AWS, and this presentation describes the 2014-15 field season activities. The three main goals of the field season were: to upgrade instrumentation on select AWS; to install new AWS in West Antarctica; and to remove select AWS. Field work was completed out of three locations: McMurdo Station, West Antarctic Ice Sheet field camp (WAIS), and South Pole Station. With five personnel working throughout the three-month-long season, the method of divide and conquer proved to be beneficial as the team could complete servicing from two locations simultaneously. The only significant shortcoming this field season is a known problem: poor weather. Less-than-ideal weather conditions at WAIS prevented the field team from installing two AWS, although others in the region were serviced. The network-wide servicing helps the AWS network remain a reliable source of meteorological surface data for researchers, forecasters, and the public. This presentation will also cover some of the research efforts ongoing at UW. Raw and quality-controlled data are made available online to enhance the efforts of scientific research topics and curious minds alike.

10:45

Fog Occurrence in Hudson Bay Region

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Fog presents a natural hazard for shipping and aviation in the Hudson Bay region. Flights are often delayed or cancelled if fog is present since the airports are less equipped to deal with low visibility operations. These flights often carry fuel, groceries or transporting medivac patients to medical facilities. Therefore, cancelled flights negatively affect the health and well-beings of those living in these communities. Nine communities on the eastern and western shores of Hudson Bay were selected. Hourly fog occurrences while the airport was in operation were analyzed in annual and seasonal scale. Both fog hours and freezing fog hours were in general decline, with some locations experiencing significant decline. Most of the northern locations in this study experienced significant decline in fog hours while southern locations' decline were not significant. For freezing fog hours, all of the locations in western shore of Hudson Bay faced significant decline while only half of the locations in eastern shore were found to be declining significantly. The spatial asymmetry between the decline in fog hours and in freezing fog hours suggest that different mechanisms may be at play. A reduction in freezing fog may be attributed to general warming in the region, lowering the

frequency of liquid water droplet frozen to the surface or forming ice crystal in the air. A reduction in fog may be also caused by warmer temperature. Since the vapour pressure of water grows at an exponential rate to higher temperature, relative humidity would be lower even if air temperature and dew point temperature were raised at the same rate as a result of a warmer surface.

11:00

Variable Precipitation Differences on Cypress Mountain during SNOW-V10

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Cypress Mountain, 20 km north of downtown Vancouver, BC, is subject to moist onshore flows from the Pacific Ocean. The field experiment SNOW-V10 (Science and Nowcasting Olympic Weather for Vancouver 2010) was undertaken on Cypress Mountain from January to April, 2010. Over the course of the field experiment, precipitation amounts were almost double on the mountain at Cypress Bowl North (1523 mm at 953 m ASL) compared to values at its base at West Vancouver (798 mm at 168 m ASL). Excess daily precipitation amounts of = 50 mm occurred on three occasions. On these days, strong, moist upslope flows = 10 m/s were commonly present, upward velocities of precipitation particles of = 1 m/s were detected by a Micro Rain Radar for = 4 h, most of the precipitation was rain, and maximum precipitation rates on the mountain (up to 16 mm/h) were more than double those at its base. When these flow conditions were not present, daily precipitation differences of = 10 mm occurred or the sign of the differences was reversed. Experimental high-resolution GEM-LAM 1-km numerical weather prediction often had difficulty simulating the timing and magnitude of the precipitation.

11:15

Optical Rain Gauge - An Alternative to Traditional Rain Gauges

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Traditionally tipping bucket and weighing type rain gauges are used for the measurement of both liquid and solid precipitation. Tipping bucket rain gauges are very inexpensive and suitable for many applications. The resolution of tipping bucket rain gauges is typically 0.1 mm accumulation. This resolution is fine for many applications but more resolution is often desirable. Of course, when used for solid precipitation measurement heaters must be used with tipping bucket rain gauges. Weighing type rain gauges can be very accurate but are generally expensive and require some type of antifreeze for use in subzero applications. Evaporation from the weighing type of rain gauge can also be an issue. A less known type of rain gauge is the optical rain gauge. This type of rain gauge has a very high sensitivity, may be used for liquid and solid precipitation, and may be used on ocean buoys and ships where tipping buckets and weighing rain gauges are not suitable. The optical rain gauge offers high resolution while at the same time does not require antifreeze maintenance or oils to reduce evaporation. Since the optical rain gauge optically measures precipitation rate in

real time errors such as evaporation, tipping bucket splash, and tipping bucket tip errors are not introduced. Remote networks of solar powered optical rain gauges may be set up. Data may be stored locally or transmitted by satellite, cellular, or other technology.

11:30

Spatial and temporal variability of fuel moisture across a heterogenous landscape

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Fuel moisture plays an important role in determining the intensity, behavior, and spatial patterns of forest fires and can vary significantly across a forested landscape. This talk will present a set of observations designed to quantify the spatial patterns of near surface drying potential across a relatively small landscape with significant variability in aspect, slope, and canopy coverage. We examine the degree to which drying potential is driven by both above canopy radiation and canopy density. We measured near-surface temperature and humidity at 25 sites, as well as precipitation, solar radiation, and wind speed, at a subset of these sites. These observations were then used to drive a fuel moisture model that includes sub-components for canopy interception of both precipitation and solar radiation. The modelled time series of fuel moisture for a number of fuel sizes at all sites were then used to assess variability in drying rates across the landscape, and whether relatively wet and non-burnable areas persist in the landscape during the fire season.

11:45

An Assessment of the Global Lightning Dataset (GLD360) over Canada

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Vaisala's Global Lightning Dataset (GLD360) is a global lightning detection network which was launched in September, 2009. The GLD360 uses VLF sensors placed at unspecified locations around the world and detects and reports stroke location (using both time- of-arrival and magnetic-direction finding methods in combination with a waveform recognition algorithm), peak current and polarity. Archived data for the month of June 2014, provided by Vaisala Inc., are used to assess the GLD360 performance relative to the Canadian Lightning Detection Network (CLDN), a precision lightning locating system. An examination of GLD360 North of 60°N showed that the northern most strokes were detected NW of Prince Patrick Island in the Arctic Ocean. Clusters of lightning strokes were also detected in an area between Banks Island and Prince Patrick Island in M'Clure Strait and on Baffin Island. NOAA19 satellite imagery (visible channel) confirmed lightning activity on June 20, 2014 between Victoria Island and King William Island. Performance characteristics (cloud-toground flash detection and median stroke location) of the GLD360 using the CLDN will be summarized for several regions in southern Canada.

10:30

Sea Ice State in Version 1 of the Regional Arctic System Model

Andrew Roberts[1], *Elizabeth Hunke*[2], *Anthony Craig*[1], *Wieslaw Maslowski*[1], *Robert Osinski*[3], *John Cassano*[4], *Alice DuVivier*[4], *Mimi Hughes*[4], *Bart Nijssen*[5], *Joseph Hamman*[5]
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We present the sea ice climate of Version 1.0 of the Regional Arctic System Model (RASM), incorporating new physics of the Los Alamos Sea Ice Model (CICE5). RASM is a high-resolution fully coupled pan-Arctic model that also includes the Parallel Ocean Program (POP), the Weather Research and Forecasting Model (WRF) and Variable Infiltration Capacity (VIC) land model. The model domain extends from the North Pole south of 45^oN and is configured to run at ≈9km resolution for the ice and ocean components, coupled to 50km resolution atmosphere and land models. It is able to resolve mesoscale storms interacting with sea ice at super-inertial timescales, runoff into narrow gulfs feeding the Arctic Ocean, and freshwater and heat exchange pathways and storm tracks connecting the Pacific and Atlantic oceans to the central Arctic. RASM's high resolution and regionally-constrained solution make it a unique tool for assessing new physics options available in CICE5, and for comparing model simulations with short-duration sea ice observations in a way seldom afforded by internal variability in global Earth System Models. In this work we present an inter-comparison the Elastic-Viscous-Plastic (EVP) rheology with Elastic-Anisotropic-Plastic (EAP) mechanics. This comparison is conducted in combination with an assessment of the new Level Melt Pond and Topographic Melt Pond schemes in CICE5, as well as form drag-affected turbulent flux exchange with the atmosphere and ocean versus a constant roughness length approximation, and prognostic salinity as compared the Bitz-Lipscomb vertical sea ice thermodynamics. Our comparisons with ICESat, in-situ buoys and passive microwave derived sea ice products illustrate that by a number of metrics the important advance in improving the distribution of sea ice mass in RASM is the implementation of the Anisotropic rheology. This result is consistent through the satellite era, including for extreme extent years of 2007, 2011 and 2012.

10:45

Seasonal forecasts of Arctic sea ice in a dynamical forecast system

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As Arctic seas are becoming more accessible, the socio-economic benefits associated with skilful seasonal forecasts of Arctic sea ice cover are becoming increasingly evident. Here we present the forecast skill of Arctic sea ice on pan-Arctic and regional scales in a dynamical forecast system that includes interactive atmosphere, ocean and sea ice components. We will present forecast skill for

sea ice area and ice-free and freeze-up dates. The forecast skill obtained by our system will be compared to estimates of potential predictability.

11:00

Numerical Modeling of Summer Arctic Boundary Layer during the Arctic Summer Cloud Ocean Study (ASCOS)

Yi Jin[1], *Shouping Wang*[1], *Sasa Gabersek*[1], *David Hebert*[2], *Pamela Posey*[2], *Rick Allard*[2], *Jason Nachamkin*[1]
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A growing body of evidence suggests that the Arctic region is experiencing rapid environmental changes. One of the most striking changes is the drastic decrease in multi-year sea ice concentrations. The coverage of the multi-year ice now comprises just 10 percent of winter ice cover, down from 40 percent 20 years ago. These changes are certain to have serious impacts on the Arctic weather and regional climate. The Arctic Summer Cloud Ocean Study (ASCOS) is one of the most extensive summer expeditions with concentrated measurements deployed for more than a month (August-September 2008) in the North Atlantic sector of the central Arctic ocean. The detailed observations provide an opportunity for evaluating model performance in capturing boundary layer structure over changing sea-ice conditions during the Arctic summer and ultimately improving Arctic weather prediction. In this study we examine the impact of the evolving sea ice states on the Arctic atmos-pheric conditions using the Navy's regional numerical weather prediction model (Coupled Ocean/Atmosphere Mesoscale Prediction System - COAMPS) driven by the sea ice surface conditions predicted by the Arctic Cap Nowcast/Forecast System (ACNFS). ACNFS is a coupled sea ice and ocean model that generates real-time forecasts of ice concentration, ice edge location, ice thickness, ice draft and ice drift for all sea ice cov-ered areas in the northern hemisphere (poleward of 40N). These fields are used by CO-AMPS as the surface boundary condition, which directly modulates distribution of turbu-lent and radiative surface fluxes. The improved physical parameterizations in COAMPS are compared with the benchmark simulations and evaluated for the Arctic conditions. Systematic verification of the boundary layer structure over the evolving sea ice with high heterogeneity is performed against the Arctic surface observations and data from the ASCOS experiment.

11:15

Simulation of Arctic climate with the Regional Arctic System Model (RASM): Sensitivity to atmospheric processes

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A new regional Earth system model of the Arctic, the Regional Arctic System Model (RASM), has recently been developed. The initial version of this model includes atmosphere (WRF), ocean (POP), sea ice (CICE), and land (VIC) component models coupled with the NCAR CESM CPL7 coupler. The model is configured to run on a large pan-Arctic domain that includes all sea ice covered waters in the Northern Hemisphere and all Arctic Ocean draining land areas. Results from multi-decadal (1979 to present) simulations with RASM will be presented and will focus on the model climate's sensitivity to atmospheric processes and a comparison of the fully coupled model and atmosphere-only simulations. The modeled radiation budget, and sea ice cover, was found to be sensitive to the details of the cloud and radiation parameterizations in the atmospheric component (WRF) of RASM, including details of cloud droplet size. Another model sensitivity was found in relation to atmosphere-land processes. Care is needed to ensure that decoupling between the atmosphere and land do not occur under strongly stable conditions over land areas in winter. Comparison of RASM near surface climate with that simulated with stand-alone WRF show areas of both improved and degraded results. Improvement in the coupled model climate are related to more physically realistic representation of coupled processes such as energy transfer from the ocean to the atmosphere through leads in the sea ice during winter. Degraded results come from feedbacks in model component biases, such as atmospheric circulation biases resulting in incorrect local sea ice cover that then result in large local atmospheric temperature biases.

11:30

ACCIMA: Regional Coupled Modeling of Antarctica for Sea Level Rise Studies

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The Atmosphere-ocean Coupling Causing Ice Shelf Melt in Antarctica (ACCIMA) project is studying the atmospheric and oceanic processes impacting West Antarctica through coupled atmosphere/ocean/ice/land surface modeling. The West Antarctic Ice Sheet is an especially important

region for ice sheet melting and therefore sea level rise. We began with the coupled model system that is used for Regional Arctic System Model (RASM). Results are analyzed for a 13-year simulation of a large Southern Hemisphere domain driven by the ERA-Interim Reanalysis and other forcings for 1999-2012. The simulation has a horizontal resolution of 60 km for the atmosphere and land and 10 km resolution for ocean and sea ice. The 13-year average of the annual-mean sea ice area is well produced in five sectors near Antarctica. The annual cycle of sea ice area, however, is larger in the simulation than that of observed Antarctic sea ice. Furthermore, there is a gradual drift towards sea ice loss during the simulation which may be related to the absence of ice shelves. We have begun simulations of the coupled Antarctic system with the Coupled-Ocean-Atmosphere-Wave-Sediment Transport modeling system (COAWST) model. COAWST includes the Regional Ocean Modeling System (ROMS) that includes ice shelves, rather than the Parallel Ocean Program (POP) employed by RASM which does not. COAWST can be applied to especially high resolution coastal applications. This should be an ideal model for studying the processes at sensitive locations such as the Amundsen Sea where heat flux in the ocean can melt ice shelves adjacent to the glaciers of West Antarctica. This process can accelerate the loss of ice from these glaciers.

11:45

Validation of near-surface variables simulated by Polar WRF over West Antarctica

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It is well known that West Antarctica is a critical component of the global climate system, but the modelling and validation of surface meteorological conditions over the West Antarctic are limited. In this study the authors try to set up a high resolution nested Polar Weather research and Forecasting (PWRF) mesoscale model, with resolutions of 45-15-5km, to simulate surface conditions during a summer (January) and a winter (July) month. The set up includes one high resolution nest (5km) over the complex terrains of Pine Island Glacier region (PIG) and another high resolution nest (5km) over inland stations. The model results are validated against observations from four Automatic Weather Stations (AWS) - two stations within the PIG nest and two within the inland nest. The model accurately simulates the surface pressure during both summer and winter months. The simulation of wind and surface air temperature (SAT) is poorer over the coastal stations, owing to the complex terrains of the coastal region. Wind is underestimated over most of the stations, which could be caused by unrealistically high surface roughness in PWRF. Summer month SAT shows an exaggerated diurnal cycle during summer, which is most likely related to the challenges in simulating cloud. The model shows good skill in simulating low pressure systems over the coastal stations, with associated peaks in wind and SAT. The study also investigates the sensitivity of model performance to surface boundary conditions, viz., sea ice, SST and topography. Inclusion of realistic high resolution sea ice and SST improves the bias and RMSE during the winter months. Introduction of better quality Bedmap2 topography data improves the simulation of wind and SAT during both summer and winter months, especially over the coastal stations.

10:30

COMET's 25 Years of Education and Training: Where We've Been and Where We're Going

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The COMET Program was founded in December, 1989 to serve as a training resource for weather forecasters during the modernization of the National Weather Service (NWS). COMET is funded in part by a cooperative agreement between the National Oceanic and Atmospheric Administration (NOAA) and the University Corporation for Atmospheric Research (UCAR). Funding for the program now comes from many agencies, including NOAA, Meteorological Service of Canada (MSC), the U.S. Navy, and the WMO. COMET distance learning (DL) materials are freely accessible by users worldwide via our MetEd website (www.meted.ucar.edu). Throughout its history, COMET has had three primary sub-programs: a residence classroom program, a DL program, and an outreach program that funds small applied research grants. The residence program has courses ranging from mesoscale analysis and prediction to satellite meteorology to climate variability and change, and hydrometeorology. COMET has offered residence courses in winter weather and mountain weather for MSC, the NWS, and international forecasters, the latter course in preparation for the 2010 Winter Olympics in Vancouver. The 2014 offering of the winter weather course focused on advanced skills in winter forecasting and satellite interpretation. COMET was at the forefront of converting residence course experiences to virtual courses taught live at a distance. This cost-effective approach has saved our sponsors' limited training funds by eliminating student travel expenses. Early on, COMET education and training targeted several thousand forecasters in the United States and Canada, a population that could not be adequately served by residence instruction. COMET's cornerstone program was DL, which has experienced incredible growth since its inception. COMET DL engages large student populations in a consistent and cost-effective manner, utilizing innovative instructional design, sound science, state-of-the-art graphics and scenario-based learning. Initially COMET DL was published on laser discs, then CD-ROM, and finally Web-based training. To date, COMET has produced over 750 hours of DL in various topic areas, and adds about 50 hours per year, available to 400,000 registered MetEd users. Since 2007, COMET has delivered 1.8 million hours of online learning sessions. COMET's DL offerings have expanded to include self-directed lessons and courses, recorded lectures, facilitated courses, webinars and learning and media object resources. A variety of topics are treated, ranging from aviation weather, climate variability and change, winter weather, hydrology, satellite meteorology and NWP. MSC has supported development of DL materials on topics such as winter weather, arctic meteorology, and satellite feature identification. Winter Weather training materials are now primarily accessible via that topic area on MetEd. The COMET Program has staff of 24, consisting of scientists, instructional designers, graphic artists and multimedia developers, who team to produce award-winning education and training. The NWS Training Division, MSC, and other agencies also provide scientists who work at COMET in Boulder and/or lend their expertise to training development. COMET is internationally recognized for its education and training. As COMET enters its second quarter century, we will continue to build toward the future by expanding our distance learning offerings

while exploiting new advances in educational technology. To maintain relevancy, it is anticipated that COMET will evolve from a primary focus on production of distance learning modules and courses to providing support services needed to qualify, certify and assure competency-based education and training outcomes. These include reusable/searchable learning elements, accredited content, competency assessment tools, simulations, faculty/facilitator support tools, instructional design support, graphics and media services. The cornerstone will be a UCAR Center for Geoscience Workforce Competency targeted at geoscience workforce development.

10:45

Effects of Spatial and Temporal Averaging on Surface Irradiance

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Two recent field campaigns (in Juelich, Germany and Melpitz, Germany) deployed an array of about 100 pyranometers to characterize the spatial and temporal structure of surface irradiance. These sensors recorded surface irradiance with a frequency of 10 Hz. Using these data, we have assessed the effects of temporal and spatial averaging on the global horizontal irradiance and clear sky index (the ratio between the measured irradiance and its theoretical, cloud-free value) with a particular focus on the implications for decentralized photovoltaic (PV) power generation. In this presentation, we will demonstrate that while 10 Hz measurements are not necessary to characterize variability in surface irradiance, the commonly-used 1-min to 10-min averaging periods substantially underestimate this variability. This underestimate is particularly pronounced for the frequent high-magnitude, short-term irradiance fluctuations known to induce variations of voltage and frequency in electrical distribution grids. As well, we will demonstrate how the spatial autocorrelation structure of irradiance varies with different prevailing sky conditions (as measured by 15-minute means and standard deviations of the clear sky index).

11:00

CoCoRaHS Canada Update

Rick Fleetwood[1]
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CoCoRaHS (Community Collaborative Rain, Hail and Snow) network is a not-for- profit volunteer based precipitation monitoring network that was developed by the Colorado State Climate Center in 1998 following a major flood. Since that time the network has expanded to all US states and in late 2011 was expanded into Manitoba to help flood forecasters and others establish better monitoring of rainfall, snowfall and snow pack changes through high quality, daily, manual measurements. As the MSC's lead on the CoCoRaHS Canada initiative, I will provide an overview of the network and its expansion since 2011, measurement equipment/procedures and the type of data that is available through the CoCoRaHS Canada web site. We'll look at Environment Canada's role and work done so far in supporting the expansion of this network along with the various provincial and private

sector partners and how it is helping the MSC meet the need to improve precipitation (especially snowfall and snow cover) monitoring across the country. The presentation will include some good examples of how this new data is being used by the MSC and others with a look ahead at future work to further incorporate this new data source into the MSC's products and services.

11:15

Proposal to Eliminate DiffEQ as Requirement for a Bachelors in Atmospheric Science

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Almost all Meteorology/Atmospheric-Science (ATSC) Bachelors (BSc) graduates in industry and Environment Canada (EC) never use differential equations (DiffEQ) after they graduate. By not requiring DiffEQ courses for the ATSC BSc degree, universities can offer more hard-core meteorology subjects earlier in the program, and can offer more courses in team-building, communication, and computer skills before hitting the credit limit (120 credits at UBC) for a non-honours BSc degree. Two tracks thru the ATSC undergrad program are recommended: (1) job track, for meteorologists not planning to go on to grad school; and (2) grad-school track for those who are. Job-track students would skip the DiffEq courses, and would take upper-level, algebra-based Physics and ATSC courses. Grad-school track students would take a course sequence similar to most existing Canadian ATSC programs, which includes DiffEQ. A two-track degree program will be presented. The non-DiffEQ option is viable because one can use algebra and trig to teach very high-level, math-based, ATSC courses in dynamics, synoptics, physics, climate-change, and most other ATSC topics. Vorticity tendency, radar dBZ, frontogenesis, omega equation, thermal- wind relationship, and Q-vectors are just a few examples that will be presented. Pros: Algebraic equations have the same physics, terms, units, quantitative rigor, interpretation and application as the DiffEQ, and allows easy computation using finite differences. Con: Cannot derive many of the eqs., so must present them as a fait accompli. . It is proposed to open discussion to request a policy change by EC on the qualifications they require for entrance into the Meteorologist program. Environmental consulting companies, utility companies, news media, and other employers of BSc-degreed meteorologists should participate in this dialog with universities.

11:30

Assessing the Impacts on Aviation by Analyzing Historical Surface Wind Patterns in Northern Quebec and Labrador Communities

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Many communities in northern Quebec and Labrador are not connected by road. While a reduction of sea ice in Hudson Bay and Hudson Strait allows more opportunities for sealift in summer, in many cases air travel remains the only year-around transportation method that connects these communities with other cities. Passengers and perishable food must continue to rely on aircraft flying into these communities regardless of the availability of sealift. Using airport's weather stations

and R software's circular package, we constructed the historical trends of daily wind directions and wind speed (1971 to 2010) at these locations. We found that a number of airports experienced a significant change in wind direction and some airports' runways are not aligned with the predominant wind direction. Limited by the amount of flat land and high construction cost, building a new runway is often not an option. Thus, planes are forced to take off and land with crosswind, a less than ideal condition in the crucial stage of a flight. As climate change causes higher wind speed in the region, this elevates the risk where accidents and crashes are most likely to occur.

10:30

Real-time Numerical Weather Forecasts for Arctic Research Flights with Polar WRF

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The polar-optimized version of the Weather Research and Forecasting model (Polar WRF) has been upgraded to version 3.6.1 of WRF. Among recent applications for Polar WRF is real-time forecasting for the Arctic in support of research aircraft flights. During September-October 2014, NASA performed C-130 flights out of Eielson Air Force Base near Fairbanks, AK for the Arctic Radiation- IceBridge Sea and Ice Experiment (ARISE) project. The Polar Meteorology Group (PMG) of Ohio State University's Byrd Polar Research and Climate Center set up an experimental forecasting system with web-available forecasts to support the ARISE flights. The PMG's primary interest in ARISE is exploring the quality of Polar WRF forecasts of polar clouds. Extensive low-level clouds were present during the ARISE flights over open water and sea ice in the Arctic Ocean. As a complement to this study, Polar WRF v3.6.1 runs are used to study simulated Arctic clouds in comparison to observations of the August-September 2008 Arctic Summer Cloud Ocean Study (ASCOS). That research project included aircraft flights in the North Atlantic sector of the Arctic Ocean. Preliminary analysis shows that low-level water clouds are too extensively simulated during the second half of the ASCOS field program. Furthermore, based upon the experience gained from earlier ARISE forecasts, real-time forecasts were performed for the October-November 2014 Polar Winds project managed by NASA and Simpson Weather Associates. The Polar Winds project used Doppler Lidar on UC-12B flights to study Arctic mesoscale phenomena. An example is the tip jets near the southern apex of Greenland. On October 31 and November 11, Polar WRF successfully forecast the low-level wind maximum near Cape Farewell. The UC-12B flight on October 31 was able to reach Southern Greenland and sample the tip jet.

10:45

Assessment of numerical weather prediction for the Antarctic Peninsula using the UK Met Office Unified Model and AMPS

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In support of aircraft operations during the month long OFCAP (Orographic Flows and the Climate of the Antarctic Peninsula) field campaign during 2011, the UK Met Office Unified Model was setup over the northern portion of the Antarctic Peninsula to provide real-time short-term high-resolution numerical weather prediction weather forecasts. In this study, the simulated 12-36 hr model output from the Unified Model at 4-km-resolution and from AMPS (Antarctic Mesoscale Prediction System) at 4.5-km-resolution is compared to 3hourly observational data from 1 manned station and 7 AWSs. Results are shown comparing the model output to surface observations of pressure, wind speed and direction, temperature, and humidity. Both statistics (bias, root-mean-

square-error, correlation) and monthly time-series of the model performance are presented. It is apparent that the forecast skill of the Unified Model and AMPS (in terms of bias, root-mean-square error, and correlation) is broadly similar. Of particular note is that both models are able to broadly capture the occurrence of foehn wind events over the Larsen C ice shelf, but have significant cold biases in the simulation of near-surface temperature. In addition, the AMPS model has quite large errors in the simulation of wind direction.

11:00

Predicting local climate changes due to reservoir impoundment using WRF

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The Weather Research and Forecasting Model (WRF) was used to predict changes in local climate and meteorology due to the creation of an 80 km long reservoir resulting from the proposed Site C hydroelectric project in northern British Columbia. The WRF model was applied in 12 km, 4 km and 1 km nested configurations, with two separate 1-way nests to 1 km to simulate the river valley in its present state without the reservoir and the future case with the valley flooded, respectively. The reservoir was incorporated into the future case by adjusting the terrain elevation and land use inputs for WRF to reflect the changes that would result from the flooding of the valley. The surface condition of the reservoir was calculated by a separate offline model and the daily average temperature and ice cover were incorporated into the WRF input stream. Effects on local climate were assessed by comparing the differences between the present and future cases for a model that was considered to be both hydrologically and climatologically representative of normal conditions. The future case impact on climate was assessed in terms of impact on standard meteorological parameters such temperature, wind speed and precipitation. To support the climate assessment, a network of eight meteorological stations were installed to establish existing conditions and to monitor changes as the reservoir is built. Data from these stations was used for model evaluation and the network will remain in place to monitor long term changes. A novel Bayesian analysis was applied to determine significance of model prediction compared to natural variability. Results show that changes to local climate greater than natural variability will be limited to within a few kilometers of the water surface.

11:15

Upcoming changes to the Canadian Global Deterministic Prediction System

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A new version of the Global Deterministic Prediction System will be implemented at the Canadian Meteorological Centre in the Fall of 2015. This system contains some important improvements to the Global Environmental Multiscale model, which will be described in this talk. The horizontal model grid has been changed from global lat/lon to a "Yin-Yang" grid that consists of two overlap-

ping limited area model domains that communicate with each other in overlapping regions. This grid configuration has the advantage of eliminating numerical poles and has important scalability attributes that will allow future implementations to run with higher horizontal resolutions. In addition to the grid change, an inconsistency in the dynamical core of the model has been eliminated, with positive results not only in idealized slab simulations of mountain waves, but also in the global circulation of the 3D numerical model. The source of this inconsistency and its resolution will be discussed, along with an overview of the other components of the upcoming global model upgrade.

11:30

Avalanche forecasting with high resolution NWP data

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Avalanche forecasters track the distribution critical snowpack layers because they cause destructive slab avalanches. Layers of buried hoar frost are a common concern, and have complex distributions due to meteorological interactions with topography. Knowledge of the load on top of these layers is also crucial. Canadian forecasters primarily rely on sparse manual observations to track these layers. Recently, snow cover properties have been simulated with data from numerical weather prediction models. We investigate the possibility of using the High Resolution Deterministic Prediction System (GEM-LAM) to map the distribution of hazardous hoar frost layers. The quality of winter forecasts in complex terrain was investigated by verifying spatial patterns at nine stations in Glacier National Park, British Columbia and by verifying precipitation amounts at over 100 stations in western Canada and northwestern US. We found GEMLAM resolved spatial structures roughly 20 km wide in Glacier National Park. Although the topography was smoothened, major differences between elevation bands such as lapse rates, inversions, drying air, and stronger winds were adequately resolved. GEM-LAM underestimated precipitation amounts, although low precipitation categories were overestimated. Quality measures were substantially lower than values published for flatter terrain in the summer. GEM-LAM forecasts were used to model the snow cover in Glacier National Park with the Swiss model SNOWPACK. Modelled hoar frost layers were mapped and verified with field surveys. The general distribution of layers across elevation bands in different drainages was resolved, and could help avalanche forecasters downscale their forecasts. An operational tool based on this resear.

11:45

An Integrated Urban High-Resolution Numerical Weather Prediction System dedicated to the 2015 Pan-American Games in Toronto

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A Sub-kilometer atmospheric modeling system with grid-spacings of 1 km and 250 m and including urban processes is currently being developed at the Meteorological Service of Canada (MSC) in

order to provide more accurate weather forecasts at the city scale. A real-time forecasting system has been designed over the Greater Toronto Area (GTA) and has provided forecasts for the last year, including new thermal comfort indices. Surface physical processes are represented with the Town Energy Balance (TEB) model for the built-up covers and with the Interactions between the Surface, Biosphere, and Atmosphere (ISBA) land surface model for the natural covers. Surface temperatures for the Great Lakes are prescribed using 2-km hourly output from an ocean model. This system is devoted to help issuing alerts during the Pan-American and para-Pan-American games in Toronto during July and August 2015 (Panam TO2015). In this study, results from different weather conditions forecasted with this new system over the GTA will be presented. As typical summertime features, the region is concerned with localized heavy rainfall, complex lake-breezes flows, and with human discomfort during heat waves. Results will be confronted against observations gathered with the dense surface and atmospheric PanAm Observational network, as well as with traditional EC network.

13:30

Variability and change in Storm Track characteristics over Canada from Regional Climate Model Perspective

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Under a changing climate, severe weather event characteristics such as intensity and occurrence are expected to increase as well as the related socio-economical damages. Over Northern America, major storms can account for these extreme events and therefore, there is a crucial need to better understand their characteristics and their plausible future change. Likewise any synoptic to intraseasonal feature, storm dynamics involves an interrelation between large-scale and regional-scale physical processes. As a consequence, they are hardly captured and described by Global Climate Models (GCMs) which have a coarser resolution to correctly handle these phenomena. Hence, the main objective of this study is to improve our understanding of the regional features of storm changes and the links between storm activities and the evolution of key atmospheric variables using better resolved models namely Regional Climate Models (RCMs). This study is part of the recent CNRCWP (Canadian Network for Regional Climate and Weather Processes) project, coordinated by UQAM/ESCER in collaboration with Environment Canada. Firstly, the performance of RCMs is evaluated against reanalysis over the recent past climate (1961-2009). Both Canadian current 2 RCMs (CRCM5 and CanRCM4) are analyzed through storm parameters such as occurrence, duration or moving speed, re-generation and intensity. Furthermore, these historical- RCMs simulated cyclones are compared with the future (i.e. 2041-2070) weather storms derived from RCMs driven by the global model CanESM2 (Canadian Earth System Model version two of CCCma/Environment Canada). The mid-tropospheric circulation is invoked to explain the so derived changes. The study finally investigates the implications of such storm characteristics changes on precipitation and temperature regimes over Canadian regions where substantial changes are anticipated.

13:45

Evaluation of maximum precipitation changes and precipitable water from Regional Climate Models over Canadian watersheds

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In the context of climate change and projected increases in heavy precipitation in many regions of the globe, and notably in North America, the question of probable maximum precipitation (PMP) and probable maximum flood (PMF) in a non-stationary climate is a growing issue for dam safety. An essential component entering into the empirical estimation of PMP is the atmospheric total column water vapor (precipitable water, PW). Recently, the idea of computing PMPs using Regional Climate Model (RCM) output, including PW, has emerged and some climate change studies are underway. Amongst such studies is a project involving climatologists and hydrologists, which is

based on data from an ensemble of runs performed with the Canadian RCM (CRCM4) at Ouranos and from the NARCCAP (North American Regional Climate Change Assessment Program), focussing on five Canadian basins (located in Manitoba, Ontario and Québec). In this talk, the Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) under Changing Climate Conditions project will be presented, along with some results, including the evaluation of the CRCM's maximum precipitable water against NVAP-M observations and the projected changes of maximum annual precipitation for different durations (1 to 5 days) from RCM (CRCM4, NARCCAP) and GCM (CMIP3, CMIP5) simulations.

14:00

The impact of atmospheric blocking on extreme winter minimum temperatures in North America

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Extreme events have large impacts on both human and natural systems. It is important to understand the relationship between large-scale circulation regimes and climate extremes and how well these relationships are simulated by regional climate models (RCMs). Atmospheric blocking in the north-east Pacific is associated with cold winter minimum temperature extremes over most of North America. Stationary and non-stationary generalized extreme value distributions (GEV) were fitted to the winter monthly minima of minimum temperature. Blocking frequency (BF) has a significant influence over the majority of the continent. Observed and reanalysis products (ERA-Interim, NARR) agree on the regions under the influence of blocking. The inclusion of BF as covariate on the location parameter significantly improves model fit in a region stretching south-east from British Columbia towards the Gulf of Mexico. There is a second region where the inclusion of BF as a covariate on the scale parameter significantly improves model fit in the south-west United States. The magnitude of the location parameter is up to 6C warmer in the reanalysis products compared to observations. The scale parameter is consistent between observations and reanalysis products in both regions. A 20% increase in BF is associated with up to a 5C decrease in TNn, while the influence of BF on the scale parameter is smaller. In the south-west a 20% increase in BF is assocaited with an average 1C increase in both the location and scale parameters TNn. These observationally-based results are compared with RCMs (CanRCM4, CRCM5, HIRHAM5, RCA4) using boundary conditions derived from ERA-Interim. CRCM5 and HIRHAM5 reproduce the pattern of blocking influence best compared to observationally-based data sets. CanRCM4 captures the influence of blocking in British Columbia and the north-west United States but the extension of influence into the southern United States is not evident. The magnitude of blocking influence is consistent with observations.

14:15

Long Term Climate Records Generator and Data Base for Canada

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Abstract In Canada it seems that record-breaking weather occurs somewhere almost every day. When it occurs there is a thirst for information about the extremes. Has a new record been set? What was the previous extreme and when did it occur? These questions are posed to MSC personnel routinely. While the questions seem simple, the process of obtaining the answer from the national archive of climate observations is not. To address this, we developed a data base of long term daily temperature and precipitation for about 800 locations across Canada by threading together the data from proximate stations. Each location corresponds to the centroid of the city pages used by weather.gc.ca. We developed a standardized algorithm to create drafts of each thread. A currently active station was used as the starting point. This was followed back as far as possible using the best data for that station. A search was then conducted to choose candidates to extend the thread back as far in time as possible. Each thread was then verified by regional experts. Web based records generator software identifies new daily extremes using present weather and presents views of extremes in several configurations. The next step is to create a similar data base of long-term monthly data.

13:30

Quantifying the water budget of Coles Lake, Northeastern British Columbia

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Climate research has repeatedly identified strong associations between anthropogenic emissions of so-called 'greenhouses gases' and observed increases of global mean surface air temperature over the past century. Studies have also demonstrated that the degree of warming varies regionally. Canada is not exempt from this situation, and evidence is mounting that climate change is beginning to cause diverse impacts in both environmental and socio-economic spheres of interest. For example, north-eastern British Columbia (BC), whose climate is controlled by a combination of maritime, continental and arctic influences, is warming at a greater rate than the remainder of the province. There are indications that these changing conditions are already leading to shifting patterns in the region's hydrological cycle, and thus its available water resources. Within this context, north-eastern BC is undergoing rapid development for oil and gas extraction: this depends largely on subsurface hydraulic fracturing ('fracking'), which uses enormous volumes of freshwater. While this industrial activity has made substantial contributions to regional and provincial economies, it is important to ensure that sufficient and sustainable water supplies are available for all those dependent on the resource, including ecological systems. This in turn demands comprehensive understanding of how water in all its forms interacts with landscapes and the atmosphere, and of the potential impacts of changing climatic conditions on these processes. The aim of this study was therefore to characterize and quantify the components of the water budget in the small watershed of Coles Lake (141.8 km^2, 100 km north of Fort Nelson), through a combination of fieldwork, observational data analysis, and numerical modelling. Baseline information generated in this way will support assessment of the sustainability of current and future plans for freshwater extraction in the basin, and help to maintain the precarious balance between economic and environmental well-being.

13:45

The practice of producing and consuming flood warning information: an ethnographic exploration of working and living the weather

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Canada has experienced an increased incidence of flash floods recently and the probability of greater frequency is likely given our changing climate and the growing rates of urbanization. At present no formal mechanism exists in Ontario to provide the public with advanced warning of flash flood risk. Environment Canada (EC) embeds flood risk information in their severe thunderstorm warnings while conservation authorities focus their flood messages on risks to watershed crossings; thus, neither group is mandated to produce urban or flash flood information for Ontario residents. Inspired by the July 8, 2013 flash flood in the Greater Toronto Area, this presentation will highlight initial findings from my doctoral research project, which examines the process of urban, flash flood communication in southwestern Ontario. The presentation will briefly describe the methodology

employed in this collaborative research undertaking with EC and the Toronto and Region Conservation Authority, and will focus mostly on the institutional processes influencing the creation of official flood information for the public; how information travels and is transformed along multiple communication channels, especially those of public news agencies and social media; and how affected Ontarians make sense of and respond to flood information.

14:00

Extremes, Remoteness and Adaptation in the Arctic

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Human societies have become a geologic agent of change, and with this is an increasing awareness of the environment risks that confront human activities and values. More frequent and extreme hydroclimate events, anomalous tropical cyclone seasons, heat waves and droughts have all been documented, and many rigorously attributed to fossil fuel emissions. These extremes, however, do not register themselves in the abstract - they occur in particular places, affecting particular populations and ecosystems. This can be considered to present a policy window to decrease vulnerability and enhance emergency management. However, the asymmetrical character of these events may lead some to treat remote areas or disenfranchised populations - such as the Arctic - as capable of absorbing the environmental damage attributable to the collective behavior of those residing in wealthy, populous, industrialized societies. Sound policies for adaptation to changing extremes must take into account the multiple interests and resource constraints for the populations affected and their broader contexts. Minimizing vulnerability to weather extremes is only one of many interests in human societies, and as noted, this interest competes with the others for limited time, attention, funds and other resources. Progress in reducing vulnerability also depends on policy that integrates the best available local and scientific knowledge and experience elsewhere. This improves the chance that each policy will succeed, but there are no guarantees. Each policy must be recognized as a matter of trial and error to some extent; surprises are inevitable. Thus each policy should be designed to fail gracefully if it fails, to learn from the experience, and to leave resources sufficient to implement the lessons learned. Overall policy processes must be quasi-evolutionary, avoiding replication without modification of failed policies and building on the successes.

14:15

A proposal for international scientific collaboration at the North Pole

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The North Pole – the intersection of the Earth's spin axis with the surface of the planet – is not a fixed point: it drifts about because of a wobble related to the oblateness of the planet and because of mass redistributions which affect its moment of inertia. While such polar wanderings are relatively small, they greatly complicate claims to ownership of the North Pole, as recently expressed by some Arctic countries. I will discuss a proposal for international scientific collaboration within a

small polar area as a focus for beneficial cooperation rather than competition in the Arctic, without significant loss of access to natural resources. Résumé Le Pôle Nord, défini comme l'intersection de l'axe de rotation de la plan'ete avec sa surface, n'est pas un point fixe. Sa position varie dû à une nutation associée à l'aplatissement de la plan'ete ainsi qu'aux échanges de masse qui perturbent son moment d'inertie. Malgré leur faible amplitude, ces déplacements compliquent les prétensions territoriales exprimées par quelques nations arctiques vis-à-vis le Pôle Nord. Je propose ici une démarche basée sur une coopération scientifique internationale au sein d'une aire entourant le pôle, démarche qui éviterait les conflits sans entrave sérieuse à l'acc'es aux ressources naturelles.

14:30

The Arctic Observing Summit 2013, 2014, 2016: Progress Towards an Integrated, Multipurpose, International Arctic Observing System

Maribeth Murray[1], *Gabriela Ibarguchi*[1], *Peter Schlosser*[2], *Lize Marie van Der Watt*[3], *Vinay Rajdev*[1]
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The biennial Arctic Observing Summit facilitates community-driven, science-based guidance for the design, implementation, coordination and sustained operation of an international pan-Arctic observing system. It is a forum for planning and priority-setting that links diverse needs for information with observing system design, data accessibility, and timely and relevant products useful for decision making. The AOS is a SAON (Sustaining Arctic Observing Networks) task to identify and pursue activities to improve Arctic observing across the full spectrum Arctic system components. The AOS led by The International Study of Arctic Change (ISAC), a multidisciplinary Arctic environmental change research program. ISAC engages researchers, community members, managers, and others in research planning, implementation, data-sharing and synthesis, and knowledge translation to advance observing and understanding of Arctic change for improved decision making. The AOS is key to implementation of the observing component of the ISAC Science Plan. The AOS is coordinated by the ISAC Program Office, the ISAC Science Steering Group and ISAC partners. In this paper we present results from the AOS 2013 and 2014, and plans for the AOS 2016. In particular we discuss ways in which the CMOS/AMS community can engage with the AOS and contribute to its objectives.

13:30

Damping of Geostrophic Motions by Oceanic Internal Waves, Critically Reflecting off the Sea Surface.

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Nowadays, physical oceanographers view density fronts as hotspots for oceanic kinetic energy dissipation. Within oceanic fronts, due to the sloping isopycnals and associated thermal wind shear, the possible directions of the group velocity of inertia-gravity waves(IGWs) depart from the classical St Andrew's cross. However, waves oscillating at the Coriolis frequency, keep one of these directions horizontal, while the other direction allows for vertical propagation of energy. This implies the existence of critical reflections of such inertial waves off the sea surface, after which incident wave energy cannot escape. This is analogous to the classical critical reflection of IGWs in a quiescent medium off a sloping bottom. We present a series of numerical experiments exploring parameter space that highlightproperties of critical (mega =), forward (. >), and backward (. <) reflections. We also report on irreversible energy exchanges between IGWs and geostrophically-balanced frontal flows that are enabled by friction and the modification of IGW-physics at fronts. We also show analytically that this is exacerbated during critical reflections where intense frictional effects under the surface induce a net transfer of energy from the balanced flow to ageostrophic motions, which are subsequently dissipated. Forward reflections are also favorable to triadic resonant interactions and therefore to turbulence which is weak in our simulations, but likely to be fully developed under oceanic conditions. The existence of this non-linear flow activity further increases the extraction of geostrophic energy from the front. On the other hand, backward reflections inhibit such non-linear flow activity.

14:00

A study of a surface trapped elliptical anticyclone at finite Rossby number

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The Oceans are driven predominantly at the surface through winds and solar heating. One model that has helped in our understanding of the dynamics of the upper ocean that arise due to buoyancy anomalies is the Surface Quasi-Geostrophic (SQG) model. It is of course limited in to describing mesoscale motions that have small Rossby number and aspect ratio. Numerical simulations of SQG dynamics often reveal an abundance of smaller scale vortices that have length scales that are in the submesoscale regime. It is well known that SQG dynamics cannot adequately describe these motions but it is not entirely clear as to what these motions should actually be doing. In an attempt to better understand what should transpire at the submesoscale where the motion is less balanced, we project a SQG solution into a Primitive Equation (PE) model. In particular, we focus on the surface trapped elliptical vortex that was presented in Held et al. (1994). We simulate the evolution

of this vortical structure for a variety of Rossby numbers. When the Rossby number is sufficiently small we of course recover the SQG solution almost identically. However, for the case of larger Rossby number we find that non-SQG dynamics appear not only at the submesoscale but on the scale of the actual vortex itself. Three significant differences are 1) the filaments on the periphery of the vortex are more stable and need not break up in to eddies 2) the energy spectrum steepens from a slope of -5/3 to something closer to -3 and 3) the vertical transport induced it amplified. This work does not detract from the value of the SQG model but instead tries to strengthen it by pointing out a range of parameters where the model is no longer applicable and how the motion differs when it does.

14:15

A simple model of ocean dynamics in Nares Strait

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The Canadian Arctic Archipelago is one of the two major oceanic gateways between the Arctic and the Atlantic Ocean. It has been estimated that the flow through this region currently accounts for about half of the freshwater transport between these two oceanic basins, its importance potentially increasing with increased melting of sea ice. However, factors such as its complex morphology, harsh meteorological conditions, the remote location and an almost continuous presence of sea ice form a hindrance to understanding the dynamics that force the flow through this region. In contrast to previous efforts which all used realistic model configurations, the approach in this study is one of a simple straight channel representing Nares Strait in a 3D primitive equation model. This enables us to disentangle and quantify the effects of barotropic forcing, baroclinic forcing, wind stress, ice cover and tides acting to drive or reduce the throughflow or alter its cross-strait structure.

14:45

Decadal Trends of Oxygen in the Northeast Pacific Ocean

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Oxygen measurements in subsurface waters of the Northeast Pacific since 1949 show declining oxygen concentrations (O2) after about 1975 to 1985 in all regions, but different trends among regions in earlier decades. These findings are based mainly on O2 on the 26.7 potential density (s.) surface in the region north of 30^{o}N and east of 170^{o}W, with similar trends on other s. surfaces in some locations. On the continental slope, O2 increased at most locations by 10 to 20 μmol kg-1 to about 1975 to 1985, followed by declines of similar magnitude in recent years. Changes in O2 are associated with changes in temperature of opposite sign south of 37^{o}N, but correlation of temperature and oxygen is irregular in more northern locations. At all locations, temperature-related solubility change is a minor cause of these O2 trends. In deep-sea waters, O2 decreased in time with a more rapid decrease from about 1995 to about 2003. At Ocean Station P (OSP, 50^{o}N, 145^{o}W) where observations are most continuous, significant linear trends of -0.4 to -0.5 μmol kg-1 y-1 are found on the 26.5, 26.7 and 26.9 s. surfaces from 1956 to 2011. In addition, a significant

sinusoidal oscillation of period 18.61 years and amplitude 18 μmol kg-1 is found on the 26.9 s. surface at OSP and a station 400 km to the east that fits reasonably well to the lunar nodal cycle. Phase of this oscillation is identical at both locations. Clear evidence of similar variability did not emerge at other open-ocean locations, nor along the continental slope. These results indicate that decadal variability must be accounted for when considering the impact of climate change in this basin.

13:30

The interannual variability of the Arctic energy budget

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Interannual variations in the top of atmosphere energy budget of the Arctic climate system are analyzed in observations (over the CERES satellite era) and compared to that in couple climate models. The absorbed solar radiation (ASR) averaged over the Arctic varies by 6 W m-2 (2s) from month and 4 W m-2 from year to year. The variability of outgoing longwave radiation (OLR) is half the magnitude of that in ASR on both time scales, suggesting that radiative input in to Arctic is driven by the variability in planetary albedo and only partially balanced by locally emitted radiation with the residual energy driving changes in ocean heat content, ice melting, and atmospheric energy transport. Ocean heat content data and atmospheric energy flux calculations (from reanalysis data) suggest that equal parts of the residual energy go into surface storage and energy export by the atmosphere. The anomalies in ocean heat content and atmospheric energy transports that are unrelated to changes in Arctic radiation are comparable in magnitude to radiatively driven anomalies. This suggests that atmospheric variability that is driven by processes external to the Arctic are responsible for as much variability of energy input to the Arctic as are processes local to the Arctic. Coupled climate models confirm these results. Anomalies in absorbed solar radiation (ASR) over the Arctic are decomposed into components due to anomalies in atmospheric reflection (primarily clouds) and surface albedo. At the monthly timescale, anomalies in ASR are primarily (70%) due to cloud changes whereas anomalies in clouds and surface albedo makes comparable contribution to interannual ASR anomalies averaged over the Arctic. Trends in ASR and OLR over the Arctic are both positive and highly significant with a 3.2 W m(-2) decade(-1) increase in ASR and a smaller magnitude (1.5 W m(-2) decade-1) increase in OLR. Surprisingly, the ASR trend is entirely associated with changes in a cloud reflection despite the significant decreases in surface albedo. Despite the decrease in surface albedo, there is a trend toward the surface reflecting slightly more radiation to space because cloud cover has decreased over Siberia which would lead to enhanced surface reflection (even if the surface was unchanged). Analysis of the natural variability of the Arctic climate system in unperturbed climate simulations suggest that the observed trend in ASR over the satellite era is very unlikely (<5% chance) to occur in the absence of external forcing, suggesting that the upward trend in ASR is indicative of anthropogenic climate change.

13:45

High Resolution NWP for the Canadian Arctic

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Commerce is increasing in the Canadian North, partly in association with the changing climate. Decreased extent of the Arctic ice cap during past summers has allowed shipping through the Northwest Passage. Remote communities are served primarily by aviation all year, and by ice roads in winter. Some of these communities are growing in response to mining of diamonds and other

minerals. In support of this commerce, UBC implemented operational high-resolution NWP in the Canadian Arctic starting in Dec 2014. This includes a new WRF-ARW forecast domain (nested 36, 12, and 4 km grid spacings) over northern Canada, centered over the Northwest Passage. Animated weather map products include those useful for shipping, aviation, and survival. In addition, point-forecast meteograms are made for 60 airports in the Canadian North, plus some in Greenland and Alaska. See the forecasts at http://weather.eos.ubc.ca/arctic/ .

14:00

Trace gas measurements at two Arctic sites using infrared emission spectroscopy: Filling the polar night knowledge gap

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The Arctic experiences prolonged periods of total darkness in the winter and continuous daylight in the summer, influencing the atmosphere and its composition in ways that are still not fully understood. The Canadian Network for the Detection of Atmospheric Change has equipped the Polar Environment Atmospheric Research Laboratory (PEARL, Eureka, Nunavut, Canada, 80^{o}05'N, 86^{o}42'W) with several spectrometers that measure atmospheric composition. Similarly the U.S. Department of Energy has established numerous ground-based observatory facilities around the world within the Atmospheric Radiation Measurement (ARM) Program, with one located at the North Slope of Alaska (NSA), Barrow, Alaska. At both sites, an Extended-range Atmospheric Emitted Radiance Interferometer (E-AERI), a ground-based Fourier transform infrared (FTIR) spectrometer, is used to measure the absolute downwelling infrared emission from the atmosphere between 400 and 3000 cm-1. A number of trace gases have emission features in this region, enabling simultaneous measurements of their total column abundances. The E-AERI has a moderate resolution of 1 cm-1 and a high sensitivity to the lower troposphere. E-AERI spectra provide information about radiative balance, budgets of trace gases, and clouds properties in the Arctic. At PEARL, the instrument was installed in October 2008. A similar instrument, the University of Idaho's Polar AERI (P-AERI) was installed at PEARL from March 2006 to June 2009. Measurements are taken by the E-AERI every seven minutes year-round (P-AERI measurements were made at sampling times of ≈30 seconds), including polar night when the solar-viewing spectrometers at PEARL are not operated. At NSA, the instrument has been operating since February 1998. Both datasets can be used to fill in the measurement gap during the Arctic night-time period when less is known about atmospheric composition. Total columns of CO, CH4, N2O and O3 have been retrieved from 2006 to 2014 (except in 2010) at PEARL and, from 1998 to 2014 at NSA using the new SFIT4 algorithm. These measurements are used to investigate the annual, seasonal and diurnal variabilities of these four species in the high Arctic.

14:15

Seasonal differences in Arctic N2O throughout the stratosphere to the lower thermosphere and its effect on stratospheric NO and O3

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In the dark polar winter, increases in N2O concentrations in the upper stratosphere and lower mesosphere have been observed and attributed to solar proton events and energetic particle precipitation. It has been suggested that the N2O production occurs at higher altitudes and descends into the upper stratosphere, where it can then be converted into NO and play a role in the catalytic destruction of xO3. This study will present ACE-FTS (Atmospheric Chemistry Experiment - Fourier Transform Spectrometer) N2O measurements and climatologies throughout the atmosphere, from the stratosphere to the lower thermosphere. From year to year, the Arctic summer ACEFTS N2O measurements are fairly consistent. However, the Arctic winter measurements in the middle atmosphere are highly dependent on the local dynamics. The ACE-FTS measurements and variations in the upper stratosphere will be compared to correlative N2O data from the satellite instruments MIPAS and MLS. We will investigate the possible sources and sinks of N2O in the middle to upper Arctic atmosphere and quantify the effect its descent into the stratosphere has on stratospheric NO and O3 concentrations. x.

14:30

Simulations of Arctic Aerosols and Climate with CanAM

Knut von Salzen[1], *Maryam Namazi*[1], *Rashed Mahmood*[2], *Jiangnan Li*[1], *Jason Cole*[1], *John Fyfe*[1], *Richard Leaitch*[3], *Sangeeta Sharma*[3], *Lin Huang*[3]
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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 the past and offer potential opportunities for mitigation actions aimed at reducing Arctic warming. In order to facilitate the detection and attribution of climate change in the Arctic and to aid policymakers, improving in modelling capabilities for the Arctic is a key priority for atmospheric physics model development activities at CCCma. This includes the introduction of an aerosol microphysics scheme in the latest version of the Canadian Atmospheric Global Climate Model (CanAM4.2). Studies with CanAM4.2 and earlier versions of the model give evidence for considerable trends in aerosol concentrations and impacts of aerosols on Arctic temperatures during recent decades. Results from these studies and implications for future changes in Arctic climate will be discussed.

14:45

A Pan-Arctic view of inversion formation and maintenance processes

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The presence of a prevalent surface-based inversion in the Arctic has been shown to play a role in enhancing surface warming, by reducing surface sensible and latent heat fluxes and thus modulating the sensitivity of the surface response (e.g. Boé et al. [2009]). Modelling studies (e.g. Boé et al. [2009], Medeiros et al. [2010]) highlighted this phenomenon, by showing that inter-model differences in Arctic climate sensitivity are largely driven by differences in inversion strength. Most Global Climate Models (GCM) in fact overestimate the strength of the inversion, leading to biases in Arctic climate sensitivity and Arctic amplification. Improved knowledge of the observed and projected changes of the Arctic surface-based inversion is critical to the understanding of the surface energy balance and Arctic Amplification. In this study, we first describe a non-linear relationship between sea ice thickness and the strength of the inversion, linked to the surface radiative balance. Secondly, we present a Pan-Arctic view of the contributions of surface cooling, subsidence, meridional transport of heat, and surface mixing to the strength of the temperature inversion.

13:30

Seamless coupled forecasting across all time scales at the Met Office, UK: ocean-ice forecasting, seasonal prediction, climate projections and Earth system modelling.

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The Met Office is the United Kingdom's national weather service and, through the Met Office Hadley Centre, is at the forefront of climate research in the UK - playing a key role in helping determine the worldwide response to climate change. In order to deliver these services the Met Office develops and maintains a fully unified framework of global and regional atmospheric, land, ocean and sea ice prediction systems operating across multiple space and time scales; from short-range forecasting and seasonal prediction through to climate change projections and palaeoclimate simulations. The Met Office coupled modelling framework is based on the Met Office Unified Model (UM) atmosphere and JULES land components coupled to the NEMO ocean model and Los Alamos sea ice model (CICE) using the OASIS coupler. In addition to these atmosphereocean- ice-land (AOIL) components, there is an increasing requirement to include Earth system complexity in the coupled modelling framework - which is undertaken by including the UKCA (United Kingdom Chemistry and Aerosols) model, the MEDUSA (Model of Ecosystem Dynamics, nutrient Utilisation, Sequestration and Acidification) ocean biogeochemistry system and the BISICLES ice sheet model. In this talk the present range of forecasting and prediction systems employed at the Met Office is introduced with a focus on the routine short-range polar forecasts and seasonal prediction of Arctic ice extent. Recent developments to the Met Office global coupled model configuration (GC3) are introduced and plans for the development of a new UK Earth System Model (UKESM1) - a joint collaboration between the Met Office and the UK's National Environmental Research Council (NERC) - will be provided. Within the GC3 and UKESM1 configurations there are many new features designed to improve prediction at high latitudes - including the introduction of dynamic ice sheet modelling and cavities under ice shelves - and these will be discussed. Finally plans for the use of the UKESM1 and GC3 configurations within CMIP6 will be provided.

13:45

The Roles of the PDO and ENSO on Regional Antarctic Warming during Austral Spring, 1979-2012

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After 1979, statistically significant warming in Antarctica is only observed in austral spring (September-November, SON) across West Antarctica and the Antarctica Peninsula. While previous work has linked this warming to reductions in sea ice cover, we note that a substantial (30-60%) portion of the warming is related to changes in the SON atmospheric circulation. In particular, western Antarctic Peninsula warming is consistent with increasing pressure in the South Atlantic, while western West Antarctica warming is tied to a deepening of the Amundsen Sea low near the eastern Ross

Sea. While both of these circulation changes are associated with increased warm, northerly flow towards the Antarctic continent, they are connected with different aspects of tropical variability. The increase in pressure in the South Atlantic is associated with a trend towards more La Nina-like conditions in the tropical Pacific, and an associated Rossby wavetrain. In contrast, the deepening of the Amundsen Sea low is more strongly tied to a shift in the Pacific Decadal Oscillation (PDO) towards its negative phase since the 1990s. Compared to typical La Nina events, the recent negative PDO events display a different tropical forcing, which drives a Rossby wavetrain that propagates more meridionally across the South Pacific, culminating in the eastern Ross Sea, rather than in the South Atlantic. The results suggest multiple independent forcing mechanisms governing the SON pressure trends and associated Antarctic Peninsula and West Antarctica warming after 1979, which partially cancel each other out in the Amundsen Sea and portions of eastern West Antarctica.

14:00

Exploring the link between human-induced Arctic sea ice loss and cold Eurasian winters

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Observed Arctic sea ice loss has been implicated in the recent prevalence of anomalously cold winters in Eurasia. Whether this linkage is a robust feature of anthropogenic sea ice loss, however, remains an open question because observed sea ice loss is due to a combination of external (human-induced) forcing and internal (random) variability. The interpretation of any warm Arctic-cold Eurasia linkages is further complicated by large wintertime internal variability over midlatitude land in observations and in atmospheric model simulations that attempt to isolate the response to sea ice loss. Here we execute two large ensembles of simulations in an atmospheric general circulation model with prescribed sea ice loss taken from five historical simulations in the associated coupled global climate model in order to isolate the impact of past human-induced sea ice loss, as distinct from observed sea ice loss, on Eurasian temperature. We find the average Eurasian temperature response is negligible due to human-induced sea ice loss, however we find long periods (120 years) of both average warming and cooling over Eurasia in early winter, linked to geopotential height anomalies over the Barents-Kara Seas region of the Arctic. This suggests that observed cold winters are due to some combination of internal variability in the sea ice itself, internal variability in the response to human-induced sea ice loss, or external factors.

14:15

The Temporal and Spatial Evolution of Atmospheric Responses to Changing Arctic Ice Cover in Present-Day CCSM4

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The rapidly diminishing Arctic sea ice cover impacts the overlying atmospheric state through changes in moisture and surface energy fluxes, and the spatial extent of this atmospheric response

remains unclear and may even reach the mid-latitudes. Synoptic atmospheric responses to surface sensible heat flux anomalies over the Arctic Ocean during autumn (SON) in the present-day climate (1974-2005) of NCAR's Community Climate System Model, version 4 (CCSM4) are investigated. The self-organizing map (SOM) technique is used to characterize important daily running-weekly-mean surface heat flux anomaly patterns over the Arctic. The importance of the week-to-week persistence and spatial extent of the surface heat flux anomalies in forcing the atmospheric response is diagnosed by creating composites of atmospheric variables (such as 2-m temperature, sea level pressure, and geopotential height, temperature, and specific humidity at 850, 500, and 300 hPa) for each heat flux pattern identified by the SOM technique. The temporal and spatial evolution of the response of the atmospheric variables associated with the direct forcing from the sea ice loss is characterized from the Arctic to 20^{o}N for each week in autumn, up to 12 weeks, in order to identify the temporal persistence required to force the remote atmospheric responses.

14:30

Pacific trade wind intensification and the recent prevalence of unusually cold North American winters

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The slow down in the rate of increase of global mean temperatures in recent years, often referred to as the global warming hiatus, has been attributed in large part to Pacific trade wind intensification. Recent studies have suggested that such tropical internal climate variability may also explain recent regional temperature trends at higher latitudes, including the recent prevalence of unusually cold North American winters. Here we show, using a 100-member ensemble of freely running coupled model simulations, two 10-member ensembles of coupled model simulations with prescribed tropical surface winds and atmospheric model simulations with prescribed sea surface temperatures that, on average, the observed Pacific wind intensification has not lead to a cooling but instead to a warming of North American winters. These results suggest that the recent cooling of North American winters are due to a combination of forced and internal climate variability not linked to Pacific trade wind intensification.

14:45

Tropical forcing of the recent rapid Arctic warming in northeastern Canada and Greenland

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Rapid Arctic warming and sea ice reduction in the Arctic Ocean are widely attributed to anthro-

pogenic climate change. The Arctic warming exceeds the global average warming due to feedbacks that include sea ice reduction and other dynamical and radiative feedbacks. We show that the most prominent annual mean surface and tropospheric warming in the Arctic since 1979 has occurred in northeastern Canada and Greenland. In this region, much of the year-to-year temperature variability is associated with the leading mode of large-scale circulation variability in the North Atlantic, the North Atlantic Oscillation (NAO). We show that the recent warming in this region is strongly associated with a negative trend in the NAO, which is a response to anomalous Rossby wave-train activity originating in the tropical Pacific. Atmospheric model experiments forced by prescribed tropical sea surface temperatures simulate the observed circulation changes and associated tropospheric and surface warming over northeastern Canada and Greenland. Experiments from the Coupled Model Intercomparison Project Phase 5 (CMIP5) models with prescribed anthropogenic forcing show no similar NAO-related circulation changes or associated tropospheric warming. This suggests that a substantial portion of recent warming in the northeastern Canada and Greenland sector of the Arctic arises from unforced natural variability.

13:30

Forecasting Polar Lows with an on-demand EPS system

Hanneke Luijting[1], *Eivind Stoylen*[1], *Gunnar Noer*[1], *Jorn Kristiansen*[1]
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Polar lows are small, intense low pressure systems, formed when cold air from the polar ice sheet (or cold land areas) flows over a relatively warm sea surface. The coast of Northern Norway is frequently hit by polar lows: cold winds coming from the ice-covered Arctic Ocean meet the warm waters of the North Atlantic Current of the Gulf Stream. On average, 12-15 polar lows form each winter over the Norwegian and the Barents Sea. Although they dissipate quickly after landfall, their small scale and the sudden onset of strong winds and heavy snow showers often put human life and property at great risk both on and off shore. The development of polar lows is generally well represented in numerical weather models, however, getting the location and timing right is a challenge. A new approach for forecasting polar lows has been developed at the Norwegian Meteorological Institute in collaboration between the research department and forecasters from Tromso. A high-resolution EPS with a flexible (on-demand) domain is available over the Nordic and Barents Seas. The forecaster selects between three different predefined model domains based on the region with most potential for a polar low. The movement of a polar low is tracked by following vorticity maxima in each of the 10 + 1 members of Harmonie EPS. The result is a strike probability map similar to those commonly used for tropical cyclone forecasting. These maps, together with the probability for wind and precipitation over certain thresholds are then used to issue a forecast. This method has been in use for the past three polar low seasons and has proved very successful. Harmonie EPS has 2.5 km horizontal grid spacing, run twice daily with a lead time of 42 hours and is a dynamical downscaling of ECMWF EPS.

13:45

Improving Land-Surface Parameterization with the Multi-Budget Soil, Vegetation, and Snow (SVS) Scheme

Syed Zahid Husain[1], *Nasim Alavi*[1], *Stéphane Bélair*[1], *Shunli Zhang*[2], *Vincent Fortin*[1], *Maria Abrahamowicz*[2], *Nathalie Gauthier*[2]
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A new land-surface parameterization scheme, namely the Soil, Vegetation, and Snow (SVS) scheme, has recently been developed at Environment Canada to replace the operationally used ISBA (Interactions between Surface, Biosphere, and Atmosphere) scheme. The new scheme is designed to address the many weaknesses and limitations of ISBA that have been identified throughout the past years. Unlike ISBA, which calculates a single energy budget for the different land-surface components, SVS introduces a new tiling approach that permits multiple energy budgets for bare ground, vegetation, ground under vegetation, and two snow packs (over bare ground and low vegetation, and under high vegetation). Implementation of the multiple energy budgets is found to generally result in a more accurate screen-level score for SVS while making any comparison of model outputs with

observational data more convenient. Furthermore, the separate energy budgets pave the way for further enhancements through possible implementation of multi-layer interactions between the atmosphere and the land-surface components. Another major change in SVS compared to ISBA is the implementation of a photosynthesis model for the determination of the surface stomatal resistance. Representation of photosynthesis is found to have significant positive impact on the surface-layer air and dew point temperatures. The representation of vertical water transport through soil has also been substantially improved in SVS through the inclusion of multiple soil layers. This helps to increase the accuracy and dynamical range of the evolving soil moisture fields at the different vertical levels within the soil. Other improvements in SVS include a modified vegetation thermal coefficient that accounts for the contribution of the bare ground visible through the vegetation canopy and better estimation of land-surface albedo and emissivity based on soil texture and soil wetness. The presentation will highlight the principal features of the SVS scheme along with a thorough comparison between SVS and ISBA.

14:00

The Weather Network's Hourly NWP Precipitation Nowcasting Model

Iain Russell[1], *Zhan Li*[2], *Majid Fekri*[1], *Yongsheng Chen*[2], *Peter Taylor*[2]
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Meteorologists at The Weather Network, in collaboration with Researchers from York University's Earth and Space Science and Engineering Department, are exploring the application of high resolution NWP to precipitation nowcasting. The traditional method for precipitation nowcasting at The Weather Network mainly relies upon radar extrapolation with a steady-state precipitation pattern assumption and without representation of new precipitation development or decay of old precipitation areas during the 0-6 hour prediction window. The Toronto 2015 Pan Am / Parapan Am Games will occur in the middle of a 2-year collaborative NWP research project between The Weather Network and York University, presenting an excellent opportunity to test-drive our experimental Nowcast-NWP model configuration in real-time for a live high profile event setting. The main features of the experimental setup are: 1. Domain centred over the Southern Ontario GTA at 3km horizontal spatial resolution, tuned for precipitation prediction with cloud- resolving modeling, and using the new Thompson microphysics parameterization scheme; 2. GSI (Gridpoint Statistical Interpolation system) data assimilation, combining the NCEP High Resolution Rapid Refresh (HRRR) as background field and 3D-Var for assimilation of real-time observations including reflectivity and radial velocity from the Canadian volumetric radar data, OQ-Net wind profiler data as well as traditional surface observations; 3. The entire system runs in the cloud (Amazon Web Services), launching one set of 12-hour forecasts every hour; Development of the NWP setup involves making prototype runs of the model, and results from these runs will be presented. Moreover this project is an excellent example of collaboration between the private sector and academia leading towards the transfer of scientific research to industry, demonstrating in a practical way the value of collaboration between different sectors of the Canadian economy.

14:15

Determining forecast skill in a numerical weather model: Case study - 1 year of daily WRF NWP results compared against observation data from the Wood Buffalo Environmental Agency Air monitoring network.

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Alberta Environment and Sustainable Resource Development recently worked with RWDI to develop a real-time plume dispersion modelling system called the Emergency Air Monitoring and Assessment System (EAMAS). The intent of the system is to model atmospheric release events in real-time in order to provide emergency response personnel with a visual indication of the magnitude and extent of ground level impacts. The system integrates numerical weather model output (WRF) with an atmospheric release model (HGSYSTEM), and an atmospheric dispersion model (CALPUFF). The purpose of this talk is to discuss the process of determining skill of the numerical weather forecast model (WRF) when compared against a network of 15 meteorological stations during the first year of operation. Results of the study will be presented.

14:30

Postprocessing of Numerical Weather Forecasts Using Online Sequential Extreme Learning Machines

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Statistical/machine learning methods have been widely used in operational weather forecasting to postprocess numerical weather prediction (NWP) model output - i.e. statistical methods are used to reduce the systematic errors in the NWP model output or to predict variables not forecasted by the NWP model. For statistical stability, a statistical model needs to be built from a long data record (i.e. long record of NWP output). Furthermore, most statistical models use batch learning, i.e. whenever new data become available, the model must be retrained using the whole data record, which can be computationally very costly. In contrast to batch learning, online sequential learning allows the model to be updated using only the new data. In this work, we use a sequential learning algorithm called the online sequential extreme learning machine (OS-ELM) to postprocess NWP model forecasts of temperature and probability of precipitation. Originated from the batch learning extreme learning machine, the OS-ELM can update itself by learning from a single new data point or multiple new data points, then discard the data. Four different postprocessing methods were tested for forecast hours 3-48. The four methods were the OS-ELM, the simple moving-average method, the Kalman filter and the online multiple linear regression. The methods were tested on temperature and probability of precipitation forecasts over stations across Canada.

14:45

Les activités de post-traitement dans la section des éléments du temps du Centre Météorologique Canadien (CMC).

Nacera Chergui[1], *Stéphane Gagnon*[1]
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La section des éléments du temps (CMDW) de la division du développement des prévisions nationales (CMDD) du Centre Météorologique Canadien (CMC) est responsable du développement et de l'amélioration des syst'emes de post-traitement requis pour la génération des produits de prévision environnementale. Les produits dérivés de ces syst'emes de post-traitement sont en quelque sorte l'interface entre les sorties des syst'emes de prévision numérique et les utilisateurs (prévisionnistes, public, médias, organismes privés et publiques). Elle s'occupe principalement du post-traitement statistique et diagnostique, des produits dérivés des différents syst'emes de prévisions numériques déterministes, d'ensembles et des prévisions saisonni'eres. Ces produits nourrissent plusieurs plateformes tels que le site meteo.gc.ca, les outils de production Scribe et NinJo ainsi que le dépôt de données DataMart du CMC. Les Priorités et les enjeux de la section seront présentés, ainsi que les projets en cours et les syst'emes en phase de développement (Exemple SPOOKI : Syst'eme de Production Orienté Objet avec une Kyrielle d'Information).

10:30

Constraining the strength of the terrestrial CO2 fertilization effect in Earth system models

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The transient climate response to cumulative carbon emissions (TCRE), which is defined as the ratio of global-mean warming to cumulative emissions at CO2 doubling in a 1% per year CO2 increase experiment, combines aspects of both climate sensitivity and carbon cycle in a single metric. The differences in TCRE among Earth system models (ESMs) are thus caused by differences both in their climate sensitivities as well as the response of land and ocean carbon cycles to increasing atmospheric CO2 and changing climate. The response of the land carbon cycle to changes in atmospheric CO2 varies widely across ESMs and it is the primary reason for differences in the response of the global carbon cycle to changes in atmospheric CO2. The response of the ocean carbon cycle, to changes in atmospheric CO2 and changing climate, is much more consistent across ESMs. Over land, the strength of the CO2 fertilization effect is biggest source of uncertainty that contributes to the large differences in response of the land carbon cycle. Here, I use results from the three generations of the Canadian Earth System Model (CanESM1, CanESM2, CanESM 4.2) to show how the net land carbon uptake over the historical period and the amplitude of the annual cycle of the atmospheric CO2 concentration may be used to constrain the strength of the CO2 fertilization effect of the land carbon cycle component. Uncertainty exists in land use change emissions over the historical period and monthly global atmospheric CO2 data go back only to the 1980s. These limitations imply that both the net land carbon uptake over the historical period and the amplitude of the annual cycle of the atmospheric CO2 concentration provide not-toostrong, but still meaningful, constraints on the strength of the CO2 fertilization effect of the land carbon cycle.

10:45

Extending the TCRE to regional climate changes

Martin Leduc[1], *Damon Matthews*[2], *Ramon de Elia*[3]
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The Transient Climate Response to cumulative Emissions (TCRE) is a metric that quantifies the response of the climate system to anthropogenic CO2 emissions. Defined as the ratio between the global mean temperature change and the amount of CO2 emitted into the atmosphere, the TCRE accounts for interactions between human activity, the climate sensitivity and the dynamics of carbon sinks. It is now well known that the TCRE metric is fairly stable over time, and approximately independent of the emission pathway. While this has been widely shown in terms of the global mean surface air temperature, here we show that the TCRE can also be treated as approximately constant at the regional scale and for a broad range of climatic regions. Using an ensemble of twelve

Earth System Models from the CMIP5 archive, we attribute a range of confidence to the TCRE spatial pattern so as to quantify the uncertainty associated with the sensitivity of the climate-carbon system across models. Together, the global and regional versions of the TCRE form a powerful set of tools for synthesizing complex climate model output for non-expert users and informing current discussions for mitigating greenhouse gases emissions.

11:00

The effect of ocean mixing on heat and carbon fluxes and the linearity between global warming and cumulative CO2 emissions

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An approximately linear relationship between global warming and cumulative CO2 emissions has been shown. The ratio between global mean temperature change and cumulative CO2 emissions is referred to as Transient Climate Response to cumulative Emissions (TCRE). The TCRE has applications for policy by relating total allowable emissions to a certain warming target and has been suggested as a benchmark for model inter-comparison. However, the reasons for the constancy of the TCRE are not well understood. Ocean heat and carbon fluxes are assumed to play a major role in the constancy of the TCRE as they are affected by the same mechanisms, but for instance changes in ocean circulation might affect ocean heat and carbon fluxes in different ways. Furthermore, land carbon fluxes need to be taken into account as well. This study explores the effect of different ocean mixing parameterizations on ocean heat and carbon fluxes and, in turn, the constancy of the TCRE, and the role of land carbon flux. The University of Victoria Earth System Climate Model (UVic ESCM), which contains a simple atmosphere, a dynamic ocean, and a land-surface scheme coupled to a dynamic vegetation model, is used. All model parts are coupled to a carbon cycle. Ocean mixing parameters and schemes are varied for different simulations that are forced with a quadrupling of atmospheric CO2. The different ocean mixing schemes introduce changes in ocean heat and carbon fluxes, which affect global mean temperature and cumulative emission, as atmospheric CO2 concentrations are prescribed. Thus, the TCRE varies between different mixing settings. However, within each mixing setting the TCRE is approximately constant over time. Furthermore, not taking land carbon fluxes into account results in a stronger deviation from constant values for the TCRE.

11:15

Exploring the proportional relationship between global warming and cumulative CO2 emissions for negative emission scenarios

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Recent research has demonstrated an approximately proportional relationship between global mean temperature change and cumulative carbon emissions. This relationship has mostly been explored for scenarios with positive CO2 emissions into the atmosphere. Negative emissions (also referred to as artificial carbon dioxide removal) are increasingly discussed as a means to mitigate climate

change, particularly in the context of scenarios meeting stringent climate targets, such as the 2^oC target. Here, we use an Earth System Model of intermediate complexity to explore the ratio of global warming to cumulative carbon emissions - a measure referred to as the Transient Climate Response to Cumulative Carbon Emissions (TCRE) - for a range of idealized scenarios entailing net negative CO2 emissions. Our results indicate that the TCRE increases during periods of negative emissions. This increase is associated with a heat flux from the ocean into the atmosphere, which prevents the system from cooling. The TCRE increase is larger for scenario with larger time-integrated top-of the-atmosphere energy imbalance. We conclude that due to the larger TCRE, the effectiveness of artificial CO2 removal in mitigating climate change may be lower than expected based on the TCRE for positive emission scenarios.

11:30

How much would five trillion tonnes of carbon warm the climate?

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Estimates of the fossil fuel resource have a lower bound of around 5 trillion tonnes of carbon (EgC), and it is of interest to know what the likely climate impacts of burning this much fossil fuels would be. The IPCC Fifth Assessment Report reports that a linear relationship between warming and cumulative carbon emissions is known to hold only up to around 2 EgC emissions. It is typically assumed that at higher cumulative emissions the warming would tend to be less than that predicted by such a linear relationship, with the radiative saturation effect dominating the effects of positive carbon-climate feedbacks at high emissions. One study using a simple climate model predicted a most likely global warming in response to 5 EgC emissions of only around 5^oC. Here we make use of RCP 8.5-Extension simulations from five Earth System models from the Coupled Model Intercomparison Project Phase 5 (CMIP5), which extend to cumulative CO2 emissions of around 5 EgC. Our results demonstrate that CO2 induced warming continues to increase approximately linearly with cumulative carbon emissions even at these high cumulative emissions. The simulations exhibit global mean warming between 9^oC and 13^oC in 2300 for cumulative CO2 emissions of approximately 5 EgC, with smaller forcing contributions from other greenhouse gases. These results indicate that the exploitation of the full fossil fuel resource would result in considerably more profound climate changes than previously suggested.

11:45

Methane Leaks from Canadian and American Gas Fields and Impacts on the UNFCCC

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The issue of methane leaks from North American gas fields is under strong debate. Around 10 % of natural gas production is escaping into the atmosphere. Only about 2% is reported to the UNFCCC by the EPA and by Environment Canada. This represents more than 30% missing from the US

and Canadian reported GHG budget of equivalent carbon dioxide. In this paper we demonstrate the sources of these large leaks. Of particular interest are the large leaks from the Baaken field. The role of leaks from coal mining operations is of particular interest to Alberta. The large leakage rates have been discovered by airborne in situ measurements. Remote sensing measurements from satellites verify the aircraft measurements.

10:30

Recent Earth system change in the interior of western Canada - recent results from the Changing Cold Regions Network

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Across the western and northern interior of Canada, rapid and severe Earth system changes have been occurring over the past several decades, accompanied by major hydro-climatic extremes. These include both the worst flooding and drought on record in the past 15 years alone, for some areas. The Canadian Changing Cold Regions Network (CCRN) is a multi-disciplinary research initiative that aims to understand, diagnose, and predict interactions amongst the cryospheric, ecological, hydrological, and climatic components of the changing Earth system over this region. The network has been engaged in evaluation and synthesis of observed changes, including analyses based on the Adjusted and Homogenized Canadian Climate Dataset, its gridded counterpart, CANGRD, and the Water Survey of Canada's Reference Hydrometric Basin Network. This provides context for more detailed observations of change and process-level understanding, from a set of 14 Water, Ecosystem, Cryosphere, and Climate (WECC) observatories over the CCRN study domain. Diagnostic evaluation of regional change and the occurrence of recent extreme events has involved studies based on North American Regional Climate Change Assessment Program and Coupled Model Intercomparison Project Phase 5 datasets, development of downscaling techniques for climate model outputs using Generalized Linear Models, and simulation of recent events using the Cold Regions Hydrological Model, Environment Canada's Modélisation Environmentale Communautaire - Surface and Hydrology and Global Environmental Multiscale - Local Area Model and, and the National Center for Atmospheric Research Weather Research and Forecasting Model. This presentation will review observed changes and trends in various Earth system components over this region, highlighting some of the recent hydro-climatic extremes such as flooding, drought, and forest fires.

10:45

Elevational dependence of climate variability and trends in British Columbia's Cariboo Mountains, 1950-2010

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Pristine mountain environments are more sensitive to climate change than other land surfaces. The understanding of climatic variations in mountainous terrain is still uncertain. Previous studies reveal inconsistent findings on the elevational dependency of warming in the mountains. In this study, the trends and elevational dependence of climatic variables in the Cariboo Mountains Region (CMR) of British Columbia are explored. A high resolution 10 km x 10 km gridded data set of climate variables over the period of 1950-2010 is used. The Mann-Kendall test is performed for evaluation of trends and their significance. The minimum and maximum air temperatures of the region have risen by 1.9^{o}C and 1.2^{o}C, respectively, in the last six decades. Although the total annual precipitation

does not show any significant trend, there is year-to-year variation of total precipitation by ±30% from its long-term mean. The minimum air temperature trend shows significant amplified warming at higher elevations. The annual minimum air temperature trends are stronger and significant at higher elevations with magnitude of more than 0.5°C decade-1 above 2000 m a.s.l. The annual maximum air temperature trends show the opposite pattern of increase with elevation, mostly below 1500 m a.s.l. The snow-albedo feedback (SAF) and increase in the cloud cover over the region may be the possible major factors responsible for elevational warming in the CMR. The potential impacts of these changes are on the endangered mountain caribou and water resources of the area.

11:00

The June 2013 Alberta Catastrophic Flooding: Water vapor transport analysis by WRF simulation

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The Weather Research and Forecasting (WRF) Model was used to simulate 2013 Alberta flooding event. In the simulation, there were 2 nested domains; the resolutions for the inner/outer domain were 3 km/27 km respectively. The boundary condition was forced by NCEP reanalysis with 1 degree resolution every 6 hours. WRF simulated precipitation was then compared to CaPA, CMOPH, and station data for calibration. The simulated timing and location of the precipitation, and the generated precipitation rates closely fit the observations, indicating that WRF model is capable to reproduce this type of severe event. Water vapor budget analysis were applied to find out the moisture sources that caused the flood to occur, including the large scale moisture convergence by advection, orographic blocking and lifting, local recycling of the water through evaporation, etc. Sensitivity test of local topography was done with reduced- mountain height, less roughness, to see how much precipitation was contributed by the blocking effect, and how the correct timing and location of the precipitation relies on the micro-meteorology process within the Rocky mountain. This work is a preparation for future WRF simulations under global warming scenario to see whether this type of extreme events may happen more frequently in future.

11:30

Improving the Representation of Snow Processes in CLASS for Western Canadian regions

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The climate of western North America, most notably British Columbia, has changed substantially over the past century and its impacts can be observed widely from its hydrological cycle. In this context, it is vital to monitor and simulate these changes and their impacts on the region's future hydrology. In this study, the Canadian Land Surface Scheme (CLASS) will be implemented to simulate the snow modelling using some of the weather stations data in western BC. The emphasis will be placed on the development of a sub-grid scale snow (SSS) parameterization and its impact on representing land surface heterogeneities. The snow parameterization will incorporate elevation bands, the consideration of slope and aspect and exposure to wind, among others. It is expected that this work will improve the depiction of snowpack evolution in western North America and will help to evaluate its impacts on regional hydrology. This study will also focus on some other important issues related to snow modelling, e.g., the impact of SSS parameterizations on the simulation of snow in mountain regions will be assessed.

11:45

Trends in Hydrological Extremes as Modelled Using Two Gridded-Climatological Datasets

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Gridded-climate data are essential to hydrologic modelling and statistical downscaling. Yet, a limited availability of station data and complex terrain make British Columbia a challenging setting to create such data. Two gridded-climatological datasets are compared in this study. The Variable Infiltration Capacity (VIC) Forcings dataset includes station data from the Environment Canada, BC Ministry of Forests, Lands and Natural Resource Operations, BC Hydro, and the US National Weather Service Co-operative networks. It was created for BC by interpolating stations to $1/16^o$ grids ($\approx$27-31 km2) using the SYMAP inverse-distance weighting algorithm, gridded fields were temporally homogenized to remove interpolation artefacts introduced by using a temporally varying mix of stations and corrected for topographic effects using ClimateWNA. The second dataset includes quality controlled Environment Canada stations. It was created for Canada using the Australian National University Spline (ANUSPLIN) implementation of a trivariate thin plate smoothing splines at $\approx$10 km resolution using elevation, longitude and latitude as interpolation predictors. One potentially influential difference in the two methodologies is that the VIC Forcings includes a temporal correction while the ANUSPLIN does not. We evaluate these methods by comparing hydrologic trends and climatologies from the VIC hydrologic model for ten sub-basins of the Peace, Columbia and Fraser River Basins, as driven by VIC Forcings and ANUSPLIN, to those from the Water Survey of Canada Reference Hydrometric Basin Network (RHBN) observations. Additionally, we carry out a validation with a Budyko based analysis that compares observed streamflow data for 17 watersheds in BC to the temperature and precipitation data provided by the two gridded-observations. These validations are a means to evaluate uncertainties in modelling hydrologic extremes due to differences in gridded climate data and to inform the robust creation of future datasets.

10:30

The CONCEPTS Global Ice-Ocean Prediction System

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Here we describe a new system running at the Canadian Meteorological Centre (CMC) entitled the Global Ice Ocean Prediction System (GIOPS). GIOPS provides ice and ocean analyses and 10 day forecasts daily at 00GMT on a global $1/4^o$ resolution grid. GIOPS includes a full multivariate ocean data assimilation system that combines satellite observations of sea level anomaly and sea surface temperature (SST) together with in situ observations of temperature and salinity. In situ observations are obtained from a variety of sources including: the Argo network of autonomous profiling floats, moorings, ships of opportunity, marine mammals and research cruises. Ocean analyses are blended with sea ice analyses produced by the experimental Global Ice Analysis System. Atmospheric fluxes for 10 day forecasts are calculated using fields from CMC's Global Deterministic Prediction System. GIOPS has been developed as part of the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS) initiative between Environment Canada, Fisheries and Oceans Canada and National Defense. The development of GIOPS was made through a partnership with Mercator-Océan, a French operational oceanography group. Mercator-Océan provided the ocean data assimilation code and assistance with the system implementation. GIOPS has undergone a rigorous evaluation of the analysis, trial and forecast fields demonstrating its capacity to provide high-quality products in a robust and reliable framework. In particular, SST and ice concentration forecasts demonstrate a clear benefit with respect to persistence. These results support the use of GIOPS products within other CMC operational systems, and more generally, as part of a Government of Canada marine core service. An update to GIOPS was made in June 2014, that revisits the blending of ice and ocean analyses and results in improved ice forecast skill. Results from an intercomparison of global ocean prediction systems (including GIOPS) made as part of GODAE Oceanview will also be presented.

10:45

Circulation, meso-scale eddies and tides simulated with the high-resolution ocean models based on NEMO

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A series of high-resolution ocean models, based on the Nucleus for European Modelling of the Ocean (NEMO), has been developed by the Canadian CONCEPTS program for various projects and applications. These models cover the North Atlantic, Arctic and North Pacific Oceans, with horizontal resolutions of $1/12^o$ and $1/36^o$ in latitude and longitude. A series of hindcast simulations (without data assimilation) are carried out, and the results are assessed with a variety of in situ and satellite remote sensing observations. It is shown that the models obtain reasonable solutions of tides and circulation patterns. For the simulation of meso-scale eddies, the eddy kinetic energy and the detailed eddy structure are very sensitive to the choice of lateral viscosity used in momentum equations, in particular at $1/36^o$ resolution. Comparison of modelled and observed spectra of eddy variability, in both frequency and wavenumber domains, guides the further improvement of these models.

11:00

A high-resolution baroclinic model of ocean circulation off southwest of Nova Scotia

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A high resolution ocean model is developed to study circulation off southwest of Nova Scotia. This work is part of a project within MEOPAR to develop a coupled relocatable atmosphere-ocean prediction system. The study aims to investigate the baroclinic response of the region to wind, density and tidal forcing. The three dimensional baroclinic model is based on NEMO (Nucleus for European Modelling of the Ocean). The model configuration has a horizontal resolution of approximately 500 m and uses 40 vertical levels with a variable spacing of 1 to 12 m. The model is forced with realistic meteorological forcing. The initial and boundary conditions are derived from a large-scale model covering the Scotian Shelf. In this presentation, details of the model development will be discussed. The model performance will also be evaluated by comparing the numerical results with observations. Furthermore, preliminary analysis of the influence of tidal, wind and density induced currents on the upwelling process off Cape Sable, southwest of Nova Scotia will be presented. This study is funded by the Marine Environmental Observation, Prediction and Response (MEOPAR) Network of Centers of Excellence.

11:15

Evaluation of Physics and Numerics of a Real-time Model of the Salish Sea

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A real-time model of storm-surge for the Salish Sea is producing two forecasts and a nowcast daily and publishing the results to the web (salishsea.eos.ubc.ca/nemo). We are developing this model to produce three-dimensional fields of velocity, tracers, the carbon system, nutrients and phytoplankton. In this presentation, we will provide details of our evaluation with an emphasis on what we have learned about the physics of the Salish Sea and the numerical model NEMO. Specific issues are: 1) the principle factors determining storm surge in the Strait of Georgia 2) the impact of mixing in the San Juan/Gulf Islands on tides, 3) the impact of river treatment on currents, temperature and salinity and 4) the deep water renewal problem.

11:30

Baroclinic circulation along the northern coast of British Columbia

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A three-dimensional numerical ocean model using the Finite Volume Coastal Ocean Model (FVCOM) is being developed to help understand the circulation in the network of islands, channels and fjords of the northern coast of British Columbia. Atmospheric forcing for the model was calculated from the high-resolution deterministic prediction system (HRDPS-west) weather model with a horizontal resolution of 2.5km. Discharge from the rivers was estimated using climatology for ungauged watersheds and discharge measurements at gauged rivers. The validation against temperature and salinity measurements and ADCP observations from July 2013 to June 2014 shows that the numerical model is able to simulate the estuarine circulation and the sharp pycnocline expected from observations. We will demonstrate the importance of accurate hydrological inputs for circulation in this region. The presence of stratification was also found to have some unexpected impacts on the tidal circulation. The numerical model will eventually be used to assist with the prevention, preparedness and response to oil spills along the north coast of British Columbia.

11:45

A relocatable coupled atmosphere-ocean prediction system

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A research and development project to develop a relocatable coupled atmosphere-ocean prediction system is in progress within the Marine Environmental Observation, Prediction and Response (MEOPAR) academic Network of Centres of Excellence. MEOPAR brings together Canadian researchers, stakeholders and users in a multi-sectoral partnership to better observe, predict and respond to marine hazards (see www.meopar.ca). This project's main goals are: build and test a coupled atmosphere-ocean forecast system that can be set up within hours of a marine emergency, anywhere in Canadian waters; provide short-term forecasts (hours to days) of physical properties of the atmosphere and ocean to guide response to a marine emergency; develop the ability to assimilate data (e.g., observations from altimeters and gliders) and downscale predictions from larger scale models; develop modules for offline prediction of movement and dispersion of plumes of hazardous materials; and develop parallel mechanisms for rapid appraisal of socio-economic values and risks in coastal areas, including community based approaches. The atmospheric model is a high resolution limited area configuration of the operational Environment Canada Global Environmental Multi-scale (GEM) weather forecast model, and the ocean model is a shelf version of the NEMO (Nucleus for European Modelling of the Ocean) ocean forecast system, starting from one already implemented by the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS) for the Gulf of St. Lawrence. A major field experiment is planned for 2016 on the Scotian Shelf to test the ocean model. The experiment will involve a small scale tracer release experiment. Preliminary drifter deployment and current-measuring HF radar validation tasks have already been carried out in the Strait of Georgia. This presentation will provide an overview of our activities for years 1-3, illustrate systems developed and research in progress, and discuss plans for years 4 and 5 of the project.

10:30

Likelihood of Microclimate Changes Caused by a Large Hydro Power Project: Application of Bayesian Two-Sample Comparison to Site C

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The filling of the reservoir for BC Hydro's Site C project near Fort St. John in British Columbia will alter the land surface characteristics in the flooded areas. As part of the project application, an environmental assessment of the project's potential impacts on the climate in the surrounding areas was performed. The Weather Forecast Research (WRF) model was run for the same twelve-month period representative of climate normals with current and future land surface characteristics. Bayesian two-sample comparison was applied to determine the spatial distribution of the statistical significance of changes in several climate parameters for each calendar month. While the mathematics is elaborate, the code for Bayesian two-sample comparison it applicable to a much broader set of problems (e.g. to verify the representativeness of the model year). Significance was expressed as likelihoods following the wording conventions of the International Panel for Climate Change to make the assessment more intuitive and accessible to the general public. This presentation will outline the approach, highlight some of the mathematical and computational hurdles, and present some specific results for Site C.

10:45

Past and potential relationships between wind speed and runoff behaviour. Implications for renewable planning development in British Columbia.

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Previous research has suggested that long-term relationships between wind speed and reservoir inflow behaviour have potential to improve wind power site selection, and that northwestern British Columbia (BC) shows promise for wind energy development. We explore the long-term relationship between wind speed and BC's water resource using different sources of data and model output. Over the period 1979-2010 we compare wind speed data from the Integrated Surface Dataset (ISD), the North American Regional Re-analysis (NARR) and an average of three ensemble outputs from the Canadian Regional Climate Model (CRCM) generated under an IPCC SRES A2 forcing. FOR the period 1979 - 2010, we investigate relationships between the wind speeds (ISD, NARR, CRCM) and an average of three ensembles of the monthly sum of total surface runoff generated by the CRCM. We use runoff as a proxy for reservoir inflow because it correlates well with historical reservoir inflow in BC and so it represents hydroelectric energy generation potential. We observe both increasing and decreasing wind speeds, and significant relationships between wind speeds and runoff vary with the source of wind speed information used. The NARR suggests predominantly positive correlations between wind speeds and runoff whereas the CRCM suggests negative correlations. We observe almost no significant relationships between the ISD wind speeds and runoff. For the period 1958-

2099, we use output from the CRCM ensemble runs to investigate future relationships (2010 - 2099) between wind speeds and runoff. We observe persistent, significant negative correlations between runoff and wind speeds in the northwest regions of BC, which may bolster the value of wind energy in these regions. Based on the findings of this research, future energy planning efforts ought to consider the value of BC's northwest region particularly with respect to wind energy.

11:00

The Dose-Response of the Power Distribution Grid to Windstorms that Affect Southwest British Columbia, Canada

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Pacific storms bringing saturating rain and strong winds routinely disrupt the power grid of Southwest British Columbia (BC). Wind-broken trees and branches striking lines and poles during these storms are a common cause. Distribution-level data from BC Hydro covering the period Oct 2005-Aug 2009 were examined in relation to weather records from the Vancouver and Abbotsford airports. Tree- related line faults within a 50 km radius of Vancouver during all independent storm events with peak winds >40 km h-1 were tallied, and then compared to the maximum wind. Routine storms bringing maximum winds of 40-55 km h-1 have a high probability of causing tree- related power outages. As speeds approach high-wind category (≈65 km h-1), the probability quickly climbs toward 100%. On average, southeasterly windstorms tend to cause approximately twice as many line faults when compared to westerly surges. There is moderate to moderately strong linear correlation between peak 2-min wind or 5-sec gust speed and the frequency of line faults. The average number of line faults for a given wind speed has a strong correlation with wind speed when using an exponential fit. Poisson regression models using single or multiple variables including peak wind, peak gust and peak wind direction all produce curves similar to an exponential fit, one approximated by peak wind speed to the sixth power in the case of the univariate peak wind model. The curvilinear models indicate the potential for catastrophic damage to the power grid when wind speeds approach that of the historic 12 Oct 1962 windstorm.

11:15

Present and Future Wind Energy Resources in Western Canada.

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Wind power presently plays a minor role in electrical generation in Western Canada. However, ongoing reductions in the cost of wind power generation facilities and the continuing environmental costs of conventional power generation, suggest that assessment of the present and future wind field in Western Canada is of some importance. To assess present wind power, raw hourly wind speeds and homogenized monthly mean wind speeds from 30 stations in Western Canada were analyzed. A regional reanalysis product, the North American Regional Reanalysis (NARR), and simulations conducted with the Canadian Regional Climate Model (CRCM) driven with global

reanalysis boundary forcing, were compared to the adjusted station wind speed time-series and speed distributions. The NARR had a somewhat better temporal correlation, but was generally worse than the CRCM in reproducing the observed speed distribution. The CRCM using a 45km grid, when driven by two Global Climate Models, for the periods 1971-2000 (using only historic emissions) and 2031-2060 (using the A2 emissions scenario), was de-biased using quantile-quantile matching to the adjusted station observations to obtain two ensembles of projected wind speed distributions for the 2031-2060 period at the station locations. Both bias correction and change factor techniques were used for de-biasing. At most station locations modest increases in mean wind speed were found for most of the projected distributions, but there is a large variance in the projections. Estimates of the wind power for the projected speed distributions suggest that wind power at the station locations is more likely than not to increase in the future. While the station locations are relatively few and not distributed evenly over the region, they are generally representative of the region, suggesting that wind energy resources in Western Canada are reasonably likely to increase at least modestly in the future.

11:30

Potential impacts of wind farms in Lake Erie: Some preliminary 1-D modelling using COHERENS

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More than 90% of the world's offshore wind is installed in Europe and China, although there are plans in the USA (including in Lake Erie - Cleveland) and Taiwan. There are also extensive plans for additional wind farms in Europe. If there were large scale offshore wind farm development in the Great Lakes, what impacts would they have? Small scale Ekman pumping, associated with spatial variation of the surface wind stress on the water surface caused by the turbine wakes will be a part of the influence of offshore wind farms but there will also be a direct effect of changes in the wind speeds and surface stress in the wind farm wake through reduced mixing of the upper mixed layer. We consider this in an idealized 1-D situation, appropriate to a large wind farm in uniform depth water, but we use real wind speed and other meteorological data to simulate variations over the ice- free season in Lake Erie. COHERENS is the numerical software that we are using. The model is run twice. In the first case it simulates conditions in the absence of wind turbines while the second run includes a reduced (typically by 25%) wind speed associated with the effects of wind turbines. In the presence of wind turbines, surface water currents decrease in response to a decrease in the wind speed. The water temperature gradient increases as there is a higher surface water temperature in response to reduced mixing and a potentially shallower mixed layer and lower bottom temperature due to less heat diffusion. The thermocline develops faster and is stronger. The mixed layer depth exists for longer but is shallower than without wind turbines. There is a decrease in the latent and sensible heat fluxes while long wave radiation heat flux remains relatively unchanged.

10:30

Sea State and Boundary Layer Physics of the Emerging Arctic Ocean

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We present a large collaborative program investigating surface processes over the Arctic Ocean during the early autumn ice advance. With recent observed and predicted declines in summer minimum sea ice extent, the nature and role of air-ice-waves-ocean interactions driving autumn ice advance are expected to change. Central to these changes, the greatly increased open water fetch permits the generation of waves that may propagate far into the ice pack. Wave-ice interactions lead to wave attenuation and scattering while simultaneously fracturing ice into ever changing floe size and thickness distributions. Thus, the processes of wave generation and wave dissipation are complicated by the marginal ice zone (MIZ). During the ice advance, waves can enhance ice formation rates through frazil/pancake generation. Further complicating these processes are forcing by winds and surface fluxes from the ocean to the atmosphere, which are episodically driven by storms. These processes moderate the release of heat from enhanced summer warming of the upper ocean, which may in turn impact the rate of ice advance. We apply a combination of numerical modeling, in situ observations, and remote sensing, with a focus on arctic conditions during the seasonal ice advance in early autumn. In preparation for a six-week cruise in the autumn of 2015, we have assessed emerging trends for the annual freeze-up of the Beaufort and Chukchi seas. Waves are clearly controlled by the extent of open water (i.e., fetch limitation) and strongly damped in newly forming ice. Winds are significantly affected by ice cover and reduced by increased atmospheric stability over the ice. The ice advance rate is nearly constant, despite extreme inter-annual variations of sea-ice extent in recent years, which suggests that large-scale thermodynamics are the dominant process.

10:45

Wind waves in arctic seas

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The reduction of the sea ice coverage during the boreal summer will lead to an increased importance of wind waves for the dynamic processes of the Arctic Seas. Larger ice free areas lead to longer fetch and thus longer and higher sea state. Wind waves will enhance upper-ocean mixing, may affect the breakup of ice sheets, and will likely lead to increased coastal erosion. Our long-term goal is a better understanding of the two-way interaction of waves and sea-ice, in order to improve wave models as well as ice models applicable to a changing Arctic wave- and ice climate. Wind, wave and ice information has been retrieved from space-borne SAR imagery (TerraSAR-X), collected during summer 2014 in the Beaufort Sea. The SAR data were co-located with drifting wave-buoys and wave gliders. This information complements and validates model data (Wavewatch III) for the spatial and temporal evolution of sea state in the Arctic. We will present examples of wind and wave fields under different wind forcing and ice conditions, and discuss the advantages of the three observational/modelling approaches. The examples highlight the strong spatial heterogeneity of the wave field in arctic regions, and the need for high resolution spatial wave observations. Satellite-based wave field observations can bridge the gap between the single point buoy observation that provide high resolution time series of wave parameters, and the output of wave models which are of relatively coarse resolution and are inherently limited by the quality of the wind and ice input fields, but are unlimited in their spatial and temporal extent.

11:00

Observation-based large scale material properties of landfast sea ice

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Daily corrected reflectance and brightness temperature imagery from the MODIS Terra and Acqua satellites are used to observe ice grounding, ice bridge formation and break up events that are behind the seasonal advances and retreats of the landfast ice cover in the Kara sea for the 2013-2014 winter. We demonstrate that the formation of the landfast ice cover in the Kara sea is characterized by the formation of ice bridges between neighboring islands, regularly forming and breaking according to the wind forcing. This network of ice bridges eventually consolidates into an extensive and stable landfast ice cover. These observations are paralleled with the three modes of landfast ice extent in the Kara sea, as observed on ice charts from the National Ice Center (NIC) for the 1976-2007 period. We demonstrate that these modes, as well as the break up of the landfast ice cover, relate to the ability of the ice bridges to resist the wind forcing. To estimate the large scale material properties of landfast sea ice that correspond to these observations, a linear elastic model is used to

reproduce the internal stress in the landfast ice cover of the Kara sea. These results are combined to the MODIS observations to calculate the yield strength of landfast sea ice, to be implemented in an observation-based dynamical sea-ice model.

11:15

Mapping thin landfast ice in the Canadian Arctic

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Ice thickness climatologies obtained at few near-shore observatories in the high Canadian Arctic show that first-year fast ice in the Canadian Arctic Archipelago grows approximately 2 m thick in the end of the winter, depending on snow thickness, and that it has changed little over the past few decades. However, concurrently there are also recurring polynyas in nearby sounds and straits, indicating that thermodynamic first-year ice growth on the Canadian polar shelf may actually be quite variable depending on oceanic conditions and ice age. Here we present results from thousands of kilometers of snowmobile ice thickness surveys performed during hunting and recreational over-ice travel and Canadian Rangers traverses, including in spring of 2015. Measurements were carried out with a novel, short, 2 m long electromagnetic ice thickness sensor mounted on a sledge. We show that this sensor provides accurate ice thickness measurements with low noise and little drift throughout the winter season, and is thus ideally suited for large-scale, seasonal mapping of the thickness of level fast ice as part of a future distributed, community-based observation network. Results show the occurrence of widespread regions of thin, less than 1 m thick ice in various fjords and straits surrounding Jones Sound and Baffin Island, and Labrador. Coincident water temperature and salinity measurements show that these regions are related to regions of increased ocean heat flux supported by local bathymetry and tidal mixing, while differences of snow thickness play a minor role. These results provide new insights into ice-ocean interaction on the Canadian polar shelf and the occurrence of these invisible polynyas, characterized by oceanic conditions intermediate between visible polynyas and near-shore shallow water regimes. Under warmer climate conditions, these regions may become open polynyas with likely strong consequences for local and regional climatic and ecological conditions.

11:30

Thermodynamics of snow-ice formation on sea ice

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Snow-ice forms on top of sea ice under negative freeboard, once brine or seawater floods the base

of snow and freezes there. Snow-ice is widespread in the spring Antarctic sea ice zone, because of abundant snow falls on relatively thin ice. Here, we focus on the freezing process, using three approaches: (i) an isolated system model based on energy, water and salt conservation; (ii) laboratory experiments - a NaCl solution poured into grated ice (a proxy for snow) in a cryogenic container - ; and (iii) field observations at the SIMBA drift station (Bellingshausen Sea, Antarctica, 10/2007). Our analysis highlights three main conclusions. (i) Solid snow ice can form provided that its brine volume is $< 40\%$. Otherwise, ice crystals are loose and float above salt water, stratifying the system. (ii) Since the snow latent heat of fusion largely dominates the energy balance, snow-ice is generally warm (T>-3^{o}C). T significantly depends on the salinity of salt water, but only marginally on the temperature of the pre-existing snow [-40, 0^{o}C] or salt water [-1.8, 20^{o}C]. (iii) In a closed system, the snow-ice salinity S would be >20 g/kg for typical values of seawater salinity and snow density. In the field, however, S is much smaller ($\approx$10 g/kg), suggesting that salt quickly expells from forming snow-ice. We discuss the implications for the large-scale progression of flooding.

11:45

Validating processes that impact sea-ice melt-back and freeze-up in coupled limited area model simulations of the marginal ice zone

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The dramatic decrease of Arctic sea-ice has led to a new Arctic sea-ice paradigm and to increased commercial activity in the Arctic Ocean. Unfortunately, the sea-ice evolution in the new Arctic involves the interaction of numerous physical processes in the atmosphere, ice, and ocean, some of which are not yet understood. Many of these interactions involve emerging complex processes that first need to be understood and then incorporated into forecast models in order to realize the goal of useful sea-ice forecasting. In this study we use a limited area coupled atmosphere-sea ice-mixed layer ocean model to simulate and validate case studies of autumn freeze-up and melt-back processes in the near-ice open water and marginal ice zone (MIZ). Diagnostic studies will be presented that focus on quantifying and validating the atmospheric forcing of sea-ice movement through stress and stress deformation and atmospheric forcing of sea-ice melt and formation through energy fluxes. Errors in the simulations of clouds, atmospheric processes, and surface energy fluxes will be quantified with measurements of the ocean state, surface energy balance, and cloud structures collected in the MIZ during the 2014 Arctic Clouds in Summer Experiment (ACSE) field campaign.

10:30

The Certainties and Uncertainties when assessing noise impact on marine mammals

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An observed increase of more than 12dB re. 1 μ Pa rmsSPL in ocean background noise over the last three decades primarily due to shipping and a parallel growing number of marine seismic exploration and subsequent drilling activities defines a need to assess the effects of noise on marine wildlife accurately. In particular marine mammals rely on acoustic signalling not only to maintain contact with each other which can span distances of a few hundred metres in smaller toothed whales to more than 500 kilometres for large baleen whales, but also to find food. Assessing acoustic impact on cetacean typically involves assessing physical injury, such as lethal (e.g. trauma and permanent hearing loss across important sections of the hearing range) and non-lethal health effects (e.g. temporary hearing loss and physiological stress). Indirect effects, however, can be as detrimental to the long term well-being of individual animals and populations but are much more difficult to identify. Those indirect effects include behavioural changes that effect foraging and mating success as well as temporary and permanent exclusion of groups and populations from important parts of their ranges, to long term effects decreasing the genetic and learned trait diversity in populations that can lead to extinction. The latter effects on what is called the evolutionary potential of a population is most difficult to assess because effects can be initially small and incremental and first only effect individuals that have traits not shared by a large number of individuals in a population. Acoustic impact, however, can get amplified if other factors such as the loss of a prey species calls for a wider range of adaptive flexibility and the need of those genetic and behavioural outliers for the population to survive. Here, I will present information of the different types of impact and the currently used types of impact assessments and the gaps that need to be filled to improve assessments.

10:45

Surveying right whale habitats using glider-mounted sonar

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The North Atlantic right whale is an endangered species that comes into Atlantic Canadian waters to feed in the late summer and early fall. There are several known habitats around Nova Scotia. Our previous work found that local circulation effects concentrate calanoid copepods at favourable depths in the known habitat. We believe that there are many unknown right whale habitats because the known habitats are periodically abandoned during the prime feeding season. In the known feeding habitats high-frequency sonar has proven useful in mapping copepod distributions as an assessment of habitat quality. In an effort to better understand the variability of copepods

in the known habitats and to search for new potential habitats, we equipped an Ocean Tracking Network Slocum glider with a 300-kHz echosounder. In September and October of 2014 it surveyed Roseway Basin, a known right whale habitat on the Scotian Shelf, and has since been collecting acoustic backscatter data on regular OTN transects across the Shelf. These preliminary data will be presented and discussed in the context of right whale observations derived from passive acoustics and visual surveys in September 2014.

11:00

Three-dimensional noise modeling in shallow water environments

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The power spectral density, vertical coherence, and horizontal coherence (directionality) of surface-generated ambient noise in shallow water environments depend on local bathymetry and oceanography. In certain bathymetric conditions, horizontal refraction and reflection must be considered in order to accurately predict the spatial properties of the noise field. In an idealized Gaussian submarine canyon, the sound field can be described using the method of normal mode decomposition applied to a three-dimensional longitudinally invariant wave-guide. The modal decomposition is carried out in the vertical and across-canyon horizontal directions and gives a semi- analytical solution describing the three-dimensional topographic effects. Additionally, the noise field for an arbitrary bathymetry can be computed using wave-equation reciprocity and either a three-dimensional cylindrical co-ordinates parabolic equation (PE) model or an ensemble of horizontally uncoupled radial PE (Nx2D) sound propagation computations. Inter-comparison of these models highlights the effect of the three-dimensional topography on the vertical coherence and mean-noise level as a function of arrival direction. In the Gaussian canyon case, these effects include the focusing of noise along the canyon axis and the frequency perturbation of vertical coherence minima.

11:15

Ambient noise from turbidity currents in Howe Sound

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The Squamish River enters Howe Sound near Squamish, British Columbia. Due to the sediment carried by the river the interface between the fjord and river is characterized by a fan delta and delta front descending into the several 100 m deep fjord. Sediment mass transport from the delta into the fjord is dominated by discrete turbidity current events which have incised semi-permanent channels on the delta front and out onto the prodelta. Subsequent turbidity currents flow through these channels modifying them and the bedforms within them. During a field trip in the spring of 2013 measurements were made which detected roughly 18 discrete turbidity currents with head speeds up to about 3 m/s. This presentation will summarize the broadband (100 Hz to 200 kHz) hydrophone

data, focussing on the noise these turbidity currents produced and the mechanism involved in this sound production. Further, the variability in this noise is compared to independently measured turbidity current and sediment properties, with the potential future goal being passive acoustic monitoring of sediment transport events of this type.

11:30

The spectrum levels of ambient noise sources in Folger Passage.

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When trying to detect a target in the underwater world, one of the most challenging tasks is to hear the target through all the background noise. This is like hearing to a friend talk while standing in a huge noisy rock concert! In the ocean too, what are the sources of background noise? As identified by Gordon M.Wenz in his foundation work on Acoustic ambient noise in the ocean, characteristic noise spectra result from different levels of shipping traffic, sea state conditions(i.e. wind speeds). The topic of underwater noise pollution due to oil & gas exploration receives immense media coverage and is a genuine concern to scientists and researchers. Studying acoustic propagation from noise sources has become one of the standard environmental impact assessment criteria for offshore developments. Such propagation studies are very useful and effective in order to determine the region of severe impact and to understand the area over which sound levels exceed normal background levels and are known to interfere with the hearing in marine mammals and fishes. In order to understand natural variations in naturally occurring background sound levels, variations in spectrum levels and the spectral form of ambient noise at the Folger passage were studied for a 12-day period starting May 15th 2014 till May 27th 2014 with the hydrophone at Folger Deep Instrument Platform at a depth of 95m. The observation site is in a continental shelf area located at Lat: 48.81378N and Lon: -125.28095W off the west coast of Vancouver Island. We plan to compare this observed variability with observations from deeper location sites in that same area such as the Barkley Canyon or the Cascadia Basin. This data was collected by the Neptune Observatory as part of the Ocean Networks Canada, University of Victoria, BC, Canada.

11:45

An study of underwater sound propagation in Barrow Strait using the CONCEPTS GIOPS ocean prediction system

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The acoustic environment in Arctic Ocean has gained significant focus in recent years due to the ever-decreasing sea-ice cover leading to increased opportunity of an open water trade route through the Arctic ocean. As a principal pathway between the Arctic and North Atlantic Oceans, Barrow Strait has been chosen as the location to monitor the ocean environment in the real time on a continuous basis using acoustic, cable and satellite communications. This talk reports on sound propagation studies in this area using an underwater acoustic propagation model fed with

background oceanographic information output from the operational CONCEPTS Global Ice-Ocean Prediction System (GIOPS). The objectives are to determine optimal frequency and location parameters for underwater acoustic communication systems for Barrow Straight. This takes in account the variation of sound propagation properties due to the seasonal changing of ocean environment which includes temperature, salinity and ice-surface.

13:30

Detection and attribution of recent Arctic sea-ice melting patterns

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Arctic sea-ice has declined sharply during recent three decades with seasonally and regionally different melting patterns. Identifying causes of the observed spatial patterns of Arctic sea-ice loss is critical to better understanding of global and regional impacts of the Arctic cryosphere, but it remains uncertain. This study carries out a quantitative attribution analysis of the observed Arctic sea-ice retreat during 1979-2012 by comparing observed and model-simulated melting trend patterns using an optimal fingerprinting technique. Satellite observations show overall decreasing trends across all seasons with stronger melting occurring over Kara-Laptev Seas, East Siberia-Chukchi Seas, and Barents Seas during warm seasons. The CMIP5 multi-model simulations including greenhouse-gas forcing can largely reproduce the observed trend patterns, enabling detection of human influence, but with weaker amplitude than observations. Recent studies has also suggested that Atlantic Multidecadal Oscillation (AMO) can affect regional variations of Arctic sea-ice cover, particularly in the Atlantic sector. In order to consider this into our analysis, we first estimate 'natural' influences of AMO on regional sea- ice extents using unforced long-term multi-model control simulations, and then remove the estimated 'natural' AMO influences from both observations and all model simulations. Detection results are found to be insensitive to the use of these AMO-residual sea-ice trends, suggesting that the recent Arctic sea ice loss is mostly due to human-induced increase in greenhouse gases.

14:00

Application of the optimal fingerprinting method to detection and attribution of Arctic sea ice change

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Extensive observations of Arctic sea ice are available since the 1980s and suggest that Arctic sea ice is undergoing immense change. During the satelite era, Arctic sea ice has been declining in both extent and volume. Previous studies have suggested these changes are the result of a combination of internal climate variability as well as external climate forcings. The Canadian Sea Ice and Snow Evolution Network (CanSISE) is focussing on the assessment of the current and near future sea ice conditions in the Arctic. Climate models can be used to simulate internal climate variability in the absence of external forcings. Climate models can also simulate expected response patterns, namely fingerprints, of the climate system in the presence of external forcings. Our detection and attribution study evaluates the extent to which response patterns (fingerprints) from the Coupled Model Intercomparison Project Phase 5 (CMIP5) simulations explain observed changes in Artic sea

ice extent.

14:15

Comparison of observed and simulated sea ice extent in the Arctic and Antarctic prior to 1979

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Continuous monitoring of the polar regions by satellites since 1979 has shown that the Arctic sea ice extent (SIE) exhibits a dramatic decrease, which has been attributed to anthropogenic influence, while the Antarctic SIE has increased slightly and the exact driving mechanisms remain uncertain. By contrast, climate model simulations including all major anthropogenic and natural climate influences simulate an average decrease in SIE from 1979 to present days over both polar regions. Here we use recently recovered satellite-based estimates of Antarctic SIE for September 1964 and May-July 1966, as well as an updated dataset without infilling based on in situ observations from the Eastern portion of the Arctic, to take a longer view and assess the consistency of observed and simulated changes in SIE in each region, hence extending the current observational record. While there is evidence of inconsistency between observed trends in Antarctic SIE and those simulated since 1979, particularly in models with realistic interannual variability, the observed trends since the mid-1960s fall within the 5-95% range of simulated trends. Thus, our results broadly support the hypothesis that the recent increase in Antarctic SIE is due to internal variability, though the reasons for the inconsistency in simulated and observed changes since 1979 remain to be determined. On the other hand, the dataset for the Arctic shows widespread increases in annual mean sea ice concentration between 1945 and 1975, consistent with climate model simulations of an aerosol-driven increase over this period. This behavior is also consistent with a well- documented Arctic cooling over the 1945-1975 period, itself largely driven by aerosol increases. These results challenge the perception that Arctic sea ice extent was unperturbed by human influence until the 1970s, showing instead that it has exhibited forced multi-decadal variations through the 20th century.

14:30

Detection, Attribution and Extreme Climate and Weather Events

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Climate change detection and attribution (D&A) research over the past decade has increasingly concerned itself with questions concerning changes in the frequency and intensity of rare, high impact weather and climate events (extremes). While D&A methods appropriate to extremes are not completely settled, the science consistently indicates that human influence is responsible for observed changes in the intensity and/or frequency of temperature extremes, and increasingly often, in precipitation extremes. A recent further development is a gathering interest in event attribution, which is loosely defined as the identification of external factors that may have contributed to the

intensity or likelihood of specific events, such as the European 2003 heat wave or the California drought. This talk will compare and contrast differences in the questions posed by D&A research (what are the causes of observed long-term changes in extremes) and event attribution (what are the causes of event that has just occurred), and in the methods that are used to answer these questions. Event attribution is challenging because of selection bias, the need for timeliness, and the difficulty in identifying relevant controlling factors, but surmounting these challenges, coupled with ongoing D&A research on long-term changes in extremes and seasonal-to-interannual forecasting, could eventually lead to reliable short-term climate forecasts of variations in the likelihood of occurrence of extremes that also take into account long-term changes in likelihood and intensity that are caused by anthropogenic forcing of the climate system.

14:45

Observationally-constrained climate projections beyond the near term

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Model projections of the simulated responses to future greenhouse gas and aerosol changes may be scaled up or down, based on the regression coefficients which give the best fit between simulated and observed changes over the historical period. Projections based on this approach underpinned assessed projections of near-term warming in the IPCC Fifth Assessment Report. However, this scaling approach only works well under conditions of steadily increasing radiative forcing, and not under stabilised forcing conditions, as found for example in the RCP 4.5 scenario by the end of the century. Hence long-term climate projections presented in the IPCC Fifth Assessment Report were based simply on the ensemble of available climate models, with no observational constraints applied, even though, for example, some climate models exhibited significantly stronger warming in response to greenhouse gas increases than observational estimates. Here I discuss and apply an approach to deriving observationally-constrained projections of long-term climate change based on weighting climate models according to the level of agreement between their Transient Climate Responses and an observationally-constrained estimate.

13:30

Using artificial neural networks to emulate the VIC hydrological model: Application to streamflow and snow water equivalent projections

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To make hydrological change projections at the regional or catchment scale in British Columbia, Canada, the Pacific Climate Impacts Consortium (PCIC) forced the Variable Infiltration Capacity (VIC) hydrological model at a daily time step with a subset of 23 downscaled climate model projections from the Coupled Model Intercomparison Project Phase 3 (CMIP3) ensemble. The computational cost of performing such hydrological projections for the full set of more than 130 CMIP3 simulations and for the next generation CMIP5 simulations is very high. To make such hydrological projections computationally affordable, the artificial neural network method is used to emulate the VIC model, i.e. ANN is trained using predictors from the CMIP3 climate projections and using predictands (streamflow and snow water equivalent, SWE) from the VIC model output. Once trained, the ANN could potentially replace the VIC model in performing the hydrological projections. Since there are various greenhouse gas emissions scenarios, if the ANN is trained with the data from one emissions scenario, would it still emulate the VIC model accurately if supplied with predictors from a different emissions scenario? Tests for the Campbell River watershed showed that the ANN trained with data from the SRES B1 emissions scenario performed well when supplied with data from the SRES A2 scenario (with higher emission rate). Following model validation, the ANN emulator was supplied with a large ensemble of CMIP5 climate model outputs ($>$ 150 simulations) to obtain daily streamflow and SWE projections for the RCP2.6, RCP4.5, and RCP8.5 scenarios.

13:45

Potential Impacts of Projected Climate on Water Availability in the Western Canadian River Basins

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This study examines the projected changes in hydro-climate variables over western Canadian river basins under two emission scenarios using statistically downscaled high resolution climate data from the latest Coupled Model Intercomparison Project (CMIP5). While individual GCM projections vary on the rate and seasonality of changes, they all indicate similar spatial and temporal trends. The highest projected increases in temperature and precipitation are mostly in the northern basins, with some decreases in summer precipitation in the southern basins. Projected changes in monthly snow water equivalent (SWE) values computed from the downscaled daily precipitation and temperature data clearly indicate the spatio-temporal shifts in the evolution of snow accumulation and melt. Moreover, evolution of the 12 and 3 - months standardized precipitation and evapo-

transpiration indices (SPEI) indicate a gradual increase in the magnitude and duration of water surplus (positive SPEI) in the northern basins, while the reverse was found for the southern basins that show a gradual increase in water deficit (negative SPEI) . Such water deficits would also be more pronounced in summer when almost all river basins in western Canada, with the exception of those located at the extreme north, are projected to experience decreasing water availability with potential increases in the frequency of severe water deficit over most of the southern and eastern basins. In general, the results of this study indicates the potential direction for spatial and seasonal redistribution of western Canadian water resources towards the end of this century.

14:00

Assessing climate change impacts on the snowpacks and water availability of the Fraser River Basin, British Columbia

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Change in air temperature and precipitation will induce important modifications to the hydrological regimes and water resources of western North America. Increases in winter and spring air temperatures will alter the precipitation phase and consequently the ratio of snowfall to rainfall and the water volume stored into snowpacks will change substantially. This study examines these climatic changes focusing on the snow hydrology of Fraser River Basin (FRB) of British Columbia using the Variable Infiltration Capacity (VIC) model. Statistically downscaled forcing datasets of Global Climate Models (GCMs) runs based on two different scenarios are used to drive the VIC model for the 30-year baseline (1981-2010) and future (2040-2069 and 2070-2099) time periods. The analyses are performed over 11 major watersheds of the FRB to evaluate the future changes in snow water equivalent (SWE) and runoff (R). The change in the ratio (Rsr) of maximum SWE to R is also assessed to estimate future contribution of snow to runoff in the FRB. Despite the variation across GCM outputs over the FRB, a significant decline in the snow water availability is revealed from the ensemble mean simulations of the VIC model. In the latter part of the 21st century, the significant changes such as earlier onsets of snow melt, more winter and spring runoff and decreases in the Rsr ratio are found in the hydrological simulations. A consistent and significant decrease in SWE is seen for the majority of the FRB. Overall these findings suggest that the climate warming will result in a substantial decline in the winter snow accumulation and snow covered areas and any increase in precipitation will not compensate for the effects of air temperature increases, therefore decreasing SWE. This study could have important ramifications for the development of strategies to address the climate change problem and to design water management systems for snow dominant regions of western Canada.

14:15

Intercomparison of snow depth and snow water equivalent measurements during WMO SPICE

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The Snow-on-Ground component of the WMO Solid Precipitation Intercomparison Experiment (SPICE) has the following objectives: 1) assessing snow depth and snow water equivalent instrument performance, 2) examining instrument thresholds of minimum snow depth (or SWE), including the impact of surface targets (if applicable), 3) examining appropriate and practicable temporal resolutions of measurements, 4) linking Snow-on-Ground measurements to gauge measurements and 5) assessing spatial representation of point measurements. The intent is to make recommendations to instrument and data users on best practices. Intercomparisons of 4 varieties of SWE sensors and 9 varieties of snow depth sensors, employing a variety of measurement techniques, have been undertaken at 10 WMOSPICE sites. Each of the 10 participating sites offers unique circumstances to assess instrumentation including low temperatures, ephemeral or inconsistent snow conditions, and extreme alpine snow packs. Each site provides reference measurements for intercomparison consisting of manual or photographic observations of snow stakes (for snow depth) and bulk density sampling (for snow water equivalent). Select results of the intercomparison for the 2013/2014 and 2014/2015 winter seasons are presented.

14:30

Spatialization of the SNOWPACK snow model in the Canadian Arctic for Peary caribou winter grazing conditions assessment

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Peary caribou is the most northern designatable unit of the caribou species and its population declined by 70% over the last three generations. The Species at Risk Public Registry of Canada identifies difficult grazing conditions through the snow cover as being the most significant factor contributing to this decline. The recently observed warming in the Arctic has led to the persistent formation of dense snow layers and ice crusts blocking access to food. This phenomenon is expected to increase in numbers and magnitude over the next few decades. Thus, the project is a part of a main assessment by Environment Canada on Peary caribou's survival, which includes assessment of food spatial distribution and changes in the sea ice formation over the years. The study area is the

Peary caribou habitat, which roughly covers the whole Canadian Arctic Archipelago. In order to simulate the snow cover, the Swiss model SNOWPACK is used. First, a coupling procedure implying the model and meteorological data was defined. Our group recently obtained climate simulations from the Canadian Regional Climate Model (CRCM and CanRCM4) which are used as input to SNOWPACK. Multiple validations were conducted, using in situ data and remote sensing. Then, statistical comparisons were performed locally between the outputted snow profiles and caribou populations, that for three critical times of year for Peary caribou which are calving, breeding and foraging. The snow cover parameters therefore identified as being the most bound with caribou populations were snow density and grain type. Density was refined as maximum, average, and over-threshold values. The project's main objective, which is the spatialization of those retained snow parameters over the study area, is now partially reached: snow profile creation was automatized for CRCM input data, extraction of the refined density parameters is partially automatized, and finally a prototype of the vector and raster deliverables has been designed.

13:30

The pathways of long period and steady state barotropic flows through the Arctic Archipelago.

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Seawater input to the North Atlantic from the Arctic Ocean between Greenland and the Canadian mainland must pass through the Arctic Archipelago, a vast collection of large and small islands defining channels of many scales. The nature of the water mass exchange between these oceans will depend on the pathways of entrance into and exits from the Archipelago, as this will determine where the deep sea - shelf interactions will occur. The scale of global and basin models being used in climate related studies is not detailed enough to give a good representation of the area. In this work we use several models running on a detailed unstructured triangular mesh, to try to pin down the nature of the barotropic flow through the complex structure of the Arctic Archipelago. The aim is to help determine how the larger domain models might represent this area to more accurately compute the exchange of water masses.

13:45

Validation and inter-comparison against observations of GODAE Ocean View Ocean Prediction Systems for the Northwestern Atlantic

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For weather forecasts, validation of forecast performance is done at the end user level as well as by the meteorological forecast centers. In the development of Ocean Prediction Capacity, the same level of care for ocean forecast performance and validation is needed. Herein we present results from a validation against observations for the North West Atlantic of 6 Global Ocean Forecast Systems under the GODAE OceanView International Collaboration Network. These systems include the Global Ocean Ice Forecast System (GIOPS) developed by the Government of Canada, two systems PSY3 and PSY4 from the French Mercator-Ocean Ocean Forecasting Group, the FOAM system from UK met office, HYCOM-RTOFS from NOAA/NCEP/NWA of USA, and the Australian Bluelink-OceanMAPS system from the CSIRO, the Australian Meteorological Bureau and the Australian Navy. The observation data used in the comparison are sea surface temperature, sub-surface temperature, sub-surface salinity and sea level anomaly. Results of the inter-comparison

demonstrate forecast performance limits, strengths and weaknesses of each of the six systems. This work establishes validation protocols and routines by which all new prediction systems developed under the CONCEPTS Collaborative Network will be benchmarked prior to approval for operations. This includes anticipated delivery of CONCEPTS regional prediction systems over the next two years including a pan Canadian 1/12th degree resolution ice ocean prediction system and limited area 1/36th degree resolution prediction systems. The validation approach of comparing forecasts to observations at the time and location of the observation is called Class 4 metrics. It has been adopted by major international ocean prediction centers, and will be recommended to JCOMM-WMO as a component for routine validation approach for operational oceanography worldwide.

14:00

Comparison between Doppler sonar observations from a seismic survey ship and ocean circulation analysis results from the CONCEPTS Global Ice Ocean Prediction System over the Grand Banks

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During marine seismic survey operations, oceanographic measurements are often collected for operational or reference purposes. Typical observations will include CTD profiles but Doppler velocity profiles are also often recorded. These data provide a potential resource for enhancing our understanding and description of the oceans, but are currently mostly used only for the seismic study during which they were collected. We explore the potential of such data by comparing 67 days of Doppler velocity profiles with equivalent profiles from the CONCEPTS Global Ice-Ocean Prediction System (GIOPS) output over a 30,000 km2 region of the Grand Banks and adjacent waters to depths of about 1000 m. Doppler data were collected with a 75 kHz RDInstruments Acoustic Doppler Current Profiler (ADCP). This instrument would normally provide profiles to 500 m depth with 10 m depth resolution but because of the operating configuration selected, only near surface velocities (to about a 10 m depth) are considered reliable. When averaged data are compared to model output, the agreement provides compelling support both for the quality of the ADCP data and the model. Both data sets show similar long period variations but shorter period (inertial) responses are also in agreement. These results provide motivation for accessing oceanographic metadata from seismic surveys on a more routine basis.

14:15

Automation Framework for a Regional Ocean Forecast Model

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The SalishSea real-time model system produces two forecasts and a nowcast daily. Without human intervention, the automation system collects the required forcing data from various web services, runs the model and publishes results in the form of plots on several web pages. Here we will present

the automation framework that accomplishes those tasks. It runs across two computer systems with the ONC cloud computing facility running the numerical model (NEMO in our case), and a local Linux server doing everything else. The automation system has a modular, asynchronous architecture that is coordinated by a messaging framework. We will discuss the roles of the manager process that coordinates the sequencing and operation of a collection of worker scripts. Of particular interest are the run- NEMO and NEMO-watcher workers that make it possible to work across the two computer systems. Techniques that make the system reasonably fault tolerant will also be discussed. The modular design easily allows contributions from researchers with a variety of skills sets to contribute to the framework to the benefit of the project and its knowledge transfer to stakeholders.

14:30

Discussion on development, validation and application of high-resolution regional ocean models

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A growing number of high-resolution regional ocean models based on the Nucleus for European Modelling of the Ocean (NEMO) are being developed for major Canadian projects such as CONCEPTS, MEOPAR, VITALS, GEOTRACES and WCTSS. The development has benefited greatly from sharing expertise, code, software and data among various groups from government laboratories and universities. This presentation reviews progress and challenges, and plans for major model configurations, followed by discussions on code versions and metrics for model evaluation. Scientific and operational applications of the models will also be discussed.

14:45

Discussion on development, validation and application of nearshore ocean models

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The unstructured-grid finite volume ocean model FVCOM has been applied for a growing number of applications including the Canadian WCTSS project. The development has benefited greatly from sharing expertise, code, software and data among various groups in Fisheries and Oceans Canada and collaborators. This presentation reviews the progress, challenges and plans of major model configurations, followed with discussions on code versions, forcing data, linkage to larger-scale NEMO model, and model evaluation metrics. Scientific and operational applications of the

models will also be discussed.

13:30

UK Environmental Prediction - integration and evaluation at the convective scale

Huw Lewis[1], *Ed Blockley*[1], *Gilbert Brunet*[2], *Chris Harris*[1], *Martin Best*[1], *Andrew Saulter*[1], *Jason Holt*[3], *Lucy Bricheno*[3], *Ashley Brerton*[3], *Eleanor Blyth*[4], *Alberto Martinez de la Torre*[4]
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It has long been understood that accurate prediction and warning of the impacts of severe weather requires an integrated approach to forecasting. This was well demonstrated in the UK throughout winter 2013/14 when an exceptional run of severe winter storms, often with damaging high winds and intense rainfall led to significant damage from the large waves and storm surge along coastlines, and from saturated soils, high river flows and significant flooding inland. The substantial impacts on individuals, businesses and infrastructure indicate a pressing need to understand better the value that might be delivered through more integrated environmental prediction. To address this need, the Met Office, Centre for Ecology & Hydrology and National Oceanography Centre have begun to develop the foundations of a coupled high resolution probabilistic forecast system for the UK at km-scale. This links together existing model components of the atmosphere, coastal ocean, land surface and hydrology. Our initial focus on a 2-year Prototype project will demonstrate the UK coupled prediction concept in research mode, including an analysis of the winter 2013/14 storms and its impacts. By linking science development to operational collaborations such as the UK Natural Hazards Partnership, we can ensure that science priorities are rooted in user requirements. This presentation will provide an overview of UK environmental prediction activities and an update on progress during the first year of the Prototype project. We will present initial results from the coupled model development and discuss the challenges to realise the potential of integrated regional coupled forecasting for improving predictions and applications.

13:45

Overview of an integrated marine Arctic prediction system for METAREAs

C. Harold Ritchie[1], *Natacha Bernier*[1], *Mark Buehner*[1], *Tom Carrieres*[2], *Serge Desjardins*[3], *Luc Fillion*[1], *Diane Johnston*[3], *Jean-François Lemieux*[1], *Pierre Pellerin*[1], *Gregory Smith*[1], *Gilles Garric*[4]
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In December 2007 Canada accepted official designation as the Issuing Service for meteorological Marine Safety Information in the form of forecasts / warnings and ice bulletins for METAREAs XVII and XVIII as part of the Global Maritime Distress and Safety System. These areas are in the Arctic bordering on Canada. An important part of Environment Canada's involvement

is the development of an integrated marine Arctic prediction system and satellite products in support of monitoring and warnings. In particular, our group is working on the development, validation and implementation of marine forecasts using a regional high resolution coupled multi-component (atmosphere, land, snow, ice, ocean and wave) modelling and data assimilation system to predict near surface atmospheric conditions, sea ice (concentration, thickness, pressure, drift, ice edge), freezing spray, waves and ocean conditions (temperature and currents). The core of the system consists of a high resolution limited area configuration of the GEM (Global Environmental Multi-scale) model as the atmospheric component coupled to the NEMO (Nucleus for European Modelling of the Ocean) ocean model, the CICE ice model and the WAVEWATCHIII wave model. An ice-ocean data assimilation system is being developed in collaboration with Mercator-Océan using their system for ocean data assimilation together with the ice analysis system developed at Environment Canada. The METAREAs research and development is a cornerstone activity within the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS). This presentation will provide an overview of these activities, illustrate systems implemented and developments in progress at the completion of the first phase of METAREAs, discuss plans for future operational systems, and link with other complementary presentations at this meeting.

14:00

Insights in low-level polar temperature biases from atmospheric-sea ice coupling in the Navy's Global Coupled Modeling System

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Low-level temperature prediction in the Polar Regions is historically difficult for global models. Difficulties are caused from the extreme cold and dry conditions, as well as the role of low-level clouds on surface temperatures. We examine low-level temperatures in the Polar Regions using the Navy's Global Coupled Modeling system to understand coupled interactions in low-level temperature prediction. The Navy's Global Coupled Modeling system utilizes the Navy's Global Environmental Model (NAVGEM), the Navy's HYbrid Coordinate Ocean Model (HYCOM), and the Los Alamos National Laboratory's sea ice (CICE) model for the atmosphere, ocean, and sea ice model respectively. The National Unified Operational Prediction Capability (NUOPC) tools based off the Earth System Modeling Framework (ESMF) is used at the coupler. Data assimilative five day hindcasts are run from March 2014 to mid-summer 2014. The transition seasons are a known time period in which NAVGEM has difficulties predicting two meter polar temperatures. Stand-alone NAVGEM runs are compared to NAVGEM runs coupled with CICE4 and CICE5. When NAVGEM is coupled with CICE4, Antarctic low- level temperature become closer to other reanalysis products during the northern hemisphere's spring, and the NAVGEM-CICE5 runs have improvements in the Arctic and Antarctic region. Improvements are due to the CICE's calculation of ice temperature. These results aid in the development and improvement of NAVGEM's stand-alone parameterizations.

14:15

Regional Simulations of Summer Arctic Boundary Layers

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Profound changes have been occurring in the Arctic. The most significant change is the rapid decline of sea ice coverage and thickness over past several decades. The observed reduction in Arctic sea ice is a consequence of both thermodynamic and dynamic processes, including such factors as preconditioning of the ice cover, changes in cloud coverage, ice export, advection of ocean heat, and ice-albedo feedback. Many crucially interactive physical processes occur in the Arctic boundary layers, where energy exchange at the interface is critical for sea ice evolution and clouds strongly interact with sea ice through radiation and turbulence. Our ability of understanding the Arctic boundary layer and modeling its temporal evolution and spatial distribution is essential to understanding the Arctic climate change. This study presents a regional simulation study of summer Arctic boundary layers. The analysis includes an evaluation of the simulations during the ASCOS (Arctic Summer Cloud Ocean Study) field campaign; it also examines the model ability to simulate some key boundary layer structures observed during ASCOS. COAMPS (Coupled Ocean-Atmosphere Mesoscale Prediction System) is used in this study. ACNFS (Arctic Cap Nowcast/Forecast System) is used to provide sea ice conditions, including sea ice temperature and concentration, to COAMPS. An advanced surface layer parameterization based on SHEBA data is implemented to provide turbulent fluxes at the surface. The simulation domain is configured to contain four grid meshes (45 km, 15 km, 5km and 1.67 km) with 60 levels in the vertical. The model provides 24 h twice daily simulations between August 1 and September 10. Observations from ASCOS are used to evaluate simulations results with a focus on the turbulent and cloud structure of boundary layer. Detailed analyses will be presented in the conference.

14:30

The Year of Polar Prediction (2017-19)

Gregory Smith[1], *Thomas Jung*[2], *Neil Gordon*[3], *Stephanie Klebe*[2], *Helge Goessling*[2], *Peter Bauer*[4], *David Bromwich*[5], *Jonny Day*[6], *Francisco Doblas-Reyes*[7], *Marika Holland*[8], *Trond Iversen*[9], *Keith Hines*[10]

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There has been growing interest in the polar regions in recent years due to the opportunities and risks associated with anthropogenic climate change. Increasing economic, touristic, transportation and scientific activities in polar regions are leading to more demands for enhanced environmental prediction capabilities to support decision-making. Furthermore, it is increasingly obvious that weather and climate in the polar regions has an influence on the lower latitudes. Recognising this, a number of initiatives are underway which focus on improved polar science and predictions. One particularly important international initiative is the Year of Polar Prediction, or YOPP, which will take place between mid-2017 and mid-2019, centred on the year 2018. YOPP is a key element of the World Weather Research Programme Polar Prediction Project. YOPP is an extended period of coordinated intensive observational and modelling activities, in order to improve prediction capabilities for the Arctic, the Antarctic, and beyond, on a wide range of time scales from hours to seasons, supporting improved weather and climate services. This concerted effort will be augmented by research into forecast-stakeholder interaction, verification, and a strong educational component. Prediction of sea ice and other key variables such as visibility, wind, and precipitation will be central to YOPP. The presence of atmospheric linkages between polar and non-polar regions suggests that the benefit of YOPP will extend beyond the polar regions. Here we present the overall plans for YOPP with a particular focus on efforts within Canada.

14:45

Analysis of the subgrid-scale variability in a land surface/atmosphere coupled system

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A persisting challenge with regard to numerical environmental prediction remains to increase the resolution of the land surface prediction system in order to properly capture both spatial and temporal heterogeneity in the different surface covers (i.e., land, urban, water, continental ice and sea ice). Most offline land surface modeling systems such as SPS (formerly known as GEM-Surf) at Environment Canada are currently limited to the forcing mode, with no feedback of the surface fluxes to the atmosphere. This work presents the forthcoming two-way coupling approach, combining SPS with the GEM atmospheric model, in which the land surface is solved at high resolution (2.5-km horizontal grid spacing) and in which high-resolution surface fluxes are upscaled to the lowest atmospheric level (10-km horizontal grid spacing). The subgrid-scale variability of the near-surface meteorological variables and the subsequent patterns of the high-resolution surface fluxes at the scale of the atmospheric model grid cell are statistically quantified for different geographic areas (e.g., glaciers, lakes, prairies) and over the diurnal cycle. The numerical results show the benefits of high- resolution land surface simulations to account for time-scales and length-scales that are more consistent with the scales at which the actual land surface balance is affected by the heterogeneous geophysical fields (i.e., roughness length, land/water mask, glacier mask, soil texture). They also highlight the potential of the GEM-SPS coupled system for improving predictions at the surface and in the atmospheric boundary layer through more accurate representations of the surface heat fluxes, in particular for ensemble operational systems.

13:30

Modeling the atmospheric boundary-layer of the marginal ice zone: an ACCACIA case study.

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The boundary layer of the Marginal Ice Zone is poorly represented in models, the presence of both ocean and ice causes problems with representing the surface and its fluxes. This creates errors in stability and moisture in the simulated boundary layer, thus poorly predicting the onset of convection and clouds. The ACCACIA (Aerosol-Cloud Coupling And Climate Interactions in the Arctic) project is focused on boundary-layer interactions with low level clouds and the physical and dynamical processes that control their properties. An aircraft campaign took place in spring 2013 with low level flights over the MIZ around the Svalbard archipelago. Two cases showing boundary-layer transitions across the MIZ during office airflow flow have been selected for further study. Simulations with the WRF (Weather Research and Forecasting) model have been carried out. This study has specifically focused on the sensitivity of the boundary layer to the surface parameterizations in the model. Tests with several boundary-layer parameterization schemes show that the simulated boundary-layer is consistently too deep and well- mixed. This indicates that the thermodynamic structure of the boundary-layer is not sensitive to the choice of parameterization scheme. This presentation gives an overview of the results of this study and discusses future work to improve the understanding of the boundary layer of the MIZ and its representation in models.

13:45

Finding the source regions of sea ice melting in the marginal ice zone: a Lagrangian approach

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Arctic sea-ice conditions are determined by the combined action of thermodynamics (ice formation and melting) and the dynamics of drift and deformation. Each fall, new sea ice floes are formed in the Arctic Ocean and drift under the action of surface wind and water relative movement. Some of these floes will drift over short distances and melt the next summer, while some will survive and become multi-year ice. This complex trajectory of sea ice creates a wide variety of source regions contributing to the marginal ice zone. The goal of this project is to use Lagrangian backward trajectories to analyse the drifting paths of ice towards different peripheral seas where it melts. If thick ice is advected in a peripheral sea, it is less likely to melt the following summer than if the ice floe was thinner. Therefore, determining source regions, which is a proxy for ice thickness, becomes really important. Results from Community Climate System Model 4 (CCSM4) for the past three decades have been compared with Polar Pathfinder 25km EASE-Grid sea ice motion vectors from NSIDC and show an important bias in source region patterns that can be mainly explain by

the difference in atmospheric forcing that drives the ice pack. The same procedure has then been applied to the Community Earth System Model 1 (CESM1-CAM5) large ensemble who is believed to have a better representation of the atmosphere over the Arctic Ocean. The completion of this work yields a better understanding of the strength and/or limitation of global climate model's predictions of future ice edge position in view of complex ice dynamics.

14:00

Arctic Sea Ice Seasonal Prediction by a Linear Markov Model

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A linear Markov model has been developed to predict the ice concentration in the pan Arctic region at the seasonal time scale, which represents an original effort of forecasting Arctic sea ice year around with a reduced-dimension statistical model. The model was built to capture co-variabilities in the atmosphere-ocean-sea ice system defined by sea ice concentration, sea surface and air temperature, geopotential height and winds at the 300mb level. Multivariate empirical orthogonal functions of these variables served as building blocks of the model. A series of model experiments were carried out to determine the dimension of the model. The predictive skill of the model was evaluated in a cross-validated fashion. The model shows considerable skill within the Arctic Basin during summer and fall. Particularly, in the region north of the Chukchi Sea, Beaufort Sea, Eastern Siberian Sea, Kara Sea, and Barents Sea, correlation skills are above 0.6 even at a 9-month lead. Because the Arctic Basin is completely frozen in winter and spring, the predictability appears in the seasonal ice zone during these seasons. The model has higher skills in the Atlantic sector of the Arctic than in the Pacific sector. The model predicts well the phases of September sea ice extent (SIE) variability but underestimates the accelerated decline in SIE, resulting in a systematic model bias. This model bias can be corrected by a constant bias correction or linear regression bias correction, leading to an improved correlation skill of 0.93 for the 2-month lead SIE prediction.

14:15

Multi-year ice replenishment in the Canadian Arctic Archipelago: 1997-2013

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In the Canadian Arctic Archipelago (CAA), multi-year ice (MYI) replenishment from first-year ice aging and Arctic Ocean MYI inflow contribute to the CAA's relatively heavy sea ice conditions at the end of the summer melt season. We estimate these components using RADARSAT imagery and the Canadian Ice Service Digital Archive and explore processes responsible for interannual variability from 1997-2013. FYI aging (52±36x103 km2) provides a larger contribution than Arctic Ocean MYI inflow (13±11x103 km2). CAA FYI aging represents ≈10% of the amount that occurs

in the Arctic Ocean. Arctic Ocean MYI inflow into the CAA represents ≈50% of Nares Strait MYI export to Baffin Bay and ≈12% of Fram Strait MYI export to the Greenland Sea. FYI aging exhibits dependence on warmer (cooler) summers that increase (decrease) melt evident from strong relationships to surface air temperature (SAT; r=-0.8), albedo (r=0.87) and total absorbed solar radiation (Qtotal; r=-0.84). Arctic Ocean MYI inflow is influenced by summer sea level pressure (SLP) anomalies over the Beaufort Sea and Canadian Basin (r=-0.57) which shifts the primary source of Arctic Ocean MYI inflow between less obstructed M'Clure Strait (low SLP anomalies) and the more obstructed Queen Elizabeth Islands (high SLP anomalies). Over the 17-record, MYI replenishment decreased by 55% from 2005-2012 relative to 1997-2004 followed by large MYI replenishment once again in 2013. The reduced replenishment period from 2005-2012 was primarily associated with more frequent positive SAT, negative albedo and positive Qtotal anomalies that facilitated more melt and less FYI aging, together with more frequent high SLP anomalies that facilitated less Arctic Ocean MYI inflow. Large MYI replenishment in 2013 was primarily from FYI aging attributed to strongly negative SAT and Qtotal anomalies and strongly positive albedo that impeded melt.

14:30

Air-Sea Interaction under a Diminishing Sea ice Cover in the Regional Arctic System Model (RASM)

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Some of the largest changes due to climate warming are expected in the Arctic. However, 21st century projections of the magnitude of these changes vary widely in the latest suite of global climate model predictions. Such sensitivities and variations are the source of large uncertainties in reconstructions of the past present and limited skill in projections of future Arctic System states. There are a number of reasons for such model limitations and they stem from a combination of coarse model resolution, inadequate parameterizations of sub-grid processes, and a limited knowledge of physical interactions. One of the least understood limitations is the crudely represented sea ice mechanics, which affect ocean-ice-atmosphere surface momentum and energy transfer. We demonstrate the capability of the Regional Arctic System Model (RASM) in simulating not only observed seasonal to decadal variability and trends in the sea ice cover but also air-sea interactions under changing climate regimes. RASM is a limited-area, coupled ice-ocean-atmosphere-land model. Its domain covers the pan-Arctic region and it is configured at an eddy-permitting resolution of $1/12^o$ for the ice-ocean and 50 km for the atmosphere-land model components. The sea ice component has been upgraded to the Los Alamos Community Ice Model version 5 (CICE5), which allows either Elastic-Viscous-Plastic (EVP) or a new anisotropic (EPA) rheology and incorporates form drag to

more realistically represent sea ice morphology and estimate ice-ocean and ice-atmosphere stresses. We use RASM to investigate the role of sea ice drift and deformation, and resulting air-sea feedbacks based on results from multiple simulations, using different CICE5 options combined with varying parameter space, to inter-compare and evaluate model results against observations with emphasis on model representation of sea ice thickness distribution and its role in exchanges across the air-sea interface.

14:45

Decadal variations of the Arctic water temperature and salinity simulated by NEMO

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In this study, we investigate the decadal variability of water temperature and salinity in the central Arctic Ocean, performing simulations for 1948 to 2009 with the ocean model, NEMO (Nucleus for European Modelling of the Ocean). NEMO is implemented in the Arctic Ocean, forced by GLORYS water temperature, salinity, current as well as CORE II surface fields. Outflows from the 13 largest rivers along the Arctic coast are implemented in the boundary conditions for the Arctic domain. The Neptune effect is applied to provide a representation of the cyclonic rim currents along the central Arctic basin. We show that compared to PHC data, NEMO can reliably reproduce the upper layer water temperature and salinity, suggesting a warm layer at intermediate depths and a salinity minimum in the Beaufort Sea. In addition, the model simulations exhibit significant decadal variations in the water temperature associated with the Atlantic water layer (AWL) and water salinity in the Beaufort Sea. In addition, there is an increase in the fresh water content in the Beaufort Sea and the water temperature at the intermediate layers after the 1990s. On average, the fresh water from the Siberian coast is transported into the eastern Arctic along the transpolar drift and into the Beaufort Sea through the coastal current; however, its pathway is shifting westward during the last decades of the simulation. Further analyses suggest that the decadal variations in the water temperature and salinity are associated with the variability of polar vortex. For example, the eastward shift of polar vortex enhances the Beaufort High in the western Arctic, which accelerates the accumulation of fresh water in Canada Basin along with the increased ice melting.

13:30

A New Statistical Method for Acoustic Backscatter Amplitude Inversion

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Detailed studies of suspended sediment dynamics under waves require non-intrusive time-resolved measurements of suspended particle size and concentration. One method for obtaining such measurements is by model inversion of multifrequency acoustic backscatter amplitudes. A limitation of existing inversion methods, however, is that they become unstable in the presence of high suspended concentration, due to along-path accumulation of statistical noise/errors via sediment-induced acoustic attenuation. This limits applications of inversion in the nearshore bottom boundary layer, which is characterized by rapid variability and high suspended concentration. With that in mind, a new method has been developed which improves inversion stability by incorporating techniques from linear statistical inverse theory and data assimilation. The new method is demonstrated using laboratory measurements of a sediment- laden jet, with a recently developed multifrequency coherent Doppler profiler (MFDop). The new method is shown to produce accurate inversion results, even in high-concentration cases for which existing methods are unstable/inaccurate.

13:45

Zooplankton biomass estimates from acoustic backscatter in the Salish Sea, British Columbia, Canada

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Ocean Networks Canada's costal cabled observatory, VENUS, includes several upward facing, platform-mounted ASL Environmental Sciences bio-acoustic profilers. Here we estimate total and size-specific biomass using data from two such profilers: 1) a single frequency 200kHz profiler located at ≈96m in Saanich Inlet, for which eight years of data exist; and 2) a multi-frequency (38, 125, & 200kHz) profiler located nearby in the central Strait of Georgia (≈299m depth) with a one year time series. We have developed algorithms which capture the seasonal cycle of euphausiid (krill) biomass throughout the long-term bio-acoustic time series for Saanich Inlet. Euphausiid-specific biomass was targeted (and calculated) by limiting echo range and removing background gain in order to more confidently remove fish and instrument noise artifacts. Applying a similar algorithm to the multi frequency data allowed us to calculate three distinct size-class specific biomass estimates based on minimum organism size. To further improve our zooplankton biomass estimate at the multi frequency site we used the lower frequencies to identify and remove fish and other large targets from the 200kHz channel. Here we demonstrate the utility of autonomous platforms to measure seasonal patterns in size-specific biomass.

14:00

Four Co-located Doppler Systems for Monitoring the Coastal Bottom Boundary Layer

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A system consisting of four co-located acoustic Doppler instruments was deployed on the VENUS observatory of Ocean Networks Canada in the Strait of Georgia. The small, compact platform hosts two Nortek and two RDI Doppler instruments, resolving the entire oceanic bottom boundary layer. Looking downward over the bottom 1m is a high resolution Nortek AquaDopp profiler. At a height of 1m, there is a point measuring Nortek Vector ADV. Looking upward are two RDI Workhorse ADCPs, with 600 kHz and 300 kHz operating frequencies. This combination provides a collection of profiles and point measurements of the near bottom velocity structure, resolving both micro- and fine-scale features from heights of a few cm to over 140m. The data can be analyzed to show the near-bottom velocities and shear, as well as a variety of turbulent characteristics, including the bottom stress, the internal Reynolds stresses and dissipation rates. The presentation will describe the physical and operating setup, and review a selection of data from near the mouth of the Fraser River in the Strait of Georgia.

14:15

Observing fish behavior using a bottom mounted Doppler velocity profiler at a proposed in-stream tidal site: Grand Passage Nova Scotia

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Normally, when acoustic backscatter from fish occurs in Acoustic Doppler Current Profiler (ADCP) data, that data are considered corrupted and the corresponding velocity profiles are rejected. However, through the processing of data from individual acoustic beams, it is possible to extract both fish and water velocities from the data. We apply this processing approach to a 3 day deployment of a 600 kHz RD Instruments Workhorse ADCP in Grand Passage Nova Scotia; a site that has been identified as having potential for in-stream tidal generation. Observations are available from September 4, till September 7, 2012. The presence of fish is determined by both acoustic backscatter levels (which identifies potential target locations), but also by using signal correlation which helps to distinguish discrete targets (fish?) from regions of continuous high backscatter. An example of how the correlation plays a role in discriminating the presence of discrete targets is in the presence of frequent sweeps of strong backscatter regions that seem linked to the surface; we hypothesis that these events are caused by bubbles swept down from the surface at fronts within the very turbulent flow. On a few occasions, there are near surface aggregations of fish that are likely herring or mackerel. These schools have a distinct velocity from that of the water flow itself. Also present throughout the data are discrete targets which have acoustic signatures consistent with being caused by fish but for the most part are travelling passively with the water. Time series

plots of the number of fish detected shows clear structure with a diurnal variation.

13:30

An analysis of extreme precipitation events in continental and coastal regions of North America: The relative roles of synoptic-scale triggers versus stratification

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The purpose of this research is to analyze historically extreme precipitation cases in the context of synthesizing crucial dynamic and thermodynamic processes occurring on planetary-, synoptic-, and mesoscales. Our analysis includes diagnoses from both the classical quasi-geostrophic and potential vorticity perspectives. The particular research utilizes historical analyses of synoptic-scale triggers in the form of tropospheric Q-vector convergence that force ascent. These large-scale forcings are assessed in the context of the atmosphere's thermodynamic conditioning in the form of its air mass evolution. In particular, we find that lower tropospheric warming and moistening are crucial to the antecedent conditioning that convectively destabilizes the region prior to the onset of large-scale ascent and precipitation. This conditioning is generally associated with historically extreme cold-season and warm-season extreme precipitation events. An additional contributor to extreme precipitation is its duration, which is typically associated with a quasi-stationary planetary-scale environment that includes an anomalously strong tropopause jet. This jet facilitates particularly strong, and persistent, baroclinic growth in the presence of anomalously strong polar and subtropical air masses.

13:45

The Dissipation Structure of Extratropical Cyclones

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The physical characteristics of extratropical cyclones are investigated based on the non-equilibrium thermodynamics. Non- equilibrium thermodynamics (mostly developed in 70-90s of century 20) has been widely used in many scientific fields. Non-equilibrium thermodynamics can reveal the dissipation structure for any thermodynamic and dynamic systems. It is found that dissipation is always present in an extratropical cyclone and the dissipation center is not always coincident with the low pressure center especially for incipient cyclones. The different components of internal entropy production correspond to different dissipation processes. Usually the thermal dissipation due to turbulent vertical diffusion and convection lags geographically the dynamic dissipation due to wind stress. At the incipient stage, the dissipation is mainly thermal in nature. A concept of temperature shear is introduced as the result of thermal dissipation. The temperature shear provides a useful diagnostic for extratropical cyclone identification. The regional study in the western Pacific clearly demonstrates that the temperature shear are the most reliable early signals of cyclone in the cyclogenesis stage.

14:00

The June 2013 Alberta Catastrophic Flooding Event

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An overview of the atmospheric features associated with the June 2013 Alberta flooding event that was triggered by June 19-22 heavy precipitation over the Bow River basin in particular is provided. Information was obtained from a variety of sources including satellites, operational model analyses, lightning network, radar, and weather stations. Substantial snowfall occurred over the mountains in the preceding winter and above-normal precipitation occurred in the month before the event. The event itself was linked with a mid-level closed low pressure system to the west of the region and a surface low pressure region initially to its south. This configuration brought warm, moist unstable air into the region that led to dramatic, organized convection with an enormous amount of lightning and some hail. Such conditions occurred in the southern parts of the region whereas the northern parts were devoid of lightning. Later on, the precipitation was mainly stratiform in nature. Initially, precipitation rates were high (up to 50 mm h-1) but decreased to lower values as the precipitation shifted to long-lived stratiform conditions. Both the convective and stratiform components were affected by the topography. Similar events, such as June 2002, have occurred over this region although the 2002 event was colder and had little if any convection over south-west Alberta. The synoptic scale features associated with the 2013 rainfall event were not particularly intense when compared to other cut off low cases. However, its storm environment was the most convectively unstable amongst the events. The localized extreme convective rainfall along with the wet surface conditions could have contributed to the large runoff and flooding.

14:15

The importance of African easterly wave critical layer in developing tropical storms

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This study brings new understanding on tropical cyclogenesis that starts with westward travelling African easterly waves that can evolve into coherent cyclonic vortices depending on their strength and other nonlinear wave breaking processes. In general, observations indicate that only a small fraction of the African easterly waves that occur in a single hurricane season contribute to tropical cyclogenesis. However, this small fraction includes a large portion of named storms. In addition, a recent study by Dunkerton et al. (2009) has shown that named storms in the Atlantic and eastern Pacific basins are almost all associated with a cyclonic Kelvin cat's eye of a tropical easterly wave typical of critical layers, located equatorward of the easterly jet axis. To better understand the

dynamics involved in hurricane genesis, the flow characteristics and the physical and dynamical mechanisms by which easterly waves form cat's eyes are investigated with the help of atmospheric reanalyses and numerical simulations. We perform a climatological study of developing easterly waves covering the 1998-2001 hurricane seasons using ERA-Interim 6-hourly reanalysis data. Composite analyses for all named storms show a monotonic potential vorticity (PV) profile with weak meridional PV gradient and a cyclonic (i.e., south of the easterly jet axis) critical line for time periods of several days preceding the cat's eye formation. In addition, the developing PV anomaly composite shows a statistically significant companion wavepacket of non-developing easterly waves. A barotropic shallow water model is used to study the initial value and forced problems of disturbances on a parabolic jet and realistic profiles associated with weak basic state meridional PV gradients, leading to Kelvin cat's eye formation around the jet axis. The results highlight the synergy of the dynamical mechanisms, including wave breaking and PV redistribution within the nonlinear critical layer characterized by weak PV gradients, and the thermodynamical mechanisms such as convectively generated PV anomalies in the cat's eye formation in tropical cyclogenesis. These findings are consistent with the analytical theory of free and forced disturbances to an easterly parabolic jet (Brunet and Warn, 1990; Brunet and Haynes, 1995; Choboter et al., 2000). 1) Dunkerton, T. J., M. T. Montgomery, and Z. Wang, 2009: Tropical cyclogenesis in a tropical wave critical layer: Easterly waves. Atmos. Chem. Phys., 9, 5587-5646. 2) Brunet, G., and T. Warn, 1990: Rossby Wave Critical Layers on a Jet. J. Atmos. Sci., 47, 1173-1178. 3) Brunet, and P. H. Haynes, 1995: The Nonlinear Evolution of Disturbances to a Parabolic Jet. J. Atmos. Sci., 52, 464-477. 4) Choboter, P. F., G. Brunet, and S. A. Maslowe, 2000: Forced Disturbances in a Zero Absolute Vorticity Gradient Environment. J. Atmos. Sci., 57, 1406-1419.

14:30

Sensitivity of Tropical Cyclone Intensification to Axisymmetric Heat Sources

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Once a tropical cyclone has been formed its major source of energy is from the release of latent heat in the main eyewall region due to the condensation of moist convection. Recent studies (both modeling and analytically) have showed the sensitivity of a tropical cyclones intensification rate to the location of this heating with respect to the radius of maximum winds (RMW), the strength of the storm, and the vertical and horizontal extents of the circulation. This study focuses on how the radial and vertical distributions of heat with respect to the RMW influence the rate of tropical storm intensification. Using realistic heating profiles obtained from an axisymmetric model simulation, we introduced the heating bubbles into a 3-D, nonlinear, dry, fully compressible balanced tropical cyclone vortex (WRF model). Sensitivity experiments on the size, strength, and radial and vertical location of the heating were performed. For each experiment the kinetic energy budget is decomposed into its mean and eddy terms to study the exchange of energy between them. In addition, the eddy and mean kinetic energies are further decomposed to determine the dominant exchange processes that drive the rate of intensification. Specifically, a direct comparison of the baroclinic and barotropic processes help determine the nature of the dominant processes. These

findings allow us determine the relationship between a thermal heat source and the ensuing vortex response as well as the thermodynamic mechanisms associated therein.

14:45

Some aspects of the problem of secondary eyewall formation in idealized three-dimensional nonlinear simulations

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Some aspects of the problem of secondary eyewall formation (SEF) are investigated with the aid of an idealized model. A series of experiments are conducted, starting with a strong annular vortex embedded in a quiescent background flow and forced by the sustained heating associated with a spiral rainband (control experiment). Following this, two experiments are configured to assess the impact of verti- cal wind shear (VWS) in the SEF process. The importance of the boundary layer force imbalance is finally investigated in a number of simulations in which surface and boundary layer physics are included. From the control experiment, it is found that in the absence of background environmental flow, the sustained latent heating associated with a spiral rainband can form a secondary eyewall even in the absence of a frictional boundary layer. The presence of VWS acts negatively in the SEF process by disrupting the organization of the potential vorticity induced by the rainband. When boundary layer physics is included, some similarities with previous studies are seen, but there is no SEF. These results suggest that the boundary layer most likely contributes to, rather than initiate, a secondary eyewall.

10:30

Tropical-extratropical teleconnections in the ECMWF sub-seasonal and seasonal prediction systems

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Teleconnections linking rainfall anomalies in the Indo-Pacific region and large-scale circulation anomalies in the northern extratropics have been investigated using re-forecast sets generated with the sub-seasonal and seasonal prediction systems of ECMWF. For the boreal winter, results show clear similarities between teleconnections associated with the MJO on the sub-seasonal scale and those related to variations in seasonal-mean rainfall with opposite anomalies in the Western Indian Ocean and the Maritime Continents. Links with ENSO variability will be discussed, showing that a stronger than observed correlation between Central Pacific and Western Indian Ocean rainfall affects the NAO response to such anomalies in the ECMWF seasonal forecasts. With regard to sub-seasonal teleconnections, results obtained with recent experiments using atmospheric horizontal resolution of about 32 km and 64 km will be compared. Although the predictability of the MJO does not seem to be significantly affected by the change of resolution, the strength of the NAO signal associated with different MJO phases tends to increase in the higher resolution runs. Overall, the high-resolution sub- seasonal experiments show a larger predictive skill for the NAO than those at the current operational resolution (≈64 km), confirming earlier results from MINERVA project.

10:45

Potential Influence of the November-December Southern Hemisphere Annular Mode on the East Asian Winter Precipitation: A New Mechanism

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As the leading mode of the global atmospheric mass inter-annual variability, the Southern Hemisphere (SH) annular mode (SAM) may exert potential influences to the Northern Hemisphere (NH) climate, but the related physical mechanism is not yet clear. In this study, it is found that the November-December (ND) SAM exhibits a significant inverse relationship with the winter precipitation over East Asia, particularly southern China. Observational and numerical evidences show that anomalous ND SAM is usually associated with a South Atlantic-Pacific dipole sea surface temperature anomaly (SSTA) which persists into ensuring winter. The dipole SSTA can modulate the variability of the Inter-tropical Convergence Zone (ITCZ) in Pacific. Subsequently, a distinguished atmospheric tele-connection pattern is induced and prevails over the NH mid-latitude region as a response to the anomalous ITCZ. Large areas of high pressure anomalies are triggered at upper troposphere over East Asia and centered over southern China, which favors less precipitation over East Asia, particularly southern China, and vice versa. Through such a physical mechanism, the notable influence of the ND SAM can sustain through the following season and impact on the NH winter climate.

11:00

The spring link between the North Atlantic Oscillation and Pacific-North American pattern

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The Pacific-North American (PNA) pattern and North Atlantic Oscillation (NAO) together account for a large proportion of atmospheric variability. This is maximized during the winter season (December-February) when both patterns reach their maximum amplitude. There are only a few decades for which there is statistically significant correlation between the winter PNA and NAO indices; however, during the late spring and early summer seasons (March-May, and April-June) there is a consistent relationship between them. To explore this relationship, 65 years of monthly anomalies from the NCEP/NCAR reanalysis dataset are used. PNA and NAO indices are derived by projection onto rotated empirical orthogonal function patterns. Regression of both the PNA and NAO indices onto 500 hPa geopotential height anomalies show that both patterns significantly relate to height anomalies which resemble the Arctic Oscillation (AO). Additionally, the NAO and PNA patterns derive energy from the mean mid-latitude zonal jet stream over the Northern Pacific Ocean. Variations in the amplitude and location of the jet stream on the dynamic tropopause show that a wave guide preceding the positive phase of the PNA extends through the Atlantic region between the North American East coast and Portugal. This same anomaly, associated with the negative phase of the NAO presents itself two months later and marks the beginning of the significant correlation between the PNA and NAO. Finally, linear removal of the signal associated with El-Nino does not change the relationship between these teleconnection patterns, and all similarities between the lagged regression patterns of the NAO and PNA are unaffected as well.

11:15

A physical analysis of the severe 2013/14 cold winter in North America

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The severe 2013/14 cold winter has been examined in the context of the previous 64 winters using the NCEP reanalysis data for the period 1951-2014. North America is dominated by pronounced cold anomalies over the Great Plains and Great Lakes in December 2013 and February 2014, but reveals an east-west contrast pattern with warm anomalies over most of the North American West in January 2014. The polar vortex associated temperature and circulation variability projects weakly on the corresponding anomalies in the 2013/14 winter, while the variability in association with the principal mode of North American surface temperature projects strongly on the corresponding anomalies in the winter. The principal mode of wintertime North American temperature anomalies is closely related to the ocean-atmosphere interaction process over the northern mid-high latitudes. The principal mode associated sea surface temperature has significant anomalies over the North Pacific and North Atlantic mid-high latitudes. The horizontal temperature gradients over the

Pacific- North American sector result in an anticyclonic anomaly over the Gulf of Alaska-Bering Sea and a cyclonic anomaly downstream over North America. Over western-central Canada and the northern US, below-average heights are associated with above-normal precipitation, implying enhanced upward vertical motion and variation of local cloud forcing, leading to the variation of surface energy budget. The surface radiative cooling, dominated by weak downwelling longwave radiation, acts to support and maintain the North American cold anomalies, while the upward surface longwave radiation damps the temperature anomalies.

11:30

Predictive anisotropy of surface wind vectors

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High-resolution, site-specific surface wind information is required for applications such as evaluation of wind energy production, prediction of climate change effects, and mitigation of airborne pollutants. Recent studies of a few locations, i.e. western and central Canada, global oceans and French Alps suggest that predictability of wind components by statistical downscaling is generally anisotropic. This study aims at providing a qualitative explanation of predictive anisotropy based on statistical analysis of observations worldwide. Specifically, large-scale fields aloft are statistically downscaled using a linear transfer function to predict daily surface wind vectors from historical observations for 2683 land stations over the globe. The results show that the predictive anisotropy is a common phenomenon. Higher degree of predictive anisotropy tends to be associated with a few factors: (1) more complex landforms, (2) weaker coupling of surface predictands and large-scale midtropospheric predictors, (3) wind components of higher kurtosis and (4) more anisotropic variance of wind components on daily time scale.

10:30

A Circulation Model for Baynes Sound, British Columbia

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A finite volume ocean circulation model with resolution as fine as 50 m has been developed and evaluated for Baynes Sound, British Columbia. The region is home to a large shellfish industry and the model will be used to estimate carrying capacity and provide other useful metrics to assist regulators in managing the industry and assessing expansion possibilities. Baynes Sound is approximately 30 by 2 km with openings into the Strait of Georgia off the northern and southern ends of Denman Island. It is relatively shallow with mudflats developing at low tide and has freshwater discharges of up to 250 m3 s-1 entering via the Courtenay River. Model accuracy is assessed by comparing results with available tide gauge, current meter, and water property measurements.

10:45

Horizontal circulation in the Strait of Georgia

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At present, quantitative estimates of the estuarine circulation in the Salish Sea, over monthly time scales, are known reasonably well under a box-model paradigm. Under this paradigm Strait of Georgia deep inflow waters have a speed of a few cm/s, and outflow currents near the surface have speeds of about 5 cm/s. However, actual measurements of the large-scale deep currents find subtidal speeds of more than 30 cm/s in some places, and outflow currents (i.e. with the "wrong" sign) in others. Long-term observations of currents from the ONC/VENUS nodes, as well as shipborne transects and drifter tracks, reveal that inflow waters hug the southeastern side of the Strait, often as a narrow boundary current, which carries a volume flux considerably greater than that of the estuarine inflow. A broad return flow in the central and western Strait compensates for this. near the surface, on the other hand, winds blow the surface water around and this dominates short-term predictability.

11:00

Physical Oceanographic Conditions in Douglas Channel, British Columbia

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Long-term ADCP and CTD observations are analyzed for the region of Kitimat, British Columbia, and particular attentions are paid to the circulations in Douglas Channel. Surface current conditions are studied to directly address the initiatives on World Class Prevention, Preparedness and Response for oil spills from ships. The circulation in the upper 100 meters presents typical estuarine circulation features; however, the velocity fluctuations at 5 m depth are highly correlated with the observed

daily winds, and at lower frequency the seasonal mean estuarine flow in the upper 5-10 meters are also modulated by seasonal mean winds. Annual long period (2 months) deep-water renewal events are observed, and these events in combination of the mixing of freshwater inputs directly determine the annual cycle of the water properties of Douglas Channel.

11:15

The 2013-15 North East Pacific Surface Warming Comes Near Shore

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The surface waters of the North East Pacific (NEP) were anomalously warm from the fall of 2013 through to the late fall of 2014. Estimates of the scale and amplitude of the anomaly suggest a significant shift in the response of the entire NEP to variations in the winds, both speed and direction, during the winter of 2013-14. For most of 2014, the warm anomaly remained off-shore, in the central NEP, but during the seasonal transition from up-welling to down-welling favourable conditions in the fall of 2014, the surface waters off the west coast of Vancouver Island migrated into coastal regions. Continuous monitoring from the Ocean Networks Canada's Folger Passage installation, with sensors at a depth of 100m, captured this encroachment in early November (2014), with temperatures rising over a full degree (1.3C) above any previous maximum. The anomalously warm temperatures remained along the coast for over three months, before relaxing in early February 2015 to historic levels. The general conditions of the NEP and the 2013-15 observed anomalies will be presented.

11:30

Representing kelp forests in a regional circulation model: the tidal circulation

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Kelps, known as the large brown seaweeds, are commonly distributed on the north coast of British Columbia, Canada. The presence of the kelps enhances the hydrodynamic drag and thus changes the tidal circulation structures. In the present study, changes in tidal circulation have been investigated with a high resolution three-dimensional hydrodynamic model based on FVCOM in which the effect of kelps is parameterized as a friction term in the standard momentum equations. The locations of kelp beds are derived from Landsat images archived in USGS and the drag coefficient due to kelps uses exiting laboratory data. The model is validated with the field observational data. Using the model results, effect mechanisms of kelp forests on the tidal circulation are discussed.

11:45

Modelling the Bay of Quinte in Lake Ontario using FVCOM

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The Bay of Quinte is an economically and ecologically important embayment of Lake Ontario which contains critical wetland nurseries for walleye and yellow perch and supports a million dollar commercial and sport fishing industry. While ecosystem modelling has thrived for this region, numerical modelling of the physical environment has lagged behind. It is paramount to accurately simulate the evolution of the temperature and circulation fields in this Bay to establish a baseline against which we can measure future changes and to provide valuable information for ecosystem management. We have used the Finite Volume Coastal Ocean Model (FVCOM) model to produce summer simulations of the hydrography of the region for the period of 1979-2006. FVCOM has been implemented to simulate the evolution of the Bay's water levels, currents and temperatures. Trends in surface and vertical temperature profiles and current fields will be presented for the period of 1979-2006 for the Bay. Mean annual lake-wide surface temperature computed from the model simulations showed an increase of approximately 0.018 C/yr. A similar calculation using maximum annual surface temperatures showed an increase of 0.028 C/yr. As the Bay is very shallow, with most of its depths less than 10 m, these surface temperature trends are a reflection of the trends in the air temperature forcing. With the projected rise in global mean air temperature, these trends will likely continue, increasing the stress on the Bay's ecosystem.

10:30

Assimilation of Cris, ATMS, and European ground-based GPS at Environment Canada

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Environment Canada is planning to assimilate operationally (summer 2015) new data types including multispectral radiances from Cris (Cross-track Infrared sounder, 102 channels) and ATMS (Advanced Technology Microwave Sounder, 15 channels), as well as ground-based GPS data from the European network. In addition, inter-channel error correlations for all radiances are now considered for the first time. Each component was evaluated individually from assimilation cycles. Results will presented for each component as well as the combined impact of the four components. This implementation will augment the volume of assimilated data by nearly 18 %.

10:45

Comparison of EnKF and EnVar-based ensemble data assimilation methods

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The current design of the global deterministic data assimilation system used at the Canadian Meteorological Centre is based on a 4D ensemble-variational approach, with 4D ensemble covariances derived from an independent ensemble Kalman filter that assimilates fewer observations than the variational system. The possibility of using a variational approach within the ensemble system itself will be explored using the results of recent assimilation cycles and idealized test. A range of techniques are introduced, from a costly design in which each ensemble member performs its own full variational analysis, to a streamlined technique in which a limited number of iterations is used in the minimization problem for ensemble perturbations rather than the member's full state. The approximations that are required to limit the cost of variational techniques used within the ensemble framework will be identifed, and their potential impacts on analyses discussed.

11:00

Arctic System Reanalysis: 15 and 30 km Versions

David Bromwich[1], *Lesheng Bai*[1], *Keith Hines*[1], *Aaron Wilson*[1], *Sheng-Hung Wang*[1], *Zhiquan Liu*[2], *Hui-Chuan Lin*[2], *Michael Barlage*[2], *Ying-Hwa Kuo*[2]
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The Arctic System Reanalysis (ASR) includes atmospheric, sea ice and land surface representations. Through data assimilation, a broad-based set of historical data streams from the surface and space are combined. The ASR is based upon the polar-optimized version of the Weather Research and Forecasting model (Polar WRF), the WRF variational data assimilation (WRF-Var) and the High Resolution Land Data Assimilation System (HRLDAS). Polar WRF includes an improved Noah land surface model and specifications for the following sea ice attributes: extent, concen-

tration, thickness, albedo and snow cover. WRF-Var assimilates NCEP-PREPBUFR observation data (in-situ surface and upper air data, remotely sensed retrievals and satellite radiance data). HRLDAS assimilates snow cover and depth, observed vegetation fraction and albedo. The T255 (0.7 degrees) horizontal resolution ERA-Interim reanalysis surface and upper air model level data are used to provide the background initial and lateral boundary conditions for the ASR. ASRv1 30km is complete for January 1, 2000 - December 31, 2012 and available at the NCAR CISL RDA. The annual precipitation patterns from ASRv1 30km and ERA-Interim are very similar. The higher resolution with the ASR results in more detailed and realistic precipitation features in regions of complex terrain. The results of the ASRv1 30km and ERA-Interim are compared with 3-h surface observations from across the ASR domain. These comparisons are based on observations from more than 4,500 surface stations obtained from the National Climatic Data Center. The higher skill in resolving surface pressure, surface temperature, surface dew point and surface wind speed are seen for ASRv1 in comparison to ERA-Interim. ASRv2 15km, with version upgrade along with modeling and assimilation improvements, is being performed and will be completed by May 2015. ASRv2 30km will follow, and we intend to keep both resolutions of ASRv2 up to date.

11:15

EnKF Data Assimilation of Canada Radar for a Lake-Effect Snowstorm in 2015

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A high-resolution data assimilation and modeling system is being developed to improve the short-term numerical weather forecasts for Southern Ontario. In this system, we take great effort to implement the Ensemble Kalman Filter (EnKF) data assimilation of radar data, especially the Canadian radar data. Using the Weather Research and Forecasting (WRF) model and the Data Assimilation Research Testbed (DART) system to conduct the EnKF data assimilation and numerical simulation at a 3-km resolution, a recent case of Ontario-Lake-effect snowstorm on January 26, 2015 is used to examine the impact of radar data assimilation on the analyses and forecasts. Due to the prevailing easterly winds, this lake-effect snowstorm occurred on the western end of Ontario Lake and produced 10-cm snowfall at Hamilton, Ontario. Because this snowstorm was well captured both by the Canadian radar at King City site (WKR) and the U. S. Nexrad radar at Buffalo site (KBUF), we had a good opportunity to compare two experiments with either WKR or KBUF radar data assimilated. With 2-hour time window of assimilating both radar radial velocity and reflectivity, the analyses from both experiments reproduce well the lake-effect snowstorm. The subsequent short-term (0-2 hour) forecasts show the WKR radar data assimilation leads to more improvement of simulating the lake-effect snow in terms of the snowstorm coverage and the snowfall intensity, compared with the KBUF radar data assimilation. Beyond 2 hour, both experiments present similar forecasts as the control experiment without any radar data assimilation. These results demonstrate the beneficial impact of the radar data assimilation using EnKF method on the numerical analysis and short- term forecasts of the lake-effect snowstorm. In particular, it is the first time to examine the performance of the EnKF data assimilation of Canadian radar data (King City site). Based on

these ensemble analysis and forecast, more studies will be performed to investigate how the radar data assimilation benefits to the simulation of the lake-effect snowstorm.

11:30

The Antarctic Radiosonde Network: Optimal Locations for Observation

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Radiosondes are crucial for capturing tropospheric structure and providing important data for model assimilation and forecast improvement. Since it is expensive and difficult to maintain a dense radiosonde network in Antarctica, it is important that the radiosondes that are deployed capture as much important information as possible. Here two idealized networks are constructed using a covariance ensemble sensitivity approach (Hryniw and Hakim 2015) using data generated by the Antarctic Mesoscale Prediction System (AMPS). The data period spans October 2008 - September 28. Optimal locations are chosen by the technique that considers locations at every 5th point on the 15km AMPS continental grid. The first network is one constructed from scratch assuming no other radiosondes currently exist, and finding five optimal locations for new observations. The second network is contingent on current observation locations on the Antarctic continent. This calculation regresses out the influence of existing observations, and then constructs an optimal network that is contingent on the existence of these other radiosonde locations. This approach allows for objective placement of new observations, and can easily be restricted so that areas where it is no feasible to launch radiosondes are not included in the calculations. Hryniw, N., and G.J. Hakim, 2015: Multivariate Approaches to Optimal Network Design for Geophysical Fields. Mon. Wea. Rev., submitted.

11:45

Assimilating GPS RO in Polar WRF to improve surface pressure estimation over Antarctica

Aaron Wilson[1], *David Bromwich*[2], *Zhiquan Liu*[3], *William Kuo*[4], *Shu-Ya Chen*[4], *Hui-Chuan Lin*[3], *Tae-Kwon Wee*[4], *Keith Hines*[5]
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The polar version of the Weather Research and Forecasting (Polar WRF) model and the WRF Data Assimilation (WRFDA) system are used to assimilate the Constellation Observing System for Meteorology Ionosphere and Climate (COSMIC) and other GPS radio occultation (RO) profiles in order to improve surface pressure estimates over Antarctica. As GPS RO measurements are extremely accurate in all-weather conditions, the desired outcome is a monthly mean surface pressure estimate to an accuracy of < 1 hPa at each location on the Antarctic ice sheet. This

will improve the correction of atmospheric mass loading in the Gravity Recovery and Climate Experiment (GRACE) measurements, thereby limiting the uncertainty of the ice-mass balance over Antarctica and its contribution to global sea-level rise. Sensitivity simulations have provided an optimal Polar WRF configuration and 3D-variational assimilation of GPR RO data for this region. Four month-long simulations (April, July, and October 2007 and January 2008) are conducted at 30 km horizontal resolution. Results show smaller surface pressure errors compared to various data sets (NCEP FNL, ERA-Interim, AWS, and other Antarctic Surface Stations) when GPR RO are assimilated, exceeding the goal of $<$ 1 hPa accuracy in many locations. Areas of complex terrain with steep topographic relief present a major challenge to improving surface pressure where higher horizontal-resolution assimilation (10-15 km) is likely needed. Assimilating GPS RO notably improves surface pressure estimates over the high interior of Antarctica and the baroclinicity across the entire Adélie Land region. Together, this leads to greater accuracy in cyclone position and development throughout the South Pacific Ocean. Additional year-long (March 2007 through February 2008) simulations over Antarctica are planned, one with and one without the assimilation of GPS RO, in order to further demonstrate improved atmospheric mass loading correction for GRACE.

10:30

Ice validation of the U.S. Navy's Global Ocean Forecast System 3.1

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The U.S. Navy's newest ocean and ice prediction system is known as the Global Ocean Forecast System (GOFS) 3.1, which is comprised of the $1/12^o$ HYbrid Coordinate Ocean Model that is two-way coupled to the Community Ice CodE in a daily update cycle with the Navy Coupled Ocean Data Assimilation and uses Improved Synthetic Ocean Profiles to project surface information downward into the water column. GOFS nowcasts/forecasts the ocean's weather, which includes the three-dimensional ocean temperature, salinity and current structure, the surface mixed layer, the location of mesoscale features, and ice concentration, thickness and drift in both hemispheres. The system has 3.5-4 km horizontal resolution near the North Pole. GOFS 3.1 is currently undergoing operational testing and is scheduled to replace GOFS 3.0 for the ocean and the Arctic Cap Nowcast/Forecast System (ACNFS) for sea ice, both of which are the existing operational systems run daily at the Naval Oceanographic Office. Error analyses used to validate ice edge location, ice thickness and ice drift will be presented.

10:45

Accuracy of short term Sea Ice Drift Forecasts using a coupled Ice-Ocean Model

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Sea ice drift forecasts for the Arctic for the summer of 2014 are investigated. Sea ice forecasts are generated for 6 hours to 9 days using the Marginal Ice Zone Modelling and Assimilation System (MIZMAS) and 6 hourly forecasts of atmospheric forcing variables from the Climate Forecast System (CFSv2). Forecast ice drift speed is compared to observations from drifting buoys and other observation platforms. Forecast positions are compared with actual positions from 24 hours to 9 days. Forecast results are further compared to those from the forecasts made using an ice velocity climatology generated from multi-year integrations of the same model. The results are viewed in the context of planning and scheduling the acquisition of high resolution images which need to follow buoys or research platforms for scientific research. RMS errors for ice speed are found in the order of 5 km/day for 24 h to 48 h using the sea ice model vs. 12 km/day using climatology. Following adjustments in the sea ice model to remove systematic biases in direction and speed, predicted buoy position RMS errors are 6.5 km for 24 hour forecasts and 15 km after 72 hours. The model remains skillful relative to the climatological forecast for 9 days. Using the forecast model increases the probability of tracking a target drifting in sea ice with a 10x10 km sized image to 95% vs. 50% using climatology.

11:00

Effect of grid resolution on ocean simulations in the sub-polar North Atlantic and Canadian Arctic using NEMO and AGRIF

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The Nucleus for European Modelling of the Ocean (NEMO) framework allows for high-resolution sub-domains by using the Adaptive Grid Refinement In Fortran (AGRIF) package. Using AGRIF inside an ocean simulation can better resolve smaller scale features that might have been resolved less accurately in the parent domain. The computational costs associated with AGRIF are not insignificant; however, the high-resolution region is user selected and not the entire domain, making AGRIF simulations considerably cheaper computationally than simulations of similar resolution across the entire domain. We used AGRIF to produce high-resolution simulations nested in the region of the sub-polar gyre, as well as the Canadian Arctic Archipelago. We explored the differences between simulations using AGRIF to achieve $1/12^o$ localized resolution, and simulations with $1/4^o$ and $1/12^o$ resolution across the entire domain. We focused our comparison on the volume, heat and freshwater transports across a number of observational sections (which were used for validation). We examined transport by water mass to characterize hydrography of the regions. Finally, we looked at other relevant fields such as sea ice, mixed layer depth and eddy kinetic energy.

11:15

Solving the sea ice momentum equation using Newton's method: Non-linearity, numerics and convergence.

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Current numerical sea ice models struggle when dealing with high resolution simulations. It is hypothesized that the strong velocity gradients present in fracture zones slow down the convergence of numerical solvers by accentuating the non-linearity in the sea ice momentum equation. This results in increased computational time, often preventing models from reaching properly refined solutions. Errors in the sea ice velocity field impact both ice cover and thickness and can in turn propagate to significantly affect weather forecasts. In order to address this issue, new numerical solvers are being considered for the sea ice momentum equation. The use of a Jacobian free version of Newton's method has allowed models to solve the equation for a velocity field more rapidly. In this presentation, the analytical Jacobian of the sea ice momentum equation will be introduced, along with preliminary results obtained by using it with Newton's method in a one-dimensional sea ice model. The advantages it provides for convergence and reliability will also be discussed.

11:30

A basal stress parameterization for modeling landfast ice

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Current large-scale sea ice models represent very crudely or are unable to simulate the formation, maintenance and decay of coastal landfast ice. We present a simple landfast ice parameterization representing the effect of grounded ice keels. This parameterization is based on bathymetry data and the mean ice thickness in a grid cell. It is easy to implement and can be used for two-thickness and multi-thickness category models. Two free parameters are used to determine the critical thickness required for large ice keels to reach the bottom and to calculate the basal stress associated with the weight of the ridge above hydrostatic balance. A sensitivity study is performed and demonstrates that the parameter associated with the critical thickness has the largest influence on the simulated landfast ice area. A six year (2001-2007) simulation with a 20-km resolution sea ice model was performed. The simulated landfast ice areas for regions off the coast of Siberia and for the Beaufort Sea were calculated and compared with data from the National Ice Center. With optimal parameters, the basal stress parameterization leads to a slightly shorter landfast ice season but overall provides a realistic seasonal cycle of the landfast ice area in the East Siberian, Laptev and Beaufort Seas. However, in the Kara Sea, where ice arches between islands are key to the stability of the landfast ice, the parameterization consistently leads to an underestimation of the landfast area.

11:45

An Anisotropic Sigma-Coordinate Sea-Ice Thermal Stress Model

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As a first step towards including thermal stress in sea-ice dynamics models, we developed a 1.5D thermal stress model that takes into account land confinement and anisotropy in thermal stress in landfast sea ice in proximity to a coastline. To simulate land confinement, the total strain of ice in the direction perpendicular to the coastline is limited from thermal expansion and contraction to the strain at the time of ice landfast onset. The simulated stresses match best the observation, when a Young's Modulus of 0.5 GPa and a relaxation time constant of 8 days are used. This simulation gives root mean square errors of 12.5 kPa and 11.9 kPa in major and minor principal stresses, respectively ($\approx$ 30 % of observed stresses). The simulated anisotropic component of thermal stress induced by land confinement also matches well with the measured data. The optimal Young's Modulus is in the low range of reported values in the literature and the optimal relaxation time constant is much larger than reported values (8 days compared to 5 days). Three simulations are done as a sensitivity study: with a linear snow and ice temperature profile, with a degraded

vertical resolution, and without snow cover. Results report the errors in the principal stresses increase by using a linear temperature profile and no snow due to the amplitude of short term stress fluctuations caused by synoptic scale temperature perturbations increase. This highlights the importance of properly simulating the internal snow and ice vertical temperature profile.

10:30

Physical Aggregation of Buoyant Trichodesmium spp. Colonies through Eddy/Wind Interaction: Observations and Modeling

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Abundances and distributions of Trichodesmium colonies of raft, puff, and bowtie morphologies were observed by Video Plankton Recorder in fall 2010 and spring 2011 in the southwestern North Atlantic. Raft abundances peaked highest in the water column, with consistent near-surface maxima. In fall 2010, patches of elevated near-surface raft abundance coincided with cyclonic eddies, in contrast to the association of Trichodesmium colonies with anticyclones previously observed farther north in the subtropical North Atlantic. Physical aggregation through Ekman flux convergence was proposed as a mechanism producing elevated Trichodesmium raft abundances in cyclones. This mechanism was evaluated through simulations of a buoyant tracer, representing Trichodesmium rafts, in cyclones and anticyclones with and without eddy-wind interaction. Simulations confirmed the potential of the eddy/wind interaction to produce abundance patterns similar to observations.

10:45

High resolution spatio-temporal patterns of surface CDOM in the Strait of Georgia, BC

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Ocean Networks Canada's coastal cabled observatory, VENUS, includes a suite of oceanographic and meteorological instruments aboard the BC Ferries vessels Queen of Alberni (QofA) and Spirit of Vancouver Island (SOVI). The QofA transits the Strait of Georgia (SoG) eight times a day between Nanaimo and South Vancouver, BC (≈50 km); while the SOVI travels to the south from Sydney through the Gulf Islands and across the SoG to South Vancouver. An additional northerly route between Nanaimo and North Vancouver will be installed in March 2015. Underway sea surface measurements (every 10 seconds) include temperature, salinity, oxygen, chlorophyll a, choromphoric dissolved organic matter (CDOM) and turbidity, as well as standard meteorological measurements. These highly resolved spatial time-series measurements are freely available online (oceannetworks.ca) in near real time. The QofA data set in particular, is unique because it crosses from oceanic waters in the west and into the Fraser River plume in the east. Variation of CDOM in the SoG is highly correlated with salinity since the dominant source of CDOM is Fraser River freshwater discharge. Concentrations of CDOM increase from late winter and peak several weeks prior to the freshet (early June). Thereafter, CDOM input and sea surface concentrations decline. Here we examine seasonal trends in the CDOM-salinity relationship to identify spatial residual

patterns. Negative residuals in the low salinity plume center were found during the winter and are most likely indicative of salinity induced flocculation and sorption; while positive residuals at low salinity during the summer indicate photo-degradation at the surface.

11:00

The Changing Arctic Ocean: new environments conducive to algal blooms

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Sea ice strongly influences the dynamics of primary producers in the Arctic. In late spring-early summer, the snowmelt results in the formation of melt ponds on the surface of the sea ice that can be colonized by unicellular algae. Subsequently, the gradual melting of sea ice stabilizes the upper water column and increases the quantity of light reaching the surface, leading to the development of phytoplankton blooms. Due to global warming, these phenomena occur earlier in the season and on a larger spatial scale. To better quantify these effects, chlorophyll a (chl a) concentrations and primary production were measured in melt ponds, located on first year ice, at ice edges and under the sea ice, in Lancaster Sound (Canadian Arctic) between 17 and 23 July 2014. The algal biomass and productivity were dominated by small cells (0.7-5 μm) in melt ponds and by large cells (>5 μm) in the water column under the ice and at the ice edge. In melt ponds, despite low algal biomass (<0.5 mg chl a m-3), primary production rates were relatively high with values ranging from 2 to 25 mg C m-3d-1. In the water column, primary production and chl a biomass ranged from 94 to 1289 mg C m-2d-1 and from 24 to 51 mg m-2, respectively. Maximum values were measured under the ice and at the ice edge on the western end of Lancaster Sound. These new measurements show the high diversity of primary production sources and their relative importance in Lancaster Sound.

11:15

Origin of the subsurface anomaly of dissolved methane in seawater on the Baffin Bay and Labrador shelves

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Punshon et al. (2014) reported a subsurface maximum of dissolved methane in the west Davis Strait, North Atlantic Ocean and further suggested that this methane anomaly originated from hydrocarbon seeps on the east shelf of the Baffin Island. During the 2013 and 2014 ArcticNet cruises, we confirmed the presence of this anomaly (up to 50 nmol/L) in a broader area on the Baffin Bay and Labrador shelves. In the meantime, highly elevated methane concentrations (up to 300 nmol/L) were observed in the bottom waters of the Scott Inlet shelf, where active seeps were detected by echosounder scanning and remotely-operated-vehicle surveillances. Based on water

mass properties and extremely slow microbial methane oxidation (turnover times: 170-870 d), we hypothesize that the subsurface methane anomaly on the Baffin Bay and Labrador shelves could be attributed to the southward advection of the seeps-derived methane on the Scott Inlet shelf by the Baffin Island and Labrador Currents.

11:30

How does iron accumulate in Antarctic sea ice?

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In situ measurements of bioavailable iron in Antarctic sea ice reveal concentrations of at least an order of magnitude higher than in the underlying ocean. It is believed that this iron store is in excess of ice algal demand. Hence, ice algae are generally not iron limited. This is in contrast to vast areas of the Southern Ocean, a well-known HNLC region (High Nutrient Low Chlorophyll), where iron limitation is an established constraint on primary production. Thus, sea ice melt serves as an important source of bioavailable iron to upper ocean phytoplankton. The mechanisms, however, by which iron accumulates in sea ice are not well understood. In particular, how important is the role of sea ice physical processes versus biogeochemistry? Here we address this question with a modeling study of Antarctic algal production using the Los Alamos sea ice model (CICE) with a vertically resolved ice-algal component. The model determines ice-ocean tracer fluxes and internal ice transport using dynamic solutions of the ice microstructural state. In addition to a bioavailable iron pool, the biogeochemistry component solves for concentrations of dissolved organic matter, multiple algal types, and macronutrients.

10:30

Aerosols effects on Numerical Weather Prediction through impacts to the microphysics.

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Precise numerical treatment of the effects of aerosols on cloud systems has proven challenging due to the complexity of aerosolcloud- precipitation interactions. This study describes the implementation, sensitivity tests and results of a new representation of aerosols into the two-moment Milbrandt-Yau (MY2) bulk microphysics scheme using the Global Environmental Multiscale (GEM) NWP model. The scheme has been updated in order to incorporate a climatology of aerosols, that can serve as Cloud Condensation Nuclei (CCN), to initialize the concentration of cloud droplets in the model. High-resolution (2.5-km horizontal grid spacing) simulations, using the 3D GEM atmospheric model over various domains in North America, were performed to test the scheme and examine the sensitivity of aerosols effects on short-term weather forecasts, including sensitivity experiments using different aerosol number concentration.

10:45

A Stochastic Bulk Rate Parameterization Driven by a Turbulent Collision Kernel

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Collision and coalescence of cloud droplets to form precipitating rain droplets is a poorly understood area of cloud microphysics. Detailed models of collision and coalescence are prohibitively expensive because the length scales of these processes and the grid sizes of climate models differ by several orders of magnitude. Bulk models were introduced forty-five years ago (Kessler 1969) and can affordably evolve the droplet size spectrum through collision and coalescence. However, they generally require postulating an assumed droplet distribution, and they also rely on the inclusion of ad-hoc (or tuning) parameters to address the closure issue. A stochastic bulk rate parameterization that avoids the use of any specific apriori distribution and includes only physically meaningful parameters has been derived. A droplet distribution is assumed to exist and to have a spectral mean. Fluctuations about this mean are modelled as stochastic processes over time. The moments of these processes are physically meaningful parameters in the bulk rate equations. The values of these parameters are acquired from data. This new bulk rate parameterization, possibly the first stochastic one, can accommodate complex kernels such as the turbulent kernel first proposed by Saffman and Turner (1956) and corrected and expanded upon by Wang et. al. (1998). Results are presented.

11:00

A comparison of direct and bulk calculations of entrainment and detrainment in a high resolution simulation of tropical convection.

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A technique to directly calculate the individual cloud entrainment and detrainment rates is used in a large-eddy simulation of deep tropical convection based forcings measured during the GATE (GARP Atlantic Tropical Experiment) Phase III field program. The model run covers an area of 86.4 km x 86.4 km and uses 1728 x 1728 x 512 grid points with 50 m grid spacing. The simulation reaches a state of quasi-equilibrium in 9 hours, and the next three hours of the simulation were used for the analysis. We analyze the directly measured cloud mass entrainment and detrainment rates of the individually tracked shallow and deep clouds for a range of cloud size distributions. The study presents a realistic model of the shallow and deep convective clouds using a high-resolution large-eddy simulation, and compares the usual bulk entrainment rate, calculated using budgets for conserved thermodynamic parameters, to the total entrainment rate, calculated by summing the directly measured entrainment rates of the individual clouds. A number of current entrainment parameterization schemes use mean cloud properties such as the cloud radius and height to parameterize the bulk entrainment rate, we interpret these relationships using our new joint distribution of cloud size and individual cloud entrainment rates.

11:15

Sub-cloud plumes and cloud-plume interactions in the marine boundary layer.

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Correctly representing the transition from shallow to deep convection in large scale atmospheric models requires an understanding of the environmental factors that control the growth of moist and dry plumes. Precipitation from shallow marine clouds plays a significant role in organizing sub-cloud convection through evaporatively-driven cold pools that determine the ability of sub-cloud plumes to overcome convective inhibition and initiate moist convection. We use large eddy simulations run at 25 meter resolution with 3dimensional plume tracking to quantify the size distribution of sub-cloud plumes that are able to overcome convective inhibition and become clouds. This analysis allows us to to determine plume-cloud transition probabilities for precipitating and non-precipitating marine boundary layers.

11:30

GABLS4: An Inter-comparison Case to Study the Stable Boundary Layer On the Antarctic Plateau

Eric Bazile[1], *Patrick Le Moigne*[1], *Fleur Couvreux*[2], *Christophe Genthon*[3], *A.A.M Holtslag*[4], *Gunilla Svensson*[4]
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Within GABLS (GEWEX Atmospheric Boundary Layer Study), inter-comparison studies focus on boundary-layer parametrisation schemes in use by numerical weather prediction and climate models. In polar regions and under stable stratifications, models still present large biases that are dependent on the parametrisations used for the surface and the boundary layer (Holtslag et al, 2013, BAMS). The fourth GABLS case aims at studying the interaction between the boundary layer and the surface in strong stability and during the diurnal transition focussing on the decrease of the turbulence. For those topics, a surface with a low conductivity and a high cooling potential, such as snow (glacier), is more accurate. The site of DomeC on the Antarctic Plateau was chosen for the availability of the in-situ measurements, the flat topography and the homogeneity of its surface. The boundary layer observations are retrieved from a 45m tower with 6 levels of sensors measuring temperature, wind and humidity (Genthon et al, 2013) and turbulent fluxes. The radiative fluxes and the temperature in the snow pack are also available. In fact, the case will consist of 3 inter-comparisons : Single Column Model (SCM), Large Eddy Simulation (LES) and land-snow model (LSM). It is organized in two phases. The first one is dedicated to the LSM and the SCM with an interactive surface (snow) scheme. Then, in the second one, the observed surface temperature will be prescribed in the SCM and in the LES models. The setup of the GABLS4 case is available since July 2014 and the first GALBS4 workshop is planned for May 2015 in Toulouse, France. The preliminary results, comparisons and discussions from the Toulouse workshop will be presented. More details are available on the GABLS4 web page (http://www.cnrm.meteo.fr/aladin/meshtml/GABLS4/GABLS4.html).

11:45

Grand Banks Fog

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A recent Hibernia Management Development Corporation (HMDC) sponsored Workshop on Meto-

cean Monitoring and Forecasting for the Newfoundland & Labrador Offshore held 22-24 September 2014, identified reduced visibility or fog and high seas as being the most significant metocean issues affecting operations in this area. Reduced visibility affects helicopter and surface vessels supplying the oil-producing Jeanne-D'Arc Basin some 340 kilometers east-southeast of St. John's in some 80 m to 100 m of water. Recent discoveries of hydrocarbons in the Flemish Pass, some 500 km east of St. John's, and in deeper water (e.g. some 1000 m), have led to increased exploration drilling in that area. Grand Banks Advection Fog, formed by warm Gulf Stream air flowing over the cold water of the Labrador current occurs quite frequently, with a peak frequency of 50% of the time (1/2 nautical mile or less) at the Hibernia Platform in August and a minimum frequency of 10% in February, as calculated from MANMAR data from 1997 to 2014. Note that the visibility should be greater than 1/2 nautical mile before a helicopter can do a landing approach to an offshore platform. The current techniques used to forecast such fogs are not well established or even verified. The mechanisms of Grand Banks Fog formation and dissipation are not well understood and there have been very few studies related to this topic. Illustrations of some unique data recently collected, and the forecasting techniques (e.g. NWP, satellite and rules based) currently being tested, will be given in this presentation. A brief description of possible future research plans will also be presented.

13:30

Monitoring and Predicing the meridional Propagation of the 30-60-day Variability of Precipitation in the East Asian Subtropical Summer Monsoon Region

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The meridional propagation of the 30-60-day intraseasonal variability (ISV) of precipitation in the East Asian subtropical summer monsoon (EASSM) region and its monitoring and prediction are investigated in the current study. Based on a multivariate empirical orthogonal function (MV-EOF) analysis of precipitation and relative vorticity at 700 hPa in East Asia, a bivariate index referred to as the EASSM-ISV index is designed using the two leading MV-EOF modes, with the objective of real-time monitoring the 30-60-day variability of precipitation in the EASSM region. It is found that this index, with its eight phases, can well explain the meridional propagation of the 3060- day ISV in precipitation and circulation in the EASSM region. Based on a singular value decomposition technique, a statistical forecast model is developed in which the EASSM-ISV indices from the preceding five pentads are used to predict the indices in future five pentads. Meanwhile, the indices are used to predict the meridional propagation of the 30-60-day precipitation anomaly in the EASSM region. This model thus provides a useful tool for intraseasonal prediction of precipitation during the raining season in China.

13:45

Simulation of MJO and Monsoon ISO in an aquaplanet GCM with a stochastic multicloud parameterization

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The representation of the Madden-Julian oscillation (MJO) and Monsoon variability on the intraseasonal time scales (ISO) is still a challenge for numerical weather prediction and general circulation models (GCMs) because of the inadequate treatment of convection and the associated interactions across scales by the underlying cumulus parameterizations. One new promising direction is the use of the stochastic multicloud model (SMCM) that has been designed specifically to capture the missing variability due to unresolved processes of convection and their impact on the large-scale flow. The SMCM specifically models the area fractions of the three cloud types (congestus, deep, and stratiform) that characterize organized convective systems on all scales. The SMCM captures the stochastic behavior of these three cloud types via a judiciously constructed Markov birth-death process using a particle interacting lattice model. The SMCM has been successfully applied for convectively coupled waves in a simplified primitive equation model and validated against radar data of tropical precipitation. In this work, the authors use for the first time the SMCM in a GCM. The authors build on previous work of coupling the High-Order Methods Modeling Environment (HOMME) NCAR GCM to a simple multicloud model. The authors tested the new

SMCM-HOMME model in the parameter regime considered previously and found that the stochastic model drastically improves the results of the deterministic model. Clear MJO-like structures with many realistic features from nature are reproduced by SMCM-HOMME in the physically relevant parameter regime including wave trains of MJOs that organize intermittently in time. More interestingly, when a warm pool like SST profile is imposed off the equator the model produces a realistic monsoon trough-like circulation about which synoptic and intraseasonal oscillations fluctuate. The have the physical features of westward moving Indian monsoon low pressure systems and intraseasonal dry and wet spells, respectively.

14:00

Summer Arctic Sea Ice Intra-Seasonal Predictability Using a Vector Auto-Regressive Model

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Recent Arctic sea ice changes may have important societal and economic impacts and also may lead to adverse effects on the Arctic ecosystem, weather and climate. Understanding the predictability of Arctic sea ice melting is thus an important task. A Vector Auto- Regressive (VAR) model is evaluated for predicting the 1979-2012 summer time (May through September) daily Arctic sea ice concentrations. The cross-validated forecast skill of the VAR model is superior over persistence at lead-times of 20≈60 days, especially over marginal seas. In addition to capturing the general seasonal melt of sea ice, the VAR model is also able to capture the inter-annual variability of the melting and September sea ice extent minimum. While the detailed mechanism leading to the high predictability of intraseasonal sea ice concentration needs to be further examined, the study reveals for the first time that Arctic sea ice concentration can be predicted statistically with reasonable skills at the intra-seasonal time scales, a first step in bridging the gap between weather and climate forecast towards seamless prediction.

14:15

Subseasonal variability of precipitation in China during boreal winter

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Subseasonal variability of precipitation in China is analyzed using pentad data for the Northern Hemisphere extended winter (November to March) from 1979 to 2012. Two leading modes are EOF1, a monopole in South China, and EOF2, a meridional dipole structure with opposite precipitation anomalies over the Yangtze River Basin and the coastal area of South China. In space, EOF2 represents a southeastward propagation of the precipitation anomaly from EOF1. In time, principal component (PC) time series associated with EOF1 and EOF2 are significantly correlated when PC2 lags PC1 one pentad, indicating a phase shift from EOF1 to EOF2. EOF1 is associated with MJO phase 3 (equatorial convection centered near 90^{o}E), while EOF2 is related to MJO

phase 5 (convection centered around 120^{o}E), but MJO contributes generally $<$10% of subseasonal precipitation variability in South China. These EOF modes are more closely associated with MJO-independent tropical convection and mid-latitude cold surge processes. Two significant precursors for EOF1 two pentads in advance are found: a southeast-northwest tilted OLR anomaly with a large positive (negative) center in the Maritime Continent (the Caspian Sea) and a negative SAT anomaly centered in Siberia. These two preceding signal sources may provide positive predictability skill for the subseasonal variability of wintertime precipitation in China.

14:30

A Bayesian Modeling Framework for Tornado Occurrences in North America

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Tornadoes represent one of nature's most hazardous phenomena that have been responsible for significant destructions and devastating fatalities. Here, we present a Bayesian modeling approach for elucidating the spatiotemporal patterns of tornado activity in North America. Our analysis shows a significant increase in the Canadian Prairies and the Northern Great Plains during the summer, indicating a clear transition of tornado activity from U.S. to Canada. The linkage between monthly-averaged atmospheric variables and likelihood of tornado events is characterized by distinct seasonality; the convective available potential energy is the predominant factor in the summer; vertical wind shear appears to have a strong signature primarily in the winter and secondarily in the summer; and storm relative environmental helicity is most influential in the spring. The present probabilistic mapping can be used to draw inference on the likelihood of tornado occurrence in any location in North America within a selected time period of the year.

14:45

Is There An Economic Advantage to Increased North Slope Navigability?

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The rapid decline of summer sea ice in the Arctic, particularly since 2007, has already brought about an increase in human activity near the ice edge, particularly in shipping. The length of the ice season remains highly variable. Even in summer, hazardous conditions impact navigability and safety. (the experience of Shell's Kulluk rig in summer 2012 is a cautionary tale.) The Beaufort-Prudhoe Bay shipping route has been crucial to operations in the Prudhoe Bay oil fields; while some materials can be flown in or trucked in via the Dalton Highway, barges are needed for the heaviest and bulkiest loads. Barges were also critical for development of the oil field in 19751976 and, more recently, the creation of Northstar Island in 2012. Using a reduced form model, we investigate the factors which govern the length of the shipping season, and then estimate effects of climate variance

on the shipping season and the associated costs and risks by applying the Black-Scholes Option Pricing formula to the ice edge variability.

13:30

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. 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 outline the state of the project at present and highlight some of the interesting preliminary results coming out of the project.

13:45

Modelled variations of deep convection in the Irminger Sea during 2003-2010

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We investigate the interannual variability of deep convective mixing in the Irminger Sea for the period between 2003 and 2010 using a high-resolution sea ice-ocean model. Simulated deep convection shows large interannual variability in good agreement with mooring data and argo floats. The interannual variability of the deep mixing is linked to the variability of the atmospheric forcing. Our analysis showed that the Western Tip Jets directly influence the deep convection area and are responsible for a large fraction of the total wintertime ocean heat loss during active convective years. The model reproduces a strong and narrow cyclonic Irminger Gyre that favoured convection by lifting the isopycnals within the gyre and by isolating the water in the center of the gyre. Combined with strong ocean heat loss by the atmospheric forcing, all conditions are gathered for deep mixing to occur during the winters of 2007-2008 and 2008-2009. The surface-forced water mass transformation showed the creation of Labrador Sea Water type in the center of the gyre. The for-

mation rate shows large interannual variability with increased volume of denser waters created for the winters of 2007-2008 and 2008-2009. Although the dense water formation in the Irminger Sea is relatively small compared to its Labrador Sea counterpart, the model is in good agreement with observation that identified the Irminger Sea as secondary location contributing to the meridional overturning system in the North Atlantic.

14:00

Pathways of Iceland-Scotland Overflow Water in the Sub-Polar North Atlantic Ocean based upon the NEMO ocean general circulation model

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Deep inflow to the sub-polar North Atlantic Ocean from the Nordic Seas across the Iceland-Scotland Ridge, combined with entrainment leads to the production of a relatively warm and salty deep water mass that contributes to the deep limb of the North Atlantic overturning circulation. This water mass circulates around the eastern part of the sub-polar gyre before being transferred to the western part of the gyre and the Deep Western Boundary Current. Although much of this transfer is believed to occur through the Charlie Gibbs Fracture Zone, it is believed that transfer occurs through other fracture zones, as well as across parts of Reykjanes Ridge. There is also export to the south directly within the eastern basin near the mid-Atlantic Ridge. Here we examine dispersal pathways of Iceland-Scotland Overflow Water in the sub-polar North Atlantic using the NEMO ocean general circulation model. Multiple configurations and experiments are used, ranging from 1/4 to 1/12 degree. The Lagrangian float tool Ariane is used to clearly identify the main pathways in the simulations.

14:15

Evolution of Baffin Bay water masses and transports in a climate change experiment including Greenland runoff

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Baffin Bay is a small water body between the Canadian Arctic and Greenland. It receives warm salty inflows from the sub-polar North Atlantic and cold and fresh Arctic waters, which it then transports south to the rest of the Atlantic. It also receives runoff from the Greenland ice sheet. This study is based on two different numerical model experiments using the coupled ocean/sea-ice general circulation model NEMO, using different atmospheric and runoff forcing for the years 1970 to 2010. One forcing set is based upon the traditional CORE inter-annual forcing devised to force ocean general circulation model. The other set comes from HadCM3 forced with an A1B climate scenario, with the climate anomalies applied to the CORE forcing using a bias correction approach. We perform a budget study examining the transports, storage and surface flux components, and their variability, in the different runs and look at the importance of runoff and atmospheric forcing in

the model response. We then look at the evolution of Baffin Bay over the next century (2010-2100) in the run forced by the A1B climate scenario.

14:30

Multiple steady solutions of the circulation in the Labrador and Irminger Seas

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A simple model of the subpolar North Atlantic can produce closed, recirculating cells in the Irminger and Labrador Seas, consistent with float data. But it can also produce an inertial solution with swift, open currents that do not recirculate. We explore this transition in a periodic channel to isolate the dynamics at work and find that weak forcing leads to the classic beta plume of linear theory, while strong forcing causes the circulation to strengthen and elongate.

13:30

Simulation of circulation and ice over the Newfoundland and Labrador Shelves

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A three dimensional ice-ocean coupled model with a 7-km horizontal resolution is developed to simulate past variability and to project future changes over the Newfoundland and Labrador Shelves. Here we present spatial and temporal variability of hydrography and circulation over 1979-2010. Daily atmospheric forcing is applied and monthly open boundary forcing is prescribed. The present model shows good skills in simulating the inshore and shelf-edge Labrador Current. The model temperature and salinity agree well with observations. Model sea ice extent compares well with observations. Based on the model results, we examine seasonal and interannual variations and secular trends for sea level, temperature, salinity, sea ice, and volume and freshwater transport.

13:45

Towards an operational 2D non-stationary hydrodynamic model of the St. Lawrence River and fluvial estuary

Pascal Matte[1], *Olivier Champoux*[2], *Yves Secretan*[3], *Jean Morin*[2], *Gregory Smith*[1], *Pierre Pellerin*[1]
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The St. Lawrence River and fluvial estuary (Quebec, Canada) is a ≈400-km freshwater stretch of the St. Lawrence system, which extends from the exit of the Great Lakes at Cornwall to the eastern tip of Orleans Island (OI) near Quebec City; it includes the Montreal archipelago as well as a series of fluvial lakes along its course. This region has a unique ecosystem and is a source of drinking water for nearly half of the Quebecers, in addition to being the site of important economic activity. Due to its importance, modeling efforts are put forward by Environment Canada to characterize this environment and monitor its evolution and quality in an operational manner. This paper presents a 2D non-stationary, finite-element hydrodynamic model of the St. Lawrence River and fluvial estuary. The model includes a drying-wetting component and is based on high density topographic data stemming from LIDAR surveys and multibeam bathymetric soundings. The finite-element grid resolution averages to 190 m. It is calibrated and validated using tide gauge data and detailed cross-sectional water level and velocity data. Flow properties exhibit significant spatial and temporal variations as a function of tides and river discharge. While the net river discharge (averaging to ≈12 000 m^3/s) can more than double on a seasonal time scale, peak values reaching more than 5 times the daily average can be observed twice a day near Quebec City, in both the upstream and downstream directions, due to the influence of the semi-diurnal tide. These flow features exhibit lateral and longitudinal variations in the model that are confirmed by field measurements. This work represents the first attempt to model the entire freshwater section of the St. Lawrence with this level of detail. This is the first step towards an operational 2D non-stationary model of the St. Lawrence River.

14:00

A Modelling Study of Coastal Upwelling on the Scotian Shelf

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Wind-driven coastal upwelling on the Scotian Shelf has important implications for the supply of nutrients to the surface layer. Two major upwelling events in the summer of 2012 were identified from the sea surface temperature (SST) observations made by the Halifax Harbour Buoy and satellite remote sensing. A multi-nested circulation model developed recently over the central Scotian Shelf (DalCoast- CSS) is used to examine the spatial and temporal evolution of the upwelling and its associated filaments. The model has four submodels downscaling from the eastern Canadian Shelf to the central Scotian Shelf using a one-way nesting method. The model is forced by tides, wind, river discharges, and heat/freshwater fluxes. Comparing with the observed SST fields and time series, the model is able to represent the development of coastal upwelling events and the characteristics of the filament on the Scotian Shelf. The modelled vertical temperature structure in the upwelling plume region is also compatible with glider observations on the Halifax Line through the Ocean Tracking Network project. Model results are also used to quantify roles of successive upwelling-favourable wind impulse, stratification, coastal irregularities, and the Nova Scotia Current on the development of coastal upwelling on the Scotian Shelf.

14:15

Using the All-Source Green's Functions to Specify Barotropic Open Water Boundary Conditions for A Regional Model

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How to specify conditions at open water boundaries of a regional ocean model is a challenge since there are no physical laws we can resort to. The radiation condition technique is a commonly practised approach in this regard. However, at its best, it can only radiate signals out of the model. It has no mechanism to let any external influences to enter into the regional domain. This presentation shows a new technique which can let the barotropic motions freely exit from or enter into a regional model domain. The new technique uses the All-Source Green's Functions (ASGF) to achieve this effect. An ASGF is a transfer function which can transfer global atmospheric and astronomic forcing fields to responses at a point of interest (POI) in terms of sea-levels and depth averaged velocities. The ASGF itself can be pre-calculated from a global model. Once it is calculated, it can be repeatedly used for any time durations of forcing fields. The ASGFs can be deployed along the open water boundaries to provide the barotropic component of the boundary conditions. This new technique will be illustrated with two examples: a linear model example and a non-linear model example. The linear model example will show how the ASGF conditions help a regional linear model to yield identical solutions that a global liner model would produce for the same region. The non-linear model example will show how the ASGF conditions and the Flather radiation boundary conditions can work together to significantly enhance the realism of the

solutions of the non-linear model.

14:30

Numerical Study of Wave-Current Interactions over the Eastern Canadian Shelf under Extreme Weather Conditions

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This study examines wave-current interactions (WCI) over the eastern Canadian shelf during Hurricane Juan in September 2003 using a coupled wave-current modelling system. The coupled modelling system is based on a three-dimensional (3D) ocean circulation model (DalCoast) coupled with a third-generation wave model (WAVEWATCH III) to enable integrating oceanic and wave processes in coastal and shelf seas. The 3D radiation stress formula and wave-enhanced vertical mixing are implemented in DalCoast to account for the effects of waves on the 3D ocean currents. In return, ocean currents modify wave fields by entering the wave action equation and changing the wind input to the wave model. The coupled wave-current system is driven by the Climate Forecast System Reanalysis (CFSR) winds. An asymmetric vortex is inserted to the CFSR winds to better resolve hurricane winds during Hurricane Juan. In addition, DalCoast is forced by tides, the net heat and freshwater fluxes at the sea surface and freshwater runoff. In comparison with in-situ wave observations, the simulated wave fields are significantly improved during and after the highest winds by accounting for the effect of currents on waves. On the right-hand side of the hurricane track, where currents are strong and almost propagate in the same direction as waves, the maximum significant wave height (SWH) is reduced by up to 18% due to the WCI. On the left-hand side of the track, the storm- induced currents are relatively weak and the maximum SWH is not affected significantly by the WCI, even though the propagation directions of waves and currents are opposite. For the effects of waves on currents, relatively strong wave-induced surface currents (up to 30 cm/s) are generated near the coast, over the shelf break and along the hurricane track, due to the strong radiation stress gradient forcing produced by hurricane Juan over these areas.

14:45

Modelling the response of Placentia Bay to hurricanes Igor and Leslie

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A three-dimensional finite-volume coast ocean model (FVCOM) is used to examine the hurricane induced response in Placentia Bay, Newfoundland. Two hurricanes chosen are Hurricane Igor (2010) and Hurricane Leslie (2012), both of which made landfall within 100 km of the mouth of the bay. The model results agree reasonably well with field observations on sea level, near-surface currents and sea surface temperature (SST). Two hurricanes feature significant different tracks, radius and maximum sustainable wind, causing the opposite shifts in inner bay circulation. Hurricane Igor overwhelms the mean inflow into the inner bay and shifts the currents to outflow. Hurricane Leslie reinforces the

inflow into the head of bay. The peak storm surge is significantly influenced by local atmospheric forcing during Leslie, but predominately due to remote forcing during Igor. The barotropic simulation retained insufficient wind energy in the surface layer, resulting in a significant underestimate of the near-surface currents, including the hurricane induced inertial oscillation.

13:30

Towards a combined surface temperature dataset for the Arctic from the Along-Track Scanning Radiometers (ATSRs)

Karen Veal[1], *Gary Corlett*[1], *Darren Ghent*[1], *John Remedios*[1]
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Model projections consistently suggest that the Polar Regions have the largest climate sensitivity to greenhouse gas increases, meaning they are likely to show larger signals than either global averages or responses in other regions. Polar observations increasingly confirm these findings, their urgency and their significance in the Arctic. It is, therefore, particularly important to monitor Arctic polar change. Satellites are particularly relevant to observations of Polar latitudes as they are well-served by low-Earth orbiting satellites. Whilst clouds often cause problems for satellite observations of the surface, in situ observations are much more sparse due to the remote locations and hostile conditions. The ATSRs are accurate infra-red satellite radiometers, designed explicitly for climate standard observations, and particularly suited to surface temperature observations. ATSR radiance observations have been used to retrieve sea and land surface temperature for a series of three instruments over a period greater than twenty years. We have combined land, ocean, and the sea-ice surface temperature retrievals from ATSR-2 and AATSR to produce a new combined surface temperature dataset for the Polar Regions. The method of cloud-clearing, use of auxiliary data for ice classification and the surface temperature (ST) retrievals used for each surface-type will be described. We will show time series of ST anomalies for each surface type. The time series for open ocean in the Arctic Polar Region shows a significant warming trend during the AATSR mission. Interpretation of this trend must take into consideration changes in open-water extent and this will be discussed. Time series for land, land-ice and sea-ice show high variability as expected but also interesting patterns. Overall our purpose is to present the state-of-the-art for ATSR observations of surface temperature change in the Arctic and hence indicate confidence we can have in temperature change across all three domains, and in combination.

14:00

Impact of observational uncertainty in determining variability and change in Arctic snow cover and sea ice extent

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A wide range of gridded snow datasets are available for climate applications (e.g. satellite and land surface model derived products). The climatologies of these snow datasets differ by as much as 50%, but their interannual variability and daily anomalies exhibit moderate correlations on both interannual and intraseasonal time scales. In this study, we identify the impact of the spread between different snow products on two climate applications: (1) the evaluation of Arctic terrestrial snow cover extent (SCE) in Coupled Model Intercomparson Project 5 (CMIP5) historical simulations, and (2) statistical analysis of relationships between observed changes in Arctic spring snow cover and summer sea ice. 'Observed' SCE was derived from three datasets: MERRA reanalysis, a

simple snow model driven by ERA-interim temperature and precipitation, and the NOAA snow chart climate data record. A comparison with CMIP5 historical simulations showed the spread in snow products (even with only 3 independent datasets) was as great as CMIP5 model spread (from 14 models) at certain points in the time series. To determine the sensitivity to inter-dataset spread in quantifying changes to the terrestrial and marine cryosphere during the satellite era (1979-2014), de-trended correlation analysis of June SCE and September sea ice concentration (SIE) was performed using the same 3 snow analyses, and 3 SIE datasets (NASA Team-2 and Bootstrap passive microwave algorithms; Hadley Centre sea ice analysis). Results were almost completely insensitive to the choice of SIE product, but the strength and significance of temporal moving window correlations between June SCE and September SIE was highly dependent on the choice of SCE dataset. Collectively, these results highlight the need to better quantify the uncertainty in current snow products to better constrain climate analyses.

14:15

Understanding the Interannual Variability of the September Sea Ice Minimum: a Dynamic Approach

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Over recent decades a reduction in the sea ice extent has been observed, with the most substantial areal losses occurring in September at the end of the melt season. Short term and seasonal forecasts of the September sea ice area currently show errors of equal magnitude to the interannual variability of the sea ice extent minimum- implying a lack in understanding of the underlying physical mechanism for this variability. We argue that a significant portion of the interannual variability is dynamically driven by the wintertime flow regime via an intensification of the transpolar drift stream leading to divergence and first year ice production in the peripheral seas of the Arctic Ocean. First year ice formed late in the season will be relatively thin due to the lack to tim remaining to grow. This first year ice is also likely to be undeformed leading to an increase in albedo when melt begins due to increased melt pond coverage. Using satellite and buoy derived velocities we backtrack the September ice edge to it's position the previous November in order to analyze the effects dynamics plays on the annual sea ice extent minimu.

14:30

A spurious jump in the satellite record: has Antarctic sea ice expansion been overestimated?

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According to the IPCC AR5, the Antarctic sea ice cover expanded during 1979-2012 at a statisti-

cally significant rate with a magnitude 1/3 as large as the rapid sea ice retreat in the Arctic. This was a substantial change from the IPCC AR4, which reported the 1979-2005 trend to be considerably smaller and statistically indistinguishable from zero. Both estimates were based on satellite retrievals that use NASA's "Bootstrap algorithm" to estimate the sea ice concentration from passive microwave radiometer measurements. The increase in trend between the two IPCC reports has generally been attributed to an acceleration in the ice advance. Here, we show instead that most of the increase occurred due to a change in the way the satellite observations were processed. The Bootstrap algorithm underwent an update in 2007 to make the dataset more consistent with a 2002-2006 record from another satellite, and the entire dataset was reprocessed with the updated algorithm. We find that this reprocessing of the Bootstrap dataset caused a previously undocumented change in the inter-calibration across a 1991 sensor transition, which caused a four-fold increase in the 1979-2006 trend. The question remains whether this undocumented change corrected an error or introduced one. Our analysis is not able to definitively answer this, but the results show that either the older dataset or the newer dataset contains a substantial and previously undocumented inter-calibration error. This suggests that numerous studies that have relied on these observations should be reexamined to determine the sensitivity to this change in inter-calibration. Implications for the uncertainty in satellite sea ice observations in both the Antarctic and the Arctic will also be discussed. Furthermore, a number of recent studies have investigated physical mechanisms for the observed expansion of the Antarctic sea ice cover. The results of this analysis raise the possibility that much of this apparent expansion may be a spurious artifact of an error in the processing of the satellite observations.

14:45

What can CMIP5 sea ice projections tell us about future navigability in Canadian Arctic Waters?

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A summertime sea ice free Arctic is commonly assumed to be when Arctic sea ice extent is less than 1 million square kilometers. In Coupled Model Intercomparison Project Phase 5 (CMIP5) simulations with anthropogenic forcing, when sea ice reaches this small extent it usually still covers a substantial portion of the Canadian Arctic sea ice domain, in particular the Canadian Arctic Archipelago (CAA). However, several previous studies have suggested a more navigable Northwest Passage through the CAA by mid-century based on certain CMIP5 simulations. The problem with these suggestions is that the CAA is a complex sea ice region with numerous narrow channels and islands that is difficult to capture with the coarse spatial resolutions commonly found in current Earth System Models (ESM). Here, we thoroughly assess the spatial and temporal representativeness of CMIP5 sea ice projections within the Canadian Arctic sea ice domain using observations dating back from 1971. We show that the timing of summer sea ice free conditions in the CAA is widely variable among models and differ from what can be extrapolated from current observational trends. In particular, we determine that the models have difficulty capturing the intricate thermodynamic and dynamic ice processes within the CAA by comparing the historical simulations with their longer

and unforced control counterpart. Our results suggest more caution is warranted with respect to the expectation of a more navigable Northwest Passage by mid-century.

13:30

Variability in Wind Forcing Drives Winter Sea Ice Drift in the Southern Beaufort Sea

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Observations of sea ice drift obtained with a large array of moored acoustic doppler current profilers (ADCP) for the winter and spring periods (January-May) of 2010 and 2011 have been analyzed to examine the response of sea ice drift to wind forcing and ocean currents over the outer continental shelf and slope of the Canadian Beaufort Sea. The short-term (5-20 days) response of sea ice drift ranges from 2.6 to 5.4% of the local wind over much of the inner continental slope, which is comparable to that in the Bering Sea and the Antarctic but larger than that in the Arctic Ocean. Sea ice drifts to the right of the local wind, at angles ranging from 10^o to 63^o. The response to wind forcing is largest near the ice edge, both over the middle portions of the slope and along the southern margins of the seasonal ice zone and during strong and steady wind of several days' duration. The large wind-driven response of ice drift observed in this study, in comparison with the Arctic Ocean proper, may result from (1) reduced levels of internal ice stress associated with the generally thin ice cover and lower areal concentration of sea ice, (2) large atmospheric drag coefficients associated with the small ice floes in areas of comparatively higher ice concentration, and (3) smooth ice bottom, caused by melting, and the associated reduction in ice- ocean drag coefficient. In more inshore areas the ice to wind coupling is reduced owing to larger internal ice stresses experienced locally due to higher ice concentrations and increased internal ice stress arising from the proximity to the landfast ice and stamukhi zone.

13:45

The role of sea ice dynamic preconditioning in recent Beaufort Sea change

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Drift and deformation of sea ice can precondition the pack for ice loss from the Beaufort Gyre. Which occurs through transport of ice to the transpolar drift, export from the central Arctic to seasonal ice zones, and mechanical redistribution of ice thickness (opening and ridging). In the last decade the Beaufort Sea has become a region of perennial ice loss with an expansive seasonal ice zone. This talk will outline the links between ice drift, deformation and recent ice loss, and present a positive feedback between ice loss, mechanical weakening of the pack and melt. Ice deformation processes are involved in maintaining the increased seasonal ice zone area in the pacific Arctic. To improve our understanding of the fate of the Arctic ice pack, there is a need to quantify the feedbacks between dynamic preconditioning and heat flux to the ice. Realistic representation of sea ice mechanical processes, including deformation and wind-stress transfer to the ice and ocean, in regional and global sea ice models is needed.

14:00

Thickness of sea ice and extreme ice features in the Beaufort Sea

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Sea ice in the Beaufort Sea has retreated strongly in recent summers, raising interest in its role for the Arctic climate and eco system, and in allowing access for shipping and offshore resources extraction both in Canada and in Alaskan waters further downstream. However, little is known about the thickness of its remaining first- and multiyear ice regimes, and the occurrence of hazardous ice features, which continue to limit the accessibility of the region for shipping and natural resource extraction. Here we present results from spring-time airborne electromagnetic ice thickness surveys performed in the Canadian Beaufort Sea between 2007 and 2015. Thousands of kilometers of various first- and multiyear ice regimes were profiled. Surveys are complemented by satellite radar imagery allowing regional extrapolation of results, and the operation of air-dropped drifting buoys. Results show large regional thickness variability with bands of first-year ice in the south and east, of heavily deformed old multiyear ice further north, and of younger multiyear ice in the Canada Basin further to the Northwest. This regional variability is hard to capture with moored ice thickness echo sounders. While the thickness of multiyear ice has generally decreased during the observation period, first-year ice thickness has changed little. Results also show the widespread occurrence of extreme ice features, defined as sections of sea ice at least 100 m long and 6 m thick. These occur both in the first-year ice regime, e.g. in near-shore shear zones, and in the band of the thickest multiyear ice originating from the coast of the Queen Elizabeth Islands. Few ice islands were also surveyed, revealing thicknesses of 20 to 30 m related to initial thickness upon calving, and length of drift period. These results are important for the design of policies and regulations for save and environmentally sustainable future offshore activities.

14:15

Seasonal Ice Loss in the Beaufort Sea: Toward Synchrony and Prediction

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The seasonal evolution of sea ice loss in the Beaufort Sea during 1979-2012 is examined, focusing on differences between eastern and western sectors. Two stages in ice loss are identified: the Day of Opening (DOO) is defined as the spring decrease in ice concentration from its winter maximum below a value of 0.8 areal concentration; the Day of Retreat (DOR) is the summer decrease below 0.15 concentration. We consider three aspects of the subject, i.e. (i) the long-term mean, (ii) long-term linear trends, and (iii) interannual variability. We find that in the mean, DOO occurs earliest in the eastern Beaufort Sea (EBS) owing to easterly winds which act to thin the ice there, relative to the western Beaufort Sea (WBS) where ice has been generally thicker. There is no significant long-term trend in EBS DOO, although WBS DOO is in fact trending toward earlier dates. This means that spatial differences in DOO across the Beaufort Sea have been shrinking over the past 33

years, i.e., these dates are becoming more synchronous, a situation which may impact human and marine mammal activity in the area. Retreat dates are also becoming more synchronous, although with no statistical significance over the studied time period. Finally, we find that in any given year, an increase in monthly mean easterly winds of $\approx$ 1 m/s during spring is associated with earlier summer DOR of 6-15 days, offering predictive capability with 2-4 months lead time.

14:30

Intense shelf-slope fluxes of particulate matter in the mid-water column of the Canadian Beaufort Sea: linkages with atmospheric, ice and ocean forcings

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The southeastern Beaufort Sea is a region characterized by extreme physical gradients and a complex sediment transport dynamics. Riverine sediment export by the Mackenzie River has increased by 50% since 2003, underscoring the need to better constrain the coupling between environmental forcings and the fate of terrigenous particles. Sea level pressure during the melt season has increased up to +4 hPa since 2007, causing an acceleration of the Beaufort Gyre and a strengthening of the coastal upwelling regime that makes the plume expand farther offshore than in the early 2000's. In parallel, the decrease in sea-ice extent and increase in late summer/fall storminess have resulted in increased wave action and current surge facilitating the potential for sediment resuspension, such as in September 2012 when the Beaufort Sea became ice free for the first time in more than 30 years. Here, we investigate the physical mechanisms that support the transfer of particulate matter across the shelf-slope interface using a 4-year time-series of mooring and sediment trap data collected as part of the ArcticNet/Industry partnership and Beaufort Regional Environmental Assessment (BREA) from 2009 to 2013. We recorded anomalously high sedimentation peaks (>2 g m-2) in fall and winter over the slope that were recorded in concomitance with the passage of Artic-born storms or following the relaxation of strong upwelling-favorable winds, two processes that could induce a displacement of sediment-laden shelf waters toward the slope. During these periods, including fall 2012, our results suggest that a combination of mesoscale eddy formation and downwelling current transported particles near the bottom at the shelf edge and in the mid-water column across the slope. Consideration of particle fluxes along with meteorological data and synchronous density time-series revealed that thermohaline convection driven by sea ice growth may act synergistically with storm winds as the main mechanisms for sediment resuspension and transport during late fall and winter.

14:45

The seasonal modification of Canada Basin Halocline Water along the Canadian Beaufort slope, Arctic Ocean

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Canada Basin Halocline Water (CBHW) resides below the surface waters and above Atlantic water in the Canada Basin of the Arctic Ocean. CBHW, located at depths of about 50-200 m, is a complex mix of meteoric water, sea ice melt, Pacific-origin water, and Atlantic-origin water (Yamamoto-Kawai et al., 2008). In temperature-salinity space, CBHW normally has a temperature maximum that is called Pacific Summer Water (PSW) around the salinity range 29-33 (Timmermans et al., 2014), a temperature minimum that is called Pacific Winter Water (PWW) around the salinity 33.1 (Coachman and Barnes, 1961), and water that warms from PWW to Atlantic water within the salinity range 33.1 to 34.8. While PWW has been observed in the Canadian Beaufort Sea (Lansard et al., 2012), both temperature-salinity (Melling et al., 1984) and geochemistry (Shadwick et al., 2011) data show that PWW is mixed with Atlantic water between the Canadian Beaufort Sea and the Amundsen Gulf. Using Industry/ArcticNet mooring data collected between 2009-2011, we apply a new method to quantify the seasonal modification of CBHW surrounding the PWW temperature minimum. We find that PWW warms in fall and cools in winter. We examine possible processes that could cause these seasonal changes including upwelling, mixing by sub-surface eddies, and the periodic intrusion of Beaufort Shelf Winter Water as it is advected from the shelf to the slope.

13:30

The effect of permafrost disturbances on carbon-dioxide exchange in a high arctic tundra ecosystem

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The Arctic is estimated 50% of worldwide below ground organic carbon. As ground temperatures increase due to global climate change, this formerly frozen organic carbon becomes available when thermokarst disturbances expose soil for microbial decomposition. On Fosheim Peninsula, Ellesmere Island, disturbances commonly take the form of retrogressive thaw slumps (RTS). We determined the net ecosystem exchange (NEE) of a typical RTS and how NEE over a RTS compares to NEE measured simultaneously from undisturbed tundra. Using a dual eddy covariance sampling approach with two towers, we measured carbon-dioxide fluxes continuously from a RTS and from undisturbed control tundra. Net ecosystem exchange (NEE) measured during the growing season of 2014 indicates the control tundra acts a small net sink (NEE = -0.12 g C m-2 day-1); however, terrain impacted by RTS acts as a net source (NEE = +0.39 g C m-2 day-1). Seasonal trends are evident throughout the sampling season as during late June and early July control tundra acts a small source (0.08 μmol m-2s-1), before shifting to a sink (-0.28 μmol m-2s-1) for the remainder of the sampling season (July) whereas the RTS acts as a carbon source throughout the season although varying in intensity. During peak growth, the main controls on NEE are temperature and vapour pressure deficit. Data were compared with fluxes measured using a static chamber system, which we were able to partition into ecosystem respiration (Re) and gross primary production (GPP). GPP and Re from the disturbance were smaller than those from control tundra, with GPP reaching a maximum mid July. Re from the disturbance peaks early season, with values decreasing throughout July, while respiration values from control tundra peak mid July, similar to GPP values.

13:45

Greenhouse gas fluxes from a disturbed bog in the Lower Fraser Valley undergoing restoration and rewetting

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Burns Bog in the Lower Fraser Valley is a large (20 km2) disturbed raised bog ecosystem in an urban area that is currently being restored to promote ecological recovery. Restoration efforts aim at raising the water table by impeding drainage, which may change emissions and uptake of long-lived atmospheric greenhouse gases (GHGs) and, in particular, may promote methane (CH4) production. We quantified summertime fluxes of the three major GHGs, viz., carbon dioxide (CO2), CH4 and nitrous oxide (N2O) from the soil in four plots representing different stages of recovery based on

time since last disturbance. The sequence of four plots was chosen to represent an ecological recovery time series (chronosequence) from a recently disturbed site (1998) to sites disturbed in the 1960s and ≈1930, and an undisturbed reference site comprising mainly lodgepole pine trees, sphagnum moss and short shrubs. GHG fluxes between the soil surface and the atmosphere were measured using portable chamber systems and manual syringe sampling with subsequent analysis using a gas chromatograph. All ecosystems exhibited strong GHG emissions during summer months, with CH4 dominating total GHG emissions when normalized by global warming potential (GWP). The highest overall CO2 equivalent GHG (CO2e) emissions (64 g CO2e m-2 day-1) were found in a water-saturated beakrush / threeway sedge (BTS) ecosystem, which experienced continuous anaerobic conditions and actively growing vegetation. Overall, CH4 was responsible for between 71% and 97% of net CO2e emissions in the four plots, but measured CH4 fluxes were highly variable in space and time. The GHG exchange of CO2 due to photosynthesis and respiration was of secondary importance compared to CH4 fluxes. No significant emissions or uptake of N2O were found. Future efforts will identify controls to guide effective GHG emission mitigation strategies that can be considered in the bog's restoration management.

14:00

Potential future carbon uptake may overcome losses from a large insect outbreak in British Columbia, Canada

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Changes in climate due to rising concentrations of greenhouse gases in the atmosphere affect terrestrial ecosystem processes in a variety of ways. Current evidence suggests that high-latitude forests are sequestering carbon in response to increasing atmospheric CO2 and changes in climate which is gradually getting warmer and wetter. Climate change, however, can potentially also increase occurrences of both insect outbreaks and fire and these disturbances have been suggested to undermine the ability of northern forests to take up and store atmospheric carbon. Here, we use a process-based terrestrial ecosystem model for the province of British Columbia (BC), Canada to investigate the response of province's ecosystems to continually increasing atmospheric CO2 and changing climate up to 2100, as well as the recent large mountain pine beetle (MPB) outbreak that started in 1999, in a combined framework. This model's response to increasing atmospheric CO2 and changing climate has been evaluated against observation-based stem wood growth rate in coastal British Columbia. Model simulations for the historical (1900-2005) and future period (2006-2100) for three climate change scenarios suggest that positive effects of increasing atmospheric CO2 (through the CO2 fertilization effect) and changing climate can potentially more than overcome the effect of the recent MPB outbreak. Over the 1999-2100 period, the cumulative impact of the recent

MPB outbreak is simulated to be 490 teragrams (1Tg = 1 megatonne) of carbon source, whereas the natural response of the province's terrestrial ecosystems to increasing CO2 and changing climate is simulated to be around 4000 to 8000 Tg of carbon uptake depending on the climate change scenario.

14:15

Satellite-observed changes in terrestrial photosynthetic activity trends across the Asia-Pacific region associated with land cover and climate from 1982 to 2011

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Understanding how vegetation dynamics respond to climate change is a critical need for projecting future ecosystem changes and acclimation in the context of global change. The Asia-Pacific (AP) region has experienced faster warming than the global average in recent decades. We investigated the spatiotemporal changes in both trends of vegetation dynamic indicators and climatic variables (air temperature and precipitation) and analyzed their relations associated with land cover across the AP region from 1982-2011. The main findings are fourfold: (1) At continental scales the AP region overall experienced a gradual and significant increasing trend in vegetation growth (at a rate of 6.22 and 3.39 x10-4 NDVI yr-1 for Asia-Australia (AA) and North America (NA) respectively) during the last three decades, and this NDVI trend corresponded with an insignificant increasing trend in temperature ($p>0.1$, at a rate of 0.007 and 0.004 ^{o}C yr-1 for AA and NA, respectively); (2) Vegetation growth was negatively and significantly correlated with the Pacific Decadal Oscillation (PDO) index and the El Nino/Southern Oscillation (ENSO) in AP ($p=0.02$) and in AA ($p=0.008$) but insignificantly in NA ($p=0.57$); (3) Of forests and shrubland/savannas, about one third experienced a significant increasing trend in vegetation growth (forests with a decreasing trend $< 10\%$); of croplands, about half displayed a significant increasing trend in vegetation growth, and half showed insignificant changes; and (4) At pixel scales, except for Australia, both vegetation growth and air temperature significantly increased in the majority of study regions and vegetation growth spatially correlated with temperature; In Australia and other water-limited regions vegetation growth positively correlated with precipitation ($p<0.05$). Spatial distribution of changes in vegetation dynamics were characterized by fragmented and mosaic than that of climate factors.

14:30

Surface-layer dispersion: Project Prairie Grass, the turbulent Schmidt number and the flux footprint

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Models for the dispersion of trace gases in the atmospheric surface layer are important in a many contexts, being (for instance) central to inverse dispersion methods for estimating ground-air exchange. This talk concerns their correct "calibration," with a focus on the value to be assumed for the turbulent Schmidt number, i.e. the ratio Sc(0) of the eddy viscosity to the eddy diffusivity,

in the neutral limit. The most common criterion for surface layer dispersion models is the classic Project Prairie Grass (PPG) experiment, but a crucial (and rarely addressed) ambiguity is the extent to which surface deposition of the PPG "tracer" (suphur dioxide) may have affected the measurements: some authors assume Sc(0)=1 and invoke deposition; others neglect deposition, but fit PPG by invoking a reduced Schmidt number Sc(0)≈0.6-0.7, contradicting evidence from flux-gradient experiments with natural scalars (specifically, water vapour). The question of the role of deposition in PPG will be revisited, by way of simulations using a Lagrangian stochastic model with/without surface deposition, and the importance of the Schmidt number will be illustrated in reference to computing the flux footprint for interpretation of eddy covariance data.

13:30

Weather, Climate and Air Quality Observations of the Northern Latitudes from a Highly Elliptical Orbit

Ray Nassar[1], *Tom McElroy*[2], *Kaley A. Walker*[3], *Chris McLinden*[1], *Chris Sioris*[2], *Dylan B.A. Jones*[3], *Randall Martin*[4], *Yves Rochon*[1], *Louis Garand*[1], *Alexander Trishchenko*[5]
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The Arctic and adjacent northern regions are undergoing changes that have implications for Canada and the rest of the world. The proposed Polar Communications and Weather (PCW) mission aims to provide continuous meteorological observations and communications capacity over the Arctic and northern latitudes from a pair of satellites in a highly elliptical orbit (HEO) configuration. A proposed enhancement to the mission, dedicated to Weather, Climate and Air quality (WCA) observations, completed a separate Phase A study through the Polar Highly Elliptical Orbit Science (PHEOS) program. The PHEOS-WCA instrument suite would consist of a high resolution Fourier Transform Spectrometer (FTS) operating in the mid-, near- and shortwave infrared and a UV-Visible grating Spectrometer (UVS), both with 2-dimensional imaging capability. These instruments would enable dense measurements of numerous species important for understanding weather (H2O and temperature profiles), climate (column-averaged CO2, CH4), and air quality (tropospheric O3, CO, NO2, SO2, NH3, HCN, CH3OH, BrO) with a pixel size of 10x10 km2 or better and repeat time targeted at 2 hours or less. Studies have demonstrated that HEO observations of CO2 offer major advantages over those from low earth orbit (LEO) for constraining CO2 surface sources and sinks in the Arctic and boreal regions, especially in the summer when there is the potential for the release of CO2 from permafrost thaw and boreal forest disturbances. This presentation will give an overview of the PHEOS-WCA mission concept, discuss its complementarity with upcoming international satellite missions, and provide an update on recent progress and the challenges in moving forward.

13:45

MOPITT Measurements of Carbon Monoxide: What Else Can We Learn?

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On 18th December 1999 the Terra platform was launched from the Vandenberg Air Force base carrying the Measurements Of Pollution In The Troposphere (MOPITT) instrument. MOPITT has now completed more than years of operation measuring carbon monoxide (CO) over the planet and it is still working! Science does not stand still and our understanding of the measurement process has improved greatly in the two decades since the original processing algorithms were put forward. An example of this progress is shown in the analysis of data from the shortwave

channels of the instrument - initially resistant to processing due to excess noise - that has resulted in considerably more information about the lower atmosphere. This presentation will briefly look at the data processing for MOPITT so far but will also look at what might be achieved in the future One area of interest is extracting data from pixels with full or partial cloud. Currently these pixels are discarded, but could be processed to provide additional limited information in areas of active weather. MOPITT was provided to the Terra spacecraft by the Canadian Space Agency and was built by COMDEV of Cambridge, Ontario. Data processing is performed by the MOPITT team at the National Center for Atmospheric Research, Boulder, CO. Instrument control is by the team at the University of Toronto.

14:00

Cloud Semi-direct Effect 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 addition, BC exerts the so-called semi-direct effect, i.e. the influence of aerosols on clouds by directly enhancing the shortwave heating rate. The consequence of this extra heating due to BC is thought to contribute to the loss of cloud cover as it exacerbates cloud evaporation. However, how to properly calculate the semi-direct effect in climate models is an unsolved problem. Therefore, a new parameterization of cloud optical properties with a mixture of BC is proposed. It is found that the changes in cloud optical properties due to mixture of BC can be treated as a perturbation to existing cloud optical property parameterizations in climate models. The advantage of the proposed scheme is that current cloud optical property parameterizations used in climate models can be kept. The GCM simulations show that the BC semi-direct effect leads to increase in stability below and within clouds. Consequently, the global total cloud fraction is reduced and the energy balance in the atmosphere is affected.

14:15

Air Quality Prediction using Machines Learning Methods

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Air quality prediction using the Extreme Learning Machine (ELM) method is evaluated against other methods. Predictor data from Environment Canada's Updatable Model Output Statistics (UMOS) are used to produce hourly spot concentration forecast of ozone (O3), particulate matter 2.5 μm (PM2.5) and nitrogen dioxide (NO2), up to 48 h for 6 test stations across Canada. Both the batch ELM model and the online sequential ELM (OSELM) model, which is more meaningful for real time forecasting, are developed. The prediction performance of the ensemble ELM is evaluated against multiple linear regression (MLR), artificial neural network (ANN), Bayesian neural network

(BNN) and the output of UMOS. The OSELM model tends to outperform the linear models (MLR, UMOS) and is fastest among nonlinear models with comparable performance.

14:30

Refining an Inverse Dispersion Method for Sources on Undulating Terrain

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It is common practice to estimate ground-air gas fluxes (Q) from agricultural sources by inverse dispersion, placing gas concentration (C) detectors upwind and downwind from the source. In many circumstances however, topography compromises an assumption that is (normally) inherent to the inverse dispersion methodology, namely that wind statistics in the atmospheric surface layer are "undisturbed" (i.e. horizontally-homogeneous). We analysed a trace gas dispersion experiment with multiple fixed point sources on gently undulating terrain, to investigate the performance of inverse dispersion using a dispersion model (WindTrax) that encodes a Lagrangian stochastic trajectory model giving wind paths from sources to detectors. Most interestingly, results indicate that the effects of this moderate terrain on the C-Q relationship can be adequately modeled by postulating an undisturbed Monin-Obukhov flow in a terrain following height coordinate, thus permitting easy extension of a well proven method to conditions that, a priori, had been considered unsuitable. We also used the measurements to study the influence (on the accuracy of retrieved Q) of discretionary elements of inverse dispersion procedure. These sensitivity studies addressed optimal placement of detectors relative to the source(s); data rejection criteria, such as threshhold values for the friction velocity and the Obhukhov length; and exclusion of mean wind directions that confound the "upwind/downwind" concentration differences. We also investigated the impact of alternative spatial representations of the source, supposing one had but partial information in that regard.

15:30

Extended-Range Forecast of Tropical Asian Summer Monsoon

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Results from several recent studies on the extended-range predictability and prediction of Asian summer monsoon rainfall are presented. The main features discussed include the quasi-biweekly oscillation over Asia and the Indo-Pacific Oceans and the subseasonal variations of regional monsoon rainfalls over the Arabian Sea, India, the Bay of Bengal, the Indo-China peninsula, the South China Sea, and southern China. The general dependence of prediction skills on location and lead time, and the importance of air-sea interaction and land-atmosphere interaction are focused. The relative influences of remote forcing (e.g. El Nino-Southern Oscillation) and local sea surface temperature for skills of monsoon rainfall prediction are also assessed. The US NCEP Climate Forecast System output and multiple observational data sets were used in the studies.

15:45

Model skill and sensitivity to initial conditions in a sea-ice prediction system

Edward Blanchard-Wrigglesworth[1], *Richard Cullather*[2], *Wanqiu Wang*[3], *Jinlun Zhang*[4], *Cecilia Bitz*[1]
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We explore the skill in seasonal forecasts of September Arctic sea-ice extent in dynamical models that are members of the Sea Ice Outlook. We find that the multi-model ensemble only offers skill for the latest summer submission in August, and that throughout the forecasting period skill is lower than that found in hindcasts of sea-ice extent performed during earlier periods of the modern satellite record. The model-mean ensemble offers slightly higher skill, but does not beat a damped persistence forecast. We also find that the models are equally unsuccessful at predicting each other, indicating a large divergence in model physics and/or initial conditions. Motivated by this, we perform an initial condition sensitivity experiment with four Sea Ice Outlook dynamical models. We apply a fixed perturbation to the initial conditions of minus one meter sea ice thickness anomaly, and find that the response varies significantly across models. This suggests that different model physics across the Sea Ice Outlook make a significant contribution to model uncertainty and forecast skill degradation. Finally, we explore whether the recent Sea Ice Outlook years have been inherently more unpredictable than past decades with the use of an idealized experiment.

16:00

The Climatologically relevant singular vector and its application in climate predictions

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In this talk, an efficient technique for the extraction of climatically relevant singular vectors (CSV) in the presence of weather noise is introduced. Emphasis is placed on the applications of the CSV in seasonal climate predictions. First, the CSV method is validated by an intermediate ENSO model. The results show that the algorithm is an effective and robust method for the calculation of the climatically relevant singular vectors of CGCM. Then, this algorithm is applied to several important high-impact events of air-sea interaction to study their seasonal climate predictability using CGCMs, including ENSO, South Asian Monsoon, and the seasonal climate anomalies over China. The CSV-based ensemble technique is developed and evaluated for these CGCMs. The results indicates that the CSVs can well characterize the optimal error growth of the predictions of these events, and all CSV-based ensemble predictions have better skill than traditional time lag ensembles (TLE). This suggests that the CSV method be effective and significant in improving the seasonal climate prediction, and should be used in operational ensemble climate predictions.

16:15

Interdecadal Variability of the mega-ENSO-NAO Synchronization in Winter

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Mega-El Nino Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO), as two principal components of the global air-sea coupling system, may have synchronous or out-synchronous fluctuations during different epochs. Understanding such connection change is instrumental for climate prediction, particularly the decadal prediction. Results in this study show that mega-ENSO has experienced a notable inter-decadal change in its linkage with the winter NAO during the past 56 years: mega-ENSO was significantly correlated with the NAO during 1957.1981 (or synchronous epoch), while such correlation has broken down since 1982 (or out- synchronous epoch). This marked change might be attributed to a sea surface temperature (SST) forcing change in the North Atlantic, based on the observational and numerical evidences in this study. The synchronous epoch is concurrent with the anomalous tropical North Atlantic (TNA) SST forcing, whereas the out-synchronous epoch is associated with the anomalous extra-tropical North Atlantic (XNA) SST forcing. Two possible reasons may explain how the synchronous behaviors between mega-ENSO and the NAO were tied to the TNA SST anomaly (SSTA). There is a positive feedback between the TNA SSTA and the NAO-like atmosphere anomalies, which helps to "prolong" the NAO impacts from the developing phase through mature phase of mega-ENSO. Additionally, the TNA SSTA itself may induce a NAO-like atmosphere anomaly. Since 1982, the TNA SSTA has been replaced by the XNA SSTA and the latter primarily favors a NAO-neutral state in the atmosphere, which

ends the synchronous epoch.

16:30

Determinants of Summer Weather Extremes over the Canadian Prairies: Implications for Long Lead Grain Forecasting

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Summary: To assess the drivers of weather extremes over the Canadian Prairies, a data matrix of 20 predictor and 11 predictand types was created at the monthly timeframe to explore drought severity, summer precipitation, and summer temperature. Applying composite, correlation, and regression techniques, a comprehensive data analysis produced a suite of composites and regression models for providing climatic outlooks a few weeks to a few months in advance of the critical May-July growing season for spring wheat. This was done for the Prairies as a whole and for four agricultural ecological (agro-eco) zones. Among the most important predictors were the Madden Julian Oscillation (MJO) (a tropical atmospheric oscillation between 20^o E. to 10^o W. longitude) and Pacific Decadal Oscillation (PDO) a slow moving oscillation covering the entire Pacific Basin both linking large scale predictors and solar parameters like the Averaged Planetary Index (API). An empirical approach, using accumulated monthly values of atmosphere-ocean indices, provides useful guidance for the forecasting of summer precipitation and temperature and hence grain yields with a lead-time of a few weeks to a few months.

16:45

GEM-NEMO global coupled model for subseasonal to seasonal predictions

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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. In this presentation, the model configuration is introduced. A multi-decade integration is analyzed. We focus on the model systematic error, the interannual variability of the tropical Pacific sea surface temperature (SST) which represents the ENSO variability, and the association of extratropical teleconnections in response to the ENSO. It is found that the model can produce a reasonable distribution of the SST variability but the amplitude is too weak comparing to the observations. Several sensitivity experiments are conducted in order to improve the ENSO simulation. Atmosphere-only GEM integration is also performed over multiple decades, in order to understand the behavior of climate integration of the GEM model and to compare with the GEM-NEMO coupled integration.

15:30

Historical and Recent Hydrographic Variability in the Labrador Sea, and Larger-Scale Linkages

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Variability in temperature, salinity, density and dissolved oxygen (DO) in the Labrador Sea, and its importance to the larger-scale Northwest Atlantic, are described using a combination of vessel, Argo float and moored measurements. The time-depth evolution of temperature and salinity in the central LS, going back to OWS Bravo sampling, is updated using Argo profiles and annual survey observations from DFO's Atlantic Zone Off-shelf Monitoring Program. Time series and time-distance displays for various layers are used to show the cross-basin evolution of anomalies on interannual to decadal time scales. Upper-layer freshening events spread across the Labrador and Nordic Seas in 2008-2010 and 2011-2014, with strongest signals in the coastal and slope waters. Potential linkages to the high recent melt rates of the Arctic and Greenland ice covers, and effects on stratification and mixing with deeper waters, are discussed. Over the past two decades the Labrador Sea's lower intermediate layer (1000-2000 m) has steadily become warmer and saltier. However, this has occasionally been interrupted, such as in the winters of 2008-2009 and 2013-2014 when enhanced wintertime convection mixed the accumulated fresher (and warmer) upper-layer water into the lower intermediate layer, leading to the formation of two new year- classes of Labrador Sea Water. Dissolved oxygen (DO) profiles confirm associated oxygen ventilation, with intermediate-layer concentrations increasing after deep-convection events. In the Sea's abyssal layer which is mostly occupied by the Denmark Strait Overflow Water transported through the region by the Deep Western Boundary Current, there was an unprecedented increase in salinity, temperature and density between 2000 and 2010. Its causes and possible effects on the dynamics of the deep waters are discussed together with its upstream and downstream linkages. Collectively, these changes indicate that the Labrador Sea remains an active contributor to the Atlantic Meridional Overturning Circulation, but with strong decadal-scale variability.

15:45

Impact of Greenland Melt on the East and West Greenland Currents and the North-West Labrador Sea

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Greenland melt is an important freshwater source in the Atlantic subarctic region. The associated buoyancy flux delivered into the East and West Greenland Currents may have a big impact on the dynamics of the coastal current system as well as downstream lateral freshwater flux exchange between the coast and interior deep basin. The lateral freshwater transport in north and west Labrador Sea has been shown to offset the surface buoyancy loss in Labrador Sea in previous studies. To study these questions, a high resolution simulation with a better representation of Greenland melt/runoff is required. In this study, we will use two NEMO based simulations using

an Arctic and Northern Hemisphere Atlantic (ANHA) configuration at 1/4th and 1/12th degree horizontal resolution. Greenland melt will be based upon the model of Bamber et al. (2012). To track the pathway of the meltwater , particularly in the Greenland coastal region and North-West Labrador sea, multiple online passive tracers will be utilized. Changes in the dynamics of the coastal currents and freshwater flux exchange will also be investigated.

16:00

Labrador Sea Water formation rate, 2002-2010, from a numerical model.

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The Labrador Sea is the coldest and freshest basin of the subpolar North Atlantic. Two fresh and cold inflows arriving from the Arctic Ocean to the North Atlantic by way of the Canadian Arctic Archipelago and the East Greenland shelf pass around the Labrador Sea margins. One of these, the Labrador Current represents the main pathway for the equatorward export of cold and fresh waters that are formed by convection in the Labrador Sea. The Labrador Sea is also a principal contributor to the lower limb of the Atlantic meridional overturning circulation (MOC). This study presents an estimate of Labrador Sea Water formation rates based upon a kinematic subduction approach by an historical reconstruction of the Labrador Sea over the period 2002-2010. The exchange through the moving mixed layer base is calculated based on exchange caused by changes in the mixed layer depth, and convergence of horizontal transport into or out of the mixed layer. Model fields were taken from a NEMO model run using the 1/4 degree Arctic and Northern Hemisphere Atlantic (ANHA4) configuration.

16:15

Using Argo-O2 data to examine the impact of deep-water formation events on oxygen uptake in the Labrador Sea

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Deep-water formation allows the deep ocean to communicate with the atmosphere, facilitating exchanges of heat as well as important gases such as carbon dioxide and oxygen. The Labrador Sea is the most studied location of deep convection in the North Atlantic Ocean. It is a strong contributor to the global thermohaline circulation, has a large economic and ecological influence on Canada, and yet we are only beginning to understand how deep convection in this location will vary with a changing climate. Convection events in the Labrador Sea show great interannual variability in magnitude, ranging from mixed layers of 100m to those greater than 1000m. Since there is no internal source of oxygen below the euphotic zone, a weakening of this deep convection starves the deep ocean of oxygen, disrupting crucial deep-sea biological processes, as well as reducing oceanic carbon uptake and ocean circulation. We used data from the extensive Argo float network to examine the impact of deep-water formation events on oxygen uptake in the Labrador Sea,

particularly a large convection event in the winter of 2007/2008. Using vertical profiles of oxygen, temperature, and salinity, we determined the change in oxygen inventory over time as well as the depth of the mixed layer and thus the depth of the deep convection event. We then compared the inventory change to the air-sea oxygen flux calculated from surface oxygen values along with NCEP wind speed data and a range of air-sea gas exchange parameterizations. This analysis highlights the expected relationship between inventory and air-sea fluxes and points toward three-dimensional complexity where they do not agree. Since oxygen exchanges at different rates than carbon dioxide, oxygen provides a different perspective on the effect of convection and air-sea exchange on gas uptake and cycling and global ocean circulation.

16:30

Recent Oceanographic Variability on the Scotian Slope and Rise, and Upstream Linkages

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Aspects of temperature, salinity, density, dissolved oxygen, currents and transport variability over the Scotian Slope and Rise are described using historical datasets, ongoing vessel observations from DFO monitoring programs on the extended Halifax line, Argo profiles, and moored measurements. The latter include near-bottom measurements of currents, hydrography and pressure across the Deep Western Boundary Current during 2004-2014, as part of the UK Rapid Climate Change program. Property distributions and variability are described in relation to upstream subpolar water masses such as Labrador Slope Water, Labrador Sea Water and Denmark Strait Overflow Water (DSOW), and to Gulf Stream variability. Time series of temperature and salinity in various layers and water depth ranges are examined for signals of anthropogenic and natural variability, but findings are limited due to strong upper-ocean seasonal variability, episodic influences of Gulf Stream meanders, and sparse deep sampling prior to the mid 1990s. Waters in the 1000-2000m depth range over the slope have gradually become warmer and saltier since the late 1990s, comparable to conditions in earlier decades. This recent change is similar to that observed over the Labrador Slope since the early 1990s, which appears to reflect a gradual recovery from the relatively cool and fresh conditions in the Labrador Sea's intermediate layer due to a period of amplified deep convection starting in the late 1980s. Nevertheless, anthropogenic warming could also be a contributor. In the deeper DSOW, there are indications of weak signals from its northern formation region reaching the Scotian Rise, but interpretation is complicated by indications of recirculations under the Gulf Stream. Estimates of recent variability in the zonally-integrated meridional transport below and relative to 1100m are provided, based on the stepping bottom-pressure method of Hughes et al. (2013, J. Atmos. Ocean Tech. 30).

15:30

The combined effect of mixing and advection for tracers within 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 global 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 through breaking of internal waves. The aim of this study is to characterize the combined effect of advection and mixing in the exchange of tracers from slope to shelf near a submarine canyon. A scaling scheme for mixing and transport of tracers within an idealized canyon during upwelling is proposed. Six non- dimensional numbers relating isopycnal and diapycnal diffusivities, initial vertical concentration gradients and curvatures, canyon length and width, depth and speed of upwelling characterize the phenomenon. Parameter space was explored with numerical simulations of an idealized upwelling canyon performed with the Massachussetts Institute of Technology general circulation model (MITgcm). The model ran in hydrostatic mode, with a horizontal resolution of 200 m within the canyon and 1 km at the boundaries; in the vertical there were 90 levels with resolution from 5 m to 200 m. Profiles for five nutrients from the Pathways Cruise 2013 over Barkley Canyon (NW Pacific) were used to find characteristic values of the non-dimensional parameters. From this case study, it was found that for all tracers horizontal advection dominates over isopycnal diffusivity, but vertical advection and diapycnal diffusivity are both relevant processes. Thus, isopycnal diffusivity may be ignored. Also, diapycnal diffusion impacts concentration faster than isopycnal processes. Horizontal and vertical relative gradients are of the same order for all tracers, but vertical second derivatives are not relevant to the tracers.

15:45

On the simulation of Algal Blooms in Lake Erie

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Lake Erie exhibited one of the largest algal blooms in 2011 caused by a combination of unique weather conditions and excessive nutrient loadings into the lake. The external forcing drivers (hydrological discharges and meteorology forcing) in this case, are assumed to have played a major role in the extent and intensity of the bloom. Hydrodynamic and water quality models applied to aquatic ecosystems allow for the simulation of the behavior of such complex processes. In this study we used a coupled 3D hydrodynamic and water quality model, which has been reasonably calibrated for Lake Erie in previous applications, in order to evaluate its capability to reproduce extreme events as the algal bloom of 2011. The modeling assumptions, findings, challenges, and recommendations for future research are presented.

16:00

Satellite Chlorophyll off the British Columbia Coast, 1997-2010

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We examine the spatial and temporal variability of satellite-sensed sea surface chlorophyll-a off the west coast of North America from 1997 to 2010, with focus on coastal British Columbia. The data were divided into 15 different regions that corresponded to commercial fishing zones. The variability in surface chlorophyll-a is shown to be complex. Amongst the 15 zones we compare the timing of the spring bloom, the timing of the peak chlorophyll abundance, and the magnitude of surface chlorophyll values. Based on these indicators we define 6 distinct surface chlorophyll regimes for the coastal northeast Pacific Ocean. The highest satellite-sensed chlorophyll concentrations occur in the Strait of Georgia, where mean values are at least two times higher than elsewhere in the northeast Pacific. Moreover, the annual average surface chlorophyll concentration has increased significantly in the Strait of Georgia from 5.9 mg m-3 in 1998 (a major El Nino year) to 8.9 mg m-3 in 2010 (a moderate El Nino year), suggesting an enhancement of biological productivity. Similarly, surface chlorophyll in the waters north and east of Haida Gwaii increased from 2.0 mg m-3 in 1998 to 2.8 mg m-3 in 2010.

16:15

The interplay of denitrification and deep-water renewal dynamics in Saanich Inlet

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Nitrogen-based nutrients limit productivity in much of the surface ocean, and yet their rates of production and removal from the ocean are poorly constrained. Denitrification and related processes in low oxygen environments transform biologically available nutrients like nitrate to unavailable N2 gas. We investigate this process using in situ sensors from the VENUS cabled observatory at mid-depth in Saanich Inlet, a seasonally anoxic fjord in British Columbia. We derive N2 excess by combining total dissolved gas pressure from a gas tension device (GTD) with dissolved oxygen measurements. We find that a previously ignored correction for the effects of hydrostatic pressure on gas partial pressures at depth significantly improves the GTD results, while calibration of the oxygen sensor is the largest uncertainty. High rates of denitrification in the bottom waters of Saanich Inlet over most of the year have been shown to generate high excess N2. During deep-water renewal events in 2012 and 2013, we observed rapidly declining oxygen and increasing N2 excess at our mid-depth location for several days. We interpret these changes as deep anoxic waters being pushed to the mid-depth sensor location by new dense water that flows to the bottom. Following each active renewal event, we describe a recovery period during which oxygen increases and N2 falls for several days. The recovery period appears to be caused by lateral mixing with new waters entering at shallower depths on the opposite side of the inlet.

16:30

Long-term variability of pH and aragonite saturation state in the Strait of Georgia

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A one-dimensional bio-physical model is used to investigate the relative importance of local variability and long-term shelf trends on pH and aragonite saturation state in the southern Strait of Georgia, British Columbia. Dissolved inorganic carbon (DIC) and total alkalinity are modeled as state variables in order to produce pH and aragonite saturation state as outputs. Hourly meteorological observations and daily freshwater fluxes are used to force seasonal-scale model behaviour, while a probability distribution of continental shelf DIC estimated from 30 years of temperature and oxygen observations is used to simulate long-term shelf variability. Near-surface pH and aragonite saturation state range seasonally from approximately 7.7 to 8.3 and approximately 0.5 to 2.0, respectively, with a persistent aragonite saturation horizon at 20 m depth which shoals to the surface in winter and during large Fraser River freshets. Long-term variability of near-surface pH and aragonite saturation state modeled using the extremes of the shelf DIC probability distribution is on the order of the seasonal-scale variability. Results highlight the roles of both local processes and larger ocean trends in producing extremes of pH and aragonite saturation state in coastal systems.

16:45

The vulnerability of the Strait of Georgia to Ocean Acidification and Hypoxia

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The Strait of Georgia (SoG), British Columbia is a relatively large (200 X 30 km) semi-enclosed basin that hosts significant aquaculture (mostly shellfish). The exchange between this basin and the Pacific Ocean is thought to occur primarily at its southern end via a number of narrow Straits, the deepest of which is Haro. Waters entering the SoG from Haro Strait (the subsurface return estuarine circulation) are heavily modified within the Haro region. Here we investigate the relative roles of O2 and CO2 gas exchange in this turbulent region in protecting the highly productive SoG from subsurface hypoxia and ocean acidification, respectively.

15:30

The climatological distribution of extreme Arctic winds, and implications for ocean and sea ice processes.

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Some of the strongest near-surface winds on Earth form in the Arctic and sub-Arctic due to intense mid-latitude cyclones and mesoscale processes, and these strong surface winds have important impacts on ocean and sea ice processes. We examine the climatological distribution of over-ocean, near-surface wind speeds within a pan-Arctic domain for 18 years (1990-2007) in four gridded datasets: the ECMWF Interim reanalysis (ERA-I), the Climate Forecast System Reanalysis (CFSR), version 2 of the common ocean-ice reference experiment dataset (COREv2), and a regional climate simulation generated using the Weather Research and Forecasting (WRF) model run at 50 km (WRF50) horizontal resolutions with ERA Interim as lateral boundary conditions. We estimate probability density functions, the annual cycle, and map the 50th and 99th percentile winds. We then perform the same statistical analysis of winds for two years when 10km WRF data are available (June 2005 to May 2007); despite the much shorter time period, the Pan-Arctic statistics are very similar to those from the 18-year analysis. We repeat the wind speed statistical analysis within a subdomain surrounding Greenland and find that WRF10 has consistently larger maximum wind speeds, but this difference only appears at wind speed percentiles higher than 99 percent. Differences in the 99th percentile wind speeds are spatially heterogeneous. An investigation of surface fluxes within WRF50 and WRF10 reveals unrealistically large sensible heat fluxes along the sea ice edge, and the geographic distribution and magnitude of these fluxes is shown to be sensitive to sea ice representation in WRF.

15:45

The Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Nunavut

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The Canadian High Arctic is very different from lower latitudes and this is particularly true for the atmosphere. The lower atmosphere has no surface solar heating term for a large portion of the year; the winter Arctic vortex and lack of sunlight produces a different and variable chemistry for the middle atmosphere and in the upper reaches of the atmosphere the interaction of the magnetic pole, charged particles and the solar wind produces unique effects. In addition, the whole region is undergoing rapid changes due to both natural and anthropogenic influences. The Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Nunavut (80N, 86W) is one of Canada's major research measurement platforms in the High Arctic. Since 2005 atmospheric measurements at PEARL have been conducted by an international team on a year-round basis using a wide variety of instruments to help us understand this environment and how it interacts with the rest of

the planet. Research at these latitudes is not easy and the challenges are many ranging from the harsh environment that rapidly degrades equipment through the financial challenges of keeping the laboratory functioning to the operational issues as basic as electricity, water and sewage. However the results are well worth the investment. This paper will give an overview of the PEARL facility. Other papers in the conference will outline the specific research in progress. PEARL is supported by the Natural Sciences and Engineering Council (NSERC), Environment Canada (EC), the Canadian Space Agency (CSA) and Dalhousie University.

16:00

Atmosphere-Ice-Ocean Interactions During Summer Melt and Early Autumn Freeze-up: Observations from the ACSE Field Program

Ola Persson[1], *Peggy Achtert*[2], *Goran Bjork*[3], *Barbara Brooks*[2], *Ian Brooks*[2], *John Prytherch*[2], *Dominic Salisbury*[2], *Joseph Sedlar*[4], *Matthew Shupe*[1], *Georgia Sotiropoulou*[4], *Michael Tjernstrom*[4], *Paul Johnston*[1]

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Surface energy fluxes are key to the annual summer melt and autumn freeze-up of Arctic sea ice, but are strongly modulated by interactions between atmospheric, ocean, and sea-ice processes. This presentation will examine direct observations of energy fluxes during summer melt and the onset of autumn freeze-up from the Arctic Clouds in Summer Experiment (ACSE), and place them in context of those from other observational campaigns. The ACSE field program obtained measurements of surface energy fluxes, boundary-layer structure, cloud macro- and microphysical structure, and upper-ocean thermal and salinity structure from pack-ice and open-water regions in the eastern Arctic from early July to early October 2014. Summer measurements showed energy flux surpluses leading to significant surface melt, while late August and September measurements showed deficits, leading to freeze-up of sea ice and the ocean surface. The deficits were at first sporadic, but daily mean net energy fluxes were consistently negative after September 15. The surface albedo and processes impacting the energy content of the upper ocean appear key to producing a temporal difference between the freeze-up of the sea ice and adjacent open water. While synoptic conditions, atmospheric advection, and the annual solar cycle have primary influence determining when energy fluxes are conducive for melt or freeze, mesoscale atmospheric phenomena unique to the ice edge region may also play a role. the variability of individual terms of the surface energy budget are examined to suggest the relative importance of the various processes.

16:15

High Frequency Temperature and Pressure Measurements in Very Stable Winter Boundary Layers at the Eureka Flux Tower

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The boundary layer in the winter high Arctic is typically very stable as a result of longwave radiative cooling and the lack of sunlight. During the frequent periods of very light surface winds traditional mixing length turbulence theory may be unable to correctly predict the fluxes between the surface and the atmosphere. Surface fluxes related to gravity waves, density currents and drainage flows can dominate. This will have important implications for understanding and predicting the magnitude of Arctic Amplification of surface temperature which is primarily a cold season effect, and for evaluating the reliability of gas fluxes between the surface and atmosphere where winter observations are typically very challenging. The flux tower at Eureka, 80degN on Ellesmere Island, has recently been modified to include a 50 Hz micro-barometer and to record the 2, 6 and 10 m air temperatures at 1 second intervals. The first results for the 2014-15 winter season will be presented. Of note is the decoupling of the pressure time series from the temperature time series. The pressure fluctuations appear to be driven by deep boundary layer height fluctuations whereas the temperature fluctuations are forced by very shallow surface flows. The implications for surface-air fluxes including sensible heat and trace gases will be discussed.

16:30

Evaluation of the Land Surface Climate in the Regional Arctic System Model (RASM)

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The Arctic region is experiencing disproportionately severe impacts due to climate change, affecting sea ice, seasonal snow cover, streamflow, permafrost, glaciers, and ice sheets as well as terrestrial and aquatic ecosystems. We use the Regional Arctic System Model (RASM) version 1.0, to better understand how changes in these processes may prompt non-linear responses and feedbacks throughout the Arctic region climate system. The net effect of these feedbacks is not easily understood without the use of coupled earth system models that allow us to evaluate the interactions between components of the climate system; determine the extent, magnitude, and sign of complex feedback processes; and to project the climate system's response to future perturbations. RASM is a high resolution, regional, coupled atmosphere - land - sea ice - ocean model that uses the Community Earth System Model (CESM) coupling infrastructure over a Pan-Arctic domain. RASM is composed of the Weather Research and Forecasting (WRF) atmospheric model, the Variable Infiltration Capacity (VIC) hydrology model, the RVIC streamflow routing model, the Parallel Ocean

Program (POP) model and the Los Alamos Sea Ice model (CICE). We evaluate RASM's abilities to capture key features of the land surface climate and hydrological cycle over the modern era (1979-present) through comparisons with reanalysis data sets, satellite estimates and in-situ observations. Of particular interest is the model's ability to capture diurnal, seasonal, and interannual variations in energetic and hydrologic fluxes and states at the land surface.

16:45

Coordinated observations of Dynamics in the Arctic Polar Mesosphere and Thermosphere: The Dynamics of the Neutral Thermosphere Project

William Ward[1], *Alan Manson*[2], *Marianna Shepherd*[3], *Qian Wu*[4], *Wayne Hocking*[5], *Young-Min Cho*[3], *Uma Das*[1], *Nayeob Gi*[1], *Samuel Kristoffersen*[1], *Chris Meek*[2], *Chris Vail*[6]
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Coordinated observations of the mesosphere and lower thermosphere at the Polar sites of Eureka and Resolute Bay were initiated in the fall of 2014 as a project termed Dynamics of the Neutral Thermosphere (through support from the Canadian Space Agency). These observations provide information on the coupling processes that link the lower atmosphere and the upper atmosphere. Analysis of observations of backround wind, temperature and airglow emissions and associated wave induced variability in the mesopause region and in the mid-thermosphere provide insights into the extent and form of this coupling. The existing instrumentation at these sites has been augmented and existing instrumentation repaired and modernized. As a result dynamical information at both locations will be observed in the meosopause region and thermosphere. Instrumentation includes a meteor radar (mesopause region winds), a red-line Fabry-Perot (thermospheric winds, airglow radiance), a field-widened Michelson interferometer (mesopause region winds and radiance), a spectral airglow temperature imager (SATI; temperature, airglow radiance) and an all-sky imager (airglow radiance) at Eureka and a multiple emission Fabry-Perot (mesopause and thermospheric winds, airglow radiance), a meteor radar (mesopause region winds) and all sky imager (airglow radiance) at Resolute Bay. The dynamical signatures observed at the two sites ($\approx$500 km apart) are being used to identify signature that are spatially correlated (horizontally and/or vertically) and to contrast and compare conditions at the two sites. Collaborations with Polardarn and RISR are also being planned. This paper describes this project and its goals and some results from the first season of observations. Data from this project is publicly available at www.candac.ca.

15:30

A Geometric Decomposition of Eddy-Mean Flow Interactions

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Understanding eddy-mean flow interactions is a long-standing problem in geophysical fluid dynamics with modern relevance to the task of representing eddy effects in coarse resolution models. Eddy momentum fluxes are captured by the eddy covariance matrix, which also encodes information about eddy size, shape, and orientation through its geometric representation in the form of the so-called variance ellipse. Exploiting this recognition suggests a potentially fruitful way forward by offering a description of eddy-mean flow interactions in terms of eddy ellipse geometry. Here we present a framework that describes eddy-mean flow interactions in terms of ellipse geometry, and illustrate it with an application to an unstable jet. We show that the eddy vorticity flux divergence F, a key dynamical quantity describing the average effect of eddies on the time-mean flow, may be decomposed into two components with distinct geometric interpretations: i) variations in the variance ellipse orientation; and ii) variations in the anisotropic part of the eddy kinetic energy, itself a function of the variance ellipse size and shape. Application of the divergence theorem shows that F integrated over a region is explained entirely by variations in these two quantities around the region's periphery. This framework has the potential to offer new insights into eddy-mean flow interactions in a number of ways. It identifies the ingredients of the eddy motion that have a mean flow forcing effect; it links eddy effects to spatial patterns of variance ellipse geometry that can potentially suggest mechanisms underpinning these effects; and finally it illustrates the importance of resolving eddy shape and orientation, and not just eddy kinetic energy, for accurately representing eddy effects.

16:00

Southern Ocean cooling in a warming world: reassessing the role of westerly winds

Yavor Kostov[1], *John Marshall*[1], *Kyle Armour*[1], *Ute Hausmann*[1]
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In contrast to the global warming trend and the loss of Arctic sea ice, the Southern Ocean has exhibited a gradual decrease in sea surface temperatures (SSTs) and a net expansion of the sea ice cover over recent decades. Moreover, historical simulations with CMIP5 global climate models do not reproduce the observed cooling around Antarctica and, instead, predict slow but steady warming and sea ice loss. Here we identify enhanced wind-driven Ekman transport as a possible dynamical mechanism allowing the Southern Ocean to cool. We furthermore discuss the discrepancy between observations and CMIP5 historical simulations. The latter underestimate the strengthening and the poleward shift of the Southern Hemisphere surface westerlies - due either to an inadequate representation of ozone forcing or, perhaps, internal variability contributing to the observed wind trends. We propose that under a realistic evolution of surface winds, CMIP5 models can produce cooling trends around Antarctica with magnitudes and spatial patterns similar to observations. To

that end we consider the unforced preindustrial control runs of CMIP5 models and examine periods with multidecadal trends in the speed and position of the Southern Hemisphere surface westerlies that are comparable to the 1979-2014 trends. Strengthening and southward displacement of surface winds produce an SST dipole around Antarctica: cooling south of 50S and warming in a zonal band along 30-50S, similar to observed patterns. These wind-induced cooling trends in the Southern Ocean are large enough to locally overwhelm the effect of greenhouse gas forcing and allow the sea ice cover to expand in a warming world. We compare our findings to those of recent modeling studies which suggest that ozone depletion results in warming around Antarctica.

16:15

Modelling Near surface winds in the Nocturnal Boundary Layer

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During the night a shallow, stably stratified layer forms near the surface with a weakly stratified layer above. In the presence of cloud-cover or large-scale pressure gradient forces the stratification is relatively weak and characterized by the presence of sustained turbulence. In contrast, clear skies and relatively weak pressure gradients can lead to the collapse of turbulence which results in a very stable layer characterized by intermittent bursts of turbulence. Existing physical models fail to capture these dynamics. To understand why we present an intercomparison of existing 1D numerical models of wind and temperature with fixed winds at the upper boundary and fixed heat fluxes at the base. These models predict two equilibrium states for low heat fluxes, and no equilibrium above a threshold heat flux. Using the idea that unstable solutions correspond to the collapse of turbulence in the atmospheric boundary layer we investigate the stability properties of the eigenvalue problem, examine the number of unstable eigenmodes and their growth rate and explain the physical relevance of the results.

16:30

The role of standing waves in driving persistent anomalies of upward wave activity flux

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Sudden Stratospheric Warmings (SSWs) are extreme dynamical events occurring in the wintertime stratosphere that consist of a reversal of the typical westerly circulation and a simultaneous warming of the polar region by 30-40K over the course of a few days. After these events occur, there is a slow downward propagation to the troposphere of the Northern Annular Mode (NAM) anomalies associated with them. This implies that prediction of certain weather variables can be improved on extended range timescales with knowledge of the occurrence of SSWs in the stratosphere. It is known that anomalous vertical wave activity flux from the troposphere is the primary driver of SSWs. We investigate the mechanisms underlying persistent wave activity flux pulses using the

linear interference framework. We establish that the component of upward wave activity flux that is linearly coherent with the stationary wave pattern is more persistent than the total wave activity flux itself. Decomposing the wave anomaly into standing and travelling parts, we show that low frequency standing waves are primarily responsible for this persistence. These standing waves have preferred zonal positions, and tend to reinforce and attenuate the climatological wave. Furthermore, we find that standing waves drive the connection between vertical wave activity flux anomalies and polar vortex strength. This holds for both correlations over all days, and during extreme events such as SSWs. The low frequency of the standing waves suggests a possibility for longer lead-time prediction of extreme stratospheric circulation changes, and hence the subseasonal forecasting of tropospheric NAM related variables.

16:45

From Snowball Earth to the Runaway Greenhouse: multiple climate states of Earth now

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Earth has numerous stable steady state climates. With Earth's present atmospheric composition and solar flux, there are at least three stable states (Snowball Earth, temperate and post-runaway greenhouse). Yes, I do mean that: we are at least tri-stable here and now, and sufficient thermal perturbation could cause transition (1000ppm CO2 is not enough). More nuanced models add even more distinct climates from known (e.g. Laurentide ice sheet on/off) to novel (a 500K ocean stabilized by increasing Rayleigh scattering optical depth with evaporation). Adding in tuning parameters like pCO2, pN2 or solar constant can help these and other states to emerge in counter-intuative ways. Various observables can be brought to bear on the problem: flux measurements of the local runaway greenhouse in the tropics confirms a low calculated OLR limit; the geologic record gives evidence of the various climates possible; comparative climatology helps in many ways. Understanding the large scale dynamics of Earth's climate gives the context for understanding climate change, even if (thankfully) we will expect to remain in our own boring little bit of phase space.

15:30

The interplay of Arctic surface fluxes, stratocumulus clouds, and cloud-driven mixed layers

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In recent years, Arctic stratiform clouds have been shown to form and persist over long periods via a complex web of interactions and feedbacks within the climate system. Doppler measurements from ground-based remote sensors have helped elucidate the dynamical structure of these clouds, wherein radiative cooling in the cloud itself drives turbulent mixing within and below the cloud. This so-called cloud-driven mixed layer can have important implications for the cloud related to local-scale energy and moisture feedbacks that help maintain the cloud in the face of dissipative processes. One key source of energy and moisture, as well as aerosols, for low-level Arctic clouds can be the surface, which seasonally consists of open water, tundra, sea-ice, snow, and various combinations of these. The degree to which the cloud-driven mixed layer interacts with the surface and atmospheric boundary layer has implications both for sustaining the cloud itself and for determining the impact of the cloud on the surface energy budget. Moreover, these interactions are likely to vary by season. This study draws linkages between these cloud and surface processes using two groups of derived parameters at the North Slope of Alaska atmospheric observatory and related observatories at other Arctic locations. One is a product that characterizes the cloud properties including microphysics, turbulence, and the cloud-driven mixed layer. This product is used to assess the coupling state of the cloud system with the surface and the effect that the clouds have on atmospheric radiation. The second product assembles important terms in the surface energy budget, including both radiative and turbulent heat fluxes. The relation of these various quantities under conditions when the cloud system is coupled to, and decoupled from, the surface are contrasted to examine the processes that determine the cloud-surface coupling state and its impact on the surface.

15:45

Satellite Constraints on the Roles of Supercooled Liquid and Snowfall on Arctic Energy and Water Cycles

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Recent analyses of ground-based observations have emphasized the importance of supercooled liquid containing clouds and falling snow in modulating surface energy and mass balance in the Arctic. Extended data records available from a few sites have further hinted at relationships between the liquid water contents of Arctic clouds and the presence and intensity of falling snow. A comprehensive understanding of these relationships and an accounting of the impact of supercooled liquid water and snowfall on the Arctic energy and water cycles have, however, remained elusive due to the limited availability of quality long-term datasets and the poor sensitivity of passive satellite measurements over bright/high emissivity snow and ice surfaces. This presentation will explore the extent to which observations from active sensors in the A-Train constellation can be used to

probe the elusive relationships between supercooled liquid clouds, snowfall, and the surface radiative budget from 60 to 82°N. Despite their sampling limitations and relatively short lifetimes, it will be demonstrated that CloudSat and CALIPSO observations provide valuable insights into the processes that relate these key influences on the Arctic energy and water cycles.

16:00

Changing arctic cloud properties at the sea-ice edge measured by airborne observations from Fall 2014

Samuel LeBlanc[1], *Jens Redemann*[2], *Michal Segal-Rosenheimer*[3], *Yohei Shinozuka*[3], *Connor Flynn*[4], *Philip Russell*[2], *K. Sebastian Schmidt*[5], *Shi Song*[5], *Anthony Bucholtz*[6], *Elizabeth Reid*[6], *Bruce Anderson*[7], *Chelsea Corr*[1]
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Additional co-authors: Edward L. Winstead , Richard Moore, Kenneth L. Thornhill, Michelle Hofton, Helen G. Cornejo, and William L. Smith Jr. NASA Langley Research Center University of Maryland SGT Inc. and NASA Goddard Space Flight Center We present changing cloud properties observed over a transect of sea ice to open water obtained from a retrieval applied to airborne measurements of transmitted sunlight and other airborne measurements. During the recent Arctic Radiation, IceBridge and Sea-Ice Experiment (ARISE), which occurred in Fall 2014, an airborne research platform was used to quantify cloud thermodynamic phase, effective radius, optical depth, and physical geometry. On September 19th, 2014, we sampled clouds near the transition zone between sea ice and open ocean in the Beaufort Sea by flying above, within, and below cloud. Sampling of these clouds was achieved via in situ cloud probes, transmission-based, reflection-based, and active remote sensors. Cloud properties retrieved near the sea-ice transition zone by satellite measurements, such as the Moderate Resolution Imaging Spectroradiometer (MODIS), often return large uncertainties partly due to the highly reflective surface and highly variable surface albedo. Using measurements of transmitted sunlight and below cloud irradiance instead of reflectance used by space-based remote sensors, we reduce the uncertainty related to surface albedo. Since traditional remote sensing methods of determining cloud particle size from reflectance result in large uncertainties when applied to transmittance, a new retrieval method is employed. We present this recently developed cloud property retrieval technique based on zenith radiance measured by the Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research (4STAR) during ARISE. This technique relies on 15 parameters that quantify spectral features in sunlight transmitted through clouds that are sensitive to cloud optical thickness, effective radius, and thermodynamic phase. The spectral features are shifts in spectral slopes, curvatures, maxima, and minima of cloud-transmitted radiance resulting from absorption and scattering of light by clouds. It is by using this new re-

trieval method in combination with measurements from other airborne instruments that we gain a preliminary understanding of cloud physics at the sea-ice edge.

16:15

Cloud influence on the surface energy budget of the Greenland Ice Sheet

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The surface energy budget plays a critical role in determining the mass balance of the Greenland Ice Sheet, which in turn has significant implications for global sea levels. Nearly three years of data (January 2011 - October 2013) are used to characterize the annual cycle of surface radiative fluxes and cloud radiative forcing (CRF) of the central Greenland Ice Sheet (GIS) at Summit Station. The surface albedo is high at Summit throughout the year, limiting the cooling effect of clouds and thus the total CRF is dominated by cloud longwave warming effects in all months. The annual average CRF is 33 W m-2, representing a substantial net cloud warming of the central Greenland surface. Unlike other Arctic sites, at Summit Station the maximum CRF occurs in July, where the annual cycle of CRF is largely driven by the occurrence of liquid-bearing clouds, with a minimum in spring and maximum in late summer. Longwave cloud forcing promotes thermodynamic equilibration between the surface and the cloud base, modifying boundary-layer stability and the depth of the mixed layer. Boundary layer and surface responses under various cloud forcing conditions are investigated by analysis of cloud forcing results alongside observations of turbulent fluxes. A conceptual model is developed for understanding the Greenland Ice Sheet surface response to clouds.

16:30

Aircraft-measured indirect cloud effects from biomass burning smoke in the Arctic

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The incidence of wildfires in the Arctic and subarctic is increasing; in boreal North America, for example, the burned area is expected to increase by 200- 300% over the next 50-100 years. In some cases, local and long-range smoke transported to the Arctic has already increased aerosol concentrations twofold, which previous studies suggest could have a large effect on cloud microphysics, lifetime, albedo, and precipitation. However, the interactions between smoke particles and clouds remain poorly understood, because of a) the confounding influence of varying meteorological and surface conditions, b) limitations of remote sensing data in polar regions, and c) limited in situ data

coverage. Here, we combine data from multiple aircraft campaigns (including the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites campaign (ARCTAS), the Indirect and Semi-Direct Aerosol Campaign (ISDAC), and the First ISCCP Regional Experiment Arctic Clouds Experiment (FIRE.ACE)) to better constrain effects of smoke on Arctic and subarctic cloud microphysics. From the most extensive in situ datasets available, we were able to compare clouds sampled under similar meteorological conditions, confirming expectations that smoky liquid-phase clouds have substantially smaller cloud droplet radii compared to clouds sampled in background conditions, consistent with the Twomey effect. Across all samples, the average cloud droplet radii in smoky liquid phase clouds (4.5±2.3 μm, n=7) were about half the size of those in the average observed background cloud (8.5±1.9 μm, n=20). Having calibrated the technique for the simpler liquid-phase cloud situation, continuing work involves assessing the impacts of smoke on mixed and ice phase clouds to more fully characterize the impact of smoke on Arctic clouds.

16:45

Polar winter aerosol optical depth (AOD) : spectrally and temporally cloud-screened (starphotometer) AODs compared with CALIOP and GEOS-Chem estimates

Konstantin Baibakov[1], *Liviu Ivanescu*[1], *Sareh Hesaraki*[1], *Norm O'Neill*[1], *Tom Duck*[2], *Randall Martin*[2], *Chris Perro*[2], *Andreas Herber*[3], *Christoph Ritter*[4], *Otto Schrems*[3]
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Aerosol optical depth (AOD) measurements were acquired during the Polar winters of 2010-2011 and 2011-2012 using ground- based starphotometry at the Eureka, NV, PEARL (Polar Environment Atmospheric Research Laboratory) observatory and the Ny Alesund (Spitsbergen) Koldeway station. Both temporal and spectral cloud screening were applied to the AOD spectra and the results were compared to analogous AODs derived from CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) profiles and GEOS-Chem simulations. The results underscore the fact that the typically weak AODs measured in the high Arctic must have been preprocessed to eliminate the effects of both homogeneous and inhomogeneous clouds.

10:30

The first year of autonomous water column measurements in Saanich Inlet: The Saanich Inlet Buoy Profiling System

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Ocean Networks Canada installed a cabled water column profiling system in Saanich Inlet on the VENUS coastal observatory in June 2014. This inshore system consists of an instrument package lowered and raised through the water column (≈200 m) by a winch mounted to a large surface float. A meteorological system equipped with air pressure, wind speed/direction, air temperature and humidity sensors is affixed to the top-side of the surface float. A downward facing 200 kHz zooplankton acoustic profiling echosounder is attached to the bottom of the float. The profiling package presently consists of a CTD, dissolved oxygen, chlorophyll fluorescence, and turbidity sensors. Profiles were limited to 2 per day during the first commissioning phase (June-December 2014), which was expanded to 4 and later 6 profiles per day starting in January 2015. Here, we present the first year of continuous water column measurements, high-lighting operational issues and signals related to periodic deep- and mid-water intrusions into the fjord from the Strait of Georgia.

10:45

Surface drift in the Douglas Channel area: adventures with a low cost satellite tracked drifter.

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The World Class Prevention, Preparedness and Response for Oil Spills from Ships Initiative is a major program of the Government of Canada to improve the overall regime under which oil tankers operate in Canada. Oceanography plays a small but vital role in this Initiative. An important part of the observational program for the north coast of BC has been the development and deployment of a low cost satellite tracked drifter. This talk will present results from the deployment of over 100 drifters over 12 months. We will look at circulation pathways and drift statistics that could be useful for emergency response planning.

11:00

Operating Oceanographic HF Radar Systems in the Coastal Waters of BC

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Coastal Ocean Dynamics Applications Radar (CODAR) systems employ high-frequency (HF) radar signals from multiple antennae to detect and map surface currents. Ocean Networks Canada has

been collecting HF-Radar current measurements since 2011 in the central southern portion of the Strait of Georgia. These initial two antennae were deployed on either side of the mouth of the Fraser River, one to the north at the Iona Waste-water Treatment Plant, and the second to the south at the West Shore coal terminal. The presentation will review the installation, configuration, operating, and data quality and control experiences from the first several years of operation. ONC is currently in the process of expanding from two to four CODAR stations in the Strait of Georgia and adding two more stations in the Prince Rupert area. A WavE Radar (WERA) HF-Radar system is also being installed near Tofino on the West Coast.

11:15

Drifter-based validation of the Ocean Networks Canada Strait of Georgia CODAR array

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Hourly surface current measurements made by high frequency radar often carry a relatively high uncertainty, and this uncertainty has a direct impact on, for example, its use in assimilative models, and on estimated particle trajectories. CODAR supplies uncertainty estimates on both the radial and total velocities, but these estimates include both unresolved oceanographic variability and instrumental noise, and they are based on assumptions of ocean variability which might not be true. Relying on other field studies to characterize the uncertainty might be of some value, but the wide range of oceanographic environments in which CODAR operates, and the wide range of instrumental configurations, probably limits the comparison. Thus, to better understand the uncertainty of the hourly current fields, we undertook a series of drifter release experiments in the Ocean Networks Canada Strait of Georgia CODAR domain. Up to 10 drifters were simultaneously released in a small selection of radar grid cells over the course of a day. A comparison of the CODAR radial velocities to the radial component of drifter speeds reveals that the overall RMS difference is about 8 cm/s, but with a very low bias of about 1 cm/s. Unresolved spatial and temporal motions cause about half of the variance, implying the remaining uncertainty must be instrumental. Finally, we show evidence that some of the instrumental uncertainty arises from errors in the direction-finding algorithm, which are likely caused by irregularities in the antenna beam pattern, although this has yet to be verified with field observations.

11:30

Hindcasts of surface drifter trajectories using high-frequency radars : skill sensitivity to drifter depth in a highly vertically- sheared environment

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Accurate surface drift forecasts are required to assist search-and-rescue operations and oil spill mitigation. Recent studies have demonstrated the benefit of using surface current observations from high-frequency (HF) radars to improve surface drift forecasts, but the sensitivity of forecast

skill to the depth of the drifting object or substance has not been fully documented. To investigate this sensitivity, surface drifters were deployed in the Lower St. Lawrence Estuary with drogues at different depths ranging from the surface (no drogue) to 7 m. Three high-frequency radars (two CODAR SeaSondes on the south shore and one WERA on the north shore) measured hourly surface currents over the area where the drifters were deployed and drifted. In addition, vertical profiles of currents from 100 m to 10 m depths were obtained from a downward-looking Acoustic Doppler Current Profiler on a nearby moored surface buoy, along with wind and wave measurements. Hindcasts of surface drifter trajectories are obtained using currents measured by the HF radars, and skill sensitivity to drifter depth is assessed in light of the vertical current shear, wind and wave conditions.

10:30

Rates and mechanisms of turbulent dissipation and mixing in the Southern Ocean

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Turbulent mixing in the Southern Ocean plays a vital role in setting the abyssal stratification and in determining the response of climate models to anthropogenic forcing. However, few observations of mixing in the Southern Ocean exist, and observations of the mechanisms underlying its intensity and distribution are scarce. In recent years, a number of experiments have been staged posing fundamental questions relating to the rates and mechanisms of turbulent mixing in the Antarctic Circumpolar Current (ACC), the main current system of the Southern Ocean. These campaigns have made observations of the circulation on a range of scales, and included pioneering measurements of the turbulent dissipation rate. We discuss results from two such experiments, the Southern Ocean Finestructure (SOFine) experiment and the Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES), both which focused on understanding patterns and processes of mixing in Southern Ocean mixing hotspots. We characterize the intensity and spatial distribution of the observed turbulent mixing rate, and consider underpinning mechanisms in the context of the internal wave field and the processes governing the waves' generation and evolution. In both experiments, the turbulent mixing rate observed is highly spatially variable. It is high in regions where internal wave energy is high, and strongly related to the strength of bottom currents and local topographic roughness, thus supporting the hypothesis that abyssal turbulent mixing is sourced in the breaking of internal waves generated by ACC-topography interactions. However, the rates of turbulent dissipation and mixing observed are generally found to be lower than those anticipated from the observed internal wave energy levels, and local turbulent dissipation appears to account for only a small proportion of the local energy flux predicted by lee wave theory. These mismatches open new important questions regarding the fate of bottom-generated internal wave energy.

10:45

Mixing in the Canadian Arctic Archipelago

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The Canadian Archipelago is a major conduit of Pacific water and freshwater from the Arctic to Davis Strait and then the Atlantic. However, as this water passes through the Canadian Arctic Archipelago it is mixed in the relatively narrow and shallow passages, and by vigorous tides. Here we present exploratory numerical simulations of the mechanisms that drive that mixing using idealized bathymetry and high resolution models.

11:00

Mixing and dissipation in a regional model of the Salish Sea

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We discuss the treatment of mixing and dissipation in a numerical model of the Salish Sea, a complex system of waterways between Vancouver Island and the mainland of British Columbia and Washington State. The exchange of fresh water from the Salish Sea to the Pacific Ocean is strongly modulated by vertical mixing over the sills between the San Juan and Gulf Islands. It is difficult to accurately represent vertical mixing in numerical models of this region due to the strong tidal currents and steep bathymetry. In this talk, we explore the relationship between the model's treatment of mixing and dissipation and the model's tidal properties and stratification. The M2 phase shift between the Strait of Juan de Fuca and the Strait of Georgia is very sensitive to mixing parameters leading to difficulties in accurate reproduction of observed M2 tidal harmonics. We explore this issue by mapping regions of high dissipation and vertical mixing at different times in the tidal cycle. In addition, the effect of dissipation on storm surge amplitude is examined by comparing surge propagation during spring and neap tides. Modelled mixing parameters such as the vertical eddy diffusivity are compared with observed values where available.

11:15

Turbulence in low Froude number stratified flows

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Stratified flow over topography creates internal waves and turbulence. For finite-height topography waves with wave speeds less than the advection speed break locally, creating turbulence dissipation and mixing. The strength of this breaking can be estimated a-priori and has been tested with coarse hydrostatic models (Klymak et. al. 2010a,b). However, there is concern that such models do not yield the appropriate amount of turbulence and mixing, so we test using direct numerical simulation and large-eddy simulation of stratified flow over isolated topography. We can also test the mixing efficiency of turbulence in breaking internal waves, and the relationship between the size of density overturns and the amount of turbulence dissipation they produce.

11:30

Small scale shear stratified turbulent mixing and its inference for the global Oceans

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Debate continues concerning the spatial and temporal variability of the efficiency with which diapycnal mixing occurs in the global oceans. In addition, an equally pressing issue to which sufficient attention has not been paid, concerns the strength of the momentum diffusion that is associated with such diapycnal diffusion of density. An improved understanding of the small scale turbulent mixing

processes is thus required to accurately address these questions. We have recently (Salehipour and Peltier 2014, JFM) proposed an improved formulation for calculating the eddy diffusivity of momentum and have shown that an Osborn-like formulation for diapycnal diffusivity may be derived as a direct mathematical consequence of the governing equations for any stratified Boussinesq flow at high Reynolds number. The latter formulation essentially relaxes the original limiting assumptions of stationarity and homogeneity in the Osborn formula (Osborn 1980, JPO). Furthermore, by analyzing an extensive series of Direct Numerical Simulations of shear-induced stratified turbulence that is generated after a Kelvin-Helmholtz wave breaks, we infer an apparently universal behaviour for the diapycnal diffusivity of stratified shear flows with respect to $\varepsilon/(\nu N2)$ (in which ε denotes turbulent viscous dissipation, ν is kinematic viscosity and N is buoyancy frequency) that is similar to the more idealized numerical studies of Shih et al. (2005, JFM). In this talk we will elaborate on the resulting mixing properties including its efficiency as well as the diapycnal diffusivity of mass and momentum, obtained from these numerical analysis. Furthermore, to illustrate the results in a more useful global context, we will present the inferred estimates of these mixing properties based on the most recent turbulent dissipation measurements taken from the global array of Argo floats (Whalen et al, 2012, 2014, GRL).

11:45

Mass transport and mixing by mode-2 internal waves

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Horizontally propagating internal waves are a regular occurrence in the ocean. Their most commonly observed vertical structure is mode-1, in which isopycnals rise and fall in concert at all depths. However a non-insignificant amount are of the second mode, for which isopycnals expand from and contract toward the centre of the pycnocline. Under the right conditions these waves can form recirculating cores which efficiently transport material and mix the pycnocline. Mode-2 waves are easily formed in the laboratory by releasing a mixed region into an ambient stratified region. Using high resolution, three dimensional, direct numerical simulations we describe the efficiency of mode-2 waves for transporting and trapping material under a variety of different initializations. Particular importance will be placed on the role of changing pycnocline structure and varying density and tracer diffusivities.

10:30

Dynamics of glacier calving in a West Greenland tidewater fjord

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Rapid mass loss of the Greenland and Antarctic ice sheets has spurred an intense interest in understanding glacial dynamics, with a recent focus on interaction and feedback between marine terminating glaciers and the ocean. Iceberg calving has long been recognized as an important term in the mass flux from glaciers, however high temporal resolution observations of calving are scarce. Here we present observations from several weeks of data in Sarqardleq fjord (during summer 2012 and 2013), focusing on calving events detected by glaciogenic ocean waves and time-lapse photography of the glacier/fjord system. Correlations between calving and environmental variables (tides, circulation, etc) are explored, revealing links between glacier and ocean response in the system.

10:45

Ocean Circulation and Marine Terminating Glaciers of the Canadian Arctic Archipelago and the Greenland Ice Sheet

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Higher latitudes have experienced a significant change in climate and physical processes within recent years. This study focuses on two regions that have experienced rapid change, the Canadian Arctic Archipelago and the Greenland Ice Sheet. It has been shown that relatively warm ocean waters may accelerate melt production of marine terminating glaciers. We explore and classify the pathways for the warmer Atlantic waters that reach the fjords along the coasts of Greenland as well as in the Canadian Arctic Archipelago. Additionally, given that the melt of these glaciers is accelerating, we look at the pathways of the low salinity melt waters from these coastal glaciers and where it is taken up in the surrounding basins. This analysis is carried out using an Arctic and North Atlantic configuration of the NEMO ocean/sea-ice general circulation model run at both 1/4 and 1/12 degree resolution. Pathways are determined using the Ariane Lagrangian float package using both forward and reverse trajectory analysis.

11:00

Recent and future evolution of Barnes ice cap (Baffin Island, Canada)

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Barnes ice cap is the last remnant of the Laurentide Ice Sheet, which covered much of North America

20 000 years ago. Following a period of relative stability over the last 3000 years, recent satellite and air-borne imagery reveal significant thinning of the ice cap that, if sustained, would lead to a loss of two-thirds of its mass by the year 2200. This observation suggests a change of regime linked to on-going climate change in the Arctic. In this study, we combine historical observations (1960-1980) with new satellite and air-borne data (1995-2010) to model the thermal, dynamical and geometric response of the ice cap to climate variation. For this purpose, we use a finite-element full-Stokes thermo-mechanical model with an adaptive mesh, coupled to a model of surface mass-balance tuned to in-situ data. Mass-balance modelling results demonstrate the significance of superimposed ice and internal accumulation at Barnes, and point to a strong north-south balance gradient along the ice cap likely associated with regional precipitation patterns. Modelled dynamics highlight the influence of contrasting viscosities between the Pleistocene and Holocene ice, necessitating an accurate determination of the Pleistocene layer thickness across the ice cap. Comparison of modelled and measured elevation changes since 1960 reveals that many sectors of the ice cap are significantly affected by glacier surges and lake-calving. This result points to the important role of ice dynamics in driving changes in ice-cap geometry, and cautions against attribution of measured surface-elevation change exclusively to mass- balance processes. With the model tuned to reproduce historical conditions, we investigate the future evolution of Barnes ice cap and attempt to constrain its future date of disappearance.

11:15

Modelling the dynamic response of Belcher Glacier (Devon Island, Nunavut) to seasonal surface melt

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Widespread speedup of tidewater-terminating glaciers in Greenland and the Canadian high-Arctic has been observed in recent years, along with significant seasonal variability in glacier flow rates. These changes have potential contributions from oceanic and atmospheric drivers through: (1) perturbations to the terminus boundary condition as a result of warm water entering the fjords, and (2) increased surface melt, in response to atmospheric warming, reaching the bed and promoting glacier slip. We examine the influence of these two processes on Belcher Glacier, a large fast-flowing tidewater outlet of the Devon Island ice cap in the Canadian Arctic. Our study uses a hydrologically-coupled ice-flow model to estimate glacier flow changes as a result of loss of sea-ice buttressing and hydrologically- driven seasonal dynamics. Daily runoff from five sub-catchments provides seasonal forcing for the model simulations. We use data from two melt seasons and present results that contrast the seasonal evolution of the subglacial drainage system and glacier velocity over the two years. Model results are compared with surface velocities derived from remote sensing and GPS measurements. Sea-ice and tidal effects are found to have a minor influence on glacier flow speed in comparison to seasonally-enhanced speed-up as a result of meltwater drainage.

11:30

Surface roughness and other controls on the albedo of ice sheets

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Ice sheets have relatively smooth surfaces in regions where there is net accumulation, but in the ablation zone, where more snow and ice melts each year than falls as snow, there are significant topographic features. These features include canyons, crevasses, depressions and mounds, some of which fill with water during the melt season to produce supraglacial lakes, ponds and rivers. Both the surface topography and the surface conditions (i.e water, snow, or ice) of an ice sheet affect the exchange of energy between the atmosphere and an ice sheet, and can locally reduce the albedo of the surface by 20% to 50%. A potential feedback exists where absorbed energy on the surface causes melting of the surface in such a way to further reduce the surface albedo. This presentation explores both the mechanisms and effects of this feedback on a range of ice/snow covered surfaces.

11:45

A comparison of surface energy balance and degree day models for mass balance of Arctic icefields and the Greenland Ice Sheet

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Glaciological models of the Greenland Ice Sheet typically use simplified melt physics, such as positive degree day models, due to the less intensive meteorological data requirements. However, these methods are missing some important potential feedbacks to climate and ice sheet variability, such as albedo changes or the correct sensitivity to changes in cloud conditions. A complete surface energy balance has recently become possible due to improved high-resolution climate models and reanalyses, although it is still difficult to use such models outside of the time window of historical climate records. Paleoclimate and future climate simulations for glaciers and ice sheets typically require climate forcing from coarser-resolution models, with anticipated degradation in model skill. In this presentation I examine the impact of different approaches to Arctic icefield melt modelling on the simulated mass balance. Classical degree day models are compared with reanalysis and GCM-driven energy and mass balance scenarios for Arctic Canada and Greenland for the historical period, 1948-2014. Additional effects are explored for simulation of ice sheet change and associated sea level rise, in particular a shift in model resolution/downscaled climatology from reanalysis- to GCM-driven climate forcing and the effects of a 'cold start' vs. glacial spinup on modelled 'secular' ice sheet changes in future forecasts. Together, these model experiments allow an examination of some of the impacts of numerical modelling strategy on near-term (e.g. 21st century) projections on ice sheet changes and associated sea level rise.

10:30

The TEMPO geostationary air quality mission and what it means for Canada

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TEMPO (Tropospheric Emissions: Measurement of Pollution), selected by NASA as the first Earth Venture Instrument and scheduled for launch in 2019, will measure atmospheric pollution over greater North America from space using ultraviolet and visible spectroscopy. Its hourly repeat cycle and high spatial resolution represent a game-changer in the utility of space-based instruments for air pollution monitoring. Capturing the diurnal variation of key pollutants (ozone, nitrogen and sulphur dioxide, proxies for volatile organic compounds, aerosols, cloud, UV radiation) at the sub-urban scale will lead to significant improvement in monitoring of population exposure, air quality forecasting, emission inventories, and enabling of effective emission-control strategies. For Canada, TEMPO represents a tremendous opportunity to provide over 99% of its population with an improved air quality health index. Maximizing this benefit, however, will mean overcoming challenges more pertinent to Canada than other nations. One important example of this is developing an improved methodology to disentangle near-surface nitrogen dioxide from what resides in the stratosphere. With this in mind, Environment Canada is developing a chemical data assimilation system which would use TEMPO (together with available surface and stratospheric profile measurements) to provide near real time chemical analyses to improve its operational air quality forecasting system. A second such challenge is developing more accurate algorithms in the presence of snow. This presentation will provide an introduction to the TEMPO mission, discuss how it can benefit Canada, and elaborate on the some challenges and how they might be met.

10:45

Carbon Monoxide Events and Trends over 15 Years from the MOPITT Space Instrument

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On 18th December 1999 the Terra platform was launched from the Vandenberg Air Force base carrying the Measurements Of Pollution In The Troposphere (MOPITT) instrument. MOPITT has now completed more than years of operation measuring carbon monoxide (CO) over the planet and it is still working! The 15 year continuous data series that MOPITT has provided (so far) affords a great opportunity to look at longer-term changes over the planet. However a time series this long was not part of the design criteria of the instrument and therefore care must be taken to ensure that trends are not artifacts. Fortunately, the instrument has been more stable than

originally predicted and care has been taken throughout the mission to ensure that the data are properly validated. The result is a well-characterised 15 year time record that can now be mined for a variety of phenomena charting decadal changes (or stability) in carbon monoxide and looking at the frequency of events that often drive anomalies in the carbon monoxide distribution. A global trend of decreasing carbon monoxide has been observed, but other more localised phenomena have also been observed - including some over Canada - caused by a mix of changes in sources, transport and sinks. This paper will consider some of these phenomena by way of case studies and statistics. MOPITT was provided to the Terra spacecraft by the Canadian Space Agency and was built by COMDEV of Cambridge, Ontario. Data processing is performed by the MOPITT team at the National Center for Atmospheric Research, Boulder, CO. Instrument control is by the team at the University of Toronto.

11:00

Re-investigation of a long term infrared spectral data set for ozone recorded at 80^o N

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From 1994 to 2008, a Bomem DA-8 high resolution Fourier Transform Spectrometer (FTS) recorded high-resolution absorption spectra of the atmosphere at one of the sites of what is today called the Polar Environment Atmospheric Research Laboratory (PEARL) located at approximately 80N, 86W near the Environment Canada (EC)Eureka Weather station on Ellesmere Island. The instrument was operated by EC and the Meteorological Reseach Institute (MRI) of Japan on an episodic bases during either the spring or fall of each year. We are re-analyzing the spring data sets using current software techniques and molecular parameters that are both much improved from those available at the time the data set was recorded. In particular, we have derived ozone total columns and partial columns and investigated the same for the symmetric and asymmetric ozone isotopomers 686O3 and 668O3 as well as related molecules. This instrument was also a part of the Network for Detection of Atmospheric Composition Change (NDACC) and was replaced in 2008 by the Canadian Network for Detection of Atmospheric Change (CANDAC) Bruker IFS125HR. The two instruments were operated concurrently for parts of two years before the DA-8 was removed and the IFS125HR became the instrument of record. We compare the total column amounts derived from both spectral data-sets during the overlap period to ensure that the two data-sets are equivalent during that time and the entire dataset can be considered as quasi-continuous. This project is supported by the Natural Sciences and Engineering Research Council (NSERC.

11:15

Cross-validation of methane retrievals from ACE-FTS, GOSAT, and ground-based solar absorption measurements, at Eureka, Nunavut.

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We present cross-validation of remote sensing observations of methane profiles at Eureka, Nunavut (80^{o}N, 86^{o}W). Methane is the third most important greenhouse gas on Earth, and second only to carbon dioxide in its contribution to anthropogenic global warming. Accurate and precise observations of methane are essential to understand quantitatively its role in the climate system and in global change. The Arctic is a particular region of concern, as melting permafrost and disappearing sea ice might lead to accelerated release of methane into the atmosphere. Pan-Arctic observations require spaceborne instruments, in particular in remote regions where surface measurements are sparse and expensive to carry out. Remote sensing of methane is an underconstrained problem, and specific validation under Arctic circumstances is required. Here, we show a cross-validation between two spaceborne instruments and ground-based measurements, all Fourier Transform Spectrometers (FTSs). We consider the Canadian SCISAT ACE-FTS, a solar occultation spectrometer operating since 2004, and the Japanese GOSAT TANSO-FTS, a nadir-pointing FTS operating at solar and terrestrial infrared wavelengths, since 2009. The ground-based instrument is a Bruker Fourier Transform Infrared (FTIR) spectrometer, measuring mid-infrared solar absorption spectra at the Polar Environmental and Atmospheric Research Laboratory (PEARL) Ridge Lab at Eureka, Nunavut (80^{o}N, 86^{o}W, 610m ASL) since 2006. Measurements are collocated considering temporal, spatial, and geophysical criteria and regridded to a common vertical grid. We perform smoothing on the higher-resolution instrument results to account for different vertical resolutions. Based on error estimates for each retrieval, we calculate the random error covariance matrix for the comparison ensemble. Then, profiles and partial columns of differences for each pair of instruments are examined. Any bias between instruments, or any accuracy that is worse than expected, needs to be understood prior to using the data. The results of the study will serve as a guideline on how to use the vertically resolved methane products from ACE and GOSAT within the High Arctic region.

11:30

Modeling of TOA radiance measured by CERES over the East Antarctic Plateau

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CERES (Clouds and the Earth's Radiant Energy System) is a satellite borne remote sensing instrument measuring solar- reflected and Earth-emitted radiation at the TOA level. CERES is designed to monitor the Earth's radiation budget. In order to observe TOA budget, instrument measured radiances are converted into upwelling fluxes using the Angular distribution Models. In this work we evaluate TOA radiance over permanent snow under clear sky conditions in the East Antarctic Plateau to test consistency between modeled and observed radiances. We revisiting this issue reported by Hudson et al 2010 with another radiative transfer model and using instantaneous atmospheric profiles. That paper reported some overestimation of TOA albedo by their model in comparison with CERES estimations. The comparison in that paper involves some uncertainties including errors in the modeled surface albedo and atmospheric model. We use radiative transfer model based on DISORT coupled with correlated-k (Kato et al 1999). We used the same approach for the lower boundary condition as in Hudson et al 2010 with modification related to modeling surface albedo (more realistic diameters of ice spheres, Mie phase function instead of Henyey - Greenstein one). The model is flexible to use a supplied atmospheric profile. In this work we create atmospheric models for the time and position of the individual observations from GEOS-4 reanalysis data. A comparison between modeling and actual observations was performed for data acquired by the CERES sensors onboard EOS TERRA (FM-1 sensor) and AQUA (FM-4), and NPP (FM-5). Some overestimation of TOA radiance by the model was discovered. The latest edition 4 of CERES Single Satellite Footprint data for FM-1, -4 appeared to be 4.6% darker than the model while FM-5 sensor is ≈3.6% darker. There is great correlation between modeled and observed radiance: coefficient of determination R2 $>$ 0.999 for all sets of data.

11:45

Geodetic Applications of Ray-tracing through the neutral-atmosphere

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Ray-tracing through the neutral-atmosphere is an important task to retrieve meteorological parameters from a numerical model. There are several ways of doing it, which implies different representations of the neutral-atmosphere, as well as different ways to integrate through the path. We have developed a ray-tracer that involves alternative models for the ray-path and the atmospheric structure involved in the operation. The ray-tracer is currently in continuous use in the evaluation of zenith delay and one of the Marini coefficients of the Vienna Mapping Functions, generated daily at UNB as a service towards GGOS. This paper overviews the main characteristics of the UNB Ray-Tracer and discusses applications when dealing with integration through numerical weather models for neutral-atmospheric delay modelling. The paper also discusses other uses of

ray-tracing in geodesy.

10:30

The Future of the Weather Enterprise

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The WMO World Weather Open Science Conference (WWOSC-2014) was held in Montreal, Canada in August 2014. This Conference brought together over 1000 attendees fro over 70 countries. With the impressive advances in the atmospheric sciences, an important focus was to discuss the steps needed to ensure the weather sensitive stakeholder community benefits from weather services. The conference also included a Special Session on The Future of the Weather Enterprise, aimed at advancing discussion on the collaboration between the private, public and academic sectors. Three separate panels were conducted - the first two exploring the important issues and problems related to the provision of weather services and the infrastructure in support of that. The final panel was oriented towards finding solutions through effective collaboration. Panellists included recognized leaders from the global weather community, including executives from the government, academic and private sectors, as well as leaders from non-government agencies, such as scientific societies. This Special Panel on the Future of the Weather Enterprise was a catalyst for the WMO and its member countries to demonstrate leadership by working together to maximize societal benefits. Already, follow-up sessions were included in this year's Annual Meeting of the American Meteorological Society and the WMO Congress. This presentation will provide a summary of some of the key outcomes of WWOSC, and in particular several recommendations arising from the Special Panel.

10:45

The NOAA Arctic Test Bed

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The National Oceanic and Atmospheric Administration (NOAA) test beds, such as the Joint Hurricane Test Bed (Miami, FL) and the Hazardous Weather Test Bed (Norman, OK) have proven to be highly effective in meeting both the unique and the pressing science and service challenges for the National Weather Service (NWS). NWS Alaska Region is establishing the NOAA Arctic Test Bed to lead the process for significant enhancements to our operational forecast and decision support capabilities in Alaska to address the emerging requirements of the Arctic. Historically, the complexity of forecast operations and the inherent challenges in Alaska have not been addressed well by the R&D programs and projects that support the Continental U.S. (CONUS) regions of the NWS. In addition, there are unique science, technology, and support challenges (e.g., sea ice forecasts and arctic drilling prospects) and international opportunities (bilateral agreements and

World Meteorological Organization research projects) that would best be worked through Alaska operations. A dedicated test bed will provide a mechanism to transfer technology, research results, and observational advances into operations in a timely and effective manner in support of the NWS Weather Ready Nation goals and to enhance decision support services in Alaska. A NOAA Arctic Test Bed will provide a crucial nexus for ensuring NOAA's developers understand Alaska's requirements that are often cross disciplinary (atmosphere, ocean, cryosphere, and hydrologic) in order to improve NOAA's responsiveness to its Arctic-related science and service priorities among the NWS and NOAA's research laboratories. The test bed will also enable better leveraging of other research initiatives and data sources external to NOAA, including academia, other government agencies, and the private sector, which are particular to the polar region (e.g., the WMO Polar Prediction Project). A review of initial projects and future capabilities will be presented.

11:00

Communicating and forecast uncertainty during the 2014 Lake Louise FIS Alpine Ski World Cup.

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Operational forecast support for the Lake Louise FIS Alpine Ski World Cup has been provided for several years. Using the 2014 event as an example, the presentation will focus on regional forecasting challenges, the day to day on-site forecast support and how RWDI has approached communication and uncertainties with multiple decision makers under occasionally stressful conditions. This particular event poses unique challenges each year due to its remote location with few representative observations, very high surrounding terrain and associated modeling shortcomings. Additionally, the nature of the event is asking for 24/7 on location support and ad hoc minute by minute briefings that further compound these challenges. The author takes a critical look at his method of communication in the hope of stimulating discussions about improving decision support for clients' risk assessments.

11:15

Access forecast uncertainties from a multi-model post-processing system

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An operational multi-model post-processing system is developed at The Weather Network to automatically calibrate Numerical Weather Prediction (NWP) models using observations. Three statistical calibration methods are applied to a collection of NWP models that vary in spatial coverage and resolution. These bias-corrected derivatives along with raw NWP model outputs are blended automatically based on historical model performance in order to drive an optimum blended solution. Results show significant improvements in forecast accuracy throughout the entire sixteen-day forecast period. Despite the increasing accuracy of weather forecasts, there is always an element of uncertainty in all predictions. Effective communication of uncertainty helps people better un-

derstand the likelihood of a particular event and improves their ability to make decisions. This postprocessing system is built in a way that it can also be seen as a multi-model and time-lag ensemble system, which provides a means to estimate the uncertainties in the forecast. Forecast uncertainty products derived from this post-processing system will be presented in this talk.

11:30

Verification of precipitation start/stop times derived from probabilistic nowcasting

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The Nowcasting system at The Weather Network derives the probabilistic Precipitation Start Stop (PSS) times within a three hour window for thousands of locations in Canada. So far, the performance of this method has only been grasped at arbitrary locations and for limited periods of time. We designed a Nowcasting Verification System (NVS) to record, verify and measure performance of PSS for all locations. The NVS prototype was designed and developed as a research tool to provide a basis for measurement and comparison of PSS output. Precipitation Nowcasting differs from the hourly forecasts both in terms of its higher temporal frequency and its higher spatial resolution. Specially, the PSS times depend on 10 minute radar composite images with 1 km resolution on a continental grid. In verification of SSP we have been dealing with three main themes: 1) Verification basis: Recording all nowcasting entries for thousands of locations at every 10 minute interval will make storage, analysis and retrieval of data more difficult over a long period of time. Also, the high spatial and temporal resolution of issued forecasts demands a matching observation source to verify against. We use real time radar observations as the baseline for verification. 2) Scoring method: The usual spatial scoring of precipitation forecast based on contingency tables takes a reference space of forecast and observation and divides each of them into precipitating and non-precipitating regions and retrieves the relative coverages as hit, miss, false alarm and correct negative regions. This method was not directly applicable to SSP point-based forecasts. 3) Timing errors: The PSS provides timing of precipitation events to users and customers, therefore, it is desired to estimate and express uncertainties in the units of time. This requires a new approaches towards measuring errors of precipitation nowcast. The primary results and statistics of several months of data are presented and discussed at National scale, and more details are provided for a selected number of most populated cities in Canada. Skill of Start/Stop nowcasts are measured with contingency method and traditional scores and uncertainties are expressed in terms of average timing errors. The results indicate significant trends that provide a first insight into the overall performance of PSS. The NVS provides constant quality control and a basis for monitoring further improvements to the precipitation nowcasting techniques.

11:45

A Heavy Precipitation Event as Observed by King City's Upgraded Dual-Polarization C-Band Radar

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Environment Canada's, Science and Technology Branch operates a C-band Dual-Polarization weather radar at King City, Ontario. This dual purpose radar supports atmospheric research and plays a vital role in EC's operational national radar monitoring program. During the winter of 2013, the King City radar underwent an upgrade that was designed around Vaisala's RVP900 digital signal processor. The RVP900 upgrade offers EC significantly more processing capability than its predecessor and provides an expanded R&D platform upon which to implement, develop and validate enhanced radar-derived solutions. An additional enhancement at King City is implementation of an Optical Rotary Joint that transfers the In-phase and Quadrature (I,Q) signals from the processor located on the antenna to EC's research offices. This enables EC engineers and scientists to parallel process, in real-time, different radar solutions and allows EC to more readily compare and assess different algorithms' implementations such as KDP, the effects of different clutter filtering, and testing and adjusting interference filters; while simultaneously allowing the King City radar to fulfill its mission of supporting the operational radar network. A significant advantage of the King City radar upgrade is the ability to perform attenuation correction; allowing the recovery of signal returns that would otherwise be lost to attenuation during periods of heavy precipitation. This presentation will show comparisons between Hydroclass, and EC's equivalent Iparca attenuation correction and classification software that occurred near Toronto during a convective event in July 2013.

15:30

Monitoring early-flood season intraseasonal oscillations and persistent heavy rainfall in South China

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Both the 10-20-day and 20-70-day oscillations play important roles in the rainfall variability during the early-flood season (April to June) in South China. In this study, three daily real-time intraseasonal oscillation (ISO) indices are compared in terms of representing the early-flood season 20-70-day ISO in South China. A new bivariate boreal summer ISO index is defined to describe the variability of 10-20 days in the East Asia - western North Pacific (EAWNP) region. Composite analysis shows that the northward propagation of the EAWNP ISO, both the 10-20-day and 20-70-day signals, has a crucial role in the anomalous rainfall in South China. According to different phase combinations of the 10-20-day and 20-70-day EAWNP ISO, nine states are defined ranging from those favorable to those unfavorable to heavy rainfall in South China. It is found that combining the ISO of both frequency bands can well describe the anomalous rainfall in South China. Thus it can be used to monitor the early-flood season ISO and persistent heavy rainfall in South China.

15:30

Initial results of simulating the hub-height wind speed from a multi-PBL scheme, multi-initial conditions source WRF ensemble in complex terrain

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Since 01 June 2014, the University of British Columbia has been evaluating the choice of planetary boundary layer (PBL) physical parameterization scheme used within their operational WRF models. The results presented here are only for a subset of the one- year long extensive study ending 31 May 2015. Eight PBL schemes have been used in daily simulations with two initial condition sources (the 32-km NAM and 0.5 degree GFS) to comprehensively evaluate the best choice of PBL scheme selection for hub-height wind forecasts at four wind farms in British Columbia. Forecast verification statistics for each PBL scheme and initial condition source will be shown. In addition, a new type of ensemble forecast made by putting together the WRF forecasts from each PBL scheme and initial condition source (48 members total) is evaluated.

15:30

Sedimentation for 2-moments microphysics models across all scales: How to make it fast, interactive, and avoid excessive size sortingv

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We present a sedimentation scheme for 2-moments microphysical models that mimic Eulerian or Lagrangian classical approaches with three major advantages. First, it is much faster and numerically efficient than classical Eulerian/Lagrangian methods and it is easy to implement. Second, it allows the microphysical processes to take into account the sedimenting particles during sedimentation; and vice versa. So that sedimentation and microphysical processes are computed at the same time. Third, it manages the sedimenting fluxes of the two moments together in order to avoid excessive size sorting, accordingly to a minimum and a maximum mean mass particle size observable in nature. This characteristic also allows much longer time step for the microphysics model with a satisfying precision, and total conservation of both mass and number of hydrometeor particles, paving the way toward the use of 2-moments microphysics schemes within operational numerical weather prediction (NWP) at global scale and climate models.

15:30

Status of Satellite-derived Snow Water Equivalent Information over Canada - Supporting Research and Operational Applications

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The Climate Research Division (CRD) of Environment Canada has a long-standing research program focussed on the development of methods to retrieve snow cover information from passive microwave satellite data for Canadian regions. Algorithms that derive snow water equivalent (SWE) have been developed by CRD and validated for a number of landscape regions including prairie, boreal forest, taiga and tundra. The SWE algorithms are used with satellite data to generate regional snow cover products that are being used to support a number of research and operational applications. Maps depicting SWE distribution over areas in western and northern Canada are produced on a regular basis each winter (e.g. weekly) using SSM/I data accessed in near real-time. These maps are distributed to a variety of users such as national and provincial water resource agencies, agricultural agencies, hydropower companies, and meteorological forecast offices to support their operational activities. The distribution of SWE maps by e-mail and the internet (Canadian Cryosphere Information Network - CCIN) has widened the range of applications for the products. This presentation will provide an overview of the current status of satellite-based SWE products over western Canada and the related challenges and opportunities for extending the products to other regions in Canada. Examples of new SWE products that are being generated internationally with passive microwave satellite data will be presented with descriptions of the various research and

operational applications for which they are being used. A perspective on needs and future opportunities to enhance SWE retrieval capabilities with new satellite missions will be provided.

15:30

Attribution of Hydroclimatic Changes in Western Canada to Human Influence

Mohammad Reza Najafi[1], *Francis Zwiers*[1], *Sanjiv Kumar*[1], *Nathan Gillett*[2]
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Many studies have attributed observed global and regional temperature changes to anthropogenic forcing factors, and several studies have now also detected human influence on precipitation, atmospheric water vapor content and ocean surface salinity at the global scale, indicating a human influence on the global hydrological cycle. In contrast, very few studies have considered the causes of changes in indicators relevant to regional surface hydrology. In this study the variations of several hydroclimatic indices are assessed over four basins in western Canada to determine whether human influence has affected their evolution over the period 1950-2005. The hydroclimatic indicators are defined based on precipitation, temperature, snow water equivalent and runoff. We use ensembles of 40 naturally forced (solar and volcanic) and all forced (anthropogenic plus natural forcing combined) climate model simulations from 9 global climate models participating in the Coupled Model Intercomparison Project Phase 5 (CMIP5), along with ≈5000 years of preindustrial simulations. The climate simulations are downscaled to $1/16^o$ degree resolution grid cells using the bias correction and spatial disaggregation (BCSD) method, and then used to drive the Variable Infiltration Capacity (VIC) hydrology model to obtain ensembles of forced and control climate variations in snow water equivalent (SWE) and runoff in the Fraser, Peace, upper Columbia and Campbell River basins of British Columbia for the period 1950-2005. VIC is also driven by observed daily maximum and minimum temperature as well as precipitation and wind speed to obtain observationally constrained SWE and runoff for this period. Analyses show that the minimum temperature has an increasing trend over western Canada while the center of timing, normalized summer flow and normalized snow water equivalent show decreasing trends. A preliminary detection and attribution analysis suggests that some indicators, in particular Tmin and SWE, have been affected by human induced climate change.

15:30

Warming of West Antarctica in austral spring linked to dramatic stratospheric changes

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The rapid warming of West Antarctica has been one of the main features of climate change in high southern latitudes in recent decades and has been most prominent in austral winter (JJA) and spring (SON). Thus far, investigations of the phenomenon have emphasized the role of atmospheric teleconnections originating from the Tropics in JJA, but have had less success in explaining the warming in SON. The latter is the subject of our investigation, which relies mainly on the ERA-Interim Reanalysis. More specifically, we narrow our focus to the month of September for two

reasons: First, September is characterized by the largest temperature trend in central West Antarctica since 1957. Second, atmospheric circulation changes (lower pressures/geopotential heights) in SON off the coast of West Antarctica since 1979 largely reflect those from September. These circulation changes have been previously identified as the main mechanism responsible for steering warm air toward West Antarctica and causing the observed warming. We find that the pattern of lower pressures/heights actually extends from sea level through the mid-stratosphere, a feature not seen in other months in the same region. We establish a link between these circulation changes and a shift in the position of the stratospheric polar-night jet. This shift can in turn be explained by the dramatic warming of the Antarctic stratosphere since 1979 in the 90E-180 quadrant, a phenomenon that previous studies have attributed to the strengthening of the Brewer-Dobson circulation and the associated increased planetary wave activity.

15:30

The NOAA Sea Ice Earth System Prediction Capability Project - Processes Impacting Sea-Ice Movement and Autumn Freeze-Up

Janet Intrieri[1], *Ola Persson*[2], *Amy Solomon*[2], *Mimi Hughes*[2], *Andrey Grachev*[2]
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The National Earth System Prediction Capability (ESPC) is a collaboration project between NOAA, U.S. Navy, U.S. Air Force, Dept. of Energy (DOE), NASA, and the NSF. The National ESPC's goal is to improve coupled model predictions on the spectrum of timescales from hours through to seasonal, annual and decadal time periods. Four focus topics have been established to demonstrate progress in specific needed areas including sea ice prediction. This ESPC sea ice demonstration project assesses how the autumn sea-ice evolution interacts with physical processes including atmospheric forcing of sea-ice movement through stress and stress deformation; atmospheric forcing of sea-ice melt and formation through energy fluxes; atmospheric forcing of the newly ice-free ocean through wave formation, solar radiation penetration and vertical mixing; ocean forcing of sea-ice through bottom heat flux and wave penetration; and ocean forcing of the atmosphere through new regions of seasonal heat release. Many of these interactions involve emerging complex processes that first need to be understood and then incorporated into forecast models in order to realize the goal of useful sea ice forecasting. This poster will highlight observations collected in previous Arctic field programs, as well as describe upcoming measurement campaigns, to better understand these interactions. The focus of our analysis is on understanding the short-term (0-20 day) ice-floe movement, the autumn freeze-up processes in the near-ice open water and the marginal ice zone (MIZ), the role of ocean waves in both the northward summer retreat and autumn advance of the sea-ice, and the role of storms in modulating the stress, heat fluxes, waves and mixing processes that impact the sea-ice evolution. A variety of analyses will be presented that quantify these interactions and assess their impacts on sea-ice evolution and validation of existing processes in models.

15:30

Modelling recent and future sea ice changes in Arctic

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Sea ice is an important component of the global climate system acting both as an indicator of climate change as an amplifier. Several authors indicate that sea ice cover is more general indicator for climate change than are temperatures trends alone because changes in the sea ice depends on integrated changes on many different climate variables such as oceanic heat transport, temperature and winds. Polar sea ice has undergone marked changes during the last decades, Arctic experience a tragic decrease in sea ice extent, whereas Antarctica shows an increase (at a rate not as pronounced as the decrease in Arctic sea ice). We examine the recent (1979-2014) and future (2011-2100) characteristics of the summer Arctic and winter Antarctic sea ice cover based on Brazilian Earth System Model (BESM) results and 10 Earth System and general circulation models from the Coupled Model Intercomparison Project, phase 5 (CMIP5). BESM is a recent Earth System Model developed by Brazilian researchers, also contributor in CMIP5.Our results show that most of the models were able to represent the seasonal cycle in the Arctic and Antarctica and also were able to predict the record decline on Arctic sea ice thickness and extent in 2007 and 2012. The long-term trends (1980-2100) suggest that thickness and extent sea ice in the Arctic ocean will continue retreating, this is primarily becouse the Temperature in the Arctic has increased at twice the rate as the rest of the globe. To Antarctic sea ice, many of the models have show markedly differs when compared with satellite data, especially regarding the trend increase observed in last decade.

15:30

On the relationship between North Atlantic baroclinic growth rate regimes and surface cyclogenesis

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Baroclinic instability is the fundamental theory explaining midlatitude weather systems, particularly cyclogenesis, as discussed by Hoskins and Valdes in their 1990 work on storm-tracks. They included measurements of dry baroclinic growth rates in their analysis, though they theorized that moist baroclinic growth rates (sm) might provide a more appropriate measure. We incorporate this metric to examine the relationship between large areal extent of high sm and surface cyclogenesis in the North Atlantic. This areal extent is calculated over the North Atlantic basin (25-60N and 0-80W) and over the vertical depth of 850-600hPa, using the National Centers for Environmental Prediction Reanalysis 1 for 1950-2013. The time series consists of standardized anomalies, obtained from removing a single, smoothed climatology spanning the entire 64-year period from the smoothed daily mean values. Concentrating solely on the cold season months (DJFM), we find 101 events with standardized anomalies greater than two. Most events last one day, with a maximum length of 10 days. Cyclone data are provided by the National Snow and Ice Data Center for the years 1958-2008.

Each of the extreme DJFM sm areal coverage events within this time period are lag-correlated with both cyclone numbers and cyclone deepening rates in the basin on each day. The DJFM events lasting longer than 3 consecutive days (n=8) are characterized by above average occurrences of explosive cyclogenesis near the end of the events. Each event occurred during periods characterized by anomalously few cyclones, below average minimum pressures, and anomalously high frequencies of explosive cyclogeneses.

15:30

Spatial-Temporal Variability of Arctic Sea Ice in the Canadian Beaufort Sea as Measured with a Dense Array of Upward Looking Sonar Instruments

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Upward looking sonar (ULS) instruments operating from subsurface moorings provide more accurate measurements of sea ice thickness (±0.1 m) and deformation and sea ice velocities through continuous data collection of ice drafts and ice velocities. Analyses of ULS-derived observations of ice drafts, ice deformation parameters and ice velocities were obtained from an extensive array of 7-8 ULS moorings operated in water depths ranging from 73 to 1010 m in the outer shelf and continental slope region of the Canadian Beaufort Sea from July 2009 to September 2011. The distance separation between individual pairs of mooring ranged from 4 km to more than 80 km. From these very extensive sea ice data sets, the spatial differences in sea ice properties are presented over daily and monthly time scales. The analysis results reveal considerable spatial differences in ice properties. Ice speeds have a large seasonal variation with the largest speeds in summer/fall and lowest in winter. Ice speeds are generally larger in the more offshore mooring sites and somewhat reduced in the shallower inner slope and outer shelf sites. Episodic occurrences of no-motion events during winter are more frequent in the shallower inner-slope/outer shelf area than in the deeper offshore waters and are more frequent in the east vs. the west. The ice drafts tend to be larger by 0.1 - 0.2 m in the shallower waters of the inner slope and shelf edge by comparison to the deeper mid- and outer slope areas. Occurrences of major deformation of sea ice is highly episodic. High deformation events occur nearly simultaneously at all sites in winter and spring. The number of large ice keels present during episodes appears to vary considerably from the west to the east. More deformation occurs at the shallower locations than for the deeper locations.

15:30

Vancouver Island School-Based Weather Station Network

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The Vancouver Island School-Based Weather Station network (VIWSN) consists of more than 150 weather stations located principally on schools on or near Vancouver Island in British Columbia, Canada. The Capital Regional District is the most densely monitored part of our network. It includes thirteen municipalities, covers an area of 2300 square kilometres and contains 105 weather stations in urban, agricultural and natural areas. Several other urban centres and remote sites are

also monitored on southern Vancouver Island. Most of the weather stations have been in operation for seven years or less but the oldest station has been collecting data for thirteen years. Minute resolution data is collected from each station and is broadcast back to the community through the website www.victoriaweather.ca where various tools are available to view maps of the measured fields in near real-time and to retrieve subsets of the data. More than six billion observations have been collected to date. As the network has grown so too has interest and awareness around Vancouver Island. Numerous applications of the weather station data for scientific, engineering and media purposes have emerged. Initial analyses of some aspects of weather and microclimate patterns of Greater Victoria and Vancouver Island at community scales are presented along with comparisons of VIWSN observations with Environment Canada weather stations where these systems overlap.

15:30

An exploratory analysis of the Industry/ArcticNet extensive array of moored ocean current ADCP datasets collected from 2009 to 2011

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The Mackenzie Shelf break area situated south of the Beaufort Sea constitute a rich region from a physical oceanography perspective. Locally, atmospheric forcing, sea ice cover and bathymetric particularities can have great repercussions on the local current dynamic. On a more macro scales, major currents present over the area can also have a great impact locally and regionally. We present here an initial exploratory analysis of the current (ADCP) data from 8 sub-surface moorings deployed simultaneously on the continental slope (6 moorings) and the outer shelf (2 moorings) as part of the Industry/ArcticNet collaboration program conducted from July 2009 to September 2011. Spatial variability along and across the slope are analyzed as well as episodic energetic events observed during the more than two years of continuous operation of the moorings Distinct spatial differences are evident in the patterns of current speed and directional distributions in the uppermost 200 m of the water column. The currents are highly variable among the different measurement locations and in time, being very episodic in nature. Below 200 m in the Atlantic Water, the currents are reduced in magnitude and exhibit bimodal directional distribution.

15:30

A model for the vertical spread of forest fire smoke within the initial smoke plume.

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A new smoke plume-rise model for the BlueSky framework, which forecasts dispersion of forest fire smoke, is presented. The thermodynamic approach incorporates the effect of the mean wind blowing across the fire front. The area between a dry adiabat and an environmental sounding representative of air in the vicinity of the forest fire is integrated. This area is set equal to the heat distributed vertically to warm the air to uniform potential temperature, thus giving a plume equilibrium-height

estimation. The model is in the preliminary testing stage and needs to be evaluated using radiosonde data along with observed plume heights derived from the multi-angle imaging spectroradiometer (MISR) instrument. Further model improvements include extending the dry-adiabat assumption to account for moist air.

15:30

UK Met Office Unified Model high-resolution simulations of an Antarctic strong wind event

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Much of the Antarctic coast is susceptible to severe and hazardous strong wind events (SWEs) associated with the enhancement of strong katabatic flow by the synoptic situation. The ability of models to simulate such events is challenging due to the complex dynamics and the significant influence of complex surface features. In this study, a SWE which occurred at Mawson, East Antarctica on 25 July 2004 involving a hurricane force wind speed of ≈39 m/s is simulated by the Unified Model at three different horizontal resolutions of 12, 4, and 1.5 km. It is apparent that all models: i) capture the qualitative evolution of the SWE suggesting that they are resolving the important forcing mechanisms, ii) capture the weaker wind speeds associated with the onset and cessation of the SWE, and iii) underestimate the peak wind speed. The strength of the underestimate is dependenton horizontal resolution, with the 4 and 1.5-km (12km) models underforecasting the peak wind speed by around 15% (46%). Additional sensitivity experiments and diagnostics are presented to improve understanding of the processes responsible for the SWE and to identify shortcomings in the model thatrequire improvements in the future.

15:30

Development of a Statistical Model for Snow Water Equivalent Estimates in British Columbia, Canada

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Numerous readily available gridded data products provide estimates of snow water equivalent (SWE) on regional to global scales. Such products include satellite passive microwave (PM) retrievals, observation-based products, land data assimilation systems (LDAS), reanalyses and hybrid products. While such products give reasonable estimates in many contexts, they exhibit poor performance in areas of complex topography, heavy forest cover, and very deep snowpacks, conditions that dominate British Columbia. In order to overcome these difficulties, an artificial neural network model has been developed to estimate SWE in BC. This model blends in-situ manual snow survey data with the best performing gridded products and identified covariates. The model improves

estimates of SWE at left-out station test sets and partially corrects large negative biases, a key shortcoming common among gridded SWE products over BC.

15:30

Comparison between the CO2 products from the Environment Canada Carbon Assimilation System and the Total Carbon Column Observing Network

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The goals of Environment Canada Carbon Assimilation System (EC-CAS) are to monitor CH4 and CO2 fluxes over Canada and address climate mitigation policies related to carbon sources and sinks. The project started in April 2011 as a collaboration between Environment Canada, the University of Toronto and the University of Waterloo. EC-CAS is based on the Ensemble Kalman Filter and the GEM-MACH model (Global Environment Multiscale Modelling Air quality and Chemistry). For this comparison, the CO2 output of ECCAS uses GEM-MACH with a modified mass constraint and a posteriori fluxes from CarbonTracker 2010. The Total Carbon Column Observing Network (TCCON) is a network of ground-based Fourier transform spectrometers recording direct solar spectra in the near-infrared spectral region. These spectra are used to retrieve column-averaged dry mole fractions (DMFs) of CO2, N2O, CH4, H2O, HDO, and HF. EC-CAS is still under development and so the purpose of this study is to compare EC-CAS model output to TCCON data to assess how well the model can simulate CH4 and CO2 on a variety of scales. The comparisons are performed following the procedure recommended for TCCON data. Results will be shown for ten TCCON sites for the year 2009, focusing on time series of EC-CAS and TCCON CO2 DMFs.

15:30

Projected changes in precipitation and temperature characteristics over the Canadian Prairie Provinces using the Generalized Linear Model based multisite multivariate statistical downscaling approach

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Atmosphere-Ocean General Circulation Models (AOGCMs) are an important tool for estimating future climates that might result from further anthropogenic modification of the atmospheric system. However, outputs from these models cannot reliably be applied directly in many environmental and water resources studies because of coarse spatial resolution and limitations in representing sub-grid scale processes. To bridge this gap, downscaling methods (i.e. statistical and dynamical downscaling methods) have been widely utilized to transform AOGCM information to local- and regional-scale resolution. In this study, a multisite multivariate stochastic modelling approach is developed based on the generalized linear model (GLM) framework, using daily observations of precipitation and minimum and maximum temperatures from 120 sites located across the Canadian Prairie Provinces: Alberta, Saskatchewan and Manitoba. Large scale atmospheric covariates from

the National Center for Environmental Prediction (NCEP) Reanalysis-I, teleconnection indices, geographical site attributes, and observed precipitation and temperature records are used to calibrate these models for the 1971-2000 period. Validation of the developed models is performed on both pre- and post-calibration period data. The calibrated models are used to generate daily sequences of the selected weather variables for the historical (conditioned on NCEP predictors), and two non-overlapping future periods (i.e. 2011-2054 and 2055-2098) using outputs from six CMIP5 (Coupled Model Intercomparison Project Phase 5) AOGCMs (CanESM2, GFDL-CM4, HADGEM2, MIROC-ESM, MPI-ESM-LR, and NorESM1-M) corresponding to RCP2.6, RCP4.5, and RCP8.5 scenarios. Preliminary results indicate that the developed models are able to capture spatiotemporal characteristics of observed precipitation and temperature fields, as well as a number of important statistics, ranging from seasonal means to characteristics of temperature and precipitation extremes and some of the commonly used climate indices such as cold and heat waves, frost days, and dry and wet days and their corresponding spells. Future changes in the mean and tail characteristics of precipitation and temperature variables are analyzed relative to the 1962-2005 reference period. The results of this analysis provide important information for decision- making. The study concludes that the GLM framework can reliably be used for multisite multivariate downscaling of AOGCM outputs in this region of Canad.

15:30

Enhancing Climate Monitoring in British Columbia

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Operational weather networks and research weather stations have come together in British Columbia with a common goal of providing data for climate monitoring in the province for other users. The Climate Related Monitoring Program, led by the BC Ministry of Environment, is made up of partners from the Ministry of Forests, Lands, and Natural Resource Operations (FLNRO), Ministry of Transportation and Infrastructure, Ministry of Agriculture, BC Hydro, and Rio Tinto Alcan; all of whom are contributing weather data to a Provincial Climate Dataset. FLNRO's Forest Ecosystem Research Network, while not an operational weather network, is helping to fill monitoring gaps in the province, most notably on the mid-coast, northern BC, and high elevations. Efforts are currently underway to create a designated climate station network with an appropriate level of geographic coverage in BC for assessing the impacts of climate change and providing information for climate modelling to the Pacific Climate Impacts Consortium.

15:30

The SMART filter: An introduction to a novel data assimilation method

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The SMART filter (simultaneous multiplicative algebraic reconstruction technique) is a relatively new filtering algorithm (Qranfal & Byrne, 2011) that minimizes a cost function of weighted cross

entropy (Kullback-Leibler) distances rather than the standard Euclidean distance. The SMART filter was originally developed to solve ill-posed inverse problems that arise in reconstructing a time-varying medical image. This algorithm holds potential for data assimilation applications in geophysical fluid problems where we are also interested in time- varying variables of large-scale systems. The SMART filter has advantages over the Kalman filter in that it does not involve matrix-matrix multiplication or matrix inversion and thus is computationally more efficient. We introduce the SMART filter as a solution to the data assimilation problem bringing the method to a new audience. We implement the SMART filter on a simple data assimilation application and compare results with those of the Kalman filter. These preliminary results demonstrate the algorithms potential benefits for geophysical data assimilation applications.

15:30

Characterizing the impact of geomagnetic storms on the electrical grid: a global comparison of sudden ionospheric disturbance data

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This study aims to determine whether certain geographical regions are more prone to solar flare damage by analyzing data from sudden ionospheric disturbance (SID) monitors around the world. Solar flare damage to the electrical grid is caused by the voltage created between the atmosphere and the earth by the solar flare or the coronal mass ejection triggered by it. This overloads the power grid and may damage it permanently. Previous studies found that in the United States the risk of solar flare damage to the electrical grid is correlated with increasing magnetic latitude, proximity to the coast, and ground conductivity. In order to substantiate the implications of these findings for Canada's electrical grid, SID data from Vancouver was compared to SID data from around the world. Stanford University's data repository supplied the global SID data and a SID monitor was set up in Vancouver to record the region's response to solar flares. The Geostationary Operational Environmental Satellite (GOES) flare catalogue was used to determine relevant intervals of solar activity for which to compare SID data. The SID signal strength from each location, which is provided at 5 second intervals, was matched with GOES X-class and C-class flares from start to end time. Then, the relative impact of each solar flare was compared by magnetic latitude, proximity to the coast, and ground conductivity. The results of this study reveal a strong correlation between magnitude of solar flare impact and magnetic latitude and minor correlations with coast proximity and ground conductivity. The major implication of this is that the Canadian government at the federal and provincial level must take steps to protect the electrical grid from damage due to geomagnetic storms.

15:30

The Super Arctic Storm in 2012: Investigation of Dynamics Mechanism

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A strikingly super and long-lasting Arctic storm occurred in August 2012, along with which a record low sea ice extent was observed. In this study, the physical processes and mechanisms responsible for its long persistence and strong intensity were investigated by using the Weather Research and Forecast (WRF) model. The storm was generated over northeastern Siberian coast on August 2, 2012, and then moved into Arctic Ocean. It intensified to reach its minimum sea level pressure of 959hPa on August 6. Afterwards, the storm lingered over the Arctic Ocean for 7 days. Its intensity and duration is greater than 99% of all Arctic storms. Our WRF simulation results suggest that both troposphere baroclinic instability and Tropopause Potential Vorticity (TPV) anomaly contribute to the drastic intensification and long persistence of the storm. If only baroclinic instability is present, the storm can intensify to some degree of its observed strength but has very short lifetime. Without the troposphere baroclinic instability, TPV anomaly alone can help to maintain the storm persistence but the intensity is much weaker.

15:30

Modelling Thermobaric Effect in Quasi-geostrophic Approximation

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Thermobaricity implies that density cannot be written as a function of potential density and pressure, implying non-conservation of potential vorticity even in the absence of viscous and diffusive effects. In this study, a modified version of QG (MQG) that takes into account thermobaric effects is considered numerically. The MQG equations include an advection-diffusion equation for "spice"; that is, for the temperature-salinity composition of the water. Lateral variability of spice affects the base state buoyancy frequency, which can no longer be thought of as a function of z alone. Because of this, the 3d elliptic inversion cannot be separated into 2d inversions for each vertical mode. A numerical technique to handle this, as well as preliminary results are presented. Our results to date suggest that the addition of spice and thermobaricity to QG turbulence can lead to an enhancement of vertical structure.

15:30

Influence of snow and soil-moisture initialization on sub-seasonal predictability skills of CanCM3

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This study examines the influence of snow and soil moisture initialization on sub-seasonal potential and actual skills of Canadian Climate Model version 3 (CanCM3) predictions of springtime (April-May) near surface air temperature. Four series of ten-member ensemble forecasts, which are initialized on 1st April where each series use different land surface initialization, were performed for the 20 year period 1986-2005. Potential predictability of temperature for extratropical Northern Hemisphere land is assessed using synthetic truth and signal-to-noise methods, and compared

with actual skills determined through validation against an ensemble mean of six reanalysis products. Three of the four land surface initializations considered are intended to be realistic. These are obtained from the Canadian LAand Surface Scheme (CLASS) land component of the climate model driven off line with bias-corrected meteorological fields, with and without rescaling to the climate model's land climatology, and from climate model runs where the atmospheric component is constrained by reanalysis fields. A fourth land surface initialization that is intended to be unrealistic consists of a "scrambled" version of that obtained from rescaled offline-driven CLASS, in which each ensemble member is assigned values from a year other than the one being forecasted. Comparisons of forecasts using the scrambled and corresponding realistic land initializations indicate that the latter show higher potential predictability skill overall especially over North America and parts of Eurasia at all lead times. The higher potential predictability is primarily attributed to correct initialization of land surface variables, in particular the snow water equivalent, and the frozen and liquid components of soil moisture. Our results indicate that predictability is governed mainly by forecast signals, with high forecast noise also playing a role. The differences between potential and actual skills are mainly attributed to the differences between observed and the initial snow conditions used in the CanCM3 model forecasts.

15:30

A modelling study of the effect of tide-surge interaction on the circulation and hydrography over the Canadian eastern seaboard

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The coastal and shelf waters of Canada's eastern seaboard are frequently affected by winter and tropical storms. The dynamics of the response of these regions to storms are not well understood. The main objective of this study is to examine the storm-induced circulation, its interaction with tides, and the effect of the tide-surge interaction on the baroclinic circulation and hydrography over these regions from numerical results. Version 3.1 of the Nucleus for European Modelling of the Ocean (NEMO) is applied to the northwest Atlantic Ocean (NWA) with 1/12o horizontal resolution and 50 vertical z-levels. The model forcing at the sea surface consists of the Climate Forecast System Reanalysis (CFSR) 6-hourly product of short wave and long wave radiation, surface wind, air temperature, relative humidity, precipitation and monthly climatology of freshwater runoff from ten major rivers. The tidal forcing consists of (a) tidal surface elevation and depth-mean currents of five major constituents at open boundaries and (b) tide-generating potential specified at each model grid. A parametric vortex is inserted to the large-scale wind forcing during a storm such as Hurricane Juan. The model reproduces reasonably well the observed sea level elevations at tide gauges and general circulation over the NWA. The model also generates significant sea surface cooling of about 5oC behind the storm during Hurricane Juan. The storm-induced circulation can be dominant over shallow coastal waters during a short period of time and the effect can last for a longer time. The effect of the tide-surge interaction on the circulation and hydrography over the

coastal and shelf waters of the NWA will be discussed.

15:30

Using WRF to improve roadway safety: impacts of adverse weather on traffic collisions.
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Adverse weather can impose safety risks to roadway users. While most drivers can recognize that many types of weather increase the risk of collision, drivers tend to not make adequate adjustments to counterbalance the effects of poor weather. We studied the effects of adverse weather in the city of Edmonton, Alberta, for three years to determine some relationships between weather and traffic collisions. We particularly focused on precipitation, wind speed, and visibility, and our analysis of traffic collisions included collisions by type and severity. Furthermore, the University of Alberta produces operational weather forecasts for the City of Edmonton's Office of Traffic Safety, producing 4 7-day forecasts every day, by using the Weather Research and Forecasting (WRF) model. These weather forecasts are one of many inputs into a speed and collision prediction model used by the Office of Traffic Safety in the hopes of preventing collisions in the city of Edmonton.

15:30

The occurrence of Yanai waves in constrained geometries
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The destabilization of Yanai, or mixed Rossby-gravity, waves has been presented as a possible mechanism for the formation of both the deep equatorial jet and the horizontal alternating zonal jet structures. However, the analytical Yanai wave solutions are in the context of an infinite equatorial geometry, unlike the ocean basins which are clearly constrained. To explore this issue, we begin by presenting the parametric formation of mixed Rossby-gravity waves as the domain transits from a thin equatorial channel into an unbounded system. The formation is shown to exhibit a two-stage behaviour: in large enough channels the classical Yanai wave solutions are recovered but when the domain is sufficiently constrained they can no longer exist. We discuss the length scales for which the Yanai waves occur and how their wave characteristics are altered by the geometry of the domain. Furthermore, the stability of Yanai waves at various stages of parametric formation is analyzed numerically and possible implications on jet formations in small equatorial bodies are discussed.

15:30

Tropospheric Ozone Variations in North America
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Ozone plays a significant role in controlling the chemical and radiative processes of the troposphere.

It influences the oxidizing capacity of the lower atmosphere, which controls the capacity of the lower atmosphere to remove pollutants. Increased levels of ozone are harmful to human beings and vegetation. Therefore, understanding of tropospheric ozone is of great importance and remains an area of very active research. In this study, tropospheric ozone variations in North America are characterized based on a newly available data set from a recent study (Liu et al., 2013). This 3-dimensional ozone climatology dataset relies on the fact that ozone is moderately long-lived tracer, and uses a special domain-filling technique with forward and backward trajectory calculations to fill in spatial gaps in ozone sonde data., Thus it is able to provide information on ozone variation over the entire continent, whereas the original ozonesonde data provides information only on areas near the measuring stations. We found that ozone in North America shows a latitudinal gradient from low ozone abundance in the south and high ozone in the north, in all layers of the troposphere (lower, middle and upper). The gradient is stronger in the winter than in the summer. Compared to the global tropospheric ozone mean, the mean in North America is higher all throughout the 1970s to the 2000s. For four decades (the 1970-2000s), ozone in North America generally increased from the 1970s to the 1980s, and decreased from the 1980s to the 1990s, and then increased again from the 1990s to the 2000s. Uncertainty of this analysis will be further discussed.

15:30

Sensing precipitation at the Atmospheric Radiation Measurement Climate Research Facility Alaskan Mega Site

Scott Collis[1], *Jessica Cherry*[2], *Jonathan Helmus*[1], *Gary Wen*[3], *Martin Stuefer*[4], *Gijs de Boer*[5], *Hans Virlinde*[6], *Christopher Williams*[7], *Matthew Shupe*[8], *Nitin Bharadwaj*[9], *Pavlos Kollias*[10]
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In order to continue its mission to improve the representation of climate pertinent processes in all scales of weather models the Atmospheric Radiation Measurement (ARM) Climate Research Facility is reorganizing around two Mega sites. One of these sites is based around the North Slope of Alaska (NSA), which includes extensive instrument deployments at Barrow and Oliktok Point. This presentation will focus on a suite of measurements to better understand precipitation processes along the North Slope. ARM employs an all of the above approach to measurements with a suite of remote sensing and in-situ instrumentation. Ice crystals, due to their complexity, provides a unique challenge. The work we will be showing is the first step towards quantitative ice precipitation microphysics retrievals that will use advanced ground based instrumentation coupled

with polarimetric Ka and X band radar retrievals. While this work is only in its initial phases we will show examples of differences in ice microphysical habit and the impact on various radar measurements.

15:30

Lateral structures in the Labrador Current.

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Here we present fine lateral scale (<1.5 km) profiles of temperature, salinity and oxygen in the boundary system of the Labrador current. The lateral structure varies from the full length of the sections to cast-by cast variations. The structure of spice is investigated in terms of theories of lateral mixing.

15:30

Ocean heat uptake and open water convection

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Understanding how the ocean takes up heat is crucial to improve predictions of the future global surface temperature increase. While many previous studies have evaluated the spatial distribution of heat content change across the global ocean, a complete explanation of the mechanisms responsible for this distribution remains largely unknown. Hence, we lack a measureable indicator to judge whether these predictions are reasonable. Here, we examine a large ensemble of climate models to understand what creates inter-model variability in deep ocean heat content change under global warming. Based on earlier studies on oceanic vertical heat transfer, we propose open water deep convection as a principal mechanism for the transfer of heat from the deep ocean to the atmosphere. Therefore, the cessation of convection, as predicted in a future climate change scenario, would contribute to the increase of deep ocean heat content. We compare the convective volume and ocean heat content anomalies in 34 climate models of the IPCC Assessment Report 5. Most of these models show signs of open water deep convection in the North Atlantic and in the Southern Ocean. Moreover, the preindustrial variability in convective volume is linked to ocean heat content anomalies in individual models. Yet, there is a wide range of model responses to the suppression of convection, suggesting additional mechanisms are in play in transporting heat to the deep ocean. Finally, in order to identify the most realistic climate models in term of these variables, a comparison with observations is achieved.

15:30

Projecting the Influence of Climate Change on Extreme Ground-level Ozone Events in the Downtown Areas of Toronto and Windsor, Ontario, Canada

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Increasingly, it is becoming clear that climate change is affecting both the physical and social environments, often in ways unanticipated. The relationship between climate change and air pollution is becoming or will become one of the major concerns to many people living in southern Ontario, Canada. Ground-level ozone (O3) is perhaps one of the most familiar pollutants in Ontario because it is associated with most smog alerts in the province. The goal of this study is to statistically downscale the Toronto and Windsor groundlevel- ozone-concentration data with the general circulation model (GCM) and use the model output to forecast the influences, the changes, and the probabilities of occurrence of future Extreme Ground-level Ozone Events (EGLOGs) that occurs in the Toronto and Windsor Downtown areas under different climate-change scenarios. The dowscaling method used in this research to generate climate- change scenarios was the Statistical DownScaling Model (SDSM) version 4.2.2. SDSM is a hybrid of regression-based and stochastic weather-generator downscaling methods. The result from this research has suggested that there will be approximately 20 - 30% of gradual increase of daily maximum ozone-concentrations in the next eight decades. In addition, the result also forecasted that the probabilities of occurrence of Extreme Ground-level Ozone events with the O3 concentration = 80 ppb (the current Ontario 1-hour Ambient Air Quality criterion for extreme ozone concentration) will gradually increase to three times of what we are experiencing today in the two downtown areas by the year of 2100 under the different future scenarios in the third version of the Coupled Global Climate Model (CGCM3).

15:30

Wavelet Analysis of Polar Vortex Variability over the 20th Century

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Recent increases in extreme weather events in the Northern Hemisphere have been linked to amplified planetary waves. Changes in planetary wave properties are linked to changes in climate; hence, finding a mechanism that links the planetary wave variability under climatic forcing and mid-latitude blocking events has engendered a great deal of interest. In this study, wavelet analysis is applied to time series of planetary wave phase speeds at high latitudes as a first step to assessing the potential for identifying these mechanisms in the observational record. A circumpolar annual cycle increase is found but signals at multiannual time scales demonstrate a more complex westward propagation pattern with periods of intense wave variability. Significant correlations between wavelet power at all timescales and albedo, snow cover, atmospheric ozone levels, and surface temperature are demonstrated.

15:30

Extrêmes hydrologiques et variabilités climatiques au Nouveau Brunswick

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Un large consensus scientifique existe à savoir que le climat planétaire subi des changements significatifs à tel point que notre société et environnement naturel en seront profondément modifiés au cours des prochaines décennies. Cette étude porte sur des analyses les inondations et les sécheresses au Nouveau-Brunswick. Une analyse de la fréquence des crues a d'abord été effectuée afin d'établir les caractéristiques des régimes de fréquences élevées. Par la suite, une analyse des sécheresses a été effectuée au Nouveau- Brunswick afin d'avoir une estimation de la probabilité des faibles débits tout au long de l'année. Ensuite, en utilisant des mod'eles de réseaux de neurones artificiels, une analyse des impacts des changements climatiques sur les régimes d'écoulement au N-B a été effectuée. D'autres données climatologiques ont été tirées du mod'ele couplé du climat du globe (MCCG3.1) sous les scénarios B1 et A2 des émissions de gaz à effet de serre du Groupe d'experts intergouvernemental sur l'évolution du climat (GIEC). Les champs d'observation du changement climatique (températures et précipitations) ont été calculés avec l'approche delta. Un réseau de neurones artificiels a permis de prédire le débit d'eau futur à des stations hydrométriques précises. Enfin, une analyse de la fréquence a été effectuée avec la fonction de distribution GEV (generalized extreme value) et les param'etres de la distribution ont été estimés selon la méthode des L-moments.

15:30

Net ecosystem exchange of a disturbed and rewetted raised bog ecosystem measured by eddy covariance

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Peatlands are ecosystems that can accumulate substantial amounts of atmospheric carbon dioxide (CO2) and sequester it over time in the form of peat. From an emission management perspective, carbon sequestered in bogs needs to be protected otherwise additional emissions due to land-cover change may occur. The Burns Bog Ecological Conservancy Area (BBECA) in Delta, BC, on Canada's Pacific Coast, is part of a remnant peatland ecosystem recognized as one of Canada's largest undeveloped natural areas retained within an urban area. Historically, it has been substantially reduced in size and affected by peat mining and agriculture. Since the year 2005, the bog has been declared a conservancy area, and restoration efforts in the BBECA focus on rewetting to promote a transition back to a raised bog. In this study, we quantify the first year of CO2 exchange measured in a Beakrush-Sphagnum ecosystem representative of the BBECA. A floating

platform with an eddy-covariance system has been established in summer 2014. We characterize how environmental factors affect the seasonal dynamics of this exchange. In the summertime (July-August), gross ecosystem photosynthesis (GEP) was 5.23 g C m2 day-1 and ecosystem respiration (Re) was 1.99 g C m-2 day-1 making the bog a net carbon sink. Measurements from November to December show a GEP of 1.70 g C m-2 day-1 and Re of 1.43 g C m-2 day-1 maintaining the bog as carbon sink. The magnitude of GPP and Re are lower at this disturbed site than in previous studies of pristine northern peatlands, raising the questions as to the low productivity is due to rewetting or the previous disturbance. The measured ecosystem is not highly productive, yet the considerably limited Re due to oxygen limitation sequesters consistently CO2. Our measurements show further that soil temperature and soil water content were major drivers on seasonal changes of net ecosystem exchange.

15:30

Analysis of a Bias-Corrected Methodology for Precipitation Measurements to improve Inconsistencies across Alaska and Yukon Border

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It is known that discontinuities exist in climate records across national boundaries because of the different instruments and observation methods used in adjacent countries. For instance, the National Weather Service (NWS) 8-inch gauge is used for precipitation measurements in the United States, and the Nipher snow gauge is the standard instrument for snow observations in Canada. Instruments also change over time in most operational networks, resulting in significant breaks in the data record. It has been realized that a combination of regional precipitation records from different sources may result in inhomogeneous precipitation time series that can lead to incorrect spatial interpretations. The objective of this work is to quantify the spatial precipitation inconsistencies across the border between Alaska and Yukon. Gauge precipitation data have been corrected to account for wind effect on the catch efficiency and other errors. We analyze the spatial variation of the bias corrections across the Alaska/Yukon border. Due to differences in precipitation measurements by the national gauges, a spatial inconsistency in the precipitation measurements is observed in monthly time series, dispersion plots, and the Double Accumulated Curves across the border. A discretization of 2 station groups was selected for the north and central regions, we find changes in the double mass curve between measured and corrected precipitation in the north part, mainly due to the difference in biases and their corrections (the mean annual correction is around 14% in Canada and 65% in United States for the North). We also see a difference in snow measurement corrections in the central part (around 3% in Canada and 7% in United States). This inconsistency in the precipitation measurements should be taken into account when using the precipitation data across the national borders, especially during winter season, when snowfall is the most bias-affected in windy and cold conditions.

15:30

Reproducing sea-ice deformation distributions with viscous-plastic sea-ice models

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High resolution sea-ice dynamic models offer the potential to discriminate between sea-ice rheologies based on their ability to reproduce the satellite-derived deformation fields. Recent studies have shown that sea-ice viscous-plastic (VP) models do not reproduce the observed statistical properties of the strain rate distributions of the RADARSAT Geophysical Processor System (RGPS) deformation fields [1][2]. Here, we investigate what could be the source of this discrepancy. To do so, we use the elliptical VP rheology and we compute the probability density functions (PDFs) for simulated strain rate invariants (divergence and maximum shear stress) and compare against the deformations obtained with the 3-day gridded products from RGPS. We find that an overestimation of the shear in the range of mid-magnitude deformations is present in all of our VP simulations tested with different spatial resolutions and parameters. Runs with no internal stress (free-drift) or with constant viscosity coefficients (Newtonian fluid) also show this overestimation and suggest that there exist an inherent shear in the wind forcing that is not properly converted by the VP model in a flatter sea-ice shear distribution. A closer look at the deformations present in the wind field (NCEP/NCAR reanalysis) used to derive our atmospheric forcing indeed shows a similar pattern of increased mid-magnitude shear that is very distinct from the RGPS distribution for sea-ice. Increasing the shear resistance of the ice could provide a way for VP models to be able to resist the wind shear forcing in this range and result in a flatter sea-ice shear distribution. [1] Girard et al. (2009), Evaluation of high-resolution sea ice models [...], Journal of Geophysical Research, 114 [2] Girard et al. (2011), A new modeling framework for sea-ice mechanics [...], Annals of Glaciology, 57, 123-13.

15:30

On the universality of the Universal Tropospheric Gravity Spectrum waves in the Arctic and non-Arctic atmosphere

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Abstract. In 1982, VanZandt proposed a universal spectrum for gravity (buoyancy) waves in the atmsphere, specifying a shape to the intensity of gravity wave energy versus their wavenumber that is independent of geographic location, meteorological conditions, and time, especially for upper altitudes. This was based in part on the oceanographic work of Garrett and Munk (1972, 1975), but with special adaptations for the atmosphere. The literature absorbed the concept of universality: many (e.g. Medvedev and Klassen 1995) produced power spectral density forms. Various theories were employed, such as Weinstock's nonlinear wave diffusion, Hines' Doppler-spread theory, shedding, and linear instability theory. Focus then shifted towards deviations from the spectrum (e.g. Eckermann 1995, Tsuda et al., 2000), and the degree of universality became less certain. Within the troposphere, where waves are often still relatively close to their sources, universality is even

more questionable, and the relative roles of waves and 2-D turbulence is an issue. We have investigate the form of the tropospheric gravity wave spectra at two quite distinct geographic locations, using several radars in Ontario and and Eureka, NU, (all in Canada), for altitudes between 1-14 km, and through different seasons over several years. We have investigated both spectral log-log slopes and power offsets. Despite the claim of universality, our analysis using Ferraz-Mello's (1981) data- compensated discrete Fourier transform method reveals distinct deviations, both random and systematic, from universality. At the Negro Creek site, for example, in southern Ontario, a weak seasonal variation is evident, while at Eureka the most significant changes are on time-scales of years, with noticeable trend evident between 2007 and 2014. These deviances will be discussed.

15:30

Numerical simulation of shoaling mode-2 internal waves

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It is well understood that coherent, large amplitude internal waves are a common occurrence in the coastal ocean. Such waves are often associated with locations in which tides interact with a sill, and examples of well studied geographical locations are the South China Sea, the Strait of Gibraltar, and Knight Inlet, British Columbia. Typically the waves observed have a so-called mode-1 vertical structure with isopycnals rising or falling together at all depths. For such waves a well defined mathematical description is available through the Dubreil-Jacotin-Long equation. There is a smaller, though not insignificant, literature that reports observations of mode-2 waves in the coastal ocean. Like their mode-1 counterparts, mode-2 waves will follow the generation-propagation-dissipation lifecycle, though in contrast to their mode-1 counterparts, mode-2 waves may experience resonance with short mode-1 waves. We present numerical simulations of mode-2 waves on the laboratory scale that shoal over bottom topography. We characterize the manner in which the mode-2 wave breaks down during shoaling, focusing on the contrast between breaking and conversion to a mode-1 wave train. Finally we compare the simulations with laboratory experiments.

15:30

Sea Ice Pressure Events in Hudson Strait from RADARSAT: Implications for Winter Shipping in the Eastern Canadian Arctic

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Resource extraction opportunities in the Canadian Arctic combined with improved navigation related to changes in sea ice has increased interest in winter shipping activities. Pressured ice can hinder the progress of or beset even ice-strengthened vessels, and this can lead to heavy costs for operators in terms of fuel and other expenses. Beset vessels can also cause environmental concerns related to unnecessary emissions and potential fuel spills. An important region of winter shipping activity in the Canadian Arctic is the corridor from Hudson Strait to Deception Bay, Quebec. Ice concentrations within the corridor are typically between 9-10 tenths during winter months and

pressured ice is known to occur but has never been quantified over long time periods. This study investigated pressured ice events in a defined shipping corridor in Hudson Strait using RADARSAT-1 and -2 imagery for the winter shipping season from 1997 to 2012. Features hazardous to ships that are associated with pressured ice (i.e. ridges, shear zones, leads, and areas of land-fast ice) were manually identified on the imagery and a 15-year time series analysis of these deformation events was constructed using an original method. Preliminary results indicate identifiable temporal and spatial patterns in ridging. The connections between besetting events and deformation features over the past 15-years were also explored. The outcomes of this work will aide in route selection and navigational decision-making and will help to better understand the influence of pressured ice on ship besetting events. This method could be used in other regions of the Arctic in order to assess patterns in sea ice pressure and sea ice dynamics.

15:30

Initial observations of ice crystal habits and size distributions at Summit, Greenland

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A Multi-Angle Snowflake Camera (MASC) was recently installed at Summit Station, Greenland in addition to the existing suite of atmosphere- and precipitation-measuring instruments associated with the NSF-funded ICECAPS (Integrated Characterization of Energy, Clouds, Atmospheric state, and Precipitation at Summit) project. The preliminary observations are presented from the first month of deployment. When a hydrometeor falls through the instrument opening, the MASC uses infrared sensors to trigger three cameras all focused on one focal point. These images are used to distinguish ice crystal habits and size distributions under different atmospheric and synoptic conditions. The size distributions may ultimately be used to constrain CloudSat-derived snowfall amounts, providing more accurate snowfall estimates over the Greenland Ice Sheet.

15:30

Atmospheric profiles in the Arctic seasonal ice zone and the role of synoptic conditions

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We use the Polar Weather Research and Forecasting (WRF) Model to simulate atmospheric conditions during the Seasonal Ice Zone Reconnaissance Survey (SIZRS) in the summer of 2013 over the Beaufort Sea. With the SIZRS dropsonde data, the performance of WRF simulations and two forcing datasets is evaluated: the Interim ECMWF Re-Analysis (ERA-Interim) and the Global Forecast System (GFS) analysis. The observed atmospheric profiles exhibit distinct thermodynamical states related to the synoptic conditions. Features such as the low- level temperature inversion, low-level jet (LLJ), and specific humidity inversion are frequently observed and are also related to the synoptic conditions. In general, these features are reproduced in the mean profiles by all three models. A near-surface warm bias and a low-level moist bias are found in ERA-Interim. WRF significantly improves the mean LLJ, with a lower and stronger jet and a larger turning angle than

the forcing. The improvement in the mean LLJ is likely related to the lower values of the boundary layer diffusion in WRF than in ERA-Interim and GFS, which also explains the lower near-surface temperature in WRF than the forcing. The relative humidity profiles have large differences between the observations, the ERA-Interim, and the GFS. The WRF simulated relative humidity closely resembles the forcings, suggesting the need to obtain more and better-calibrated humidity data in this region. We find that the sea ice concentrations in the ECMWF model are sometimes significantly underestimated due to an inappropriate thresholding mechanism. This thresholding affects both ERA-Interim and the ECMWF operational model. The scale of impact of this issue on the atmospheric boundary layer in the marginal ice zone is still unknown.

15:30

Current surges and suspended sediments dynamics: Evidence for seabed erosion near the shelf break? Canadian Beaufort Sea

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Sustainable development of marine hydrocarbon resources along the continental margins and slopes in the Arctic Ocean will depend on a more thorough understanding of factors influencing the distribution and dynamics of seabed sediments that occur near the shelf-break and continental slope. Recent seabed research in the southern Canadian Beaufort Sea conducted in response to release of deep water leases for hydrocarbon exploration drilling indicates only a thin veneer (≈0.3 m) of recent sediments overlie sediment dated at 9000 BP; the veneer of recent sediment thickens significantly down slope away from the shelf-break. We estimate the erosion potential of bed sediments and the magnitude of the resulting suspended load in relation to current velocity and direction near the shelf-break with the aim of understanding the variability of sediment transport mechanisms within the bottom boundary layer. Measurements obtained during Industry-ArcticNet collaboration (2009-2011) and the Beaufort Regional Environmental Assessment (BREA 2011-2013) reveal that near-bottom currents on the upper slope (140 to 150 m isobaths) are characterized by recurring episodes of high velocities (instantaneous speeds up to ≈50-60 cm s-1) that are extensions of current surges (≈60-80 cm s-1) occurring in the core of the shelf-break jet located at ca. 90-120 m isobath. These surges appear linked to the development of large-scale systems of strong winds (>15-20 m s-1) propagating across the western Arctic Ocean, such as during epic storms of November 2011, September 2012, and major ice-fracturing events linked with storms in January-March 2013. Strong currents correlate closely with high suspended sediment concentrations (up to ≈1 kg m-3) in the near bottom boundary layer (< 15 m) implying rapid advection and a local source. Mean suspended load and erosion potential were approximately double at the western end of the Canadian shelf-break compared with the shelf-slope break further west suggesting that shear velocity and sediment resuspension are topographically enhanced by the Mackenzie Trough.

15:30

Validation of ocean temperature and salinity based on the Regional Ocean Modeling System (ROMS) in Korea Meteorological Administration

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Climate of the Korean Peninsula which is surrounded by sea on three sides is strongly influenced by sea surface temperature. Sea surface temperature affected by the interaction of the atmosphere and the ocean with insolation, radiation, and flux, but it also changes substantially depending on tides and ocean currents. Numerical models are used to understand the currents and temperature distribution in the ocean due to large variability of ocean currents and difficulty of observation. In order to simulate three-dimensional ocean circulation of the northwestern Pacific Ocean including around the Korean Peninsula, Korea Meteorological Administration has been operating ROMS since year 2012 which is developed at Rutgers University in USA . The ROMS configuration consists of 8 km spatial resolution and 20 vertical layers with 115E - 150E longitude and 20N-50N latitude to produce the ocean state every 1 hour and 72h forecasts once a day. The ROMS forecast verified against sea temperature and salinity which is observed from ARGO observation. Validation period is from January to August 2014 and the error is analyzed for 10m to 2000m depth. Sea temperature predicted from ROMS underestimated in the middle depth of the ocean. Salinity showed the large difference between the model and observation near surface of the ocean and the maximum difference showed around 800m depth. Spatial difference of sea temperature showed the maximum value over the East Sea and Pacific Ocean of east Japan. Spatial distribution of salinity difference showed that ROMS model forecast underestimated over the model domain. The ROMS forecast system need to be improved with data assimilation in the future study.

15:30

Historical Antarctic station-based pressure changes in austral summer during the 20th century

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Several recent studies point to a profound influence of stratospheric ozone depletion on the Antarctic pressure variations over the last 30 years. Yet, as with much of Antarctic data, researchers are left with neither long-term point (station) measurements of pressure variations across Antarctica, nor gridded pressure data from reanalyses or models that can be deemed reliable, given very little in situ data to constrain the solution across the high southern latitudes. Thus, it is not clear how unique these changes are in a longer historical context spanning the entire 20th century. Using reconstructions of Antarctic pressure based on the method of principal component regression, pressure variations across the austral summer since 1905 are examined for the first time. Notably, the reconstruction skill is the highest in austral summer compared to other seasons, allowing for a detailed investigation of the historical pressure variability. The poster will present several reconstructions from East Antarctica, the Antarctic interior, and the Antarctic Peninsula. It will be

shown that there are significant negative pressure trends at many stations, most marked in East Antarctica, over the last 30 years. In the newly afforded historical context, these trends are the strongest they have been over the last century, highlighting the uniqueness of stratospheric ozone depletion on the austral summer Antarctic circulation. Future work includes examining other seasons as well as comparing the reconstructions to climate model simulations with different forcing mechanisms.

15:30

A Geochemical Journey: Fingerprinting the Rivers of the Canadian Arctic Archipelago

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We present a unique dataset on the geochemistry of rivers in the Canadian Arctic Archipelago (CAA). During the summer of 2014, we conducted a preliminary investigation of six rivers draining into the straits of the southern CAA, from Coronation Gulf in the west to Queen Maud Gulf in the east. Our observations reveal surprising differences in the geochemical fingerprints of each river, despite collecting samples at similar flow stages. Drainage basin geology, permafrost cover, and precipitation are considered to explain fingerprint patterns. We also carried out a time series study of Freshwater Creek, draining into Cambridge Bay, from ice-break up in June until low flow in late August. These data illustrate the dynamic seasonality of an Arctic river's geochemical fingerprint over its annual hydrograph. In light of the limited historical data for the region, our observations highlight the need for comprehensive geochemical measurements covering the entire flow cycle of CAA rivers. As the warming climate acts to increase permafrost thaw and precipitation north of the Arctic Circle, a change in the magnitude of terrestrial carbon and nutrient inputs from rivers within the CAA will be impossible to assess without these types of baseline data. A primary goal of this work is to establish a framework for community-based geochemical monitoring and develop a long term data set from which to assess environmental change.

15:30

Adjusting the Fischer Porter/Belfort 3000 precipitation gauge for the systematic undercatch of snowfall

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The Fischer Porter precipitation gauge, which became the Belfort 3000 precipitation gauge in the early 1980s, has been used extensively across Canada in both operational and research observation networks for the all-season measurement of precipitation. Like most precipitation gauges, this gauge is susceptible to wind induced under-catch of snowfall (Goodison, 1977). Although the gauge has

become largely obsolete, it had a relatively long period of use necessitating the requirement for a robust adjustment for wind under-catch that can be applied to historical measurements. Since 2003, a Belfort 3000 inside a single Alter wind shield (which is a typical configuration) has been co-located at the Bratt's Lake observatory with a Geonor inside a Double Fence Intercomparison Reference (DFIR) wind fence. This Geonor gauge inside the DFIR, which will be called the Geonor-DF, will serve as the reference for this intercomparison. As anticipated, the precipitation totals for the Belfort 3000 and Geonor-DF agree quite closely during rain events but deviate substantially during snowfall events. A preliminary catch efficiency - wind speed relationship for snowfall is presented to facilitate adjusting the snowfall under-catch for this gauge.

15:30

Glider Deployments to Measure Microstructure on the Beaufort Sea Continental Shelf, Summer 2015

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We present plans to deploy three Slocum G2 gliders (two deep, one shallow) equipped with microstructure sensors in Amundsen Gulf and on the Mackenzie Shelf in August 2015. This region is traditionally challenging for glider operations because of rapidly changing sea-ice conditions and strong stratification between the surface and the Atlantic Water (≈300 m) layers. However, if conditions are favourable the gliders will be capable of providing a unique dataset of microstructure shear, temperature, and conductivity measurements that can be used in conjunction with existing CTD and ITP measurements to determine turbulent energy dissipation rates, observe turbulent mixing mechanisms, and to quantify shelf-basin exchanges.

15:30

Instabilities of Mesoscale Jets Over Shelf Topography in a Two-Layer Ocean Model

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Along-shelf coastal currents are ubiquitous in the world's ocean. However, the combination of stratification and topography has made a full study of their stability difficult. The stability characteristics of oceanic jets are investigated using a two-layer, rotating shallow water model. We consider a geostrophic Bickley jet overlying a gently sloping continental shelf with a piecewise vertical structure to idealize physical oceanic jets. We use a stability analysis to compute the linear stability characteristics and modal structures of several types of profiles including: purely barotropic flow, mostly baroclinic flow, surface-layer intensified flow, and bottom-layer intensified flow. These profiles are generic enough to give insight into how real mesoscale jets evolve over shelf topography. The analysis allows us to classify the unstable modes and also determine how their spatial struc-

tures depend on the governing non-dimensional parameters. Subsequently, we use numerical tools to study the nonlinear evolution to learn about the nonlinear equilibration process.

15:30

Spatio-Temporal Coherence of Double Diffusive Structures in Saline Powell Lake

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Double diffusive staircase structures are found at high latitudes in the ocean, and may play an important role in the regulation of vertical heat flux. Although they are easily observed, their spatio-temporal evolution characteristics are poorly understood. An ideal, isolated natural observation site for double diffusive convection (DDC) is found in Powell Lake in British Columbia, Canada, which contains geothermally heated relic sea water, trapped at the lake bottom, with cooler, fresh water at the surface. Previous work here has shown that the DDC staircase structures are present in multiple vertical regions near the lake bottom. Three years of CTD profiles along the length of the lake, along with a month long mooring with two current meters and over thirty temperature sensors (with a vertical resolution of seven centimetres over two metres), have provided novel observations of the spatio-temporal variations of this structure both on the scale of the overall 'staircase' as well as a single 'step'. Significant variability has been observed on the time scale of hours within individual steps, even though the overall layer structure shows coherency on the time scale of years.

15:30

Flux-Profile Relationships under Stable Conditions at Arctic Terrestrial Sites.

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Atmospheric energy fluxes are the key to understanding annual temperature cycles, seasonal land snow cover, and the decrease of pack ice in the Arctic. The process of atmosphere-surface exchange mechanisms can be applied to modeling and forecasting improvement; this requires continuous measurements of energy budget components over multiple years. This study focuses on a turbulent surface flux analysis based on measurements made at two different sites located near the coast of the Arctic Ocean at Eureka (Canadian territory of Nunavut) and Tiksi (East Siberia). Covariance turbulent fluxes and mean meteorological data are measured continuously and processed to yield hourly values for a 10-m (Eureka) and 20-m (Tiksi) flux towers. The data shows strong sensible and latent heat fluxes that form clear diurnal cycles during the summer months whereas during polar winter and cold seasons these fluxes were small and irregular generally indicating stable conditions. The stable conditions are of greatest interest since it is observed in Arctic Boundary Layer 80% of the time. Turbulent fluxes and vertical profiles of wind, air temperature and humidity are analyzed in the framework of the Monin-Obukhov Similarity Theory. The flux-profile relationships for wind speed, temperature, and humidity were compared to parameterization of the gradients

using three commonly used functional forms (Businger-Dyer, Beljaars-Holtslag formulaes, CASES-99 and SHEBA field campaign) Besides the turbulent fluxes of momentum, sensible heat and water vapor the atmospheric and surface measurements include mean wind speed, air temperature and humidity, upwelling and downwelling short-wave and long-wave atmospheric and surface radiation, snow depth, surface albedo, soil heat flux, active layer temperature profiles that will lead in future studies to all components of the surface- atmosphere net and energy exchange budgets.

15:30

Bottom Pressure Recorders Track Ocean Swells in Real-time

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The high-precision bottom pressure recorders (BPR) deployed on the NEPTUNE observatory of Ocean Networks Canada are capable of detecting a wide range of phenomena related to sea level variations. The observatory BPRs include quartz pressure sensors built by Paroscientific Inc. and low-power, high-precision frequency counters developed for the Pacific Geoscience Centre by Bennest Enterprises Ltd.; they provide observations of nano-resolution pressure variations which correspond to sub-millimeter scale surface height variations in several kilometers of water. Detected signals include tides, tsunamis, infragravity waves, swells (at sites shallower than 500 m), microseisms, storm surges, and seismic signals. Spectral analysis reveals many of these phenomena with periods ranging from a few seconds to many hours. Dispersion patterns from distant swells are prominent in the swell and microseism bands. By comparing the difference of arrival times between longer period waves, which arrive first, and shorter period waves we can estimate the distance the swells have travelled since they were generated. Using this information, swells can be tracked back to specific storms across the Pacific. The presentation will high-light some of the more interesting signals over several years of observations.

15:30

Weather and Climate Decision Support Services in Alaska's Arctic

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Alaska's Arctic communities are almost entirely disconnected from wider infrastructure. This isolation ranges from standalone power stations and local telecommunications systems to the absence of all-season land-transportation connections to other communities. And, it is precisely because of this isolation that decision makers require long lead times ahead of community actions in advance of hazardous weather events. To meet these requirements, the National Oceanic & Atmospheric Administration (NOAA) National Weather Service (NWS) Alaska Region focuses more attention on

the details of the 6-to-14 day outlooks than is commonly done at mid-latitudes. At this time range, dynamic model ensemble systems are critical to providing the best forecast information possible, including uncertainty and alternate scenario information that decision makers need to properly assess risk. This presentation will examine both tools used in developing impactful weather outlooks and ways that information is conveyed to NWS partners.

15:30

NWS Alaska Sea Ice Program: Current and Future Operations

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The National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Alaska Sea Ice Program (ASIP) is designed to service customers and partners operating and planning operations within Alaska waters. The ASIP offers daily sea-ice and sea-surface temperature analysis products. The program also delivers a five-day sea-ice forecast three times a week, provides a three-month sea ice outlook at the end of each month, and has staff available to answer sea-ice related information inquiries. The analysis and forecast products issued by the ASIP are used by many entities to support navigational safety and community strategic planning. Our customers represent academia and research institutions, local, state, and federal agencies, re-supply barges, coastal subsistence hunters, gold dredgers, fisheries, and the general public. Due to a longer sea-ice-free season during recent years, the waters around Alaska have become more congested. This has led to a rise in decision support services from the ASIP, which remains in almost constant contact with both the NOAA National Ice Center and the United States Coast Guard (USCG) to ensure the best opportunity for safe navigation. In the past, the ASIP provided briefings to the USCG in support of Search and Rescue efforts. This near-term support mission continues; however, the ASIP has now begun briefing on sea-ice outlooks into the next few months to meet emerging planning requirements. As Arctic marine traffic increases, NWS Alaska anticipates the ASIP will be asked to provide increased services on varying time scales to meet customer needs. This talk will address the many facets of the current ASIP as well as delve into what we see as the future of the program.

15:30

An Effective Approach to Remap Runoff onto an Ocean Model Grid

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Runoff is one of the most important freshwater sources for the ocean, particularly in the high Arctic region where freshwater plays an important role in ocean stratification and circulation. A poor representation of runoff in ocean model leads to saltier water in the river estuaries, impacts boundary currents and the fronts and plays a role in the salinity drift seen in many high resolution ocean models. Here we present an effective approach to remap runoff data onto any resolution model grid. This method has a volume-conserving feature that guarantees the ocean model receives the same amount of freshwater as the original runoff data. It also provides an option to distribute

the runoff at desired locations, consistent with the source of that freshwater. As an example, we will apply the Dai and Trenberth 1x1 degree runoff climatology to a 1/4th degree Arctic and Northern Hemisphere Atlantic (ANHA4) ocean model configuration and show the difference in amount of runoff received in various basins in the model, as well as the resulting impact on the hydrography and circulation in the model.

15:30

Spatial and temporal analysis of near-surface temperature lapse rates along two elevation transects in the Rocky Mountains in south western Alberta

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Hydrological models often rely on interpolated temperatures based on nearby valley bottom stations. Surface temperature inversions, whereby temperatures increase with increasing elevation, can occur in mountainous regions and impact these models. Daily minimum and maximum lapse rates were calculated using data collected between October 2013 and August 2014 along two elevation transects 50 km apart in the south western Canadian Rockies. Each day was classified into one of six different weather types using discriminant function analysis applied to surface meteorological measurements for the region. The variability of lapse rates between and within weather types was examined and the relationship between weather type and inversions was investigated. There is a statistically significant separation between mean lapse rates for some weather types. However, there is also substantial overlap in the distributions of the lapse rates per weather type, indicating meteorological variability even within the same weather type. Positive lapse rates (inversions) occur more frequently for daily minimum temperatures, with values exceeding 5^{o}C/km on several days. Transect 1 minimum temperatures show inversions on approximately 35% of days, but only 10% of days show maximum temperature inversions. This implies the influence of cold-air drainage for many of the inversions. Maximum temperature inversions are most common during cold polar air events, but are not systematically observed under these conditions. While inversions for transect 2 are less common, approximately 80% of days having inversions at transect 2 also have inversions at transect 1, indicating inversions can be regional as well as local occurrences. Overall, the data provide guidance on the 'best choice' of temperature lapse rate to use for a given weather system. Based on the high variability within each weather type, however, we recommend a statistical approach for hydrological or ecological model applications, where daily lapse rates are sampled from a distribution.

15:30

Examining transport of freshwater across the Labrador shelf-break using gliders

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Transport of freshwater from the Labrador Shelf into the interior Labrador Sea has the potential to influence deep convection by controlling the salinity of surface waters. To examine this transport,

we deployed two deep underwater gliders that traversed the continental shelf-break more than 10 times between July 5 and August 22, 2014, as part of the VITALS (Ventilation, Interactions and Transports Across the Labrador Sea) project. The field campaign yielded a unique data set of temperature, salinity and oxygen across the shelf-break at unprecedented spatial resolution. We examine two mechanisms of cross-shelf transport: Ekman transport and transport due to mesoscale eddies. Glider observations show a tongue of freshwater emanating from the shelf along the surface, indicative of Ekman transport. This surface Ekman transport is quantified using satellite wind stress. The eddy induced transport is scaled using thickness gradients of layers of uniform potential density. Our results reveal a very different balance from that suggested for the transport of freshwater from the Antarctic shelf in the Weddell Sea using glider observations and similar scaling techniques, where both Ekman transport and mesoscale eddies are principally moving freshwater towards the shelf.

15:30

Atmospheric Effects on Communications in the High Arctic

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With the ubiquitous nature of satellite TV and other forms of space-based communication, it is easy to think that satellite communications is a solved problem. However in the High Arctic the view angle of geostationary satellites becomes very low and the atmospheric path very long and atmospheric effects become important. This is especially so at the Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Nunavut which maintains what is thought to be the most Northerly geostationary communications link on the planet. Over the last decade we have gained much operational experience in communications in such marginal areas and also in the effect of the atmosphere on the link. This has resulted in experiments with vertical diversity and multiple links and the rules for switching between them due to atmospheric fading and scattering which are in turn a function of the meteorological conditions. This talk will focus on the physics of the links and how the atmosphere and other elements of the environment affects them as well as the operational aspects of keeping such links operational through all conditions. PEARL is supported by the Natural Sciences and Engineering Council (NSERC), Environment Canada (EC), the Canadian Space Agency (CSA) and Dalhousie University.

15:30

Dissolved Methane in the Beaufort Sea

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Concentrations of dissolved methane ([CH4]s) were determined in coastal and offshore waters of the Beaufort Sea in August and September 2014. Surface water [CH4]s ranged from 2.95 to 10.86

nmol L-1 (mean: 3.80 nmol L-1) with elevated values occurring on the river-impacted Mackenzie Shelf. Methane in surface water was mostly supersaturated relative to the atmosphere throughout the study area. Shallow subsurface [CH4] maxima (up to 25.52 nmol L-1) were observed on the Mackenzie Shelf at similar depths of subsurface chlorophyll maxima. In contrast, methane was enriched (up to 30.78 nmol L-1) in bottom water on the continental shelf of Barrow, Alaska, suggesting an input of methane from underlying sediments. A vertical profile collected in the slope water off Barrow, Alaska revealed a deep [CH4] maximum at 1500 m with a concentration of 14.37 nmol L-1, contrasting the very low [CH4]s (less than 1 nmol L-1) found in deepwaters of the Canada Basin. Relationships between [CH4] distributions and water mass characteristics were discussed.

15:30

Measurements and modelling of surface energy balance at a glacier in the Interior Mountains, British Columbia.

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Energy balance melt models provide the most physically-based method to model surface mass balance for a glacier since they account for radiative and turbulent exchanges occurring at the snow or ice surface. Direct measurements of turbulent fluxes, however, are uncommon given the complexity of making reliable measurements of turbulent energy exchange on alpine glaciers. Most studies thus rely on the bulk aerodynamic method used to parameterize turbulent fluxes; an approach that may be inaccurate due to poorly specified empirical coefficients. Here we present measurements of radiative and turbulent energy fluxes for an alpine glacier in the Interior Mountains of British Columbia for ablation season in 2010 and 2012. We evaluate the performance of an energy balance model in simulating the in-situ surface melting on sub-daily scales and validate the performance of bulk methods in simulating the turbulent fluxes relative to directly measured fluxes by eddy covariance method.

15:30

Wind Profiler and RASS Applications for Severe Weather Forecasting in Coastal BC

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Severe Weather forecasting is improved using the 915 MHz (33 cm) Doppler Radar Wind Profiler

(WP) and Radar Acoustical Sounder (RASS) system located at Squamish BC, near sea level along the Sea to Sky Corridor. This profiler system is useful for real-time tracking of changes in freezing level, snow level (SL), wind speed and direction, virtual temperature (Tv), and precipitation (type and intensity). The SL is defined as the lowest elevation where snow accumulates and lies at the base of the Radar Bright Band (BB). By building on the lessons learned during the Vancouver 2010 Olympics, new products were developed for operational meteorologists to better display active weather using hydrometeor reflectivity from the Doppler Signal to Noise Ratio (DVV-SNR) and hydrometeor fall speed using the Doppler vertical velocity (DVV). Additionally, this WP system allows tracking of inertial gravity waves, clear air turbulence, wind shear, downburst potential, boundary layer land-sea breeze circulations, major density currents (such as stratus surges and arctic fronts), mid-latitude cyclone airflow and frontal systems, and allows separation of hydrometeor fall speeds from vertical air motions in the melting snow layer. The greatest discrepancies in the DVV-SNR reflectivity data are observed at the SL as shown by comparing the half hour Consensus (CNS) reflectivity data provided by the instrument manufacturer (Vaisala-SciTech LAP-XM) software to our new 1 minute Spectral reflectivity products (with SNR corrected by CMML for PSPC-MSC operations). The discrepancies are best explained by the coexistence of many precipitation types and sizes accelerating through the SL and BB base, such as collapsed melting snow flakes and aggregates, rain, graupel, sleet and slush. Overall, the wind profiler with the RASS system allows better analysis and prognosis under a variety of weather conditions. Examples are provided to demonstrate how the Squamish profiler system can help forecasters address public safety challenges during severe weather events through improved situational awareness.

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