CMOS 57th Congress

May 28 – June 1, 2023 – ST. JOHN'S, NL

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Local Arrangements Committee (LAC) and Science Committee (SPC)

CMOS
Canadian Meteorological and Oceanographic Society

SCMO
Société canadienne de météorologie et d'océanographie

Connecting on the Rock

From the Marine Environment To the Blue Economy

Congress 2023
May 28 - June 1, 2023

Sheraton Hotel
St. John's, NL

CMOS
Canadian Meteorological and Oceanographic Society

SCMO
Société canadienne de météorologie et d'océanographie

Rendez-vous sur le rocher

De l'environement marin À l'économie "bleue"

Congrès 2023
28 mai au 1 juin 2023

Hôtel Sheraton
St. John's T-N

CONGRESS SCHEDULE

Sunday, May 28, 2023

Program time zone is Newfoundland Daylight Time (NDT).

12:00 – 19:00
Registration and Information Desk
Pre-function area

14:00 – 15:30
Public Talk: “Weathering the Storm: Navigating Extreme Weather in Newfoundland and Labrador”
Salon B

15:30 – 18:00
Selfguided Hike to Quidi Vidi Brewery
Meet in Sheraton Lobby

18:00 – 18:30
Shuttles Back From Quidi Vidi Brewery to the Sheraton

19:00 - 22:00
Ice Breaker Event: Trivia Night
Salon A+B

Monday, May 29, 2023

Program time zone is Newfoundland Daylight Time (NDT).

08:00 – 17:00
Registration and Information Desk
Pre-function area

08:30 – 11:00
Tours and Beach Clean Up
Meet in Sheraton Lobby

09:30 – 11:00

Concurrent Science Sessions

MUL: Satellite Earth Observation: A unique view of our planet and a long-term strategic vision for Canada (Part 1)
Salon A

OCE: Coastal Oceanography and Inland Waters (Part 1)
Salon B

MUL: Ocean and Ecological Studies in the Seasonally Ice-Covered Coastal Waters of Nunatsiavut and the Labrador Sea

Salon C

ATM: Environmental sustainability of observing systems and methods: a paradigm shift for weather and climate observational programs and policies

Salon D

11:00 – 12:30
Lunch on your Own

Off-site

12:30
Official Congress Opening

Salon A+B

13:00
Opening Plenary Speaker:

Severe Post-Tropical Cyclone Fiona – Forecasting and Historical Context
Speaker: **Chris Fogarty, Program Manager (Meteorologist), Canadian Hurricane Centre;**

Salon A+B

14:00 – 15:30
Concurrent Science Sessions

OCE: Quantifying the marine carbon cycle and ocean carbon uptake (Part 1)

Garrison

MUL: Satellite Earth Observation: A unique view of our planet and a long-term strategic vision for Canada (Part 2)

Salon A

OCE: Coastal Oceanography and Inland Waters (Part 2)

Salon B

ATM: Weather Nowcasting

Salon C

CLM: Climate Variability and Predictability (Part 1)

Salon D

15:30 – 16:00

Refreshment Break in Exhibit Area + Poster Session

Courtyard Garden/Avalon/Battery

Concurrent Science Sessions

16:00 – 17:30

OCE: Quantifying the marine carbon cycle and ocean carbon uptake (Part 2)

Garrison

ATM: Severe Post Tropical Storm Fiona

Salon A

OCE: Coastal Oceanography and Inland Waters (Part 3)

Salon B

MUL: Satellite Earth Observation: A unique view of our planet and a long-term strategic vision for Canada (Part 3)

Salon C

OCE: Lagrangian perspectives on ocean transport and mixing

Signal

16:00 – 17:00

CLM: Climate Variability and Predictability (Part 2)

Salon D

17:00 – 17:30

CLM: Climate change projections for the Marine sector

Salon D

17:30 – 19:00

PICO – F Scientific Presentation Competition en Français

Salon A

Tuesday, May 30, 2023

Program time zone is Newfoundland Daylight Time (NDT).

08:00 – 17:00

Registration and Information Desk

Pre-function area

08:30 – 09:30
Plenary Speaker:

Modern Weather and Climate Monitoring, Modelling and Service Provision: Perspectives from the Meteorological Service of Canada

Presenter: **David Harper, Director General of the Monitoring and Data Service Directorate of the Meteorological Service of Canada, ECCC**

Salon A+B

09:30 – 10:00
Refreshment Break in Exhibit Area + Poster Session

Courtyard Garden/Avalon/Battery

10:00 – 11:30

Concurrent Science Sessions

OCE: Marine Carbon Dioxide Removal (mCDR) – Emerging Solutions, Opportunities, and Research Needs

Garrison

MUL: Atmosphere, Ocean, and Climate Dynamics (Part 1)

Salon A

OCE: Coastal Oceanography and Inland Waters (Part 4)

Salon B

MUL: Satellite Earth Observation: A unique view of our planet and a long-term strategic vision for Canada (Part 4)

Salon C

ATM: MSC-Overview of numerical modelling tools and services from the Canadian Meteorological Centre (Part 1)

Salon D

CLM: Radiative Forcing and Feedbacks in Earth's Climate System

Signal

11:30 – 13:00

On-site Lunch + Poster Session

Courtyard Garden/Avalon/Battery

13:00 – 13:45
Plenary Speaker:

Opportunities and Risks for Ocean and Climate Science to Contribute to an Equitable and Sustainable Future

Presenter: **Dr. Gerald Singh, University of Victoria**

Salon A+B

14:00 – 15:30

Concurrent Science Sessions

OCE: Defence Applications of Oceanography

Garrison

MUL: Atmosphere, Ocean, and Climate Dynamics (Part 2)

Salon A

OCE: Discussions on development, evaluation and analysis of ocean circulation and biogeochemical models or Developing Ocean Modelling Capacity in Canada (Part 1)

Salon B

MUL: Satellite Earth Observation: A unique view of our planet and a long-term strategic vision for Canada (Part 5)

Salon C

ATM: MSC-Overview of numerical modelling tools and services from the Canadian Meteorological Centre (Part 2)

Salon D

CLM: Advancing science and technology for monitoring greenhouse gases (Part 1)

Signal

15:30 – 16:00

Refreshment Break in Exhibit Area + Poster Session
Courtyard Garden/Avalon/Battery

16:00 – 17:30

Concurrent Science Sessions

MUL: Data modelling and reproducible processes in geophysics
Garrison

ATM: Severe Convective Storms – Detection, Prediction, Climatology and the Future (Part 1)
Salon A

OCE: Discussions on development, evaluation and analysis of ocean circulation and biogeochemical models or Developing Ocean Modelling Capacity in Canada (Part 2)
Salon B

MUL: Satellite Earth Observation : A unique view of our planet and a long-term strategic vision for Canada (Part 6)
Salon C

MUL: Atmosphere, Ocean, and Climate Dynamics (Part 3)
Salon D

CLM: Advancing science and technology for monitoring greenhouse gases (Part 2)
Signal

19:00
Pub Night/Movie Night/Board Game Café
Various venues

Wednesday, May 31, 2023

Program time zone is Newfoundland Daylight Time (NDT).
08:00 – 17:00
Registration and Information Desk
Pre-function area

08:00 – 10:00
CV Writing Workshop
Salon C+D

08:00 – 09:30

Plenary Session:

AI Takes on Weather Prediction

Salon A+B

09:30 – 10:00

Refreshment Break in Exhibit Area + Poster Session

Courtyard Garden/Avalon/Battery

10:00 – 11:30

Concurrent Science Sessions

ATM: Severe Convective Storms – Detection, Prediction, Climatology and the Future (Part 2)

Salon A

OCE: A special session on ocean science and environmental statistics in tribute to Professor Keith R. Thompson (Part 1)

Salon B

MUL: Changing Arctic: Science and Policy Studies (Part 1)

Salon C

MUL: Atmosphere, Ocean, and Climate Dynamics (Part 4)

Salon D

11:30 – 13:00

Lunch on your own

Off-site

13:00 – 14:30

Plenary EDIA Panel Discussion:

Ocean, Atmosphere, Earth and Climate Science for and by everyone: Discussions on equity, diversity, inclusion and accessibility

Moderator: **Mx. Alexa J. Goodman, Training Program Manager, Marine Environmental Observation Prediction and Response Network (MEOPAR);**

Panelists:

Karine Morin, Director, EDI Strategy, NSERC;
Dr. Fanny Noisette, Professor in Biological Oceanography at the Institute of Ocean Sciences, University of Quebec at Rimouski;
Stephanie Arnold, PEI Climate Services Specialist, CLIMAtlantic;
Dr. Hind Al-Abadleh, Professor, Wilfrid Laurier University;
Dr. Gerald Singh, University of Victoria

Salon A+B

14:30 – 16:00

Concurrent Science Sessions

ATM: Advances in Precipitation Measurement and Modeling (Part 1)

Garrison

SER: Advances in Weather & Climate Risk Communication (Part 1)

Salon A

OCE: A special session on ocean science and environmental statistics in tribute to Professor Keith R. Thompson (Part 2)

Salon B

MUL: Changing Arctic: Science and Policy Studies (Part 2)

Salon C

OCE: Recent advances in ocean biogeochemistry in Canada (Part 1)

Salon D

OCE: Acoustical Oceanography and Underwater Sound (Part 1)

Signal

16:00 – 16:30

Refreshment Break in Exhibit Area + Poster Session

Courtyard Garden/Avalon/Battery

Concurrent Science Sessions

16:30 – 17:15

ATM: Advances in Precipitation Measurement and Modeling (Part 2)
Garrison

17:15 – 18:00
ATM: MSC-Air Quality Measurement and Modelling
Garrison

16:30 – 18:00
SER: Advances in Weather & Climate Risk Communication (Part 2)
Salon A

OCE: A special session on ocean science and environmental statistics in tribute to Professor Keith R. Thompson (Part 3)
Salon B

OCE: Acoustical Oceanography and Underwater Sound (Part 2)
Signal

MUL: Changing Arctic: Science and Policy Studies (Part 3)
Salon C

OCE: Recent advances in ocean biogeochemistry in Canada (Part 2)
Salon D

19:00 – 22:00
Congress Reception and Awards Banquet
Courtyard Garden/Avalon/Battery (Banquet: Salon A+B)

Thursday, June 1, 2023

Program time zone is Newfoundland Daylight Time (NDT).

Joint CMOS and ORCA Programming

CMOS and ORCA are offering joint programming on Thursday. CMOS delegates are free attend any ORCA related programming

at no cost. For details on the ORCA programming, please register with ORCA.

08:00 – 17:00
Registration and Information Desk
Pre-function area

08:00 – 09:15
INFO SESSION: ORCA 101/Ocean Decade 101 (ORCA)
Salon A+B

08:00 – 09:30
OCE: Environmental DNA (eDNA) application in marine sciences: An ecosystem's approach from microbes to mammals (Part 1)
Garrison

08:30 – 10:30
Workshop:

Communicating Risk in the Face of Increasing Extreme Events
Salon C+D

09:15 – 09:45
Refreshment Break + ORCA Poster Session
Courtyard Garden/Avalon/Battery

09:45 – 10:45
Ocean Decade themed SeaSide Chat (ORCA)
Salon A+B

10:45 – 11:30
Ocean Decade Breakout Sessions (ORCA)
Various rooms

10:45 – 12:00
Virtual Event:

The ECCC Weather Radars: A Virtual Tour And Discussion
Salon C

11:30 – 14:00
Job Fair (lunch provided for students and early career professionals)
Courtyard Garden/Avalon/Battery

11:30 – 13:00

Lunch on your own

Off-site

13:00 – 13:45
Ocean Decade Breakout Sessions (ORCA)

Various rooms

14:00 – 15:30

CMOS and ORCA Concurrent Sessions

OCE: Environmental DNA (eDNA) application in marine sciences: An ecosystem's approach from microbes to mammals (Part 2)

Garrison

OCE: Enhancing the analyses and applications of ocean observational and modelling data: Toward development of Made-in-Canada Digital Twins of the Ocean (Part 1)

Salon B

MUL: Collaborative Earth System Modelling in Canada (Part 1)

Salon C

OCE: Operational applications using Canadian operational ocean forecasting systems

Salon D

SER: Mixed Media and Crossed Wires: Challenges and Opportunities Presented by Contemporary and Traditional Media for Disaster Preparedness, Warning, and Response Communication (Panel)

Signal

15:30 – 16:00
Refreshment Break + ORCA Poster Session

Courtyard Garden/Avalon/Battery

CMOS and ORCA Concurrent Sessions

16:00 – 17:30
MUL: Collaborative Earth System Modelling in Canada (Part 2)

Garrison

SER: Addressing the Risks in the Marine Environment to Become Climate Resilient

Salon C

MUL: Sharing lessons learned in collaborative environmental research with communities.

Salon D

OCE: Gulf of St. Lawrence Tracer Release Experiment (TReX)

Signal

16:00 – 16:30

OCE: Enhancing the analyses and applications of ocean observational and modelling data: Toward development of Made-in-Canada Digital Twins of the Ocean (Part 2)

Salon B

16:30 – 17:30

OCE: Improving Ocean Accessibility in the Ocean Decade + DISCUSSION

Salon B

Friday, June 2, 2023

Program time zone is Newfoundland Daylight Time (NDT).

ORCA Program

08:00 – 17:00

Registration and Information - ORCA

08:00 – 10:00

ORCA Concurrent Sessions

10:00 – 10:30

Refreshment Break + ORCA Poster Session

10:30 – 12:30

ORCA Concurrent Sessions

12:30 – 13:30

ORCA Closing Session

Partners

Lead Supporter - Genesis Grant

Major Supporter - Newfoundland & Labrador

Signature Supporter - Canadian National Committee for SCOR / Comité national pour SCOR

Signature Supporter - Vaisala

Participating Supporter - ASL Environmental Sciences

Participating Supporter - Campbell Scientific

Participating Supporter - Cat IQ

Participating Supporter - Hoskin Scientific

Participating Supporter – RBR

Supporter - Ocean Frontier Institute

Supporter - Pelmorex Corp

Pub Night on George Street

Map to Pub Night Spots

Get Screeched In!

Screeching In Ceremonies at:

- Trapper John's – On the Hour ($25 includes ceremony + certificate)
- Christian's – 7pm & 9pm ($32.50 includes ceremony + certificate + shot glass)

Grab a Bite!

- Kelly's – Fish & Chips Special

Listen to Music!

- O'Reilly's – Open Mic Night 7pm-11pm
- Green Sleeves – Stephen Green 6pm-10pm Nick Earle 10pm-2am

CMOS Education Day / Journée de formation de la SCMO

Wednesday morning (9:30-13:30), 31 May 2023 CMOS is welcoming 140 grade 8/9 students for CMOS Education Day. They will be moving between four different spaces, including Garrison, Signal, Plymouth and the pre-function area (the space with the registration desk).

Mercredi matin (9h30-13h30), le 31 mai 2023, le SCMO accueille 140 élèves de 8ème et 9ème année pour la journée éducative du SCMO. Ils se déplaceront entre quatre espaces différents, à savoir Garrison, Signal, Plymouth et la zone de pré-fonctionnement (l'espace où se trouve le bureau d'inscription).

Le livret du banquet

The banquet booklet

CMOS-SCMO
Canadian Meteorological and Oceanographic Society
Société canadienne de météorologie et d'océanographie

2023-05-31
St. John's – Sheraton Hotel Newfoundland

57E CONGRÈS SCMO – CMOS 57th CONGRESS

In Memoriam

Clara Baker
Robert (Bob) Black
Otto Braun
Glenn Brydon
Monsey Peter Capeling
R Allyn Clarke
Blane Coulcher
James Derham-Reid
Lyle Fleming
Gregory Gardiner
Bill Grandy
Lionel Haughn
Doug Henry
Victoria Hudec
Ben Janz
Ken Harry Jones
Mary Helen Kaizer
George Kearey
Louise Kindree
Donald (Sandy) MacLeod
Ron MacKenzie
Allan Martin
Mary Hardy Martin (Knox)
Jim McCulloch
Elaine Moores
Dick Nelis
Michael G. Newman
Steve Nikleva
David Nowell
Michael Pancura
Allan (Al) Pearson
Ed Quigg
Floyd Rushton
Mike Shewel
François Simoneau
Peter Summers
Bjørn Sundby
Marcel Sévigny
Clive Temperton
Keith Thompson
Alan Webster
Isztar Zawadzki

Menu

Légumes verts avec amandes, canneberges séchées, fromage de chèvre et vinaigrette au vin rouge et à la truffe / Greens with Almonds, Dried Cranberries, Goat Cheese and Red Wine & Truffle Vinaigrette

Suprême de poulet poêlé avec réduction de thym au miel, assortiment de légumes frais de saison et de pommes de terre /Frenched Supreme of Chicken with Honeyed Thyme Reduction, Medley of Fresh Seasonal Vegetables and Potatoes

Gâteau au chocolat végane et sans gluten/Vegan & Gluten free Chocolate Cake

Jackson Triggs Pinot Grigio
Robert Mondavi Private Selection Pinot Noir

Mots d'accueil

Au nom du comité organisateur local du congrès de la SCMO je vous remercie d'être ici ce soir.

J'espère que vous profiterez simplement de ce moment, que vous discuterez avec des collègues qui sont devenus des amis au fil des ans, que vous prendrez le temps de vous détendre un peu, que vous partagerez un verre de vin avec des personnes que vous n'avez pas vues depuis un certain temps, ou même jamais vues. J'espère également que vous vous réjouirez avec ceux qui reçoivent des prix ce soir. C'est un moment particulier pour eux, et nous sommes heureux de célébrer leur excellence.

Rendez-vous virtuellement l'année prochaine pour le 58e congrès de la SCMO.

Shannon Nudds, présidente du comité local de la SCMO

Welcome words

In the name of the CMOS local organizing committee, I want to thank you all for being here tonight.

I hope that you will simply enjoy this moment, chatting with colleagues that have become friends through the years, taking the time to relax a little bit, sharing a glass of wine with people you haven't seen for some time, or even never before. I also hope you will be rejoicing with the ones who are receiving awards tonight. This is a special moment for them, and we are glad to celebrate their excellence.

See you all virtually next year for the 58th CMOS congress.

Shannon Nudds, CMOS local organizing committee chair.

Les prix / Awards

Government of Canada / Gouvernement du Canada

Pêches et Océans Canada / Fisheries and Oceans Canada

Médaille Timothy R. Parsons soulignant l'excellence dans un domaine multidisciplinaire lié à l'océanographie / Timothy R. Parsons Medal for Excellence in Multidisciplinary Ocean Science[1]

Dr. Kenneth Lee

Conseiller scientifique principal national (retraité) – Science des écosytèmes, Pêches et Océans Canada

National Senior Science Advisor (Retired) –Ecosystem Science, Fisheries and Oceans Canada

Pour souligner l'excellence dans un domaine multidisciplinaire lié aux sciences océaniques.
For excellence in multidisciplinary ocean sciences.

[1] The Timothy R. Parsons Medal is awarded to residents of Canada for distinguished accomplishments in multidisciplinary facets of ocean sciences while working for Canadian Institutions or for the benefit of Canadian Science. The medal was established in honour of Dr. Timothy R. Parsons. / La médaille Timothy R. Parsons est décernée aux résidents du Canada qui se sont distingués par leurs réalisations dans les facettes multidisciplinaires des sciences océaniques, alors qu'ils travaillaient pour des institutions canadiennes ou au profit de la science canadienne. La médaille a été créée en l'honneur de Timothy R. Parsons.

Environment and Climate Change Canada | Environnement et Changement climatique Canada

Service météorologique du Canada (SMC) / Meteorological Service of Canada (MSC)

Médaille de service distingué de Patterson / The Patterson Distinguished Service Medal[1]

Dr. Peter Yau

Professeur émérite – Département des sciences de l'atmosphère et de l'océanographie, Université McGill

Professor Emeritus –Department of Atmospheric and Oceanic Sciences, McGill University

Pour l'excellence et l'innovation dans les sciences atmosphériques, notamment la physique des nuages, la prévision des précipitations et la dynamique des tempêtes tropicales; pour son leadership exemplaire dans le domaine de la météorologie, ce qui a permis d'enrichir les connaissances de la communauté scientifique; pour son dévouement en tant que mentor auprès des jeunes scientifiques.

For excellence and innovation in the atmospheric sciences, including cloud physics, precipitation forecasting, and tropical storm dynamics; for exemplary leadership in meteorological academics, increasing the wealth of knowledge available to the scientific community; and dedicated mentorship of young scientists.

[1] The Patterson Medal Award is given to residents of Canada for distinguished service to meteorology in Canada. The medal was established in honour of Dr. John Patterson, controller of the MSC from 1929 to 1946. / Offerte aux résidents du Canada pour des services distingues rendus à la météorologie. Le prix a été créé en l'honneur de M. John Patterson, un météorologue qui a été directeur et contrôleur du SMC de 1929 à 1946.

Canadian National Committee for SCOR
Comité national canadien pour SCOR
Scientific Committee on Oceanic Research

Le prix du comité national canadien pour SCOR / Canadian National Committee for SCOR Award

Prix pour océanographe en début de carrière / Early Career Ocean Scientist Award

***Erin Bertrand* (*Dalhousie University*)**

Les prix de la SCMO / CMOS Awards

Pour étudiants / For Students

Bourses d'étude du 1er cycle / Undergraduate Scholarships

Bourses SCMO / CMOS Scholarship ($1,000)

***Pallawi Paudel* (*U. Alberta*)**

Florence Dion-Ladouceur* (*U. Québec à Montréal)

Bourse SCMO Daniel G. Wright / CMOS Daniel G. Wright Undergraduate Scholarship ($1,000))

***Monica Figueroa* (*U. Alberta*)**

Bourse SCMO-MétéoMédia/The Weather Network / CMOS-The Weather Network/MétéoMédia Scholarship ($1,500)

***Shannon Fernando* (*York U.*)**

Pour enseignants / For Teachers K-12
Project Atmosphere Summer Workshop

***Warren Hartery* (*Newfoundland and Labrador Youth Centre, Whitbourne, NL*)**

Project Ocean Summer Workshop

***Bonnie Anderson* (*Simcoe County District School Board, Midhurst, ON*)**

Les prix de la SCMO / CMOS Awards

Prix Tertia M.C. Hughes pour étudiants diplômés / Tertia M.C. Hughes Memorial Graduate Student Prize ($1,000)

***Andrew Grace* (*U. Waterloo*)**

Pour son excellente thèse intitulée / his excellent thesis titled *"Numerical simulations of convection and gravity currents near the temperature of maximum density"* (U. Waterloo)

Prix Roger Daley de publications postdoctorale / Roger Daley Post-Doctoral Publication Award

***Jannes Koelling* (*Dalhousie U, Halifax, NS*)**

Pour son article publié intitulé "*Oxygen export to the deep ocean following Labrador Sea Water formation*" qui a montré un travail méticuleux et des résultats remarquables et convaincants sur les différentes étapes entre l'absorption d'oxygène à la surface et son exportation dans le courant profond de la frontière occidentale, confirmant ainsi l'importance de la convection profonde de la mer du Labrador dans l'oxygénation des eaux profondes de l'Atlantique Nord.

For his published article entitled "*Oxygen export to the deep ocean following Labrador Sea Water formation*" which showed meticulous work and outstanding and convincing results on the different steps between the oxygen uptake at surface and its export within the Deep Western Boundary Current, thus confirming the importance of Labrador Sea deep convection in the oxygenation of the deep North Atlantic.

Les prix de la SCMO / CMOS Awards

Médaille J.P. Tully en Océanographie / J.P. Tully Medal in Oceanography

***Rolf Lueck* (*Rockland Scientific, Victoria, BC*)**

Pour avoir fait progresser notre connaissance de la turbulence océanique. Son travail porte sur tous les aspects de la turbulence océanique, qu'il s'agisse du développement et du perfectionnement des outils de mesure, de l'amélioration de notre compréhension fondamentale de la turbulence, de son application à de nouveaux domaines de recherche scientifique, de la démocratisation de son étude par la commercialisation et la production de ces outils et, enfin, de l'encadrement de nouvelles générations d'océanologues.

For advancing our knowledge of ocean turbulence. His work transcends all aspects of ocean turbulence, from developing and refining the tools to measure it, to improving our fundamental understanding of it, to applying it to new areas of scientific inquiry, to the democratization of its study by the commercialization and production of those tools, and finally, to the mentoring of new generations of ocean scientists.

Les prix de la SCMO / CMOS Awards

Prix du Président / President's Prize

Alex Cannon

(*Environment and Climate Change Canada, Victoria, BC*)

Pour son article de 2018 intitulé "*Multivariate quantile mapping bias correction: an N-dimensional probability density function transform for climate model simulations of multiple variables*", publié dans Climate Dynamics. L'article de M. Cannon aborde un problème délicat dans l'application des prévisions du changement climatique mondial pour prédire les choses qui comptent pour les individus ou les communautés : la correction des biais et la réduction d'échelle. L'approche analytique novatrice décrite dans l'article de M. Cannon a été adoptée dans le monde entier.

For his 2018 paper "*Multivariate quantile mapping bias correction: an N-dimensional probability density function transform for climate model simulations of multiple variables*," published in *Climate Dynamics*. Dr. Cannon's paper tackled a tricky problem in the application of global climate change predictions to predict things that matter to individuals or communities: bias correction and downscaling. The novel analytical approach detailed in Dr. Cannon's paper has been adopted around the globe.

Les prix de la SCMO / CMOS Awards

Prix de François J. Saucier en océanographie appliqué / François J. Saucier Prize in Applied Oceanography

***Gregory Smith* (*Environment and Climate Change Canada, Dorval, QC*)**

Pour son leadership dans le vaste réseau opérationnel canadien de systèmes couplés de prévision environnementale (CONCEPTS). Au cours de la dernière décennie, Greg a joué un rôle scientifique majeur dans le développement, le perfectionnement et l'enrichissement des systèmes océanographiques opérationnels qui fonctionnent aujourd'hui et de ceux qui sont en cours de développement et dont le réalisme et la précision ont été améliorés.

For his leadership in the large Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS) collaboration. Greg took major scientific leadership over the last decade in the development, refinement and enrichment of the operational oceanographic systems that are running operationally today, and those under development with increased realism and accuracy.

Médaille Neil J. Campbell pour service bénévole exceptionnel / Neil J. Campbell Medal for Exceptional Volunteer Service[5]

***Karen Smith* (*U. Toronto, Toronto, ON*)**

Pour son leadership au sein de la SCMO en tant que présidente de la commission de l'éducation scolaire et publique et directrice du projet "Improving Equity, Diversity, Inclusion and Accessibility in the Canadian weather water, and climate workforce".

For her leadership within CMOS as Chair of the School and Public Education Committee and driver of the Improving Equity, Diversity, Inclusion and Accessibility in the Canadian weather water, and climate workforce project.

Information and Legend for Sessions and Abstracts

Codes for presentations and posters:

ATM - Atmosphere

CLM - Climate

MUL - Multidisciplinary

OCE – Oceanography

SER – Services & Communication Blue Economy

Session information and session talk titles are **in bold**.

Plenary sessions are in blue / bold

Please use search pdf using keywords, author name or session date / time if known.

Day 1 – 29 May 2023

Coastal Oceanography and Inland Waters - Part 1

Monday, May 29
8:00 - 9:30 EDT

(15 Mins) Quantifying the effects of tides and sea ice on the hydrography of the northwest Atlantic Ocean using numerical modelling - Kyoko Ohashi

(15 Mins) Multi-decadal simulation of the East Coast of Canada and Gulf of St. Lawrence using Coastal Ice-Ocean Prediction System – East - Jean-Philippe Paquin

(15 Mins) Intra seasonal response of the Gulf of St. Lawrence to atmospheric forcing in the operational Canadian coastal ice-ocean prediction system

- Francois Roy

(15 Mins) Turbulent Plumes from Submarine Groundwater Discharge - Sam Aucoin

(15 Mins) Dynamic flushing leads to differential redox reaction rates in seasonally anoxic Saanich Inlet - Roberta Hamme

(15 Mins) Predictability of wind-driven coastal upwelling fronts on the Scotian Shelf - Shiliang Shan

This session will focus on all aspects of monitoring and modelling physical and biogeochemical processes in coastal domains, shelf seas, estuaries and inland waters. Topics include but are not limited to coastal physical oceanography, storm surges, tsunamis, estuarine dynamics, hydrology and hydrodynamics of large lakes, mixing and dispersion of materials. Contributions related to both observational and modelling aspects of biogeochemistry in coastal and inland waters are welcome. Papers can be on improving our knowledge of physical and biogeochemical conditions in the past and present climate and/or on predictions of changes and extremes in marine conditions in response to climate change.

OCE-Quantifying the effects of tides and sea ice on the hydrography of the northwest Atlantic Ocean using numerical modeling

The physical and biogeochemical states of the northwest North Atlantic Ocean (NWA) have implications for the global climate, giving rise to a need to better understand the processes at work in this region. Two physical factors that heavily influence the NWA, especially its coastal waters, are tides and (in the northern part of the region) sea ice conditions. Quantifying the effects of processes such as tides and the formation, melting, and advection of sea ice requires a coupled, numerical ocean circulation-sea ice modelling system that performs reasonably well without nudging of the model state to external values. A coupled modelling system has been developed recently with the goal of meeting this requirement, with components based on the ocean circulation model ROMS and the sea ice model CICE. We first evaluate a prognostic control simulation made with this system, forced by realistic inputs such as atmospheric reanalysis and a global tidal model solution. We then compare the results of the control simulation to those of two additional simulations, one with the tidal forcing turned off and another with coupling to the sea ice model turned off. Analyses of model results demonstrate that tides and sea ice have considerable effects on the sea surface temperature and salinity of the NWA for example, the simulated sea surface temperature in Baffin Bay, averaged over the summers of 2015-2018, is higher by up to about 5C in the simulation without sea ice than in the control simulation.

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OCE-Multi-decadal simulation of the East Coast of Canada and Gulf of St. Lawrence using Coastal Ice-Ocean Prediction System – East

The Coastal Ice-Ocean Prediction System for the East Coast of Canada (CIOPS-E) provides high-resolution (~2 km) operational short-term forecasts of the ocean and sea ice conditions over the Gulf of St. Lawrence, the Grand Banks of Newfoundland, the Scotian Shelf and the Gulf of Maine and Bay of Fundy.

Multi-decadal hindcast simulation are required to better understand the systems behaviour, intrinsic biases and interrannual variability. This study presents the general evaluation of the first CIOPS-E hindcast, covering the period from 1992 to 2018. The hindcast uses atmospheric forcing from ECCCs Global and Regional Deterministic Reforecasting Systems (G/RDRS), whilst the ocean boundary conditions and deep ocean nudging uses the Copernicus Global 1/12o Oceanic and Sea Ice GLORYS12 Reanalysis. The analysis will focus on the evaluation of sea surface temperature, sea ice cover and comparison with available in situ observations of temperature and salinity with a particular interest in the representation of interrannual variability.

Jean-Philippe Paquin[1], François Roy[1], Gregory C. Smith[1] [1]Environnement et changement climatique Canada jean-philippe.paquin@ec.gc.ca

OCE: Intra seasonal response of the Gulf of St. Lawrence to atmospheric forcing in the operational Canadian coastal ice-ocean prediction system

The Gulf of St. Lawrence (GSL) water masses evolve under a complex estuarine circulation. Continental freshwaters travel downstream at the ocean surface and mix with the cold waters entering the GSL through Belle-Isle Strait (Labrador Current), and with some of the warmer and saltier Atlantic waters entering through Cabot Strait at depth in the Laurentian Channel that crosses the continental shelf outside the GSL and connects to the Gulf Stream area. A first step to better understand the transformation of these water masses, in response to atmospheric forcing, is to look at depth transport profiles bounding key regions of the GSL. We study this response with multi-year simulations of the Canadian Ice Ocean Prediction System East (CIOPS-E). CIOPS-E is based on the NEMO-CICE modeling framework applied to a northwest Atlantic 1/36 degree resolution domain. It covers the Gulf Stream region, the Canadian east coast and the GSL. The atmospheric forcing is taken from the Canadian High-Resolution Deterministic Prediction System (HRDPS, 2.5 km). In this study, the response to atmospheric forcing is decomposed into four modes, based on wind stress direction and intensity, that reflect the general influence of the GSL orography on weather systems. We show how the intensity and frequency of these modes influence the simulated seasonal transports between 2016 and 2021. Results give us a hint of how the accumulation of weather events modulate the variability in having more or less inflows through the Strait of Belle-Isle versus renewal events of Atlantic waters from the deep Laurentian channel.

Francois Roy[1], Gregory C. Smith[1], Jean-Philippe Paquin[1] [1]ECCC francois.roy@ec.gc.ca

OCE-Turbulent Plumes from Submarine Groundwater Discharge

Turbulent plumes are a ubiquitous phenomenon in the ocean; point sources of buoyancy and momentum tend toward a plume structure in a stratified fluid. A potentially pervasive but little studied source of buoyancy at depth in the coastal ocean is the offshore discharge of fresh water from confined aquifers. These groundwater systems are often called subterranean estuaries, as they are known through tracer studies to be globally important sources of nutrients, carbon, and metals (Moore, Annu. Rev. Mar. Sci, 2010). Research on submarine groundwater discharge to date has been limited to locations where the presence of the discharge is revealed by some manifestation at the sea surface. Advancing our knowledge of the oceanographic and ecologic impacts of these hidden buoyancy sources requires state of the art surveying and modelling tools. To this end, we investigate the structure of a submarine freshwater discharge plume at turbulent eddy-resolving time and space scales using an open-source Large Eddy Simulation ocean model, acoustic backscatter imagery, and theory.

The observations are from a submarine spring at 45m depth at the head of Cambridge Fiord, Nunavut. Both the acoustic imagery and the model results reveal the presence of intermittent O(10 m) scale boluses of buoyant water rising at ca. 30 cm/s velocities. The estimates of buoyancy flux at the seafloor and entrainment of ambient seawater into the plume are used to determine the effects of the discharge on mixing rates and vertical stratification in the immediate vicinity of the discharge.

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OCE-Dynamic flushing leads to differential redox reaction rates in seasonally anoxic Saanich Inlet

Oxygen deficient waters are expanding globally, making the study of biogeochemical transformations at low oxygen levels ever more pressing. Saanich Inlet, a fjord in SW British Columbia, has a sill at its mouth that prevents flushing of its deep waters over most of the year, except in late summer/early fall when dense flows bring oxygen and nitrate to the anoxic waters. Here, we present data from a series of cruises spanning two deep-water renewal events through the return to anoxic, sulfidic conditions. In the deep waters, each injection of oxygen was consumed within a couple weeks. Three distinct layers formed beneath the oxic-anoxic interface. Simultaneous dissolved N2/Ar gas, nitrate concentration, and nitrate isotope data show that initial denitrification rates were highest in the shallowest layer, with the next highest rate in the bottom waters, and the slowest rate in the layer between them. Nitrate was fully consumed within several months. Increasing sulfide concentrations tell a similar story of water layering with different redox rates. Parallel analysis of microbial 16S rRNA amplicon sequences identified clear differences in microbial community structure and subsequent succession patterns that closely mirror changes in redox chemistry. We hypothesize that conditions in each layer proceeded along their own biogeochemical cascade at different rates, depending on the extent to which the deep-water renewal replaced the water in these different layers. Understanding these dynamics in Saanich Inlet will help to inform our understanding of how oxygen deficient zones evolve after flushing events.

Roberta Hamme[1], Erinn Raftery[2], Brett Jameson[1], Karen Casciotti[3], Kim Juniper[1], Catherine Stevens[1] [1]University of Victoria [2]Fisheries and Oceans Canada [3]Stanford University rhamme@uvic.ca

OCE-Predictability of wind-driven coastal upwelling fronts on the Scotian Shelf

Coastal upwelling is a prominent oceanic process that brings nutrient-rich deep waters to the sunlit surface, thereby regulating many productive fisheries and marine ecosystems around the globe. The nonlinear nature of coastal upwelling fronts makes their numerical prediction very challenging. In this study, the performance of a new high-resolution operational Coastal Ice-Ocean Prediction System for the East Coast of Canada (CIOPS-E) is evaluated in predicting the observed upwelling fronts on the Scotian Shelf. The CIOPS-E pseudo-analysis and 48-h forecasts are compared with observations from various platforms, including marine buoys, remote-sensing satellites, and autonomous underwater gliders. The spatiotemporal predictability of upwelling fronts is further investigated in terms of along-shore wind impulse, summer stratification, and Nova Scotia Current.

Shiliang Shan[1], Jean-Philippe Paquin[2], Gregory Smith[2] [1]Department of Physics and Space Science, Royal Military College of Canada [2]Meteorological Research Division, Environment and Climate Change Canada Shiliang.Shan@rmc.ca

Environmental Sustainability of Observing Systems and Methods: A Paradigm Shift for Weather and Climate Observational Programs & Policies

Monday, May 29
8:00 - 9:30 EDT

(30 Mins) Overview of the WMO initiative on the Environmental Sustainability of Observing Systems and Methods - Shannon Kaya

(15 Mins) WMO survey on the Environmental Sustainability of Observing Systems and Methods: Overview and Results - Micheal Earle

(15 Mins) Innovations to Reduce Environmental Footprint of Upper-Air Soundings - Herb Winston

(15 Mins) Floating a green idea: efforts to reduce the environmental impact of weather balloons - Janet Shelley

(15 Mins) Advancements in Sustainable Upper Air Measurements via UAS - Brad Guay

Weather and climate monitoring have become vitally important in the modern world to keep citizens safe and informed, and to help us understand how our climate is changing. Environmental observing networks are designed and operated to meet national and international data and service requirements; however, the methods used to monitor weather and climate can have both positive and negative environmental impacts. The detrimental environmental impacts of collecting critical weather and climate observations, while acknowledged, are often superseded by financial and operational feasibility considerations. Globally, we are seeing major organizations moving toward "greener" operational models. In line with this trend, the World Meteorological Organization (WMO) has launched an initiative to enhance the environmental sustainability of observing systems and methods, with the Meteorological Service of Canada (MSC) serving as the international focal point. This initiative will advance recommendations to reduce the environmental impact of observing technologies and practices, guiding WMO Member states to adopt cleaner, sustainable approaches in all areas of their work. The WMO initiative covers meteorological, marine, hydrological, and atmospheric chemistry observational domains, and will inform the future vision for the WMO Integrated Global Observing System (WIGOS), which fuels global environmental prediction. This session will share information on the WMO initiative on Environmental Sustainability of Observations and its progress to date. It will provide a venue to discuss greener and more sustainable observing technologies and approaches, and to explore linkages with other greening initiatives. The session will also consider opportunities and implementation challenges from both operational and policy perspectives, with the goal of inspiring a paradigm shift toward more environmentally sustainable approaches to weather and climate monitoring.

Earth system observations and prediction are a global enterprise. The World Meteorological Organization (WMO) Integrated Global Observing System (WIGOS) and its component Global Basic Observing Network (GBON) program provide a framework for Members to collectively increase the number and coverage of observations in support of enhanced weather and climate data, products, and services. GBON sets requirements for the spatial coverage and temporal frequency of observations, driven largely by the needs of global numerical weather and environmental prediction. The environmental impacts of meeting these requirements for example, new infrastructure, more waste, additional service and maintenance requirements can be significant, motivating the WMO to launch an initiative to advance the environmental sustainability of observing systems and methods. With Canada in a leading role, this initiative aims to foster collaboration among WMO Members and industry, with the goal of developing practical and pragmatic policy recommendations for WMO consideration. These recommendations will be informed by international benchmarking of current and emerging observing system technologies and practices across four observational domains: meteorological (surface and upper air), marine, hydrological, and atmospheric chemistry. An overview of the initiative will be presented, highlighting key milestones and expected outcomes, in the interest of identifying opportunities for collaboration and alignment with other regional, national, and/or international activities and initiatives.

Shannon Kaya[1], Jeff Anderson[1], Peter Leibiuk[1], Michael Earle[1] [1]Transformation, Innovation and Engineering Division, Meteorological Service of Canada shannon.kaya@ec.gc.ca

ATM-WMO survey on the Environmental Sustainability of Observing Systems and Methods: overview and results

Global weather and environmental prediction drive requirements for the type, geographic distribution, and frequency of Earth system observations. The World Meteorological Organization (WMO) Global Basic Observing Network (GBON) defines these requirements for WMO Members; however, the environmental impacts associated with meeting these requirements can be significant (e.g. new station installations, more radiosonde launches). To address this challenge, the WMO is promoting the development and adoption of environmentally sustainable observing system technologies and practices through a dedicated initiative, with Canada as the international Focal Point. Through this initiative, an international survey was conducted to benchmark current, planned, and/or potential approaches employed by WMO Members to mitigate the environmental impacts of observations in meteorological (surface and upper air), marine, hydrological, and atmospheric chemistry domains. The survey results will inform best practices for network design, operations, and procurement, and provide the evidence base for potential policy changes via updates to WMO regulatory documentation. An overview of the survey, results, and key takeaways will be presented, including insight into how WMO Members perceive the opportunities and implementation challenges for greener and more sustainable approaches to Earth system observations.

Michael Earle[1], Roya Ghahreman[1], Jeff Anderson[1], Peter Leibiuk[1], Alicia Campbell[1], Paige Aldridge[1], Shannon Kaya[1] [1]Transformation, Innovation and Engineering Division, Meteorological Service of Canada michael.earle@ec.gc.ca

ATM-Innovations to Reduce Environmental Footprint of Upper-Air Soundings Abstracts

Radiosondes are used to obtain crucial information about the atmosphere for the

purposes of weather forecasting, including public safety, critical severe weather forecasting, medium range numerical weather prediction, as well as climatological and other atmospheric research. The societal value of radiosondes is significant in that they provide backbone data for numerical models and weather forecasting to help to prevent loss of life and property. By nature of the radiosonde observation system, some of the radiosondes remain in the environment after their use and are not recovered. The radiosonde flight train consists typically of a latex weather balloon, filled with hydrogen or helium, a parachute, a cord that separates the radiosonde from the weather balloon and the radiosonde. This presentation explores the methods to holistically reduce the environmental impact of radiosonde observations. Systematic Life Cycle Analysis can be used as a means to understand the overall impacts to the environment throughout the whole lifecycle. The presentation introduces a new innovation for a material that can be used to
reduce the post-life impact of the radio soundingsto the environment.

Mika Hemming[1], Matti Lehmuskero[1], Herb Winston[2] [1]Vaisala Oyj [2]Vaisala Inc
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ATM-Floating a green idea: efforts to reduce the environmental impact of weather balloons

Radiosondes and upper air observations are critical for the provision of meteorological services - supporting numerical weather prediction, aviation, hazards warning and forecasts, and numerous other functions. Along with other anthropogenic sources, these observations contribute to plastics and toxic chemicals in the natural environment, adding to the risks of harm or death to animals through ingestion and entanglement.

As Australias national weather, climate and water information agency, the Bureau of Meteorology collects observations across all of Australia and its external territories. With operations extending from the Indian Ocean to the Pacific, north of the equator to Antarctica, and encompassing fragile environments such as the World Heritage listed Great Barrier Reef, the Bureau has long recognised its responsibility to continually seek to reduce potential environmental harm. Our work with suppliers, public interest groups and scientists has contributed to many improvements, including the introduction of blue balloons to reduce the likelihood of ingestion by marine animals.

This session explores the Bureau’s journey to proactively reduce the impact of the upper air program on the environment, and how collaboration between stakeholders can achieve meaningful outcomes to reduce the impact of weather and climate observations on the environment.

Janet Shelley[1], Nadine D'Argent[1] [1]Bureau of Meteorology janet.shelley@bom.gov.au

ATM-Advancements in Sustainable Upper Air Measurements via UAS

The Meteomatics Meteodrone, a small Unmanned Aircraft System (UAS), offers an environmentally friendly solution for collecting atmospheric profiles. The system measures temperature, humidity, wind speed and direction, and barometric pressure up to 6,000 metres above mean sea level (AMSL), approximately corresponding to the 500 hPa geopotential height level. Meteodrones provide high-resolution vertical profiles suitable for ingestion into Numerical Weather Prediction (NWP) models.

The use of Meteodrones offers several advantages over traditional balloon-based

radiosondes. Minimal environmental waste is produced during measurement campaigns, as the Meteodrone returns to its launch location after each flight and is reused. Flights are battery-powered, producing no local emissions, and requiring no hydrogen or helium supply chain to be maintained. Multiple Meteodrone systems may be operated remotely from one central location, reducing the need for on-site support and travel by technicians. Additionally, the systems modular design enables long-term maintenance and upgrades. Lastly, Meteodrones show potential for data quality improvements, as profiles are taken directly over the starting coordinate, rather than drifting with the ambient wind.

This presentation will showcase our learnings from the operational use of Meteodrones, including the technologys evolution and a roadmap for a sustainable increase in the frequency and geographic density of upper air measurements. We will also discuss future applications and concepts for further improvements to the Meteodrone platform.

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Ocean and Ecological Studies in the Seasonally Ice-Covered Coastal Waters of Nunatsiavut and the Labrador Sea

Monday, May 29
8:00 - 9:30 EDT

(15 Mins) Physical controls and ecological implications of the timing of the spring phytoplankton bloom on the Newfoundland and Labrador shelf - Frédéric Cyr

(15 Mins) Insights from Winter 2021-22 using an Acoustic Zooplankton Fish and Ice Profiler in Nunatsiavut Settlement Area Coastal Waters - Matthew Asplin

(15 Mins) Close to Home: co-producing research questions and solutions to

climate-accelerated coastal erosion in Nunatsiavut - Emma Harrison

(15 Mins) Temporal and spatial variations of sea ice along coastal Nunatsiavut and the Labrador shelf - May Wang

Climate change is impacting the Subarctic region of Labrador, and theClimate change is impacting the Subarctic region of Labrador, and the ocean ecology of the Labrador Sea. Nunatsiavut is an Inuit self-governing territory located in northern Labrador which has been experiencing rapid climate change, increasingly affecting the livelihoods and well-being of Labrador Inuit living in coastal communities. Temperatures are rising and sea ice extents have declined by as much as 75% since 1968, affecting safe travel over the land (including the water and ice). The historical institutional lack of scientific data collection in this region, particularly ocean physical and biophysical data, is being addressed today by an expanding network of ocean science projects co-led by academic-indigenous research partnerships, and through the expanding ocean and environmental stewardship efforts of the Nunatsiavut Government. There is also an increasing appreciation amongst academia and government researchers of the depth of Inuit knowledge of the ocean, sea ice, weather and climate in the region. Efforts are thus underway with the aim to bring together Inuit and western scientific knowledge to develop climate change and environmental management plans which emphasize Labrador Inuit accessing their lands and resources safely and sustainably. This session will feature results from projects undertaken, past and present, in this region across the realm of marine system science that will be used to inform Nunatsiavut community members and other stakeholders of projected future changes in the marine environment and contribute to marine stewardship. ocean ecology of the Labrador Sea. Nunatsiavut is an Inuit self-governing territory located in northern Labrador which has been experiencing rapid climate change, increasingly affecting the livelihoods and well-being of Labrador Inuit living in coastal communities. Temperatures are rising and sea ice extents have declined by as much as 75% since 1968, affecting safe travel over the land (including the water and ice). The historical institutional lack of scientific data collection in this region, particularly ocean physical and biophysical data, is being addressed today by an expanding network of ocean science projects co-led by academic-indigenous research partnerships, and through the expanding ocean and environmental stewardship efforts of the Nunatsiavut Government. There is also an increasing appreciation amongst academia and government researchers of the depth of Inuit knowledge of the ocean, sea ice, weather and climate in the region. Efforts are thus underway with the aim to bring together Inuit and western scientific knowledge to develop climate change and environmental management plans which emphasize Labrador Inuit accessing their lands and resources safely and sustainably. This session will feature results from projects undertaken, past and present, in this region across the realm of marine system science that will be used to inform Nunatsiavut community members and other stakeholders of projected future changes in the marine environment and contribute to marine stewardship.

MUL-Physical controls and ecological implications of the timing of the spring phytoplankton bloom on the Newfoundland and Labrador shelf

The Newfoundland and Labrador (NL) shelf, and more specifically the Grand Banks of Newfoundland, are located at the extreme east of the North American continental shelf. They have been known as iconic fishing areas for centuries. Match/mismatch hypotheses have linked the recruitment and biomass of forage and commercial fish species, to the timing of the phytoplankton spring bloom (PSB). The timing of the PSB in

this region has been historically linked to the melting of sea ice, which stratifies the water columns and promotes conditions that are favorable to plankton growth and accumulation. But with sea ice gradually disappearing from the region, we revisited here the physical drivers responsible for the initiation of the spring bloom on the Grand Banks and on the NL shelf as a whole. In particular, we found that the initiation of the PSB on the Grand Banks can be predicted from the stratification of the water column measured at a nearby monitoring station. We also showed that large-scale climate indicators are good proxies for the timing of the PSB on the NL shelf, and for the surviving success of the zooplankton species Calanus finmarchicus, the keystone of many food webs. This work paves the way for a better integration of physical properties into ecosystem modeling and for the inclusion of climate variables into an ecosystem approach to fisheries management.

Frédéric Cyr[1], Keith Lewis[1], David Bélanger[1], Paul Regular[1], Stephanie Clay[2], Emmanuel Devred[2] [1]Fisheries and Oceans Canada (DFO-NL) [2]Fisheries and Oceans Canada (DFO-MAR) Frederic.Cyr@dfo-mpo.gc.ca

MUL-Insights from Winter 2021-22 using an Acoustic Zooplankton Fish and Ice Profiler in Nunatsiavut Settlement Area Coastal Waters

Improved understanding of the role of the ocean in moderating climate and sustaining complex food webs is required to support ocean stewardship and ocean protection goals being pursued through Indigenous-led initiatives across Canadas coastlines. The traditional territorial waters of the Nunatsiavut in the Labrador Sea contain a rich and diverse marine ecosystem regulated by a combination of physical oceanography and the presence of seasonal sea ice cover, transported southward by wind and ocean currents. The Nunatsiavut Government operates a growing research program to understand and monitor this complex biophysical system to support effective environmental management. As part of this research program, they are now in the fourth year of monitoring over-winter ocean and sea ice conditions at an offshore site near Nain, Labrador. Measurements made at this site have included water temperature, salinity, dissolved oxygen, turbidity, currents, and ice drafts and velocities. The Nunatsiavut Government has collaborated with ASL Environmental Sciences to further develop the information content at this site by supporting the first-ever deployment of the new ASL instrument known as the AZFP-ice. The AZFP-Ice is designed to collect high temporal and spatial resolution measurements of ice draft and research grade biological observations from its calibrated (1dB) multifrequency sensors. Preliminary analysis of the data collected during an over-winter deployment from 2021 to 2022 has provided invaluable insights into the biology of the region, and their interactions with the sea ice and atmosphere-ocean interface. We focus on winter and spring case studies and relate our observations to the biophysical environment.

Matthew Asplin[1], Rodd Laing[2], Michelle Saunders[2], James Bartlett[1], Julek Chawarski[1], Dawn Sadowy[1], Steve Pearce[1], Nicholas Lee[1], Jan Buermans[1], Todd Mudge[1], Keath Borg[1], Dave Billenness[1] [1]ASL Environmental Sciences Inc. [2]Nunatsiavut Government masplin@aslenv.com

MUL-Close to Home: co-producing research questions and solutions to climate-accelerated coastal erosion in Nunatsiavut

Local knowledge in Nain, Nunatsiavut identifies Webbs Bay, located ~30 km north of Nain, as a bellwether of coastal change in the region. Rates of coastline loss have accelerated dramatically in recent years, now threatening peoples homes, habitat for

cultural keystone species, and access to a culturally significant place. The Webb family, who have occupied Webbs Bay for generations, explain that the change is driven by the combined effects of changing weather patterns and the loss of a protective ice barrier during the winter storm season. Shifts in seasonality are enhancing the vulnerability of coastal beaches to erosion by altering discharge regimes in coastal rivers and the winds that affect the nearshore zone. Sea ice forms later in the year, leaving coasts unshielded from winter storms. In this research effort, we compare historical data with measurements collected during a year-long monitoring campaign, with the aim of assessing bluff stability under current, historical, and potential future geomorphic conditions. This project is a collaboration between Inuit knowledge holders and scientists, and we combine data generated from multiple ways of constructing knowledge to bear on our research questions. Our understanding of the historic ocean-atmosphere dynamics is derived from a combination of modeled environmental data and records kept by Webb family members. For comparison with current conditions, we are monitoring sea level, wind, waves, and event-driven volumes of erosion over 2022-2023. This monitoring campaigns results will inform context-appropriate efforts to decelerate beach loss and predict future changes for adaptive planning.

Emma Harrison[1], Ronald Webb[2], Joey Angnatok[2], Michelle Saunders[3], Audrey Limoges[4], Clark Richards[5], Alexandre Normandeau[6] , Eric Oliver[1] [1]Dalhousie University [2]Nain, Nunatsiavut [3]Nunatsiavut Government Environmental Research Division [4]University of New Brunswick [5]Bedford Institute of Oceanography [6] Geologic Survey of Canada, Atlantic Division ej.harrison@dal.ca

MUL-Temporal and spatial variations of sea ice along coastal Nunatsiavut and the Labrador shelf

The spatial extent and thickness of sea ice in the Northern Hemisphere have changed noticeably since the mid-20th century in the context of accelerating anthropogenic climate change. Responses of sea ice to anthropogenic climate change include ice thinning, more unpredictable landfast ice conditions, shorter ice seasons, and a decline in sea ice extent. These changes have the potential to affect the health of regional ecosystems, and the livelihood of coastal communities, who rely on the sea ice for travel and hunting. In this presentation, we describe the climatology, long terms trends and variability of sea ice along coastal Nunatsiavut and the Labrador shelf using a novel dataset consisting of 42 years (1979-2021) of weekly sea ice volume derived from Canadian Ice Services sea ice charts. We find that over the 42 year period, the average sea ice volume has decreased substantially, with a larger decrease in the peak season (February-April) than in the growth season (December-January). We then use Empirical Orthogonal Function analysis to identify and investigate the dominant modes of variability and link them to atmospheric and oceanic forcing. We will show that most (67.8%) of the total variability in the dataset is driven by local air temperature anomalies, suggesting that this region will be strongly sensitive to future climate warming.

May Wang[1], Benjamin Richaud[1], Eric Oliver[1] [1]Dalhousie University may.wang@dal.ca

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Satellite Earth Observation : A unique view of our planet and a long-term strategic vision for Canada - Part 1

Monday, May 29
8:00 - 9:30 EDT

(30 Mins) Perspectives and reflections on Canada's evolving EO landscape - Guennadi Kroupnik

(15 Mins) Canada's involvement in international collaboration with the Group On Earth Observations (GEO) - Carla Schmitt

(15 Mins) The Arctic Observing Mission (AOM): current status and an update on pre-formulation study activities - Matt Arkett

(15 Mins) An overview of the Surface Water and Ocean Topography (SWOT) satellite mission and preparatory activities in Canada - Jean Bergeron

(15 Mins) Coupling Through the Terrestrial Atmosphere System - William E. Ward

Satellite Earth observation provides a unique global perspective on our planet's atmosphere and surface, including the oceans, land, vegetation, ice, and snow. Current and planned satellite missions from Canada and international agencies have provided and will provide a wealth of new information about the Earth system and that can be used to investigate a wide range of environmental and scientific questions. This session encourages contributions from across the full Earth observation value chain, upstream, midstream and downstream. This includes new measurement technologies and techniques, both passive and active; mission development; retrieval algorithms; demonstration and calibration of instruments; validation of satellite products; assimilation of data into numerical models; scientific results and discoveries; operational utilization and development of services.

MUL-Perspectives and reflections on Canada's evolving EO landscape

Driven by Canada's Strategy for Satellite Earth Observations, the Government of Canada is making unprecedented investments in space science and technology to advance satellite Earth Observation (EO) capabilities across the value chain and across the country. In collaboration with domestic and international partners, the CSA is working on the Canadian-led WildFireSat (WFS) mission, the NASA-led HAWC (High-altitude Aerosols, Water vapour and Clouds) mission, and the recently launched NASA and CNES-led SWOT (Surface Water and Ocean Topography) mission. Canada is also modernizing its ground-based infrastructure and making early investments in Digital Earth Canada platform. Moreover, the Government of Canada, through a number of programs such as Space Technology Development Program and SmartEarth program, continues to support Canadian companies and academia in advancing innovative research, technology and application development. Taking into account past and present investments, results stemming from the 2nd Edition of the National EO Forum, and the Government of Canada's renewed efforts in convening and mobilizing Canadian EO communities, this presentation will offer some reflections and perspectives on the current EO landscape in Canada and possible future outlook, with an objective to continue receiving inputs from stakeholders to inform federal decision-making for the benefit of Canadians.

Guennadi Kroupnik[1] [1]Space Utilization at the Canadian Space Agency

MUL-Canada's involvement in international collaboration with the Group On Earth Observations (GEO)

Canada is a member of the Group on Earth Observations (GEO), an international partnership of 114 Member Countries and 144 Participating Organizations working together to increase the open access and use of Earth observation (EO) for decision-making, including the advancement of work on global priorities such as Sustainable Development Goals, Climate Action, and Disaster Risk Reduction. At the national level, the Canadian GEO community comprises of academic, government, and industry members, who engage with international experts and stakeholders to advance common goals in areas like biodiversity, disaster resilience, sustainable agriculture, and health. This work aligns with Canadas Strategy for Satellite Earth Observation, which recognizes the significance of international collaboration in a rapidly growing EO sector. This evolving EO landscape is also influencing the global GEO communitys approach in developing a new direction beyond 2025, the follow-up work to the GEO Strategic Plan 2016-2025. This presentation will provide an overview of GEO, Canadas involvement, the benefits of engaging with GEOs network and the next steps GEO is considering to address our global challenges.

Carla Schmitt[1], David Harper[1], Shannon Kaya[1] [1]Environment Climate Change Canada carlavanessa.schmitt@canada.ca

MUL-The Arctic Observing Mission (AOM): current status and an update on pre-formulation study activities

The Arctic Observing Mission (AOM) is a satellite mission concept currently under study by the Canadian Space Agency (CSA) in partnership with Environment and Climate Change Canada (ECCC). AOM would use a highly elliptical orbit (HEO) to enable frequent observations of meteorological variables, greenhouse gases (GHGs), air quality and space weather over northern regions, addressing the current sparsity in spatial and temporal coverage beyond the usable viewing range of geostationary (GEO) satellites. These observations are important for operational activities, environmental monitoring and scientific research aligned with key Government of Canada priorities. AOM is envisioned to be implemented as a Canadian-led international partnership. The CSA and ECCC are actively discussing potential contributions to the mission with prospective partners from the United States and Europe. This presentation will provide an update on plans and progress of the Canadian-led AOM project. An overview of AOMs objectives, scope and planned instrumentation will be given, along with an update on the AOM pre-formulation study (PFS), which is scheduled to conclude in late 2024. The PFS includes technical mission architecture and design studies, technology development/demonstration, science/application studies and a socio-economic benefits study. Throughout the pre-formulation study, Canada will continue to work with prospective international partners to define their roles and solidify their contributions to AOM in the ongoing effort towards achieving high quality quasi-geostationary northern Earth observation and space weather data for the free and open use by the international community.

Ray Nassar1, Alec Casey1, Matt Arkett1, Josep Aparicio1, Chris Sioris1, Chris McLinden1, Joseph Mendonca1, Geneviéve Garièpy2, Kurtulus Yilmaz2, Helena van Mierlo2, Marwan Haroun2, Shen-En Qian2, Oleg Djazovski2, Hany Fawzy2, Isabelle Jean2, Alexander Trishchenko3

MUL-An overview of the Surface Water and Ocean Topography (SWOT) satellite mission and preparatory activities in Canada

The Surface Water and Ocean Topography (SWOT) satellite mission, which launched on December 16, 2022, will provide spaceborne measurements of surface water

elevation over inland water bodies and oceans. The Canadian Space Agency (CSA) contributed to the satellite development and continues to support SWOT science activities through grants to Canadian universities and through shared investments with Environment and Climate Change Canada, and with Fisheries and Oceans Canada. Canadian scientists are carrying out validation activities over the Canadian territory and anticipating the use of SWOT data in applications that will benefit Canadians such as monitoring and forecasting inland water bodies, rivers, estuaries and coastal ocean zones. The presentation provides a mission status update and a portrait of Canadian-led SWOT science activities supported by CSA.

Jean Bergeron[1] [1]Canadian Space Agency jean.bergeron@asc-csa.gc.ca

MUL-Coupling Through the Terrestrial Atmosphere System

As our understanding of various regions of the Sun-Earth system increases, an appreciation of the importance of inter-region coupling is becoming more and more apparent. This is reflected in the development of whole atmosphere models and proposed NASA and ESA solar-terrestrial missions focussing on the coupling between the neutral and ionised atmospheres in the magnetosphere-ionosphere-atmosphere system. This coupling is mediated through waves, constituent/charged particle flows and electric and magnetic fields. In this paper, this coupling and relevant observations are summarized. Of particular interest in this regard is RADiation Impacts on Climate and Atmospheric Loss Satellite (RADICALS) Mission, a recently funded Canadian satellite mission, scheduled to launch in 2027. RADICALS will provide detailed information for the first time on the high energy electrons and protons incident on the lower thermosphere. This information is necessary for understanding the production of odd nitrogen, which is transported into the stratosphere where it leads to the destruction of ozone in polar night.

William E. Ward[1], Ian R. Mann and RADICALS Team[2] [1]University of New Brunswick [2]University of Alberta wward@unb.ca

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Opening Plenary - Severe Post-Tropical Cyclone Fiona – Forecasting and Historical Context

Monday, May 29
11:30 - 12:30 EDT

On September 23rd, 2022, severe post-tropical cyclone Fiona underwent rapid extratropical transition from a category-3 major hurricane as it tracked just north of Bermuda and made landfall in Nova Scotia early on September 24th. This very large and powerful storm brought extreme winds, 2m+ storm surge and devastating ocean waves to many parts of Atlantic Canada. The storm set a new national record for lowest sea level pressure of a marine cyclone making landfall in Canada. Near ¾ of a billion dollars in insured damage was inflicted on the region and almost all residents described the storm as the worst in their memory. Fiona was the costliest natural disaster in Atlantic Canada's history. In this talk I will describe the forecast process at the Canadian Hurricane Centre and will discuss the context of this event with other significant tropical events that have impacted Canada over the past 150 years.

Dr. Chris Fogarty
PH.D., PROGRAM MANAGER (METEOROLOGIST)
Canadian Hurricane Centre

Climate Variability and Predictability - Part 1

Monday, May 29
12:30 - 14:00 EDT

(15 Mins) Forecast skill of soil moisture in the Canadian Seasonal to Interannual Prediction System version 2.1 (CanSIPSv2.1) - Reinel Sospedra-Alfonso

(15 Mins) Skill Assessment of Various Coupled Climate Models for Predicting Arctic Sea Ice on Seasonal Timescales - Joseph Martin

(15 Mins) Seasonal Predictability of Antarctic Sea Ice with the Canadian Earth System Model version 5 - Robert Payne

(15 Mins) Seasonal predictions of dominant patterns of wintertime surface air temperature in the extratropical Northern Hemisphere - Hai Lin

(15 Mins) Regional and global climate model skills in simulating historic wind speed and direction in the Quebec region. - Yoandy Alonso

(15 Mins) Spatio-temporal variations of atmospheric river occurrence frequency from the ERA5 reanalysis: Global and North American perspectives - Ruping Mo

This session invites contributions that deal with climate variability and predictions on subseasonal, seasonal, interannual and decadal-interdecadal time scales. Contributions are solicited on topics including studies of the Madden-Julian Oscillation (MJO) and tropical waves, El Nino/Southern Oscillation (ENSO), atmospheric circulation patterns, tropical-extratropical interaction and teleconnections, and impacts of these processes on predictability and predictions. Equally welcome are contributions on extended- and long-range weather forecasts, and predictions of climate variability on various time scales, including ensemble and initialization techniques, model development, forecast skill assessment, downscaling and calibration, and end-user value and applications. Results from diagnostic, modelling, model inter-comparison, and theoretical approaches are all welcome.

CLM-Forecast skill of soil moisture in the Canadian Seasonal to Interannual Prediction System version 2.1 (CanSIPSv2.1)

We assess the representation of soil moisture (SM) in version 2.1 of the Canadian Seasonal to Interannual Prediction System (CanSIPSv2.1). SM plays a key role in the land surface water and energy balance, the modulation of thermal properties at the soil-atmosphere interface, and the recycling of precipitation. The ability to predict SM is therefore critical for drought and flood prediction, water resource allocation, and so forth. We provide a comprehensive evaluation of CanSIPSv2.1 SM hindcasts and the reconstruction runs giving their initial conditions. Different strategies are used to initialize the two CanSIPSv2.1 models, with contrasting impacts on SM initial conditions and forecast skill. We decompose the forecast correlation skill into contributions from

persistence of the initial anomalies and contributions not linked to persistence. We further quantify the effects of remote surface oceanic states on SM skill by computing the association between precedent oceanic climate states and SM hindcasts, while controlling for the persistence of the initial anomalies. Seasonal SM skill is significant depending on initial and forecast months, with contributions not linked to persistence becoming more notable at longer lead times. At shorter leads, globally averaged multi-model CanSIPSv2.1 SM skill tends to be higher during summer and fall, and is comparable to the skill of the best performing model, whereas multi-model skill surpasses that of the single models during spring and winter. At longer leads, remote climate influences from the Pacific Ocean contribute to skilful SM variability in teleconnected regions.

Reinel Sospedra-Alfonso[1], William J. Merryfield[1], Viatsheslav V. Kharin[1], Woo-Sung Lee[1], Hai Lin[1], Gulilat Diro[1], Ryan Muncaster[1] [1]Environment and Climate Change Canada reinel.sospedra-alfonso@ec.gc.ca

CLM-Skill Assessment of Various Coupled Climate Models for Predicting Arctic Sea Ice on Seasonal Timescales

Seasonal forecasting of Arctic sea ice conditions is important to the scientific understanding of our changing climate as well as to the operations of regional stakeholders. This work assesses the skill of four coupled climate models (CanCM3, CanCM4, GEM-NEMO, and CanESM5) in forecasting sea ice extent on a pan-Arctic scale as well as in various Arctic regions. Skill assessment is further provided for different versions of the Canadian Seasonal to Interannual Prediction System (CanSIPS) which applies a multi-model approach using various combinations of these models. This analysis demonstrated the consistent advantage of using a multi-model system as all three versions of CanSIPS showed greater skill than any individual model on the pan-Arctic scale. Regional analyses found greater predictive skill for predicting sea ice extent in Atlantic regions versus Pacific regions. The spring predictability barrier occurs where spring-initialized forecasts are substantially less skillful than those initialized later. This phenomenon is seen on the pan-Arctic scale as well as in some regional assessments. Further, we show that more accurate sea ice thickness initialization increases predictive skill of sea ice extent on the pan-Arctic scale and in several regions. This effect is also shown through a comparison of the predictive skill of these models to the predictive skill of the initial sea ice thickness conditions they use. The importance of sea ice thickness initialization and the superior skill of multi-model forecast systems are underscored by this study.

Joseph Martin[1], Adam Monahan[2], Robert Payne[2], Michael Sigmond[3] [1]Royal Canadian Navy [2]University of Victoria [3]Canadian Centre for Climate Modelling and Analysis joeymartin888@gmail.com

CLM-Seasonal Predictability of Antarctic Sea Ice with the Canadian Earth System Model version 5

We present an assessment of Antarctic sea ice forecast skill for the Canadian Earth System Model version 5 (CanESM5), with comparison to a previous assessment of sea ice forecast skill in two constituent models of the Canadian Seasonal to Interannual Prediction System version 2 (CanSIPSv2), CanCM4 and GEM-NEMO. CanESM5 notably uses an improved and higher resolution ocean model (NEMO) and sea ice model (LIM2) in comparison to CanCM4, with the ocean model being similar to that in GEM-NEMO. Based on hindcasts between 1980 and the 2010s, we find that CanESM5

demonstrates greater predictive skill than CanCM4 over the majority of target months, forecast lead times, and geographical regions. All three models are found to show noticeable variation in their forecast skill depending on the region and time period analysed, while being especially sensitive to whether or not the considered time interval includes late 2016. During this precipitous decline of sea ice in 2016, GEM-NEMO is found to capture the sudden negative anomalies in sea ice extent remarkably well. This is in contrast to CanCM4 and CanESM5, which capture the general downward trend but lack the ability to ascertain the observed large negative anomalies. An analysis of model experiments nudged to observed winds suggests that the wind fields may have played an important role in the general downward trend in Antarctic sea ice after 2015, but cannot entirely explain the sudden drop in 2016.

Robert Payne[1], Michael Sigmond[2], Adam Monahan[3], Joseph Martin[3] [1]University of Victoria [2]Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada [3]School of Earth and Ocean Sciences, University of Victoria bobbypayne1654@hotmail.com

CLM-Seasonal predictions of dominant patterns of wintertime surface air temperature in the extratropical Northern Hemisphere

The forecast skill of wintertime seasonal mean surface air temperature over the extratropical Northern Hemisphere continents is in general low, and our understanding on its sources of predictability is limited. Here we assess the performance of the Canadian Seasonal to Inter-annual Prediction System version 2.1 (CanSIPSv2.1) in predicting dominant patterns of surface air temperature in Northern Hemisphere winter. Based on an empirical orthogonal function (EOF) analysis of the ERA5 reanalysis monthly mean 2-meter temperature (T2m) in the extratropical Northern Hemisphere, three leading patterns are identified. EOF1 is correlated with the Arctic Oscillation / North Atlantic Oscillation, whereas EOF2 and EOF3 are associated with the Warm Arctic-Cold North American (WACNA) and the Warm Arctic-Cold Eurasian (WACE) patterns, respectively. These three patterns are well simulated in the two CanSIPSv2.1 models as modes of internal variability. The forecast skill of DJF-mean principal component (PC) time series of these three EOFs is evaluated for the CanSIPSv2.1 hindcast in 1981-2020 at lead-times of 0 to 9 months. It is found that only PC3 has significant forecast skill for a lead-time longer than a month. The high-latitude center of EOF3 has a correlation skill over 0.6 at all lead-times, which is associated with sea surface temperature (SST) and sea ice concentration anomalies near the Barents Sea region. The middle-latitude center of EOF3 also has statistically significant forecast skill at lead-times up to four months. This indicates that part of the T2m variability in the middle-latitude Eurasian continental region is predictable and is thus of an origin other than atmospheric internal dynamics. Possible sources of skill are discussed.

Hai Lin[1], Ryan Muncaster[1], Bin Yu[1], William Merryfield[1], Marko Markovic[1], Gulilat Diro[1] [1]Environment and Climate Change Canada hai.lin@ec.gc.ca

CLM-Regional and global climate model skills in simulating historic wind speed and direction in the Quebec region.

Surface winds control turbulent sensible and latent heat fluxes and are responsible for the transport and dispersion of anthropogenic pollution, making the accuracy of their modeling an essential step for analyzing the performance of future scenario modeling. This work provides a detailed analysis and evaluation of wind speed and direction within Quebec from a set of high-resolution global models from the Coupled Model

Intercomparison Project (CMIP6) and regional climate models from the North American component of Coordinated Regional Downscaling Experiment (CORDEX-NA) driven with CMIP5. For this analysis, homogenized meteorological station data and re-analysis products (ERA5, NARR, MERRA-2, and NCEP-NCAR) are summarized over the study period; from 1950-2012 for the CMIP6 and from 1980-2014 for the CMIP5 models. Overall, ERA5 performed the best among the re-analysis products with the lowest mean bias over the range of Quebec meteorological station data. No significant differences in the CMIP6 HighResMIP estimations of the wind speed and wind direction were found using different spatial resolutions. However, the higher resolution CORDEX-NA members outperform the lower resolution CORDEX-NA members for estimating wind speed. For wind speed and direction above the surface (850, 500, and 200 mb), the performance of the models is improved compared to the surface level in global climate models. Additionally, the trend of the mean wind speed shows a slight increase in the wind speed in the northern region of the province, as well as a slight decrease in it in the southern region.

Yoandy Alonso[1], James King[1] [1]Université de Montréal yoandy.alonso@umontreal.ca

CLM-Spatio-temporal variations of atmospheric river occurrence frequency from the ERA5 reanalysis: Global and North American perspectives

Atmospheric rivers (ARs) are long and narrow corridors of strong horizontal water vapor transport. Here we apply a popular AR identification and tracking algorithm to the ERA5 reanalysis of 73 years (19502022) and analyze the spatio-temporal variations of AR occurrence frequency (AROF) at the global and regional scales. Four centers of maximum AROF are found over the extratropical oceans, with the seasonal maximum of 16.5% over the North Pacific in the second quarter (Q2) of the year. Over North America (NA), high AROFs cover both the west and east coast in the cold seasons (Q4 and Q1) and shift to higher latitudes in summer. A surge of inland-penetrating ARs into the central United States occurs in spring. Worldwide, the strongest orographic enhancement for the AR-induced precipitation is along the southeastern edge of the Himalayas, with an average precipitation rate reaching 4.5 mm/h in summer. In NA, the Coast Mountain Ranges in British Columbia and Alaska provide the most effective orographic enhancement in the cold seasons. The most significant increasing trends in the AR frequency of occurrence occur in the Southern Hemisphere westerlies (1.0% ~ 1.8% per decade). Over NA, some regions experience increasing trends of AROF in the range of 0.5% to 0.8% per decade, and there are also significant changes on interannnual-to-decadal timescales caused by the ENSO and Pacific Decadal Oscillation systems. A better understanding of these influences of climate trend and variability contributes to a more comprehensive assessment of near-future AR activities and the associated hydrometeorological impacts.

Ruping Mo[1], Bin Guan[2], Rita So[3], Christopher Emond[1], Roxanne Vingarzan[4] [1]National Laboratory-West, Environment and Climate Change Canada [2]Jet Propulsion Laboratory, California Institute of Technology [3]Environmental Protection Branch, Environment and Climate Change Canada [4]Applied Sciences, PSOW, Environment and Climate Change Canada ruping.mo@ec.gc.ca

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Coastal Oceanography and Inland Waters - Part 2

Monday, May 29
12:30 - 14:00 EDT

(15 Mins) Hydrodynamics in Coastal Embayments of Nova Scotia during Upwelling and Downwelling Events - Qiantong Pei

(15 Mins) Estimating the Stokes drift with a single high frequency radar - Abigaelle Dussol

(15 Mins) Near-inertial internal wave generation within the waters of the Canadian Arctic Archipelago - Lina M. Rotermund

(15 Mins) Long-term monitoring of wave run-up on a highly dissipative beach - Carmen Holmes-Smith

This session will focus on all aspects of monitoring and modelling physical and biogeochemical processes in coastal domains, shelf seas, estuaries and inland waters. Topics include but are not limited to coastal physical oceanography, storm surges, tsunamis, estuarine dynamics, hydrology and hydrodynamics of large lakes, mixing and dispersion of materials. Contributions related to both observational and modelling aspects of biogeochemistry in coastal and inland waters are welcome. Papers can be on improving our knowledge of physical and biogeochemical conditions in the past and present climate and/or on predictions of changes and extremes in marine conditions in response to climate change.

OCE-Hydrodynamics in Coastal Embayments of Nova Scotia during Upwelling and Downwelling Events

Critical coastal ecosystems such as wetlands and estuaries of the Scotian Shelf (ScS) are particularly vulnerable to climate change. Numerical models are useful for predicting the hydrodynamic conditions over coastal and shelf waters. In this study, a high-resolution nested-grid ocean model is used in examining the three-dimensional (3D) circulation and hydrodynamic connectivity in coastal embayments such as Halifax Harbour and St. Margarets Bay over the ScS, based on the Regional Ocean Modeling System (ROMS). The 3D model results are also used in quantifying interactions between these two embayments and inner shelf waters of the ScS. Analyses of model results demonstrate that, during coastal upwelling and downwelling events, the hydrodynamic conditions in St. Margarets Bay differ significantly from their counterparts in Halifax Harbour. The physical mechanisms resulted in the major different hydrodynamic responses of these two embayments during upwelling and downwelling events are studied based on the model results.

Qiantong Pei[1], Jinyu Sheng[2] [1]Dalhousie Univeristy [2]Dalhousie University
qn317878@dal.ca

OCE-Estimating the Stokes drift with a single high frequency radar

It has been recently established that High-Frequency (HF) radars measure half of the surface Stokes drift in addition to Eulerian currents. For some applications such as assimilating HF radar measurements into purely Eulerian ocean numerical models, it is necessary to remove this wave-induced contribution from these measurements. Due to the horizontal variability of the wave field in coastal environments, a single instrument measuring the wave spectrum is not sufficient to estimate the surface Stokes drift over the entire area covered by HF radar. Thus, a method to estimate the Stokes drift is proposed using a theoretical Toba wave spectrum determined from the wind field retrieved by a single HF radar. Radar estimations of the Stokes Drift are compared with in-situ observations of the wave spectra by a bottom-mounted Acoustic Wave and

Current Profiler (AWAC) deployed in an area covered by four HF radars: two Wellen Radars (WERA) and two Coastal Ocean Dynamics Applications Radars (CODAR). The average correlation coefficient between the radar-estimated Stokes drift and the AWAC Stokes drift is 0.87 for the WERAs and 0.86 for the CODAR.

Abigaelle Dussol[1], Cédric Chavanne[1] [1]Institut des Sciences de la Mer de Rimouski Abigaelle.Dussol@uqar.ca

OCE-Near-inertial internal wave generation within the waters of the Canadian Arctic Archipelago

Near-inertial internal wave (NIW) generation and modification by sea ice cover is examined through a 13-year (1998 - 2011)in situ record of ocean and ice velocities across Barrow Strait, Nunavut. Barrow Strait is within the newly designated Tallurutiup Imanga National Marine Conservation Area, a region of ecological and social importance for the eastern Canadian Arctic Archipelago (CAA). NIWs drive turbulent mixing which can impact local sea ice conditions and nutrient fluxes, and in turn can affect primary production. Near-inertial speed in the upper 50 m of the water column exhibits a clear seasonal cycle, with increased strength during ice free or low ice cover conditions and are weakest during heavy ice cover and landfast ice conditions. A similar seasonal signal has been reported in other locations in the Arctic Ocean basin and shelf regions. However, near-inertial speeds in Barrow Strait tend to be marginally weaker, likely due to the proximity of coastal boundaries. Episodic NIW events are further investigated; group velocity and energy fluxes are estimated where possible. Characteristics of NIW events that occur during ice free, mobile ice and landfast ice conditions are compared. Examining NIW generation and modification by seasonal sea ice cover will lead to a better understanding of their influence on mixing in the region.

Lina M. Rotermund[1], Ruth C. Musgrave[1], Clark G. Richards[2] [1]Dalhousie University [2]Fisheries and Oceans Canada, Dalhousie University lina.rotermund@dal.ca

OCE-Long-term monitoring of wave run-up on a highly dissipative beach

Wave run-up is defined as the maximum extent that water reaches up a sloping beach from breaking waves, with the magnitude determined by both wave set-up and swash up-rush. The behaviour of this run-up, particularly extreme events in the tail-end of the distribution, is relevant for studying coastal erosion processes, planning infrastructure, and protecting the public from harm. Research in this field has historically been limited to short-term studies, conducted over time scales of hours to weeks. We present over two years of near continuous wave run-up data from a highly dissipative beach on the west coast of Vancouver Island, Canada. This study looks at the statistics of the entire wave run-up time-series as extracted from infrared video data. Additional instruments deployed during the study enable us to track the transformation of the wave field from the nearshore, into the surf zone, and finally onto the beach. Also discussed is the occurrence of extreme run-up events resulting from bore-bore capture, where a faster moving bore catches up to a slower moving bore. The relative importance of two primary processes to extreme run-up, bore-bore capture and large offshore waves propagating onto the beach, is evaluated. The outcomes of this research will improve the tools used by local risk managers for wave hazard assessment. Beyond the societal impact, this work contributes important statistics and insights into wave field evolution in shallow water.

Carmen Holmes-Smith[1], Johannes Gemmrich[1] [1]University of Victoria carmen.holmes.smith@gmail.com

Quantifying the marine carbon cycle and ocean carbon uptake: Part 1

Monday, May 29
12:30 - 14:00 EDT

(15 Mins) Baffin Bay surface-ocean pCO2 variability, 2011 to 2021 - Gina Nickoloff

(15 Mins) Investigating Effects of Atmospheric Forcing Conditions on Deep Convection in the Labrador Sea Using a High-Resolution Earth System Simulation - Romina Piunno

(15 Mins) Enhancing the Estimation of the Carbonate System Across Time and Depth: Combining CO2SYS with Statistics - Claire Boteler

(15 Mins) Predicted versus observed seasonality of pCO2 and air-sea CO2 fluxes in the Central Labrador Sea. - Ricardo Arruda

(15 Mins) Air-sea CO2 Flux Variability in the North East Pacific Coastal Ocean - Patrick Duke

(15 Mins) Improving Prediction skill of the variable ocean carbon flux - Parsa Gooya

As countries around the world look to include natural carbon pools and fluxes in their carbon stocktaking efforts to address climate change, quantification of the marine carbon sink, and indeed marine carbon cycling in general, remain poorly quantified. The ocean acts as a major sink for human carbon dioxide emissions, and is the largest quickly-exchanging reservoir of carbon on earth. Processes driving ocean carbon air-sea exchange, biological uptake, and physical circulation and temperature changes are rapidly shifting under climate change. Progress is being made to better understand these controls and their associated variability across the open ocean to nearshore continuum, as well as on seasonal, interannual, decadal, and long-term timescales using observations and models. This session will showcase the latest progress in our understanding of the marine carbon cycle from local to global scales. We welcome contributions that quantify the rates and processes of fluxes and storage of carbon, the modification of the carbon cycle due to physical, chemical, and biological processes, and studies of carbon dioxide removal approaches to increase ocean carbon uptake. Timescales from seasonal to millennial are of interest. Contributions from studies that address open ocean and coastal regions; the surface or the interior; and that apply observations, models, or a combination of both, are welcome.

OCE-Baffin Bay surface-ocean pCO2 variability, 2011 to 2021

Utilising a ten-year high-resolution underway dataset we resolve pCO2 dynamics over Baffin Bay during the open-water season, June to October, 2011 to 2021, as a baseline understanding of air-sea carbon dynamics in this region. We found the bay to be highly favourable to uptake of atmospheric CO2, as is common in cold, Arctic ocean areas. Yearly pCO2 was generally well-undersaturated over Baffin Bay during the open-water season, with highest regional average pCO2 remaining ~100 atm below saturation. Strongly undersaturated pCO2 is well-correlated with cold temperatures in the Nares

Strait region. The Baffin Island current region experiences elevated pCO2 during instances of high ice cover, usually in early spring. The West Greenland current region is perennially ice-free, with relatively-consistent surface ocean temperature and salinity, and has lower average pCO2 in comparison to the Baffin Island current both in early spring and over the open-water season. Overall, surface ocean temperature, salinity and ice-influence were found to be the strongest controls to surface-ocean pCO2. Despite spatial and temporal variation over the open-water-season, Baffin Bay surface waters remain strongly undersaturated, a potentially high CO2 sink, even in comparison to other uptake regions in the Canadian Arctic.

Gina Nickoloff[1] [1]University of Calgary ginanickoloff@live.com

OCE-Investigating Effects of Atmospheric Forcing Conditions on Deep Convection in the Labrador Sea Using a High Resolution Earth System Simulation

Deep oceanic convection occurs in few locations around the globe. One such location is found in the Labrador Sea where dense waters subside to depths in excess of 2km below the surface. The weak stratification preconditions the water column for deep convection, triggered by wintertime surface cooling associated with high wind speed events. The convected water brings with it dissolved gases, such as Carbon Dioxide, which are in constant flux between the ocean and the atmosphere. It is thought that this process of turbulent boundary layer interactions coupled with deep convection is responsible for mixing these gases into the deep ocean, making the ocean the largest sink of anthropogenic carbon. Convective overturning is governed by turbulent fluxes of heat and salinity meaning that the rate of deep-water formation is subject to change with Earths changing climate. Here we analyze model output from a high - resolution configuration of the Community Earth System Model version 1.3. The model is run with a 0.25 horizontal resolution for atmospheric processes and 0.1 for oceanic processes. This climate simulation spans the years 1850-2100 using historical records and the RCP 8.5 scenario. From these simulations, we investigate the impact of large-scale atmospheric circulation patterns such as the North Atlantic Oscillation on turbulent fluxes and thus convective overturning. Through characterizing conditions which favour deep-water formation, we aim to quantify the impacts climate change may have on the sequestration of anthropogenic carbon dioxide.

Romina Piunno[1], Kent Moore[1] [1]University of Toronto romina.piunno@mail.utoronto.ca

OCE-Enhancing the Estimation of the Carbonate System Across Time and Depth: Combining CO2SYS with Statistics

The Northwest Atlantic Ocean (45°~-~65°~N and 20°~-~55°~W) is an important global sink for atmospheric carbon produced by anthropogenic activities. However sparse and irregular sampling makes it difficult to capture a full picture of the variations of carbonate system variables: dissolved inorganic carbon, total alkalinity, pH and fugacity of carbon dioxide. We used a state space model and Kalman Smoother to sequentially estimate monthly time series of these variables for multiple depths through the water column. These variables are connected through chemical equilibrium equations, which was used to improve estimates where observations were lacking for some but available for other variables. The state space model also contains a covariance matrix that implements the correlation between adjacent depth layers. The proposed method is flexible, such that multiple data sources (i.e. GLODAP, SOCAT and ARGO) were incorporated, amalgamating them using their uncertainty limits. The time-depth estimates for the carbonate system variables show

many features, notably how the variable temporal trends change with depth. The results have also provided visuals of the increasing rates of DIC (0.12-0.75 $\mathrm{\mu mol~kg^{-1}~year^{-1}}$) and fCO_2 (0.94-1.59 $\mathrm{\mu atm~year^{-1}}$), as well as the steady acidification of pH (0.0015 $\mathrm{year^{-1}}$). Total alkalinity has minimal fluctuations after removing the influence of salinity.

Claire Boteler[1], Michael Dowd[1], Eric C. J. Oliver[1], Douglas W. R. Wallace[1] [1]Dalhousie University claire.boteler@dal.ca

OCE-Predicted versus observed seasonality of pCO2 and air-sea CO2 fluxes in the Central Labrador Sea.

The Central Labrador Sea is one of the regions of the North Atlantic Ocean with lowest ocean surface pCO2 and with highest uptake of atmospheric CO2, presenting elevated spatial-temporal variability of pCO2, which is influenced by exchange of both natural and anthropogenic carbon. Overall, this region acts as a sink of atmospheric CO2 year-round, intensifying this uptake in the Spring and lasting through Summer/Fall. Here, we compile surface observations of pCO2 from 3 moorings, and underway measurements (SOCATv2021 database) from the Central Labrador Sea (the region of deep convection), to define an observation-based annual cycle of pCO2 and air-sea CO2 fluxes in this data-poor but important region. We also show the distribution of recent pCO2 observations in and around the Labrador Sea, highlighting observations (2000-2020) still not listed in SOCATv2021. The additional data indicate how data coverage might improve in the near-term and, therefore, where and when observations are most needed. Since global estimates often have elevated uncertainties in high latitude regions such as the Labrador Sea, we compare available climatologies for this region from several global products: Takahashi et al., (2002; 2009) and six climatologies derived from SeaFlux (Gregor and Fay, 2021). These predictions show considerable disagreement between themselves and with our observations in the seasonal cycle of pCO2 and the intensity of CO2 fluxes, indicating that increased data coverage will be critical for better understanding of the seasonality and spatial distribution of pCO2 and for constraining air-sea CO2 fluxes in this region and their sensitivity to changing climate.

Ricardo Arruda[1], Douglas Wallace[1], Dariia Atamanchuk[1] [1]Dalhousie University ricardo.arruda@dal.ca

OCE-Air-sea CO2 Flux Variability in the Northeast Pacific Coastal Ocean

Coastal oceans disproportionately contribute to oceanic uptake of anthropogenic emissions relative to global ocean surface area. Taking steps towards quantification of carbon fluxes at this highly dynamic land-ocean interface is critical for development of carbon and climate policies, determining trends in oceanic carbon uptake, and assessing coastal ocean acidification impacts. Here, we use a two-step neural network approach as a method of gap-filling sparse observations to basin wide estimates in the coastal Northeast Pacific Ocean. We compiled partial pressure of carbon dioxide (pCO2) observations as well as a range of predictor variables including bathymetry, physical oceanographic reanalysis products, and satellite-based sea surface temperature and biological estimates. With the predictor variables acting as proxies for known processes affecting pCO2, we can create non-linear relationships to interpolate observations from 1998-2019. Using wind speed and atmospheric CO2, we evaluate spatiotemporal dynamics of air-sea CO2 fluxes. Seasonally, we see strong oceanic uptake in the spring driven by high biological productivity drawing down CO2 leading to widespread undersaturation. In the nearshore within the Salish Sea, Alexander Archipelago, and Cook Inlet there is a strong outgassing signal through much of the

year driven by tidal circulation bringing high CO2 waters to the surface, weak winter productivity, and high freshwater input. We also see strong outgassing from the center of the Alaskan Gyre off the south coast of Kodiak Island through the winter. Overall, our results suggest that the region is a net sink for atmospheric CO2.

Patrick Duke[1], Roberta Hamme[1], Debby Ianson[2], Peter Landschützer[3], Neil Swart[4], Paul Covert[2], Jamie Shutler[5] [1]University of Victoria [2]Institute of Ocean Sciences [3]Flanders Marine Institute [4]Canadian Centre for Climate Modelling and Analysis [5]University of Exeter pjduke@ucalgary.ca

OCE-Improving prediction skill of the variable ocean carbon flux

Predicting changes in the ocean carbon sink is of great relevance to climate policy, informing the Global Stocktake, and the setting of emission targets. Long term increases in ocean carbon uptake are driven by increasing atmospheric CO2 concentrations, are well understood and predictable. However, inter-annual to decadal changes in the ocean carbon flux produced by climate variability challenges the predictability of the flux on these shorter timescales. Climate models initialized using observations have proven skillful for near term predictability of the key physical climate variables. By comparison predictions of biogeochemical fields such as the ocean carbon flux are in their infancy, although initial studies have indicated that skillful predictions are possible for lead times up to six years at the global scale for some of the CMIP6 Earth System Models. In this study we propose a new approach for improving the skill of decadal ocean carbon flux predictions. Our method uses the two-step neural network of Landschutzer et al. (2016) that is trained on SOCAT observational data. We apply this network using physical input variables derived from decadal prediction hindcasts from CanESM5, to produce predictions of the surface ocean carbon flux. We conduct evaluation of our neural network derived flux predictions relative to the observations and the raw predictions made by CanESM. Our results suggest the neural network is capable of producing skillful predictions of the carbon flux globally and regionally, and in many regions it significantly outperforms the raw predictions made by the biogeochemical model component of CanESM.

Parsa Gooya[1], Neil Swart[1] [1]Environment and Climate Change Canada (ECCC) parsa.gooya@ec.gc.ca

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Satellite Earth Observation: A unique view of our planet and a long-term strategic vision for Canada - Part 2

Monday, May 29
12:30 - 14:00 EDT

(15 Mins) Preliminary estimates and evaluation of global ground heat flux from satellite remote sensing data - Francisco José Cuesta-Valero

(15 Mins) Hyperspectral imaging for the coastal ocean and inland waters: ongoing and planned activities at the Canadian Space Agency - Jean Bergeron

(15 Mins) Adjacency Effect Modelling for Remote Sensing of Inland and Coastal Waters - Yulun Wu

(15 Mins) Field-scale soil moisture over agricultural areas, based on physical modelling, land data assimilation, and machine learning - Aston Chipanshi

(15 Mins) Reconstruction of coastal circulation off British Columbia from simulated SWOT data - Guoqi Han

(15 Mins) SWOT in-situ and airborne validation campaign in the St. Lawrence Estuary - Pascal Matte

Satellite Earth observation provides a unique global perspective on our planet's atmosphere and surface, including the oceans, land, vegetation, ice, and snow. Current and planned satellite missions from Canada and international agencies have provided and will provide a wealth of new information about the Earth system and that can be used to investigate a wide range of environmental and scientific questions. This session encourages contributions from across the full Earth observation value chain, upstream, midstream and downstream. This includes new measurement technologies and techniques, both passive and active; mission development; retrieval algorithms; demonstration and calibration of instruments; validation of satellite products; assimilation of data into numerical models; scientific results and discoveries; operational utilization and development of services.

MUL-Preliminary estimates and evaluation of global ground heat flux from satellite remote sensing data

Continental heat storage is the second largest term of the Earth heat inventory after the ocean, accounting for 6 % of the total heat storage within the Earth system. Ground heat storage -the heat used to warm the continental subsurface, represents 90 % of the continental heat storage, followed by permafrost heat uptake (9 %) and the warming of inland water bodies (~1 %). Ground heat flux estimates derived from the global network of deep subsurface temperature profiles are the main source of information about heat flux and heat storage within the continental subsurface, although this database presents a bias towards the northern hemisphere locations, and the number of logs decreases sharply after the year 2000. Heat flux plate measurements in eddy-covariance towers are another database for analyzing ground heat flux, but the number of records available is not enough to understand changes in heat flux at decadal scales. Here, we estimate ground heat flux at the near-global scale between 1996 and 2020 using four land surface temperature products (ENVISAT-AATSR, MODIS-Aqua, MODIS-Terra, and SSMI-SSMIS) derived as part of the Climate Change Initiative (CCI) of the European Space Agency (ESA). Ground heat fluxes derived from these products yield root mean squared errors between 3.8 to 5.2 W m-2 at monthly resolution using FLUXNET observations as reference. These results show the potential of satellite remote sensing data to provide near-global estimates of ground heat flux.

Francisco José Cuesta-Valero[1], Jian Peng[1] [1]Helmholtz Centre for Environmental Research (UFZ) francisco-jose.cuesta-valero@ufz.de

MUL-Hyperspectral imaging for the coastal ocean and inland waters: ongoing and planned activities at the Canadian Space Agency

The growing effects of climate change and anthropic pressures are rapidly affecting Canadas most economically, ecologically and strategically important inland and coastal water bodies. Data scarcity limits effective water color monitoring and management, highlighting a need for timely, consistent and nationwide monitoring of Canadas fresh and marine water resources. Space-based hyperspectral imaging providing 100 m spatial sampling on a sub-weekly revisit basis has been identified as a promising

complementary approach to current efforts to provide water color information over Canadian water bodies. This approach has been the subject of many studies and technological developments led by the Canadian Space Agency (CSA) in the past years, in close collaboration with Environment and Climate Change Canada (ECCC) and the Department of Fisheries and Oceans Canada (DFO). In this presentation, we will give an overview of the ongoing and planned activities related to aquatic hyperspectral imaging at CSA. In particular, we will report on the development of the Dual Imaging spectrometer COCI Experiment (DICE) airborne demonstrator, currently under development. The DICE instrument, covering a 360-910 nm spectral range with 1.25 nm spectral sampling interval (440 bands), has a 19.6 field-of-view (equivalent to a 240-km swath in a 675-km orbit) and a target peak SNR of 950:1 at 550 nm. A first test flight is planned in the summer of 2023 to validate the instrument performance and a series of flights are expected to occur in 2024 to demonstrate its use to develop coastal and inland water data products and applications.

Genevieve Gariepy[1], Shen-En Qian[1], Caren Binding[2], Emmanuel Devred[3], Laurent Giugni[1], Jean Bergeron[1], Ralph Girard[1] [1]Canadian Space Agency [2]Environment and Climate Change Canada [3]Fisheries and Oceans Canada genevieve.gariepy@asc-csa.gc.ca

MUL-Adjacency Effect Modelling for Remote Sensing of Inland and Coastal Waters

INTRODUCTION A major challenge in satellite-based observation of coastal and inland waters is the atmospheric scattering of light from land surfaces, a phenomenon known as the adjacency effect. The adjacency effect often makes coastal and inland waters much brighter at certain wavelengths, leading to failed satellite-based retrieval of water-quality parameters such as chlorophyll concentration and turbidity. We present a 3D radiative transfer code that characterizes such effects. METHODS Radiative properties of the atmosphere and the water are calculated through Monte Carlo ray tracing. Six aerosol models and six atmosphere models are included in the Python library associated with this study. Cox-Munk wave slope statistics is used to determine waters specular reflectance, and topography is modelled by triangulating the elevation of land pixels. CASE STUDIES We compared modelled radiometric quantities with measurements. In one case study, we found that the adjacency effect explained 83.7% of the variance in the near-infrared reflectance of 47 lakes in Minnesota, emphasizing the significance of the adjacency effect to water-quality-retrieval algorithms that depend on near-infrared bands. In another case study, the modelled surface-reflected light was in good agreement with field measurements, indicating accurate characterization of the radiative properties of the atmosphere and the water surface. SIGNIFICANCE This study and the associated Python library will support development and validation of methods that remove the adjacency effect in remote sensing of coastal and inland waters. This is essential in improving, sometimes even enabling, satellite-based monitoring of waterbodies in such environments.

Yulun Wu[1], Anders Knudby[1], David Lapen[2] [1]Univerisity of Ottawa [2]Agriculture and Agri-Food Canada yulun.wu@uottawa.ca

MUL-Field-scale soil moisture over agricultural areas, based on physical modelling, land data assimilation, and machine learning

Accurate knowledge of soil moisture is important for a large number of applications related to environmental prediction and analysis. In the context of agricultural

applications, a collaborative project between Environment and Climate Change Canada (ECCC) and Agriculture and Agri-Food Canada (AAFC) was just recently completed. This projects main objective is to improve the two departments ability to produce accurate estimates of soil moisture at field-scale (~ hundreds of meters) for both near-surface and root-zone layers. Aspects related to land surface physical modelling, land data assimilation, and machine learning were researched and developed to achieve this goal. For physical modelling, several components of ECCCs Soil, Vegetation, and Snow (SVS) scheme and of AAFCs Versatile Soil Moisture Budget (VSMB) models were improved, including representation of hydraulic properties, freeze-thaw processes, and evaporation over bare ground. For land data assimilation, a field-scale configuration of the Canadian Land Data Assimilation System (CaLDAS), including soil moisture products from space-based sensors such as SMAP (Soil Moisture Active Passive mission), was tested. For the machine learning component, near-surface soil moisture was retrieved from compact polarimetric observations from the RADARSAT Constellation Mission (RCM) using the random forest algorithm. The impact of these modifications was tested for two warm seasons (2020 and 2021) against observations from AAFCs Real-time In-situ Soil Monitoring for Agriculture (RISMA) network in Southern Manitoba. These results will be presented and discussed at the conference, along with upcoming opportunities for technological transfer to operational systems at both ECCC and AAFC.

Aston Chipanshi[1] [1]Agriculture and Agri-Food Canada Aston.Chipanshi@agr.gc.ca

MUL-Reconstruction of coastal circulation off British Columbia from simulated SWOT data

A high-resolution coastal ocean model has been developed and evaluated off British Columbia. Daily sea surface height (SSH) from the model is used to generate simulated surface water and ocean topography (SWOT) data by a SWOT simulator. The simulated SWOT data are then used to generate gridded SSH fields using an optimal interpolation scheme in time and space. Subsequently geostrophic surface currents are calculated from the gridded SSH fields. It is found that major coastal currents and eddies are reconstructed fairly well from SWOT data.

Guoqi Han[1] [1]Fisheries and Oceans Canada guoqi.han@dfo-mpo.gc.ca

MUL-SWOT in-situ and airborne validation campaign in the St. Lawrence Estuary

The Surface Water and Ocean Topography (SWOT) mission will provide the first 2D observations of sea surface height in the global and coastal oceans, and measurements of water surface elevation, slope and extent over terrestrial surface waters, at unprecedented spatial resolutions. Successfully launched in December 2022, SWOT is scheduled to enter its 90-day Calibration/Validation (Cal/Val) phase in March 2023 on a 1-day repeat orbit. During this phase, SWOT will collect daily data equivalent to 5.2 years of SWOT Science data with exact 21-day repeat, over only a few regions worldwide. The St. Lawrence Estuary is the only estuary in Canada advantageously located under the Cal/Val orbit, which will benefit from data at both high temporal and spatial resolution. This site is one of the most energetic and dynamically complex region of the St. Lawrence System. With propagating tides reaching 7m in range and with its unique geomorphology, it presents significant spatiotemporal variability in surface conditions at all scales. Notably, it is a hot spot for internal tides generation and propagation through eddies and fronts. In this presentation, a summary of pre- and post-launch Cal/Val activities conducted in the St. Lawrence Estuary will be given. In particular, two airborne campaigns (LiDAR and AirSWOT), supported by a network of

in-situ gauges and buoys, GNSS-IR sensors, HF radars, ADCPs and RCM, are used to provide context on tides, waves, currents and ice conditions as well as to validate SWOT data across each orbit swath and under contrasting dynamical and environmental conditions. This effort represents the largest SWOT validation campaign in an estuary.

Pascal Matte[1], Marc Simard[2], David Purnell[3], Mohammed Amine Bessar[3], Mohammed Dabboor[1], François Anctil[3], Vincent Fortin[1], Cédric Chavanne[4], Dany Dumont[4]
[1]Environment and Climate Change Canada [2]California Institute of Technology
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Weather Nowcasting

Monday, May 29
12:30 - 14:00 EDT

This session will focus on activities related to using and improving Nowcasting systems. There is particular interest in operational Nowcasting and in associated research topics that offer promising support for Nowcasting in operational weather forecasting. Topics of interest include but are not limited to:

Better use of existing and new sources of observation data

Nowcasting techniques

Point nowcasting versus nowcasting on a grid

Blending techniques for nowcasting with numerical weather prediction data

Deterministic versus probabilistic nowcasts

New methods like machine learning and artificial intelligence of interest to nowcasting

Verification techniques applied to current weather, high impact weather, societal impacts

Nowcasting systems to support urban centers in high impact weather Conditions

Extending nowcasting systems to new types of products like UV Index nowcasts, renewable energy nowcasts

(15 Mins) Analysis of Data from the SOLMA Lightning Jump Tool - Lisa Alexander

(15 Mins) Hindsight on Canadian Weather Radar Renewal Project: What are the impacts on users? - Simard Corinne

(15 Mins) Investigating the potential of profiling mesonets for nowcasting applications - Dominque Brunet

(15 Mins) Mesoscale Data Assimilation for Nowcast of Weather Elements on Grid - Weiguang Chang

(15 Mins) Update on CMC's Nowcasting of Weather Elements on Grid (NCWEonG) Project - Lewis Poulin

(15 Mins) Comparison of Severe Storms measured by the MPLCAN lidar network to the Southern Ontario May 2022 Derecho - Victoria Pinnegar

ATM-Analysis of Data from the SOLMA Lightning Jump Tool

A lightning jump, or rapid increase in total lightning activity of a storm, can be a precursor of some severe weather occurrence on the ground. A real-time lightning jump tool developed to work with the data from the Southern Ontario Lightning Mapping Array (SOLMA) has been evaluated for performance on detecting significant lightning increases in the study area and how these may relate to severe thunderstorms. The SOLMA was installed in April 2014 and decommissioned in September 2018. The period considered for this study included May to September of 2017 and 2018. Here we look at lightning jump frequency, lightning jump length, lead time for severe weather occurrence, maximum flash rate, etc. Studying the data reveals a number of patterns and insight that could help aid operational meteorologists in nowcasting severe thunderstorms when taking lightning activity into consideration.

Lisa Alexander[1], Helen Yang[1] [1]Environment and Climate Change Canada lisa_s_a@yahoo.ca

ATM-Hindsight on Canadian Weather Radar Renewal Project: What are the impacts on users?

With over 90% of the radars installed, the Meteorological Service of Canadas (MSC) Canadian Weather Radar Replacement Program (CWRRP) is approaching its completion. One important objective of the project is to enhance the quality of various radar products by utilizing new features such as dual polarization technology, resulting in significant impact to the broad user community. During the project, key achievements were reached, including the reduction of the radar network scan strategy cycle from 10 to 6 minutes, lengthening Doppler coverage, and introducing new dual polarization products, some of which are now accessible to our internal and external users and to the public. While many improvements have been made to operational radar production, there are still opportunities for further advancements in the near future. In this presentation, we will share details on these upcoming improvements, such as making the Surface Precipitation TyPe (SPTP) and radar extrapolation (short-term radar echo forecast or future radar) products available to the public and external users. Finally, we will give a status update on the CWRRP project and present an overview of the progress made on the Open Data project, which was presented at previous CMOS events.

Simard Corinne[1], Ahmed Mahidjiba[1], Rabah Hachelaf[1], Meriem Kacimi[1], Ilyass Hajji[1], Yacine Bouzid[1], Sudesh Boodoo[2], Janti Reid[3] [1]Canadian Meteorological Centre Operations, Meteorological Service of Canada, Environment and Climate Change Canada [2]Meteorological Research Division, Science and Technology Branch, Environment and Climate Change Canada [3]Forecast System Integration and Innovation, Meteorological Service of Canada, Environment and Climate Change Canada corinne.simard@ec.gc.ca

ATM-Investigating the potential of profiling mesonets for nowcasting applications

Many weather elements (e.g. precipitation type, fog) and meteorological indices (e.g. CAPE, CIN, bulk shear) depend on the temperature, humidity and wind profiles in and above the planet boundary layer (PBL). Radiosondes and numerical weather prediction (NWP) forecasts can be used to obtain these profiles, but the former is only available at a few locations every 12 hours and the latter is not necessarily accurate enough in the 0-6 hour time window. The goal of this study is to assess the potential of near-real time profiling instruments such as Doppler lidars and microwave radiometers for nowcasting applications. It is envisioned that the improvement in knowledge of the state of the PBL will improve forecasters situational awareness, provide near real-time analysis for automated nowcasting systems, while allowing more in-depth verification of NWP forecasts. As a proof-of-concept, we use archived profiler 10-min observations from the 17 sites of the New York State (NYS) mesonet. We explore 3D interpolation of temperature, humidity and wind vectors using kriging/Gaussian Processes Regression (GPR), including vector-valued and divergence-free variants for the interpolation for wind vectors. We use co-located radiosonde observations to characterize the observational error profile. NWP forecasts were compared with 3D-interpolated profiling observations. Finally, we compare meteorological indices computed directly from NWP with those obtained from the 3D interpolation of the profiling observations. Observations and high-resolution NWP outputs from the May 21st 2022 Canadian derecho event are used as a case study to demonstrate the mesonets potential usefulness.

Dominique Brunet[1], Zen Mariani[1], Minh Phung[1] [1]Environment and Climate Change Canada Dominique.Brunet@ec.gc.ca

ATM-Mesoscale Data Assimilation for Nowcast of Weather Elements on Grid

At the Canadian Centre for Meteorological and Environmental Prediction (CCMEP), a mesoscale data assimilation system produces hourly gridded analyses for the Nowcast of Weather Elements on Grid (NCWEonG). The analysis system applies 2D-Var method to incorporate surface observations (SYNOP, METAR and SWOB) into 2.5km-resolution forecasts (national HRDPS) with a latency ~20min. Different from traditional data assimilation, the mesoscale analyses do not launch numerical models. They are therefore allowed to be much closer to the observation values without worry of model shocks. For the same reason, cross-validation method is necessary for optimally balancing the observation and forecast error-covariance matrices R and B. The cross-validation shows also significant error reduction in analyses, compared to raw HRDPS national forecast. A separate system NCWEonG then uses the analyses and the increments (i.e. analysis minus forecast as background) to calculate 6-hour nowcasts of 2m temperature, 2m humidity, 10m horizontal wind components, 10m wind gusts, visibility and 25 other variables for the weather elements on grid projet. It adds the 0-hour increments to the raw forecasts for hours 1-6. A weight factor gradually reduced from 1.0 to 0 is applied to the increments so as to blend the nowcast to the forecast by the nowcasts 6 hour lead-time. So far, the comparison between our 24x7 nowcast runs and raw HRDPS national forecasts presents evident improvements as a result of using the mesoscale analysis in the nowcast. It also highlights challenges such as gridded wind nowcasting in complex topographical areas like western Canada.

Weiguang Chang[1], Lewis Poulin[1], Zhiyong Huang[1] [1]Environment and Climate Change Canada weiguang.chang@ec.gc.ca

ATM-Update on CMC’s Nowcasting of Weather Elements on Grid (NCWEonG) Project

The Nowcasting of Weather Elements on Grid (NCWEonG) project is part of the Meteorological Service of Canadas ongoing transformation projects. This presentation provides an overview of NCWEonG recent developments and status. In particular, how to deal with the challenge of combining many types of grid based observation datasets in a system that runs at 10-minute intervals. A first module creates the mesoscale surface analysis, which includes the difference (or increments) between observations and numerical model data. A second module prepares all observation data used as input to be place on the same HRDPS national 2.5km resolution grid. This includes incorporating data from Canadas S-band radars and from GOES east and west satellites. Finally, a third module takes this preprocessed data to produce a 6-hour Nowcast that includes blending the Nowcast data with numerical model data. Finally, some comments on performance and future plans will be presented.

Lewis Poulin[1] [1]ECCC MSC CMC lewis.poulin@ec.gc.ca

ATM-Comparison of Severe Storms measured by the MPLCAN lidar network to the Southern Ontario May 2022 Derecho

Severe storms have been increasing due to the changing climate. The Windsor-Quebec corridor was hit with a severe storm on May 21, 2022, dubbed The Derecho. Due to its intense nature, the region sustained serious damage and injury. Understanding this storms evolution and impact can help prepare the area for future Derecho events. Lidars are a valuable tool for this goal. While more effective instruments are available for observations during the event, lidar provides an alternative method to radars for storm detection. Our study aims to utilize the observed properties in identifying and predicting storms while exploring the evolution of these storms across the network. The Micro Pulse Lidar Canadian network (MPLCAN) has been operating since 2020. Each site operates a micro-pulse lidar capable of cloud, aerosol, planetary boundary layer, and polarization measurements. CIMEL sunphotometers compliment these lidars in conjunction with AERONET/AEROCAN. Surface particulates are measured using PurpleAir sensors. Three sites operate on the Windsor-Quebec corridor in London, Toronto and Sherbrooke, with additional sites in Sandy Cove, Nova Scotia and Eureka, Nunavut. The three Ontario-Quebec nodes observed The Derecho and showed an ascending cloud formation indicative of a cold front post-precipitation event. Further investigation of severe weather events similar to The Derecho will allow for the augmentation of real-time forecasting and warnings utilizing the lidar network.

Victoria Pinnegar[1], Debra Wunch[2], Norman O'Neill[3], E. J. Welton[4], Robert Sica[1] [1]Western University [2]University of Toronto [3]Universite de Sherbrooke [4]NASA vpinnega@uwo.ca

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Climate Variability and Predictability - Part 2

Monday, May 29
14:30 - 15:15 EDT

(15 Mins) A physical analysis of summertime North American heatwaves - Bin Yu

(15 Mins) Regional Climates Expected to Continue to Change Significantly After

Global Climate stabilizes - Andrew MacDougall

(15 Mins) Quantifying future changes in climate variability for northern Quebec and Labrador using a 50-member single initial conditions model ensemble - Léandre Houde-Labrecque

This session invites contributions that deal with climate variability and predictions on subseasonal, seasonal, interannual and decadal-interdecadal time scales. Contributions are solicited on topics including studies of the Madden-Julian Oscillation (MJO) and tropical waves, El Nino/Southern Oscillation (ENSO), atmospheric circulation patterns, tropical-extratropical interaction and teleconnections, and impacts of these processes on predictability and predictions. Equally welcome are contributions on extended- and long-range weather forecasts, and predictions of climate variability on various time scales, including ensemble and initialization techniques, model development, forecast skill assessment, downscaling and calibration, and end-user value and applications. Results from diagnostic, modelling, model inter-comparison, and theoretical approaches are all welcome.

CLM-A physical analysis of summertime North American heatwaves

This study examines the dominant heatwave variability over North America (NA), extracted from an EOF analysis of summertime warm extreme index anomalies over 1959-2021. The principal mode features a dipole structure with a large area of anomaly over northwestern NA and an anomaly of opposite sign over the southern U.S. The corresponding principal component is associated with a large-scale atmospheric wavetrain extending from the North Pacific to North America (NP-NA) and a northeastward injection of moisture from the subtropical western Pacific towards western NA, which are key factors in supporting the NA heatwave variability. The NP-NA wavetrain can be systematically reinforced and supported by synoptic-scale eddies, and may also be forced by an anomalous convection over the tropical-subtropical western Pacific. Surface radiation heating is dominated by anomalous downwelling shortwave and longwave radiations. In association with a positive phase of the heatwave variability, the NP-NA wavetrain brings an anticyclonic anomaly over northern NA, leading to anomalous descent, reduced total cloud cover and below-normal precipitation and surface relative humidity over northern NA. Over northwestern NA, the anomalous subsidence causes air to warm through compression. Reduced cloud cover results in increased downward shortwave radiation that is a key contributor to surface radiation heating. In addition, increase in vertically integrated water vapour through the moisture injection collocates with tropospheric warming. The atmosphere has more water vapor holding capability and acts as a greenhouse gas to increase downward longwave radiation that is the second major contributor to surface radiation heating.

Bin Yu[1], Hai Lin[1], Ruping Mo[1], Guilong Li[1] [1]Environment and Climate Change Canada
bin.yu@ec.gc.ca

CLM-Regional Climates Expected to Continue to Change Significantly After Global Climate stabilizes

The Zero Emissions Commitment (ZEC) is the expected temperature change following the cessation of anthropogenic emissions of climate altering gases and aerosols. Recent model intercomparison work has suggested that global average ZEC for CO2 is close to zero. However there has thus far been no effort to explore how temperature is

expected to change at spatial scales smaller than the global average. Here we analyze the output of nine full complexity Earth System Models which carried out standardized ZEC experiments to quantify the ZEC from CO2. The models suggest that substantial temperature change following cessation of emissions of CO2 can be expected at large and regional spatial scales. Large scale patterns of change closely follow long established patterns seen during modern climate change, while at the regional scale patterns of change are far more complex and show little consistency between different models. Analysis of model output suggest that for most models these changes far exceed pre-industrial internal variability, suggesting either higher climate variability, continuing changes to climate dynamics or both. Thus it appears likely that at the regional scale, where climate change is directly experienced, climate disruption will not end even as global temperature stabilizes. Such indefinite continued climate changes will test the resilience of local ecosystem and human societies long after economic decarbonization is complete. Overall substantial regional changes in climate are expected following cessation of CO2 emissions but the pattern, magnitude and sign of these changes remains highly uncertain.

Andrew MacDougall[1], Josie Mallett[1] [1]St. Francis Xavier University amacdoug@stfx.ca

CLM-Quantifying future changes in climate variability for northern Quebec and Labrador using a 50-member single initial conditions model ensemble

Internal variability is an important source of uncertainty in climate projections at the regional scale. It also has important social impacts, since any large or unsuspected departure from a regions climate mean can dramatically affect society, its infrastructure, and thus its population. Therefore, it is of great interest to quantify future changes in internal variability in terms of its spatial patterns and the different time scales involved. Single Initial condition Model Large Ensembles (SMILEs) serve as a powerful tool to quantify such variability. They consist of a single model for which small perturbations are applied to the initial conditions. Considering the atmospheres chaotic nature, these perturbations create multiple independent and equiprobable realizations of the future climate. This allows the calculation of a suite of ensemble statistics for which model uncertainty is minimized. So for our study, we investigate the future projections of internal variability for the snow water equivalent, surface air temperature, and start/duration/end of the continuous snow cover season, as well as the interactions between these two variables for the regions of Northern Quebec and Labrador. To do so, we use the ClimEx large ensemble which was generated using the Canadian Regional Climate Model version 5 (CRCM5) with a 12 km resolution grid over northeastern North America. We find that snow water equivalent variability will increase during the spring in the northernmost part of Quebec and Labrador.

Léandre Houde-Labrecque[1], Martin Leduc[2], Alejandro Di Luca[1] [1]UQÀM [2]Ouranos ek891993@ens.uqam.ca

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Coastal Oceanography and Inland Waters - Part 3

Monday, May 29
14:30 - 16:00 EDT

(15 Mins) A near-surface hydrologic model calibration of freshwater discharge to Canada's oceans - Rick Danielson

(15 Mins) Association of North Atlantic right whale aggregation areas with

thermal fronts in the western Gulf of St. Lawrence - Jing Tao

(15 Mins) Modelling inland waters runoff to Canada's Pacific Ocean and St. Lawrence Estuary, and contaminant loads being threats to endangered whales. - Felix Ouellet

(15 Mins) Coastal High resolution of long-term Observations of HF Radar in Canada - Manman Wang

(15 Mins) A numerical study of circulation, ice and seasonal variability in Bras d'Or Lakes - Shengmu Yang

This session will focus on all aspects of monitoring and modelling physical and biogeochemical processes in coastal domains, shelf seas, estuaries and inland waters. Topics include but are not limited to coastal physical oceanography, storm surges, tsunamis, estuarine dynamics, hydrology and hydrodynamics of large lakes, mixing and dispersion of materials. Contributions related to both observational and modelling aspects of biogeochemistry in coastal and inland waters are welcome. Papers can be on improving our knowledge of physical and biogeochemical conditions in the past and present climate and/or on predictions of changes and extremes in marine conditions in response to climate change.

OCE-A near-surface hydrologic model calibration of freshwater discharge to Canada's oceans

The WRF-Hydro model is configured to perform climate simulations of freshwater discharge from a fixed Canadian river network at two-km resolution. Historical calibration of individual catchment areas is examined using ERA5 atmospheric forcing, with ECCC HYDAT observed river flows as a reference for WRF-Hydro model output. Comparisons for rivers with significant flows to the ocean are highlighted, including those influenced by dams and reservoir controls, such as the St. Lawrence. Methods of bias adjustment are proposed for streamflow representations at seasonal or annual scales (i.e., without historical coverage), as well as for representations starting at subdaily scales (i.e., with historical coverage), for which satellite comparisons may also be sought, but subject to fixed differences in observed and modelled river networks and their corresponding catchments.

Rick Danielson[1], Joël Chassé[1], Will Perrie[1] [1]DFO rick.danielson@dfo-mpo.gc.ca

OCE-Association of North Atlantic right whale aggregation areas with thermal fronts in the western Gulf of St. Lawrence

Sea surface temperature (SST) gradients based on satellite measurements are widely applied to detect fronts and eddies. The location of increased frequency of fronts could be a proxy for advective supply and aggregation of prey, which may attract fish and whales. Here, the variability of SST fronts is analyzed for the period 2000-2021 using satellite observations in the western Gulf of St. Lawrence (wGSL), which is recognized as a North Atlantic Right Whale (Eubalaena glacialis; NARW) aggregation area and feeding ground. Analyses of monthly frontal probability distributions in the wGSL from May to October reveal a prominent seasonal and regional variability. Time series of averaged SST gradients display a similar significant interannual variability for the Shediac Valley and northern Gasp Peninsula subregions; these variations are relatively strong during 2017-2020. In addition, we also investigate the association between SST frontal activity and aggregation areas of NARW sightings in the wGSL, whereby a

monthly probability time series pattern is developed for whale occurrence in the wGSL, using two simple criteria: SST gradient over the threshold value 0.035 oC/km and water depth range within 50-200 m. We show that NARW sightings are generally co-located within these strong probability areas during spring and summer seasons in 2015-2021. The overall results demonstrate that satellite-derived SST gradients are useful to repeatedly monitor the variations of spatial distributions of frontal activity and can also be used to understand the interannual variability of whale aggregation areas.

Jing Tao[1], Hui Shen[1], Rick Danielson[1], William Perrie[1] [1]Bedford Institute of Oceanography Jing.Tao@dfo-mpo.gc.ca

OCE - Modelling inland waters runoff to Canada's Pacific Ocean and St. Lawrence Estuary, and contaminant loads being threats to endangered whales.

Water runoff and yield modelled for years 2000 to present using SWAT+ will be presented for watersheds in 1) British Columbia: Fraser River, Coastal British Columbia, Vancouver Island, and Haida Gwaii, and 2) Southern Qubec: main tributaries to the St. Lawrence River between Montral and Qubec City. Wet vs dry years conditions will be discussed in a context of changing climate. Loadings in water and sediments for contaminants that are threats to Southern and Northern Resident Killer Whales and St. Lawrence Estuary Beluga will be presented for the Fraser River basin, and the St. Lawrence River and its main tributaries in Qubec. The sources for these loadings will be discussed.

Felix Ouellet[1], Agnes Richards[1] [1]Environment and Climate Change Canada felix.ouellet@ec.gc.ca

OCE-Coastal High resolution of long-term Observations of HF Radar in Canada

Ocean Networks Canada (ONC), an initiative of the University of Victoria, has operated high-frequency (HF) surface radar systems for monitoring surface currents since 2011. Initially, four SeaSonde CODAR systems were deployed in the Salish sea operating at a frequency of 25 MHz then two additional SeaSonde antennae were deployed in Juan de Fuca Strait in March 2020 with frequency of 16 MHz. Along British Columbias northern coast, there are two in Prince Rupert (25 MHz) and ONC maintain and operate two additional radars installed by Fisheries and Oceans Canada (DFO) in Hecate Strait (5 MHz). On the east coast of Canada, ONC archives two CODAR systems maintained and operated by Dalhousie University in Halifax with frequency of 5 MHz. In addition to the SeaSonde systems, we operate a single WERA system along the west coast of Canada in Tofino for tsunami and wave detection. The long-term observations in the Salish sea show complex surface current patterns that vary with seasonal river and wind conditions. These observations are used to understand the circulation, validate model simulations, and assist in oil spill tracking and search and rescue efforts. Quality control of HF radar surface current data based on IOOS QARTOD principles are now being implemented to ONCs Oceans 3.0 data portal to deliver high-quality surface current data to users. This presentation reviews the long-term HF radar observations, quality control procedures, and the scientific and practical applications.

Manman Wang[1], Alice Bui[1], Steven Mihaly[1], Richard Dewey[1], Kevin Bartlett[1] [1]Ocean networks canada manmanw@uvic.ca

OCE-A numerical study of circulation, ice and seasonal variability in Bras d'Or Lakes

A coupling circulation-ice modelling system for Bras dOr Lakes (CMS-BDL) is used to examine the three-dimensional (3D) circulation and hydrography in the Lakes. The CMS-BDL is based on the ROMS and the CICE, and uses the three-level nested-grid setup. The ERA5 hourly reanalysis data and GLORYs daily reanalysis data are used in driving the modelling system. The tidal forcing with 15 tidal constituents from the TPXO9 dataset is specified along the open boundaries of the outmost component of the CMS-BDL. Time series of hourly freshwater discharges from 11 rivers around the Lakes are constructed using the Storm Water Management Model (SWMM) from the hourly rainfall observations at weather stations in Cape Breton Island. The performance of the CMS-BDL in simulating the tidal and general circulation in the Lakes is assessed using various types of observations. The monthly mean circulation in the Lakes produced by the CMS-BDL is characterised as a two-layer circulation with seaward flow in the upper layer and lake-ward flow in the lower layer. Influenced by the net heat flux at the lake surface and variability of freshwater discharges, the circulation and stratification structure in the Lakes have large seasonal variability. Consistent with observations, the simulated ice in the Lakes starts to form in early January and disappears in late April, with the maximum coverage occurring in mid-March. Process studies using the CMS-BDL show that winds can affect significantly the circulation and hydrography in the whole Lakes during the ice-free period. The large effect of tides occurs mainly in the Great Bras dOr Channel, with the maximum tidal velocity up to ~1.0 m/s in the Channel.

Shengmu Yang[1], Jinyu Sheng[1], Bruce Hatcher[2] [1]Dalhousie University [2]Cape Breton University Shengmu.Yang@dal.ca

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Lagrangian perspectives on ocean transport and mixing

Monday, May 29
14:30 - 16:00 EDT

(15 Mins) The Influence of Near-Intertial Wave-Mesoscale Turbulence Interactions on Passive Tracer Fluxes - Joseph Fitzgerald

(15 Mins) Interannual and seasonal water mass analysis in the Salish Sea - Becca Beutel

(15 Mins) Lagrangian tracking of microfibers in the Salish Sea - Jose Valentí

(15 Mins) Swish floats - an inexpensive neutrally boyant float to monitor dispersion in coastal seas - Samuel W. Stevens

Lagrangian tools can be used to provide a detailed description of transport pathways, timescales, and offer tools to understand the mechanisms driving these pathways. Understanding the transport of freshwater, salt, heat, pollutants, and other tracers via these pathways is important when considering the time and space variability of export into Canada's inland and coastal waters, as well as on ocean-basin scales. High resolution models and large ensemble simulations can be used to calculate trajectories and infer transport pathways and are increasingly important in tracking the dispersal of tracers. Lagrangian measurements via freely-floating instrumentation also form a key component of many observational frameworks. This session will focus on Lagrangian studies in Canada's inland and shelf seas with a scope ranging from basin-scale circulation

experiments to smaller-scale exchange, mixing, and pollutant dispersal studies. We encourage abstracts from numerical and observational studies.

OCE-The Influence of Near-Inertial Wave–Mesoscale Turbulence Interactions on Passive Tracer Fluxes

The dynamics of near-inertial waves (NIWs) interacting with mesoscale eddies (MEs) has received much recent attention in theoretical, modelling, and observational studies. Previous work has established that NIWME interaction can lead to significant NIWME energy exchange and can modify the state of ocean macroturbulence. However, the impact of these interactions on the transport of passive tracers by MEs remains an open question. Eddy fluxes of passive tracers are climatologically important, affecting, for example, the transport of anthropogenic carbon into the oceans interior. As NIWME interactions are likely ubiquitous in the ocean, understanding how these interactions influence transport processes is important to our understanding of the climate system. In this work we investigate how NIWME interactions modify isopycnal tracer fluxes using a forceddissipated model in which barotropic balanced turbulence interacts with baroclinic NIWs that have an assumed plane wave vertical structure. Tracer fluxes are produced as the eddy field stirs a uniform background tracer gradient. Simulations in which the forcing excites only balanced turbulence are compared with those in which additional forcing is added to excite NIWs. We find that the presence of NIWs weakens the tracer fluxes carried by the eddies and reduces the equilibrium level of maintained tracer variance. NIW-ME coupling thus produces a system in which increasing the forcing strength, by adding NIW forcing, reduces transport. We explore the physical mechanisms behind the reduced tracer transport using recently advanced asymptotic models that describe the coupled dynamics of NIWs and balanced turbulence.

Joseph Fitzgerald[1], Joern Callies[2] [1]Memorial University of Newfoundland [2]California Institute of Technology jgfitzgerald@mun.ca

OCE-Interannual and seasonal water mass analysis in the Salish Sea

The Salish Sea is a semi-enclosed coastal sea on the coast of British Columbia and Washington State, invaluable from both an economic and ecologic perspective. Pacific inflow to the Sea through Juan de Fuca Strait is the main contributor of many biologically important constituents. The contribution of Pacific water masses to the flow through Juan de Fuca Strait (JdF), the Salish Seas primary connection to the Pacific Ocean, is explored by applying quantitative Lagrangian particle tracking to two numerical ocean models: CIOPS-W in the shelf region, and SalishSeaCast in the Salish Sea. Water parcels seeded near the entrance of JdF were integrated forwards and backwards in time to assess water mass path from the shelf region and once within the Salish Sea, in more detail than previously possible. During summer upwelling, flow from the north shelf and (unexpectedly) offshore dominate inflow, while during winter downwelling, flow from the south shelf and the Columbia River plume are the dominant sources. A weaker and less consistent estuarine flow regime in the winter led to less Pacific inflow overall and a smaller percentage of said inflow reaching the Salish Seas inner basins than in the summer. Nevertheless, it was found that winter dynamics are the main driver of interannual variability, in part due to the strongly anti-correlated behaviour and distinct properties of the two dominant winter sources. This analysis extends the knowledge on the dynamics of Pacific inflow to the Salish Sea and highlights the importance of winter inflow to interannual variability.

Becca Beutel[1], Susan Allen[1] [1]University of British Columbia bbeutel@eoas.ubc.ca

OCE-Lagrangian tracking of microfibers in the Salish Sea

Microplastics are ubiquitous ocean contaminants and represent a major ecological and environmental concern. Polyester microfibers are one of the primary sources of microplastics in coastal urbanized areas like the Salish Sea and have been found in water samples throughout the globe. However, the dynamics and distribution of these negatively buoyant particles are poorly understood and introduce many questions. We use SalishSeaCast, a high-resolution ocean model that resolves submesoscale dynamics in the Salish Sea; and Ocean Parcels, a Lagrangian model that can incorporate additional physical processes to build a specialized microplastic model aiming to recreate Polyester microfibers dynamics in the Salish Sea. To construct this model, we use the current knowledge of microplastic dynamics and new observations from other team members of the Plastics-SoG, a multidisciplinary NSERC-funded project at UBC. The model has been able to predict feasible distributions and concentrations of polyester microfibers that agree with observations in and out of the Salish Sea. The model results provide a tool for future microplastic research and could be useful to the industry or to construct smart policies around some of the concerns related to microfibers.

Jose Valentí[1] [1]UBC jvalenti@eoas.ubc.ca

OCE-Swish floats- an inexpensive neutrally buoyant float to monitor dispersion in coastal seas

The direct measurement of subsurface ocean currents using neutrally buoyant floats has been used for decades by oceanographers. These observations are useful to observe regional kinetics via repeated Lagrangian measurements, particularly in coastal regions where float observations are scarce due to the increased risk of damage to instrumentation. When using neutrally buoyant floats for these purposes, it can be preferable to gather many individual observations of a flow to improve the statistical significance of any determinations of a mean flow over a period of time. With this in mind, many economical observations from inexpensive instruments can be an effective approach. In this talk, I will describe a simple neutrally buoyant GPS float that has been developed at a cost of 300 CAD per unit to measure subsurface dispersion on timescales up to a month. The floats share some passing similarities with the original Swallow floats, thus they are nicknamed Swallow-ish, or Swish floats. I will outline the float design; discuss the principles governing the neutrally buoyant nature of the floats; and present results from several deployments in the Salish Sea and the Gulf of St. Lawrence, showing how these simple floats are being used track the dispersion of pollutants and other chemical tracers through coastal systems via measurements of advection, diffusion, and vertical motion.

Samuel W. Stevens[1], Rich Pawlowicz[1] [1]University of British Columbia sstevens@eoas.ubc.ca

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Quantifying the marine carbon cycle and ocean carbon uptake: Part 2

Monday, May 29
14:30 - 16:00 EDT

(15 Mins) Estimating Net Primary Production in the Labrador Sea using in situ and remotely sensed bio-opotical observations - Kitty Kam

(15 Mins) Biogeochemistry of Suspended and Sinking Organic Matter in the Labrador Sea - Carolina Cisternas-Novoa

(15 Mins) A protein-based approach for estimating primary producitivity - Erin Bertrand

(15 Mins) Effects of Ocean Akalinity Enhancement on the phtotochemical efficiency of phytoplankton - Marie Egert

(15 Mins) Seagrass blue carbon: Five things to know about mud - Sophia Johannessen

As countries around the world look to include natural carbon pools and fluxes in their carbon stocktaking efforts to address climate change, quantification of the marine carbon sink, and indeed marine carbon cycling in general, remain poorly quantified. The ocean acts as a major sink for human carbon dioxide emissions, and is the largest quickly-exchanging reservoir of carbon on earth. Processes driving ocean carbon air-sea exchange, biological uptake, and physical circulation and temperature changes are rapidly shifting under climate change. Progress is being made to better understand these controls and their associated variability across the open ocean to nearshore continuum, as well as on seasonal, interannual, decadal, and long-term timescales using observations and models. This session will showcase the latest progress in our understanding of the marine carbon cycle from local to global scales. We welcome contributions that quantify the rates and processes of fluxes and storage of carbon, the modification of the carbon cycle due to physical, chemical, and biological processes, and studies of carbon dioxide removal approaches to increase ocean carbon uptake. Timescales from seasonal to millennial are of interest. Contributions from studies that address open ocean and coastal regions; the surface or the interior; and that apply observations, models, or a combination of both, are welcome.

OCE-Estimating Net Primary Production in the Labrador Sea using in situ and remotely sensed bio-optical observations

Net Primary Production (NPP) provides a quantitative measure of potential organic carbon export into the deep ocean via biological carbon pump (BCP), which is one of the major pathways for carbon sequestration in the Labrador Sea. With mixed layer deepening up to 2000m, winter convection supplies nutrients and inorganic carbon to the surface for the spring phytoplankton bloom. Seasonal variability of NPP has served as a proxy to monitor intra-annual change of BCP. Early shipboard measurement was accomplished occasionally, remote sensing and autonomous bio-optical sensing have greatly improved global coverage of NPP observations. However, satellite-based observation is limited by cloud coverage and propagating uncertainties of empirically derived parameters, notably chlorophyll and phytoplankton carbon concentrations, leading to NPP underestimation. Here, we present a comparison of NPP estimates from in situ and remotely sensed observations using chlorophyll-based and carbon-based productivity models. Bio-optical parameters, measured by a high-frequency moored profiler in the Central Labrador Sea, provide a unique time series of depth-resolved NPP (NPPin-situ) with high temporal resolution. This offers a rare opportunity to

compare NPP from MODIS-aqua satellite (NPPsatellite), where temporal and spatial resolution vary between both NPPs. Preliminary results show higher surface NPPin situ than NPPsatellite during bloom seasons. Subsurface production below mixed layer might be overlooked by NPPsatellite, especially during late summer. This study demonstrates the importance of high-frequency depth-resolved observations at ocean reference site for validation and reconciliation of NPP observations to improve our measurement of BCP.

Kitty Kam[1], Dariia Atamanchuk[1], Douglas Wallace[1] [1]Department of Oceanography, Dalhousie University, Halifax, Canada kitty.kam@dal.ca

CLM-Biogeochemistry of Suspended and Sinking Organic Matter in the Labrador Sea

The downward flux of organic matter from the euphotic zone via the biological carbon pump is critical for the export of carbon to the oceans interior and carbon sequestration by the ocean. Particle sinking velocities and particle sizes are generally assumed to be positively correlated, but recent studies concluded that aggregate composition is crucial to constrain sinking velocity-size relationships. Early summer of 2022, we collected suspended, slow- and fast-sinking intact particles from different phytoplankton communities in the Labrador Sea using the Marine Snow Catchers (MSCs). MSCs were deployed at three depths below the mixed layer at eight stations, and samples were collected from all three fractions. Samples were analyzed for particulate organic carbon and nitrogen (POC/N), amino acids, exopolymeric particles, ballasting material, and aggregate size and shape. POC concentration was between 5 and 13 times higher in the suspended fraction than in the sinking fraction. POC concentrations of fast-sinking particles were between 60 and 90% higher than those of slow-sinking particles, except at stations characterized by a Phaeocystis bloom. At the stations characterized by this bloom, POC concentrations of slow and fast-sinking particles were similar between 80 and 160 m, and large (> 0.5 mm) aggregates were abundantly observed in the slow sinking fraction. This data set allows us to explore compositional differences between sinking and non-sinking particles.

Carolina Cisternas-Novoa[1], Elisa Romanelli[2], Uta Passow[1] [1]Ocean Science Centre, Memorial University of Newfoundland, St. John’s, NL, Canada [2]University of California, Santa Barbara, USA acisternasno@mun.ca

OCE-A protein-based approach for estimating primary productivity

We have developed a novel quantitative mass spectrometry-based approach to measure Ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) concentrations in the ocean. Because Rubisco catalyzes carbon fixation, we can use these measurements to estimate total and phytoplankton group-specific primary production rates. Here well share results of Rubisco measurements from the Canadian Arctic, Southern Ocean, and other regions. In the Southern Ocean, we found these rates to closely mirror primary productivity measured at the same locations using classical methods. In the Arctic, we found these rates to be within the range of historical primary production measurements made using classical methods in the same region. Well describe limitations and utility of these measurements for oceanographic studies wishing to quantify the carbon cycle moving forward.

Erin Bertrand[1], Maya Bhatia[2], Jodi Young[3], Megan Roberts[1], Elden Rowland[1], Patrick

White[2], Scott Pollara[1] [1]Dalhousie University [2]University of Alberta [3]University of Washington erin.bertrand@dal.ca

OCE-Effects of Ocean Alkalinity Enhancement on the photochemical efficiency of phytoplankton

Ocean Alkalinity Enhancement (OAE) is a carbon dioxide removal (CDR) measure based on increasing the oceans alkalinity to enhance uptake of atmospheric CO2, which is converted to bicarbonate for long-term sequestration. This CDR method requires the release of alkaline substances such as magnesium hydroxide at appropriate locations allowing for broad dispersal in surface waters. Estuaries or human-made greywater discharges are likely to be suitable discharge points. Before large-scale application, the impact on phytoplankton must be understood since the addition of hydroxides for OAE is accompanied by a rise in pH, altering the growth environment. The effects of short-term hydroxide exposure on photosynthetic competence are being assessed in cultures and natural assemblages of phytoplankton using variable chlorophyll a fluorescence. As the release of hydroxide needs to occur near the air-water interface to facilitate an uptake of CO2, the potential effect of increased pH on responses to high light is of particular relevance. This is assessed by measuring the rate constants for photodamage and photorepair in hydroxide-treated and control samples using the protein synthesis inhibitor lincomycin. Preliminary results suggest a species-dependent reduction in photosynthetic efficiency relative to controls under combined high pH and high light. This study contributes to a realistic assessment of the implications arising from OAE. It thus provides a clearer understanding of the potential environmental impact of this approach to CDR.

Marie Egert[1], Hugh MacIntyre[1] [1]Dalhousie University mr594601@dal.ca

OCE-Seagrass blue carbon: Five things to know about mud

Seagrasses take up carbon dioxide and transform it into organic carbon, some of which is buried in meadow sediments. Enormous carbon burial rates have been claimed for seagrass meadows globally, and international protocols have been developed with a view to awarding carbon credits under the Verified Carbon Standard. Unfortunately, these protocols do not adequately account for post-depositional processes in marine sediment, and the resulting global estimates are at least an order of magnitude too high. To determine accurate seagrass carbon burial rates, the following factors must be considered: 1) bioturbation or mixing of surface sediment; 2) remineralization of organic carbon; 3) grainsize and energy of the environment; 4) species or type of seagrass meadow; 5) the difference between flux and standing stock. Seagrass meadows provide valuable habitat and protect coastlines from erosion. They can also play an important role in short-term climate change mitigation, so long as their carbon burial rates are calculated correctly. However, if carbon credits are awarded based on inflated estimates and used to offset emissions elsewhere, the net effect could be an increase in carbon dioxide emissions to the atmosphere.

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Satellite Earth Observation: A unique view of our planet and a long-term strategic vision for Canada - Part 3

Monday, May 29
14:30 - 16:00 EDT

(15 Mins) Combining Spaceborne, Airborne, In-Situ, and Reanalysis Data to Constrain Snow Loading on Arctic Sea Ice and Sea-Ice Thickness Retrieval - Paul Kushner

(15 Mins) Continuation of MODIS Vegetation Index Time Series with VIIRS: Impact of Spectral Response Differences - Alexander Trishchenko

(15 Mins) Trends in Summer Minimum Snow/Ice Extent over Canadian Arctic and Greenland in 2000-2022 - Alexander Trishchenko

(15 Mins) Plans forward for the dissemination of MSC satellite imagery products through WMS - André Giguère

(15 Mins) Canadian Space Agency Opportunities for Scientific Research in Universities - Cassandra Bolduc

(15 Mins) DACCS: An Advanced Scientific Platform for Earth Observation and Climate Science - Steve Easterbrook

Satellite Earth observation provides a unique global perspective on our planet's atmosphere and surface, including the oceans, land, vegetation, ice, and snow. Current and planned satellite missions from Canada and international agencies have provided and will provide a wealth of new information about the Earth system and that can be used to investigate a wide range of environmental and scientific questions. This session encourages contributions from across the full Earth observation value chain, upstream, midstream and downstream. This includes new measurement technologies and techniques, both passive and active; mission development; retrieval algorithms; demonstration and calibration of instruments; validation of satellite products; assimilation of data into numerical models; scientific results and discoveries; operational utilization and development of services.

MUL-Combining Spaceborne, Airborne, In-Situ, and Reanalysis Data to Constrain Snow Loading on Arctic Sea Ice and Sea-Ice Thickness Retrieval

Snow on floating Arctic sea ice represents an important source of uncertainty in retrievals of Arctic sea ice thickness from space-borne altimetry. For operational sea-ice thickness retrieval, computationally cheap and simple snow-load models with a minimum of inputs and tunable parameters are required. The NASA Eulerian Snow on Sea Ice Model (NESOSIM) currently provides estimates of snow-load on sea ice that feed into NASAs ICESat-2 sea ice thickness retrievals. NESOSIM is a two-layer coarse-resolution snow-load model with simple representations of the processes of accumulation, wind packing, loss due to blowing snow, and redistribution due to sea ice motion. We have previously calibrated snowfall input to NESOSIM from reanalysis by using snowfall retrieved from CloudSat satellite radar reflectivity. But NESOSIM includes parameters related to snow loss and densification that cannot be directly constrained by local observations. To objectively constrain these parameters, we have developed an automated technique which combines observations from airborne snow

depth observations from Operation IceBridge, in situ CRREL-Dartmouth snow buoy measurements, and historical drifting station density measurements in a Markov Chain Monte Carlo (MCMC) optimization. This produces estimates of NESOSIM parameter values and their uncertainty that are consistent with an array of observations. The parameter uncertainty can be propagated into the sea ice thickness uncertainty estimate, thus isolating the effect of snow model uncertainty on ice thickness uncertainty. This technique can quantify uncertainty both for model parameters across meteorological driving datasets.This demonstrates the feasibility and utility of combining satellite earth observations, airborne and in-situ measurements, and reanalysis via simple modelling to objectively produce critically important snow on sea ice and sea ice thickness products and their associated uncertainty.

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MUL-Continuation of MODIS Vegetation Index Time Series with VIIRS: Impact of Spectral Response Differences

The Visible Infrared Imaging Radiometer Suite (VIIRS) is an operational imager for global observations from the NOAA polar-orbiting satellites S-NPP, JPSS-1,2. In terms of spectral coverage and spatial resolution the VIIRS imager is comparable to the Moderate Resolution Imaging Spectroradiometer (MODIS) operated by NASA since 2000. The Normalized Difference Vegetation Index (NDVI) derived from these sensors is widely used for crop yield forecasting, drought monitoring, climate change studies and other environmental applications. The MODIS NDVI is derived from the spectral reflectances observed in MODIS band B1 (visible, VIS) and MODIS band B2 (near-infrared, NIR) acquired at 250 m spatial resolution at the nadir direction. The VIIRS NDVI is derived from imaging bands I1 (VIS) and I2 (NIR) acquired at 375 m and moderate resolution bands M5 and M7 acquired at 750 m at the nadir direction. Despite their spectral similarity, the MODIS bands B1 and B2 and the VIIRS bands I1, I2 and M5, M7 all have slightly different shapes of the spectral response function (SRF). As a result, the spectral reflectances observed by different sensors for the same target may differ depending on the spectral variation of the target surface reflectance, the atmospheric transmission, and the solar spectrum. The analysis is conducted in this study for MODIS and VIIRS NDVI differences due to SRF effect using observations and modeling results. This work is supported through the project on high-frequency Long-Term Satellite Data Records as part of the Cumulative Effects and the Status and Trends Mapping Program.

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MUL-Trends in Summer Minimum Snow/Ice Extent over Canadian Arctic and Greenland in 2000-2022

Time series of annual Minimum Snow/Ice (MSI) cover extent since 2000 are being produced at the Canada Centre for Remote Sensing (CCRS) at 250-m spatial resolution from MODIS/Terra observations over the Northern circumpolar land area. The product is generated using a specialized data processing chain developed at the CCRS that ingests Level 1 imagery for MODIS bands B1-B7 designed for land applications. The input images are spatially enhanced to 250 m using the spatial downscaling technique. Time series of the minimum snow/ice extent for 23 years are analyzed for the Canadian Arctic and Greenland regions. The CCRS-derived annual MSI extent variations are compared with a) the Randolph Glacier Inventory (RGI 6.0), and b) Global Land Ice

Measurements from Space (GLIMS) data. Comparison has been also conducted for a series of land cover maps from the European Space Agency (ESA) Climate Change Initiative (CCI) project. The derived inter-annual variations were also analyzed separately for each of the seven major glacier catchments/basins of the Greenland Ice Sheet. Five out of seven regions of Greenland demonstrated statistically significant negative trends in the MSI extent. Our analysis showed overall systematic positive bias in GLIMS data relative to RGI 6.0 for the Northern circumpolar land area. This work is supported through the project on high-frequency Long-Term Satellite Data Records (LTSDR) as part of the Cumulative Effects (CE) and the Status and Trends Mapping Program at CCRS.

Alexander Trishchenko[1], Calin Ungureanu[1] [1]Canada Centre for Remote Sensing alexander.trichtchenko@nrcan-rncan.gc.ca

MUL-Plans forward for the dissemination of MSC satellite imagery products through WMS

With the advent of the GOES-R satellite series, the number of channels and possible products to be used by operational forecasters, expert users and the general public have increased significantly. The current means of dissemination through the usual methods of production and dissemination, within the Meteorological Service of Canada and toward our external clients and partners have reached their limit, and many products and innovations cannot reach our forecasters and clients. We will show you how the Canadian Meteorological Centre Operations division of the MSC intends to make these larger range of products available through web mapping services (WMS) with some examples and projects such as the WMOs North American Vegetation Fire and Smoke Pollution - Warning Advisory Center.

André Giguère, Kyle Ziolkowski[1] [1]Meteorological Service of Canada andre.giguere@ec.gc.ca

MUL-Canadian Space Agency Opportunities for Scientific Research in Universities

An overview will be presented of the Canadian Space Agency (CSA) scientific activities in the Sun-Earth System Sciences (SESS) group, which includes Atmospheric and Earth System Sciences, that are of interest to the academic sector and aims in particular at supporting students and early career researchers. First, an overview of our 2016 and 2020 Satellite Data Analysis grants will be given, followed by results from a performance indicator review as well as scientific advances that were enabled by this funding. Second, the newly developed Research Opportunities in Space Sciences (ROSS) announcement of opportunity (AO) will be presented. The ROSS AO will accept new proposals until July 14, 2023. Finally, an overview of other CSA funding opportunities will be given and information about how SESS distributes their announcements is provided.

Cassandra Bolduc[1] [1]Canadian Space Agency cassandra.bolduc@asc-csa.gc.ca

MUL-DACCS: An Advanced Scientific Platform for Earth Observation and Climate Science

Advanced scientific platforms aim to deploy complex processing workflows near large amounts of data to avoid unnecessary data transfers and duplication, while leveraging a powerful computing infrastructure. In this regard, satellite earth observation (SEO) and climate science share similar needs and challenges in handling large data sets, but also use common software tools and formats such as xarray and the NetCDF file format. The platform called DACCS (Data Analytics for Canadian Climate Services) aims to develop an advanced scientific platform for both the manipulation and remote processing of large datasets. In terms of SEO, the platform provides backend services to create multi-temporal and multi-sensor analysis-ready data cubes on the fly from open source imagery (e.g. Sentinel-1 and 2, Landsat). The resulting SEO data cubes then become part of the infrastructure and can be exported for change detection applications or advanced machine learning tasks. These services are packaged as OGC API processes (https://ogcapi.ogc.org/processes/), allowing interoperability with other systems and applications. They can be invoked by users via a Jupyter server using Python notebooks. This project, funded by the Canadian Foundation for Innovations (CFI), is led by the University of Toronto within a Canadian consortium that includes several universities (McGill, Concordia, Victoria) and research centers (CRIM and Ouranos).

Samuel Foucher[1], Steve Easterbrook[2], Francis Charette-Migneault[3] [1]University of Sherbrooke [2]University of Toronto [3]Computer Research Institute of Montreal
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Severe Post-Tropical Storm Fiona

Monday, May 29
14:30 - 16:00 EDT

(15 Mins) Hurricane Fiona – Forecast and Messaging Review - Chris Fogarty

(15 Mins) Importance of Mesonet Data for Analysis of Superstorm Fiona - Jonathan Buffett

(15 Mins) A&P in Action: Involvement of the Analysis & Prognosis section with respect to Hurricane Fiona's forecast impacts over Atlantic Canada - Alissa Steeves

(15 Mins) On the Interactions of two Atmospheric Rivers with Hurricane Fiona - Ruping Mo

(15 Mins) Attribution of the 2022 extratropical storm Fiona - Elizaveta Malinina

(15 Mins) Catastrophic Losses from Hurricane Fiona - Carolyn Floyd

On September 23rd, 2022, severe post-tropical cyclone Fiona underwent rapid extratropical transition from a category-3 major hurricane as it tracked just north of Bermuda and made landfall in Nova Scotia early on September 24th. This very large and powerful storm brought extreme winds, 2m+ storm surge and devastating ocean waves to many parts of Atlantic Canada. The storm set a new national record for lowest sea level pressure of a marine cyclone making landfall in Canada. Near ¾ of a billion dollars in insured damage was inflicted on the

region and almost all residents described the storm as the worst in their memory. Fiona was the costliest natural disaster in Atlantic Canada's history. In this session, we invite topic submissions related to the forecasting of all aspects of this event, including the factors that made it so severe in terms of wind, storm surge and ocean waves. We also welcome submissions that focus on the impact the storm had on the ocean and in particular the Gulf of St Lawrence and the severe dynamic-fetch waves that impacted southwestern Newfoundland. Any studies or reports related to the social science aspects of this severe storm such as forecast communication, preparedness and impacts are sought as well

ATM-Hurricane Fiona – Forecast and Messaging Review

On September 23rd, 2022, severe post-tropical cyclone Fiona underwent rapid extratropical transition from a category-3 major hurricane as it tracked just north of Bermuda and made landfall in Nova Scotia early on September 24th. This very large and powerful storm brought extreme winds, 2m+ storm surge and devastating ocean waves to many parts of Atlantic Canada. The storm set a new national record for lowest sea level pressure of a marine cyclone making landfall in Canada. Near of a billion dollars in insured damage was inflicted on the region and almost all residents described the storm as the worst in their memory. Fiona was the costliest natural disaster in Atlantic Canadas history. Primary aspects of the operational forecasting of this event will be the focus of this presentation.

Chris Fogarty[1] [1]ECCC/CHC chris.fogarty@ec.gc.ca

ATM-Importance of Mesonet Data for Analysis of Superstorm Fiona

Fiona struck Atlantic Canada in September 2022, bringing unprecedented damage to many areas of the region. A combination of both the government and private weather station networks (mesonets) played a critical role in analyzing exactly what occurred where, and to what duration and intensity. This was crucial in determining landfall, exact track her circulation centre as she crossed eastern Nova Scotia, areas that received strongest winds and rainfall, and the Canadian record for lowest sea level pressure recorded on land. This proved to be an essential tool to aid in post storm analysis.

Jonathan Buffett[1] [1]ECCC jonathan.buffett@ec.gc.ca

ATM-A&P in Action: Involvement of the Analysis & Prognosis section with respect to Hurricane Fiona's forecast impacts over Atlantic Canada

Analysis and Prognosis section, National Prediction Operations Division, Canadian Centre for Meteorological and Environmental Prediction, Meteorological Service of Canada, Environment and Climate Change Canada Hurricane Fiona transitioned to a post-tropical storm a few hours before making landfall over southeastern Nova Scotia during the overnight hours of September 24, 2022. Fiona was the most intense and costliest post-tropical storm to hit Canada in recorded history, with widespread damage, some extreme, reported across parts of Atlantic Canada and Eastern Quebec. The Analysis and Prognosis (AP) section of the National Prediction Operations Division at the Canadian Centre for Meteorological and Environmental Prediction (CCMEP) is responsible for monitoring meteorological phenomena at the synoptic scale with the goal of serving their Environment and Climate Change Canada (ECCC) clients and other federal departments as part of its mandate. AP is also the authority for the National Meteorological and Environmental Forecasting System (NMEFS) performance

verification for the Canadian models. Here we will cover critical AP activities in the days leading up to Fionas passage through Eastern Canada, including forecast briefings, written forecast discussions, graphical representation of the anticipated impacts, and initiatives apart from prescribed work.

Alissa steeves[1], Amin Erfani[1], Marc Larocque[1], Olivier Fortin[1], Eric Chénard[1], Yvan Larocque[1], Jean-Philippe Morin[1], Alexander Donaldson[1], Victor Thomas[1], Todd Bate[1], Trevor Kerr[1] [1]Environment & Climate Change Canada alissa.steeves@ec.gc.ca

ATM-On the Interactions of two Atmospheric Rivers with Hurricane Fiona

Fiona was a powerful Category 4 Atlantic hurricane turning into a costliest and most intense post-tropical cyclone to hit Canada in late September 2022. In this study, we focus on a North American (NA) atmospheric river (AR) that caused a predecessor rainfall event and became fully engaged with the extratropical transition of Fiona. This AR began to develop on 21 September as an energetic cold front moved across the Great Lakes. It reached the NA east coast on the 22nd, bringing heavy showers and gusty winds to the Northeastern United States and Atlantic Canada. Its further advance led to a direct collision with Hurricane Fiona, with its head merging with the hurricane outflow and its tail being absorbed into the storm inflow. The synergistic interactions between this AR and an upper-level jet through diabatic processes resulted in the development of a coastal area of secondary cyclogenesis, which, together with the AR-induced sensible heat and moisture flux, created a favourable thermodynamic environment for the northward movement and post-tropical transition of Fiona. The footprints of the AR tail can be traced as a unique inflow component through Fionas post-tropical transition process until a new AR was span up by the storm on 24 September. This reborn AR brought extremely heavy rainfalls and destructive winds to Atlantic Canada. Our analysis indicates that the main features of the AR-hurricane interaction and the associated hydrometeorlogical impacts were correctly predicted six days in advance by the operational weather forecast systems of Environment and Climate Change Canada.

Ruping Mo[1], Shunli Zhang[2], Chris Fogarty[3] [1]National Laboratory-West, Environment and Climate Change Canada [2]Canadian Centre for Meteorological and Environmental Prediction, Environment and Climate Change Canada [3]Canadian Hurricane Centre ruping.mo@ec.gc.ca

ATM-Attribution of the 2022 extratropical storm Fiona

In late September 2022, the Atlantic Hurricane Fiona transitioned to an extratropical cyclone making a landfall in the Canadian Atlantic provinces and setting a new national lowest pressure record. The insured damage from the resulting windstorm and flooding is estimated to be 800 million CAD. In this study, we analyze the maximum daily near-surface wind speeds in Atlantic Canada using reanalysis and CMIP6 HighResMIP data. According to our preliminary results from ERA5 reanalysis, the 2022 Fiona wind speeds were the highest in Atlantic Canada since 1950, with an estimated return period of 500 years. Additionally, using HighResMIP data from the models with a spatial resolution exceeding 56x56 km, we compare the wind speeds in the current climate with those from 1950-1969 and in 2031-2050 under the highres-future scenario, similar to RCP8.5. We find a statistically significant increase in the mid-21st century maximum wind speeds in Atlantic Canada in comparison to the 1950-1969 with a best estimate risk ratio of 3.8. We apply similar analysis to the data from CAM5 model as well as to the CMIP6 precipitation data in the region.

Elizaveta Malinina[1], Nathan Gillett[1], Michael Wehner[2], Xuebin Zhang[1] [1]ECCC [2]Lawrence Berkeley National Laboratory elizaveta.malinina-rieger@ec.gc.ca

ATM-Catastrophic Losses from Hurricane Fiona

In Canada, post-tropical cyclone Fiona resulted in nearly 750,000,00 CAD of insurance payouts, making it the costliest tropical event in Canadian history. This presentation will explore the catastrophic insured loss data for Fiona and provide a more granular view of insurance claims and insured losses. This loss data will then be compared with the total sums insured data to produce mean damage ratios (the loss as a percentage of the exposure). A comparison of Fiona and previous events in Atlantic Canada will also be provided. This type of data is useful in determining the financial magnitude for future tropical, or post-tropical, storms that enter Canadian waters.

Laura Twidle[1], Caroline Floyd[1] [1]Catastrophe Indices & Quantification Inc (CatIQ) laura.twidle@catiq.com

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Climate Change Projections for the Marine Sector

Monday, May 29
15:15 - 16:00 EDT

(15 Mins) Limits and caveats regarding applying weighting schemes to regional climate projections - Martin Leduc

(15 Mins) High resolution coastal projection for estimating current and future national carbon storage potential - Dipti Hingmire

(15 Mins) Assessment of climate change impacts on storm surge and wave conditions along the coast of Newfoundland and Labrador - Aline Kaji

Changes in climate have the potential to create significant disruption and uncertainty in marine ecosystems and sector activities. This includes changes in sea surface temperature and the pH of ocean water, which can alter marine ecosystems and food security through the supply of seafood products. Rising sea level contributes to coastal flooding that can turn dry land into wetland or open water, and affect coastal infrastructure. Moreover, the intensification of extreme events, such as storm intensity and frequency, and the change in the extent of sea ice are expected to affect all maritime transport and port activities. This session seeks contributions to explore the state of climate projections for the marine sector and facilitates an understanding of how such projections inform sectoral planning, policy, and decision-making. Contributions are invited across the full range of climate projections for the marine sector, including sea-level change, change in sea ice extent, future losses to coastal zones, changes in storm intensity and frequency, changes in sea surface temperature, changes in the pH of ocean water and changes in other sea variables used to track the health of the oceans. The conveners seek to improve the understanding of climate projections by identifying their limitations and improved methodologies to reduce and quantify uncertainties, with the goal of supporting adaptation to climate change in the Canadian marine sector.

CLM-Limits and caveats regarding applying weighting schemes to regional climate projections

Until very recently, the one model, one vote paradigm was the main approach used by climate scientists to analyse multi-model ensembles of climate change projections. The last IPCC AR6 report, where multiple lines of evidence have been applied to constrain uncertainties in future projections for a limited number of global variables such as surface air temperature, brought the community one step beyond a long-lasting scientific statu quo. Since these techniques highly depend on model evaluation against a selected set of evaluation metrics, weighting future climate change projections involves at least two important assumptions: 1) the selected evaluation metrics are robust criteria for quantifying model performance and 2) the evaluation metrics are good predictor of the model ability to predict future climate. In this work, we show that it is critical, especially at the regional scale, to first identify robust metrics before applying them to constrain ensemble projections. To evaluate the robustness of these metrics, we assume that the resulting model weights should not be much sensitive to internal climate variability, which is an intrinsic source of (random) uncertainty affecting both the observed and modeled climate system. By using an initial condition large ensemble as several equiprobable pseudo-references, we show how the robustness of a weighting scheme depends on both internal variability model uncertainty. Our results for temperature and precipitation suggest that performance metrics based on interannual variability and historical climate of trends offer poor robustness as evaluation metrics at the regional scale. On the other hand, metrics based on climatic means are more robust against internal variability, although they are generally not useful as a future climate predictor.

Martin Leduc[1], Dominic Matte[1], Anne-Marie Bégin[1], Dominique Paquin[1], Isabelle Chouinard[2] [1]Ouranos [2]Ouranos / UQAM leduc.martin@ouranos.ca

CLM-High resolution coastal projection for estimating current and future national carbon storage potential

Blue carbon ecosystems (BCE) are coastal habitats that sequester significant amounts of carbon from the atmosphere and ocean and store it in biomass and sediments for a longer time. Canada has the worlds longest coastline; hence, BCEs may offer a means for the country to achieve its net zero commitments by 2050. However, there is a lack of estimates of the carbon sink potentials of Canadian BCE. In this multidisciplinary effort, we aim to quantify the current and possible future distribution of Canadian BCEs and their carbon storage potential. The availability of very high-resolution oceanographic input data is the first requirement for assessing the distributions of BCE using species distribution models. Here, we describe a two-step dynamical downscaling methodology to produce high-resolution future projections of oceanographic datasets. In the first step, we will use boundary conditions from the state-of-the-art Earth system model (ESM) output from the 6th phase of the Climate Model Intercomparison Project (CMIP6) to create a collection of km-scale projections of atmospheric conditions using the Weather Research and Forecasting Model (WRF). We will then use this collection of high-resolution WRF outputs to drive Regional Ocean Modeling System (ROMS) at 0.5km resolution. ROMS will include the nutrient-phytoplankton-zooplankton-dissolved oxygen module to model biologically-significant tracers. We plan to implement this downscaling process for three CMIP6 ESMs with different physical parameterizations to account for uncertainty due to differences in how models respond to emissions. For each ESM we will downscale two ensemble members to account for the effects of internal variability.

Dipti Hingmire[1], Hansi Singh[1], Haruki Hirasawa[1], Parker MacCready[2], Matt Csordas[1],

Jennifer MacHenry[1], Graham Epstein[1], Julia Baum[1] [1]University of Victoria [2]University of Washington dhingmire@uvic.ca

CLM-Assessment of climate change impacts on storm surge and wave conditions along the coast of Newfoundland and Labrador

The coast of Newfoundland and Labrador is comprised of a complex system of coves, inlets and fjords, with highly variable bathymetric and shoreline features that are exposed to a range of oceanographic forcings, such as tides, storms and waves, which can lead to coastal flooding. As recently demonstrated during the devastating impacts of Hurricane Fiona (2022) in Port-Aux-Basques, the reliable prediction of coastal flood risks is increasingly important in a changing climate. In recent years, the Province of Newfoundland Labrador has developed a series of coastal flood mapping projects, together with industry and Federal partners, that used innovative methods and tools to develop more comprehensive coastal flood risk mapping products, that account for future climate change. As part of this effort, a series of hydrodynamic and wave models were developed using DHIs MIKE 21 modelling suite to estimate extreme nearshore surge levels and wave conditions based on a hindcast and a forecast of future trends to the local surge and wave climate along the entire coast of Newfoundland and Labrador. A hybrid methodology which combines dynamical downscaling (process-based models) and statistical tools was applied. The models are forced by surface wind and pressure projections from climate reanalysis and regional climate projections, including regional sea level changes based on IPCC AR6. This study aims to inform decision makers and planners on existing and future flood risk using accessible and easy to interpret results, including maps and analyses for key locations.

Aline Kaji[1], Gabriel Vieira de Carvalho[1], Méven Robin Huiban[1], Danker Kolijn[1], Jose Ignacio Ribba Esteva[1], Paula Dawe[2], Mohammad Khayer[2], Rob Holloway[2], Haseen Khan[2], Andrew Weiss[3] [1]DHI Water & Environment Inc [2]Water Resources Management Division - Government of Newfoundland and Labrador [3]KGS Group alka@dhigroup.com

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PICO-F * Scientific Presentation Competition en Français

(* Présentation Intensive et Courte pour Orateurs Francophones)

Monday, May 29
16:00 - 17:30 EDT

PICO was a science-social event where researchers were invited to give three minute presentations in French. PICO was an event to include activities for our francophone members. Prizes were awarded by a panel of judges. Prizes were announced during the Awards Banquet on 31 May and details may be found in the Congress photo collage.

Day 2 – 30 May 2023

Modern Weather and Climate Monitoring, Modelling and Service Provision

Tuesday, May 30
7:00 - 8:00 EDT

Canada, like much of the world, is advancing its activities alongside ever evolving technologies and trends around weather and climate monitoring, modeling and service provision, including keeping pace with open data policies, AI, big data, and impact based decision support to provide critical services in a time of increased extreme weather events. The Meteorological Service of Canada (MSC) is built on a strong foundation of scientific research and development, and is known for delivering accurate and timely weather and environmental information and warnings to help the public plan daily activities and make decisions about their health, safety and economic well-being. By integrating environmental monitoring, science, operations, services and policy functions, the MSC is an authoritative source of meteorological and water resource information in Canada, where it delivers weather, water, ice, air quality, climate and related environmental services. This presentation will highlight MSC's perspectives on and approaches to continuous transformation, innovation and modernization of its weather and environmental services to meet evolving user, stakeholder and partner needs.

David Harper, Meteorological Service of Canada, ECCC

Atmosphere, Ocean, and Climate Dynamics - Part 1

Tuesday, May 30
8:30 - 10:00 EDT

(15 Mins) Lake Melville Southeasterlies - Tiffany Cheeks

(15 Mins) Marine Heatwaves in the Arctic Ocean: drivers, feedback mechanisms and interactions with sea ice - Benjamin Richaud

(15 Mins) Nonlinearity of the equation of state effects dynamics of nonlinear internal waves in late winter lakes - Marek Stastna

(15 Mins) Observations of submesoscale features in a large eddy using underwater gliders - Bernard Yang

(15 Mins) New perspectives for the numerical modelling of sea-ice drift dynamics - Boualem Khouider

(15 Mins) Earth system model sea-ice loss experiments are wrong. Are they useful? - Paul Kushner

This session combines submissions that document studies of the dynamics of the atmosphere, oceans and/or climate system. The scope of the session is deliberately broad in order to include research that spans a broad range of spatial and temporal scales. Studies of the dynamics of mesoscale processes that act on hourly timescales are as welcome in this session as those that document the evolution of planetary-scale structures in a changing climate. Such investigations

may include diagnoses and theoretical studies of forecast, climate, and process models, or studies based on reanalysis and other observational datasets; however, any topic that is relevant to atmosphere, ocean, or climate dynamics will fit well into this session. Please note we have run this session at CMOS Congresses since around 2009.

MUL-Lake Melville Southeasterlies

Lake Melville, near Happy Valley-Goose Bay in Labrador, sits just below the up to 1180 m Mealy Mountains. It is known that east to southeasterly winds can be enhanced over Lake Melville due to these mountains, particularly in the Etagaulet Bay area, though they can extend beyond there. While known, in the past it has not normally been reflected in marine forecasts for the area. This case study looks at examples where these winds have occurred and ways they can be predicted in the future. By taking satellite derived observations and comparing them to model winds over the area this study aimed to come up with a general rule of thumb for forecasting these types of events, taking the onus off the mariner to recognize the situation and add the enhancement themselves. I found, through these examples, that enhanced wind speeds can generally be expected to occur ahead of an approaching warm front, and that a good estimate of these speeds can be found in the model winds just below the inversion.

Tiffany Cheeks[1] [1]ECCC tiffany.cheeks@ec.gc.ca

MUL-Marine Heatwaves in the Arctic Ocean: drivers, feedback mechanisms and interactions with sea ice

Arctic regions are warming at a rate faster than the global average. Superimposed on this trend, marine heatwaves and other extreme events are becoming more frequent and intense. Simultaneously the sea ice phenology with which these events interact is also changing. While sea ice can absorb atmospheric heat by melting and therefore acts as a heat buffer for the ocean, meltwater-induced stratification and albedo changes can provoke positive feedbacks on the heat content of the upper ocean. Disentangling those effects is key to better understanding and predicting the present and future state of the Arctic Ocean, including how it responds to forcing by extreme events. Using a three-dimensional regional ice-ocean coupled numerical model, we calculate a two-layer heat budget for the surface mixed layer of the Arctic Ocean, using a novel approach for the treatment of residuals. We present a statistical overview of the dominant drivers of marine heatwaves at the regional scale as well as more in-depth analyses of specific events in key regions of interest. The characteristics of marine heatwaves under different sea ice conditions is also considered, to identify anomalous ice-ocean interactions. Finally, potential feedback mechanisms are investigated to verify their existence and quantify their importance.

Benjamin Richaud[1], Eric C.J. Oliver[1], Xianmin Hu[1], Sofia Darmaraki[2], Katja Fennel[1] [1]Dalhousie University [2]Coastal Marine Research Laboratory, Institute of Applied and Computational Mathematics, FORTH benjamin.richaud@dal.ca

MUL-Nonlinearity of the equation of state effects dynamics of nonlinear internal waves in late winter lakes

In late winter many lakes are iced over, and hence remain cut off from the mechanical forcing due to wind. At the same time, strong radiative forcing modifies the inverse stratification associated with wintertime conditions. The inverse stratification occurs due to the fact that freshwater has a temperature of maximum density (around 4 degrees Centigrade) and the equation state of freshwater is thus nonlinear. In this talk I will demonstrate that this nonlinearity has a profound influence on the characteristics of nonlinear internal solitary-like waves in the cold water regime. In particular, predcitions of waves made using a piecewise linear density profile yield waves with the opposite polarity to those calculated using temperature profiles and the full nonlinear equation of state. I will present results based on the Dubreil-Jacotin Long theory, but similar conclusions can be made based on weakly nonlinear (KdV) theory. Time permitting I will discuss implications of these results for shoaling.

Marek Stastna[1] [1]University of Waterloo mmstastn@uwaterloo.ca

MUL-Observations of submesoscale features in a large eddy using underwater gliders

Observations from an underwater glider in the Northeast Pacific during the winter of 2020 revealed the detailed 3D structure of a Haida eddy. The eddy was 2 years old and carried warmer, fresher shelf waters with higher nutrients from its generation site at the south tip of Haida Gwaii towards the open ocean. The spatial resolution of the glider measurements captured interleaving layers (tendrils) on the outer edges of the eddy, which has not been previously observed by ship-based CTD sampling. The interleaving layers are the most prominent at the edges of the eddy in the east-west direction with radial scales on the order of 10 km. However, the interleaving layers were not present in the north-south section, suggesting that the layers are asymmetrical. We derive a metric for the cohesiveness of the eddy based on a lateral spice sorting procedure along the isopycnals. The estimate suggests that although the eddy has travelled through the Northeast Pacific for 2 years, the eddy maintained high cohesiveness. We use the high-resolution dataset to estimate the lateral diffusivity due to the tendrils detaching from the eddy. Our estimates of the lateral diffusivity are broadly consistent with previous studies based on dye-releasing experiments and provide an estimation of a 1 to 3-year lifetime for the eddy.

Bernard Yang[1], Tetjana Ross[2], Jody Klymak[1] [1]University of Victoria, Victoria, BC [2]Institute of Ocean Sciences, Sidney, BC byang123@uvic.ca

MUL-New perspectives for the numerical modelling of sea-ice drift dynamics

Recent field experiments have revealed that the drift of sea-ice in response to ocean and wind stresses can be modelled as an elastic-plastic material. Due to numerical intractability however, sea-ice dynamics models that are currently in use in Earth System Models are based a viscous-plastic and elasto-viscous-plastic rheologies based on an elliptic yield curve. This however leads to a system of partial differential equations that are not smooth and highly nonlinear. Their analytical properties are unsettled and it remains unclear whether they are well posed or not and the search for accurate and efficient numerical solutions remains a scientific grand challenge. In this talk, some recent improvements in the development of Jacobian-free Newton-Krylov methods for

the viscous plastic equations as well as the development of a new Newton-type infinite dimensional linearization approach will be surveyed. Moreover, a new methodology for the unification of elasto-plastic dynamics using convex analysis tools allowing the treatment of arbitrary complex yield curves will be presented and applied for the elasto-plastic sea-ice rheology.

Boualem Khouider[1] [1]University of Victoria khouider@uvic.ca

MUL-Earth system model sea-ice loss experiments are wrong. Are they useful?

Our poor understanding of how the Arctics atmosphere, sea ice, and ocean are coupled limits what we can say about Arctic change from greenhouse warming, and what Arctic change means for global weather and climate. Earth system models that simulate Arctic and global change, while complicated and imperfect, are useful to understand drivers of Arctic change and its global influence. In the virtual world of models, you can remove Arctic sea ice and analyze its local and remote response, without greenhouse warming. Or, you can keep sea ice unchanged and investigate a virtual world of greenhouse warming without sea ice loss. But this virtual exploration can fool us: recent work by Mark England and colleagues has shown that this kind of sea ice removal, when carried out in the setting of coupled ocean-atmosphere models, artificially amplifies Arctic warming, with global implications. The basic problem is that these simulations use Arctic sea ice loss as a stand-in for Arctic warming, but targeted ice loss does not account well for the effect on the Arctic of greenhouse warming. We confirm the England et al. result but argue that sea ice loss experiments can nevertheless provide physically reasonable results, if they are linearly combined with greenhouse warming experiments using scaling suggested by simple energy balance models. This post-processing step, along with refined methods for inducing sea ice loss, allows us to gain value from sea ice loss experiments and avoid some of the difficulties arising from interpreting these experiments at face value.

Paul Kushner[1], Luke Fraser-Leach[1], Alexandre Audette[1] [1]University of Toronto paul.kushner@utoronto.ca

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Coastal Oceanography and Inland Waters - Part 4

Tuesday, May 30
8:30 - 10:00 EDT

(15 Mins) Estimation of the wind field with a single high frequency radar - Cédric Chavanne

(15 Mins) Spatial Distribution of Microplastics in Placentia Bay, Newfoundland - Olivia Dillon

(15 Mins) Seasonal variations of iron-humic ligands in a peat dominated catchment and their faith in the ocean - Kavi Heerah

(15 Mins) Modification of Arctic–derived waters in the western Canadian Arctic - Igor Dmitrenko

This session will focus on all aspects of monitoring and modelling physical and biogeochemical processes in coastal domains, shelf seas, estuaries and inland

waters. Topics include but are not limited to coastal physical oceanography, storm surges, tsunamis, estuarine dynamics, hydrology and hydrodynamics of large lakes, mixing and dispersion of materials. Contributions related to both observational and modelling aspects of biogeochemistry in coastal and inland waters are welcome. Papers can be on improving our knowledge of physical and biogeochemical conditions in the past and present climate and/or on predictions of changes and extremes in marine conditions in response to climate change.

MUL-Estimation of the wind field with a single high frequency radar

For a number of decades, coastal High Frequency (HF) radars have been used to remotely measure ocean surface parameters, including current, wave and wind fields. These measurements are crucial for many ocean engineering applications. Wind direction can be estimated from the relative strength of the positive and negative Bragg-resonant spectral peaks, which correspond to wind-driven waves approaching and receding from the radar, respectively. However, with a single HF radar there is a left-right directional ambiguity around the radar beam direction. Previously proposed algorithms to remove this ambiguity have been tested, and a new algorithm is proposed, using observations from four HF radars installed in the Lower St. Lawrence Estuary (Quebec, Canada). Wind speed is then estimated from wind directions and wind-driven radial currents measured by a single HF radar using an artificial neural network. Radar measurements of the wind field are compared with in-situ observations from meteorological stations on le Bicquette and PMZA-RIKI buoy. The average correlation coefficient between the radar-estimated and the in-situ wind directions is 0.90 for the Wellen Radars (WERA) and 0.92 for the Coastal Ocean Dynamics Applications Radars (CODAR). The average correlation coefficient between the radar-estimated wind speed and the in-situ wind speed is 0.91 for the WERAs and 0.92 for the CODARs. Estimating wind speed and direction from single HF radars based on Bragg-resonant spectral peaks maximizes the spatial coverage of the wind field.

Cédric Chavanne[1], Abigaelle Dussol[1] [1]Institut des Sciences de la Mer de Rimouski
Cedric_Chavanne@uqar.ca

OCE-Spatial Distribution of Microplastics in Placentia Bay, Newfoundland

Microplastics (MPs) are a growing concern of global significance, from the remote Antarctic Peninsula to the placentas of unborn babies. We determined the spatial distribution of microplastic in the water and sediments in one of Newfoundlands most prominent fishing regions, Placentia Bay. MPs under 300 m were collected with Neuston and Plankton nets at nine stations, sediment grab samples were collected at six stations. MP fragments and fibers were isolated by digestion of organic matter for water samples or by density separation for sediment samples. MPs were analyzed microscopically with the chemical composition determined via Raman microspectroscopy. MPs larger than 300 m were found at all stations at concentrations between 1.04 MPm-3 and 0.01 MPm-3, with no systematic difference between neuston and plankton samples. The highest MP concentrations were found in the inner Bay, and over 60% of MP particles consisted of fibers, with the rest mostly fragments. Sediments contained 177 MP fibers per kg, and few fragments, above 75 m. Raman microscopy revealed fragments to be mostly polypropylene and polyethene. Fibers in the water were also mostly polypropylene and polyethylene, but fibers in sediments consisted largely of cotton or cellulose, rather than plastic.

Olivia Dillon[1], Uta Passow[1] [1]Memorial University of Newfoundland Oldillon@mun.ca

OCE-Seasonal variations of iron-humic ligands in a peat dominated catchment and their faith in the ocean

Iron is a limiting nutrient in the ocean but is present in high quantities in terrestrial environments. Dissolved free iron is not stable in oxic marine waters, and readily flocculates as iron oxy-hydroxide minerals in estuaries and in the open ocean. Humic ligands present in peat and boreal environments have been shown to complex with iron and transport greater quantities of dissolved iron into oceanic environments. Newfoundland, Canada is dominated by peat and boreal forest, with large swathes of peat barrens located on the eastern part of the island. A small catchment located in eastern Newfoundland was sampled 2 km upstream of where the main branch of the river drains into the coast. In addition to the main branch of the catchment, two tributaries mixing just above the primary site were also sampled, one draining peatlands and the other draining a series of small lakes. Sampling occurred on a monthly basis for a year collecting water colour, total organic carbon, and iron concentrations along with structural information of the ligands and changes in these properties upon exposure to an artificial salinity gradient. The river was found to transport high amounts of iron and humic ligands through the salinity gradient, remaining in solution at open-ocean salinities, with varying efficiencies throughout the year. Better understanding the seasonal variations of terrestrial rivers can help inform coastal productivity models and achieve a greater understanding of key biogeochemical cycles.

Kavi Heerah[1], Heather Reader[1] [1]Memorial University of Newfoundland and Labrador kmheerah@mun.ca

OCE-Modification of Arctic–derived waters in the western Canadian Arctic

Here we present a unique set of conductivitytemperaturedepth (CTD) and nitrate profiles collected in the Canadian Arctic Archipelago (CAA), specifically Expedition Fjord and Iceberg Bay, in AprilMay 2022. The profiles are examined within the context of upstream observations in the Arctic Ocean and downstream observations in the western Canadian Arctic, and reveal the origin of water masses and interactions with ambient water from the continental slope and the nearby tidewater glacier outlet. The subsurface water (25180 m depth) is associated with the Pacific water outflow from the Arctic Ocean. The underlying halocline separates Pacific water from a deeper layer of polar water that has interacted with the warm (>0C) Atlantic water recorded below 240 m depth. Water column is significantly modified compared with the adjoining Arctic Ocean. At the front of the tidewater glacier outlet, colder water intrusions of ~0.25C deviate the temperature of Pacific water down to ~140 m due to the oceanglacier interaction. Data shows no thermal signature of Pacific summer water. Comparing with the adjacent Arctic Ocean, adeeper fraction of Pacificderived water and the Atlanticmodified polar water are warmer. In contrast, underlying Atlantic water is cooler than off the CAA. Our results suggest that Pacific and Atlantic water in the fjord system is modified due to enhanced vertical diffusivity in a narrow band over the continental slope and shelf off the CAA. This is consistent with upstream and downstream CTD observations and results of preceding research.

Igor Dmitrenko[1], Sergei Kirillov[1], Bert Rudels[2], Nicolas-Xavier Geilfus[3], Jens Ehn[1], David Baab[1], David Lilien[1], Dorthe Dahl-Jensen[4] [1]Centre for Earth Observation Science,

University of Manitoba [2]Finnish Meteorological Institute [3]Tvärminne Zoological Station, University of Helsinki [4]Niels Bohr Institute, University of Copenhagen
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Marine Carbon Dioxide Removal (mCDR) - Emerging Solutions, Opportunities, and Research Needs

Tuesday, May 30
8:30 - 10:00 EDT

(15 Mins) A high-resolution coupled circulation-biogeochemical model to study the effects of alkalinity additions in a mid-latitude coastal fjord - Arnaud Laurent

(15 Mins) The effects of surface turbulence on ocean alkalinity enhancement - Josiane Ostiguy

(15 Mins) Planetary Technology's recent breakthroughs in the research, development and deployment of Ocean Alkalinity Enhancement - Will Burt

(15 Mins) The passive dye tracer experiments in Bedford Basin to mimic Ocean Alkalinity Enhancement - Bin Wang

(15 Mins) Running Tide's MRV framework for open-ocean CDR - Anna Savage

(15 Mins) Direct Air Carbon Dioxide Capture and Storage powered by Ocean Thermal Energy Conversion - Sophia Olim

The exploding promotion of and emerging industries associated with marine-based carbon dioxide capture and storage requires the immediate attention of the marine science community. Recent assessments of the joint needs for significant global carbon dioxide emission reductions and negative emission (capture and storage) technologies has put new focus on the existing roles the ocean plays, and possible means for enhancing carbon storage in the marine environment. This session plans to present important issues related to all aspects of marine carbon dioxide removal (mCDR) and stimulate discussion and assessment by both industry and the science community. Key elements for discussion include the various possible mCDR solutions under consideration, site selection, scalability, storage duration and durability, impact assessment, and the needs for both baseline carbon-cycle knowledge and monitoring, reporting, and verification (MRV) programs during any field trials. In addition to several overview summaries, we welcome papers that highlight initiatives and activities either underway or planned that relate to the capture and storage of carbon in the diverse Canadian marine environments.

OCE-A high-resolution coupled circulation-biogeochemical model to study the effects of alkalinity additions in a mid-latitude coastal fjord

Numerical models are important tools for marine carbon dioxide removal (mCDR) research and will be essential to monitor, report, and verify (MRV) mCDR attempts. Among those, high resolution regional models are arguably best suited because they represent coastal and nearshore processes and therefore can resolve the spatial scales associated with mCDR (often planned from land facilities or coastal ships). Here we

describe a coupled circulation-biogeochemical model in a nested grid configuration that reaches a very high spatial resolution in Bedford Basin, a coastal fjord in eastern Canada that is being considered as a test site for ocean alkalinity enhancement (OAE). We will present a multi-year hindcast validated against the long-term weekly time series available at the compass buoy in the centre of the Basin. We will discuss the model capabilities with respect to OAE and the challenges ahead.

Arnaud Laurent[1], Bin Wang[1], Albert Pei[1], Kyoko Ohashi[1], Jinyu Sheng[1], Edmundo Garcia Larez[1], Caroline Fradette[1], Subhadeep Rakshit[1], Dariia Atamanchuk[1], Kumiko Azetsu-Scott[2], Christopher Algar[1], Doug Wallace[1], Will Burt[3], Katja Fennel[1] [1]Dalhousie University [2]Bedford Institute of Oceanography [3]Planetary Tech arnaud.laurent@dal.ca

OCE-The effects of surface turbulence on ocean alkalinity enhancement

Negative emission technologies, such as ocean alkalinity enhancement (OAE), may provide a method to mitigate the effects of high atmospheric CO2 concentration. The process of OAE seeks to increase ocean alkalinity in order to store carbon in the ocean as bicarbonate or carbonate ions. OAE therefore accelerates CO2 uptake from the atmosphere through air-sea gas exchange. Near-surface ocean turbulence will have an impact on the efficiency of OAE as turbulent mixing processes may cause a high alkalinity plume to sink out of the mixed layer, where it will no longer be in contact with the atmosphere, potentially causing its impact on CO2 drawdown to be delayed by many years. We explore the impact of ocean surface processes on the evolution and downwards diffusion of an alkalinity-enhanced plume as influenced by seasonal variations as well as different temperature, precipitation, and wind conditions. A large eddy simulation (LES) is coupled with a simple carbonate system solver to evaluate the potential impact of surface turbulence on OAE efficiency and CO2 flux into the ocean.

Josiane Ostiguy[1], Ruth Musgrave[1], Douglas Wallace[1], Anneke ten Doeschate[2], Graigory Sutherland[3], Daniel Bourgault[4] [1]Dalhousie University [2]Rockland Scientific [3]Environment and Climate Change Canada [4]Université du Québec à Rimouski josiane.ostiguy@dal.ca

OCE-Planetary Technology’s recent breakthroughs in the research, development and deployment of Ocean Alkalinity Enhancement

Halifax-based Planetary Technologies is a world leader in the development and deployment of Ocean Alkalinity Enhancement (OAE), a marine carbon dioxide removal (CDR) method with significant potential to be part of a critical climate change mitigation portfolio. In this talk, we provide a brief introduction to OAE before highlighting Planetarys RD milestones, including field deployments that demonstrate quantifiable CDR, as well as progress towards a public-facing Measurement, Reporting, and Verification (MRV) framework. Also, we share Planetarys progress towards as many as three prolonged OAE field trials beginning in 2023 (in the UK and Canada), including our regulatory, stakeholder, and public engagement. Finally, we describe Planetarys OAE Ocean Science Sandbox concept, whereby we promote and facilitate worldwide collaborative OAE research at our pilot sites during our live OAE trials.

Will Burt[1], Rau Greg[1], Yuanyuan Xu[1], Brenan Duhamel[1], Pete Chargin[1], Mike Kelland[1] [1]Planetary Tech will@planetarytech.com

OCE-The passive dye tracer experiments in Bedford Basin to mimic Ocean Alkalinity Enhancement

Ocean Alkalinity Enhancement (OAE) is considered as a potential technique to mitigate ocean acidification and remove carbon dioxide (CO_2) from the atmosphere. Bedford Basin, which connects to the open ocean through a shallow channel, is an ideal location for OAE pilot studies because the ongoing Bedford Basin Monitoring Program (BBMP) has collected weekly hydrographic and chemical data since 1992, and microbiological and inorganic carbon parameters have begun more recently by Dalhousie scientists. In this study, a suite of passive dye tracer experiments is conducted using a high-resolution nested model, which will be described by Laurent et al., (2023) in this same session. The objectives of these experiments are to estimate residence times in the Basin and to mimic different strategies of OAE implementation, e.g., a pulsed versus a continuous release. Passive dye tracer simulations for different seasons will be presented for two representative years, one where bottom intrusions of shelf water have been observed at the monitoring station (2014) and one where they were not observed (2015). The residence time of dye tracers within the mixing layer and the subsurface water will be estimated and exposure maps will be presented that provide information on the potential environmental impacts of OAE. Preliminary results show that the residence time is longer in the summer and in 2015 because stratification is stronger then.

Bin Wang[1], Arnaud Laurent[1], Katja Fennel[1] [1]Dalhousie University Bin.Wang@dal.ca

OCE-Running Tide's MRV framework for open-ocean CDR

Running Tides multipath approach to ocean-based CDR enhances the oceans natural capacity for carbon removal and durable storage. Our free-floating drifters integrate macroalgae cultivation, biomass sinking, and ocean alkalinity enhancement in order to successfully optimize carbon removal and mitigate impacts to local environments. There are numerous advantages of a passively drifting nature-based CDR system, but it requires careful planning and deployment of the free-floating platforms, monitoring of the system as it floats and disperses in the ocean, and quantification of its impact on the carbon cycle and marine ecosystems. The MRV (monitoring, reporting, and verification) framework at Running Tide is an iterative system consisting of global ocean general circulation models, specific empirical and process-based models (e.g. macroalgal growth and Lagrangian drift simulations), and in-situ observations via a first-of-its-kind open-ocean macroalgal growth observation platform. We support MRV from open-ocean pilot deployments with highly monitored inter-coastal macroalgae farms and laboratory experimentation. In this presentation, we will provide an overview of Running Tides MRV framework and briefly discuss how it interacts with our environmental impact assessments (EIAs) and siting selection process.

Anna Savage[1], Max Chalfin[1], Rishi Masalia[1], Kay Suselj[1], Alison Tune[1] [1]Running Tide savage@runningtide.com

OCE-Direct Air Carbon Dioxide Capture and Storage powered by Ocean Thermal Energy Conversion

In the 2015 Paris Accord, 196 nations agreed to keep global warming below 2C and to pursue efforts to limit it to 1.5C. The Earth has already warmed by ~1.1-1.2C since preindustrial times. If worldwide fossil fuel combustion was immediately eliminated, the direct and indirect net cooling effect of atmospheric aerosol loading would rapidly

dissipate. The aerosol cooling realized since the preindustrial era would be eliminated, taking the Earth rapidly to 1.7-1.8C warming. The IPCC noted the requirement of widespread negative emissions technology in order to meet the 1.5C target. In direct air carbon dioxide capture and storage (DACCS), CO2 is scrubbed from the atmosphere and injected into underground geological formations. The combination of DACCS and Ocean Thermal Energy Conversion (OTEC) offers a new approach for independently powered DACCS plants to inject concentrated CO2 into deep ocean storage. OTEC is a form of electricity production that exploits the temperature difference between deep and shallow ocean waters analogous to land-based heat pumps. Our results suggest OTEC could power DACCS to store at least 10 Gt of CO2 a year without widespread negative ecosystem effects. Areas where OTEC is most efficient (in the tropics) overlap with several depleted oil and gas fields that are feasible sites for long term carbon storage. In this project, the UVic Earth System Climate Model is used to explore the feasibility of using OTEC to power DACCS in selected areas of the ocean floor.

Sophia Olim[1], Andrew Weaver[1], Anna Nickoloff[1], Michael Eby[1], Natalia Gurgacz[1]
[1]School of Earth and Ocean Sciences, University of Victoria solim@uvic.ca

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MSC-Overview of numerical modelling tools and services from the Canadian Metorological Centre - Part 1

Tuesday, May 30
8:30 - 10:00 EDT

(15 Mins) Operational weather and environmental services of CCMEP – Recent accomplishments and future directions - André Giguère

(15 Mins) Transforming the MSC : The Weather Elements on Grid - Rares Gheti

(15 Mins) Environment and Climate Change Canada/Meteorological Services Canada (ECCC/MSC) Upper-air Renewal Program – An Overview - Herb Winston

(15 Mins) Optimal use of multimodel ensembles: reducing ensemble uncertainty while preserving model democracy - Charles Curry

This MSC session aims to provide an overview of the myriad of numerical modelling tools and services offered by the development division at CMC, and to look at how new innovations are helping bridge the gap between raw modelling output and the production of weather forecasts for Canadians. Modelling data is provided to support many client requirements, and the community must be actively modernizing to adapt to changing demands. Presentations will cover the specifics of the systems and products now in use, discuss how updates will unfold in the years ahead (including the process for continuous development), examine different means by which the application of post processing algorithms can add value to the numerical data, and show examples of how these systems can aid in the forecasting process. The goal of these presentations is to outline what is happening within the modelling community, and to stimulate discussion about how to meet future needs.

ATM-Operational weather and environmental services of CCMEP – Recent accomplishments and future directions

The demand for weather and environmental information is increasing, particularly in terms of the accuracy and timeliness of model forecasts for high-impact weather events. In the heart of Environment and Climate Change Canada (ECCC)s Meteorological Service of Canada (MSC), the Canadian Centre for Meteorological and Environmental Prediction (CCMEP) is responsible for delivery of continuous real-time weather and environmental forecasts. The operational division of CCMEP plays the key role in providing 24/7/365 support for implementation of more than 30 numerical weather and environmental systems. It also responds operationally to various international, national and local environmental emergencies such as releases of nuclear and toxic materials, volcanic ash and chemical substances during the forest fire season. This division has also a section dedicated to the air quality modeling and applications in support of environmental policy development. Another main responsibility of the operations division of CCMEP is the real-time delivery of new radars data and products being released as part of the 7-years Canadian Weather Radar Replacement Program (CWRRP) project. As another mission critical 24/7 service, this center plays a leading role for almost two decades in the provision of observation, analysis and prediction data open to the public. This presentation will review the main structure of operations division of CCMEP, its current services and future directions with focus on ways of addressing the extreme events and the various emergency situations.

Sébastien Chouinard[1] André Giguère[1]*
[1]ECCC/Meteorological Service of Canada/Canadian Centre for Meteorological and Environmental Prediction

ATM-Transforming the MSC : The Weather Elements on Grid

The Weather Elements on Grid (WEonG) are a critical component of the major transformations currently underway by the Meteorological Service of Canada (MSC). They optimally fill the gap between the raw numerical weather products and the information required to perform the main forecasting programs mandated by the MSC. The WeonGs are physical and statistical post-processed outputs that use elegant and relatively simple algorithms. Their role is to function as numerical guides or directly in support of various programs (public, marine, aviation, air quality..etc). Their main strengths are their adaptability for adding scientific improvements, ease of maintenance and portability to various deterministic and ensemble systems. The development workflow focuses on technical and scientific optimizations, continuous subjective and objective verification and collaboration with various stakeholders. This discussion will quickly summarize some of the most important methods used in the WEonG production system including some examples of their utility in the context of producing and delivering forecasts to the general public.

Rares Gheti[1] [1]Environnement and Climate Changes Canada rares.gheti@ec.gc.ca

ATM-Environment and Climate Change Canada/Meteorological Services Canada (ECCC/MSC) Upper-air Renewal Program – An Overview

Environment Climate Change Canada (ECCC)/Meteorological Services Canada (MSC) is embarking on a national upper-air renewal program. Initiated in 2022, the program

consists of two separate yet complementary initiatives. The first is a manual radiosonde sounding program that will replace each of MSC's 30+ current fixed and portable sounding stations with Vaisala's MW41 DigiCORA sounding systems. This program also includes delivery of Vaisala RS41-SG (GPS-based altimetry) radiosondes and ozone sonde interface boards over the next five years with options through 2032. The second program is the Automated Radiosonde Launching (ARLS) System that is based on Vaisala's latest AS41 Autosonde. The tenants of the ARLS program are to improve consistency of upper-air measurements, promote sustainability and reduce life-cycle costs. Using the same RS41-SG radiosondes as the manual program, The ARLS supports up to sixty sequential radiosonde launches between intervention. Combined with the ability to remotely schedule launches, the ARLS will enable MSC to optimize use of its resources. Additionally, the ARLS system enables MSC to use either helium or hydrogen as a lift gas through its design that meets Canadian-specific CSA electronics and 'hazards' standards. As of the drafting of this abstract, MSC has deployed approximately 50% of the manual stations and the first of four ARLS systems was installed by Vaisala at Pickle Lake and is now operational. The paper will provide an overview and roll-out schedule of the two programs, present content on the operational characteristics of the ARLS and discuss the practical advantages of upper-air automation in a national operational meteorological service.

Herb, Winston[1], Matti Lehmuskero[2], Oskari Hakkarainen[2] [1]Vaisala Inc
[2]Vaisala Oyj herb.winston@vaisala.com

ATM-Optimal use of multimodel ensembles: reducing ensemble uncertainty while preserving model democracy

Multi-model ensembles emerging from successive rounds of the Coupled Model Intercomparison Project (CMIP) continue to grow in size, as more modelling centres around the world develop expertise in computational earth system modelling. Following a "model democracy" approach, this virtually guarantees that the spread in climate model projections examined at a specified future period will grow with each successive CMIP, other things being equal—as was indeed seen from CMIP5 to CMIP6. This has led to a renewed interest in model screening and weighting approaches, for example by using historical observations to effectively underweight certain models deemed less realistic than others. Alternatively, placing a higher priority on each model's ability to achieve a given forced response, such as a given level of global mean temperature change (ΔGMT), irrespective of when it is achieved, preserves model democracy. Eliminating the ensemble spread in ΔGMT has the co-benefits of: 1) reducing ensemble uncertainty in other climate variables both globally and regionally, despite increasing ensemble size; and 2) effectively removing scenario uncertainty. While these benefits come at the expense of apparent precision in the timing of a specified level of warming, this does not preclude practically useful outcomes for users of climate projections, of which several illustrations will be provided.

Charles Curry[1], [1]Pacific Climate Impacts Consortium, University of Victoria & School of Earth and Ocean Sciences, University of Victoria cc@uvic.ca

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Radiative Forcing and Feedbacks in Earth's Climate System

Tuesday, May 30
8:30 - 10:00 EDT

(30 Mins) Changes in Earth's relative humidity climatology inferred from satellite observations (how the water vapour feedback operates) - Colin Goldblatt

(15 Mins) Development of a neural network to evaluate radiative feedback - Diana Laura Diaz Garcia

(15 Mins) A novel technique to diagnose stratospheric aerosol effective radiative forcing and global feedback in volcanically forced model simulations - Matthew Toohey

(15 Mins) Sensitivity of past ice sheet evolution using fully coupled ice/climate simulations - Marilena Geng

(15 Mins) Development of a Cloud Parcel Model to Bridge Between Cloud Physics and Aerosol Chemistry - Dan Barthaux

Earth's climate is strongly impacted by its radiative budget, yet climate models are unable to accurately reproduce various aspects pertaining to Earth's radiation budget compared to observations. Our planet's projected climate change is also highly uncertain in large part due to the contribution of radiative feedbacks in the climate system. These feedbacks are induced by various changes in the climate system such as clouds, water vapour, temperature, aerosols and surface albedo, including sea ice in the polar regions, in response to a perturbation to Earth's climate system. Climate radiative feedbacks play an important role in Earth's projected climate change by amplifying or damping Earth's surface temperature response to a radiative forcing such as an increase in anthropogenic-induced greenhouse gas emissions. This session invites submissions on advances in the study of radiative forcing and feedbacks in Earth's climate system. Applications and analyses of small and large-scale models, comparisons against observations and theory are welcome.

CLM-Changes in Earth's relative humidity climatology inferred from satellite observations (how the water vapour feedback operates)

We have developed a climatology of Earths relative humidity profiles over the ocean, and examine how this has changed with time. Our climatology uses a k-means clustering technique applied to data from the Atmospheric Infrared Sounder on Aqua to quantitatively sort observed relative humidity profiles into classes (6 classes for clear-sky observations, 8 classes for all-sky observations). Each class emerges in distinct geographical regions, related to Earths general circulation, and has particular relationships to sea surface temperature and outgoing longwave radiation. The relative humidity profiles of each class in the free-troposphere do not change much with warming, however the distribution of each class and the fraction of the area that each class occupies changes with seasonal and sub-seasonal cycles (ENSO, MJO), and with global warming. Interestingly, the increase in the fractional area of the ocean covered by the moistest and driest classes both increase with warming, somewhat offsetting each other and also increasing the potential for extreme events. A weighted average of our profiles yields a global mean with a boundary layer relative humidity around 80%, decreasing to 35% at 700hPa, then constant through through the rest of the troposphere. This is quite distinct from the oft-used Manabe and Weatherald (1967) profile, which corresponds only to a very limited geographical area and not the global mean.

Colin Goldblatt[1], Carsten Abraham[2] [1]University of Victoria [2]ECCC czg@uvic.ca

CLM-Development of a neural network to evaluate radiative feedback

Most processes, including radiative transfer, in the Earth system are nonlinear; despite of this, the current method to evaluate radiative feedback, is primarily based on linear assumptions (kernel method). Neural networks (NNs) can emulate nonlinear radiative transfer in that their structure and activation functions add nonlinearity to the model. This study aims to test whether neural networks can be used to evaluate radiative feedbacks and also to not use them as a black box, but understand how they work. Our analysis is currently focused on the shortwave radiative feedbacks driven by such feedback variables as surface albedo, cloudiness, and water vapour. To begin, we train NN models based on idealized cases where the truth values are simulated from a radiative transfer model using the partial radiative perturbation method. Two heuristic cases are analyzed: a univariate feedback where only albedo variable is perturbed and a bivariate feedback where albedo and cloud cover are perturbed at the same time. We identify the minimal NN model structure and predictor variables needed for an accurate prediction by analyzing the importance of features and their impact on the prediction of the radiative fluxes. After the evaluation of the NN model developed with the idealized case, a NN model for comprehensive shortwave feedback evaluation is developed using reanalysis data, and is used to evaluate radiative feedbacks from real changes in atmospheric profiles.

Diana Laura Diaz Garcia[1], Yi Huang[1] [1]McGill University diana.diazgarcia@mail.mcgill.ca

CLM-A novel technique to diagnose stratospheric aerosol effective radiative forcing and global feedback in volcanically forced model simulations

Radiative forcing from stratospheric aerosols, particularly following large volcanic eruptions, is the primary external cause of pre-industrial climate variability. Better understanding of aerosol radiative forcing and the climate feedbacks to aerosol forcing may shine light on processes relevant to greenhouse gas warming. The Model Intercomparison Project on the climatic response to volcanic forcing (VolMIP) prescribed a set of experiments with stratospheric aerosol optical properties implemented consistently across participating models. However, it remains unclear to what degree the same aerosol optical properties implemented in different models produce the same radiative forcing. Diagnosing effective radiative forcing (ERF) is usually achieved through dedicated model simulations where sea surface temperatures (SSTs) are held fixedthe ERF represents the instantaneous forcing from the aerosol plus rapid adjustments, but not changes in top-of-atmosphere radiative flux associated with surface temperature changes. Fixed SST experiments were not part of the VolMIP protocol. Here, we show first results using a novel technique to diagnose ERF and the global feedback parameter from the coupled VolMIP volc-pinatubo-full simulations, which assumes that ERF is a linear function of the prescribed stratospheric aerosol optical depth (SAOD). We find a multi-model mean ERF-to-SAOD ratio of -22 W/m2, a value that is broadly consistent with prior estimates, but we also find a wide inter-model spread in the 6 models participating in VolMIP, with values ranging from -17 to -26 W/m2. The global feedback parameter derived for stratospheric aerosol forcing is compared to that for CO2 forcing from other CMIP6 experiments.

Matthew Toohey[1], Yun Xing[1] [1]University of Saskatchewan matthew.toohey@usask.ca

CLM-Sensitivity of past ice sheet evolution using fully coupled ice/climate simulations

The glacial cycles of the last few million years provide a natural experimental record of Earths system response to changes in radiative forcing. It also offers a test for earth system models under different boundary conditions and forcings, which is of high social relevance given current greenhouse gas emission trajectories. Most paleoclimate modelling is non-transient and forced with input ice sheet boundary conditions. As such, two-way consistency between ice and climate may be severely broken for all such modelling. Without the stabilizing influence of a fixed boundary condition or forcing, fully coupled ice and climate models may not capture key aspects of the last glacial cycle without unstably reverting to a super-glacial or non-glacial state. Here, we present an ensemble of transient sensitivity simulations with the fully coupled ice/climate model LCice, which can reproduce the sea level changes of the last two glacial cycles within proxy uncertainties. LCice is a coupled version of the Loveclim Earth system model of intermediate complexity and the GSM glacial systems model. The current configuration includes all four ice sheet complexes and is subject to only orbital and greenhouse gas forcing. We show that capture of the last two glacial cycles is a strong constraint on climate model tuning, with model fit to present-day climate characteristics no guarantee that past ice/climate evolution can be captured. Through sensitivity experiments, we also examine the relative role of forcings (orbital and greenhouse gas) and key feedbacks/couplings (such as albedo, meltwater, and orography) in driving the coupled ice and climate system.

Marilena Geng[1] [1]Memorial University of Newfoundland and Labrador msgeng@mun.ca

CLM-Development of a Cloud Parcel Model to Bridge Between Cloud Physics and Aerosol Chemistry

Clouds are an essential part of weather and climate models. While much progress has been made in understanding cloud formation and droplet activation, the inclusion of physicochemical processes affecting them are often not considered. We will present work on a new particle-resolved parcel model. It tracks each condensation nucleus in an ascending air parcel, can account for fluctuations in supersaturation and allows for the inclusion of semi-volatile organic compounds, which can co-condense into the aerosol particles. We simulate changes in properties such as the effective dry size, wet diameter, surface tension, and hygroscopicity during parcel ascent and cloud formation. We demonstrate that implementing a simple organic-film model impacting surface tension noticeably increases the number concentration of activated droplets compared to using common assumptions of constant surface tensions. The insertion of gasparticle partitioning and associated co-condensation acts to increase the number of activated droplets in general, despite lowering the effective hygroscopicity of the aerosol population. Depending on the aerosol dry size distribution, the changes in particle properties via co-condensation of organics have the potential to alter their direct radiative effect at elevated relative humidity, as well as affecting the radiative albedo of formed clouds. The incorporation of these aerosol processes with the cloud microphysical ones, and the ability to easily manipulate the aerosol population within this custom-built model, can aid in the development of better parameterization schemes for weather and climate models and serve as a tool in the advancement of research into aerosol cloud interactions.

Dan Barthaux[1], Andreas Zuend[1] [1]McGill University dan.hassan-barthaux@mail.mcgill.ca

Satellite Earth Observation: A unique view of our planet and a long-term strategic vision for Canada - Part 4

Tuesday, May 30
8:30 - 10:00 EDT

(15 Mins) Carbon Monoxide and Trends and Events from Two Decades of the MOPITT Instrument - James R Drummond

(15 Mins) Climatologies developed from the Atmospheric Chemistry Experiment (ACE) data set - Kaley Walker

(15 Mins) The Canadian Built OSIRIS Instrument – More than Twenty-Two Years of Operation - Doug Degenstein

(15 Mins) Results from the Atmospheric Chemistry Experiment's MAESTRO spectrometer on CSA's SCISAT satellite in its 20th year - Tom McElroy

(15 Mins) Validation of ACE-FTS version 4.1/4.2 ozone data with ozonesonde measurements - Jiansheng Zou

(15 Mins) Broadband radiative transfer calculations for the EarthCARE mission - Jason Cole

Satellite Earth observation provides a unique global perspective on our planet's atmosphere and surface, including the oceans, land, vegetation, ice, and snow. Current and planned satellite missions from Canada and international agencies have provided and will provide a wealth of new information about the Earth system and that can be used to investigate a wide range of environmental and scientific questions. This session encourages contributions from across the full Earth observation value chain, upstream, midstream and downstream. This includes new measurement technologies and techniques, both passive and active; mission development; retrieval algorithms; demonstration and calibration of instruments; validation of satellite products; assimilation of data into numerical models; scientific results and discoveries; operational utilization and development of services.

MUL-Carbon Monoxide and Trends and Events from Two Decades of the MOPITT Instrument

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 measuring carbon oxide (CO). Although manifested for a 5-year mission, the Terra satellite and MOPITT have now completed more than 23.5 years of operation. The 23+ years of continuous data series from MOPITT provide a great opportunity for investigations all over the globe. The instrument has been very stable and throughout the mission, the data have been validated. The result is a well-characterised time record that can now be mined for a variety of phenomena. Over the time that MOPITT has measured, it appears that the global burden of CO is decreasing, but superimposed on this trend are episodic events, and some of these recent events especially 2020 for both Australia and North America have extremely high values. Using the long MOPITT dataset, it is possible to look at the differences and similarities of these events and

consider whether they are increasing or decreasing. MOPITT was built in Canada by COMDEV of Cambridge, ON, data processing is performed at the National Center for Atmospheric Research in Boulder, CO. The Terra satellite is funded and operated by NASA, and the MOPITT instrument and operations are funded by the Canadian Space Agency.

James R Drummond[1], The MOPITT Team[2] [1]Dalhousie University [2]University of Toronto james.drummond@dal.ca

MUL-Climatologies developed from the Atmospheric Chemistry Experiment (ACE) data set

The Canadian-led Atmospheric Chemistry Experiment (ACE) mission on board the SCISAT satellite has been making routine measurements of the Earths atmosphere since February 2004. The long lifetime of ACE has provided a valuable, nearly two decade-long time series of composition measurements that contribute to our understanding of ozone recovery, climate change and pollutant emissions. The two instruments on board SCISAT use infrared and UV-visible spectroscopy to make their solar occultation measurements. The ACE Fourier Transform Spectrometer (ACE-FTS) is an infrared FTS operating between 750 and 4400 cm-1 and the ACE-MAESTRO (Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation) is a dual UV-visible-NIR spectrophotometer which was designed to extend the ACE wavelength coverage to the 280-1030 nm spectral region. This paper will describe current studies being undertaken using upper tropospheric and stratospheric climatologies derived from ACE measurements and from sampling the specified dynamics version of the Canadian Middle Atmosphere Model (CMAM39) to match the measurement climatologies. This work focuses on ozone and water vapour in the UTLS and on total inorganic chlorine, Cly, in the stratosphere.

Kaley Walker[1], Laura Saunders[1], Niall Ryan[1], Paul Jeffery[1], David Plummer[2], Patrick Sheese[1], Christopher Sioris[2] [1]University of Toronto [2]Environment and Climate Change Canada kaley.walker@utoronto.ca

MUL-The Canadian Built OSIRIS Instrument – More than Twenty-Two Years of Operation

In February 2001, the Odin spacecraft was launched into low earth orbit from a military base in Siberia. Shortly afterward, the Canadian built Optical Spectrograph and InfraRed Imaging System (OSIRIS) began making measurements of vertically resolved, spectrally dispersed limb scattered sunlight. These measurements that contain spectral signatures of ozone, nitrogen dioxide, bromine monoxide and stratospheric aerosol have been used for over two decades to infer global distribution of these key atmospheric constituents and these retrieved distributions have made contributions to many international initiatives including both the quadrennial WMO Ozone Assessment and the IPCC Assessment report. This talk will detail the long history of OSIRIS and will also indicate that the recent scientific advancements, enabled by OSIRIS measurements, imply the best days of OSIRIS may yet be future days.

Doug Degenstein[1] [1]University of Saskatchewan doug.degenstein@usask.ca

MUL-Results from the Atmospheric Chemistry Experiment's MAESTRO spectrometer on CSA's SCISAT satellite in its 20th year

The Canadian Space Agencys SCISAT satellite, carrying the ACE-FTS and MAESTRO (Measurement of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation) which comprise the Atmospheric Chemistry Experiment ACE), was launched in August, 2003. Both instruments continue to provide solar occultation observations of the composition of the upper atmosphere. The satellite is about 1 m in diameter and 1 m deep with a mass of 150 kg. MAESTRO provides measurements of ozone, water vapour and aerosol, as well as nitrogen dioxide during the first years of operation. Like the ACE-FTS, MAESTRO delivers results from nearly 30 occultation measurements per day, but with a higher vertical resolution of just over 1 km over a range as large as 5 to 50 km as meteorological conditions allow. It measures from 500 nm to 1000 nm with a resolution of 1 to 2 nm. The instrument design and performance will be briefly discussed and the algorithms developed to process the data and deal with peculiarities in the performance of the satellite will be described. Recent progress in improving the retrievals has resulted in improved accuracy and a larger number of successful retrievals, especially at lower altitudes. A revised dataset will be released imminently. The results of analyses evaluating the improvements in these retrieval products will be presented. The ACE satellite was funded by the Canadian Space Agency (CSA) and launched by NASA. The CSA funds the MAESTRO data processing. Environment Canada (EC) partly supported the construction of the MAESTRO instrument.

Tom McElroy[1], Kaley Walker[2], James Drummond[3], Jiansheng Jiansheng Zou[2], Paul Jeffery[2] [1]York University [2]U Toronto [3]Dalhousie University TMcElroy@yorku.ca

MUL-Validation of ACE-FTS version 4.1/4.2 ozone data with ozonesonde measurements

The 16-year ACE-FTS version 4.1/4.2 ozone data (2004-2020) are validated with global ozonesonde measurements at more than 40 stations from three networks: Network for the Detection of Atmospheric Composition Change (NDACC), World Ozone and Ultraviolet Radiation Data Centre (WOUDC), and Southern Hemisphere ADditional OZonesondes (SHADOZ). The biases between the ACE-FTS and ozonesonde measurements are first estimated by analysing coincident data. Another approach taken for comparisons with ozonesonde records is to generate ACE-FTS time series by sampling ACE-FTS data within latitude/longitude boxes (5 x 30) surrounding the stations and calculating the monthly mean time series. Biases, correlations, and variation patterns between the two time series are examined. The instrument drifts, i.e., linear trends of the ACE-FTS and ozonesonde difference time series, are assessed over different latitude ranges. There are a number of ozonesonde records experiencing ozone column drop-offs starting around 2016 which can impact the instrument drift calculations. The average instrument drifts, determined by excluding the drop-off stations, are found to be insignificant in the stratosphere. Results from the coincident and time series comparisons and instrument drift calculations for ACE-FTS and ozonesonde measurements will be presented.

Jiansheng Zou[1], Kaley Walker[1], Patrick Sheese[1], Chris Boone[2], Ryan Stauffer[3], Anne Thompson[3], David Tarasick[4] [1]University of Toronto [2]University of Waterloo [3]NASA/Goddard Space Flight Center [4]Environment and Climate Change Canada jzou@atmosp.physics.utoronto.ca

MUL-Broadband radiative transfer calculations for the EarthCARE mission

The EarthCARE satellite mission, whose expected launch date is in mid-2024, aims to deliver unprecedented synergistic datasets that will allow scientists to study global relationships between clouds, aerosols, and radiation. Top-of-atmosphere (TOA) broadband radiances will be measured by EarthCAREs BroadBand Radiometer (BBR) for three along-track views (nadir plus 53 degrees fore and aft) with an across-track swath of 30 km, and pixel resolution of ~0.6 km. These radiances are subsequently converted into BB upwelling solar and infrared fluxes at TOA. To perform radiative assessment, 1D and 3D forward radiative transfer models will operate on clouds and aerosols derived from passive and active measurements made concurrently by EarthCAREs multi-spectral radiometer, backscattering lidar, and cloud-profiling radar. This paper will describe the 1D and 3D forward radiative transfer and illustrate the importance of using 3D radiative transfer for the radiative assessments.

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Plenary - Opportunities and Risks for Ocean and Climate Science to Contribute to an Equitable and Sustainable Future

Tuesday, May 30
11:30 - 12:15 EDT

Presented by: Dr. Gerald Singh, PhD, University of Victoria

Interest in ocean and coastal areas is growing both as areas of potential climate change mitigation as well as for emerging economic activity. Several national and international policies and platforms have been established for ocean and climate science communities to help aid these sustainable development initiatives (such as Canada's Blue Economy and the UN Decade of Ocean Science for Sustainable Development), through helping identify opportunities and risks to ocean economies and coastal communities. However, there are opportunities and threats presented by the models of science implemented through these programs. For example, if science is not aligned with policy actions the applicability of the science will be limited. I will discuss areas where I think the science community may inadvertently contribute to risks towards sustainable development and Blue Economy aspirations, as well as potential (and largely unexplored) opportunities for the science community to aid better decisions towards sustainable development aspirations.

Advancing science and technology for monitoring greenhouse gases - Part 1

Tuesday, May 30
12:30 - 14:00 EDT

(15 Mins) Joint use of NO2 and CO2 measurements from space to quantify CO2 emissions in the Northern high latitudes - Nasrin Mostafavi Pak

(15 Mins) Comparing Total Column and Mobile In Situ Estimates of Methane Flux from Landfills in Southern Ontario - Lawson Gillespie

(15 Mins) Mobile survey of greenhouse gas concentrations in Greater Montreal: Preliminary analysis of seasonal emissions variability and spatial interpolation methods - Jacob Asomaning

(15 Mins) Quantifying Facility-Scale CO2 Emissions using OCO-2 and OCO-3 and the potential for future operational monitoring - Ray Nassar

(15 Mins) Quantifying emissions of CO2 from the Bełchatów power plant using OCO-3 data and the WRF-XSTILT model - Zixuan Xiao

Climate action needs to be based on accurate knowledge of the emissions, distribution, and sinks of greenhouse gases. The objective of Canada and other nations to achieve net-zero greenhouse gas emission requires the monitoring of atmospheric greenhouse gases concentrations at unprecedented levels, to understand their variations, identify optimal emission control strategies and verify achievement of reduction goals based on inventories. We welcome abstracts aiming to address this grand challenge and to improve the science and technology of greenhouse gas monitoring, including but not limited to the following aspects:

Science and technology developments to measure greenhouse gases, including carbon dioxide, methane, and other potent radiative gases, in the atmosphere and from emissions sources at varying scales ranging from global to national, regional and city levels.

Field as well as theoretical and modeling studies, especially those deploying a top-down measurement-based approach, to understand greenhouse gas distribution in space and time and to identify and quantify emission sources.

We encourage submissions using a wide range of measurement methods including mobile surveys, eddy flux measurements, isotopic analyses for source apportionment, remote sensing from the ground and from space, vertical profiling, and studies that compare direct measurements with inventory-based emission estimates.

CLM-Joint use of NO2 and CO2 measurements from space to quantify CO2 emissions in the Northern high latitudes

The Government of Canada has committed to achieve net zero greenhouse gas emissions by 2050. Monitoring greenhouse gas levels in the atmosphere is necessary to evaluate the effectiveness of the countrys emission reduction plan. The Arctic Observing Mission is under consideration by the Government of Canada with the aim to measure greenhouse gas and air pollutant abundances in Northern high latitudes from space. To monitor greenhouse gas emission trends, investigating emissions from large point sources and area sources is of great importance. Due to its relatively short atmospheric lifetime, measurements of NO2 abundances from space can be employed to identify large industrial sources and urban areas with high CO2 emissions associated with fossil fuel combustion. In this study, we identify large industrial sources and hot spots in urban areas in Canada and other high latitude countries using TROPOMI NO2

retrievals and OCO-2 and OCO-3 CO2 retrievals. We compute the CO2/NO2 enhancement ratios for different regions and industries and compare them with the values derived from bottom up emission inventories.

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CLM-Comparing Total Column and Mobile In Situ Estimates of Methane Flux from Landfills in Southern Ontario

Direct, facility-level measurements of methane emissions are an important tool for verifying highly uncertain methane emissions inventories. In this presentation, we introduce flux estimates derived from coincidental total column and mobile in situ measurements of methane emitted from the Twin Creeks and Petrolia landfills in Southern Ontario from summer measurement campaigns in 2021 and 2022. Within the urban environment, solid waste treatment represents the largest, and one of the most uncertain sources of methane emissions. These sites measured two very different landfills, at disparate stages in their life cycles. Petrolia is a smaller, closed site of approximately 0.25 square kilometers producing electricity from generators powered by a renewable biogas capture system. Twin Creeks is a large, active landfill about four times larger with a significant open working face. We took XCH4 measurements with two ground based solar tracking portable FTIR EM27/Sun spectrometers, located on prevailing upwind and downwind sides of the landfill. We use a mass-balance approach to quantify emissions between the upwind and downwind measurement sites. During these measurements, coincidental mobile in situ concentrations were recorded by different vehicle-based laboratories. We use an inverse Gaussian plume model to quantify emissions from multiple downwind plume transects of atmospheric methane concentrations, taken on multiple days under different wind conditions. We present and analyze estimates of the methane emissions from both facilities from each of these experimental methods.

Lawson Gillespie[1], Sebastien Ars[2], Nasrin Pak[3], Felix Vogel[2], Debra Wunch[3] [1]University of Toronto/ECCC [2]ECCC [3]University of Toronto lgillespie@physics.utoronto.ca

CLM-Mobile survey of greenhouse gas concentrations in Greater Montreal: Preliminary analysis of seasonal emissions variability and spatial interpolation methods

Mobile surveys can be a powerful tool for identifying greenhouse gas (GHG) emissions sources, estimating emissions fluxes, and analyzing the spatial distribution of GHG sources and surface-level concentrations in complex urban environments. Montreal is a large urban center with a highly seasonal climate, and seasonal temperature and precipitation variability may have a large influence on specific important urban CH4 and CO2 fluxes. Identifying and quantifying this seasonal variation could be important for accurate monitoring of Montreal GHG emissions, and for verifying emissions inventories. We are developing a project to carry out high-frequency mobile surveys by automobile and bicycle in the Montreal metropolitan region to analyze spatial and temporal variability in surface level CH4 and CO2 concentrations, and to monitor seasonal variability in emissions from key point sources of CH4, including active and inactive landfills, sewage and wastewater treatment infrastructure, natural gas transport infrastructure, and urban waterways. In this poster we present data collected in mobile surveys from November 2019, May 2022, and March-April 2023. We identify key zones

of CH4 emissions plumes and likely sources, and use plume modelling to estimate emissions fluxes during the different measurement periods. We also analyze different spatial interpolation methods for developing maps of GHG concentrations across the urban area as for comparison with vertical profile measurements and as inputs for numerical modeling studies. Finally, we assess the utility mobile survey data to analyze large-scale spatial patterns in surface CO2 concentrations related to the density of roadways, housing, and vegetation.

Regina Gonzalez-Moguel[1], Jacob Asomaning[1], Peter Douglas[1], Felix Vogel[2], Sebastien Ars[2], Yi Huang[1], Djordje Romanic[1], John Gyakum[1] [1]McGill University [2]Environment and Climate Change Canada regina.gonzalezmoguel@mail.mcgill.ca

CLM-Quantifying Facility-Scale CO2 Emissions using OCO-2 and OCO-3 and the potential for future operational monitoring

We will review capabilities for quantifying power plant CO2 emissions and emission changes using observations from NASAs Orbiting Carbon Observatory-2 and 3 (OCO-2/3) missions with a series of examples. These examples include CO2 emission estimates from OCO-3 Snapshot Area Mapping (SAM) mode observations, the first facility-scale emission quantification using OCO-2 Target mode and efforts to quantify emissions from smaller facilities by combining multiple overpasses, building off our earlier work with simulated data. Notable examples include CO2 emission changes at US power plants where the accuracy is assessed against reported hourly emissions, emissions from Bełchatów (Europes largest fossil fuel burning power plant) and new results for Canadian CO2 emission sources. This research gives a glimpse of the potential capabilities and limitations of upcoming CO2 imaging satellite missions and reinforces the value of such data to support operational monitoring and verification of CO2 emissions for climate change mitigation including the UNFCCC Paris Agreement.

Ray Nassar[1], Omid Moeini[1], Jon-Paul Mastrogiacomo[2], Chris O'Dell[3], Robert Nelson[4], Matthäus Kiel[4], Greg Osterman[4], Abhishek Chatterjee[4], David Crisp[5], Annmaire Eldering[6] [1]Environment and Climate Change Canada [2]University of Toronto [3]Colorado State University [4]Jet Propulsion Laboratory [5]Crisp Spectra [6] National Institute of Standards and Technology ray.nassar@ec.gc.ca
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CLM-Quantifying emissions of CO2 from the Bełchatów power plant using OCO-3 data and the WRF-XSTILT model

Atmospheric CO2 concentration has increased dramatically since the pre-industrial period due to human activity such as fossil fuel combustion and land use change. Space-based measurements offer an effective means of monitoring changes in atmospheric CO2, and of quantifying surface fluxes of CO2 using inverse modeling approaches. In this context, better monitoring and quantifying emissions from power plants is critical as electricity power generation is responsible for more than 40% of globalanthropogenic CO2 emissions. Here we use observations of column-averaged dry air mole fraction of CO2 (XCO2) from NASAs Orbiting Carbon Observtory-3 (OCO-3) Snapshot Area Maps (SAMs) together with the column version of the Stochastic Time-Inverted Lagrangian Transport (X-STILT) model to quantify emissions from the Bełchatw power plant in Poland. The Bełchatw power plant is the 5thlargestfossil fuel burning power plant worldwide,with reported emissions of more than 100 ktCO2 per day. To produce simulated XCO2, X-STILT is driven by the Weather Research and Forecasting (WRF) model with a grid spacing of 1 km and convolved with a priori CO2

emissions from the Open-source Data Inventory for Anthropogenic CO2 (ODIAC). The modeled XCO2 are then integrated with XCO2 data from OCO-3 in a Bayesian inversion approach to constrain daily CO2 emissions from theBełchatw power plant.

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Atmosphere, Ocean, and Climate Dynamics - Part 2

Tuesday, May 30
12:30 - 14:00 EDT

(15 Mins) Reflection of Rossby waves from the western boundary and quasi-permanent meanders of the Kuroshio Extension - Iakov Afanassiev

(15 Mins) High-resolution numerical modeling used understand precipitation mechanisms over the central Himalaya - Ujjwal Tiwari

(15 Mins) Turbulence in the deep ocean: understanding the interaction of currents with underwater topography - Marie Babineau

(15 Mins) Precipitation and the impact of lakes in North American continental-scale regional climate simulations - Mani Mahdinia

(15 Mins) Assessing errors in near-surface wind speeds in the CRCM6-GEM5 model using AmeriFlux data - Alejandro Di Luca

This session combines submissions that document studies of the dynamics of the atmosphere, oceans and/or climate system. The scope of the session is deliberately broad in order to include research that spans a broad range of spatial and temporal scales. Studies of the dynamics of mesoscale processes that act on hourly timescales are as welcome in this session as those that document the evolution of planetary-scale structures in a changing climate. Such investigations may include diagnoses and theoretical studies of forecast, climate, and process models, or studies based on reanalysis and other observational datasets; however, any topic that is relevant to atmosphere, ocean, or climate dynamics will fit well into this session. Please note we have run this session at CMOS Congresses since around 2009.

MUL-Reflection of Rossby waves from the western boundary and quasi-permanent meanders of the Kuroshio Extension

An interesting feature of the Kuroshio Extension is two large meanders located just eastward of the point where the current separates from the coast of Japan. Motivated by this observation, we model an entire subtropical gyre in the rotating water tank. The flow is forced by mass injection within the domain. Laboratory altimetry provides accurate records of the circulations that reveal the emergence of propagating -plumes (Rossby-

wave envelopes) which close at the western boundary of the domain with a jet-like western boundary current. Experiments are supplemented by numerical simulations and theory which extend the range of control parameters. We demonstrate that meanders occur in the northern branch of the gyres, within an eastward current similar to those in the Kuroshio Extension. The meanders are due to the Rossby wave reflection from the boundary rather than any bottom topography feature as was hypothesized for the Kuroshio Extension. The wavelength of the meanders is selected by the condition of stationarity of the westward propagating Rossby-wave phase within an eastward current.

Iakov Afanassiev[1], Yang Zhang[2] [1]Memorial University of Newfoundland [2]Guangdong Ocean University afanai@mun.ca

MUL-High-resolution numerical modeling used understand precipitation mechanisms over the central Himalaya

The interaction between the synoptic monsoon flow and the complex topography results in a distinct precipitation pattern over the central Himalaya. However, the scarcity of surface and upper-air observations in the Himalaya poses a significant challenge to understanding the mesoscale structures associated with precipitation dynamics. In this study, we applied the Weather Research and Forecasting (WRF) model at convection-permitting 1 km horizontal resolution over the central Himalaya during the core monsoon period (July and August) of 2013 to examine the precipitation mechanism over the central Himalaya. The comparison of our WRF output with the high-altitude station data indicates that the WRF model performs well in capturing the spatial and temporal precipitation variability over the central Himalaya. Analysis of our WRF output shows that the radiative heating/cooling of the Himalayan slopes controls the moisture flow pattern during the diurnal cycle, which then determines the precipitation intensity and timing over the high-altitude regions of the central Himalaya. Additionally, glaciers in the central Himalaya have a strong control over the timing of precipitation because the downslope flows from the cold glaciers are blocked by the topographically-heated upslope flow along the lower Himalayan slope, causing the precipitation at high altitudes to start only by the evening once the downslope heating has ceased.

Ujjwal Tiwari[1], Andrew B.G. Bush[1] [1]University of Alberta utiwari@ualberta.ca

MUL-Turbulence in the deep ocean: understanding the interaction of currents with underwater topography

Internal waves, known as lee waves, are generated by stratified currents flowing over topography. Several studies show that lee wave breaking is an important contributor to mixing in the water column. However, questions about the rates at which these waves are generated and where they dissipate remain. In the southern ocean, lee wave energy dissipation rates derived from observations are 2 to 3 times lower than theoretical models predictions. These models were often simplified by assuming a constant background current. Furthermore, recent work by Kunze Lien (2019) and Baker and Mashayek (2021) demonstrated such simplification could explain the discrepancies. To test the impact of depth varying currents on lee wave energetics and energy dissipation, we ran numerical simulations using idealized 2D sinusoidal bathymetry. These simulations show that wave-mean flow interactions change the wave frequency, group velocity and energy path, and the wave kinetic energy through energy exchanges with the background current. Additionally, we demonstrate that when the lee wave frequency is Doppler-shifted to the local Coriolis parameter, f, they become evanescent and

dissipate. In contrast, when the lee wave frequency is Doppler-shifted to the local Buoyancy frequency, N, they reflect downwards generating interference patterns and areas of enhanced energy dissipation.

Ruth Musgrave[1], Marie Babineau[1] [1]Dalhousie University RMusgrave@dal.ca

MUL-Precipitation and the impact of lakes in North American continental-scale regional climate simulations

Despite the successes of global climate models (GCMs), phenomena like alpine snowpack, lake effects, and orographic precipitation are under-resolved in GCMs, so regional climate models (RCMs) are vital for better representing such features. This studys goal is to represent major drivers of the North American (NA) climate, such as mountain ranges, and particularly lakes, in a regional climate model. We use the Weather Research and Forecasting (WRF) model, forced by the recent ERA5 reanalysis, with intermediate/high resolutions of ~22/~11 km. The representation of precipitation is evaluated against observations, with special attention given to snow representation, highlighting the increasing level of detail in RCM simulations. Also, large lakes, a major component of the NA landscape, are known to have a considerable effect on their surrounding regions (e.g., lake-effect precipitation), and so different lake models as well as different setups are investigated to determine which renders the best representation of reality, not only in the immediate vicinity of the lakes, but also in the wider lake-affected regions. Investigated lake regions include major lakes (e.g. Laurentian Great Lakes) and regions with smaller lakes (e.g. the Canadian Shield). The evaluated lake models include the default model, FLake (a widely used empirical model) and the GLERL model (a physics-based model). Furthermore, the representation of the seasonal snowpack is evaluated against observations, e.g., the recent CanSWE datasets. This is of particular interest in lake-effect snow regions, and also in regions of strong orographic precipitation such as the Coast and Rocky Mountains of western Canada.

Mani Mahdinia[1], Andre Erler[2], Yiling Huo[3], W. Richard Peltier[4] [1]University of Toronto Department of Physics, Aquanty [2]Aquanty [3]PNNL [4]University of Toronto Department of Physics mani.mahdinia@utoronto.ca

MUL-Assessing errors in near-surface wind speeds in the CRCM6-GEM5 model using AmeriFlux data

The wind speed near the surface is a key variable in several applications, including the calculation of heat and windchill indices to quantify impacts on human and animal health, the assessment of the potential for wind-generated electricity and the evaluation of high wind hazards in weather forecasting. We study the ability of version 6 of the Canadian Regional Climate Model, which is based on version 5 of the GEM (Global Environmental Multiscale) model, to simulate near-surface wind speeds, friction velocity and other near-surface variables using data from 39 stations measuring eddy-covariance fluxes across North America. The model, which uses the Monin-Obukhov similarity theory to estimate the wind speed near the surface, is tested using various configurations including different land-surface models, stability functions and strategies to deal with stable regimes. We find that the model has difficulties representing the wind speeds and friction velocity, particularly when the atmosphere is in a stable regime. The newer version of the model has made some changes to address the very stable regime. We find that while the windspeeds are improved in some cases, it introduces

anomalous peaks in friction velocities that are inconsistent with observations. We discuss the use of the Monin-Obukhov similarity theory in the model when some assumptions are violated.

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Defence Applications of Oceanography

Tuesday, May 30
12:30 - 14:00 EDT

(30 Mins) Temporal Dependence of Seafloor Scatter Measurements on Environmental Variability - Jenna Hare

(15 Mins) Reducing false alarm rates for coherent change detection with Synthetic Aperture Sonar (SAS) interferometric phase statistics - Emma Shouldice

(15 Mins) Marine Mammal Mitigation during High-power Sonar Trials - Joshua Tabor

(15 Mins) Creating an ensemble GIOPS ocean analysis: Progress and Application - K Andrew Peterson

(15 Mins) Evaluating the impact of operational oceanographic products on acoustic performance predictions - Emma Shouldice

The session aims to cover a variety of oceanographic and meteorological application to defence research for coastal, continental and open ocean environments. Submissions related to any defence activity that enhances situational awareness in the ocean are acceptable for this session, including but not limited to the following: Environmental impact assessment of defence activities, Short- and long-term ocean modelling, Forecasting of water column or seabed properties, Seabed imaging, Acoustic propagation, Ambient noise measurement, Underwater acoustic communication Authors will give a 20-minute presentation including time for questions and discussions.

OCE-Temporal Dependence of Seafloor Scatter Measurements on Environmental Variability

In the ocean, active sonar systems are used for the purposes of navigation, animal monitoring, object detection, or sea-bed classification. Importantly, the performance of these systems depends on the acoustic properties of the seafloor, which is often assumed to have no temporal dependence. However, daily to monthly variations in near-bottom hydrodynamics and biological activity may affect seafloor properties and, in turn, influence the acoustic response of the seafloor. Previous work has mainly focused on the dependence of seafloor scatter on sediment type, transmit frequency and incidence angle. Thus, questions remain as to the dependence of seafloor scatter on evolving environmental parameters. We are interested in measuring seafloor scatter using high-frequency active acoustic systems to determine the dominant environmental parameters that regulate seafloor scattering on daily to monthly time scales. We

analyzed several datasets from a series of experiments containing seafloor scattering measurements from downward-looking sonars deployed in two shallow water locations: a wave-dominated site and a site dominated by strong tidal currents. The experimental set-up consists of a tripod placed on the seafloor equipped with three transducers operating at 38 kHz, 70 kHz and 200 kHz and other sensors providing environmental measurements (e.g., temperature, salinity, water depth and significant wave height). Daily, weekly and monthly trends in mean scattered levels and the mechanisms causing their temporal variability are discussed. The results will increase our understanding of the interaction between high-frequency sound and the ocean floor, leading to improved remote-sensing techniques for object detection and continuous seafloor monitoring.

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OCE-Reducing false alarm rates for coherent change detection with Synthetic Aperture Sonar (SAS) interferometric phase statistics

Coherent Change Detection (CCD) compares Synthetic Aperture Sonar (SAS) image pairs to detect small-scale changes to the seafloor. Coherence loss between image pairs, increases the false alarm rate by making it difficult for an operator to distinguish between tactically relevant seafloor changes and other sources of decorrelation. A method to differentiate between possible sources of decorrelation is presented and builds upon the interferometric phase statistics developed for Synthetic Aperture Radar (SAR). A single-pass pair of SAS images is categorized into four zones based on acoustic amplitude and coherence properties. Results suggest that regions of low coherence caused by a scene change can be differentiated from regions of low coherence due other sources of decorrelation. Phase statistics could provide a technique to reduce the false alarm rate in CCD. Further studies are required to validate the approach for repeat-pass SAS imagery and consider the effects of temporal decorrelation and misregistration errors on the phase distributions

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OCE-Marine Mammal Mitigation during High-power Sonar Trials

Low- and mid-frequency high-power sonar have been shown to adversely impact marine mammals. When high-power sonar trials and experiments are necessary, they must be conducted responsibly including implementation of a comprehensive plan to mitigate risk. This includes focused efforts during trial planning and execution. It starts with analyzing important influence metrics such as sound exposure level (SEL) along with acoustic modelling and then structuring trials to limit these as much as possible. Residual risk is managed by defining an exclusion zone and performing visual and/or acoustic monitoring for marine mammals during trials, with sonar shut down when marine mammals are detected within the exclusion zone. GeoSpectrum, a leading manufacturer of sonar systems, developed a comprehensive mitigation plan with the aid of local industry experts. This includes planning tools, monitoring equipment, specialized training, and all required approvals. We will provide information about our process and tools, including valuable lessons learned.

Joshua Tabor[1], Alex Whitworth[1], Matt Coffin[1] [1]GeoSpectrum Technologies Inc.
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OCE-Creating an ensemble GIOPS ocean analysis: Progress and Application

Quantifying uncertainty in ocean forecasting products has been identified as a major objective for the Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) program. As part of that initiative, and in general to move forward with global ocean analysis systems at the Canadian Centre for Meteorological and Environmental Predictions (CCMEP), we have been working towards creating an ensemble ocean analysis. Using existing ensemble atmospheric analysis and forecast to sample uncertainty in ocean surface boundary forcing, along with a suite of stochastic parameter perturbations (SPP) and stochastic perturbed physics tendencies (SPPT) to further sample uncertainty in ocean modelling dynamics, an ensemble version of the ocean analysis component of the global ice ocean prediction system (GIOPS) has been created. We will show how this system both creates suitable spread to sample uncertainty in the system, as well as reducing the error in the system. Potential use of these uncertainties to better constrain error covariance relations in the analysis will be mentioned. Potential applications to probabalistic prediction of shallow sound ducts in the ocean and reducing unconstained error in ocean current predictions will also be discussed.

K Andrew Peterson[1], Gregory Smith[1], Cristina Tollefsen[2], Andrea Storto[3] [1]Environment and Climate Change Canada [2]Defence Research and Development Canada [3]Consiglio Nazionale delle Ricerche andrew.peterson@ec.gc.ca

OCE-Evaluating the impact of operational oceanographic products on acoustic performance predictions

Sonar performance is affected by the ocean bottom depth and composition, surface roughness, and vertical sound speed profile (SSP). The impact of using operational oceanography outputs to forecast acoustic conditions was investigated through a combination of measurements and modelling. The Forecasting Acoustic VAriability (FAVA) 2020 trial consisted of a Royal Canadian Air Force (RCAF) flight on 09 Oct 2020 which acquired a combined environmental-acoustic dataset consisting of 14 temperature profiles and a 2-hour acoustic transmission loss (TL) dataset in a 225 nmi2 area near the North Wall of the Gulf Stream. The Canadian operational ocean models accurately predicted mixed layer depth but disagreed with observations of mixed layer temperature and its gradient below the mixed layer. Two acoustic propagation paths were observed, a faint intermittent surface duct path and a strong stable bottom bounce path. Acoustic propagation modelling using SSPs derived from the in situ measurements and operational ocean models accurately predicted TL for the bottom-bounce path, and showed some evidence of a surface duct propagation path. An ensemble version of the ocean model was used to investigate the probability of surface duct occurrence, first, by directly providing an ensemble of SSP inputs for the acoustic model, and second, by analyzing the ensemble SSP features across a wide area. The FAVA 2020 trial resulted in a unique dataset for analyzing acoustic and environmental variability, as well as for assessing the impact of using operational ocean model outputs as inputs to acoustic propagation models.

Cristina D. S. Tollefsen[1], K. Andrew Peterson[2] [1]Defence Research and Developemtn Canada [2]Environment and Climate Change Canada cristina.tollefsen@gmail.com

Discussions on development, evaluation and analysis of ocean circulation and biogeochemical models or Developing Ocean Modelling Capacity in Canada - Part 1

Tuesday, May 30
12:30 - 14:00 EDT

(15 Mins) Sea ice locking of icebergs in Baffin Bay - Juliana Marson

(15 Mins) Exceptional sea ice loss leading to anomalously deep winter convection north of Svalbard in 2018 - Chuanshuai Fu

(15 Mins) Downstream propagation of biases in the modelled Labrador shelf-break current - Jared Penney

(15 Mins) Toward a one-dimensional model of the spring phytoplankton bloom on the Newfoundland and Labrador shelf - Jared Penney

(15 Mins) A novel approach for implementing freshwater fluxes into nearshore ocean models - Laura Bianucci

(15 Mins) Improving a Coastal Ocean Model Configuration: Rivers, Bathymetry, Surface Waves and Resolution - Susan Allen

Ocean circulation and biogeochemical models are widely used for both research and operational forecasting. However, there are challenges for small research groups to handle the increasing complexity of the model codes, evaluation with various observational datasets, and analysis of the increasing amount of model output data. This session aims to stimulate discussions on potential coordination and collaboration between Canadian government laboratories and universities in the development, evaluation and analysis of ocean circulation and biogeochemical models for hindcast and forecast at various time scales. Specific topics may include:

1 progress of model research and applications in various regions with different spatial resolutions;

2 new evaluation and analysis results that demonstrate the strength and weakness of the models;

3 improvements in model numerics and parameterization of sub-grid processes;

4 new analysis methods;

5 new forcing and evaluation datasets;

6 model inter-comparison; and

7 data presentation and visualization tools.

OCE-Sea ice locking of icebergs in Baffin Bay

Every year in spring, the International Ice Patrol carefully monitors the coast of Newfoundland and Labrador for icebergs that can pose a threat to navigation. Icebergs reaching this region come mostly from west Greenland, and many need to cross Baffin Bay before reaching the Labrador Sea. In their journey, icebergs are affected not only by ocean currents and winds but also by sea ice conditions. Numerical models used to study and predict iceberg trajectories still represent the sea ice forcing on icebergs as a simple drag force. However, it has been observed that when sea ice concentration and strength are high, icebergs are locked inside the sea ice pack, which then moves as a continuum. In this study, we introduce a new parameterization in the Nucleus for European Modelling of the Ocean (NEMO) iceberg module to represent this sea ice-locking condition. Results show that icebergs will tend to cross Baffin Bay (instead of following its cyclonic circulation) more frequently during winter. The locking behaviour and associated iceberg trajectories obtained from the model is supported by iceberg beacon data and remote sensing of sea ice and icebergs.

Juliana Marson[1], Paul Myers[2] [1]University of Manitoba [2]University of Alberta Juliana.MariniMarson@umanitoba.ca

OCE-Exceptional sea ice loss leading to anomalously deep winter convection north of Svalbard in 2018

Deep convection sites, where deep waters are ventilated and air-gas exchange into the deep ocean occurs, have begun to exhibit a trend of moving northward into the Arctic Ocean. We conduct this study by using the regional configuration Arctic and North Hemisphere Atlantic of the ocean/sea ice model NEMO, running at 1/12 resolution (ANHA12). Focusing on a region near the Arctic gateway of Fram Strait, our study identifies a significant sea ice cover reduction north of Svalbard in 2018 compared to the past decade, shown in both ANHA12 and the observations. The open water condition allows intense winter convection over Yermak Plateau in 2018, because more oceanic heat is lost to the atmosphere without the insulating sea ice cover, causing the mixed layer depth to be over 400 m. The sea ice loss is primarily attributed to the excess heat brought by the Atlantic Water, which reaches its maximum in the preceding winter in Fram Strait. The anomalous wind prior to the deep convection event forces offshore sea ice movement and partly contributes to the reduced sea ice cover. The deep convection event corresponds to enhanced mesoscale eddy activity on the boundary of the Yermak Plateau, especially to the east. The resulting substantial heat loss to the atmosphere also leads to a heat content reduction integrated over the Yermak Plateau region. This event can be linked to the minimum southward sea ice volume flux through Fram Strait in 2018, which is a potential freshwater anomaly in the subpolar Atlantic.

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OCE-Downstream propagation of biases in the modelled Labrador shelf-break current

The Newfoundland and Labrador (NL) continental shelf provides important habitats for a variety of marine species, many of which have economic and cultural importance in the NL region. Since 1998, the Atlantic Zone Monitoring Program (AZMP) has performed

physical oceanographic measurements of a consistent set of transects along this shelf, in order to build an understanding of climatological conditions and interannual variations. Oceanographic modelling can complement this data by providing a testbed for hypothesized causal mechanisms for the observed variations. However, it can only provide an approximate picture of historical processes, due to the limited spatial scales of resolved phenomena and empirical parametrizations for unresolved phenomena. Non-linear processes in regions of strong gradients, like exchange across the Labrador frontal shelf-break current, are the least likely to be represented accurately, due to their sensitivity to the representation of the oceanographic state. This presentation compares NL shelf oceanographic conditions from AZMP observations against those from the GLORYS12 model, which is a global, oceanographic reanalysis product that covers years 1993 to 2019 at 1/12deg resolution. Biases between the modelled and observed data are identified on the northern Labrador transects in the region of the shelf-break current. The existence of cross-shelf flows and mixing during downstream advection can lead to the spread of these biases into the interior of the continental shelf. This presentation explores how uncertainties and biases in shelf-break processes can affect the representation of shelf conditions as a whole.

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OCE-Toward a one-dimensional model of the spring phytoplankton bloom on the Newfoundland and Labrador shelf

In temperate seas, the spring phytoplankton bloom is a key driver of overall marine productivity. Variability in the timing and magnitude of the bloom impacts the reproduction, growth and recruitment of many higher trophic level species and affects the global carbon cycle. This presentation will discuss the development of a one-dimensional nutrient-phytoplankton-zooplankton-detritus (NPZD) model to forecast the spring phytoplankton bloom on the Newfoundland and Labrador shelf and investigate its timing under an ensemble of different hypothetical forcing conditions. The model is based on a bloom forecasting model designed to simulate conditions in the Strait of Georgia that accounts for a number of physical, chemical, and biological processes that affect phytoplankton growth and is forced using available observational data. Initial efforts have focused on representing the physical conditions at Atlantic Zone Monitoring Program Station 27 (47.55N, 52.59W), for which multidecadal time series of oceanographic data are available for model formulation and validation. Initial model development has included the analysis and implementation of forcing, boundary, and initial conditions appropriate for Station 27, as well as the design of region-specific modifications, such as parameterizations of physical processes like freshwater flux and wind-driven coastal upwelling. Results of early model tests driven using historical data for comparison with physical observational data will also be presented.

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OCE-A novel approach for implementing freshwater fluxes into nearshore ocean models

Nearshore ocean ecosystems are vital areas, extensively used for traditional, recreational and economic services. These socially and economically important ocean

margins are, however, often difficult to monitor with enough spatial and temporal resolution to accurately constrain both present-day dynamics and any potential future changes. This is particularly true for fjord and inlet systems. These regions are home to numerous fisheries and communities, are characterized by unique circulation features and steep bathymetric gradients within narrow channels, and are highly influenced by freshwater inputs. Increasing oceanographic monitoring and using high-resolution ocean models are ways to better understand these complex ocean ecosystems. However, it is nearly impossible to gauge all of the numerous rivers and streams impacting fjord systems, which is an important factor towards characterizing these regions. Here, we use a high-resolution FVCOM model of Quatsino Sound, located on the northwest corner of Vancouver Island in British Columbia, as a case study to investigate into the impacts of river discharge on fjord systems, and how to better simulate freshwater inputs in high-resolution nearshore models. We show results from model sensitivity tests using simple rainfall-runoff models to estimate river discharge into Quatsino Sound. Our methods and results can be applied to other coastal models and highlight whether simulating even relatively small rivers can be important for accurately simulating conditions in nearshore regions.

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OCE-Improving a Coastal Ocean Model Configuration: Rivers, Bathymetry, Surface Waves and Resolution

Once a numerical configuration is working, one has a long list of possible improvements to increase accuracy. Here we will discuss refinements to our coastal model with the goal of aiding other modellers in prioritizing. SalishSeaCast is model of the Salish Sea based on the NEMO modelling framework. We will discuss our experiments with four types of improvements: changing the river forcing, the bathymetry, the parametrization of the impact of surface waves on mixing and the model resolution. We will also present a useful method for surface current evaluation based on drifters. The fresh water forcing in the Salish Sea is dominated by the Fraser River and this river has always been forced using daily, observed values. Change One is moving all other river discharges from monthly climatologies to daily values based on observations of a few gauged rivers. The original bathymetry used the mean-sea-level isobath as the coastline and deepened all water shallower than 4m to 4m. Change Two is moving the coastline to the 2m isobath. The original surface wave parameterization was the default in NEMO. Change Three is moving to a coastal wave parameterization. The original resolution was about 500m in the horizontal and 1m to 27m in the vertical. Change Four is increasing the resolution in all three dimensions by a factor of two. For each change we will briefly describe the rationale behind the advancement, how the improvement was implemented, the major resulting enhancements to the model results and the difference in evaluation statistics.

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MSC-Overview of numerical modelling tools and services from the Canadian Metorological Centre - Part 2

Tuesday, May 30
12:30 - 14:00 EDT

(15 Mins) Developing an Uncertainty Budget for Air Temperature Measurements in the Meteorological Service of Canada's Automatic Weather Station Network - Annie Chow

(15 Mins) MSC automatic weather station measurement uncertainty at high temperatures - Jeffery Hoover

(15 Mins) Data Rescue of 19th Century Canadian Weather Observations: scouring past records to understand climate variability and extreme events - Victoria Slonosky

(15 Mins) GEMnet1.0 : A CNN based simulator for MSC's global forecast model using archived model data - Vikram Khade

(15 Mins) Using Self-Organizing Maps to Improve Understanding of Extreme Wind Gusts in Canada - Alessio Spassiani

This MSC session aims to provide an overview of the myriad of numerical modelling tools and services offered by the development division at CMC, and to look at how new innovations are helping bridge the gap between raw modelling output and the production of weather forecasts for Canadians. Modelling data is provided to support many client requirements, and the community must be actively modernizing to adapt to changing demands. Presentations will cover the specifics of the systems and products now in use, discuss how updates will unfold in the years ahead (including the process for continuous development), examine different means by which the application of post processing algorithms can add value to the numerical data, and show examples of how these systems can aid in the forecasting process. The goal of these presentations is to outline what is happening within the modelling community, and to stimulate discussion about how to meet future needs.

ATM-Developing an Uncertainty Budget for Air Temperature Measurements in the Meteorological Service of Canada's Automatic Weather Station Network

The Meteorological Service of Canada (MSC) operates a surface network of approximately 600 Automatic Weather Stations (AWS) across Canada, where air temperature data is collected. Data is central to MSCs mission to provide timely and accurate weather, water and climate services to Canadians. Monitoring data of known quality is an essential component to this mission. It is of particular importance to fully quantify the measurement uncertainty of the system. Current work on air temperature in the MSC focuses on metrological traceability and calibration processes of the operational and reference sensors. Environmental effects on the quality of air temperature measurements at the AWS level require more exploration and present a novel area for metrological research. The objective of this research is to develop an uncertainty budget for air temperature measurements in the AWS network, with a particular focus on the World Meteorological Organization (WMO) Measurement Quality Classification Scheme. The main components are as follows: (i) operational sensor, (ii) reference thermometers and calibration systems, (iii) instruments and coupling, (iv) maintenance and field verification, (v) environmental effects, and (vi) sensor siting classification system. This research will help further improve our understanding of the individual sources of uncertainty in the field, and our confidence in the quality of air temperature data in the AWS network. This will in turn help pave the path forward for tiering the AWS network and improve MSCs data services to Canadians.

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ATM-MSC automatic weather station measurement uncertainty at high temperatures

Extreme air temperatures can have large impacts on infrastructure, agriculture, and public health and safety. On June 29, 2021, Lytton, British Columbia registered a new Canadian record high temperature of 49.6 C during an unprecedented heat wave that broke more than 1000 daily temperature records over 11 days. The Meteorological Service of Canada (MSC) operates Automatic Weather Stations (AWS) across Canada which measure air temperature and other meteorological parameters including pressure, relative humidity, wind speed, precipitation accumulation, and snow depth. These measurements are critical for weather, climate, hydrology, transportation and validation of remote sensing products. For the measurement of air temperature at MSC AWS stations, a YSI44212 temperature probe employing a thermilinear network of three thermistors and three fixed resistors provides a near linear resistance-temperature response over the -50 C to 50 C temperature range. As extreme air temperatures continue to climb, with the potential to exceed this upper limit, it is important to understand the performance of the temperature measurement system including the sensor and datalogger. In this study, the YSI44212 response and associated measurement uncertainties are quantified between 50 C to 60 C. Modelling and experimental results show systematic negative errors above 50 C due to the nonlinearity in the thermistor resistance-temperature response. Adjusting for the thermistor nonlinearity at high temperatures results in significant reductions in the measurement uncertainty at higher temperatures. This adjustment can be applied universally to all YSI44212 probes through the datalogger processing algorithm and warrants consideration for operational deployment.

Jeffery Hoover[1], Zlatko Vukovic[1], Tomasz Stapf[1], Hagop Mouradian[1] [1]Environment and Climate Change Canada jeffery.hoover@ec.gc.ca

ATM-Data Rescue of 19th Century Canadian Weather Observations: scouring past records to understand climate variability and extreme events

An important challenge is continuing our understanding of the range and variability of Canadian climate. Extending the record of climate observations across Canada two centuries into the past helps us to further our understanding of the envelope of extreme weather Canada has faced in the past. This in turns helps us understand future possibilities of Canadian climate. Open Data Rescue, with the support of Environment and Climate Change Canada, has been working on the transcription and processing of 19th century weather observations from stations across Canada that have been discovered in archives from institutions outside Canada, including the United States National Archives and Records Administration and the United Kingdoms Meteorological Office Archive. Open Data Rescue has recovered, transcribed and processed observations from over 30 stations across the country, with record lengths ranging from a few years to over two decades. McGills Data Rescue: Archives and Weather (DRAW) has also been working on the in-depth recovery and analysis of one station, the McGill University Observatory from 1874 to the mid 20th century. These projects are both concerned with the recovery of as much information as possible of the original records,

including all recorded variables of the original observations, such as temperature, wind direction, cloud cover, weather descriptions, and pressure, humidity and other observations when recorded. The data recovery process is designed to be traceable and transparent. Some preliminary analysis of the observations will be presented and discussed.

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ATM-GEMnet1.0 : A CNN based simulator for MSC's global forecast model using archived model data

Deep learning models are being increasingly used to develop simulators for atmospheric models. A particular type of Deep Learning Model known as Convolutional Neural Network (CNN), used in the computer vision community, is particularly well suited for such simulators. This is because atmospheric fields are basically images with different values at different pixels (i.e. grid boxes). Typically, the training of such simulators is computationally intensive. However, after the simulator is trained the generation of atmospheric forecast is relatively fast. In this work, we discuss the development of a CNN based simulator (GEMnet) for the global forecast model GEM. The archived model output is used to train GEMnet to simulate a 6 hour forecast at three levels 1000mb, 900mb and 850mb for four variables namely surface pressure, temperature, geopotential height and U-component of the wind. GEMnet consists of 6 convolutional layers, 2 upsampling layers and 2 Max Pooling layers. GEMnet uses zero padding and the ReLU activation function. Though only 10 ensemble members, from one year of the total archived data are used, the results are promising. The GEMnet test RMSE for 1000mb temperature is 1.74 deg. cel. The simulator outperforms the persistence forecast by about 0.9 deg. cel. in the RMSE. We assess the sensitivity of the simulator to the kernel size and conclude that a kernel size of 9 gives the best accuracy on the train and test set.

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ATM-Using Self-Organizing Maps to Improve Understanding of Extreme Wind Gusts in Canada

Extreme wind gusts result in billions of dollars in damage to global infrastructure each year. Structures need to be designed to ensure they will withstand the strongest winds likely to occur at a location over a significant period. Calculating the risk due to extreme wind gusts requires an understanding of the physical processes responsible for the occurrence of these events as well as reliable and robust observational data. While some attention has been given to understanding historical and future projections of wind means, little research has been conducted with respect to extreme wind gusts in Canada. Self-organizing Maps (SOMs) are utilized to improve the understanding of the large-scale physical processes associated with the occurrences of extreme wind gusts in Canada. The SOMs sort synoptic type weather maps, over North America, into different weather regimes using hourly ERA-5 data. Additionally, hourly gust data extracted from surface weather stations, between 1998-2020, were used to develop an observational dataset of extreme wind gusts for 5 cities across Canada. Vancouver, Calgary, Toronto, Montreal, and Halifax were chosen since they provided some of the most robust and complete, in both time and space, observational data. Extreme wind gusts are defined here as those greater than 90kmh-1. The observational data are coupled with the SOMs to determine relationships between the large-scale weather

regimes and the occurrence of these events. The developed SOMs can then be utilized with global climate models to examine potential changes in the occurrence rate of different weather regimes and associated extreme gusts.

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Satellite Earth Observation: A unique view of our planet and a long-term strategic vision for Canada - Part 5

Tuesday, May 30
12:30 - 14:00 EDT

(15 Mins) Demonstration of offshore methane detection from space using sun glint measurements with the GHGSat constellation - Jean-Phillipe MacLean

(15 Mins) The Effect of Aerosols on GHGSat Methane Retrievals - Qiurun Yu

(15 Mins) Estimation of NO2 surface concentrations in North America utilizing TROPOMI observations and machine learning - Debora Griffin

(15 Mins) WildFireSat: The Canadian Operational Mission - Morgan Crowley

(15 Mins) Satellite-Based Analysis of CO Variability Caused by Wildfires - Heba Marey

(15 Mins) Identifying episodic carbon monoxide emission events in the MOPITT measurement dataset - Paul Jeffery

Satellite Earth observation provides a unique global perspective on our planet's atmosphere and surface, including the oceans, land, vegetation, ice, and snow. Current and planned satellite missions from Canada and international agencies have provided and will provide a wealth of new information about the Earth system and that can be used to investigate a wide range of environmental and scientific questions. This session encourages contributions from across the full Earth observation value chain, upstream, midstream and downstream. This includes new measurement technologies and techniques, both passive and active; mission development; retrieval algorithms; demonstration and calibration of instruments; validation of satellite products; assimilation of data into numerical models; scientific results and discoveries; operational utilization and development of services.

MUL-Demonstration of offshore methane detection from space using sun glint measurements with the GHGSat constellation

The high spatial resolution GHGSat satellite constellation measures methane plumes with a pixel resolution of ~2525 m2 and measurement precision below 2% of background. These satellites consistently detect and quantify methane emissions from a variety of anthropogenic terrestrial sources: from oil gas to hydroelectric reservoirs, coal mines, and landfills. The ability to detect and quantify emissions from offshore platforms, which represent approximately 30% of oil gas production, is also of considerable interest to provide actionable feedback to industrial operators. However, offshore measurements of methane from satellite instruments in the shortwave-infrared are challenging due to the low reflectance of water surfaces. Nonetheless, the

measured signal can be made high enough to retrieve methane column densities by aligning the target of interest with the specular reflection of sunlight, using a sun glint geometry. We use the GHGSat instrument in a sun glint geometry to observe offshore targets across the world. We provide an overview of the constellations offshore measurement capabilities, analyze the measured noise in retrieved methane column densities, and present a variety of examples of offshore methane emissions detected and quantified, including the 2022 Nord Stream pipeline leak. With six additional satellites planned for launch by the end of 2023, the GHGSat satellite constellation will have 10 operational satellites in orbit for detecting methane emissions, which will enable the detection and the quantification of methane emissions from any site, on and offshore, with near daily revisit times.

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MUL-The Effect of Aerosols on GHGSat Methane Retrievals

GHGSat is a constellation of hyperspectral satellites monitoring methane emissions at 1.65 m. Its retrieval of methane mixing ratio (XCH4) enhancement is impacted by aerosols which alter the light path via scattering and absorption. This study examines errors in XCH4 enhancement measurements caused by aerosols under varying surface and aerosol conditions and performs Observing System Simulation Experiments (OSSE) to retrieve XCH4 and aerosol optical depth (XAOD) enhancement using angle-dependent scattering information under certain error assumptions. Results indicate that when neglecting aerosols, errors in XCH4 enhancement change from negative to positive as surface albedo increases and intensify with AOD, which is consistent with previous studies. Using multiple satellite viewing angles during the GHGSat observation sequence with AOD of 0.1 and a scattering angle ranging from 100-140, the mean bias of XCH4 enhancement for simultaneous XCH4 and XAOD enhancement retrievals is between -0.16% to 0.13%, -0.14% to 0.13%, and -0.10% to 1.16% for sulfate, dust, and black carbon aerosols when albedo ranges from 0.05 to 1. The precision of XCH4 enhancement is approximately 2% for most aerosols, except for black carbon with median surface albedo. These errors are not limited to the accuracy or precision of the source rate estimate. The largest XCH4 enhancement errors are induced by sulfate aerosols over low and high albedo surfaces and by black carbon aerosols over mid-range albedo surfaces. The correlation coefficient between XCH4 and XAOD enhancement shifts from positive to negative with the increase of surface albedo because of the competing effect between aerosol direct scattering and aerosol-surface multiple scattering.

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MUL-Estimation of NO2 surface concentrations in North America utilizing TROPOMI observations and machine learning

Nitrogen dioxide (NO2) is one of the key pollutants affecting the air quality and is needed to establish the air quality health index (AQHI). NO2 plays a significant role in the tropospheric production of ozone and has adverse effects on the environment and human health. Over 600 surface air monitoring stations are distributed across Canada and the United States measuring NO2, but many areas still remain unmonitored leading to incomplete AQHI information. Existing traditional methods rely on modelled profiles to

obtain NO2 surface concentrations from satellite observations. Thus, making these traditionally satellite-derived surface concentrations dependant on how well the location and magnitude of NO2 emissions is already known. Here, we compare this traditional method to a machine learning approach that utilizes NO2 observations from the Tropospheric Monitoring Instrument (TROPOMI), together with meteorological parameters from ERA5, land cover type, topography, and emission inventories. Our results show that the machine learning (using random forest) yields to significantly less bias between the surface monitoring measurements and the satellite-derived surface concentrations, significantly improved the correlation coefficient (R2~0.8-0.9) compared to the traditional method (R2~0.4), and reduced the computational burden.

Debora Griffin[1], Colin Hempel[1], Shailesh Kharol[2], Chris McLinden[1] [1]Environment and Climate Change Canada [2]AtmoAnalytics Inc. debora.griffin@ec.gc.ca

MUL-WildFireSat: The Canadian Operational Mission

The Government of Canada has committed to delivering the WildFireSat operational satellite mission, with a launch target 2029. The mission aims to adapt fire monitoring science to deliver the world's first dedicated operational wildfire monitoring satellite mission. WildFireSat is designed with a uniquely Canadian solution to address critical gaps in satellite fire monitoring for Canada's diverse geography, and to primarily address the needs of wildfire and smoke management. The first of its kind, WildFireSat is routed in unique Canadian technologies and enhances international capabilities by forming a virtual constellation. This presentation provides a summary of the system design, the concept of operations, alignment with existing systems, value-added data products, and data delivery systems. The mission will deliver comprehensive situational awareness to wildfire managers and decision-makers in near-real-time, support smoke and air quality forecast services and carbon emission estimates.

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MUL-Satellite-Based Analysis of CO Variability Caused by Wildfires

Wildfires are important sources of aerosols and atmospheric trace gases that affect public health and air quality. In September 2020, theWestern United Statesexperienced severewildfires that were considered the most destructive since 1990. The fires produced dense smoke plumes that eventually covered most of the US region. In this study, we examine the atmospheric impact of these wildfires on CO variability, with a focus on the North American domain. We compare the ability of the following satellite sensors to capture the variability in CO under extreme pollution conditions: Measurements of Pollution in the Troposphere (MOPITT), the Infrared Atmospheric Sounding Interferometer (IASI), and the Tropospheric Monitoring Instrument (TROPOMI). In general, all instruments show excellent agreementunder typical atmospheric CO conditions. Strong enhancements of CO total column were clearly observed by all sensors as a result of the fire emissions. However, the collocated CO from the three sensors indicated large discrepancies in regions of elevated CO. Those discrepancies highlight the importance of the differences in sampling, vertical sensitivity and retrieval algorithm of the three sensors. In order to assess the potential influence of aerosol loading on the observed CO, the TROPOMI aerosol index (AI) and available CALIPSO data are utilized. A strong relationship between heavy smoke aerosols and

elevated TROPOMI CO was found, which suggests the possibility of retrieval overestimation in the optically thick wildfire regions as a result of multiple scattering. Our results suggest that appropriate quality filtering should be used when analyzing pollution events with these data

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MUL-Identifying episodic carbon monoxide emission events in the MOPITT measurement dataset

The Measurements Of Pollution In The Troposphere (MOPITT) instrument aboard NASAs Terra satellite has been measuring carbon monoxide (CO) since March 2000, providing the longest satellite record of this trace gas to date. This dataset is well-suited to numerous applications, including trend analysis and the construction of CO budgets. However, episodic emission events, such as large wildfires or other biomass burnings, can release large quantities of CO into the atmosphere with irregular timing that can complicate these analyses. The chaotic nature of these events is a large source of variability in CO budgets and models, and they need to be properly characterized to better constrain their effects on tropospheric CO. The work presented here describes the development of a multi-step algorithm used to identify large episodic emission events using the daily-mean MOPITT total column measurements gridded to 0.5 by 0.5 degree spatial resolution. The core component of this procedure involves empirically determining the expectation density function (EDF) that describes the departure of daily-mean CO observations from the baseline behavior of CO, as described by its periodic components and trends. Observation flags are produced following this methodology, and the distribution and frequency of these flagged measurements is examined to illustrate the properties of these events. MOPITT was built in Canada by COMDEV of Cambridge, ON, and data processing is performed at the National Center for Atmospheric Research in Boulder, CO. Funding and operations of Terra is provided by NASA, and MOPITT and its operations are funded by the Canadian Space Agency.

Paul Jeffery[1], James Drummond[2], Jiansheng Zou[1], Kaley Walker[1] [1]University of Toronto [2]Dalhousie University paul.jeffery@mail.utoronto.ca

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Advancing science and technology for monitoring greenhouse gases - Part 2

Tuesday, May 30
14:30 - 16:00 EDT

(15 Mins) Year-round trace gas observations from infrared emission spectroscopy in Eureka, Nunavut: 2008 to 2022 - Joseph Hung

(15 Mins) In-situ Measurements and Vertical Profiles of Greenhouse Gases from the Canadian Atmospheric Laser Absorption Spectrometer Experiment Test-bed - Mark Panas

(15 Mins) Ground-based infrared hyperspectral profiling of atmospheric CO2 - Beatroz Porto Gjorardi

(15 Mins) Development of a Long-Term Relative Humidity Climatology in the Free Troposphere from Vibrational-Rotational Raman Lidar Measurements - Vasura

Jayaweera

Climate action needs to be based on accurate knowledge of the emissions, distribution, and sinks of greenhouse gases. The objective of Canada and other nations to achieve net-zero greenhouse gas emission requires the monitoring of atmospheric greenhouse gases concentrations at unprecedented levels, to understand their variations, identify optimal emission control strategies and verify achievement of reduction goals based on inventories. We welcome abstracts aiming to address this grand challenge and to improve the science and technology of greenhouse gas monitoring, including but not limited to the following aspects:

Science and technology developments to measure greenhouse gases, including carbon dioxide, methane, and other potent radiative gases, in the atmosphere and from emissions sources at varying scales ranging from global to national, regional and city levels.

Field as well as theoretical and modeling studies, especially those deploying a top-down measurement-based approach, to understand greenhouse gas distribution in space and time and to identify and quantify emission sources.

We encourage submissions using a wide range of measurement methods including mobile surveys, eddy flux measurements, isotopic analyses for source apportionment, remote sensing from the ground and from space, vertical profiling, and studies that compare direct measurements with inventory-based emission estimates.

CLM-Year-round trace gas observations from infrared emission spectroscopy in Eureka, Nunavut: 2008 to 2022

Trace gasses in the Canadian High Arctic play an important role in the energy balance of the region, particularly in relation to the prolonged periods of darkness and daylight. This interaction is especially important in the infrared spectrum, where the terrestrial emission is signifcant. In order to conduct these measurements, an Extended-range Atmospheric Emitted Radiance Interferometer (E-AERI) was installed at the Polar Environment Atmospheric Research Labratory (PEARL) at Eureka, Canada (80N, 86W) in October 2008. The E-AERI is a automated, moderate resolution (1 cm1) Fourier Transform Infrared Spectrometer that measures the absolute downwelling infrared spectral radiance from the atmosphere between 400 and 3000 cm1. Spectra are recorded every 7 minutes year round, including during the polar night. We will present the first decadal year-round timeseries of total column concentrations of selected trace gasses (CO, O3, CH4, and N2O), from 2008-2022. These results are retrieved using a modified version of the optimal estimation-based SFIT4 retrieval algorithm to allow for analysis of emission spectra. We additionally include a modification to account for the emission contribution from the water vapour continuum in the far and mid-infrared. The effectiveness of this modification is evaluated, along with comparions against co-located instruments at PEARL during the polar day and sonde launches throughout the year. Trends and the diurnal and interannual variability of the retrieved variables over this period will also be presented. Finally, we will evaluate the degreee to which emission measurements can be used to observe rapid changes in selected trace gas concentrations, such as those associated with Arctic springtime ozone depletion events and wildfire-induced enhancements to CO.

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CLM-In-situ Measurements and Vertical Profiles of Greenhouse Gases from the Canadian Atmospheric Laser Absorption Spectrometer Experiment Test-bed

Two balloon-borne spectrometers for in-situ measurements of greenhouse gases have been flown as part of the Canadian Atmospheric Laser Absorption Spectrometer Experiment Test-bed project. The goals of the CALASET project are to develop instruments capable of high precision, high time resolution measurements of trace gas vertical profiles needed for remote-sensing measurement validation. The work described here will highlight one of the spectrometers, an infrared tunable diode laser absorption spectrometer operating at 4.5 um in an open-path multipass cell with a 15 m pathlength. This instrument collects spectra containing CO2 and N2O absorption lines with an approximate tuning window of 1 cm^-1 at a rate of about 3 Hz. The results of the stratospheric balloon flight as part of the August 2022 STRATOS campaign in Timmins, ON will be discussed. The instrument collected profiles during the ascent and descent portions of the flight, with average vertical resolutions of 25 m and 8 m, respectively, after spectral averaging. These two profiles showed similar layered structure in N2O in the middle and lower stratosphere. The N2O profiles showed general agreement with profiles from the Microwave Limb Sounder on Aura. The limitations of this instrument and measurement technique will be discussed, especially the difficulties of using the open-path multipass cell in the challenging environmental conditions encountered during flight.

Mark Panas¹, John E. Saunders², Michael Howorucha², Pierre Fogal², Wolfgang Jäger³, Jennifer G. Murphy¹, Kaley A. Walker² ¹University of Toronto Department of Chemistry ²University of Toronto Department of Physics ³University of Alberta Department of Chemistry mark.panas@mail.utoronto.ca

CLM-Ground-based infrared hyperspectral profiling of atmospheric CO2

The increase of atmospheric CO2 concentration has significant climate impacts, which makes accurate measurements of its variability crucial to understanding climate change. One of the outstanding challenges is to observe the vertical distribution and variation of CO2. Having this information would help us to identify emission sources and atmospheric processes controlling the atmospheric CO2 distribution as well as monitor emission control effectiveness. Here, we explore innovative methods to perform profiling measurements using a ground-based infrared hyperspectrometer, the Atmospheric Emitted Radiance Interferometer (AERI). In order to understand the feasibility of CO2 vertical profile retrieval, we first conduct a simulation experiment-based assessment, using a Line-By-Line Radiative Transfer Model (LBLRTM) as the forward model and the Optimal Estimation method as the inverse method. By evaluating key metrics of the retrieval technique, such as the Degrees of Freedom for Signal (DFS), we verify whether a vertical profiling of CO2 using AERI is possible and, if so, which vertical levels can be best sounded. This finding is then used to help design observational campaigns utilizing both ground and in-air measurements to validate the retrieval and to quantify the temporospatial variability of CO2 particularly in urban environments.

Beatriz Porto Ghirardi¹, Lei Liu¹, Yi Huang¹, John Gyakum¹, Peter Douglas¹, Djordje Romanic¹ ¹McGill University beatriz.portoghirardi@mail.mcgill.ca

CLM-Development of a Long-Term Relative Humidity Climatology in the Free Troposphere from Vibrational-Rotational Raman Lidar Measurements

Raman lidar is a well-established technique for measuring the tropospheres water vapor content as a function of altitude. Hicks-Jalali et al. (2020) have computed a tropospheric water vapour climatology and derived a height-resolved trend analysis between 950 mbar and 250 mbar pressure levels using measurements obtained by the Raman Lidar for Meteorological Observations (RALMO) in Payerne, Switzerland. Their results suggest that relative humidity is not conserved but shows a positive trend. To address the relative humidity question in more detail, Gamage et al. (2020) developed a method in which RALMO relative humidity and temperatures are retrieved directly from the lidar measurements. Accurate relative humidity determinations require the lidar to be calibrated. The most common approach to performing this calibration is to use an external reference like radiosondes. Here, we present a new method to improve our temperature calibration time series using an internal calibration technique originally implemented by Sherlock et al. (1999). This method uses solar background measurements to track the temporal evolution of the calibration coefficient. This technique renders the temporal evolution of the calibration independent from external reference instruments such as radiosondes and eliminates the effects of drifts in the radiosonde measurements and the lidar detector system. We will use this method to determine the calibration coefficients required to reprocess the existing 12 years of RALMO data to calculate a full relative humidity climatology in the troposphere to look at trends in relative humidity as a function of altitude.

Vasura Jayaweera[1], Robert Sica[1], Alexander Haefele[2], Giovanni Martucci[2] [1]Western University, Canada [2]MeteoSwiss, Payerne (Switzerland) yjayawee@uwo.ca

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Atmosphere, Ocean, and Climate Dynamics - Part 3

Tuesday, May 30
14:30 - 16:00 EDT

(15 Mins) Iron (Fe) in the atmospheric aerosol and its role in air quality, climate, and the ocean - Hind A. Al-Abadleh

(15 Mins) Projecting climate responses using an AI Implementation of the Fluctuation-Dissipation Theorem trained on CESM2 Large Ensemble data - Haruki Hirasawa

(15 Mins) Correcting radiation biases over the subtropical south Pacific improves biases of South Asian Summer Monsoon precipitation - Dipti Hingmire

(15 Mins) Projections of Snow Water Equivalent Indices - Émilie Bresson

(15 Mins) Modulation of the UHI and convergence maxima by synoptic circulation patterns in the Valley of Mexico. - Lourdes Aquino

(15 Mins) Challenges pertaining to fine-scale orography in numerical weather prediction - Syed Zahid Husain

This session combines submissions that document studies of the dynamics of the atmosphere, oceans and/or climate system. The scope of the session is deliberately broad in order to include research that spans a broad range of spatial and temporal scales. Studies of the dynamics of mesoscale processes that act on

hourly timescales are as welcome in this session as those that document the evolution of planetary-scale structures in a changing climate. Such investigations may include diagnoses and theoretical studies of forecast, climate, and process models, or studies based on reanalysis and other observational datasets; however, any topic that is relevant to atmosphere, ocean, or climate dynamics will fit well into this session. Please note we have run this session at CMOS Congresses since around 2009.

MUL-Iron (Fe) in the atmospheric aerosol and its role in air quality, climate, and the ocean

Atmospheric aerosols effects on human and ecological health remain uncertain due to their highly complex and evolving nature. Global atmospheric and oceanic models need to incorporate more realistic representations of aerosol particles especially their surface chemistry and physics. Accounting for the evolution in aerosol physicochemical propertiesdue to redox reactions of transition metals, specifically Fe, is desirable as well.In this talk, I will highlight recent advances in our fundamental understanding of Fe reactivity in aerosols.Because of the complexity of Fe-containing aerosol particles from natural and anthropogenic sources,my collaborators and I call for the creation of transdisciplinary scientific networks to facilitate knowledge exchange and collaboration and efficiently improve predictive models whose results are used to advance knowledge and enact new policies.

Hind A. Al-Abadleh[1] [1]Wilfrid Laurier University halabadleh@wlu.ca

MUL-Projecting climate responses using an AI Implementation of the Fluctuation-Dissipation Theorem trained on CESM2 Large Ensemble data

Earth System models are computationally expensive, typically requiring thousands of core-hours of simulation time to achieve sufficient sample sizes to estimate the climate response to a forcing. Here, we present a novel method for projecting forced climate responses using a combination of a novel AI model, AiBEDO, and the Fluctuation-Dissipation Theorem (FDT). AiBEDO is a Spherical-Multilayer Perceptron (S-MLP) model that emulates the relationship between radiative flux anomalies and surface climate anomalies at a range of lag intervals. As FDT requires a large sample of internal variability, we use month-to-month internal variability from the CESM2 Large Ensemble as the training dataset. By integrating the AiBEDO models at different lags, we are able to successfully project the pattern of surface temperature, precipitation, and surface pressure responses to historical anthropogenic forcing and marine cloud brightening climate intervention. Thus, by leveraging the huge data pool made available by the CESM2 LE, we have created a method that can rapidly generate estimates of climate response to forcings which can be used to prototype new experiments and explore forcing scenarios on scales that are impractical with CESM2 simulations.

Philip Rasch[4] [1]University of Victoria [2]Palo Alto Research Center [3]University of California San Diego [4]University of Washington hhirasawa@uvic.ca

MUL-Correcting radiation biases over the subtropical south Pacific improves biases of South Asian Summer Monsoon precipitation.

Like many ESMs, the Community Earth System Model 2 (CESM2) has systematic errors in simulating the climatological mean summer monsoon precipitation over South Asia, including wet biases over the Indian Ocean and dry biases over the northern land regions of the subcontinent. In CESM2 simulations, the precipitation bias over the South Asian subcontinent is coincident with systematic radiation biases over the subtropical southern hemisphere. These radiation biases are due to short-wave cloud radiative effects which arise due to poor representation of low stratocumulus clouds. Here, we hypothesize that short-wave radiation biases over the Southern hemisphere alter the energetics of tropical regional precipitation and cause climatological biases. We test this hypothesis using cloud perturbation experiments in CESM2. We fix the Cloud Droplet Number Concentration (CDNC) over selected regions in the southern hemisphere to correct the too-weak downwelling short-wave cloud radiative flux in CESM2 simulations in those regions. We studied the South Asian Summer monsoon precipitation response to these perturbations in equilibrium CESM2 coupled simulations. We find that correcting the radiation bias over stratocumulus decks in the subtropical South Pacific reduces around half of the dry bias over the central Indian land region. Correcting radiation biases in subtropical southern Pacific, reduces lower tropospheric circulation biases through the La Nina-like Walker circulation response and partially corrects the dry precipitation bias over land regions of SASM.

Dipti Hingmire[1], Hansi Singh[1], Haruki Hirasawa[1], Phil Rasch[2], Peetak Mitra[3], Sookyung Kim[4], Subhashis Hazarika[4], Kalai Ramea[4] [1]University of Victoria [2]University of Washington [3]Excarta [4]Palo Alto Research Center dhingmire@uvic.ca

MUL-Projections of Snow Water Equivalent Indices

In boreal regions, several economic sectors need snow cover information to plan their winter activities, and snow pack melt can play a role in spring floods. Thus, in the context of climate change, stakeholders and decision-makers require a comprehensive and easily acccessible picture of the projected snow cover. To meet this need, we collected snow water equivalent and snow cover indices that are pertinent to a large range of sectors, such as beginning, end and duration of continuous snow cover. We bias-adjusted daily snow amount time series from an ensemble of regional climate model simulations. This bias adjustement was performed using a reconstruction, evaluated against observations, as reference. Based on these bias-adjusted time series, we calculated the annual indices for historical and future periods. We will present these results for Quebec province, which will be available through climate data platforms in near future.

Émilie Bresson[1], Pascal Bourgault[1], Éric Dupuis[1] [1]Ouranos bresson.emilie@ouranos.ca

MUL-Modulation of the UHI and convergence maxima by synoptic circulation patterns in the Valley of Mexico.

In the Valley of Mexico, local thermally forced circulations such as anabatic/katabatic winds occur on slopes and by heat island (UHI) due to the particular orographic formation of the region and the change in land use and vegetation cover that it has experienced throughout decades. Synoptic scale conditions strongly modulate local

mesoscale phenomena immersed in the atmospheric boundary layer. A cluster analysis of 500 hPa winds over a 30-years (19902019) identifies a set of weather patterns that help us to explore the magnitude of the UHI and the intensity of the circulations. For case studies, simulations with WRF (forced with ERA5) permit the study of the dynamics and intensity of forced local circulations. Results from the cluster analysis show that synoptic high-pressure systems centered over central Mexico have a high probability during the dry season. This weather pattern leaves low cloud cover, increases solar radiation, weakens surface winds, and causes a strong morning temperature inversion that persists later than usual. The weather patterns produce the intensification of longitudinal and meridional thermal gradients that allow the intensification of convergence zones in the center of the Valley of Mexico. The maximum negative divergence in the afternoon is associated with the eastward shift of the high-pressure system.

Lourdes Aquino[1], Arturo Quintanar[1], Ochoa Moya[1], Yanet Díaz[1] [1]UNAM
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MUL-Challenges pertaining to fine-scale orography in numerical weather prediction

In order to improve flow representation at the finest scales over complex terrain, operational numerical weather prediction (NWP) systems are increasingly opting for higher spatial resolutions. Furthermore, there is a growing focus on retaining the finest scales in the orography field with minimal filtering. However, the presence of orography scales near the Nyquist limit, particularly with terrain-following coordinate (TFC) in the vertical, can lead to various numerical issues resulting in degraded forecast quality. With conventional hybrid TFCs, fine-scale terrain imprints can remain in a models vertical coordinate surfaces even around the upper troposphere and stratosphere. Under certain meteorological conditions, these fine-scale terrain imprints can lead to considerable numerical error through spurious generation and amplification of vertical motion. Following the concept of SLEVE (Smooth LEvel VErtical) coordinate, this issue can be adequately addressed by adopting a more sophisticated definition of the TFC that permits scale-selective progressive attenuation of the terrain imprints with increasing height. An option for such a SLEVE-type TFC has recently been introduced in Environment and Climate Change Canadas (ECCCs) operational Global Environmental Multiscale (GEM) model. Another major issue related to fine-scale orography is erroneous near-surface flow evolution, which in the case of GEM results in spurious winter-time valley warming. Such an error cannot be eliminated using the SLEVE-type coordinate and necessitates the determination of optimal orography resolution for generating acceptable forecasts. Details regarding the new SLEVE-type TFC in GEM and the study on identifying the models optimal orography resolution will be presented at the conference.

Syed Zahid Husain[1], Leo Separovic[1], Jean-François Cossette[1] [1]Environment and Climate Change Canada syed.husain@ec.gc.ca

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Data modelling and reproducible processes in geophysics

Tuesday, May 30
14:30 - 16:00 EDT

(15 Mins) Use of artificial intelligence (AI) in historical records transcription: Opportunities, challenges, and future directions - Yumeng Zhang

(15 Mins) What can collocated geophysical data tell us about their error statistics? - Annika Vogel

(15 Mins) Black Box Variational Inference For Stochastic Multicloud Model Calibration - Carlos Sevilla

(15 Mins) How well do reanalyses reproduce observed winds over Canada? - Houssenyni Sankare

(15 Mins) Developing humidex projections for the 21st century: a multivariate downscaling approach - Kenneth Kin Cheung Chow

This session invites contributions on data modelling and reproducible science that yield insight into processes of an atmospheric, oceanic, or hydrologic nature. All sources of data (theoretical, numerical, observational, and combined products) and processes covering any range of scales are of interest. Methods that employ any modelling language are welcome, as are general reviews and perspectives on data modelling in related scientific fields. We especially prompt submissions on:

Reproducible workflows, open repositories, and collaborative efforts

Discovery of patterns in big data and their connection to processes

Machine learning of parameterizations intended as embedded process models

Methods of verification, including proposals that address simplified or complex models

Metrological challenges of traceability in weather/climate data

Calibration and validation using familiar geophysical datasets as a reference

MUL-Use of artificial intelligence (AI) in historical records transcription: Opportunities, challenges, and future directions

Millions of valuable weather historical records exist in paper format. Data rescuers worldwide have attempted to preserve those records in digital format so they can be indexed, searched and analyzed. The key is to scan not just pages of logbooks, but to transcribe the individual observations. To accomplish this, researchers have experimented with automatic transcriptions, which have not been reliable or sufficiently accurate on handwritten data. Recent advances in artificial intelligence (AI) and machine learning like optical character recognition (OCR) promise automation. Unlike other systems using OCR (e.g., tax receipts), data rescuers have needed to build systems from scratch and the results have not been promising. We designed an end-to-end workflow that uses AI to automate observations on logbook pages, which were written in cursive handwriting. The workflow was comprised of five steps: image preprocessing, text line segmentation, bounding box detection, OCR, and data rearrangement. We tested the workflow using the historical climate records from the Data Rescue: Archives and Weather (DRAW) project. We report on the results at each step as well as an accuracy assessment. We designed the workflow to accommodate future advances (e.g., new training data, better layout detectors). We hope the workflow can serve as a guideline that is replicable and utilizable for other historical datasets.

Yumeng Zhang[1] [1]McGill University yumeng.zhang@mail.mcgill.ca

MUL-What can collocated geophysical data tell us about their error statistics?

The amount of available data is increasing rapidly in many fields of geophysics. In atmospheric- and ocean- sciences, numerous satellite products, numerical forecasts and other datasets are available with an increasing coverage and resolution. One consequence is a large overlap or even a complete spatio-temporal collocation of these different datasets, which enables their comparison and validation. Traditionally, validation of datasets is performed with respect to a reference dataset, which is assumed to have neglectable errors statistics. However, all datasets from real geophysical systems may be subject to uncertainties. The 3-cornered hat method (3CH) and triple collocation (TC) are long-known methods to estimate error covariances of three collocated datasets simultaneously. Some approaches exist which extent this statistical error estimation to more datasets, however they require more assumptions than necessary. This contribution provides a generalized view on the maximum amount of error statistics which can be estimated and the number of assumptions required to close the estimation problem. It is demonstrated that the relative amount of estimated error statistics increases with the number of collocated datasets. However, a certain number of assumptions are always required, and the minimal and optimal conditions to setup the estimation problem will be discussed. Reference: Vogel, A. and Mnard, R.: How far can the error estimation problem in data assimilation be closed by collocated data?, EGUsphere [preprint, under review], https://doi.org/10.5194/egusphere-2022-996, 2022.

Annika Vogel[1], Richard Ménard[1] [1]Environment and Climate Change Canada annika.vogel@ec.gc.ca

MUL-Black Box Variational Inference For Stochastic Multicloud Model Calibration

In recent years, developments in stochastic multicloud models have been used to successfully represent subgrid organized tropical convection, a so far poorly understood form of climatic variability(Frenkel, 2013; Khouider, 2010). However, these models use key timescale parameters that must be calibrated with cloud data. Currently this inference process uses Markov Chain Monte Carlo (MCMC) which is computationally expensive and slow to converge(De La Chevrotiere, 2014; De La Chevrotiere, 2015). This slowness severely occludes the use of sufficiently long timeseries spanning multiple phases of interesting seasonal oscillations, such as the MJO. A developing alternative, derived from machine learning is variational inference (VI), which finds an optimal proposal distribution and has been shown to significantly speed up processes traditionally reliant on MCMC. VI has become a rapidly emergent field among other machine learning methods, boasting a wide array of different techniques(Blei, 2017; Jordan, 1999). A black box variational inference approach is used along with a natural gradient and synthetic multicloud data. An extensive study of the rate of convergence of this new inference model compared to MCMC and using different adaptive learning rates such as AdaGrad, Adam and AdaDelta is then conducted.

Carlos Sevilla[1] [1]University of Victoria csevilla@uvic.ca

MUL-How well do reanalyses reproduce observed winds over Canada?

The Canadian Centre for Climate Services (CCCS), within Environment and Climate Change Canada, aims to help Canadians understand and adapt to climate change by providing guidance and resources in support of climate-informed decisions. Projected changes to mean and extreme wind speeds at fine spatial scales were identified as a high priority to support climate risk assessments and climate change adaptation activities. Changes in mean or extreme wind speeds will affect renewable power generation, critical infrastructure, fire activity, ecological processes, and maritime and air transportation. Global climate model projections of wind are available at coarse spatial resolutions, which can limit their utility within climate risk and impact assessments. A common solution is statistical bias adjustment and downscaling using finer-scale, gridded observational products as a target dataset. For wind, the most commonly used gridded observational products are reanalyses, which combine historical meteorological observations with an atmospheric circulation model to produce a dataset with continuous spatial and temporal coverage. However, reanalyses also contain deficiencies in simulating wind speed due to model resolution and parametrization constraints, and assimilation of observations is dependent on availability. In this talk, we will present an evaluation of wind speed from four reanalyses: ERA5, and agERA5 from ECMWF, MERRA2 from NASA, and RDRSv2 from CCMEP-ECCC. . Performance of these four reanalyses will be assessed against wind speed from Canadian meteorological stations, mindful of the inherent challenges in assessing gridded products against station observations, and the applicability of reanalysis wind speed for bias adjustment and downscaling will be discussed.

Housseyni SANKARE[1], Laura Van Vliet[1], Emilia Diaconescu[1] [1]Centre Canadien des Services Climatique, ECCC housseyni.sankare@ec.gc.ca

MUL-Developing humidex projections for the 21st century: a multivariate downscaling approach

Humidex is an index developed by the Meteorological Service of Canada to describe how hot and humid the weather feels to the average person. In Canada, it is recommended that outdoor activities be moderated when the Humidex exceeds 30, and unnecessary activities cease when it passes 40. With the increase in temperature projected by climate models over the coming decades over Canada, increases are also expected in the number of days with high-value Humidex across the country, which will have important consequences for human health. In order to help with preparedness efforts of Canadian public health and safety systems for adaptation to climate change, we have developed a multi-model ensemble of climate change projections for Humidex and three threshold indices, for three emission scenarios: SSP126, SSP245 and SSP585. The ensemble is based on 19 Coupled Model Intercomparison Project Phase 6 (CMIP6) global climate models and is bias corrected and statistically downscaled using the N-dimensional probability density function transform multivariate quantile mapping (MBCn) and hourly data from ERA5-Land, using on a methodology suggested in Diaconescu et al. (2022). This talk will present steps for the data production, including the evaluation of the target historical gridded data and the selection of downscaling method, and present as example humidex climate projections at the end of the century.

Kenneth Kin Cheung Chow[1], Housseyni Sankaré[1], Emilia Diaconescu[1] [1]Environment and Climate Change Canada kenneth.chow2@ec.gc.ca

Discussions on development, evaluation and analysis of ocean circulation and biogeochemical models or Developing Ocean Modelling Capacity in Canada - Part 2

Tuesday, May 30
14:30 - 16:00 EDT

(15 Mins) Why discontinuous spectral elements might still be relevant for ocean modelling today - Frédéric Dupont

(15 Mins) Downscaling Climate Projections of Northwest Atlantic Circulation and Sea Ice: Importance of Bias Correction and Spatiotemporal Scales - Christoph Renkl

(15 Mins) Impacts of Ocean Model Resolution and External Forcing on the Estimated Atlantic Meridional Overturning Circulation at the OSNAP West Section - Pouneh Hoshyar

(15 Mins) Preparing the 1/12-degree model of Canada's Three Oceans for multi-decade historical hindcast simulation of ocean and sea-ice variations - Sarah MacDermid

(15 Mins) Comparison of eddy permitting, eddy rich and sub-mesocale permitting global configurations based on NEMO 4.2 OGCM - Clément Bricaud

(15 Mins) Exploration of Lab60: A 1/60th degree AGRIF nest of the Labrador Sea

Ocean circulation and biogeochemical models are widely used for both research and operational forecasting. However, there are challenges for small research groups to handle the increasing complexity of the model codes, evaluation with various observational datasets, and analysis of the increasing amount of model output data. This session aims to stimulate discussions on potential coordination and collaboration between Canadian government laboratories and universities in the development, evaluation and analysis of ocean circulation and biogeochemical models for hindcast and forecast at various time scales. Specific topics may include:

1 progress of model research and applications in various regions with different spatial resolutions;

2 new evaluation and analysis results that demonstrate the strength and weakness of the models;

3 improvements in model numerics and parameterization of sub-grid processes;

4 new analysis methods;

5 new forcing and evaluation datasets;

6 model inter-comparison; and

7 data presentation and visualization tools.

OCE-Why discontinuous spectral elements might still be relevant for ocean modelling today

20 years on, I have the opportunity to reflect on our field. One aspect that strikes me is the little interest raised in the ocean community by discontinuous spectral elements. I have seen some small applications but nothing time lasting so far. However, the method still sounds quite promising. Relative to the present existing (let us restrict ourselves to Boussinesq hydrostatic models) finite element, difference or volume discretizations, it offers much higher order of accuracy and excellent conservation of momentum/energy/enstrophy. Most of the computational work is done at the element level, thus delivering very good scaling properties on large processor parallel machines. H-p Adaptibity is easily implementable. All aspects required by advanced modelling techniques. On the down side, the treatment of coastline can be complex and the monotonicity enforcement or the initialization tricky. I will review the existing literature and draw a roadmap for improving on our existing models.

Frédéric Dupont[1] [1]ECCC frederic.dupont@ec.gc.ca

OCE-Downscaling Climate Projections of Northwest Atlantic Circulation and Sea Ice: Importance of Bias Correction and Spatiotemporal Scales

In the Northwest Atlantic (NWA), including the Labrador Sea, interactions between the atmosphere, ocean circulation, and sea ice play a critical role in regulating the global climate system. Future projections of NWA circulation and sea ice can help address pressing questions about changes in the climate system and mitigate their potential impacts. However, the spatial resolution of current climate models is often insufficient to accurately represent important features in the NWA, e.g., the location and strength of the Gulf Stream and Labrador Current and their dynamical interactions. This can lead to biases in the models mean state, and a misrepresentation of the temporal and spatial scales of ocean variability, e.g., mesoscale eddies, deep convection, etc. Regional ocean models with grid spacing <10 km have a more accurate representation of these properties and can be forced by global climate simulations to improve estimates of historical and future circulation and hydrography. However, given the limited spatial resolution and biases in global climate models, a challenge of downscaling their simulations is the appropriate reconstruction of the forcing fields. Here, we demonstrate the value of correcting biases in the mean and variance of global climate simulations from the Coupled Model Intercomparison Project (CMIP6) prior to downscaling. This study is based on a series of simulations of the NWA using an eddy-resolving, coupled circulation-sea ice model based on the Regional Ocean Modeling System (ROMS) and the Los Alamos Sea Ice Model (CICE). Implications for the design of model experiments for future projections will be discussed.

Christoph Renkl[1], Eric C.J. Oliver[2] [1]Woods Hole Oceanographic Institution [2]Dalhousie University christoph.renkl@whoi.edu

OCE-Impacts of Ocean Model Resolution and External Forcing on the Estimated Atlantic Meridional Overturning Circulation at the OSNAP West Section

We investigate the Atlantic Meridional Overturning Circulation (AMOC) in the sub-polar North Atlantic. The AMOC, a significant component of the global thermohaline circulation along a north-south axis in the Atlantic Ocean, is defined as the transformation of buoyant warm, salty, northward surface water flow by air-sea fluxes into the denser cold and fresh deep waters flowing south. Most numerical models over-

estimate the overturning linked to the water mass formation within the Labrador Sea, as opposed to recent OSNAP (Overturning in the Subpolar North Atlantic Program) observations that suggested a weaker contribution of Labrador Sea in the subpolar AMOC. This study focuses on examining the impact of model resolution, atmospheric forcing, and Greenland melt input on the simulated AMOC using varying resolution configurations in the NEMO ocean model. The Arctic Northern Hemisphere Atlantic configuration with 1/4◦ (ANHA4) and 1/12◦ (ANHA12) horizontal resolution and 50 vertical levels are used as coarse- and intermediate-resolution configurations. The high-resolution configuration, which uses 75 vertical levels, uses the LAB60 (Labrador) configuration with 1/4◦ background horizontal resolution, a 1/12◦ AGRIF nest covering the Subpolar North Atlantic, and an additional inner AGRIF nest with 1/60◦ in the Labrador Sea. The OSNAP observations estimate of mean AMOC across the OSNAP West section is best predicted by the high-resolution configuration. Sensitivity experiments with the high-resolution configuration indicate that the Greenland melt input and air-sea forcing do influence the simulated AMOC results.

Pouneh Hoshyar[1], Paul G. Myers[1], Clark Pennelly[1] [1]University of Alberta hoshyar@ualberta.ca

OCE-Preparing the 1/12-degree model of Canada’s Three Oceans for multi-decade historical hindcast simulation of ocean and sea-ice variations

Here we report the progresses of a collaboration project entitled Assessing on-going ocean climate change: A high-resolution climate simulation for Canadas Three Oceans from 1958-to-Present day. It is supported by the Competitive Science Research Fund of Fisheries and Oceans Canada, over three years starting in April 2022. Up to now, the main efforts have been put on refining the previous configuration of the ocean and sea-ice model. We hope to seek advice and inputs from colleagues to guide model improvement, evaluation and analyses. Currently, the Three Oceans model is based on version 3.6 of Nucleus for European Modelling of the Ocean (NEMO) and version 3 of the Louvain-la-Neuve Sea Ice Model (LIM3). The model domain covers north of 45N in the North Pacific, the whole Artic, and north of 7N in the North Atlantic. The models nominal horizontal resolution is 1/12 in longitude/latitude with 75 z-levels in the vertical. With the help of colleagues, we have prepared and tested 1) tidal input forcing through lateral open boundaries , tidal potential, self-attraction and loading; 2) hourly surface atmospheric forcing from the ECMWF ERA5 reanalysis; 3) initial conditions of temperature and salinity (T/S), and lateral monthly boundary conditions of T/S, and non-tidal current and sea surface height from the ECMWF ORAS5 global ocean reanalysis; 4) initial sea-ice concentration and ice thickness from ORAS5 and ice temperature from ERA5; and 5) the inter-annually varying monthly data of lateral freshwater inputs from rivers and the melting of the Greenland ice sheet and Arctic Glaciers.

Sarah MacDermid[1], Li Zhai[1], Lu Youyu[1], David Brickman[1] [1]DFO sarah.macderid@dfo-mpo.gc.ca

OCE-Comparison of eddy permitting, eddy rich and sub-mesocale permitting global configurations based on NEMO 4.2 OGCM.

In the framework of the Copernicus Marine Environment Monitoring Service, Mercator Ocean International operates a global high-resolution forecasting systems at the resolution of 1/12. Increasing resolution appears necessary to improve the quality of service and to satisfy the users needs in the operational application (Le Traon, 2019).

Resolving scales below 100 kilometers, and in particular sub mesoscale processes (1-50 km), appears to be essential to better represent the circulation in the open ocean, and, to improve the large-scale representations thanks to a more explicit energy transfers between finer and larger scales. A deeper understanding of their various contributions and their role in the global ocean kinetic energy budget will improve the knowledge of these energy transfers between different scales. In 2019, it has been decided to go towards higher resolution and develop a new global sub mesoscale-permitting model. Benefiting from the context of the European H2020 IMMERSE project, a new 1/36 global configuration (2 to 3 km resolution), based on the NEMO 4.2 OGCM, has been developed. In 2022, a hierarchy of multi-year simulations at 1/4, 1/12 and 1/36 resolution and with/without explicit tide representation has been performed: for each resolution, after a 3-years spin up without tidal forcing, 2 twin 3-years runs have been realized: one without tidal forcing and one forced by the 5 tidal components K1, O1, S2, M2, N2. These models are driven at the surface by the 8km/1hour ECMWF IFS system. Atmospheric pressure forcing have been activated. We propose a first evaluation of the benefits due to the resolution increase and tidal forcing. Circulation, energy, tidal representation and mixing of the experiments are compared to each others.

Clément Bricaud[1], Jérôme Chanut[1], Romain Bourdalle Badie[1], Perrine Abjean[1], Gilles Garric[1] [1]Mercator Ocean International cbricaud@mercator-ocean.fr

OCE-Exploration of Lab60: A 1/60th degree AGRIF nest of the Labrador Sea

The Labrador Sea is a very dynamic region, with physical processes occurring at a variety of scales, from large scale gyre circulation to small scale convection processes. These small-scale features are difficult to represent with numerical simulations due to high computational costs. We carry out NEMO simulations incorporating two AGRIF nests to achieve 1/60th degree horizontal resolution (about 900m) in the Labrador Sea. Three iterations of this simulation have been run, all covering 2010-2018, using three different atmospheric forcings, and with/without Greenland runoff. We use these experiments to explore exchange from the boundary currents to the interior, evolution of the basins stratification and deep-water formation. Another question is if we can quantify the impact of Greenland melt over the past decade. We also mention preliminary work on a new 60th Arctic simulation.

Paul Myers[1], Clark Pennelly[1], Ruijian Gou[2], Pouneh Hoshyar[1] [1]University of Alberta [2]Ocean University of China pmyers@ualberta.ca

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Satellite Earth Observation: A unique view of our planet and a long-term strategic vision for Canada - Part 6

Tuesday, May 30
14:30 - 16:00 EDT

(15 Mins) Moments of total column water vapour distribution and their representation in climate models - Carsten Abraham

(15 Mins) Temperature and water vapor retrievals from joint airborne hyperspectral microwave radiometer and ground-based hyperspectral infrared radiometer measurements - Lei Liu

(15 Mins) The Aerosol Limb Imager on HAWC - Landon Rieger

(15 Mins) Next-generation nano-DIHM platform for 4-dimensional observation of small aerosols of 1-200 nm dimeters from space - Parisa Ariya

(15 Mins) Evaluation of MODIS aerosol optical depth retrievals over the North American and European Arctic - Norm O'Neill

(15 Mins) Assessment of the added value of far-infrared spaceborne radiometry for cloud remote sensing using ground-based observations and end-to-end simulator. - Yann Blanchard

Satellite Earth observation provides a unique global perspective on our planet's atmosphere and surface, including the oceans, land, vegetation, ice, and snow. Current and planned satellite missions from Canada and international agencies have provided and will provide a wealth of new information about the Earth system and that can be used to investigate a wide range of environmental and scientific questions. This session encourages contributions from across the full Earth observation value chain, upstream, midstream and downstream. This includes new measurement technologies and techniques, both passive and active; mission development; retrieval algorithms; demonstration and calibration of instruments; validation of satellite products; assimilation of data into numerical models; scientific results and discoveries; operational utilization and development of services.

MUL-Moments of total column water vapour distribution and their representation in climate models

We use satellite data from the Atmospheric Infrared Sounder on Aqua and ERA5 reanalysis to evaluate novel diagnostics of higher order moments of distributions of daily mean atmospheric total column water vapour (TCWV) to validate climatologies of modelled water vapour in CMIP6 models. The mean and skewness of TCWV distributions are linearly correlated with low and large mean TCWV being associated with positive and negative skewness, respectively. Large mean TCWV occur in the tropics where deep convection efficiently transforms water vapour into liquid water causing upper TCWV thresholds and thus the negatively skewed TCWV distributions. The linear relationship between the mean and skewness of the TCWV distributions also holds for specific humidity distributions in all tropospheric levels, however, with increasing heights specific humidity distributions approach normal distributions. This transition towards normal distributions of humidity follows a power-law relationship with height. While climate models from CMIP6 simulate linear relationships between the mean and skewness of humidity distributions, they often have difficulty representing their slopes. The biases depend on two main factors: the conversion efficiency of water vapour into liquid water in deep convection cells influencing upper TCWV thresholds, and detrainment rates of deep convection determining the transition from negatively skewed to normally distributed humidity in the upper troposphere. As a consequence, the new diagnostics provide a useful means to calibrate and validate deep convection parameterizations in climate models allowing for better representations of TCWV distributions, thus their variability, which is important for radiative properties of the atmosphere and extreme precipitation events.

Carsten Abraham[1], Elizaveta Malinina[1], Colin Goldblatt[2] [1]Environment and Climate Change Canada [2]University of Victoria carsten.abraham@ec.gc.ca

MUL-Temperature and water vapor retrievals from joint airborne hyperspectral microwave radiometer and ground-based hyperspectral infrared radiometer measurements

Accurate monitoring of atmospheric temperature and water vapor profiles at high spatial resolution is essential for both weather forecasting and climate research. Such profiles can be inferred by exploiting hyperspectral radiance measurements. The latter contain a wealth of information about various atmospheric molecules, characterized by their distinct absorption spectra. In this study, the High Spectral Resolution Airborne Microwave Sounder (HiSRAMS) and the Atmospheric Emitted Radiance Interferometer (AERI) were utilized simultaneously to collect microwave and infrared radiance measurements. Both radiometers have high spectral resolution, which allows for the detection of subtle changes in temperature and water vapor profiles. Clear-sky temperature and water vapor concentration profiles have been successfully retrieved from collocated HiSRAMS flight measurements and AERI ground measurements. The retrieved temperature and water vapor concentration profiles were compared to radiosonde measurements, and good agreement was found. Joint retrievals employing the two instruments reduced the retrieval uncertainty and increased the Degree of Freedom for Signal (DFS) for both temperature and water vapor compared to using either instrument alone. Furthermore, to evaluate the capability of high spectral resolution microwave radiometer in comparison to high spectral resolution infrared radiometer, collocated HiSRAMS and AERI ground measurements were collected to compare the retrieval uncertainty and information contents between the two instruments.

Lei Liu[1], Yi Huang[1], John Gyakum[1], Natalia Bliankinshtein[2], Philip Gabriel[3], Shiqi Xu[2], Mengistu Wolde[2] [1]McGill University [2]NRC [3]Horizon Science & Technology lei.liu5@mail.mcgill.ca

MUL-The Aerosol Limb Imager on HAWC

The interaction of clouds, aerosols and water vapour in the upper troposphere and lower stratosphere remains a large uncertainty in understanding Earths changing climate. However, high resolution measurements of these parameters have been historically difficult, with no single system capable of monitoring the interaction. To help address this gap, Canada will launch the High altitude Aerosols, Water vapour and Clouds (HAWC) observation system as part of NASAs Atmosphere Observing System (AOS). The Aerosol Limb Imager (ALI) is one of three instruments on HAWC and will take two-dimensional multi-spectral images of Earths limb from the ground to 45 km, providing information on aerosol extinction and microphysics. This work showcases three significant ALI abilities: - Cloud and aerosol discrimination using polarization information. - Particle size retrievals using wavelengths in the visible and near infrared. - Tomographic retrievals for improved horizontal resolution. ALI will provide critical information on aerosols that impact the radiative balance, and influence cloud formation and evolution. This Fall, ALI will be flown alongside the Spatial Heterodyne measurements Of Water (SHOW) instrument on an ER-2 aircraft campaign. This will provide a unique test of the two limb-viewing instruments on HAWC and the benefits of coincident water and aerosol measurements.

Landon Rieger[1], Adam Bourassa[1], Doug Degenstein[1], Jeffery Langille[2], Yann Blanchard[3], Jean-Pierre Blanchet[3] [1]University of Saskatchewan [2]University of New Brunswick [3]Université du Québec à Montréal landon.rieger@usask.ca

MUL-Next-generation nano-DIHM platform for 4-dimensional observation of small aerosols of 1-200 nm dimeters from space

Most airborne particles, or aerosols, are submicron, and particles less than 200 nm (nanosized) constitute most aerosols. They are the most critical component in Earths climate and play an essential role in the changing regional and global climate. Yet, space-borne observation cannot account for their size distribution, shape, topography, surfaces, selected composition, and many other physicochemical characteristics significant in aerosol-cloud interactions. Thus, there is an utmost need to improve understanding of the role of aerosols in the Earths climate system.Here, we aim to detect airborne nanosized particles and micro-size particles using novel technology (Nano-DIHM) developed and patent-pending technology at McGill University. We have demonstrated that the Nano-DIHM successfully measures the four-dimensional tracking of the vast size range of aerosol particles, shape, and surface properties in various fluids, including air (indoor and outdoor on mobile units), water, and snow, using a relatively inexpensive visible laser, modification of optics and very detailed Artificial Intelligence. We have also demonstrated that we can observe particles from a few nanometers to a few micrometres, in millisecond time resolution. Furthermore, Nano-DIHM provides a single particle tracking and an ensemble of particle tracking, concurrently and remotely.We will discuss our ongoing Canadian RD to transform ground techniques to aerial and satellite platforms.

Parisa Ariya[1] [1]McGill University parisa.ariya@mcgill.ca

MUL-Evaluation of MODIS aerosol optical depth retrievals over the North American and European Arctic

The MODIS-Aqua and MODIS-Terra DT (dark target) and DB (deep blue) aerosol optical depth (AOD) product is a critical indicator of the spatio-temporal variation of aerosol columnar-abundance across the globe. It has notable challenges in the difficult surface reflectance and lighting conditions of the Arctic. Validation results of a 20 year MODIS-AOD climatology versus a 20 year, low- to high-Arctic AERONET/AEOCAN climatology across six stations in the North American and European Arctic will be presented. This will include event- and climatological-scale examples of both successes and significant biases in the retrievals.

Keyvan Ranjbar[1], Alireza Aslemand[2], Norm O'Neill[2] [1]NRC [2]Université de Sherbrrooke Keyvan.Ranjbar@USherbrooke.ca

MUL-Assessment of the added value of far-infrared spaceborne radiometry for cloud remote sensing using ground-based observations and end-to-end simulator.

By modulating radiation, precipitation, and atmospheric composition, clouds alter the water balance and contribute strongly to perturbing the atmospheric and surface energy budgets. Processes and feedback mechanisms involving clouds and aerosols also represent one of the largest sources of uncertainty in our understanding of Earths climate system. To study these critically important factors, Canada has proposed the High-altitude Aerosols, Water vapour and Clouds (HAWC) observation system, composed of three instruments, including a nadir-viewing imaging radiometer covering the mid- to far-infrared. This paper presents the projected performance and scientific benefits for cloud and radiation studies using a sophisticated end-to-end simulator. The simulator implements realistic input atmospheres, an instrument model aligned with the Phase 0 concept, and a retrieval algorithm to estimate the impact of noise levels, calibration errors, and a priori assumptions on the level 2 products. Ground-based

observations of clouds, from ARM and Canadian Arctic stations, are used to initiate the simulator and to calibrate systematic biases. Relying on the instrument parameters proposed in Phase 0, nadir-viewing simulations of the same scenes highlight the contribution of far-infrared spaceborne radiometry when compared to ground-based instruments and standard thermal infrared sensors.

Yann Blanchard[1], Jean-Pierre Blanchet[1], Atif Taoussi[1], Ludovick Pelletier[2] [1]ESCER / UQAM [2]ECCC yann.blanchard@usherbrooke.ca

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Severe Convective Storms – Detection, Prediction, Climatology and the Future - Part 1

Tuesday, May 30
14:30 - 16:00 EDT

(15 Mins) Update on a Canadian Hail Report Database (2005-2022) and on a national hail climatology determined using a lightning proxy - Dominique Brunet

(15 Mins) F/EF2+ Tornado Environments In Parts Of Canada - John Hanesiak

(15 Mins) Investigation of the atmospheric environments prone to downbursts in Canada using machine learning models - Mohammed Hadavi

(15 Mins) The Billion Dollar Ontario-Québec Derecho of 21 May 2022 - David Sills

(15 Mins) A Case Study of two Ultra-Violent Winds in the Manjil Valley, the Largest Gap in the Alborz Mountains in Iran - Jeff Sepehri

(15 Mins) Spatial Variation in the Synoptic Structure of Convective Systems over the Great Plains - Iaroslav Verevkin

Many of Canada's most costly natural disasters are caused by severe convective storms. Insured losses from these storms are increasingly reaching the billion dollar mark. Anthropogenic climate change may significantly alter the probability of such disasters occurring in the future. This session will focus on severe convective storms and their hazards (tornadoes, downbursts, hail, heavy rainfall), and in particular their detection, prediction, historical climatology and possible future climatology. This includes a wide range of possible topics, from event case studies and verification statistics to climatological trend analyses and modelling future changes to storms and/or hazards. The session aims to highlight new insights that improve our physical understanding of, and our detection and prediction capabilities for, such events. A 30-min invited presentation is likely to lead off the session.

ATM-Update on a Canadian Hail Report Database (2005-2022) and on a national hail climatology determined using a lightning proxy

We first present a revised and updated version of a Canadian hail report database for 2005-2022, including new reports from 2022. The database contains 7,000 unique entries with estimates of the timing and location of the hail reports and estimated hail size (in mm). In the second part, we revisit the methodology that we recently developed to construct an estimate of the hail climatology across Canada using manual hail observations at airports and a lightning proxy. We do this by estimating the probability of

hail occurrence at airport locations across the country at any given hour using Bayesian inference. We then interpolate in space the probabilities to obtain smooth prior probabilities of hail occurrence at any location in Canada. These probabilities are then refined using lightning flashes density as a proxy for the likelihood of severe (or significant severe) hail. Finally, we aggregate the posterior probabilities of severe (or significant severe) hail over time and space and compare those results with the number of reports found in the 2005-2022 Canadian hail database.

Dominique Brunet[1], Julian Brimelow[2] [1]Environment and Climate Change Canada [2]University of Western Ontario Dominique.Brunet@ec.gc.ca

ATM-F/EF2+ Tornado Environments In Parts Of Canada

There is a general lack of understanding of the different tornadic storm environments within Canada; for example, how Ontario environments differ from western Canada. This study uses ERA5 derived convective parameters (e.g. CAPE, wind shear, and severe storm indices like SCP) with the main objective to characterize historical F/EF2+ tornadic environments between 1980 2020 from Alberta to Quebec, and to compare regional differences. First, ERA5 convective parameters agree quite well with observation-derived convective parameters from relevant radiosonde sites, with correlations ranging from 0.85 0.98, MLCAPE MAE ~250 J kg-1, and 0-6 km bulk shear MAE ~2 m s-1(5 knots) over Canada as a whole. This suggests that ERA5 convective parameters are reasonable enough to characterize strong tornado environments in Canada. Overall results suggest that the Alberta (AB) environment can be quite different than other parts of Canada, and the current STP formulation is not very practical for western Canada. The Prairie provinces as a whole, are very different than southern Ontario/Quebec (SOnt/QC), particularly Saskatchewan/Manitoba (SK/MB) that see the highest CAPE, mid-level lapse rates, LCLs and LFCs. Southern Ontario is only different than northern Ontario with respect to a few thermodynamic parameters (e.g. low-level moisture, CAPE and mid-level lapse rates). SOnt/QC generally has much stronger bulk shear and SRH at all levels as well as better streamwise vorticity in low levels (0-1 km) compared to western Canada. Composite hodographs suggest that AB right-moving supercells have the largest deviant motions, while SOnt/QC have the smallest deviants.

John Hanesiak[1], Mateusz Taszarek[2], David Walker[1], Chun-Chih Wang[1] [1]University of Manitoba [2]Adam Mickiewicz University

ATM-Investigation of the atmospheric environments prone to downbursts in Canada using machine learning models

Windstorms are the most severe weather hazard in Canada. Our analysis of insured losses showed that ~75% of all weather-related catastrophes in Ontario and Quebec during 20082021 were wind disasters. We also demonstrated that convective storms are the most disastrous wind type, imposing 67% of the total wind damage. Hence, utilizing machine learning models, this study investigates atmospheric environments prone to damaging downbursts across Canada. The downburst data were obtained from the Northern Tornado project database. A double-stage verification process was used to train 30 models for discriminating environments preceding observed (1) downburst; (2) lightning flashes but without downburst; and (3) neither downburst nor lightning flashes. Atmospheric conditions were analyzed using the ERA5 reanalysis data during 20192022. Combining two indicesone representing thermodynamics (vertical gradient of equivalent potential temperature) and another dynamics (effective bulk shear) features

of the atmospherethis research proposes a new and robust downburst diagnostics index called Downburst Precursor Parameter (DPP) with the accuracy score of 0.90. DPP higher than 2 indicates a high risk of downburst development. We further showed that damaging downbursts were not observed from the Rockies westward while ~45% of the total of 294 damaging downbursts occurred in southeastern Canada, where squall lines were the dominant storm type (~57%). Considering downbursts accompanied with lightning (~70% cases), nearly half of the events were supercell thunderstorms. A low amount of surface precipitation was often detected (i.e., dry downbursts) for the rest 30% indicating that these downburst-producing storms were not deep moist convection.

Mohammad Hadavi[1], Djordje Romanic[1] [1]McGill University
mohammad.hadavi@mail.mcgill.ca

ATM-The Billion Dollar Ontario-Québec Derecho of 21 May 2022

The primary goal of the Northern Tornadoes Project is to detect, assess, and document all tornadoes that occur in Canada and make results publicly available. However, NTP also documents other damaging wind phenomena including downbursts. And for the first time since its inception in 2017, NTP has documented a derecho one with historic impacts. It is now Canadas most impactful and thoroughly documented derecho. On 21 May 2022, a derecho with wind damage rated up to EF2 affected Canadas most populous urban corridor, from Windsor Ontario to Qubec City Quebec (over 1000 km). Several tornadoes were also generated along the leading edge of the storm, with up to EF2 damage. There were 12 fatalities and at least 12 injuries due directly to the storm, and over a billion dollars in insured losses. The presentation will focus on the various damage surveys (ground plus remotely piloted aircraft system) and the satellite-based damage analyses that were completed in order to fully characterize the widespread impacts of this storm. The climatology of derechos in Canada will also be discussed.

David Sills[1], Connell Miller[1], Lesley Elliott[1], Aaron Jaffe[1], Joanne Kunkel[1], Gregory Kopp[1] [1]Western University david.sills@uwo.ca

ATM-A Case Study of two Ultra-Violent Winds in the Manjil Valley, the Largest Gap in the Alborz Mountains in Iran

Manjil valley is the enormous gap in the Alborz Mountains in the North of Iran. The Alborz mountains separate the humid Caspian Sea area from the semi-dry Iran plateau. The unique structure of this gap causes the collision of climatic contrasts in two different regions of Central Iran and the Caspian Sea region. For example, the channelling of the airflow can cause severe storms in the valley when there is no storm on either side of it. The valley studied here is in the southwest part of the Caspian Sea. The unique condition of Manjil valley makes it one of the windiest parts of Iran, which has almost a regular wind regime. The largest wind farm in Iran has been built there due to the regular daily Wind. The valley wind mostly blows in spring and summer and less in autumn and winter. In this article, we demonstrate what happens on the synoptic scale in two specific storm conditions in the valley while there was no particular condition outside. At the time that there was not a severe wind speed on either side, the windspeed in the valley was around the Hurricane-force on the Beaufort scale. We used leeward and windward stations to compare the inside valley stations and the data of the nearest radiosonde. The two severe mesoscale storms investigated are those that happened inside the valley on April 3, 2003, and September 10, 2004. Continuing work on these extreme valley winds using WRF simulation is planned.

Jeff Sepehri[1] [1]York University Jeff.Sepehri@gmail.com

ATM-Spatial Variation in the Synoptic Structure of Convective Systems over the Great Plains

Models have difficulty in simulating the diurnal time of nocturnal rainfall over the Great Plains. Deep convection in this region is often associated with severe weather. We explorehow the structure of deep convective rain events over the Great Plains varies with longitude. The diurnal time of maximum rain becomes progressively delayed in going eastward from the Rocky Mountains, where it peaks in the afternoon, such that maximum rain occurs near 3 am local time over much of the Great Plains. We use Rapid Refresh reanalysis data from July and August of 2009-2019 to show that there is continuous spatial variation in the mean structure of the high rain events that occur along this anomalous diurnally propagating rainfall feature. High rain events that occur further from the Rockies are more likely to be associated with a larger warm anomaly to the south of the rain event center, a smaller cold anomaly, a larger negative surface pressure anomaly, and increased low-level southerly meridional wind. We also use the IMERG rainfall dataset to show that, on hourly timescales, afternoon rainfall that occurs over the Rocky Mountains propagates eastward onto the Great Plains but is rapidly attenuated and becomes negligible east of 100 W. This eastward rainfall propagation appears to be mediated in part by the formation of a low-level cold anomaly and increased surface pressure over the Rocky Mountains, a reversal of the upslope wind, and increased low-level zonal mass convergence over the adjacent Near Plains.

Iaroslav Verevkin[1], Ian Folkins[1] [1]Dalhousie University ir818820@dal.ca

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Day 3 – 31 May 2023

AI Takes on Weather Prediction

Wednesday, May 31
6:30 - 8:00 EDT

(AI), the field of meteorology is poised for significant advancements that will help us better understand and predict weather patterns. This panel session will bring together top experts in the field of meteorology and AI to discuss the future of this critical area of research. The first guest, from Environment and Climate change Canada (ECCC), will address the current state of AI in weather forecasting in Canada. The second guest, from the European Centre for Medium-Range Weather Forecasts (ECMWF), will discuss their roadmap for the next 10 years in machine learning. Finally, a representative from DeepMind will present their work on "GraphCast: Learning skillful medium-range global weather forecasting".

The panelists will provide a view of the future of meteorology and AI, exploring both the potential benefits and challenges that lie ahead. This session will be dynamic, with an interactive format that includes a discussion period. Participants will have the opportunity to engage directly with the panelists, ask questions, and share their own perspectives.

With its diverse lineup of panelists, engaging format, and critical discussion of the future of meteorology and AI, this session promises to be an enlightening and thought-provoking experience for all participants. The session will be held in hybrid mode, with the possibility of attending in person or virtually.

(15 Mins) Introduction to AI and panelists - Tremblay Miguel

(15 Mins) AI strategy at Science and Technology Branch and Canadian Centre for Meteorological and Environmental Prediction - Gauthier Jean-Phillipe

(15 Mins) Machine learning at ECMWF - Chantry Matthew

(15 Mins) GraphCast: Learning skillful medium-range global weather forecasting - Lam Remi

(15 Mins) Q&A and discussion - Tremblay Miguel

With the growth of big data and advancements in artificial intelligence (AI), the field of meteorology is poised for significant advancements that will help us better understand and predict weather patterns.

This panel session will bring together top experts in the field of meteorology and AI to discuss the future of this critical area of research. The first guest, from Environment and Climate change Canada (ECCC), will address the current state of AI in weather forecasting in Canada. The second guest, from the European Centre for Medium-Range Weather Forecasts (ECMWF), will discuss their roadmap for the next 10 years in machine learning. Finally, a representative from DeepMind will present their work on "GraphCast: Learning skillful medium-range global weather forecasting".

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With its diverse lineup of panelists, engaging format, and critical discussion of the future of meteorology and AI, this session promises to be an enlightening and thought-provoking experience for all participants. The session will be held in hybrid mode, with the possibility of attending in person or virtually. Make sure to mark your calendar!

ATM-AI strategy at Science and Technology Branch and Canadian Centre for Meteorological and Environmental Prediction

Advances in deep learning over the last ten years now allow us to consider integration at certain stages of the weather and environmental forecasting chain with potential gains in terms of the quality of the final forecasts and therefore of the services to clients. However, the implementation of such systems must be done carefully because it also presents major challenges in terms of the explainability of forecasts, especially when they are eventually missed. We will present the strategy and vision for the integration of AI in the weather and environmental forecasting chain of the Science and Technology Branch and Canadian Centre for Meteorological and Environmental Prediction. Les avancées de l’apprentissage profond au cours des dix dernières années nous

permettent maintenant d'envisager une intégration à certaines étapes de la chaîne de prévision météorologique et environnementale avec des gains potentiels en terme de qualité des prévisions finales et donc des services aux clients. Cependant, la mise en opération de tels systèmes doit se faire prudemment car elle présente aussi des défis majeurs quant à l'explicabilité des prévisions, en particulier lorsqu'elles seront éventuellement ratées. Nous présenterons la stratégie et vision pour l'intégration de l'IA dans la chaîne de prévision météorologique et environnementale de la DSTA et du CPMEC.

Jean-Philippe Gauthier, Martin Charron Chief Information Officer / Research Director, Atmospheric Science and Technology - ECCC

ATM-Machine learning at ECMWF

Machine learning is rapidly emerging as a valuable tool in a vast range of applications, with its incredible capacity to learn extremely complex systems from sufficiently large datasets. In 2021 ECMWF published a roadmap, envisaging how the upcoming decade of machine learning for weather forecasting might progress. In the meantime, tech companies have begun exploring the capacity of machine learning to replace conventional forecast models entirely, leveraging ECMWF's ERA5 reanalysis product as training data. Here we will present our progress with the machine learning roadmap, an assessment of the field of data-driven forecasts, and our vision for machine learning in weather prediction for the years to come.

Matthew Chantry, Victoria Bennett, Christine Kitchen. Machine learning coordinators, ECMWF

ATM-GraphCast: Learning skillful medium-range global weather forecasting

We present our recent paper "GraphCast: Learning skillful medium-range global weather forecasting" (https://arxiv.org/abs/2212.12794). GraphCast is a machine-learning (ML) based weather simulator, trained from the ERA5 reanalysis archive, which can make forecasts, at 6-hour time intervals, of five surface variables and six atmospheric variables (37 vertical pressure levels), on a 0.25-degree grid (~25 km at the equator). GraphCast can generate a 10-day forecasts (35 gigabytes of data) in under 60 seconds, while outperforming ECMWF's deterministic operational forecasting system, HRES, on 90.0% of the 2760 variable and lead time combinations we evaluated, as well as all other ML baselines. These results represent a key step forward in complementing and improving weather modeling with ML, opening new opportunities for fast, accurate forecasting. In this talk we will go into the details of the model architecture, as well as providing a detailed evaluation against HRES.4 presentation abstract/overview

Research Scientist (DeepMind, apart of Alphabet)

Remi Lam, Alvaro Sanchez-Gonzalez, Matthew Willson, Peter Wirnsberger, Meire Fortunato, Alexander Pritzel, Suman Ravuri, Timo Ewalds, Ferran Alet, Zach Eaton-Rosen, Weihua Hu, Alexander Merose, Stephan Hoyer, George Holland, Jacklynn Stott, Oriol Vinyals, Shakir Mohamed, Peter Battaglia.

A special session on ocean science and environmental statistics in tribute to Professor Keith R. Thompson - Part 1

Wednesday, May 31
8:30 - 10:00 EDT

(30 Mins) Overview of Keith Thompson's Major Scientific Contributions - Hal Richie

(15 Mins) Study Ocean Variability and Predictability through Combined Statistical and Dynamic Analyses: My Learning from Professor Keith Thompson - Youyu Lu

(15 Mins) Biogeochemical data assimilation with model bias and non Gaussianity– lesson learnt from 1D and 3D settings. - Tsuyoshi Wakamatsu

(15 Mins) Improving ECCC's global total water level forecast system, part 1: Adding baroclinicity - Pengcheng Wang

(15 Mins) Effect of tides on the Indonesian Seas circulation and the Indonesian Throughflow - Anna Katavouta

Professor Keith Thompson of Dalhousie University passed away on July 11, 2022. Professor Thompson held a Tier I Canada Research Chair in "Marine Prediction and Environmental Statistics: and participated in many international committees including "Coastal Ocean Observations Panel of the Global Ocean Observing System". Professor Thompson made exceptional contributions in ocean science research and high-quality training. He made significant contributions in developing a storm surge prediction model that is now being used operationally. This session will have an overview of Dr. Thompson's research work and his major contributions. We invite abstracts from everyone particularly from his former students and his collaborators on any research topics including modelling and prediction of coastal and shelf waters, environmental statistics, process studies of dynamics in atmospheres and oceans, and data assimilation.

OCE-Overview of Keith Thompson's Major Scientific Contributions

Professor Keith Thompson made major research contributions in a wide range of topics including modelling and prediction of global, coastal and shelf waters, data assimilation, environmental statistics, and studies of atmospheric and ocean dynamics. Keith was a wonderful friend and colleague who played a leading role in many national and international networks and projects, and an inspiring teacher and mentor who trained many students and other highly qualified personnel. This presentation will give a broad overview of Keiths career contributions, punctuated by some anecdotes, and setting the stage for more specific following presentations in this special tribute session.

Hal Ritchie[1], Natacha Bernier[1], Michael Dowd[2], Youyu Lu[3], Jinyu Sheng[2] [1]Environment and Climate Change Canada [2]Dalhousie University [3]Fisheries and Oceans Canada
Hal.Ritchie@ec.gc.ca

OCE-Study Ocean Variability and Predictability through Combined Statistical and Dynamic Analyses: My Learning from Professor Keith Thompson

My research career was greatly benefited from the mentorship of, and interactions and collaborations with Professor Keith Thompson over twenty years. In this presentation Ill start with a summary of important research methodology and style that I learned from Keith, and will then focus on the study of ocean variability and predictability through combining statistical and dynamic analyses. I will use examples from my collaborative study with Keith on the ocean response to atmospheric intra-seasonal variations, and recent work on variability and predictability of sea levels, sea-ice and temperature at intra-seasonal, interannual and decadal time scales.

Youyu Lu[1] [1]DFO Maritimes Youyu.Lu@dfo-mpo.gc.ca

OCE-Biogeochemical data assimilation with model bias and non Gaussianity– lesson learnt from 1D and 3D settings.

The Ensemble Kalman filter is one of the most popular data assimilation systems in ocean data assimilation community. Fundamentally, it relies on model ensemble forecast covariance for propagating observed information to unobserved variables. However, its two major foundation pillars, Gaussianity and unbiased assumption are not satisfied by model ensemble occasionally in real world application. The situation is especially so with the ocean biogeochemical (BGC) model. Through the efforts of operational biogeochemical reanalysis data production for the European climate monitoring program Copernicus, we have encountered numerous such cases with TOPAZ ocean biogeochemical reanalysis system. The series of incidents were cataloged, and a clear mechanistic ill condition amplified by the break of both foundation pillars emerged. Unlike physical data assimilation, ensemble covariance of biogeochemical variables or physical-biogeochemical coupled variables form covariance relation through two distinct inter-variables connectivity. Primary production process is major source of biogeochemical and physical coupled inter-connectivity and formulates healthy covariance for BGC data assimilation. However, ocean mixing induced interconnectivity occasionally formulates ill covariance introducing strong correlation among variables through vertical or potentially lateral dilution. The latter case is amplified under the perfect combination of the non Gaussianity and biased case. In this presentation we report cataloged cases of such emergency of ill covariance in the BGC data assimilation system from our 3D and 1D practices and discuss potential mitigation for more stable filter design for the future operational system.

Tsuyoshi Wakamatsu[1], Laurent Bertino[1] [1]Nansen Environmental and Remote Sensing Center and Bjerknes Centre for Climate Research tsuyoshi.wakamatsu@nersc.no

OCE-Improving ECCC's global total water level forecast system, part 1: Adding baroclinicity

Operational and climate flood forecast systems are typically barotropic. This study shows the inclusion of baroclinicity can lead to significant improvements in forecasts of total water level (TWL) at relatively low computational cost. The method is illustrated using a light baroclinic, high-resolution (1/12 degree) global model with an optimized vertical grid of nine ocean levels. Temperature and salinity for each layer are weakly nudged to forecast fields provided by a coarser resolution (1/4 degree), data-

assimilative ocean model. The nudging effectively includes low-frequency baroclinic contributions captured by the 1/4 dgree model, while allowing higher frequency variability generated by the 1/12 dgree model to evolve freely. Accounting for baroclinic processes in this manner results in only a 10% additional computational cost. The value of adding baroclinicity is demonstrated across the sea level frequency spectrum using observations of TWLs made by 211 globally-distributed tide gauges. Large improvements (up to 42 cm) are found for low-frequency (greater than 15 days) variability where baroclinic processes are known to make significant contributions. At higher frequency, baroclinicity also improves the predictions of peak surges (by up to 15 cm), particularly over narrow shelves. Finally, the importance of modeling baroclinically-modified coastal trapped waves is illustrated.

Pengcheng Wang[1], Natacha Bernier[1] [1]Environment and Climate Change Canada pengcheng.wang@ec.gc.ca

OCE-Effect of tides on the Indonesian Seas circulation and the Indonesian Throughflow

Prof. Keith Thompson patiently mentored me and inspired me to delve into the intricacies of processes operating on the shelf-seas and their modelling during my PhD; which (unbeknownst to me back then) has defined my current and future research endeavours. Under Keiths supervision, I studied the interaction between the tidal and seasonal variability of the Gulf of Maine and Scotian Shelf, which was the main inspiration for this work on the effect of tides in the Indonesian Seas. This study is truly a consequence of Keiths guidance during the early steps of my career. The study explores the effect of tides on the Indonesian Throughflow (ITF) in a regional ocean model of the South East Asia. Our model simulations, with and without tidal forcing, reveal that tides drive only a modest increase in the ITF volume, heat and salt transports toward the Indian Ocean. However, tides drive large regional changes in these transports through Lombok Strait, Ombai Strait and the Timor Sea, and regulate the partitioning of the ITF amongst them. Specifically, the interaction between the tides, the topography and stratification within the Indonesian Seas causes tidally-induced ocean currents that force more water to exit through the Timor Sea, at the expense of less water exiting through the Lombok and Ombai straits. Hence, tides regulate the pathway of water exiting into the Indian Ocean through the Indonesian Seas and so may affect the transport of physical, biogeochemical and pollution-related materials in this region.

Anna Katavouta[1] [1]National Oceanography Centre, UK annkat@noc.ac.uk

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Atmosphere, Ocean, and Climate Dynamics - Part 4

Wednesday, May 31
8:30 - 10:00 EDT

(15 Mins) Representation of Extreme Winds in Variable Resolution CESM - Micheal Morris

(15 Mins) PERFORMANCE COMPARISON OF SEVERAL NUMERICAL WEATHER PREDICTION MODELS IN THE FATIMA 2022 CAMPAIGN PERIOD - Zheqi Chen

(15 Mins) BOUNDARY LAYER MIXING, MARINE STRATUS AND FOG - Peter Taylor

This session combines submissions that document studies of the dynamics of the atmosphere, oceans and/or climate system. The scope of the session is deliberately broad in order to include research that spans a broad range of spatial and temporal scales. Studies of the dynamics of mesoscale processes that act on hourly timescales are as welcome in this session as those that document the evolution of planetary-scale structures in a changing climate. Such investigations may include diagnoses and theoretical studies of forecast, climate, and process models, or studies based on reanalysis and other observational datasets; however, any topic that is relevant to atmosphere, ocean, or climate dynamics will fit well into this session. Please note we have run this session at CMOS Congresses since around 2009.

MUL-Representation of Extreme Winds in Variable Resolution CESM

Extreme near-surface wind speeds in cities can have major societal impacts but are not well represented in climate models, in part due to coarse spatial resolution. Despite this, large-scale dynamics in the free troposphere, which models resolve better, could provide reliable constraints on local extreme winds. In this talk, I will discuss the synoptic circulations associated with midlatitude extreme wind events and assess how resolution affects their representation in reanalysis and a climate model framework. Composites of reanalysis (ERA5) sea level pressure and upper tropospheric winds during observed extreme wind events reveal distinct circulation structures for each quadrant of the surface-wind rose. I examine how these circulation patterns are represented in a climate model using the NCAR Community Earth System Model. A set of two otherwise identical simulations, one with globally uniform standard resolution (CESM-SE-UNIF), and the other with spatial resolution refined over Southern Ontario (VR-CESM), allows us to isolate the effects of regional refinement on the representation of extreme winds under historical climate conditions. Results show that VR-CESM improves representation of surface ageostrophic circulations and the strength of vertical coupling between upper-level and near-surface winds. Simulations with end-of-century RCP8.5 forcing show diverging climate change projections of extreme winds between the uniform and refined resolution models.This work motivates further investigation into the added value of regionally refined resolution for the study of wind extremes under climate change.

Michael Morris[1], Paul Kushner[1], G.W.K. Moore[1] [1]University of Toronto
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MUL-PERFORMANCE COMPARISON OF SEVERAL NUMERICAL WEATHER PREDICTION MODELS IN THE FATIMA 2022 CAMPAIGN PERIOD

The FATIMA (Fog and turbulence interactions in the marine atmosphere) project is a multi-year project seeking advance leaps in the fundamental understanding of the marine-fog life cycle via a cross-disciplinary approach. In July 2022, a field campaign was conducted on Sable Island (offshore from Nova Scotia) as well as over the Grand Banks area. Sable Island is a narrow and long island, with significant amount of fog during the summer. Thanks to the land, various sets of equipment can be set up for observations. ECCC (Environment and Climate Change Canada) also has a weather station on the island. During the campaign, there were daily weather briefing meetings where the weather conditions in the next 1-2 days were forecasted and discussed, as a guide to the crews on the field for equipment set-ups. Some regional scale NWP

(numerical weather prediction) models were used to forecast the period. They were the COAMPS (Coupled Ocean/Atmosphere Mesoscale Prediction System) model from the U.S. Navy, and two WRF (Weather Research and Forecasting) models with different settings. The models are high-resolution so that the relatively narrow (~ 1km) sand bar land of Sable Island can be seen in the domains. The results of the models are compared to the ECCC observations, including temperature, dew point, wind speed, wind direction, and fog periods. It is found that different models can give similarly good results of temperature, dew point and wind. However, fog period prediction is not as accurate as other variables, and the models performs differently.

Zheqi Chen[1], Sasa Gabersek[2], Reneta Dimitrova[3], Yongsheng Chen[1], Peter Taylor[1]
[1]York University [2]U.S. Naval Research Laboratory [3]Notre Dame University
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MUL-BOUNDARY LAYER MIXING, MARINE STRATUS AND FOG

A simple 1-D RANS model of the time evolution of the Planetary Boundary Layer is extended to include water vapor and cloud droplets plus transfers between them. An underlying ocean surface is treated as a source of water vapor, and as a sink for cloud or fog droplets. With a constant sea surface temperature and a steady wind, initially dry or relatively dry air will moisten, starting at the surface. Turbulent boundary layer mixing will then lead towards a layer with well-mixed potential temperature (and so temperature decreasing with height) and well mixed water vapor mixing ratio. As a result the air will, sooner or later, become saturated at some level and stratus cloud will form. If that air is later advected over colder water the air will cool and the base of the stratus cloud will lower. Fog may then extend down to the surface. The liquid water mixing ratio is essentially zero at the surface but will increase with height to a maximum, typically in the lowest 100- 500 m height range, depending on conditions. Relative humidity is 100% throughout this layer and is what is typically observed, e.g. by G.I. Taylor in 1915. There are however no published observations that we know of, that provide the variations of liquid water mixing ratio with height in marine fog. I am hoping that analysis of data from the 2022 FATIMA program may provide these critical measurements.

Peter Taylor[1] [1]York University pat@yorku.ca

Changing Arctic: Science and Policy Studies - Part 1

Wednesday, May 31
8:30 - 10:00 EDT

(15 Mins) A critical assessment of climate and weather observations in the Canadian North - Robert Way

(15 Mins) Evaluating ERA5 in the Western Canadian Arctic- Ruth Moore

(15 Mins) Extreme Precipitation in the Baffin Bay Region: Exploring High-Resolution Climate Models - Nicole Loeb

This interdisciplinary session will present emerging scientific results on the rapidly changing Arctic and northern environment. The physical environment of the Arctic has changed dramatically over the past decades with the underlying causes of these changes, in terms of the cryosphere, oceanography, hydrology

and meteorology, being addressed through various scientific approaches. The application of the scientific results in relation to policy issues associated with federal government and Indigenous-led management efforts will be considered. The importance of Arctic research and its consequences in looking ahead is very timely and pertinent to informing northern communities, the public and contributing to a range of policy issues in this strategically important part of Canada. Papers are sought from research, science and policy activities that are nearing completion, currently being undertaken, or those planned and just getting under way.

MUL-A critical assessment of climate and weather observations in the Canadian North

Canadas northern communities are facing a pressing threat from climate change, which could have severe economic, cultural, and social consequences. The challenges posed by climate change are compounded by the lack of climate resilient infrastructure and climate services in many of these regions, as well as the ongoing legacy of settler colonialism. While integrating Indigenous Knowledge into multidisciplinary research is essential for anticipating and preparing for the risks of contemporary and future climate change, the success of climate adaptation efforts is often hindered by a lack of core baseline climate information in much of the North. These gaps are particularly concerning for Canadas most at-risk fly-in communities, which rely heavily on the availability of accurate weather, water, ice and climate (WWIC) information. In this contribution, the author applies a critical lens to the current state of weather and climate monitoring in northern Canada with a particular focus on remote fly-in communities and the region of Inuit Nunangat. Analysis of existing WWIC datasets reveals large spatio-temporal coverage gaps that reduce community-level confidence in meteorological forecasts and impact our understanding of historical environmental change. Comparison against an Environment Canada WWIC-based needs index reveals discrepancies between the areas most at risk of climate change impacts and the priorities for meteorological network configuration. These results highlight the need for greater investment in WWIC infrastructure and climate data rescue initiatives to support climate change adaptation initiatives in Canadas north.

Robert Way[1] [1]Northern Environmental Geoscience Laboratory, Department of Geography and Planning, Queen’s University robert.way@queensu.ca

MUL-Evaluating ERA5 in the Western Canadian Arctic

Considerable progress has been made in understanding why severe changes in temperature are occurring in the Arctic. Increasingly, the cause for this has been attributed to an increase in precipitation and humidity. Changing precipitation influences local and global climates and is an understudied and often mis-constrained variable in reanalysis output.

Due to temporal and spatial limitations, few studies have explored both the changing climate of the Western Canadian Arctic (WCA) and the validity of reanalysis for the region. ERA5 reanalysis is the most commonly used reanalysis product for the Arctic region but has not been verified for use in the WCA. ERA5 is compared to station observations to verify its ability to characterize precipitation within the WCA. ERA5 is seen to produce significant amounts of additional "trace" precipitation, which does not match the seasonal cycle. ERA5 overestimates both summer and winter precipitation

accumulation. Work to date has corrected this by removing data less than 1mm/day. For the WCA, this amounts to almost 40% of all precipitation days of the year; therefore, a more rigorous correction method is required.

By using a ratio between the total station observational and ERA days of precipitation, and the total accumulation, a value of trace precipitation and a ratio to correct for accumulation is found. ERA5 corrected data is seen to match well with both annual and interannual variability. Further work will validate these two metrics in space and time.

Ruth Moore[1], Anaïs Orsi[1] [1]UBC, EOAS rmoore@eoas.ubc.ca

MUL-Extreme Precipitation in the Baffin Bay Region: Exploring High-Resolution Climate

Much of coastal Baffin Bay receives a considerable portion of its annual precipitation via extremes, meaning that it is vulnerable to changes in the frequency and intensity of heavy precipitation events. Here, extreme precipitation is identified as the top 5% of days with at least 1 mm of precipitation. Understanding potential shifts in extreme precipitation climatology is difficult because of their localized scale, limited in situ observations, and the coarse resolution of most climate models. Past studies have shown that high-resolution climate models (<0.25) generally perform well in representing precipitation extremes due to their ability to capture small-scale weather patterns. This can be achieved via downscaling of coarser climate models. The Variable-Resolution Community Earth System Model (VR-CESM) is a version of CESM that allows for the nesting of higher-resolution grids (0.25) within the global 1 grid to better represent an area of interest. The Regional Atmospheric Climate Model (RACMO2.3) is a regional climate model (0.1) that has been used for detailed explorations of Arctic climate. Historical and future extreme precipitation in the Baffin Bay region is explored in RACMO2.3 and VR-CESM to explore similarities and differences in the two downscaling techniques. Climatological event statistics from the historical period (1980-2000) are compared to reanalyses to assess agreement, including metrics such as seasonality and magnitude, to contextualize their ability to capture the current climate. Projections of future extremes following SSP5-8.5 for 2080-2100 will also be assessed in each model to investigate potential changes as the climate continues to warm.

Nicole Loeb[1], Alex Crawford[1], Julienne Stroeve[1], John Hanesiak[1] [1]University of Manitoba loebn@myumanitoba.ca

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Severe Convective Storms – Detection, Prediction, Climatology and the Future - Part 2

Wednesday, May 31
8:30 - 10:00 EDT

(15 Mins) Enhancing Warnings for Most Effective Community Responses - Gordon McBean

(15 Mins) Canadian Weather Alert Dissemination Challenges - Isabel Ruddick

(15 Mins) Meteorological Service of Canada’s Convective Alert Modernization

Project - Bradley Power

(15 Mins) A First Independent Assessment of National Tornado Warning Performance in Canada - Lesley Elliott

(15 Mins) A New Community Radar Suite Aimed at Canadian Users: Instant Weather Pro - David Sills

(15 Mins) The Urban Heat / DRY Island - G.S. Strong

Many of Canada's most costly natural disasters are caused by severe convective storms. Insured losses from these storms are increasingly reaching the billion dollar mark. Anthropogenic climate change may significantly alter the probability of such disasters occurring in the future. This session will focus on severe convective storms and their hazards (tornadoes, downbursts, hail, heavy rainfall), and in particular their detection, prediction, historical climatology and possible future climatology. This includes a wide range of possible topics, from event case studies and verification statistics to climatological trend analyses and modelling future changes to storms and/or hazards. The session aims to highlight new insights that improve our physical understanding of, and our detection and prediction capabilities for, such events. A 30-min invited presentation is likely to lead off the session.

ATM-Enhancing Warnings for Most Effective Community Responses

There is strong connections between impending hazards and the overall risks and impacts that they can cause. It is important that citizens be informed and wehre and where appropriate warning about impending events and the impacts they will or may have. We need integrated envrionmental prediction leading to most effectviely informing, raising awarenesss and warning socieites about weather, water, air pollution, storm surges and mosre - for the exposed and vulnerable people and infrastructure and ecosystems that will or may be impacted.

Gordon McBean[1] [1]Western University gmcbean@uwo.ca

ATM-Canadian Weather Alert Dissemination Challenges

The Meteorological Service of Canada (MSC) communicates meteorological hazard and risk information (for winter weather, hurricanes, tornadoes, etc), through its alerting service. Common Alerting Protocol (CAP) is the vehicle used to communicate these threats to agents along the path of distribution, which in turn broadcast this information to interested and affected audiences. Information included in MSC alerting service include impacted locations, applicable time periods, measures of urgency, severity, confidence values, and much more.Downstream dissemination systems utilize this information to notify audiences of the elevated risk of weather-driven impacts to life and property. These dissemination channels include wireless public alerting, television/radio networks, as well as web and mobile platforms. These systems and channels ensure that once MSC alert information is generated, it is communicated in a timely and effective way to all audiences. This presentation will demonstrate how alerting information is packaged and transmitted to these dissemination channels by the MSC. A severe weather event scenario will be presented highlighting limitations and challenges that exist, some of which may result in over-alerting in either time, space, or message

frequency. Improvements to the system, both recent and upcoming, will also be shared.

Norm Paulsen[1], Isabel Ruddick[1], P. Focus Rahman[1], Omar Khan[1] [1]ECCC MSC
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ATM-Meteorological Service of Canada's Convective Alert Modernization Project

Currently, the Meteorological Service of Canada (MSC) uses predefined zone-based polygons to describe areas under threat from meteorological hazards. However, the areal extent of hazardous convective events (severe thunderstorms and tornadoes) do not follow these pre-defined boundaries. Thus, areas are unintentionally being warned when theyre not predicted to be under threat. Though the MSC has introduced enhanced tools and training to improve the warning decision making process for its forecasters over the last 5 years, improvements in the final step of creating the convective warning product can still be made. The Convective Alert Modernization (CAM) project, initiated in early 2022, has been tasked with modernizing the production and delivery of convective warnings in Canada. The project aims to reduce areal over-alerting of tornado and severe thunderstorm hazard risks by introducing forecaster defined free-form polygons to more precisely represent the boundaries of the predicted convective threat areas. Preliminary testing of the new alert production software during the summer of 2022, highlighted a significant improvement in forecaster workflow. The testing also highlighted potential challenges with the introduction of this new threat boundary paradigm to the Canadian context. This presentation will introduce the CAM project and will highlight the development work underway, including challenges encountered, to introduce free-form polygon-based warnings that can move with the storm threat in Canada. These modifications are set to not only improve the tools that forecasters use to generate more precise convective alerts, but also to improve the timeliness and usability of service products available on the MSC open-data portal. Additionally, this presentation will describe proposed changes to alerting practices made possible with this threat-based polygon paradigm.

Bradley Power [1], Bradley Power[1] [1]ECCC MSC bradley.power@ec.gc.ca

ATM-A First Independent Assessment of National Tornado Warning Performance in Canada

The Northern Tornadoes Project (NTP) completed an independent assessment of national tornado warning performance in Canada for 2019-2022. The study was undertaken in the spirit of contributing to improvements to Canadas warning system and making verification results publicly available. Understanding tornado warning issues unique to Canada is necessary in order to better tornado warning performance here. Utilizing the 2019-2021 NTP tornado event database, Environment and Climate Change Canada (ECCC) tornado warnings were reviewed for accuracy and timeliness. This required defining a warning hit for the study. Over 340 tornadoes occurring during the study period, and the standard contingency table-based scores (POD, FAR, CSI and Bias) were calculated. Results showed that there is significant room for improvement in the scores, with the majority of tornadoes having had no tornado warning issued. It was noted, however, that warning performance improved for EF2+ tornadoes and supercell tornadoes. The results were compared with US NWS tornado warning scores for warning regions along the Canadian border to provide context.NTP made several recommendations to increase tornado warning performance in the future. NTP also issued a simplified report card - aimed at public consumption - that took into

consideration ECCCs national performance targets for tornado warning accuracy and lead time, as well as the issuance of tornado watches, over the 2019-2021 period.That report card, and a new one covering the 2022 season, will be discussed.

Lesley Elliott[1], David Sills[1] [1]Western University Lesley.Elliott@uwo.ca

ATM-A New Community Radar Suite Aimed at Canadian Users: Instant Weather Pro

Instant Weather has joined forces with Western Universitys Northern Tornadoes Project (NTP) and Northern Hail Project (NHP) to bring Canadian users the first professional radar suite that can display full-resolution Canadian and US radar data inside of a webapp. Called Instant Weather Pro, it allows users to open multiple simultaneous radar windows, enabling comparisons between different radar sites and products. This innovative tool also offers access to up to 17 tilts of radar data, adjustable quality control, and swiping between radar products that allows one to easily see if a reflectivity hook echo and a radial velocity shear couplet are co-located, for example. Hail size estimation, lightning data, storm reports and the users location (stationary or mobile) are other available features. Over the past year, Instant Weather Pro has been used by the NTP for assessing damaging wind events and by the NHP for real-time hail collection operations. And after extensive testing, Instant Weather Pro is scheduled to be launched this May via subscription (see instantweather.ca). Plans for upgrades in the near future include the development of severe storm detection, tracking and nowcasting algorithms using techniques based on the latest science. Many of these upgrades will be open source in order to benefit from the expertise and input of weather professionals and enthusiasts across the country and beyond.

Adam Skinner[1], David Sills[2] [1]Instant Weather Inc. [2]Western University adam.skinner@instantweather.ca

ATM-The Urban Heat / DRY Island

Mobile transects of pressure, temperature, and humidity were collected during 2005-08 to investigate pre-storm drylines over Alberta foothills. While travelling through small towns such as Sundre (population ~2500) and Olds (~9000), weak urban heat islands (UHI) of less than 1C were observed, but more surprising, urban DRY islands (UDI) of just under 1g/kg were observed at the same time. This prompted further investigation later, carrying out transects across the city of Edmonton (population ~1 million) on several days during the 2009 summer. The transects revealed a sharp discontinuity of both temperature and mixing ratio at the edges of Edmonton, and a heat island of 2-3 C and dry island of 2-3 g km-1 in the city centre. The UDI raised questions concerning possible effects on convective thunderstorms approaching the city. One might expect a UHI to contribute to an increase in storm intensity through an increase in dry heat, and a decrease through loss of latent heat. One example presented itself on 21 August 2009, when a severe thunderstorm approached southwest Edmonton. Tornado funnels had already been observed, prompting Environment Canada to issue a rare tornado warning. However, just before the storm entered the Edmonton urban area, it appeared to collapse suddenly, and only minor showers were reported in the city. The limited data that were available could not confirm whether the UDI caused the storm collapse, but that is one possibility. Further research with transects should be carried out.

G.S. Strong[1] [1]retired geoff.strong@shaw.ca

EDIA Panel Discussion - Ocean, Atmosphere, Earth and Climate Science for and by everyone: Discussions on equity, diversity, inclusion and accessibility

Wednesday, May 31
11:30 - 13:00 EDT

There is growing recognition that embracing equity, diversity, inclusion and accessibility (EDIA) in scientific research, the workforce and academia reduces barriers and bias in the way we conduct research, recruit highly qualified personnel, and disseminate and interpret our creative scholarly outputs. By considering EDIA principles, we build collaborative and engaging partnerships in service of a more equitable and just society. So, what does the EDIA landscape look like for CMOS and ocean, atmosphere, earth and climate science at-large? During this discussion, we bring together a group of panelists with experience in EDIA principles to explore topics like:
• What does EDIA look like in science?
• What does it mean to be an EDIA ally? What is the difference between allyship and solidarity?
• How can we make workspaces, team meetings, labs, etc., more accessible and inclusive?
Whether you are an EDIA ally, identify with an equity-deserving group or unsure what EDIA is all about, this event is for everyone. Bring your questions related to EDIA and join in on the insightful discussions

Participants
Moderator: Mx. Alexa Goodman (they/she) Training Program Manager and EDIA Specialist, MEOPAR

Panelists:
Karine Morin (she/her/elle) Director EDI Strategy, NSERC
Dr. Fanny Noisette (she/her/elle) Professor, Université du Québec à Rimouski
Stephanie Arnold (they/them) PEI Climate Services Specialist, CLIMAtlantic
Dr. Hind Al-Abadleh (she/her) Professor, Wilfrid Laurier University
Dr. Gerald Singh (he/him) Assistant Professor, University of Victoria

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A special session on ocean science and environmental statistics in tribute to Professor Keith R. Thompson - Part 2

Wednesday, May 31
13:00 - 14:30 EDT

(30 Mins) Extreme Sea-Levels, Coastal Flood Risks, Storm Surges, and Tides: A Love Story to the Benefit of Canadians - Natacha Bernier

(15 Mins) Measuring accuracy and relative errors in a tide-surge model - David Greenberg

(15 Mins) Rapid drop of ocean temperatures off the coast of Atlantic Canada during a recent cold air outbreak - Michael Casey

(15 Mins) Coastal Mean Dynamic Topography and Implications for Model

Validation and Ocean Monitoring - Christoph Renkl

(15 Mins) Evaluation of budget of local sea level trends along coast of Canada during 1958-2015 - Li Zhai

Professor Keith Thompson of Dalhousie University passed away on July 11, 2022. Professor Thompson held a Tier I Canada Research Chair in "Marine Prediction and Environmental Statistics: and participated in many international committees including "Coastal Ocean Observations Panel of the Global Ocean Observing System". Professor Thompson made exceptional contributions in ocean science research and high-quality training. He made significant contributions in developing a storm surge prediction model that is now being used operationally. This session will have an overview of Dr. Thompson's research work and his major contributions. We invite abstracts from everyone particularly from his former students and his collaborators on any research topics including modelling and prediction of coastal and shelf waters, environmental statistics, process studies of dynamics in atmospheres and oceans, and data assimilation.

OCE-Extreme Sea-Levels, Coastal Flood Risks, Storm Surges, and Tides: A Love Story to the Benefit of Canadians

The story behind the operationalization of Canadas flood forecast systems is presented. Throughout this presentation, we journey through 25 years of research and development. We begin with Dalcoast, a simple, linear, barotropic system, developed for the East Coast. We continue with updates that quickly followed such as the inclusion of non-linear terms and tidal forcings. We discuss the arrival of Canadas first operational ensemble ocean (surge) system. We continue with a review our work of the past decade to transition from a regional system to a global one able to serve Canadians along all ocean coastlines. We mentions highlights of the new NEMO based system such as the addition of baroclinic and ice effects. We briefly discuss hindcasts, extremal analysis and upcoming projection. Throughout this talk, we share the privilege it has been to take this 25-year journey along side Professor K.R. Thompson. We remember his love of physical oceanography and enlightening statistics and his passionate relationship with scientific writing.

Natacha Bernier[1] [1]World Meteorological Organization, WMO natacha.bernier@ec.gc.ca

OCE-Measuring accuracy and relative errors in a tide-surge model

High on the list of topics to which Kieth Thompson contributed was the evaluation of models. Keith was frequently consulted on aspects of this study looking at storm surges in the Northwest Atlantic. Much of the material here has been covered in earlier congresses. A full year of tide-surge is computed and compared with data from satellites and long term tide gauges. We try to quantify the errors in the reproducing the tide and the meteorologically driven surge as well as the relative accuracy of solutions when different forcing terms are left out. The emphasis is on the aspects where Keith was very influential and where there have been recent advances in the study.

David Greenberg[1] [1]Bedford Institute of Oceanography
davidgreenberg@alumni.uwaterloo.ca

OCE-Rapid drop of ocean temperatures off the coast of Atlantic Canada during a recent cold air outbreak

The ocean temperature changes off the coast of Atlantic Canada, associated with an extreme Arctic air outbreak that occurred February 3-4, 2023, are analyzed. The ocean temperatures produced by the operational CIOPS-E (Coastal Ice-Ocean Prediction System -East) system, developed by Environment and Climate Change Canada, are first validated with available observations. Space-time variations of water temperature at both sea surface and seabed, including the magnitudes and rates of decrease and recovery, are then quantified. The causes of the space-time variation, including the identified cold spots during this event, are explored based on surface atmospheric forcing and regional ocean dynamics. The ocean temperature changes of this recent event are compared with that of December 15-18, 2016, a cold event for which the solution of another ocean model identified a sudden cold spot that developed in St. Marys Bay, Nova Scotia, which was coincident with a substantial fish kill reported in that area at the time. We speculate that rapid drops in ocean temperature driven by atmospheric cold outbreaks may create challenges to fish in isolated coastal bays.

Michael Casey [1], Youyu Lu[1], Sarah MacDermid[1] [1]DFO Maritimes Michael.Casey@dfo-mpo.gc.ca

OCE-Coastal Mean Dynamic Topography and Implications for Model Validation and Ocean Monitoring

It has long been recognized that the alongshore tilt of mean dynamic topography (MDT) plays an important role in the dynamics of shelf circulation. Tide gauge observations in combination with the latest generation of geoid models are providing observations of coastal MDT with unprecedented accuracy. High-resolution ocean models are providing better representations of nearshore circulation and the associated tilt of MDT along their coastal boundaries. This will be demonstrated using a regional ocean model of the Gulf of Maine and Scotian Shelf (GoMSS) with a grid spacing of 1/36. The accuracy of the model predictions of tilt will be assessed through comparison with coastal tide gauge observations referenced to the Canadian Gravimetric Geoid model (CGG2013). Using the validated GoMSS model and several idealized models, it will be shown that the alongshore tilt of MDT can be interpreted in two complementary, and dynamically consistent, ways. In the coastal view, the tilt of MDT along the coast can provide a direct estimate of the average alongshore current. In the regional view, the tilt can be used to approximate upwelling averaged over an offshore area. This highlights the usefulness of using geodetic MDT estimates for model validation and ocean monitoring.

Christoph Renkl[1], Keith R. Thompson[2] [1]Woods Hole Oceanographic Institution [2]Dalhousie University christoph.renkl@whoi.edu

OCE-Evaluation of budget of local sea level trends along coast of Canada during 1958-2015

The Canadian crustal velocity model has recently been updated (NAD83v70VG) through assimilation of observations from the Global Navigation Satellite System network. Estimates of vertical land motion (VLM) from this model are used to evaluate the budget of contributions to relative sea level (RSL) trends at tide gauge sites along the east and west coasts of Canada, and the adjacent USA, during 1958-2015. The

RSL trends are also influenced by other processes including sterodynamics (SD), glacial isostatic adjustment (GIA), and changes in earth gravity, earth rotation and viscoelastic solid earth deformation (GRD). For these contributions, we have used data from a recent study on global RSL trends (Wang et al., 2021). Using the VLMs from NAD83v70VG, the RSL budgets along both the western and eastern coasts of Canada are generally improved. The budget in the St. Lawrence River and its estuary is slightly deteriorated, due to the inaccuracy in the SD component from the global ocean models that do not include long-term variations of river runoff. Along the coast of British Columbia, the SD component is well simulated by the global models despite of their coarse spatial resolutions and the use of river runoff climatology.

Li Zhai[1], Youyu Lu[1], Blair Greenan[1] [1]Fisheries and Oceans Canada Li.Zhai@dfo-mpo.gc.ca

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Acoustical Oceanography and Underwater Sound - Part 1

Wednesday, May 31
13:00 - 14:30 EDT

(15 Mins) Where's the fish? Modeling split-beam sonars for fisheries - Axel Belgarde

(15 Mins) Macroturbulence in high flow tidal channels: Comparisons between acoustic tomography measurements and a non-hydrostatic, using Large-Eddy Simulation (LES) coastal model - Alex Hay

(15 Mins) Broadband discrimination of the target strength spectra from three co-occurring Arctic species: Boreogadus saida, Pandalus borealis, and Gadus morhua - Maxime Geoffroy

(15 Mins) Calibration of Decoupled Digital Systems in a Small, Reverberant Tank at Low Frequencies - Dylan DeGrâce

(15 Mins) Determining the speed dependent source level of a snowmobile traveling on sea-ice - Emmanuelle Cook

Acoustic techniques provide means for underwater communication and remote sensing for humans and animals alike. The focus of this session is to highlight the roles of acoustic methods, measurements, and monitoring in all aspects of oceanography and marine sciences. Areas of interest include, but are not limited to: sonar, bio-acoustics, passive acoustic monitoring, fisheries acoustics, geophysical applications, acoustic communication, defence applications, ambient and ocean noise, anthropogenic noise, acoustic ecology, long-range propagation, tomography, high-frequency scattering, imaging, and quantitative inversion.

OCE-Where's the fish? Modeling split-beam sonars for fisheries

Single transducer sonar systems provide information over the range of a target but fail to provide accurate target strength measurement due to the intensity being a function of the acoustic beam pattern. Split-beam transducers are split into four independent quadrants and detect a phase delay between each receiver from an incoming wavefront

angled off the acoustic axis. The position of the target can be determined by using the transducer geometry and be used to compensate the target strength measurement using the known beam pattern function, providing a method of direct target strength measurement. We report on a model of the split-beam system that can be used to predict the performance accuracy of given geometries and optimize sonar performance before committing to a particular hardware design. Beam patterns have been generated to match the transducer geometry of prototype instruments and used to simulate acoustic backscatter signals based on the scattering of sound from particles in a three-dimensional domain. Field trials of a prototype system were conducted under controlled conditions by lowering a calibration target sphere to a range of 200 m in the acoustic beam. Comparisons of model prediction and actual system performance will be presented.

Axel Belgarde[1], Len Zedel[1], Mahdi Razaz[2] [1]Memorial University of Newfoundland [2]University of Southern Mississippi axelbelgarde@gmail.com

OCE-Macroturbulence in high flow tidal channels: Comparisons between acoustic tomography measurements and a non-hydrostatic, using Large-Eddy Simulation (LES) coastal model

Velocity spectra from a pilot tomography experiment in Grand Passage, Nova Scotia, exhibit structure at 10 m to several 100 m scales similar to the spectra of vertically-integrated velocity registered by bottom-mounted acoustic Doppler profilers. The experiment was motivated in part by the need for flow and turbulence measurements at sites targeted for in-stream tidal power development, and by the potential of acoustic tomography for providing this information from shore-based locations in near real time. The measurements were made using a single pair of acoustic transceivers operating at 7 kHz and separated by 1.5 km at an oblique angle to the channel axis. Limited to a single cross-channel path, the experiment provided no information on the spatial structure of the turbulence. To investigate this structure, virtual tomographic experiments were carried out by propagating pulses through meter-scale resolution velocity fields from a non-hydrostatic large-eddy simulation (LES) model of flow in Grand Passage. Results from these virtual experiments are presented, and their implications discussed, in relation to the potential of multi-transceiver tomography for macro-turbulence measurement and the role of horizontal shear in macro-turbulence production in coastal environments.

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OCE-Broadband discrimination of the target strength spectra from three co-occurring Arctic species: Boreogadus saida, Pandalus borealis, and Gadus morhua

The Northern shrimp (Pandalus borealis) fishery, a valuable commercial fishery in both the North Atlantic and Barents Sea, reports large amounts of by-catch of Arctic cod (Boreogadus saida), a key forage fish species. Furthermore, the spatial distribution of Atlantic cod (Gadus morhua) is expanding northward and increasingly overlaps spatially with Northern shrimp and Arctic cod, both prey of large Atlantic cod. Acoustic discrimination between Arctic cod, Atlantic cod and Northern shrimp could provide more information on the risk of cod by-catch in the Northern shrimp fishery and the spatial dynamics of these three species. In January 2023, we conducted a series of single-specie mesocosm experiments for target strength measurements of Arctic cod, Atlantic cod and shrimp to assess the potential for discrimination of their target spectra. The fish

and shrimps were trawled from Billefjorden and Kongsfjorden, Svalbard, and transferred alive to an in situ mesocosm deployed from a wharf in Ny-lesund. Acoustic backscattering measurements were collected with a Wideband Autonomous Transceiver (WBAT) at frequencies ranging from 90 to 255 kHz. Thereafter, we tested the applicability of the mesocosm measurements of target spectra at discriminating between Arctic cod, Atlantic cod and shrimp in a mixed assemblage by lowering a WBAT probe in a sound scattering layer at the trawling sites.

Muriel Dunn[1], Geir Pedersen[2], Stig Falk-Petersen[1], Malin Daase[3], Jørgen Berge[3], Emily Venables[3], Sunnje Basedow[3], Lionel Camus[1], Maxime Geoffroy[4] [1]Akvaplan-niva [2]Institute of Marine Research [3]UiT The Arctic University of Norway [4]Marine Institute of Memorial University mbd@akvaplan.niva.no

OCE-Calibration of Decoupled Digital Systems in a Small, Reverberant Tank at Low Frequencies

Scientists and engineers require a detailed understanding of acoustic transducer characteristics to conduct much of their work. One important characteristic is their acoustic sensitivity, which allows users to convert recorded signals to physical units (e.g., dB re. Pa). Each transducer can have slightly different acoustic sensitivity due to practical limitations, including material selection and manufacturing. Thus, per unit acoustic calibration can be required. This is traditionally performed using closed-loop calibration systems such as GeoSpectrums Portable Acoustic Calibration System (PACS). However, the PACS is not capable of performing calibration for digital systems that record data internally. Digital systems can also be limited to lower sample rates, which are not conducive to traditional calibration processing techniques. It is often desirable to perform these calibrations in laboratory test tanks to mitigate the cost, risks, and challenges of open-sea calibration. Due to space and cost constraints, test tanks tend to be smaller and lack anechoic material adding typical challenges related to very-short free-field measurements. Our team has addressed these challenges through careful planning of test procedures, including manual synchronization, and application of customized analysis algorithms. These improvements result in system calibration accuracy of fractions of a dB for many cases, though low-frequency calibration remains a challenge similar to that of PACS-based calibration.

Dylan DeGrâce[1], Chris Peacock[1], Joey Hood[1] [1]GeoSpectrum Technologies Inc. dylan.degrace@geospectrum.ca

OCE-Determining the speed dependent source level of a snowmobile traveling on sea-ice

As part of the Sustainable Nunatsiavut Futures project, a field experiment to determine the acoustic properties and underwater radiated sound level of a snowmobile was designed and executed. The fieldwork consists of lowering acoustic recorders under the sea ice and driving a snowmobile with a known position and velocity to evaluate its speed-dependent source level. This experiment is the first step toward collaborative Dalhousie and community research on underwater sound as it relates to the marine habitat, human use of the ocean, and sea-ice in Nunatsiavut. The experiment has been conducted multiple times between Caraquet, NB and Hopedale, NL with discussion and improvements added to the experimental procedure during each iteration of the experiment. Each fieldwork experiment also adds information on the effect of skidoo type and differing snow and ice conditions have on underwater received levels. The winter of 2023 we conducted fieldwork in person for the first time in Hopedale, NL. The

experiment started with a single hydrophone sensor and evolved to a vertical array of hydrophones as well as added accelerometers on the snowmobile and in-air microphones. Comparing the different types of data have permitted the team to distinguish the different sound generation mechanisms. Skidoo specifications for each site were recorded as well as sea-ice thickness, temperature, salinity, and sound-speed data were collected. Spectrograms of skidoos traveling at different speeds were computed. Comparisons between received levels at different velocities, sites and ranges are shown and the impact of sea ice and snowmobile specifications on received levels are discussed.

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Advances in Precipitation Measurement and Modeling - Part 1

Wednesday, May 31
13:00 - 14:30 EDT

(15 Mins) The atmospheric water cycle at river basin scales over Eastern Canada simulated by a high-resolution regional climate model - Benjamin Serralheiro-O'Neill

(15 Mins) Simulations of ice pellets with the Predicted Particle Properties (P3) microphysical scheme - Mathieu Lachapelle

(15 Mins) Impacts of using adjusted solid precipitation amounts for wind speed undercatch on the Canadian Precipitation Analysis system. - Catherine Aubry

(15 Mins) Improvement of Surface Precipitation Estimates by the Canadian Precipitation Analysis (CaPA) during the Cold Season - Pei-Ning Feng

(15 Mins) Assessment of the impact of the assimilation of radars for solid precipitation on the Canadian Precipitation Analysis system (CaPA) - Julie M. Thériault

(15 Mins) Improving accuracy and reliability of hydrometeorologic data: Challenges and solutions in the Great Lakes Basin - André Guy Tranquille Temgoua

This session will cover the latest research on precipitation measurement and modeling techniques for improved hydrometeorological analysis. Presentations will cover topics such as regional climate modeling, accuracy assessments of precipitation measurement tools, the impact of solid precipitation assimilation on analysis systems, the effects of model resolution on simulated precipitation types and snowfall projections. The discussions will focus on identifying the challenges and solutions to improving accuracy and reliability of hydrometeorologic data, as well as their implications.

ATM-The atmospheric water cycle at river basin scales over Eastern Canada simulated by a high-resolution regional climate model

The role of moisture flux and convergence leading to precipitation has been investigated and verified in many studies, notably over the North American west coast and mainland. The convergence of moisture and condensates helps to explain the occurrence of extreme precipitation. However, very few studies have investigated these patterns for river basins located in Eastern Canada. The objective of this study is to compare the water budget for several Eastern Canada river basins using two regional climate model simulations. The Canadian Regional Climate Model version 6 (CRCM6/GEM5) was run at 2.5 km and 12 km spatial resolutions over a 15-month period and the simulation outputs were used to quantify the atmospheric moisture flux convergence. Combined with evapotranspiration and precipitation values also simulated by the model, these allow a detailed evaluation of the models ability to simulate the components of the atmospheric water budget. These simulations were then compared with existing observational datasets such as the ERA5 reanalysis. Preliminary results suggest that the water budget component is better represented by the higher resolution simulation than by the coarser one. Overall, this study contributes to a better understanding of the relative role of the water component entering and leaving relatively small river basins, which will help to explain the occurrence of extreme precipitation events that can lead to major flooding.

Benjamin Serralheiro-O'Neill[1], Biljana Music[2], Julie Thériault[1], Katja Winger[1] [1]UQÀM [2]Ouranos serralheiro-o_neill.benjamin@courrier.uqam.ca

ATM-Simulations of ice pellets with the Predicted Particle Properties (P3) microphysical scheme

The numerical prediction of hazardous winter precipitation types such as freezing rain and ice pellets commonly relies on the diagnostic of the temperature and humidity vertical profile at every grid point in the model. This method, however, may lead to mis-forecasts because it does not consider some key processes that can alter the precipitation type distribution at the surface. As an example, ice pellets will form if supercooled raindrops collide with tiny ice crystals that have been advected or produced in the same region. In the absence of these ice crystals, freezing rain would reach the surface. The goal of this study is to simulate key processes and complex interactions between precipitation types that eventually lead to ice pellet formation. To do that, the multiple free ice category configuration of the Predicted Particles Properties (P3) scheme was modified and used to include a new secondary ice production process. A well-documented ice pellet event that occurred in the Montreal region in January 2020 was simulated. During that event, ice pellets and tiny ice crystals were observed at the weather station in downtown Montreal during more than 10 hours. These surface conditions were closely reproduced when multiple ice categories and the new secondary ice production process were used in the simulation. This research shows that secondary ice production in P3 could be used to improve the numerical prediction of ice pellets and freezing rain.

Mathieu Lachapelle[1], Julie Thériault[1], Mélissa Cholette[2] [1]UQAM [2]Environment and Climate Change Canada lachapelle.mathieu@courrier.uqam.ca

ATM-Impacts of using adjusted solid precipitation amounts for wind speed undercatch on the Canadian Precipitation Analysis system.

Knowing the spatiotemporal distribution of precipitation in near real-time is critical for various purposes, including weather and flood forecasting, monitoring drought, and some applications such as irrigation management, fire forest prevention, and hydroelectric production. These activities can be optimally managed when available precipitation estimates are reliable. The Canadian Precipitation Analysis (CaPA) is a national project developed and coordinated by the Meteorological Research Division and the Meteorological Service of Canada of Environment and Climate Change Canada (ECCC). This analysis system aims to provide a near real-time North American-wide precipitation estimate. In winter, CaPA underestimates the amount of precipitation, primarily because it does not assimilate solid precipitation due to the gauge undercatch caused by the wind. There is a high variation of the collection efficiency at given wind speeds. The objective of the study is to evaluate the added value of using these adjusted precipitation amounts due to the wind speed undercatch in CaPA. First, the new database of automatic stations across Canada is included in CaPA, with precipitation amounts adjusted based on a transfer function. Second, an analysis of the climatology of precipitation observations, wind speed, and temperature was performed to provide an understanding of the impact of their inclusion in CaPA. Third, additional transfer functions were used to investigate the impact on the CaPA products. Overall, results from this study suggest that increasing solid precipitation using transfer functions improves the CaPA precipitation estimates.

Catherine Aubry[1], Stéphane Bélair[2], Julie M. Thériault[1] [1]Département des sciences de la Terre et de l'atmosphère, Université du Québec à Montréal, Montréal, Québec, Canada [2]Meteorological Research Division, Canadian Meteorological Centre, Dorval, Québec, Canada aubry.catherine.2@courrier.uqam.ca

ATM-Improvement of Surface Precipitation Estimates by the Canadian Precipitation Analysis (CaPA) during the Cold Season

The Canadian Precipitation Analysis System (CaPA) is an operational system combining weather gauge observations with short-term forecasts from a numerical weather model to produce near-real-time estimates of precipitation amounts for 6 and 24-hour periods. While many observations from the gauges are assimilated during the warm season, most observations are rejected in winter by quality control (QC) procedures due to the well-known problem of solid precipitation undercatch under windy conditions. In this study, an attempt is made to improve precipitation analyses over central Canada during winter seasons from 2018-2019 to 2021-2022. Relaxing the wind speed threshold as the QC procedure in CaPA and adjusting automated precipitation amounts using a universal transfer function (TF) were tested. Even if the immediate impact of relaxing QC is lowering CaPAs precipitation amounts, leading to lower (and worse) biases in frequency and amounts, the overall results are positive. The equitable threat score (ETS) is improved due to a substantial decrease in the false alarm ratio (FAR) despite a deterioration in the probability of detection (POD). The adjustment of the TF is as expected to increase, in turn, improve the biases in terms of frequency and amounts, associated with improvement to POD for all precipitation thresholds and deterioration of FAR for large thresholds. The results of the experiments are compared and discussed in the context of interannual variability in weather conditions for individual winters. Limitations of the evaluation protocol used to compare the relative performance of the experiments are also discussed.

Pei-Ning Feng[1], Stéphane Bélair [2], Julie M. Thériault[1], Eva Mekis[3], Dikraa Khedhaouiria[2], Franck Lespinas[4] [1]Centre ESCER, Department of Earth and Atmospheric Sciences, Université du Québec à Montréal (UQAM) [2]Environment and Climate Change Canada, Atmospheric Science and Technology [3]Environment and Climate Change Canada, Climate Research Division [4]Environment and Climate Change Canada, Canadian Centre for Meteorological and Environmental Prediction feng.pei-ning@uqam.ca

ATM-Assessment of the impact of the assimilation of radars for solid precipitation on the Canadian Precipitation Analysis system (CaPA)

Detaining real-time knowledge on precipitation is crucial for society and its accurate determination is essential for communication of meteorological risks, particularly in remote and sparsely populated areas of Canada subject to extreme weather conditions. The Canadian Precipitation Analysis system (CaPA) provides high-quality, near-real-time precipitation estimates, but its snow products are limited due to the lack of accurate precipitation measurements to correct the model first-guess. The advent of dual-polarized radars presents an opportunity to add valuable precipitation estimates to CaPA in the winter. These new radars, which have been operational since 2020, provide more accurate estimates of solid precipitation rates than previous single-polarized radars. This project aims to assess the impact of the radar product on solid precipitation estimations in CaPA by assimilating radar pixels during freezing conditions. Case studies and an objective evaluation against surface measurements serve as a basis for the evaluation, which is conducted on the Canadian Prairies domain during the winter months of 2020-2021 and 2021-2022. The results of the evaluation suggest a positive impact of the radars on CaPA during the winter, especially for small precipitation thresholds (<1mm/h). The importance of bias correction of the radar data before assimilation will also be discussed, as it has been identified as a potential limitation of the assimilation. This project will contribute to improving real-time solid precipitation estimates in cold regions. By using dual-polarized radars and conducting a comprehensive evaluation, this project provides a thorough assessment of the impact of weather radar data on solid precipitation estimates in Canada.

Florence Beaudry[1], Stéphane Bélair[2], Julie M. Thériault[1] [1]Centre pour l'Étude et la Simulation du Climat à l'Échelle Régionale (ESCER), Department of Earth and Atmospheric Sciences, Université du Québec à Montréal, Montréal, Québec, Canada [2]Meteorological Research Division, Environment and Climate Change Canada, Dorval, Canada beaudry.florence@courrier.uqam.ca

ATM-Improving accuracy and reliability of hydrometeorologic data: Challenges and solutions in the Great Lakes Basin

Hydrometeorologic data is essential for understanding physical processes and model results, but it is subject to multiple sources of uncertainty. Properly detecting and correcting these uncertainties is crucial to avoid biased analyses and decision-making. However, determining the source of uncertainty can be challenging. The five main sources of uncertainty include measurement uncertainty, derived data uncertainty, interpolation uncertainty, scaling uncertainty, and data management uncertainty. Measurement uncertainty refers to errors that arise from the measurement process itself, such as sensor inaccuracies or environmental factors that affect the measurement. Derived data uncertainty arises when measurements are used to calculate other parameters, such as evapotranspiration or streamflow. Interpolation

uncertainty is associated with spatial variability, such as the use of interpolation methods to estimate values at unmeasured locations. Scaling uncertainty occurs when data collected at one scale is used to estimate values at a different scale. Finally, data management uncertainty arises from errors in data collection, processing, and storage. To address these sources of uncertainty, a comprehensive understanding of measurement and data processing methods, quality control protocols, data validation and verification, and appropriate statistical analysis is also required. This work provides an overview of the hydrometeorologic data processing methods used over the Great Lakes, as well as the limitations and assumptions underlying the data. Properly detecting and correcting these uncertainties leads to more accurate and reliable hydrometeorologic data, which can be used to improve the results of hydrological models.

André Guy Tranquille Temgoua[1], Frank Seglenieks[1], Narayan Shrestha[1], Nicole O'Brien[1] [1]ECCC andreguy.temgoua@ec.gc.ca

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Advances in Weather & Climate Risk Communication - Part 1

Wednesday, May 31
13:00 - 14:30 EDT

(15 Mins) The influence of affective response on information seeking during Hurricane Fiona: Analysis of the Risk Information Seeking and Processing model - Amber Silver

(15 Mins) Machine Classification of Official Weather Alerts on Canadian Social Media to Improve Public Engagement and Situational Awareness - Renee Sieber

(15 Mins) Spatial Distribution of Heat Vulnerability in Toronto - Karen Smith

(15 Mins) Breaking the equation between extreme weather and disruptive events - Victoria Slonosky and Yumeng Zhang

(15 Mins) Sea Change in Marine Forecasting & Fishing Safety: Navigating Weather and Relationships in Commercial Fisheries - Joel Finnis

(15 Mins) Predicting and Alerting for Coastal Flooding Project - Devon Telford

The weather and climate services landscape is evolving at a rapid pace, as public and private service providers seek to meet growing demand for increasingly diverse guidance. The result is an ever-expanding volume of products, communicated through a variety of new and traditional channels (e.g., broadcast television/radio, websites, social media), to diverse audiences with increasingly sophisticated and specific needs. This effort is also motivating greater interactions between service providers and end-users, answering calls for greater co-production of weather and climate information to ensure that products (both new and old) effectively inform and advise users on their weather and climate risks. These developments present exciting prospects for science and risk communication; however, fully capitalizing on opportunities afforded by new technology, data sources, and stakeholder interests requires an interdisciplinary approach. This session invites researchers to discuss these opportunities, related challenges, and novel solutions.

SER-The influence of affective response on information seeking during Hurricane Fiona: Analysis of the Risk Information Seeking and Processing model

In 2022, Hurricane Fiona was forecasted to make landfall in Atlantic Canada. Information about the storm was shared well in advance of its arrival with a great deal of attention paid to whether it would be Canadas strongest-ever storm. Hurricane Fiona eventually came ashore in Nova Scotia on September 24 as a post-tropical cyclone with wind speeds of 170 km/hr (105 mph). The storm caused widespread impacts across the region, including power outages that left over 500,000 thousand customers without power. The storm weakened as it continued northwards, but its storm surge and sustained winds caused substantial destruction in the community of Port aux Basques, Newfoundland. The research team developed a questionnaire instrument based on insights from the risk information seeking and processing (RISP) model to explore how official and unofficial information about the storm influenced affective responses, which in turn influenced information seeking behaviors. The preliminary results of the study provide insight onto the influence of affect on protective action decision-making during extreme events.

Amber Silver[1], Brandon Behlendorf[1], Joel Finnis[2], Jennifer Spinney[3] [1]University at Albany [2]Memorial University [3]York University asilver@albany.edu

SER-Machine Classification of Official Weather Alerts on Canadian Social Media to Improve Public Engagement and Situational Awareness

Crisis managers aim to prevent injuries and fatalities during extreme weather events by issuing official alerts across a variety of platforms including social media. The effectiveness of official warnings on social media platforms such as Twitter remains inadequately studied. Our project, funded by Environment and Climate Change Canada, used Natural Language Processing (NLP) to automatically classify social media content. This approach enables us to examine how people interact and engage with expert alerts (operationalized as Specific Area Messaging Encoding or SAME Alerts) across differing user posts that range from comments on infrastructure damage to the best foods to eat during a snowstorm. Making our analysis relevant and useful to crisis managers means determining how to filter out useful information in real-time from the constant stream of content on social media. Supervised NLP models rely on training examples labeled with predetermined categories, which removes costly content analysis and produces rapid actionable results. Existing training datasets, such as CrisisNLP, include events like earthquakes and floods in Pakistan, which can fail to capture important aspects of Northern climates (e.g., snowstorms and the infrastructure to mitigate them). Unsupervised classification does not have the overhead of training datasets but its ad hoc nature requires more interpretation to achieve actionable results. In this presentation, we discuss our research into building a labeled data repository for Northern climates, conducting unsupervised classification to determine important labels, building a classification scheme, crowdsourcing to train our models on it, and deploying a supervised classification model with a user interface.

Renee Sieber[1], Drew Bush[2], Andrei Romascanu[1], Martin Pleynet[1], Zander Bamford-Brown[1], Frida Buitron[1] [1]McGill University [2]Mount Washington Observatory renee.sieber@mcgill.ca

SER-Spatial Distribution of Heat Vulnerability in Toronto

The frequency, intensity and duration of heatwaves are expected to increase in Toronto due to both climate change and urban heat island (UHI), which will result in enhanced heat vulnerability for Toronto residents. Therefore, designing appropriate heat management plans requires information about how heat vulnerability is distributed across the city. To fill the knowledge gap, two distinct methods are examined to quantify heat vulnerability across the city at the dissemination area level. Heat vulnerability indices (HVIs) consisting of three primary dimensions, exposure, sensitivity and adaptive capacity, are generated using these two distinct methods from remotely sensed land surface temperature and socio-economic features collected from census data. The first method uses principal component analysis to derive a heat vulnerability index (HVI), and the second method assigns equal weight to each input feature to derive a HVI. Both HVIs display a similar U-shaped pattern of high heat vulnerability from the northwest of Toronto to the downtown and back up to the northest, with the low heat vulnerable areas being primarily located along the Lake Ontario shoreline and near the ravines. Further cluster analysis reinforces this spatial pattern. In summary, this study offers two methods to quantify, analyze and visualize heat vulnerability at the dissemination area level and provides a means for visually communicating heat vulnerability and risk for heat management outreach, planning and implementation in Toronto.

Shuchen Bu[1], Karen Smith[1], Fadi Masoud[2], Alex Sheinbaum[2] [1]University of Toronto Scarborough [2]University of Toronto shuchen.bu@mail.utoronto.ca

SER-Breaking the equation between extreme weather and disruptive events

Are the most disruptive weather and climate events necessarily extreme events, or are there other social factors in play that can turn ordinary weather and climate into socially disruptive events? Why do some extreme weather events pass by with little impact, while others are remembered for generations? In the absence of a centralized repository for impacts, we use social commentaries such as newspapers and tweets to look the events that impacted people and to try to understand the cause of these impacts.We use artificial intelligence (natural language processing)to explore the interaction between weather and society to discover if links can be found between weather, how weather events are perceived by society, and how society responded to events. The project looks at records from two periods. Weather reports, newspaper accounts, and tweets from the Montreal region are examined from 2000-2020 to determine what events proved disruptive, or worthy of commentary. Weather observations from the McGill data rescue project DRAW, and newspapers for the period 1880-1900 (La Presse, La Patrie, The Gazette) are also studied for disruptive events such as floods and snowstorms. We report on the first tranche, an 1880-1900 corpus of digitally recognized text from the newspaper articles, using optical character recognition and unsupervised classification, to characterize the impacts and responses of these events. Comparisons of the different impacts and responses between the two periods, and how the evolution of society has brought both increased safety and new challenges, will be explored.

Victoria Slonosky[1], Renée Sieber[1], Frédéric Fabry[1], Gordon Burr[1], Alyssa Conlon[1], Yumeng Wang[1], Oliver Wang[1] [1]McGill University victoria.slonosky@mail.mcgill.ca

SER-Sea Change in Marine Forecasting & Fishing Safety: Navigating Weather and Relationships in Commercial Fisheries

Commercial fish harvesters are one of the primary users of marine forecasts, and rely heavily on these reports to manage weather hazards in their work at sea. Despite the intrinsic user-producer connection between forecasters and fish harvesters, direct interaction between these groups remains relatively rare; this simultaneously limits mutual user/producer understanding and opportunities for meaningful co-production of forecast materials. Drawing from a series of qualitative studies of marine forecast production and fishing safety, we explore aspects of this divide, and evaluate fisher approaches to assessing and navigating marine risk. Finally, we present three examples of public meteorological services actively working to build closer relationships with fish harvesters, either by i) developing new products targeted to specific fisheries; ii) providing greater access to guidance informing marine forecasts; or iii) operationalizing forecaster/fisher interactions.

Joel Finnis[1], Emily Reid-Musson[2], Maaike Knol-Kauffman[3], Jelmer Jeuring[4] [1]MUNL [2]St. Francis Xavier [3]U. Tromso [4]Norwegian Met Inst Jfinnis@mun.ca

SER-Predicting and Alerting for Coastal Flooding Project

Environment and Climate Change Canadas Meteorological Service of Canada has under taken a national project for Predicting and Alerting for Coastal Flooding. This project builds on coastal flooding investments under the 2018 Adapting Canadas Weather and Water Services to Climate Change and the 2019 Emergency Management Strategy. Predictions Services Operations Atlantic Ice (PSO-AI), a division within the Meteorological Service of Canada, has been issuing Storm Surge and High Water Level Warnings as part of the Public and Marine Programs Since 2001 and more recently for regions of Quebec. These warnings are intended to inform the Public and Marine Communities of coastal flooding impacts. This project will upgrade the existing Atlantic coastal flooding service and will expand the operational capacity for prediction of storm-induced coastal flooding towards an integrated, national system of comprehensive coastal flooding prediction and alerting serving all marine coasts and the Great Lakes and St Lawrence. With the goal of enhancing public safety and improve decision support for Provinces and Territories, EMOs Canadians; this project is investing in new modelling and visualization innovations while engaging Provincial and Territorial partners to identifying vulnerable areas and alerting thresholds to develop coastal flooding risk products and services out to 5 days to provide early notification. This presentation will provide a project overview and status of both the external and internal products and services that have been developed during the project as well as future improvements.

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Changing Arctic: Science and Policy Studies - Part 2

Wednesday, May 31
13:00 - 14:30 EDT

(15 Mins) Fine vertical structure in Arctic clouds simultaneously measured by two lidars - Emily McCullough

(15 Mins) Using Ground-Based Fourier Transform Infrared Spectroscopy to Validate Models of Short-Lived Climate Forcers in the High Arctic - Erin McGee

(15 Mins) Investigating Tropospheric Pollutant Trends in the High Arctic Region -

Tyler Wizenberg

(15 Mins) Seasonal and vertical variability of aerosol size distributions in the Canadian Arctic Archipelago - Phillipe Gauvin-Bourdon

This interdisciplinary session will present emerging scientific results on the rapidly changing Arctic and northern environment. The physical environment of the Arctic has changed dramatically over the past decades with the underlying causes of these changes, in terms of the cryosphere, oceanography, hydrology and meteorology, being addressed through various scientific approaches. The application of the scientific results in relation to policy issues associated with federal government and Indigenous-led management efforts will be considered. The importance of Arctic research and its consequences in looking ahead is very timely and pertinent to informing northern communities, the public and contributing to a range of policy issues in this strategically important part of Canada. Papers are sought from research, science and policy activities that are nearing completion, currently being undertaken, or those planned and just getting under way.

MUL-Fine vertical structure in Arctic clouds simultaneously measured by two lidars

Four years of 532 nm lidar measurements from the Candac Rayleigh-Mie-Raman Lidar (CRL) have revealed frequent instances of fine internal structure in the form of laminations, or vertically stacked layers, within Arctic clouds at Eureka, Nunavut. These layers, measured using lidar backscatter and depolarization techniques appear to be liquid layers alternating with layers of randomly oriented ice particles. They range in thickness from 30 m or more down to as thin as the vertical resolution limit of the CRL lidar (7.5 m). Days with laminated clouds are strongly correlated (r = 0.63) with precipitating snow conditions at ground level, while days with non-laminated clouds (r = -0.40) and clear sky days (r = -0.43) are moderately anti-correlated with snow precipitation. Correlations of laminations with other types of weather, as measured by the co-located Environment and Climate Change Canada (ECCC) Weather Station, were not significant. Therefore, the 10s-of-m-scale structure within clouds is relevant to their precipitation generation processes. In 2021, a micropulse lidar (MPL) was installed at Eureka as part of the MPLCAN (Canadian) and MPLNET (worldwide) networks of autonomous lidars. Here, we update the lamination study to include CRL measurements from 2020 and 2021. We compare simultaneous MPL and CRL measurements to validate the previous measurements, and extend our investigations of the fine-scale cloud structures. By extension, we comment on the feasibility and utility of extending this project to include MPL measurements from other locations.

Emily McCullough[1], Robin Wing[2], James Drummond[1], Victoria Pinnegar[3], Robert Sica[3], Ellsworth Judd Welton[4] [1]Dalhousie University [2]Leibniz Institute for Atmospheric Physics [3]Western University [4]NASA Goddard Space Flight Center e.mccullough@dal.ca

MUL-Using Ground-Based Fourier Transform Infrared Spectroscopy to Validate Models of Short-Lived Climate Forcers in the High Arctic

Short-Lived Climate Forcers (SLCFs) are atmospheric species with climate impacts and lifetimes shorter than that of carbon dioxide; they are a major subject of interest of the Arctic Monitoring and Assessment Programme (AMAP), a working group of the Arctic Council, and were the focus of the 2021 AMAP Assessment Report. AMAP studies and documents the effects of climate change and pollution on Arctic climate with the intent

of informing policy recommendations. AMAP used multiple models to determine levels of SLCFs in the Arctic; these models include CESM, CMAM, DEHM, EMEP-MSC-W, GEM-MACH, GEOS-Chem, MATCH, MATCH-SALSA, MRI-ESM2, UKESM1, and WRF-Chem. The present study compares carbon monoxide and methane outputs from these models, where possible, to data from ground-based Fourier Transform Infrared (FTIR) Spectrometers focused on the near-infrared spectral region. These spectrometers are part of the Total Carbon Column Observing Network (TCCON), with Arctic stations in Eureka (Nunavut, Canada), Ny Ìesund (Spitzbergen, Norway), and Sodankyl (Finland). TCCON has been used for many validation studies in the past due to it having very low site-to-site bias. The model outputs are 3-D mixing ratios given at three-hour intervals for the years 2014 and 2015; these are sampled at TCCON locations and smoothed using TCCON averaging kernels in order to be compared to the TCCON column-averaged dry air mole fraction (Xgas) data product. We evaluate the AMAP models against TCCON observations to assess their ability to simulate carbon monoxide and methane in the High Arctic, and ultimately better understand their suitability for informing SLCF policy decisions.

Erin McGee[1], Kimberly Strong[1], Kaley A. Walker[1], Cynthia H. Whaley[2], Rigel Kivi[3], Justus Notholt[4], The AMAP SLCF Modelling Team[5] [1]University of Toronto [2]Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada [3]Finnish Meteorological Institute [4]Institute of Environmental Physics, University of Bremen [5]Various e.mcgee@mail.utoronto.ca

MUL-Investigating Tropospheric Pollutant Trends in the High Arctic Region

Tropospheric pollutants such as carbon monoxide (CO), formaldehyde (HCHO), acetylene (C2H2), ethylene (C2H4), ethane (C2H6), peroxy acetyl nitrate (PAN), methanol (CH3OH), and formic acid (HCOOH) can have broad impacts on air quality, atmospheric chemistry, and the climate. These effects can be even more pronounced in a sensitive environment such as the high Arctic, where transported mid-latitude pollution is a significant driver of inter-annual variability, and where there are relatively few local sources and low background concentrations. Reliable measurements of many of these trace gases in the Arctic region are currently sparse, and the observational conditions for satellite-borne infrared sensors are challenging, making the task of monitoring and assessing trends in these pollutants difficult. In this study, we present long-term trends for eight tropospheric species derived from measurements from two high-Arctic ground-based Fourier transform infrared (FTIR) instruments at Eureka, Nunavut (80.05N, 86.42 2006-2020), and Thule, Greenland (76.53N, 68.74 1999-2021). The observational results are complemented by long-term model simulations from the GEOS-Chem chemical transport model, providing an additional perspective on the trends and inter-annual variability of these trace gas species.

Tyler Wizenberg[1], Kimberly Strong[1], Dylan Jones[1], Emmanuel Mahieu[2], Ivan Ortega[3], James Hannigan[3] [1]University of Toronto [2]University of Liege [3]NCAR

MUL-Seasonal and vertical variability of aerosol size distributions in the Canadian Arctic Archipelago

Atmospheric aerosols are important radiative forcing agents, emitted by a large variety of natural and anthropogenic sources. The Arctic is of particular interest in aerosol studies due to its high sensitivity to climate warming and its wide range of aerosol-climate effects. The continuous 7-year dataset of size-resolved aerosol number and mass concentration collected at the PEARL station (800311 N 862459 W) on Ellesmere Island in the Canadian Arctic Archipelago is a valuable record for a better understanding

of aerosol sources, processes, transport, and climate effects. Here we present an analysis of the seasonality in aerosol number concentration observed at the PEARL station. Our results indicate significantly higher aerosol mass concentrations during winter (approx. 8.68 g/m3) and spring (approx. 9.09 g/m3) compared to the pristine summertime atmosphere. A decrease (approx. 2.16 g/m3) in the mean size of the aerosols is also observed in the summer relative to winter/spring. In spring, coarse-mode particles are more abundant than in other seasons. Coupled with these aerosol seasonal variations observed in situ at PEARL, the changing meteorological conditions are expected to create a stratification of aerosols in the overlying atmosphere. The GEOS-Chem chemical transport model coupled to the TwO-Moment Aerosol Sectional microphysics scheme (TOMAS) was used to explore aerosol vertical profiles. Our results reinforce the knowledge of evident seasonal changes in observed aerosol concentrations in the Canadian Arctic Archipelago and contribute to understanding how these aerosols influence global climate.

Phillipe Gauvin-Bourdon[1], Betty Croft[1], Patrick Hayes[2], Rachel Chang[1] [1]Dalhousie University [2]University of Montreal phillipe.gauvin-bourdon@dal.ca

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Recent advances in ocean biogeochemistry in Canada - Part 1

Wednesday, May 31
13:00 - 14:30 EDT

(30 Mins) Increasing hypoxia in Canadian coastal waters: should we mitigate? - Douglas Wallace

(15 Mins) Dynamics and sources of inorganic carbon in the bottom-waters of the Gulf of St. Lawrence, Canda - William Nesbitt

(15 Mins) Sudden oxygen decline in the recently hypoxic waters of the St. Lawrence Estuary - Mathilde Jutras

(15 Mins) Disentangle Nitrogen budget in the Estuary and Gulf of Saint Lawrence from measurements of N2 accumulation in hypoxic bottom water - Gwenaelle Chaillou

(15 Mins) Variability in oxygen uptake, export, and storage in the Labrador Sea - Jannes Koelling

The Oceans regulate the world's climate, absorbing heat and carbon dioxide. The impacts of this climate regulation manifest as warming, deoxygenation and acidification, with consequences on marine ecosystems. In the current context of high carbon dioxide emissions and climate change, it is therefore crucial to understand the biogeochemistry of the oceans. Canadian waters have recently experienced marked changes in their biogeochemistry. Both the Atlantic and Pacific coasts have experienced deoxygenation marked by hypoxic events over recent years. Deoxygenation is accompanied by carbonate chemistry extremes that are linked to ocean acidification, which has also been affecting Arctic waters. Heat waves are becoming more frequent and more extreme, while an overall increase in water temperature is affecting biological processes such as nutrient cycling and organic matter remineralization. These biogeochemical extremes often co-occur, increasing the severity of the effects on ecosystems. This session invites contributions on all aspects of biogeochemistry in Canadian waters, including, but not restricted to, deoxygenation, ocean acidification, carbon

cycling, nutrient cycling, physical-biogeochemical interactions, and effects on ecosystems or marine organisms. With this session, we hope to bridge the gap between the Atlantic, Pacific and Arctic research communities. While the focus is on Canadian waters, studies discussing adjacent basins are also welcome.

OCE-Increasing hypoxia in Canadian coastal waters: should we mitigate?

The concentration of dissolved oxygen can be critical for the sustainability of life below water. Direct and indirect effects of human activity are now causing widespread decreases of oxygen in both open ocean and coastal waters. Model projections suggest oxygen loss coupled with warming could impact marine life globally to the same extent as fishing by the end of this century unless greenhouse gas emissions are curbed (Penn and Deutsch, 2022). Coastal water bodies of eastern Canada are amongst those threatened, however conventional conservation measures (e.g. MPAs) are powerless to prevent such impacts. We discuss two case studies: a) in Bedford Basin, Nova Scotia we show that recent years with mild winters and reduced mixing have led to intense hypoxia. This has, in turn, led to major increases in formation of N2O, a potent greenhouse gas, demonstrating, on a local scale, a positive feedback on climate change. In the Gulf of St. Lawrence, time-series suggests key, ecologically sensitive areas are on the threshold of hypoxia. We argue that it is now necessary to consider the potential for mitigation of deoxygenation in some coastal water bodies. We show that a green hydrogen plant proposed for SW Newfoundland will produce pure oxygen is an appropriate location and in sufficient quantities to mitigate the ongoing deoxygenation throughout the Gulf of St. Lawrence. The uncertainties and research needs, in both ocean science and process engineering, required to evaluate such a mitigation option will be discussed.

Douglas Wallace[1], Mathilde Jutras[2], Subhadeep Rakshit[1], Adriana Reitano[3], Adam Donaldson[1] [1]Dalhousie University [2]McGill University [3]Concordia University douglas.wallace@dal.ca

OCE-Dynamics and sources of inorganic carbon in the bottom-waters of the Gulf of St. Lawrence, Canada

The St. Lawrence Estuary and Gulf are the largest enclosed estuary in the world and have undergone drastic changes over the past century. The bottom-waters of this system have developed persistent hypoxia and acidification over this time, creating a growing threat to the ecosystem. In October of 2021, during the Gulf of St. Lawrence Tracer Release Experiment (TReX), a large-scale survey of the Gulf of St. Lawrence was conducted measuring parameters such as Dissolved Inorganic Carbon (DIC) and its corresponding 13C isotopes, Total Alkalinity (AT), and Dissolved Oxygen (DO). Subsequently, further surveys were conducted in June and October/November of 2022. In this presentation, we investigate the spatial DIC- 13C distribution in the Gulf of St. Lawrences bottom-waters from the Cabot Strait to the head of the estuary. Trends in AT from the Cabot Strait to the mouth of the Estuary are examined as well as the relationship of DIC- 13C vs DIC, AT, and DO. Implications of the spatial variability of DIC- 13C on its own and in relation to the above-mentioned parameters are used to characterize carbon dynamics in the Gulf as well as define likely sources contributing to DIC.

-William Nesbitt[1], Claire Normandeau[1], Olivier Hérard[2], Gwenaëlle Chaillou[2], Douglas

Wallace[1] Alfonso Mucci3 [1]Dalhousie University [2]ISMER/UQAR 3McGill University william.nesbitt@dal.ca

OCE-Sudden oxygen decline in the recently hypoxic waters of the St. Lawrence Estuary

The bottom waters of the Lower St. Lawrence Estuary became hypoxic in the mid-1980s, and minimum oxygen levels remained relatively invariant until 2019. Through 2019-2021, the deep-water minimum oxygen concentrations dropped by half, reaching levels of ~35 mol/kg. Concomitant with this decline, the extent of the hypoxic zone in the St. Lawrence Gulf increased more than 7-fold since 1993, when it was first estimated at ~1300 km. The hypoxic zone now reaches well into the western Gulf of St. Lawrence and covers nearly 9400 km. The deoxygenation of the St. Lawrence Estuary and Gulf is driven by the combined effect of eutrophication and an increase in the relative contribution of warm, oxygen-poor Gulf Stream Waters, at the expanse of cold, oxygen-rich Labrador Current Waters, entering the system. We attribute the sudden 2019 decline to the complete withdrawal of Labrador Current Waters from the system. In addition to presenting these results, we will quickly discuss the mechanisms responsible for the path undertaken by the Labrador Current in the western North Atlantic Ocean.

Mathilde Jutras[1], Alfonso Mucci[1], Gwenaëlle Chaillou[2], William Nesbitt[3], Douglas Wallace[3] [1]McGill University [2]Institut des Sciences de la Mer de Rimouski (ISMER) - Université du Québec à Rimouski [3]Dalhousie University mathilde.jutras@mail.mcgill.ca

OCE-Disentangle Nitrogen budget in the Estuary and Gulf of Saint Lawrence from measurements of N2 accumulation in hypoxic bottom water

The inventory of nitrogen-containing nutrients is driven by the balance between N2 fixation and losses from denitrification (including canonical denitrification and anaerobic ammonium oxidation) that returns fixed-N to N2. In oxygen-depleted waters, denitrification occurs in both the water column and sediments and may lead to an imbalance in the N budget. The Estuary and Gulf of St. Lawrence, the largest estuarine system in the world, is characterized by a density-driven estuarine circulation where seawater penetrates from the North Atlantic, dives deeply (>150 m depth) and flows sluggishly landward. Drastic oxygen depletion was observed in the bottom waters of the St. Lawrence Estuary, with minimum dissolved oxygen concentrations passing from 55-65 mol L-1 between 1984 and 2019 to ~26 mol L-1 in 2022. The drop was associated with a spatial expansion of the depleted zone to the Gulf. Here, we will use the dissolved N2:Ar measurements in the bottom water to constrain the denitrification rates along the oxygen landward gradient, assuming a capped system that only exchanges with the underlying sediment. Our preliminary results show that N2:Ar and N concentrations are almost constant along the gradient as long as oxygen is higher than 52 mol L-1. Below this threshold, N2:Ar and N concentrations exhibit a strong linear increase in the landward direction. The N2 enrichment suggests denitrification processes occur, likely modifying the N budget. A comparison with sediment core incubation and a mass balance calculation will determine denitrification rates and balance the N budget in the context of bottom water deoxygenation.

gwenaelle chaillou[1], Ludovic Pascal[1], Olivier Hérard[1], Douglas Wallace[2] [1]ISMER / UQAR [2]Department of Oceanography / Dalhousie University gwenaelle_chaillou@uqar.ca

The Labrador Sea is a key region for deep ocean ventilation, as it is one of the few places globally where atmospheric oxygen can reach depths of 1000m or more. This happens primarily during deep wintertime convection, when strong atmospheric forcing drives a strong uptake of oxygen, which is incorporated into newly formed Labrador Sea Water (LSW). Here, we use data from moored sensors in the Labrador Seas outflowing boundary current in order to assess how the oxygen taken up in the interior subsequently spreads out of the basin towards the rest of the ocean. We find that LSW is exported southward primarily during the summer months, carrying away about half of the oxygen taken up during convection. Additionally, we use the extensive historical record of shipboard oxygen measurements to study decadal variability in the central Labrador Seas oxygen content and relate it to changes in convection. We also employ data from global climate models to gain a better understanding of how this variability relates to uptake of oxygen from the atmosphere, and lateral export by advection and eddies. Our results suggest that in the long-term mean, the large net uptake of oxygen occurring each winter is primarily balanced by lateral exchanges, with newly ventilated Labrador Sea Water being exported and replaced by less oxygenated waters. On decadal time scales however, oxygen storage also plays an important role, with more than half of the variability in gas exchange contributing to building up the local oxygen reservoir, rather than being exported immediately.

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A special session on ocean science and environmental statistics in tribute to Professor Keith R. Thompson - Part 3

Wednesday, May 31
15:00 - 16:30 EDT

(30 Mins) Exceptional Training in Marine Prediction and Environmental Statistics Made by Keith Thompson - Jinyu Sheng

(15 Mins) Improving ECCC's global total water level forecast system, part 2: Adding sea ice effects - Pengcheng Weng

(15 Mins) Effects of surface gravity wave on the upper ocean dynamics over the northwestern Atlantic during Hurricane Arthur - Colin Hughes

(15 Mins) Response of a Simple Sea Ice Model to Stochastic Forcing - Benjamin Richaud

Professor Keith Thompson of Dalhousie University passed away on July 11, 2022. Professor Thompson held a Tier I Canada Research Chair in “Marine Prediction and Environmental Statistics: and participated in many international committees including “Coastal Ocean Observations Panel of the Global Ocean Observing System”. Professor Thompson made exceptional contributions in ocean science research and high-quality training. He made significant contributions in developing a storm surge prediction model that is now being used operationally. This session will have an overview of Dr. Thompson’s research work and his major contributions. We invite abstracts from everyone particularly from his

former students and his collaborators on any research topics including modelling and prediction of coastal and shelf waters, environmental statistics, process studies of dynamics in atmospheres and oceans, and data assimilation.

OCE-Exceptional Training in Marine Prediction and Environmental Statistics Made by Keith Thompson

Professor Keith Thompson was a top researcher in physical oceanography and environmental statistics. He held a joint appointment in both the Department of Oceanography and Department of Mathematics Statistics at Dalhousie University. For many years Keith also held Tier 1 Canada Research Chair in Marine Prediction and Environmental Statistics. His research chair not only established the Environmental Statistics program at Dalhousie, but also created two new Statistics faculty positions. Keith was our role model for providing exceptional and high-quality training of graduate students and post-doctoral fellows. Keiths methodology for training graduate students was comprehensive, with a strong emphasis on both theoretical and practical aspects, as reflected in both his teaching and research areas. Keith generously shared his time and skills with so many people, mentoring both students and junior faculty. He left an important teaching and training legacy in both Oceanography and Statistics, having for decades taught graduate courses (Time Series Analysis, Multivariate Analysis) and as a dedicated, long-time instructor for the first-year Introductory Statistics. He had a special talent for crafting clever examples to illustrate key concepts, and also for providing guidance to help students achieve their full potential. We will take this opportunity to share examples of appreciation and admiration from his former students and post-doctoral fellows.

Jinyu Sheng[1], Michael Dowd[1] [1]Dalhousie University Jinyu.Sheng@Dal.Ca

OCE-Improving ECCC's global total water level forecast system, part 2: Adding sea ice effects

In operational flood forecast systems, the effect of sea ice is typically neglected or parameterized solely in terms of ice concentration. In this study, an effective and efficient way of adding ice effects to global total water level prediction systems, via the ice-ocean stress, is described and evaluated. The approach features a novel, consistent representation of the tidal relative ice-ocean velocities based on a transfer function derived from ice and ocean tidal ellipses given by an external ice-ocean model. The approach and its impact are demonstrated in the Arctic Region over four ice seasons (3.5 years). We show that adding ice effects helps the model reproduce most of the observed seasonal modulations in tides (up to 40% in amplitude and 50 degrees in phase for M2). The dominant driving mechanism for the modulations is the under-ice friction, acting in areas of shallow waters (less than 100 m), and its accompanied large shifts of amphidromes (up to 125 km). Important contributions from baroclinicity and tide-surge interaction due to ice-ocean stress are also found, and both processes generally reinforce modulations induced by the under-ice friction. In forecast systems that neglect or rely on simple ice concentration parameterizations, storm surges tend to be overestimated. With the inclusion of the ice-ocean stress in this study, corrections up to 1.0 m to the surge overestimation are achieved. Remaining limitations regarding the overestimated amphidrome shifts and insufficient ice break-up during large storms are discussed.

Pengcheng Wang[1], Natacha Bernier[1] [1]Environment and Climate Change Canada pengcheng.wang@ec.gc.ca

OCE-Effects of surface gravity wave on the upper ocean dynamics over the northwestern Atlantic during Hurricane Arthur

Surface gravity waves alter air-sea interactions, turbulent vertical mixing and circulation in the wind mixed layer during hurricanes. In this study, the influence of wave-current interactions on the upper ocean dynamics during Hurricane Arthur in July 2014 is examined based on model results. The wave-related processes evaluated include Langmuir turbulence, wave breaking turbulence, the momentum transfer from wind to waves to near-surface currents and conservative Stokes drift terms. The coupled wave-circulation model in the COAWST modeling system was modified to include parameterizations of these processes. Large-scale reanalysis wind and realistic hurricane wind data are blended to provide the reliable wind forcing during the storm in the model. Model results, including the tides, sea surface temperature and salinity, and significant wave heights, are compared to observations made by tidal guages and buoys, and satellite altimeter data to validate the model performance. Model results indicate that while Langmuir turbulence often enhances the vertical mixing to the right of the hurricane center, its effect in other regions differs. Features such as wind-wave misalignment and the nonlinear interactions between Langmuir turbulence and other wave effects will be explored.

Colin Hughes[1], Guoqiang Liu[2], William Perrie[2], Jinyu Sheng[1] [1]Dalhousie University [2]Fisheries and Oceans Canada, Bedford Institute of Oceanography Colin.Hughes@Dal.ca

OCE-Response of a Simple Sea Ice Model to Stochastic Forcing

The Arctic is experiencing fast and drastic changes under anthropogenic climate change, including air and ocean warming and sea ice loss. Over the past few decades, the main source of ice melt has shifted from the atmosphere to the ocean, due to increased heat transport from the Pacific and Atlantic Oceans. Increased areas of open water modify the local cloud formation with feedback on longwave radiation, while the poleward shift of storm tracks modifies wind speeds with impacts on sensible heat fluxes. The complex dynamics of, and strong coupling between, atmosphere, sea ice and ocean leads to high uncertainties in the future of sea ice, despite steady improvements of ice observations and modelling. Stochastic models provide a statistical representation of climate processes while relying on simple deterministic equations based on physical principles, filling the gap between overly simplified deterministic models and complex fully coupled numerical models. In this study, we develop a set of governing equations for ice growth and melt which include only a handful of external forcing variables and internal parameters. We show that this model reproduces observed sea ice climatology under realistic forcing conditions. We then force the model under a range of forcing conditions, including realistic stochasticity in the forcing variables. We investigate the implications of non-linearities in the system on the mean state of ice thickness and the time scales at which sea ice responds to specified atmospheric forcing. The effects of increased oceanic heat flux on the variability of sea ice will be discussed.

Benjamin Richaud[1], Eric C.J. Oliver[1], Michael Dowd[1], Christoph Renkl[2] [1]Dalhousie University [2]Woods Hole Oceanographic Institution benjamin.richaud@dal.ca

Acoustical Oceanography and Underwater Sound - Part 2

Wednesday, May 31
15:00 - 16:30 EDT

(15 Mins) A deep learning model for detecting Arctic marine mammals: Bearded Seals - Ruwan Abeywardlhana

(15 Mins) Possible sounds produced by American Lobsters (Homarus americanus) in their natural habitat - Russell Wyeth

(15 Mins) Acoustic source mechanisms and soundscapes of hydrothermal vents - Brendan Smith

(15 Mins) Partitioning the vertical structure of ambient sound in the Challenger Deep, Mariana Trench - David Barclay

(15 Mins) Quantifying ship noise recorded in the western Canadian Arctic - Najeem Shajahan

(15 Mins) Long-term soundscape observations in the Northeast Pacific on Ocean Networks Canada's cabled acoustic infrastructure - Lanfranco Muzi

Acoustic techniques provide means for underwater communication and remote sensing for humans and animals alike. The focus of this session is to highlight the roles of acoustic methods, measurements, and monitoring in all aspects of oceanography and marine sciences. Areas of interest include, but are not limited to: sonar, bio-acoustics, passive acoustic monitoring, fisheries acoustics, geophysical applications, acoustic communication, defence applications, ambient and ocean noise, anthropogenic noise, acoustic ecology, long-range propagation, tomography, high-frequency scattering, imaging, and quantitative inversion.

OCE-A deep learning model for detecting Arctic marine mammals: Bearded Seals

The Arctic marine environment is rapidly changing, exhibiting sea ice loss and increased anthropogenic activity. Both have affected marine animals in a variety of ways. To understand these effects, it is required to study the spatial and temporal distributions of Arctic marine animals. Passive acoustic monitoring is used for examining the presence of marine mammal vocalizations which, when analyzed manually, require a significant time contribution of experienced bio-acousticians. In recent years, deep neural networks have proven highly successful at solving a wide range of detection tasks, outperforming existing methods. As the first step of a series of automated Arctic marine mammal detectors, we present an automated bearded seal acoustic detector using the ResNet deep neural network architecture. The deep model was trained using underwater acoustic data from the Sachs Harbour area and Cambridge Bay area. The dataset, acquired and labeled by the Wildlife Conservation Society Canada, included more than 15000 bearded seal call annotations. The trained model was tested against 15% of the samples, and results show that the model is capable of predicting bearded seals vocalizations with 91% of both recall and precision. Additionally, a command-line tool was developed to enable bio-acousticians to efficiently utilize the detector to adapt the current model to their acoustic data set for the purpose of detecting and annotating

bearded seal vocalizations.

Ruwan Abeywardhana[1], Fabio Frazao[1], Bruno Padovese[1], William Halliday[2], Amalis Riera[3], Romina Gehrmann[1], Stan Matwin[1] [1]Dalhousie University [2]Wildlife Conservation Society Canada [3]University of Victoria r.abeywardhana@dal.ca

OCE-Possible sounds produced by American Lobsters (Homarus americanus) in their natural habitat

Recent studies have shown that marine decapods such as crab and lobster produce sounds. However, studies of sound production by American lobsters (Homarus americanus) have dealt only with acoustic behaviour in the lab. Understanding the role lobster sounds may play in animal communication would benefit from field studies. Our goal was to identify possible sounds produced by American lobster in their natural habitat. These may include communication signals or sound by-products of other behaviours. Using hydrophones and video cameras, we recorded American lobsters interacting with various baits off the northern coast of Nova Scotia. Synchronized audio and video were used to catalog behaviours and corresponding sounds, either by associating sounds with known behaviours or vice versa. Some behaviours showed no consistent correlation with sounds, while others were occasionally associated with sounds that we hypothesize were by-products of lobster movements. In contrast, two consistent sounds (squeak and crackle), where repeatedly observed across multiple trials. These sounds were only recorded when at least one lobster was in view of the camera, and were more frequent when more lobsters were present. Comparison of spectrograms showed that squeaks are short (100 - 200 ms), broadband, single pulse sound events that contain greater energy in the higher frequencies (> 2 kHz). Crackles consisted of multiple broadband pulses with greater energy at lower frequencies (< 2 kHz), and typically occurred in pairs spanning 50 to 100 ms. No visible behaviours consistently co-occurred with these sounds. It is not clear whether these sounds match those recorded in previous lab studies. Nonetheless, our findings suggest that lobsters produce sounds when foraging, both as by-products of other behaviours and potentially as communication behaviours.

Laura Brady[1], David Barclay[2], Russell Wyeth[1] [1]St. Francis Xavier University [2]Dalhousie University rwyeth@stfx.ca

OCE-Acoustic source mechanisms and soundscapes of hydrothermal vents

Hydrothermal vents are locations on the sea floor where geothermally heated seawater is discharged. The high-temperature, chemically rich environment hosts uniquely adapted marine life. Due to the high temperature and caustic nature of the vent fluid, direct monitoring of vent activity over long time periods can be challenging, and detection of new vent sites typically requires sea floor mapping or chemical plume detection. Vent soundscapes may contain acoustic cues for endemic vent species as well as signals enabling both vent detection and passive acoustic monitoring of hydrothermal vent dynamics. In this study, hydrothermal vent sound production mechanisms are analyzed with regards to their relationship with vent activity and the feasibility of long-term monitoring using passive acoustics. Results from the Main Endeavour Vent Field, using hydrophone recordings and other oceanographic sensors from Ocean Network Canadas NEPTUNE Observatory, show tidal period variations in sound level which suggest a link to hydrothermal vent activity. Finally, a soundscape analysis highlighting the unique features of hydrothermal vent soundscapes is used to

compare the Main Endeavour Vent Field, the Lucky Strike vent field (with data from the European Multidisciplinary Seafloor and water column Observatory), and the Cascadia Basin abyssal plain.

Brendan Smith[1], David Barclay[1] [1]Dalhousie University Brendan.Smith@dal.ca

OCE-Partitioning the vertical structure of ambient sound in the Challenger Deep, Mariana Trench

The Deep Acoustic Lander (DAL) was deployed to the bottom of the Challenger Deep, where it collected a vertical profile of seawater properties, directly measured sound speed, and ambient sound in the Mariana Trench. The DAL is a full ocean depth-rated autonomous platform that carries an array of four hydrophones, with 3 aligned vertically and a pair aligned in the horizontal, and an integrated conductivity, temperature, depth, and sound velocity meter. From the acoustic pressure time series, the vertical and horizontal noise coherence (directionality) were computed as a function of depth and used to decompose the depth and frequency dependent ambient sound field into locally generated surface wave noise, distantly generated sound trapped in the Deep Sound (SOFAR) channel, and local ship noise. The sound field decomposition allows the attribution of ambient sound power to the three processes, and the energy partitioning of locally and distantly generated noise.

David Barclay[1], Najeem Shajahan[2], David Burns[3] [1]Dalhousie University, Dept of Oceanography [2]University of Victoria [3]Dalhousie University, Department of Oceanography dbarclay@dal.ca

OCE-Quantifying ship noise recorded in the western Canadian Arctic

Ships transiting the Arctic region have increased as a result of extended ice-free seasons caused by climate change. The increased ship traffic increases underwater noise, so quantifying the impact of shipping on the Arctic soundscape is crucial. Passive acoustic data collected from eight locations in the western Canadian Arctic from 2015 to 2021 served as a source of opportunity for ship source level estimation in this study. Combining Automatic Identification System data with acoustic data and a hybrid sound propagation model, a method was developed for determining the source level of individual ships. In total, 114 measurements were obtained from 22 unique vessels, with research and fishing vessels contributing more to the source level estimates. In comparison to existing empirical source level models, estimated source levels showed a weak dependence on ship parameters such as speed and length. An analysis of residuals between estimated and modelled source levels found that the JOMOPANS-ECHO model was in good agreement with our estimates. However, to determine how source level correlates with ship properties and type as well as develop an Arctic-specific model of source level, more passive acoustic data and source level measurements are required.

Najeem Shajahan[1], William Halliday[2], Stephen Insley[2] [1]University of Victoria [2]Wildlife Conservation Society najeemtkm@gmail.com

OCE-Long-term soundscape observations in the Northeast Pacific on Ocean Networks Canada's cabled acoustic infrastructure

Ocean Networks Canada (ONC), a University of Victoria initiative, operates a number of cabled observatories on the three coasts of Canada, totaling over 50 instrumented sites. These include the VENUS coastal observatory in the Salish Sea (installed in 2006) and the NEPTUNE offshore deep-sea observatory in the Northeast Pacific Ocean. Each observatory includes a set of nodes providing continuous power and high bandwidth communications to a number of sites. At each site, a range of ocean and geophysical sensors provide high-resolution, multidisciplinary time series, the longest of which cover a time span of over 16 years. Of the 430+ GB of data collected daily by ONCs sensors and archived, the vast majority are acoustic, recorded by a number of single hydrophones and (more recently) four volumetric arrays. These installations cover a variety of environments, from the busy, relatively shallow waters of the Salish Sea to the 2600 m depth of the Cascadia Basin. This presentation illustrates examples of scientific studies and results obtained from the analysis of ONCs acoustic data in the region, such as long-time-series ambient-noise changes during the COVID anthropause, the detection of distant earthquakes, source localization by the arrays, soundscape characterization at a hydrothermal-vent field and bioacoustics applications.

Lanfranco Muzi[1], Jasper Kanes[1], John Dorocicz[1], Martin Heesemann[1], Fabio De Leo[1], David Barclay[2], Brendan Smith[2], Steve Mihály[1], Richard Dewey[1], Martin Scherwath[1], Kohen Bauer[1] [1]Ocean Networks Canada, University of Victoria [2]Department of Oceanography, Dalhousie University muzi@oceannetworks.ca

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Advances in Precipitation Measurement and Modeling - Part 2

Wednesday, May 31
15:00 - 15:45 EDT

(15 Mins) How does the resolution of regional climate models affect the precipitation type and amount accuracy during mixed precipitation events - Olivier Chalifour

(15 Mins) Changing nature of high-impact snowfall events in Eastern North America - Dominique Paquin

(15 Mins) Accuracy and wind bias assessment of the automated Lambrecht rain[e]H3 gauge for precipitation measurement in Canadian operational networks. - Amber Ross

This session will cover the latest research on precipitation measurement and modeling techniques for improved hydrometeorological analysis. Presentations will cover topics such as regional climate modeling, accuracy assessments of precipitation measurement tools, the impact of solid precipitation assimilation on analysis systems, the effects of model resolution on simulated precipitation types and snowfall projections. The discussions will focus on identifying the challenges and solutions to improving accuracy and reliability of hydrometeorologic data, as well as their implications.

ATM-How does the resolution of regional climate models affect the precipitation type and amount accuracy during mixed precipitation events ?

During the cold season, storms can bring a mix of precipitation types to southern Quebec, which can sometimes lead to catastrophic events. A good example of such an event is the January 1998 ice storm. The accurate representation of the precipitation fields in regional climate models could help to anticipate such extreme events. Furthermore, as the spatial resolution of the regional climate models increases, the representation of fine-scale processes such as clouds, precipitation, and orography also improves. This study aims to evaluate the amount and phase of precipitation simulated by the Canadian Regional Climate Model version 6 (CRCM6/GEM5) for the years 2020-2022 at two spatial resolutions. Two simulations, which are at 11 km and 2.5 km grid-spacing, were performed. The precipitation fields are compared with precipitation amounts and phases measured at 32 weather stations in the province of Quebec. These stations are equipped with disdrometers, precipitation gauges, liquid water equivalent snowpack sensors, and standard meteorological instruments. Using the ERA5 reanalysis product, a comparison of precipitation patterns is conducted for both years. The 2.5 km simulation suggests an improvement in the simulation of precipitation amount and phase over our domain compared to the coarser resolution simulation. The finer grid also shows less spatial bias than at 11 km grid-spacing. Precipitation patterns are examined during case studies and good agreements are found between simulations and measurements. Overall, these results highlight the need to use higher-resolution regional models to better represent the amount and phase of precipitation during mixed precipitation events.

Olivier Chalifour[1], Julie Thériault [1], Biljana Music[2], Alexis Bédard-Therrien [3], Daniel Nadeau[3], François Roberge [1] [1]Université du Québec à Montréal [2]Ouranos [3]Université Laval

ATM-Changing nature of high-impact snowfall events in Eastern North America

Snowstorms cause substantial disruption in the eastern United States and Canada each winter. While reductions in annual snowfall are projected over most of this region due to anthropogenic global warming, daily snowfall extremes that have the greatest impacts may not decrease in the same manner. We examine changes to two extreme snowfall metrics: the 95th percentile of daily snowfall (SF95, cm) and the number of events during which 10% of the mean annual snowfall is exceeded during a single day (TC10, events/year). We explore changes to these metrics in two ensembles of the fifth-generation Canadian Regional Climate Model (CRCM5), including four 0.22˚ simulations driven by different coupled general circulation models as well as the higher-resolution (0.11˚) ClimEx ensemble, driven by 50 members of the CanESM2 large ensemble. We find that while mean annual snowfall is projected to decrease over our domain, SF95 is projected to remain relatively constant, suggesting that the most extreme daily snowfalls currently observed are likely to occur even in a warmer future climate. The region of the largest TC10 values exhibits a northward shift, with a larger percentage of annual snowfall occurring during a few large events along the U.S.-Canada border. These projected changes to the nature of snowfall events may have important socioeconomic consequences in this densely populated region of North America.

McCray Christopher[1], Dominique Paquin[1], Gavin Schmidt[2], Martin Leduc[1] [1]Ouranos [2]NASA-GISS mccray.christopher@ouranos.ca

ATM-Accuracy and wind bias assessment of the automated Lambrecht rain[e]H3 gauge for precipitation measurement in Canadian operational networks.

Reduction in service requirements and increased environmental sustainability are some key drivers for organizations to transition from manual to automated precipitation gauge measurements. The transition to new instruments has the potential to create inhomogeneity in the climate record. In order to help ensure consistency of precipitation observations, the availability of overlapping old and new systems is acutely important, especially for the measurement of snowfall events because of the higher propensity for errors related to the impact of the environment on the measurement. Currently, the aviation weather monitoring network operated by NAV CANADA, in an effort to modernize, is installing Lambrecht rain[e]H3 heated tipping bucket / weighing type gauges to replace manual (Nipher or Type B gauges or snow ruler) observations of precipitation. This study assesses the reliability, accuracy, and wind bias of the Lambrecht gauge by comparing Lambrecht precipitation measurements to reference methods (either automated or manual) at four Meteorological Service of Canada (MSC) operated sites: Downsview (ON), Dorval (QC), Whitehorse (YT), and Prince George (BC). Additionally, overlapping observations of the Lambrecht gauge and the Double Fence Automated Reference (DFAR) measurements are available at the Environment and Climate Change Canada (ECCC) Bratts Lake (SK) precipitation intercomparison supersite. Results indicate that the Lambrecht gauge performs relatively well for rain events. However, snow and mixed precipitation under high wind speed conditions exhibit substantial undercatch and other measurement disparities. As such, the impact on long-term climate time series inhomogeneity could be significant where the gauge is deployed in cold and windy environments.

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Advances in Weather & Climate Risk Communication - Part 2

Wednesday, May 31
15:00 - 16:30 EDT

(15 Mins) Crossing Discipline Boundaries to Fill Climate Information Gaps - Lea Braschi

(15 Mins) Climate-Change Scaled IDF data: a new user-driven dataset on ClimateData.ca - Carrington Pomeroy

(15 Mins) Costing Climate Resilient Infrastructure On-Reserve - Charles Antoine

(15 Mins) Consumers and citizens making impact on Canada’s Net Zero challenge - Charles Lin

(15 Mins) The Immoralities of Climate Change - G.S. Strong

The weather and climate services landscape is evolving at a rapid pace, as public and private service providers seek to meet growing demand for increasingly diverse guidance. The result is an ever-expanding volume of products, communicated through a variety of new and traditional channels (e.g., broadcast television/radio, websites, social media), to diverse audiences with increasingly sophisticated and specific needs. This effort is also motivating greater

interactions between service providers and end-users, answering calls for greater co-production of weather and climate information to ensure that products (both new and old) effectively inform and advise users on their weather and climate risks. These developments present exciting prospects for science and risk communication; however, fully capitalizing on opportunities afforded by new technology, data sources, and stakeholder interests requires an interdisciplinary approach. This session invites researchers to discuss these opportunities, related challenges, and novel solutions.

SER-Crossing Discipline Boundaries to Fill Climate Information Gaps

The need for the interdisciplinary co-production of actionable climate information requires an expansion of traditional project scopes to include more components of the climate data pipeline (which includes elements such as climate modelling, downscaling, bias-correction, post-processing, impact modelling, risk assessment, engineering design, and policy development). In addition to an increase in partnerships, there also needs to be more cross-over of individuals (such as researchers engaged in downstream applications and practitioners engaged in upstream research). This presentation will share example projects illustrating cases where upstream climate data analysis was completed to fulfill downstream climate information needs. For example, data gaps for projected changes in winter precipitation across Newfoundland and Labrador were addressed to the degree possible based on available information and, while considering limitations, converted to infographics for use in decision-making by the winter tourism industry.

Lea Braschi[1] [1]CBCL Limited lbraschi@cbcl.ca

SER-Climate-Change Scaled IDF data: a new user-driven dataset on ClimateData.ca

Intensity-Duration-Frequency (IDF) data are widely used for flood forecasting and urban drainage design. They describe short-duration rainfall intensity across a range of rainfall event timescales, and corresponding frequencies of occurrence, which can be used for design and decision-making at various levels of risk tolerance. In fact, historical IDF data are the most frequently accessed dataset on ClimateData.ca. However, where climate information is used for design it is no longer appropriate to use historical information alone but to consider climate change explicitly. After successfully launching guidance focused on adjusting historical IDF data to incorporate climate change, the CCCS shifted focus to scaling ECCCs IDF data to account for a changing climate. The methods described in CSA PLUS 4013:2019 Technical Guide: Development, interpretation and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners, were used to scale IDF data at the 714 ECCC IDF stations using a common reference period across Canada. These data are now accessible on ClimateData.ca via an interactive map. In this talk we will share how the CCCS identified user needs, how the data were developed and what features and accompanying guidance are provided on ClimateData.ca. We will highlight how working with practitioners, training experts and scientists helped to co-develop a robust and useable product to facilitate decision-making.

Carrington Pomeroy[1], Trevor Murdock[1], Jeremy Fyke[1] [1]Environment and Climate Change Canada carrington.pomeroy@ec.gc.ca

SER-Costing Climate Resilient Infrastructure On-Reserve

As the intensity and severity of extreme weather events increase are exacerbated by climate change, it is expected to increase the deterioration of on-reserve infrastructure upon which many Indigenous communities rely. New infrastructure must be built to withstand future climate conditions, which will in turn affect the costs associated with construction. Budgeting for these new costs will be important to ensure that Indigenous Services Canada (ISC) can continue providing resilient infrastructure services to on-reserve communities now and in the future. WSP will present the methodology and results of a project to estimate the costs of adapting new community infrastructure on-reserve to six climate hazards. The presentation will demonstrate how cost estimations accounted for a) varying designs and types of assets on-reserve in Canada, b) geographic-specific conditions of reserves in Canada, c) varying degrees of climate risks and projections for reserves in Canada, and d) the multitude of adaptation interventions available to address the climate hazards of concern. The outputs are an adaptation rule of thumb, expressed as the percentage increase of adaptation costs for new infrastructure under changing climate conditions. The presentation will provide an example of a rule of thumb calculated for on-reserve residential buildings for two climate hazards, including coastal sensitivities. The examples will highlight lessons learned, and opportunities for further study and innovation. The presentation serves as a starting point for discussion on methods to account for the costs of adapting new infrastructure to climate change and highlight how further study can improve the results.

Christina Schwantes[1], Hana Lapp[1], Charles-Antoine Gosselin[1] [1]WSP
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SER-Consumers and citizens making impact on Canada’s Net Zero challenge

The Canadian federal government has committed the country to reach Net Zero anthropogenic CO2 emissions by 2050 in accordance with the Paris Agreement, where emissions are balanced by removals. Different jurisdictions in Canada have also adopted their own net zero plans. For example, the City of Torontos plan, TransformTO, aims to reduce community-wide emissions to net zero by 2040; it is one of the most ambitious municipal targets in North America. Governments, corporations and citizens all have a role in the net zero journey. Impact Net Zero (INZ) is a group of concerned citizens who have created a movement and online presence (https://impactnetzero.ca/) to inform and engage Canadians on this journey. Into our third year, our primary focus is on scalable actions by individuals, as both consumers and citizens, in creating awareness and impact. In this talk, we discuss the published research on the impacts of individual actions on mitigating carbon emissions. We report on INZs recent outreach activities: hosting Net Zero Cafs to discuss personal mobility and Albertas view on the energy transition, engaging with the Toronto City Council on its net zero strategy, bringing awareness to Canadians on different green choices on our website, and collaborating with community groups. We also discuss new initiatives for the coming year.

Charles Lin[1], James Lin[2], Stephen Phoon[3], Shu Yi Chu[4], Veronika Kosova[5] [1]Retired [2]University of Alberta [3]Seneca College [4]University of Oxford [5]Comenius University
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SER-The Immoralities of Climate Change

Most people are familiar with the devastating impacts of heat domes, atmospheric moisture rivers, and rampaging hurricanes. We were appalled that the heat dome that moved through southern BC in June 2021 claimed more than 600 deaths, and that Hurricane Ian caused 150 deaths and between $50-65 billion in insured damages after it made landfall in western Florida last September. However, neither media nor western governments pay much attention to frequent deaths from famine exacerbated by global warming in the subtropics. Oxfam reported in May 2022 that one person dies of hunger every 48 seconds in drought-ravaged east Africa alone; that's more than 650,000 deaths per year, and much of this can be attributed to climate change. More sobering is the fact that the industrial mid-latitude countries are primarily responsible for global warming. This should trigger serious questions about our ethical responsibilities to humanity and our shared biosphere. This presentation takes a brief look at the human impacts of climate change through the lens of the question: What do we owe Earths descendants? If we decide that fighting for the futures of all Mother Earth's descendants, human and non-human alike, is the greatest moral cause of our time, we must act accordingly. We discuss the shrinking set of potential solutions for reducing carbon emissions as soon as possible. The remaining question is simply: Will we act in time to ensure a habitable future for our descendants?

G.S. Strong[1], Garth Mihalcheon[1] [1]retired geoff.strong@shaw.ca

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Changing Arctic: Science and Policy Studies - Part 3

Wednesday, May 31
15:00 - 16:30 EDT

(15 Mins) No-Motion Sea-Ice Events on the Eastern Canadian Beaufort Sea, 1999-2018 in relation to wind forcing and sea-ice fractures - David Fissel

(15 Mins) Atmospheric Forcing of Wind-Driven Regional Sea Ice Motion In Winter and Early Spring in the Canadian Beaufort Sea - Matthew Asplin

(15 Mins) Assessing possible climate interventions to stabilize Arctic Sea Ice - Kerry Nickols

(15 Mins) Quantifying the shear viscosity of the marginal ice zone using aerial imagery - Éloïse Pelletier

(15 Mins) Glacier Meltwater Contributions within the Regional Freshwater System of Jones Sound - Claire Parrott

This interdisciplinary session will present emerging scientific results on the rapidly changing Arctic and northern environment. The physical environment of the Arctic has changed dramatically over the past decades with the underlying causes of these changes, in terms of the cryosphere, oceanography, hydrology and meteorology, being addressed through various scientific approaches. The application of the scientific results in relation to policy issues associated with federal government and Indigenous-led management efforts will be considered. The importance of Arctic research and its consequences in looking ahead is very timely and pertinent to informing northern communities, the public and contributing to a range of policy issues in this strategically important part of Canada. Papers are sought from research, science and policy activities that are

nearing completion, currently being undertaken, or those planned and just getting under way.

MUL-No-Motion Sea-Ice Events on the Eastern Canadian Beaufort Sea, 1999-2018 in relation to wind forcing and sea-ice fractures

Events of no-motion in sea ice are important to Inuit travel on sea ice in late winter and spring and policies for planning year-round shipping operations. An analysis of no-motion events were derived from sea-ice velocity data sets obtained over a 20 year period (1999-2018) in the eastern Canadian Beaufort Sea. Most of the no-motion events have durations of 2-3 days, but some events are much longer at up to 46 days. Days of no-motion occur more than 40% of the time in late winter and early spring at the mid-shelf site with slightly lower occurrences, on average, at the shelf edge site. No-motion occurrences during 10% or more of each month are prevalent from mid-Dec to mid-May. Surface winds are important to both the onset and the cessation of no-motion events: The onset is most often associated with westerly wind events while the cessation is most often associated with easterly wind events in the vicinity of the moorings. Recent studies have shown that in four years over the 21-year period (1993-2013), periods of strong easterly winds over the entire Beaufort Sea continental margin coincided with large scale sea-ice fracturing and the break-up of the ice cover with large westerly movement on regional scales (RheinIndear et al., 2022; Jewel Hutchings, 2023). The patterns of sea-ice fracture in the local area and over larger areas, are analysed for the times immediately before and after no-motion events to examine their role in the onset and cessation of no-motion events.

David Fissel[1], Matthew Asplin[1], Keath Borg[1], Dawn Sadowy[1], Alex Graham[1], Humfrey Melling[2] [1]ASL Environmental Sciences Inc. [2]Institute of Ocean Sciences DFO
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MUL-Atmospheric Forcing of Wind-Driven Regional Sea Ice Motion In Winter and Early Spring in the Canadian Beaufort Sea

Atmospheric forcing of the winter Arctic Sea ice cover strongly controls sea ice motion in the Canadian Beaufort Sea. An anti-cyclonic wind driven Beaufort Sea ice gyre promotes ice transport, sea ice lead formation and dynamic thickening of ice. Basin-scale winter anticyclones are key synoptic weather features, whose intensity, geographical extent and relation to nearby low-pressure atmospheric features will determine the strength and orientation of the sea-level isobaric pressure gradient, thereby influencing wind-forcing of the sea ice. The duration and persistence of pressure patterns that favour strong easterly and southeasterly winds in the Eastern Beaufort Sea combined with favourable compressive pack ice strength may maintain ice movement within the Beaufort Gyre. The absence of a basin-scale anti-cyclone may permit extended periods of no-motion to occur. A companion analysis by Fissel et al., (2023) presents results of no-motion events identified from analyses of 20 years (1999-2018) of sea ice velocity data in the eastern Canadian Beaufort Sea. Many no-motion events have durations of 2-3 days, but some events are much longer at up to 46 days. We explore synoptic meteorological drivers for (1) no-motion events and (2) rapid westward sea ice motion following no-motion events. The analysis uses a synoptic climatology based upon principal components analysis (PCA) and k-means clustering of gridded NCEP-NCAR II mean sea-level pressure data. These events are explored through analyses of the persistence, duration, spatial extent and transition characteristics of the daily synoptic classifications, representative of the mean sea-level pressure conditions that coincided with these events.

Matthew Asplin[1], David Fissel[1], Keath Borg[1], Dawn Sadowy[1], Alex Graham[1], Humfrey Melling[2] [1]ASL Environmental Sciences Inc. [2]Institute of Ocean Sciences, Department of Fisheries and Oceans Canada masplin@aslenv.com

MUL-Assessing possible climate interventions to stabilize Arctic Sea Ice

Halting emissions of greenhouse gases as well as the removal of carbon dioxide from the environment are essential to limiting further rise in global temperatures. The best available science, however, suggests that neither decarbonization nor negative emissions, alone or combined, will cool the planet in time to prevent massive shifts and loss of function for critical marine ecosystems, such as Arctic sea ice. Given this risk and the enormity of the potential impacts to the ocean and the planet, we must consider interventions that may be able to forestall ecosystem transitions. Ocean Visionsis leading an international, multidisciplinary, multisector collaborative mapping process to assess and document the current status, critical needs, and highest priorities to advance the conversation around climate interventions to stabilize and/or repairArctic sea ice.The map will review the current state and potential of all relevant technology pathways, social and environmental risks and co-benefits of such technologies, policy and governance considerations, and the knowledge gaps that need attention to further evaluate the interventions. The road map will be available on an interactive web platform. Importantly, Ocean Visions is not an advocate for climate interventions, but acts to create a space where parties can engage in informed decision-making. Ocean Visions previous roadmapping efforts (www.oceanvisions.org/roadmaps) have allowed interested actors to work together on key priorities and are regularly updated and refined as advances emerge in science, technology, governance, policy, and ethics.

Kerry Nickols[1], Brad Ack[1], David Koweek[1] [1]Ocean Visions kerry@oceanvisions.org

MUL-Quantifying the shear viscosity of the marginal ice zone using aerial imagery

The marginal ice zone (MIZ) is the portion of the ice cover that is or has been morphologically and dynamically influenced by ocean waves. How is the rheology altered by wave-induced break-up and floe motion and how does it respond to forces at play in the MIZ still remain open and rich questions. Experiments carried out in the St. Lawrence Estuary by Sutherland and Dumont (2018) have revealed how the wave radiative stress can significantly thickens the ice near the edge, where most of the momentum carried by the wave field is absorbed and transferred to the ice. The thickening is facilitated by the ice in the MIZ being broken-up in floes typically smaller than a wavelength and, when waves persist, being reduced into brash or slush. The compressive strength of such an ice cover is significantly lower than undeformed sea ice of equivalent thickness. What about the shear strength? In this study we use photogrammetric data acquired by an unmanned aerial vehicle to inform a model of a stationary MIZ in which the sheared along-edge ice velocity field forced by waves coming at an oblique angle is balanced by the shear viscosity of the MIZ. Particle image velocimetry is used to extract both the wave energy attenuation, from which the radiative stress is derived, and the mean deformation field. Data from several events all recorded in Bic national park, Rimouski, Canada, with different ice conditions will be presented and implications on the MIZ rheology will be discussed.

Éloïse Pelletier[1], Dany Dumont[1], Jérémy Baudry[1], Peter Sutherland[2] [1]UQAR – ISMER [2]IFREMER eloise.pelletier@uqar.ca

MUL-Glacier Meltwater Contributions within the Regional Freshwater System of Jones Sound

Marine-terminating glaciers, numerous in the Canadian Arctic Archipelago (CAA), are an important and dynamic source of freshwater to the Arctic freshwater system, with glacial inputs modifying local ocean properties and contributing to regional freshwater budgets. Despite their abundance, knowledge is lacking on glacier-ocean systems across the CAA, and these systems are often omitted in regional studies of freshwater transport or storage. In this study, we examine the nature and spatial extent of glacial meltwater influence on freshwater dynamics in Jones Sound, a marine-terminating glacier-rich region in the CAA. Specifically, our goal is to better understand the contributions of glacier meltwater to the regional oceanic freshwater system, the inter-annual and spatial variability of freshwater within Jones Sound, as well as the transport and export of freshwater from the region. We use in-situ near-shore observations at glacierized sites, collected in collaboration with community members from Ausuittuq (Grise Fiord, NU) from 2019-2022, providing fjord-scale resolution of water column properties from glacier terminus to open ocean. Further, we employ a high-resolution regional model (Nucleus for European Modelling of the Ocean (NEMO) framework of the Arctic and Northern Hemisphere Atlantic at 1/12 degree resolution) to examine regional freshwater transport and storage. Preliminary results show notable year-to-year variation in ocean structure at the glacierized sites, suggesting that there is potentially important spatial and temporal variability of glacially-sourced freshwater to Jones Sound that should be considered in regional freshwater budget estimates.

Claire Parrott[1], Stephanie Waterman[1], Paul Myers[2], Maya Bhatia[2], Erin Bertrand[3], Andrew Hamilton[2], Terry Noah[4], David Didier[5], Eric Brossier[6] [1]UBC [2]University of Alberta

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Recent Advances in ocean biogeochemistry in Canada - Part 2

Wednesday, May 31
15:00 - 16:30 EDT

(15 Mins) Modelling nitrogen cycling and the stable isotopic composition of nitrate during a Phaeocystis bloom in the Labrador Sea - Britton Dempsey

(15 Mins) Glacier-ocean interactions and marine biogeochemical cycles in the Canadian Arctic Archipelago marine system - Maya Bahtia

(15 Mins) Advances in surface ocean carbonate system mapping in the northeast Pacific

(15 Mins) Empirical relationships allow autonomous monitoring of the carbonate system in Queen Charlotte Sound, British Columbia - Alex Hare

(15 Mins) Estimating carbonate system parameters using empirical routines in the Northeast Pacific Ocean - Hayley Dosser

(15 Mins) Tracing the influence of continental and glacial runoff on ocean biogeochemistry in Inuit Nunangat - Birgit Rogalla

The Oceans regulate the world's climate, absorbing heat and carbon dioxide. The impacts of this climate regulation manifest as warming, deoxygenation and acidification, with consequences on marine ecosystems. In the current context of high carbon dioxide emissions and climate change, it is therefore crucial to understand the biogeochemistry of the oceans. Canadian waters have recently experienced marked changes in their biogeochemistry. Both the Atlantic and Pacific coasts have experienced deoxygenation marked by hypoxic events over recent years. Deoxygenation is accompanied by carbonate chemistry extremes that are linked to ocean acidification, which has also been affecting Arctic waters. Heat waves are becoming more frequent and more extreme, while an overall increase in water temperature is affecting biological processes such as nutrient cycling and organic matter remineralization. These biogeochemical extremes often co-occur, increasing the severity of the effects on ecosystems. This session invites contributions on all aspects of biogeochemistry in Canadian waters, including, but not restricted to, deoxygenation, ocean acidification, carbon cycling, nutrient cycling, physical-biogeochemical interactions, and effects on ecosystems or marine organisms. With this session, we hope to bridge the gap between the Atlantic, Pacific and Arctic research communities. While the focus is on Canadian waters, studies discussing adjacent basins are also welcome.

OCE-Modelling nitrogen cycling and the stable isotopic composition of nitrate during a Phaeocystis bloom in the Labrador Sea

Dissolved inorganic nitrogen (DIN), such as ammonium (NH4+), nitrite (NO2-), and nitrate (NO3-), limits the growth of marine primary production within the euphotic zone, and subsequent export of particulate organic carbon (POC) to depth. Therefore, it is essential to constrain the distribution and magnitude of microbial processes that manipulate DIN and POC pools before assessing the impact of future climatic perturbation on POC export. However, the characterization of intraseasonal dynamics involving these processes within phytoplankton blooms in the Northwest Atlantic is not well defined. Here, we assess the biological controls on DIN speciation and POC production over a 13-day period during the dissipation of a Phaeocystis bloom in the Labrador Sea using measured rates of ammonium, nitrite, and nitrate uptake, ammonium regeneration, and nitrification using 15N tracer incubations, and natural abundance 15NNO3 and 18ONO3 measurements. Measured rates of nitrogen transformation processes are then used to constrain a 1-D reaction-diffusion model of ammonium, nitrite, nitrate, 15NNO3, and 18ONO3, where associated isotope effects of each process can be inversely determined. Results from this work will: (i) improve our understanding of the expression of nitrogen transformation processes within 15NNO3 and 18ONO3 profiles, and (ii) help reassess classical assumptions related to POC export in the open ocean by examining the vertical distribution of new production, regeneration, and nitrification.

Britton Dempsey[1], Rachel Sipler[2], Colleen McBride[3], Carolyn Buchwald[1] [1]Department of Oceanography, Dalhousie University [2]Bigelow Laboratory for Ocean Sciences [3]Memorial University of Newfoundland britton.dempsey@dal.ca

OCE-Glacier-ocean interactions and marine biogeochemical cycles in the Canadian Arctic Archipelago marine system

The Canadian Arctic Archipelago (CAA) is vulnerable to climate warming, and with over 300 tidewater (marine-terminating) glaciers, is a hotspot for enhanced glacial retreat and meltwater runoff to the ocean. Compared to Greenland and Antarctic systems, CAA glaciers and their impact on the marine biogeochemical environment remain largely unexplored. Since 2019 we have worked in Jones Sound in the eastern CAA, a region surrounded by glaciers and home to the Inuit of Aujuittuq, exploring the impact of melting glaciers on marine biogeochemical processes and cycles. This work is conducted in collaboration with the local community to collect year-round marine observations that span the nearshore coastal zone to the open Sound, comparing glacierized and non-glacierized fjords and multiple glaciers of varying type (land-terminating, tidewater), grounding line depth, and size. In total these observations represent over 400 casts measuring water column temperature, salinity, turbidity, dissolved oxygen, and chlorophyll a, with paired bottle samples characterizing carbon, nutrient, metal, and phytoplankton community composition and activity to elucidate how these properties evolve with distance from the shore. Our efforts aim to establish a long-term, community-based monitoring program centered around the co-consideration of Indigenous and scientific knowledge to understand ongoing change in high Arctic marine ecosystems. Results from this study substantially further our understanding of glacier-ocean impacts on marine biogeochemical cycles in the sparsely sampled CAA, while also providing data critical to accurate future projections of high-latitude marine change in regions that are a hotspot for tidewater glacial retreat and meltwater runoff to the ocean.

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OCE-Advances in surface ocean carbonate system mapping in the northeast Pacific

Coastal oceans experience a variety of natural processes, such as differences in freshwater input, seasonally high rates of phytoplankton production, areas of high organic matter degradation, and physical influences from winds and tides, which alter marine carbonate chemistry over a broad range of time and space scales. Many of the processes that shape marine carbonate chemistry are not occurring in isolation, and the impacts of their interaction are often difficult to disentangle without adequate data coverage. Furthermore, changing climate is both directly altering the carbon content of seawater and impacting the processes that shape the inherent carbonate system variability. Mapping regions of highest vulnerability, as well as areas of refugia, is a key activity to support management and conservation efforts in addition to discussions of ocean-based climate solutions. There is also great potential for non-traditional partnerships to play significant roles in providing this critical data. Here, we first provide an overview of results from a passenger ferry operating along the northeast Pacific Inside Passage before describing a new effort to map multiple surface ocean carbonate system parameters (carbon dioxide partial pressure and total dissolved inorganic carbon) simultaneously from a tug boat. The data generated from these platforms collectively showcase non-traditional partnerships with industry to help fill major observing gaps.

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OCE-Empirical relationships allow autonomous monitoring of the carbonate system in Queen Charlotte Sound, British Columbia

Queen Charlotte Sound off the central coast of British Columbia is a biological hotspot supporting fragile sponge reef ecosystems and numerous commercial and subsistence fisheries. This region has high socio-economic and cultural value, and therefore contains several conservation and marine protected areas that require monitoring to ensure sustainability. Models project trends toward warmer, more acidified, and lower oxygen conditions that will threaten this region in coming decades. Infrastructure is in place to monitor some stressors, specifically temperature and oxygen conditions observed from autonomous gliders maintained by the Canadian Profiling Robotic Ocean Observing Facility (C-PROOF), but monitoring ocean acidification is currently challenging from such platforms due to in situ sensor limitations. Here, we provide an alternative approach that uses empirical relationships developed from discrete measurements collected at regularly occupied nearshore oceanographic stations. These relationships underwent triple validation by assessing their ability to recreate observed marine carbonate system measurements from a subset of training data, a high-resolution moored pH time series, and cross-shelf measurements from oceanographic surveys. Finally, we apply these relationships to the C-PROOF glider data to show the benefit of extending the existing measurement suite to track ocean acidification conditions, including quantification of the uncertainties in derived parameters.

Alex Hare[1], Wiley Evans[1], Simone Alin[2], Hayley Dosser[3], Charles Hannah[3], Tetjana Ross[3], Jennifer Jackson[3] [1]Tula Foundation / Hakai Institute [2]NOAA [3]DFO
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OCE-Estimating carbonate system parameters using empirical routines in the Northeast Pacific Ocean

The Northeast Pacific Ocean is losing oxygen and undergoing ocean acidification due to anthropogenic climate change. As a result, the vertical extent of the oxygen minimum zone is expanding, with serious implications for ecosystem health. This region is also one of very few globally with a 30+ year ship-based time-series of carbonate and hydrographic observations spanning from the shelf to the deep-sea, along the Line P transect. In recent years, ocean gliders have provided high-resolution data along the same transect, capturing a wide range of spatiotemporal scales in temperature, salinity and oxygen. Combining these datasets allows us to estimate carbonate system parameters using ocean glider data, by creating a statistical multiple linear regression (MLR) model that provides predictions of DIC and aragonite saturation state based on temperature, salinity, and oxygen, with corresponding uncertainty estimates. This model builds on existing empirical models for carbonate system parameters in British Columbias shelf waters and on a robust total alkalinity-salinity relationship for Line P. Our MLR model is evaluated for robustness and predictive skill in both time (1990-2020, all seasons) and space (30-1000 m depth, all Line P stations). We will explore the effect of both anthropogenic forcing and changes in circulation and ventilation in modifying the relationships between variables on inter-decadal timescales, and consider how to create a scheme to recalculate these relationships given new data from repeat sampling cruises. Finally, we will apply this model to ocean glider data and describe spatial and

temporal patterns in the estimated saturation horizon for aragonite.

Hayley Dosser[1], Tetjana Ross[1], Debby Ianson[1] [1]Fisheries and Oceans Canada
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OCE-Tracing the influence of continental and glacial runoff on ocean biogeochemistry in Inuit Nunangat

The Arctic Ocean is fed by rivers with catchment basins that are undergoing rapid change rising temperatures and an acceleration of the hydrological cycle are increasing river discharge, causing permafrost thaw, glacial melt, and a shift to a groundwater-dominated system. The implications of these changes for the distributions of nutrients and other runoff constituents on the coastal Arctic Ocean are unclear. We will present results from sensitivity experiments with an ocean model of manganese (Mn) in Inuit Nunangat (the Canadian Arctic Archipelago) from 2002 to 2020, using Mn as a tracer of glacial and continental runoff in the coastal ocean. With these experiments, we see that the heterogeneity in Arctic drainage basins creates a north-south separation in influence, and identify the extension of glacial runoff influence to the Pikialasorsuaq North Water polynya. Our findings highlight how runoff changes within Inuit Nunangat can impact the marine biogeochemistry both locally and downstream in Baffin Bay.

Birgit Rogalla[1], Susan Allen[1], Manuel Colombo[2], Paul Myers[3], Kristin Orians[1] [1]University of British Columbia [2]Woods Hole Oceanographic Institution [3]University of Alberta
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MSC - Air Quality Measurement and Modelling

Wednesday, May 31
15:45 - 16:30 EDT

(15 Mins) Toward a Single Regional Air Quality Deterministic Prediction System at ECCC by summer 2024 - Daniel Digueras Nieto

(15 Mins) Assessing the Potential Benefits of Small Low-Cost Air Quality Sensors to MSC's Air Quality Forecasts - Andrew Teakles

(15 Mins) Can Hygroscopicity Be Reliably Retrieved From PurpleAir PM2.5 Sensor Measurements? - Robert Sica

Air quality monitoring and prediction is one of the main operational goals of ECCC, underpinning the continued safety of Canadians from many forms of air pollution, e.g., urban, wildfire smoke, industrial, and rural wood-burning. The advent of low-cost air quality gas and aerosol sensors is changing the landscape of high-density monitoring, but requires careful consideration of what is lost in comparison to high-cost "federal reference method" instrumentation. At the same time, advances in air quality forecasting, which make the issuing of the Air Quality Health Index (AQHI) possible, are challenged by the high volumes of real-time but heterogeneous surface and satellite-based data regarding aerosol and gas concentrations, as well as wildfire smoke events. This session welcomes all contributions related to AQ monitoring and prediction

ATM-Toward a Single Regional Air Quality Deterministic Prediction System at ECCC by summer 2024

Currently, two air quality (AQ) forecast systems are operational at Environment and Climate Change Canada (ECCC): the Regional Air Quality Deterministic Prediction System (RAQDPS) and the FireWork system, which is identical to the RAQDPS but with the inclusion of satellite-derived near-real-time biomass burning emissions. Both systems are running year-round, twice daily at 00 and 12 UTC, over a 10-km horizontal grid spacing domain, covering most of North America, to produce 72-hours forecasts. Since both systems are identical, except for the inclusion of wildfire emissions in FireWork, the contributions of wildfire emissions to the total forecasted concentration can be obtained by subtracting the forecasted concentration of the RAQDPS from thoses of FireWork. With recent improvements to Firework, the use of a single AQ forecast system to provide numerical guidance is a priority for the next ECCC innovation cycle planned for summer 2024. However, using a single system will not provide the same PM2.5 wildfire product. Therefore, a new product (proxy) needs to be developed to identify air masses where the PM2.5 is dominated or controlled by wildfire emissions. In this presentation, we will provide an overview of the ECCC AQ program. The risks and uncertainties associated with the merging of the two AQ systems will be presented. We will also show the scientific approach used in the development of the new proxy, and some results for the summer 2022 period. Finally, conclusions and future directions of the Canadian operational AQ program will be discussed.

Rodrigo Alpizar-Munoz[1], Paul Makar[1], Jack Chen[1], Kontantinos Menelaou[1], Daniel Figueras Nieto[1] [1]ECCC Rodrigo.Munoz-Alpizar@ec.gc.ca

ATM-Assessing the Potential Benefits of Small Low-Cost Air Quality Sensors to MSC’s Air Quality Forecasts

A National Small Sensor Pilot project is being under-taken by the Meteorological Service of Canada (MSC) to examine the use of emerging low-cost air quality sensor technology to provide new monitoring opportunities for the AQHI forecast program to leverage into its forecast products and better inform Canadians on their air quality related health risk. The pilot aims to understand the value and fit-for-purpose of emerging small sensor technology for MSCs use. As part of the evaluations of the sensors, the Applied Science-Atlantic group has collocated Purple Air sensors at National Air Pollution Surveillance (NAPS) sites in Atlantic Canada. A group of active citizen scientists have also been engaged as part of the pilot, through a partnership with The New Brunswick Lung Association. This presentation will showcase the value this emerging technology has shown to date, including how these sensors have proven useful for the forecasting of high-impact air quality events such as smoke from wildfires.

Lucy Chisholm[1], Andrew Teakles[1] [1]Meteorological Service of Canada Lucy.Chisholm@ec.gc.ca

ATM-Can Hygroscopicity Be Reliably Retrieved From PurpleAir PM2.5 Sensor Measurements?

PurpleAir sensors provide a unique opportunity for a large scale, and in places densely packed, array of sensors to study surface air quality. We have previously demonstrated that a physically-based optimal estimation method (OEM) can offer additional advantages when used for calibration of the sensors against more robust, and costly,

detectors compared to statistical methods. We are continuing to investigate whether PurpleAir sensors can provide information about the hygroscopic growth of aerosols. This additional information enters the calibration through the sensitivity of the calibration to relative humidity, which affects the measured size distribution of the aerosols. Our OEM-based retrieval for the calibration includes an estimation of the bulk hygroscopicity. Using this physically-based calibration reduces the average daily Mean Absolute Error (MAE) of the PM2.5 measurements from 5.58 g/m^3 to 1.64 g/m^3, and the average daily bias from 4.75 g/m^3 to -1.52 g/m^3. It also reduced the average hourly MAE from 6.79 g/m^3 to 2.78 g/m^3 and the average hourly bias from 5.29 g/m^3 to -1.12 g/m^3 for season averages made over a year from London, Ontario. We are currently exploring if the retrieved bulk hygroscopicity is of sufficient quality to be included as a new data product for the PurpleAir sensors.

Robert Sica[1], Jillian Psotka[2] [1]The University of Western Ontario [2]University of British Columbia sica@uwo.ca

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Day 4 – 1 June 2023

Environmental DNA (eDNA) application in marine sciences: An ecosystem's approach from microbes to mammals - Part 1

Thursday, June 1
6:30 - 8:00 EDT

(30 Mins) Combining random forest machine learning with eDNA metabarcoding for environmental monitoring around marine aquaculture sites - Thomas Wilding

(15 Mins) Chytrid biodiversity across watersheds in Maine: insights from a three-year multi-method survey - Etain Cullen

(15 Mins) Long-term biodiversity monitoring using citizen science and eDNA - Matthew Lemay

(15 Mins) Understanding global marine microbial diversity patterns requires a seasonal perspective - Shannon Myles

(15 Mins) Global distribution of marine nitrogen-fixing microorganisms based on metabarcoding of marker gene nifH, encoding a subunit of the nitrogenase enzyme - Julie LaRoche

The session will explore the rapid strides that are made in the application of environmental DNA (eDNA) detection in marine systems. eDNA is DNA that is found in the environment and in the ocean, it is composed of both microbial and phytoplankton DNA as well as invertebrate larva, and fish eggs. In addition, eDNA is recovered from cells shed via skin, mucus and feces. The eDNA is recovered by filtration of a water sample onto a membrane and a variety of downstream analyses of the DNA provide a rich resource to assess biodiversity in the marine ecosystem. The application of eDNA currently ranges from biomonitoring of marine protected areas and coastal seas to applications in aquaculture, deep sea oceanography, detection of harmful algal blooms, invasive species and

endangered species. This session on eDNA will cover the detection of microbes, phytoplankton, invertebrates, fish and mammals, focusing on the strengths and limitations of the current approaches and applications of eDNA in marine systems. In the context of the blue economy, a non-exhaustive list of recommended topics for presentations will include:

1 Assessment of specific gene markers for target groups of organisms (whales, fish, invertebrates, microbes);

2 Advancements in bioinformatic pipelines for the analysis of barcoding data from amplicon sequences or metagenomics and their integration with other types of oceanographic data;

3 Case studies featuring the eDNA approach in various marine environments and their applications to specific problems;

4 The development of new technologies using eDNA for the rapid and reliable detection of ecosystems perturbations.

OCE-Combining random forest machine learning with eDNA metabarcoding for environmental monitoring around marine aquaculture sites

Scottish farmed salmon is the UKs largest food export sector with a turn-over in excess of 1B. Like any industry, fish-farms change the environment, and fish-farmers are required to assess the seabed condition around their sites towards the end of every production cycle. Traditionally, assessment is via an analysis of macrobenthic assemblages characterising farm-proximal sediments that are collected using a grab. Traditional macrobenthic analysis is expensive, time-consuming and, frequently, results are only available after the site has been harvested, preventing active management. We are developing an eDNA-based alternative to traditional macrobenthic analysis by training a random-forest (RF) algorithm to link patterns of bacterial taxa derived from eDNA metabarcoding to metrics resulting from traditional macrobenthic assessment. Our results show a high degree of congruence between RF predicted and actual macrobenthic indices (specifically the infaunal quality index) on the several hundred samples analysed to date from across the coast of Scotland. Furthermore, using our optimised RF, we are able to identify taxa that are key indicators of distinct infaunal communities.

Thomas A. Wilding, Scottish Association for Marine Science

OCE-Chytrid biodiversity across watersheds in Maine: insights from a three-year multi-method survey

Chytrids are one of the dominant groups of fungi in aquatic ecosystems, playing important ecological roles as parasites and decomposers. Their distribution, taxonomy, and ecological functions are poorly understood. To better understand the biodiversity of aquatic, saprotrophicchytrids in Maine, we integrated eDNA metabarcoding with traditional culturing surveys across four watersheds in Maine. We will discuss large-scale chytrid biodiversity patterns over time and space that emerged from this study, as well as the benefits and limitations of both survey methods. Overall, we found that merging traditional and eDNA methods is crucial for understanding chytrid biodiversity and ecosystem function.

Peter Avis[1], Jessica Hayden[1], Erin Grey[1], Etain Cullen[1], Joyce Longcore[1] [1]University of Maine peter.avis@maine.edu

OCE-Long-term biodiversity monitoring using citizen science and eDNA

Species extinction, the introduction of invasive species, and range-shifts in response to climate change all have a dramatic impact on biodiversity, yet we often lack sufficient data to track these processes in real-time. The genomics of environmental DNA (eDNA) is a new, exciting, and rapidly growing field with great promise to revolutionize how we study biodiversity. The key advantage is the ability to track species without the need to visually observe their presence, which is a valuable tool for the early detection of invasive species and for measuring range-shifts in elusive and cryptic taxa. In 2019, we created theIntegrated Coastal Observatory (ICO), which is a coordinated network of citizen-scientist partners along the coast of British Columbia who are using eDNA to monitor marine biodiversity.At the core of this initiative is the desire to generate high-quality open-data that can be used by our partners to quantify regional biodiversity.Environmental DNA samples from seawater are collected monthly to track the diversity of fish present at each partner location site. The resulting data provide an important tool for monitoring changes in diversity over broad spatial and temporal scales. Our results demonstrate the advantages of democratizing the collection and dissemination of eDNA-based biodiversity data.

Matthew Lemay[1], Sue Velazquez[1], Rute Carvalho[1], Evan Morien[1], Mathew Brown[1], Colleen Kellogg[1] [1]Hakai Institute matt.lemay@hakai.org

OCE-Understanding global marine microbial diversity patterns requires a seasonal perspective

Understanding the drivers of marine microbial diversity is essential, as variations in their alpha- and beta-diversities can alter biogeochemical fluxes and ecological dynamics. While global oceanographic expeditions and ocean basin-wide transects show positive correlations between microbial diversity and either temperature or productivity, they often lack temporal replication to capture seasonal features. This is especially true in high latitudes and polar regions over the winter months. Here, using seasonal amplicon sequence data from eight time series in the northern and southern hemispheres, we show that on a multiannual basis marine microbial species richness and evenness correlate less with temperature and chlorophyll a (as a proxy for primary production) than with day length. Our results suggest that microbial diversity, and an annually recurring community composition, are governed by similar principles from subtropical to polar oceans. We detected these trends across datasets regardless of collection method, DNA extraction chemistry, primer sets and the targeted 16S rRNA hypervariable region, the sequencing technology, or bioinformatics pipeline. Deviations from the diversity cycles are discussed and related to earths orientation to the sun, a heating event, and nutrient regimes. Our synthesis highlights the need for regular sampling at time-series sites over seasonal cycles to understand environmental drivers of microbial diversity.

Eric Raes[1], Shannon Myles[2], Liam MacNeil[3], Julie LaRoche[2] [1]Minderoo - Flourishing Oceans - OceanOmics [2]Dalhousie University [3]GEOMAR - Helmholtz Centre for Ocean Research - Kiel eraes@minderoo.org

OCE-Global distribution of marine nitrogen-fixing microorganisms based on metabarcoding of marker gene nifH, encoding a subunit of the nitrogenase enzyme.

The successful application of environmental DNA approaches to assess biodiversity in marine ecosystems depends to a large extent on the availability of curated and interoperable databases for the accurate assignment of taxonomy and function. Microbial ecologists have long taken the approach of utilizing DNA sequences to assign taxonomy to microbes, given that phenotypic traits cannot resolve the large diversity that is observed in the microbial world. High throughput DNA sequencing approaches based on metabarcoding of ribosomal RNA (rRNA) hypervariable regions are now overwhelmingly applied to microbial biodiversity studies, with the caveat that the resulting DNA sequence reads reflect relative rather than absolute abundance of the dominant species in the environment, hindering the detection of rare taxa. Targeting functional genes for amplicon sequencing is an alternative approach to study rare but ecologically important species. Here we present a global dataset of nifH amplicon sequences that specifically target nitrogen-fixing microbes, or diazotrophs, in diverse oceanic ecosystems. Diazotrophs are key players in the marine nitrogen cycle but, with a few exceptions, are usually found at very low abundance in the marine microbiome. We describe the workflow implemented to create an interoperable curated nifH amplicon dataset originating from more than 4000 globally-distributed samples, to which each amplicon sequence variant (ASV) was assigned a best taxonomic identification using a two-step approach. Finally, we present the distributions of the most important ASVs representing diverse nitrogen-fixers in the global ocean.

Julie LaRoche[1], Brent Robicheau[1], Jennifer Tolman[1], Tatjana Zivkovic[1], dhwani Desai[1], Amelie Frappier[1] [1]Dalhousie University julie.laroche@dal.ca

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Workshop: Communicating Risk in the Face of Increasing Extreme Events

Thursday, June 1
7:00 - 9:00 EDT

Climate change is contributing to an increase in extreme weather events. Recent historical events include Hurricane Fiona, the Derecho in Ontario & Quebec, wildfires in the West, the Heat Dome and the Atmospheric River. Ultimately, the challenge is to effectively warn the public and have them take action ahead of events they have never experienced before!

The Weather Enterprise is responsible for conducting research and delivering services related to weather extremes. The public will benefit from an effective preparedness and warning program that is delivered in a collaborative way, taking advantage of the talents and experience of each component of the weather enterprise: government and private sector science & services, academic research, and media communications. CMOS has a leadership role to encourage this conversation as a non-profit within the "enterprise".

Our goal is to discuss and recommend options to better communicate risk within the Weather Enterprise (Government, Academia, Private Sector, and Media) so that the public take affective actions to protect their lives and livelihoods from extreme weather events.

The ECCC Weather Radars: A Virtual Tour And Discussion

Thursday, June 1
9:15 - 10:00 EDT

Join local ECCC and DFO representatives for a virtual tour of the weather RADAR station located in nearby Holyrood. The tour will provide an overview of current ECCC Radar technology, network, and products.

Collaborative Earth System Modelling in Canada - Part 1

Thursday, June 1
12:30 - 14:00 EDT

(30 Mins) The Canadian Earth System Model: recent progress and future plans - Neil Swart

(15 Mins) Future Climate Simulations for the Salish Sea Using Dynamically Downscaled Atmospheric Projections - Eva Gnegy

(15 Mins) Impacts on regional climate modeling of improved driving data by applying run-time empirical biais corrections to the global climate model - Dominic Matte

(15 Mins) The Canadian Earth System Model: a different spin - Jason Cole

(15 Mins) The Collaborative Platform for CanESM (CP4C) - Update - Paul Kushner

Earth System Models (ESMs) are the principal tools used to understand and attribute past climate changes, to make projections of future climate, and to carry out near-term environmental predictions. The Canadian research community pursues collaborative research with ESMs across many domains, from the perspective of atmosphere/ocean science, cryospheric science, carbon-cycle science, and research related to land surface and hydrological processes. This collaborative research occurs within Canada and internationally, within government and academic settings, and within academic-government partnerships. Whatever the setting, the complexity and technical challenges associated with ESMs pose barriers to their development, application, and analysis without formal collaborative structures and advanced technical tools to facilitate their use. New technologies, including machine-learning and novel data-science approaches, advanced version control systems, reproducible runtime environments (containers), community analysis packages, and common computing resources are affording new collaborative opportunities from development to analysis to application. This session invites submissions on Earth System Models and modelling applications taking place in Canada, ranging from model descriptions through to applications and analysis procedures, across many earth system science domains that are unified by their use of ESMs and could be enhanced by stronger collaborative partnerships. Areas of interest include atmospheric/ocean model process and parameterization development (including sea-ice modelling), short-lived climate forcers and geoengineering/climate intervention, carbon cycle modelling (including climate change mitigation approaches such as atmospheric carbon dioxide removal),

land-surface model development and application, and sea-ice/land-ice modelling. We invite submissions covering the modelling environment within Canada (including CanESM, the UVic ESM, GEM-NEMO, CanRCM, CRCM, etc.) and internationally (including CESM, WRF, CliMA, etc.)). We seek to continue the discussion concerning challenges and opportunities for collaboration between universities, government laboratories, and the private sector; and the scientific results emerging from such collaborations.

MUL-The Canadian Earth System Model: recent progress and future plans

The Canadian Earth System Model (CanESM) is the culmination of 50 years of climate model development in Canada, led by the Canadian Centre for Climate Modelling and Analysis. CanESM has been a leading contributor to international and domestic climate assessment reports, providing foundational information for mitigation and adaptation decision making. The release of CanESM5, and its widespread scientific application have been documented at previous CMOS congresses. Moving forward, further model development is required to satisfy the ever increasing demand for more robust, higher resolution, multi-faceted climate change information. Here we report on key development progress since version 5.0, including the solution to some key model biases, alternate tunings which result in a lower climate sensitivity version of the model, and planned inclusion of new physical parameterizations. Our efforts to facilitate collaboration with the broader earth system science community in Canada though the Collaborative Platform for CanESM are described. Finally, we report on plans and progress for the release of the next major model version, CanESM6. In particular, CanESM6 is planned to incorporate the GEM dynamical core with CCCma physics on the Yin Yang grid for the atmosphere, along with major updates to the land, ocean and sea-ice components. We describe the challenges associated with attempting a globally novel Yin-Yang based climate model, and the opportunities it offers for enhanced integration and collaboration across weather and climate modelling in Canada.

Neil Swart[1], CanESM development team[1] [1]Climate Research Division / Environment and Climate Change Canada neil.swart@ec.gc.ca.ca

MUL-Future Climate Simulations for the Salish Sea Using Dynamically Downscaled Atmospheric Projections

The Salish Sea, a marginal sea between Vancouver Island, mainland British Columbia and Washington state, supports an active and diverse ecosystem in addition to the economic and recreational activities of nearly 9 million locals who live along its shores. Given the Salish Seas importance, future climate projections can provide useful information for how to manage the resources and services it provides in the years to come. However, global climate models (GCMs) are often too coarse in spatial resolution to capture the small-scale features of coastal regions, especially ones like the Salish Sea that are also largely affected by topography. To fill this gap in knowledge, the Weather Forecast Research (WRF) model is being used to dynamically downscale the latest Canadian Earth System Model (CanESM2), a coarse GCM, to create high-resolution projections for the Salish Sea basin. Dynamical downscaling is a modeling technique that extrapolates the effects of large-scale climate processes from the coarse models, using them as initial boundary conditions to drive high-resolution models, allowing for small-scale processes, especially those affected by local geography (e.g. coasts, topography), to be resolved within the model rather than parameterized. A historical period (1986-2005) has been completed for validation and to assess the

changes in the Salish Sea, and future simulations (2046-2065) have been created under two climate mitigation scenarios.This model will be used to drive ocean models to investigate changes in temperature, oxygen, and ocean acidification. The goal of this project is to identify vulnerable regions for conservation and protection in future climates.

Eva Gnegy[1], Timothy Chui[1], Amber M. Holdsworth[2], Michael Dunphy[2], Natasha Ridenour[2], Roland B. Stull[1], Rachel H. White[1] [1]University of British Columbia [2]Fisheries and Oceans Canada egnegy@eoas.ubc.ca

MUL-Impacts on regional climate modeling of improved driving data by applying run-time empirical biais corrections to the global climate model

A novel runtime empirical bias correction (EBC) has recently been developed and applied to The Canadian Center for Climate Modelling and Analysis (CCCma) global earth system model CanESM and been shown to improve future projections under strong climate change. The application of EBC to CanESM provides improved driving data for dynamical downscaling by regional climate models (RCMs). This project compares the impact of the improved EBC driving data in two RCMs CanRCM5 (CCCma) and CRCM5 (Ouranos) to gauge the systematic improvement of meteorological variables. Using several 10-member ensembles, we investigate the added value of using EBC to drive two RCM simulations. The first set of ensembles is produced using the original CanESM5 as driving data, the second set of ensembles is produced using the original CanESM5 but with EBC on sea surface temperature (SST) and sea ice concentration (SIC); and the third set of ensembles is produced using a bias-corrected atmosphere and SST/SIC. All three ensembles use ERA5 as a reference over the historical period. Preliminary results show a clear advantage of using EBC, especially where bias is originally strong. The key outcome of the proposed research is an evaluation of the EBC methodology including, its expected added value over uncorrected RCM driving data; its ability to reduce inter-model spread in future projections of outputs used to drive hydrological models; and its utility for the community as a methodology to reduce uncertainty in downscaled projections of future climate change.

Dominic Matte[1], Marie-Pier Labonté[1], John Scinocca[2], Viatcheslav V. Kharin[2], Martin Leduc[1], Dominique Paquin[1] [1]Ouranos [2]CCCma matte.dominic@ouranos.ca

MUL-The Canadian Earth System Model: a different spin

A common thought experiment is to infer climate of Earth if it had a different, or reversed, rate of rotation. While this is an interesting exercise, there are real world applications, for example, the detection of Earth-like exoplanets. The Canadian Earth System Model version 5.1 (CanESM5.1) is used to examine the impact on climate for four scenarios: current rotation, a faster rotation, a slower rotation and reversed rotation. For each scenario, CanESM5.1 was spun-up from rest using 1850 forcing for at least 6000 years so that many variables are close to equilibrium. From these 1850 control simulations, a subset of CMIP6 DECK experiments were launched, including 4xCO2 and 1% per year increases in CO2, as well as historical simulations. Key results about the atmosphere, ocean and carbon responses will be presented.

Jason Cole[1], Neil Swart[1], Jim Christian[2] [1]ECCC [2]DFO jason.cole@ec.gc.ca

MUL-The Collaborative Platform for CanESM (CP4C) - Update

This talk will provide an update on our university-government partnership focused on the use of the Canadian Earth System Model (CanESM),Environment and Climate Change Canada (ECCC) flagship model contributing to international climate assessment. This effort involves the development and implementation of the Collaborative Platform for CanESM (CP4C), a research platform for CanESM that will enable the Canadian research community, within and outside of ECCC, to use CanESM in partnership with ECCC for development, analysis, and application. In the last year most functionality ofCanESM5 has been ported to Digital Research Alliance of Canada (DRAC) infrastructure and several scientific projects have been outlined using CanESM5. Plans for transitioning this system towards newer version of CanESM will be discussed. This effort promises to lower barriers to collaboration with ECCC in RD activities focused on CanESM.

Paul Kushner[1], Neil Swart[2] [1]University of Toronto [2]ECCC/CCCma
paul.kushner@utoronto.ca

Enhancing the analyses and applications of ocean observational and modelling data: Toward development of Made-in-Canada Digital Twins of the Ocean - Part 2 / Improving Ocean Accessibility in the Ocean Decade + Discussion

Thursday, June 1
14:30 - 16:00 EDT

(30 Mins) Model-based state of the ocean in Eastern Canada - Joël Chassé

(15 Mins) Explore CIOOS: Canada's home for ocean observing data - Jonathan Kellogg

(15 Mins) Towards Interoperable Freshwater Data in Canada - Jim M.C. Young

(30 Mins) Discussion on ideas and collaborations toward development of Canada's Digital Twins of the Ocean - Youyu Lu

Canada has a vast holding of ocean data from observations and numerical models (hindcast, forecast and future climate projections). Marine scientists from various disciplines have a long history of utilizing these data for quantifying, understanding and predicting the oceanic changes, developing applications in protecting the ocean environment, ecosystems and fishery resources, and for safe marine transportation and supporting offshore economy activities, etc. These activities well fit the recent international initiatives toward development of Digital Twins of the Ocean (DTO) under the framework of the United Nations Decade of Ocean Science for Sustainable Development. In fact, various projects toward developing DTOs in Canada have been supported in government, academia, NGOs, and the private sector. Besides the demands for data collection and management, and software technology, etc., data analysis and development of applications remain key components for DTO development. This work can greatly benefit from improving knowledge exchange and collaborations among different groups with different expertise. Through a combination of contributed and invited presentations, this session aims to bring together national and international researchers 1) to review the status of available and future development of ocean observation and modelling data; 2) to introduce classical

and novel methodologies of ocean data analysis; 3) to present achievements in developing applications for ocean data including the effective presentation of ocean data to end users, and 4) to discuss the collaboration opportunities both nationally and internationally. We welcome both oral and poster presentations.

OCE-Model-based state of the ocean in Eastern Canada

Ocean monitoring is typically conducted during specific months and locations. Therefore large data gaps often exist in the observational system and numerical models are useful to fill data gaps to support the State of the Ocean reporting. This initiative draws on national and international modelling expertise to provide a four dimensional analysis, in space and time, of environmental variables from the atmosphere to the bottom of the ocean in Atlantic Canada. It aims to supplement the reporting based on observational systems which is traditionally conducted under DFOs Atlantic Zone Monitoring Program (AZMP). Re-analysis from six atmospheric models were used to derive the atmospheric conditions over the ocean while seven ocean models were used to estimate ocean conditions. The covered time periods vary among models but range from 1948 to 2022. Ensemble results of the atmospheric and ocean variables as well as their anomalies from the long-term average will be presented. Biogeochemical conditions will also be presented when available from models.

Joël Chassé[1], Nicolas Lambert[1], David Brickman[2], Guoqi Han[3], Zeliang Wang[2], Diane Lavoie[4], Olivier Riche[4], Jacqueline Dumas[4] [1]Fisheries and Oceans Canada, Gulf Region [2]Fisheries and Oceans Canada, Maritimes Region [3]Fisheries and Oceans Canada, Pacific Region [4]Fisheries and Oceans Canada, Quebec Region Joel.Chasse@dfo-mpo.gc.ca

OCE-Explore CIOOS: Canada’s home for ocean observing data

From the Beaufort Sea to the Bay of Fundy, the Canadian Integrated Ocean Observing System (CIOOS) is Canadas nucleus for integrated ocean science and observing activities. Our work with partners from coast to coast to coast is applying internationally recognized standards to consolidate data into a resource for all ocean people. CIOOS makes fully interoperable data available across Canadas ocean basins and, with continued development of new tools to explore the resources, it is now easier than ever to connect the dots and better manage our ocean resources. By improving access to past observations and present data streams, CIOOS is enabling ocean users to make place-based decisions for our ocean future. Join us to learn how CIOOS can help your planning efforts or data management legacy.

Jonathan Kellogg[1], Naomi Boon[2], Brad de Young[1], Andréane Bastien[3], Germain Sauvé[3], Shayla Fitzsimmons[4], Jeff Cullis[4], Pramod Thupaki[1] [1]CIOOS Pacific [2]CIOOS [3]St Lawrence Global Observatory [4]CIOOS Atlantic jonathan.kellogg@hakai.org

OCE-Towards Interoperable Freshwater Data in Canada

In 2019, the Government of Canada committed to establish a federal Canada Water Agency to work with the provinces, territories, Indigenous communities, and other stakeholders in order to find the best ways to keep Canadas water safe, clean, and well-managed.In 2021, Environment Climate Change Canada commenced foundational

work to advance development of a national freshwater data management strategy, and in March 2023, a National Freshwater Data Strategy Framework was released. Some of the foundational work included leading a National Freshwater Data Engagement Workshop, and a compilation of a preliminary inventory of existing freshwater datasets. This presentation will describe a potential path forward on the way freshwater data is managed in Canada, with the goal of enabling every Canadian to determine what freshwater data exists, how to easily find and access the data they are looking for, and to support decision-making, innovation, and adaptation activities. With some foundational data principles such as FAIR, TRUST, and CARE, we propose the data strategy principles of quality data, findable accessible data, data stewardship and capacity building. These will serve to underpin the road map for the development of the National Freshwater Data Strategy in collaboration with key partners and stakeholders, including: federal departments, provinces and territories, Indigenous Peoples, non-governmental organizations, academia, and industry. We will map out how the Canada Water Agency plans to work jointly with partners and stakeholders to improve freshwater data discoverability and accessibility across existing platforms to better develop value-added products and tools.

Jim M.C. Young[1], Daniel Ingram[1], Henry Jupe[1] [1]Enivronment & Climate Change Canada jim.young@ec.gc.ca

OCE-Discussion on ideas and collaborations toward development of Canada's Digital Twins of the Ocean

Under the framework of the United Nations Decade of Ocean Science for Sustainable Development, there are many initiatives related to development of the Digital Twins of the Ocean (DTO). Full development of DTO requires many aspects of work, including data collection and management, software technology, data analysis, and development of client oriented applications, etc. Here we invite participants of this session to discuss ideas and collaborations on enhancing the contributions to the development of Canadas DTO. To stimulate the discussion, we will briefly showcase some of the ongoing work in Canada that could contribute to digital twins, for example, data collection and management (expanded access to ocean data through the Canadian Integrated Ocean Observing System); data analysis (a new project to derive physical indices relevant to marine conservation and protection areas planning based on the results of high-resolution regional ocean models, led by DFO Maritimes).

Hui Shen[1], Youyu Lu[1], Corinne Bourgault-Brunelle[2], Fraser Davidson[3], Mike Smit[4], Pramod Thupaki[5] [1]Fisheries and Ocean, Maritime Science [2]Fisheries and Oceans, Service Desk for Operational Oceanography [3]ECCC [4]Dalhousie University [5]Hakai Institute hui.shen@dfo-mpo.gc.ca

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Environmental DNA (eDNA) application in marine sciences: An ecosystem's approach from microbes to mammals - Part 2

Thursday, June 1
12:30 - 14:00 EDT

(30 Mins) Advancing environmental genomics for fisheries management and ecosystem modeling - Beverly McClenaghan

(15 Mins) Do pseudogenes pose a problem for eDNA studies on marine animal communities? - Jessica Schultz

(15 Mins) Exploring the drivers of variability in exploited populations of North Atlantic sea cucumbers along a longitudinal gradient - Kevin Ma

The session will explore the rapid strides that are made in the application of environmental DNA (eDNA) detection in marine systems. eDNA is DNA that is found in the environment and in the ocean, it is composed of both microbial and phytoplankton DNA as well as invertebrate larva, and fish eggs. In addition, eDNA is recovered from cells shed via skin, mucus and feces. The eDNA is recovered by filtration of a water sample onto a membrane and a variety of downstream analyses of the DNA provide a rich resource to assess biodiversity in the marine ecosystem. The application of eDNA currently ranges from biomonitoring of marine protected areas and coastal seas to applications in aquaculture, deep sea oceanography, detection of harmful algal blooms, invasive species and endangered species. This session on eDNA will cover the detection of microbes, phytoplankton, invertebrates, fish and mammals, focusing on the strengths and limitations of the current approaches and applications of eDNA in marine systems. In the context of the blue economy, a non-exhaustive list of recommended topics for presentations will include:

1 Assessment of specific gene markers for target groups of organisms (whales, fish, invertebrates, microbes);

2 Advancements in bioinformatic pipelines for the analysis of barcoding data from amplicon sequences or metagenomics and their integration with other types of oceanographic data;

3 Case studies featuring the eDNA approach in various marine environments and their applications to specific problems;

4 The development of new technologies using eDNA for the rapid and reliable detection of ecosystems perturbations.

OCE-Advancing environmental genomics for fisheries management and ecosystem modeling

Biodiversity monitoring in marine environments is logistically challenging but advances in environmental genomics provide simple, unified, and scalable solutions to collect high resolution data on target species and whole ecosystems. Here we will provide an overview of two RD programs at the Centre for Environmental Genomics Applications, CEGA, that lead technology development for fisheries and marine monitoring in Canadas north. In the OceanDNA project, supported by the Canadian Ocean Supercluster, we (1) develop new sampling protocols for eDNA collection by fishing crews, (2) compare detection efficiency for target species using qPCR, amplicon sequencing, and capture probes, (3) design a quantitative metabarcoding workflow for biomass estimation of fish, (4) devise a population-level eDNA analysis workflow, and (5) integrate whole community biodiversity data from eDNA with complementary biodiversity and environmental data from conventional surveys to form new, enhanced ecosystem models. In our UN Ocean Decade project entitled Monitoring ecological resilience in Northern Fisheries inshore regions through community-based environmental genomics, we partnered with northern communities to gather marine biodiversity data from coastal and near-shore areas. By training locals to collect eDNA samples we are generating valuable biodiversity data at an ecosystem scale from these remote, hard to survey areas throughout the year while also building capacity in

Canadas North. Environmental genomics offers unparalleled levels of detail about biodiversity and is an affordable solution to sustainable ocean management.

Nicole Fahner[1], Beverly McClenaghan[1], Avery McCarthy[1], Greg Singer[1], Mehrdad Hajibabaei[1] [1]eDNAtec nicole@ednatec.com

OCE-Do pseudogenes pose a problem for eDNA studies on marine animal communities?

Because eDNA typically employs sequence diversity among amplicons of the mitochondrial cytochrome c oxidase I (COI) gene to estimate species richness, nuclear mitochondrial pseudogenes (NUMTs) can inflate diversity. This study quantifies the incidence and attributes of NUMTs derived from the 658 bp barcode region of COI in 156 marine animal genomes. The number of NUMTs meeting four length criteria (≥150 bp, ≥313 bp, ≥500 bp, ≥650 bp) was determined, and they were then examined to ascertain if they could be recognized by their possession of indels or stop codons. In total, 389 NUMTs ≥100 bp were detected, with an average of 2.49 per species (range = 050) and a mean length of 336 bp ± 208 bp. From this total, 107 (27.5%) lacked indels or stop codons. NUMTs appear to pose the greatest interpretational risk when short (100-150 bp) amplicons are used, such as in eDNA studies, dietary analyses, or processed seafood identification. Studies based on non-protein coding genes (e.g., 12S, 16S), triple the risk of exposure to NUMTs. However, only 6.2% of all 389 NUMTs appear likely to be co-amplified by the standard COI primers used in marine metabarcoding and eDNA studies. While bioinformatic advances will improve NUMT detection, the best defense involves targeting long amplicons and developing reference databases that include both mitochondrial sequences and their NUMT derivatives.

Jessica Schultz[1], Paul Hebert[1] [1]Centre for Biodiversity Genomics, University of Guelph, Guelph jschul02@uoguelph.ca

OCE-Exploring the drivers of variability in exploited populations of North Atlantic sea cucumbers along a longitudinal gradient

In response to declines in finfish fisheries, commercial harvests of underutilised species such as whelks and sea cucumbers were developed in many jurisdictions to generate economic growth. The sea cucumber Cucumaria frondosa is an abundant benthic species on the continental shelves of eastern Canada and several other countries in the North Atlantic, making it a good candidate for a commercial fishery. On the St. Pierre Bank off the southern coast of insular Newfoundland (NAFO Division 3Ps), the biomass of sea cucumbers was estimated to total about 255,000 metric tonnes in 2016. Recently, harvesters and processors have reported differences in size-frequency distribution along an eastwest gradient, with increasingly greater proportions of smaller individuals coming from the eastern area of the fishing ground. Here, we analysed and described this phenomenon, applied corrections to account for variability in sea cucumber size (e.g., body length, whole wet weight), and evaluated topographic and oceanographic factors that may explain this distributional pattern. Findings highlight the importance of elucidating the environmental drivers of sea cucumber abundances, and advocate for the incorporation of population dynamics into prospective stock assessments while adopting a more cautious fishery in NAFO Division 3Ps.

Kevin C. K. Ma[1], Robert Trenholm[2], Jean-François Hamel[3], Annie Mercier[2] [1]Department of Ocean Sciences, Memorial University [2]Fisheries and Marine Institute, Memorial

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Mixed Media and Crossed Wires: Challenges and Opportunities Presented by Contemporary and Traditional Media for Disaster Preparedness, Warning, and Response Communication (Panel)

Thursday, June 1
12:30 - 14:00 EDT

Panelists: Steve Bowen, Armel Castellan, Amber Silver, Jennifer Spinney.
Moderator: Joel Finnis

The communication of hazard-related information usually begins with the detection of a potential hazard through observation of phenomena. The data are analyzed and/or modeled and meaning or implications are drawn from the results. Depending on the time scale of the anticipated hazard, this is then communicated in a variety of ways (reports, sirens, alerts, images, simulation, maps, narrative, graphs, numerical equations), to one or many audiences (same agency, different agencies, decision-makers, public). At each step of the communication process, the message format and content can be (or may need to be) altered to fit the audience, channel, or circumstances. The selection of data or model outcome to communicate, the communication of uncertainty or probability, as well as aspects of the message format and content may result in the communication of a meaning different than initially intended or a message that amplifies one aspect but attenuates another. Testing processes and messages with the end-user and obtaining feedback, is critical, but may not always occur. Traditional media (radio, TV, print or electronic media) and social media play a strong role in hazard information dissemination exchange with both challenges and opportunities for interaction, multi-directional information flow, information gathering and dissemination. The panelists will discuss the challenges of maintaining the fidelity of the message meaning for each audience through the multi-step communication process for a variety of coastal hazards such as sea-level rise, flooding, extreme weather events, and tsunamis.

Operational applications using Canadian operational ocean forecasting systems

Thursday, June 1
12:30 - 14:00 EDT

(15 Mins) SalishSeaView - Development of a CIOOS Information Service

(15 Mins) Predicting coastal storm impacts in the Canadian High Arctic, Grise Fiord (NU)

(15 Mins) Implementing a new operational drifting modelling at Environmental and Climate Change Canada (ECCC)

(15 Mins) End user driven development of application for visualization and access to ocean forecasting systems

(15 Mins) A probabilistic prediction of rogue waves for the northeast Pacific.

(15 Mins) Navigation: A real-time application to navigate the Saint-Lawrence for recreational user

In the last decade, operational ocean forecasting in Canada has seen a number of advances which have been supported by government-academic partnerships, international collaborations, and inter-governmental programs such as the Canadian Operational Network for Coupled Environmental PredicTion Systems (CONCEPTS) and the Oceans Protection Plan (OPP). Ocean forecasts in Canada are currently used in an increasing number of applications, such as marine search and rescue, response to oil spill and drift, modelling, ocean acoustics, and marine ecosystem monitoring. These applications require reliable service delivery mechanisms and strong engagement with end-users. To that end, this session invites abstracts that present applications using ocean forecasting systems with an emphasis on the tools and systems that support those applications to enable and support various operations.

OCE-SalishSeaView - Development of a CIOOS Information Service

Making ocean data accessible requires more than just consolidating it in one place and providing web access.It is a good startbut raw ocean data, things like temperature and salinity profiles,are only useful to those fewpeople with specialized training. The Pacific Association of theCanadian Integrated Ocean Observing System (CIOOS) has been working to expand data access and availability through development of tools that are more intuitive for end users, such as the CIOOS Data Explorer. Clearly though, we must go beyond data access to become a sustainable ocean observing system. We recognize that we must meet the wider needs of society for ocean information.CIOOS Pacific is focussed on theinformation needs around the coastal environment and is developing an information service for the British Columbia Coast - SalishSeaView.SalishSeaViewwill build upon the existing strengths of the CIOOS catalogue and Data Explorer. It will provide access to key ocean information through an intuitive graphical interface. In this presentation, we will consider the societal needs for ocean information, as opposed to ocean data. We will review some of the existing services offered, considering both their strengths and gaps.We will present the SalishSeaView and consider who might want to use such a service.

Brad deYoung[1], Taimaz Bahadory[2], Ray Brunsting[3], Nate Rosenstock[3], Pramod Thupaki[3], Jorin Weatherston[3] [1]CIOOS Pacific [2]Memorial University [3]Hakai Institute
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OCE-Predicting coastal storm impacts in the Canadian High Arctic, Grise Fiord (NU)

The community of Grise Fiord, Nunavut, experienced numerous coastal storms in the last decade. During the short open water season, concomitant waves, surge and tides can produce high total water levels at the shoreline, inducing coastal erosion and overwash. In order to develop a cartographic tool for the identification of flooding areas, a community-based research project was implemented in 2020. Nearshore pressure sensors, offshore wave buoys, timelapse imagery and video monitoring of the swash motions on the beach form the basis of the empirical approach for a morphodynamic analysis. Moreover, numerical simulations of offshore wave conditions in Grise Fiord

have been performed using a high-resolution regional configuration (1km) of the hydrodynamic model WaveWatch III. The configuration covers the entire Baffin Bay, including Jones sound which is an important hunting ground for the Inuit of Grise Fiord. Atmospheric forcing and ocean/ice conditions were provided by the High-Resolution Deterministic Prediction System (HRDPS) and the Regional Ice Ocean Prediction System (RIOPS) produced by the Meteorological Service of Canada (MSC), respectively. The configuration also includes state-of-the-art parameterization of wave attenuation through sea ice (Dumont et al. 2020). Results from a six month hindcast have been compared to wave buoys data collected in fall 2021 during the Dark Edge mission and community-based field campaigns in Grise Fiord. The resulting model parameterization will be applied for wave runup and total water level forecasts in Jones Sound to help coastal communities to better prepare against upcoming storm events.

David Didier David_Didier@uqar.ca

OCE-Implementing a new operational drifting modelling at Environmental and Climate Change Canada (ECCC)

The ECCC Environmental Emergency Response Section (EERS) operating at the Canadian Centre for Meteorological and Environmental Prediction (CCMEP) has adapted its oil spill modelling COSMoS (Canadian Oil Spill Modelling Suite) for the modelling of objects adrift. This capacity responds to a seeming increasing need in drift modelling of ships adrift. Cases studies have also been done on various objects adrift such as carcasses of dead birds and whales, and containers lost overboard. The work to adapt the Modle Langragien de Prdiction des Particules (MLDP) in COSMoS for this new capacity will be presented. COSMoS can now use the 9 parameters to characterize the leeway and crosswind effects on various objects adrift listed in the USCG table. Also presented will be the work to determine the most appropriate parameters to use for large ships such as bulk carriers, not accounted for in the USCG table. An operational implementation is planned at CCMEP in the summer of 2023 with Standard Operational Procedures (SOP) involving the National Environmental Emergency Centre (NEEC) of ECCC. The display and graphical outputs in consultation with NEEC will be presented. Finally, the work done to prepare EERS to take on this new operational responsibility will be discussed along with the remaining steps towards full operational implementation.

Paul Pestieau[1], kuo-Hsien Chang[1], Laura Lam[1] [1]Environment and climate change canada paul.pestieau@ec.gc.ca

OCE: End user driven development of application for visualization and access to ocean forecasting systems

The Canadian Operational Network of Coupled Environmental PredictTion Systems (CONCEPTS) is a collaborative initiative among several federal government departments working towards the development of operational coupled atmosphere-ice-ocean-wave assimilation, analysis, and prediction capability for Canada. This initiative, existing since 2009, is now mature with operational ocean forecasting systems running daily at ECCC. Visualization and accessibility tools for ocean forecast systems are vital for nurturing and sustaining end use of ocean forecast systems for societal benefit. A key challenge is to enable ocean forecast systems to support end use. An application to facilitate and increase the understanding, uptake and utility of ocean forecasts and

ocean observation is being developed at DFO, NL Region. The application is an intuitive web accessible server system built on front end web interface (JavaScript), analysis tools (Python) and data archive (SQL database and NetCDF files). With a client driven approach, development of the application is focused on supporting the various operations of end users, including DND and DFO CCG. End users have the ability to access and visualize ocean forecasting systems, subsetting data as transects, point coordinates and areas (e.g. virtual moorings, Hovmller diagram, etc.). Data is downloadable in various user friendly formats that allow the end user to efficiently ingest in their own operational processes. In addition, verification of model output is provided against in situ observations made available by regional and global monitoring programmes (e.g. GODAE Ocean View and RIOPS Assimilated Observations).

Vanessa Sutton-Pande[1] [1]DFO vanessa.sutton-pande@dfo-mpo.gc.ca

OCE-A probabilistic prediction of rogue waves for the northeast Pacific.

Rogue waves are individual ocean surface waves that are large compared to the prevailing sea state; i.e. the height of a rogue wave is greater than 2.2 times the significant wave height. Although rogue waves are rare events, they can pose significant danger to marine operations, structures, and beachgoers, especially when encountered in high sea states. Operational wave models are capable of predicting bulk sea state parameters with high accuracy. However, individual wave heights cannot be predicted by those spectral models, and the prediction of rogue wave occurrence has to be in a probabilistic sense. Recent studies established that the average correlation of wave crests and troughs can serve as a predictor of the rogue wave probability. Here, we demonstrate that crest-trough correlation can be forecast by the operational Regional Deterministic Wave Prediction System (RDWPS) WAVEWATCHIII model with moderate accuracy. We establish a functional relation between crest-trough correlation and rogue wave occurrence rate, based on multi-year wave buoy observations from the northeast Pacific. This calibration enables us to turn predicted crest-trough correlations into probabilistic rogue wave predictions. Combining the predictions of rogue wave probability and significant wave heights we can identify regions of enhanced rogue wave risk. Results from a case study of a large storm in October 2021 are presented to evaluate RDWPS at high seas, and to present the rogue wave probability forecast based on crest-trough correlation.

Leah Cicon[1], Johannes Gemmrich[1], Benoit Pouliot[2], Natacha Bernier[2] [1]University of Victoria [2]ECCC leah.cicon155@gmail.com

OCE-Navigation: A real-time application to navigate the Saint-Lawrence for recreational users

The river, estuary and gulf of St. Lawrence are essential economic and touristic waterways where the environmental conditions greatly impact the activities. For recreational users, it can be overwhelming to find all the necessary information to practice their hobby. In the past year, the St. Lawrence Global Observatory (SLGO) developed the application Navigation to make available the most appropriate data for safe navigation on the St. Lawrence. A successful beta phase where targeted users shared with us their needs, drove our development until its official launch in 2022. Today, the application offers a selection of valuable data layers, such as: prediction of surface currents, weather, water levels, tides and wind speed, and gusts. It also features an itinerary tool, tracking the data results along a chosen path. The application

displays a combination of observations and forecasts of environmental conditions of the St. Lawrence and relies on operational ocean forecasting from the Canadian Hydrographic Service (CHS) and Environment and Climate Change Canada (ECCC). Future developments are meant to include waves and sea ice conditions to answer users needs.The development of applications using ocean forecasting raises challenges, for example, being able to face the constant developments and innovation in the area of ocean forecasting. In this presentation, we will go over the Navigation application and tackle some challenges and requirements that arise for developing and maintaining such a tool based on operational ocean forecasting.

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Addressing the Risks in the Marine Environment to Become Climate Resilient

Thursday, June 1
14:30 - 16:00 EDT

(15 Mins) Lessons Learned - Nova Scotia Municipal Climate Change Action Planning: 2014-2023 - Brennan Vogel

(15 Mins) Building Climate Resilient Marine Environment Communities - Gordon McBean

(15 Mins) A multi-stakeholder perspective of community climate change risk and vulnerability - Jeff Birchall

(15 Mins) Categorizing Extreme Sea State Events for Offshore Newfoundland & Labrador - Nicholas Camizzi

(15 Mins) Climate change risk assessment (CCRA) for Offshore Oil and Gas Activities in Atlantic Canada - Arpana Datta

Much of the Canadian economy and communities are in or next to the marine environment and as the climate warms and the sea level rise, these communities and issues become more exposed and at risk. This session will bring together the expertise and wisdom on these issues of the interactions of the marine environment with the communities and what would be effective approaches to becoming more resilient in the marine environment. The session will include presentations across the disciplines and the weather-climate-governance-societal-health issues that will most effectively motivate actions and lead to action by all levels of governance and by individuals to become resilient and reduce the impacts of climate-related extremes.

SER-Lessons Learned - Nova Scotia Municipal Climate Change Action Planning: 2014-2023

In 2014, Nova Scotia’s municipalities were mandated and financially incentivized to complete Municipal Climate Change Action Plans under the Federal/Provincial Gas Tax Transfer Agreement and by the directive of the Provincial government. Almost 10 years later, what lessons can be learned from this first Canadian multi-level governance policy

example of a regulatory mandate and financial incentive for catalyzing local climate change risk and vulnerability assessmentx and adaptation plans? Building on the work of Vogel and Henstra (2015) and the findings of Vogel, Henstra and McBean (2018), this presentation will analyze, review and provide additional policy and practice insights based on the follow-up MCCAP research subsequently completed by Philp and Cohen (2019) and Righter and Chang (2023) as well as the complementary analysis provided by Birchall, Bonnett and Keller (2023). Policy insights for advancing resilience in coastal communities at risk of climate loss and damage will be provided.

Brennan Vogel[1] [1]King's University College bvogel@uwo.ca

SER-Building Climate Resilient Marine Environment Communities

Much of the Canadian economy and communities are in or next to the marine environment and as the climate warms and the sea level rise, these communities and issues become more exposed and at risk. This presentation will discuss the approaches and advances that are needed for climate resilient coastal communities and the marine environment. The weather-climate-governance-societal-health issues are important for actions and how these issues will most effectively motivate actions and lead to action by all levels of governance and by individuals to become resilient and reduce the impacts of climate-related extremes.

Gordon McBean[1] [1]ICLR and Western University gmcbean@uwo.ca

SER-A multi-stakeholder perspective of community climate change risk and vulnerability

In fall 2021, British Columbias Fraser Valley experienced erratic weather that triggered a natural disaster. After a devastating wildfire season, atmospheric rivers [SW1]brought extreme rain and early snow melt that resulted in massive flooding and landslides. The severity of impacts felt by communities demonstrated the regions vulnerability to climate change, bringing the urgency of risk abruptly into the public eye and sparking interest in how preparedness for flooding events, and general resilience to climate change, could reduce risks moving forward. With buy-in for adaptation action greatest following an extreme event, the occurrence of the 2021 floods provided a timely opportunity to shed light on how to overcome barriers preventing adaptation and preparedness. To do so, this study utilized key actor interviews and a policy document review to achieve the following empirical objectives: a) explore the role of adaptation planning for flood preparedness at the local/regional district scale in BCs Fraser Valley; b) examine decision dynamics around flood preparedness and lessons learned from the recent flooding events, and the nature and extent of local planning for climate adaptation in general; and, c) explore the value a community planning perspective brings to discourse on flood resilience and climate adaptation. The proposed session will share the results of this research, including insights from local stakeholders and policy influencers (elected officials, planners, engineers, emergency management, NGOs). This research highlights the critical need for climate policy and exposes many barriers preventing local decision-makers from adequately prioritizing their enactment.

Jeff Birchall[1], Sarah Kehler[1], Sebastian Weissenberger[2] [1]University of Alberta [2]Université Téluq jeff.birchall@ualberta.ca

SER-Categorizing Extreme Sea State Events for Offshore Newfoundland & Labrador

Through an initiative within the Open Offshore Project, we studied 34 extreme sea state events (forecast and/or observed over > 6.0 m significant wave height) for 2020 and 2021. Reducing forecast errors during high sea state events is of importance to offshore industry due to regulatory flight restrictions and logistical impacts. While overall wave model errors and corresponding forecast errors have decreased with modeling advancements, we can still improve forecasts for these larger impactful events. Prior studies have suggested that wave models cannot reproduce the peaks found in severe storms (Cavaleri 2009). For the study period, the high sea state events were analyzed using offshore synoptic observations, buoy wave observations, ERA5 reanalysis wind, sea, and temperature data, WSP forecasts, WWIII and GDWPS wave models, and RDPS, NAM, RAP, and GDPS temperature, pressure, and wind data. The events were subcategorized into 8 categories depending on the type of low, the track of the low, whether the low was intensifying, and how it tracked in relationship to offshore sites. Different sources of potential wave model and forecast error are discussed such as forecast precision, timing, track, and wave building in different atmospheric stability regimes. Detailed performance metrics will be presented.

Nicholas Camizzi[1], Terry Bullock[1], Steve Beale[1] [1]WSP E&I Canada, Limited nicholas.camizzi@woodplc.com

SER-Climate change risk assessment (CCRA) for Offshore Oil and Gas Activities in Atlantic Canada

Development of offshore oil and gas sector in the Atlantic Canada demands some of the most stringent engineering and design requirements in the world due to the relative remoteness of these developments, the complexity of their operations, and the dynamic and extreme physical conditions in the surrounding environment. For example, in Atlantic Canada, extreme environmental conditions occur due to cyclonic activity, cold air and water temperatures, and the presence of icebergs. The increasing frequency and/ or intensity of cyclonic activities in the North Atlantic Ocean can lead to longer development schedules for exploration, drilling, oil and gas export or supply activities resulting in a material effect on the economic performance of offshore developments. A high-level climate change risk assessment (CCRA) was conducted for Natural Resources Canada to identify the potential climate impacts to offshore oil and gas assets and activities in Atlantic Canada and to provide adaptation measures to mitigate those impacts. The potential climate hazards were identified by conducting interviews with industry and regulatory stakeholders and reviewing historical events and published literature. The climate change risk assessment approach was aligned with ISO 31000:2018 - Risk Management - Principles and Guidelines. Future climate conditions were based on the Fifth Coupled Model Intercomparison Project (CMIP5) climate projections data for RCP 8.5 emission scenario. The CCRA identified several moderate climate risks to offshore oil and gas activities in Atlantic Canada, identified some potential barriers to adaptation measures, and provided an effective way of prioritizing adaptation measures for the identified climate risks.

Brian Bylhouwer[1], Arpana Datta[1], Norman Shippee[1], Michael Murphy[1] [1]Stantec Consulting Ltd. Brian.Bylhouwer@stantec.com

Collaborative Earth System Modelling in Canada - Part 2

Thursday, June 1
14:30 - 16:00 EDT

(15 Mins) Model developments in the UVic-ESCM towards the study of nature-based climate solutions on land - Alexander MacIssac

(15 Mins) Modelling the global impact of carbon leaching from marine plastic debris - Natalia Gurgacz

(15 Mins) Oceanic Response to Widespread Ocean Thermal Energy Conversion - Anna Nickoloff

(15 Mins) Dependence of Climate Responses to on Pattern of Marine Cloud Brightening Interventions - Haruki Hirasawa

(15 Mins) A data-driven unified stochastic mass flux cumulus parametrization for organized convection - Boualem Khouider

(15 Mins) Simulation of Mean state in the NCEP-CFSv2 through a Stochastic Multicloud Model calibrated through Indian Radar Data - Kumar Roy

Earth System Models (ESMs) are the principal tools used to understand and attribute past climate changes, to make projections of future climate, and to carry out near-term environmental predictions. The Canadian research community pursues collaborative research with ESMs across many domains, from the perspective of atmosphere/ocean science, cryospheric science, carbon-cycle science, and research related to land surface and hydrological processes. This collaborative research occurs within Canada and internationally, within government and academic settings, and within academic-government partnerships. Whatever the setting, the complexity and technical challenges associated with ESMs pose barriers to their development, application, and analysis without formal collaborative structures and advanced technical tools to facilitate their use. New technologies, including machine-learning and novel data-science approaches, advanced version control systems, reproducible runtime environments (containers), community analysis packages, and common computing resources are affording new collaborative opportunities from development to analysis to application. This session invites submissions on Earth System Models and modelling applications taking place in Canada, ranging from model descriptions through to applications and analysis procedures, across many earth system science domains that are unified by their use of ESMs and could be enhanced by stronger collaborative partnerships. Areas of interest include atmospheric/ocean model process and parameterization development (including sea-ice modelling), short-lived climate forcers and geoengineering/climate intervention, carbon cycle modelling (including climate change mitigation approaches such as atmospheric carbon dioxide removal), land-surface model development and application, and sea-ice/land-ice modelling. We invite submissions covering the modelling environment within Canada (including CanESM, the UVic ESM, GEM-NEMO, CanRCM, CRCM, etc.) and internationally (including CESM, WRF, CliMA, etc.)). We seek to continue the discussion concerning challenges and opportunities for collaboration between universities, government laboratories, and the private sector; and the scientific results emerging from such collaborations.

MUL-Model developments in the UVic-ESCM towards the study of nature-based climate solutions on land

Nature-based climate solutions are a proposed method for removing carbon dioxide from the atmosphere and are therefore potentially an important tool to mitigate climate change. These solutions include reforestation, regenerative agriculture, restoring wetlands, among other interventions in the Earth system. While a goal of an NbCS is to help stabilize global warming, actions that change land cover can lead to climate effects which counteract this goal. An important contribution to climate change mitigation studies is thus to better quantify the climate effects of NbCS. The University of Victoria Earth Systems Climate Model (UVic-ESCM) has been proposed as a tool for simulating nature-based climate solutions. However, at present, the UVic-ESCM represents only five plant-function types (PFTs). Greater PFT distinctiveness is required to more accurately quantify the biophysical effects of forest-based NBCSs on climate change. Recent model development has been conducted to address this need where plants are now represented by nine functional types. Model development has added regionality and leaf types to distinguished between PFTs, for example: broadleaf trees are now represented by tropical broadleaf evergreen, temperate broadleaf evergreen and temperate broadleaf deciduous trees. Needleleaf trees and shrubs are now both divided between evergreen and deciduous varieties. These upgrades are intended to improve the distribution of PFTs across the globe, yield greater accuracy in the seasonality of surface albedo, and provide clearer results on the climate benefit of the regional application of NbCSs. In this presentation, we describe the model developments, and compare simulations with the new model configuration to the previous version.

Alexander MacIsaac[1], Andrew MacDougall[2], Kirsten Zickfeld[3] [1]St. Francis Xavier University/Simon Fraser University [2]St. Francis Xavier University [3]Simon Fraser University amacisaa@stfx.ca

MUL-Modelling the global impact of carbon leaching from marine plastic debris

Since the beginning of its large-scale production in the early twentieth century, plastic remains a critical material used throughout several industries. Despite serving many benefits, plastics are resistant to degradation and instead, accumulate in the ocean and affect marine ecosystems. The leaching of toxic compounds from plastics has been widely researched, but only recently have studies begun to explore dissolved organic carbon as a leachate from marine plastic debris, as well as its effects on microbial communities. Furthermore, research has only recently begun to explore the potential effects of plastic-carbon leaching on the global carbon cycle and hence, Earths climate system. Here we quantify an upper bound estimate for this effect using the UVic Earth System Climate Model with the addition of global and regional carbon fluxes, based on current and projected marine plastic values. The results of these modelling integrations indicate that the addition of the plastic-carbon flux results in only minor changes to the Earths climate, emphasizing the need to focus research on plastic production and incineration associated emissions, which are a greater threat to climate.

Natalia Gurgacz[1], Karin Kvale[2], Michael Eby[1], Andrew Weaver[1], Sophia Olim[1], Anna Nickoloff[1] [1]University of Victoria [2]GNS Science ngurgaczsafianowicz@uvic.ca

MUL-Oceanic Response to Widespread Ocean Thermal Energy Conversion

Ocean Thermal Energy Conversion (OTEC) is a form of marine renewable energy that harnesses the temperature gradient between warmer surface waters and cooler deep waters to power a heat engine and produce electricity. OTEC has capacity to produce immense amounts of continuously available, renewable energy, although to date the technology has only been implemented in small-scale, pilot plants. Some have proposed widespread implementation of OTEC technology to contribute to the worlds energy needs. Prior to widespread implementation of OTEC technology, the biological, physical, and chemical implications of such a deployment must be quantified. The technology has many prospective benefits, such as the production of renewable electricity and desalinated water, a temporary cooling of surface waters, and a potential increase in biological production stimulated by the upwelling of cool, nutrient rich waters. Nevertheless, there are negative environmental impacts associated with the technology that must be considered. These impacts potentially include the disruption of large-scale ocean circulation patterns and a significant alteration of surface water properties in zones of OTEC upwelling. This study presents several multicentury simulations of the UVic Earth Systems Climate Model version 2.9 to better understand the projected magnitude and significance of the impacts of widespread OTEC implementation.

Anna Nickoloff[1], Michael Eby[1], Sophia Olim[1], Natalia Gurgacz[1], Andrew Weaver[1]
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MUL-Dependence of Climate Responses to on Pattern of Marine Cloud Brightening Interventions

Marine cloud brightening (MCB) is a proposed climate intervention technology in which sea salt aerosol is injected into marine boundary layer clouds with the aim of increasing cloud albedo, increasing the scattering of incoming solar radiation, and cooling the surface. Due to the short atmospheric lifetime of sea salt aerosol, MCB interventions are generally regional in nature. This introduces additional uncertainty in the climate response to MCB, as we must consider inter-model uncertainty in the atmosphere-ocean circulation response to the forcing. Here, we describe simulations in CESM2 and E3SMv2 in which MCB forcings are applied in three regions in the subtropics: Northeast Pacific (NEP), Southeast Pacific (SEP), and Southeast Atlantic (SEA). We find substantial differences in the global mean temperature sensitivity depending on the model and forcing region. In particular, MCB forcing in the SEP induces La Nina-like responses in both models with strong global temperature effect, while SEA forcing results in Atlantic cooling but Pacific warming with weak global mean cooling in E3SMv2 and near-zero temperature effect in CESM2. We find that while MCB reduces the risks to tipping points in most cases, forcing in some regions can instead increase tipping point risk. For example, SEA forcing reduces Amazon rainfall, increasing the risk of Amazon rainforest dieback. Thus, the pattern-dependence of MCB forcing responses must be carefully considered when evaluating MCB intervention scenarios.

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MUL-A data-driven unified stochastic mass flux cumulus parametrization for organized convection

Cumulus parametrization (CP) remains one of the most important challenges in Earth System Modelling. The use the stochastic multicloud model (SMCM), which aims at representing the subgrid variability of organized convection based on the stochastic evolution and interactions of the main cloud types that are associated with tropical convective systems, led to striking improvements in the simulation of the dominant tropical modes of variability such as the Madden-Julian oscillation, monsoons, and convectively coupled waves. However, this early development of the SCMC is based on a simplified CP using empirical heating profiles associated with congestus, deep, and stratiform cloud types. A new stochastic mass flux CP, based on the Zhang-Macfarlane parameterization framework, is thus developed and proposed as a more universally portable extension of the SMCM and is implemented in the NCAR Community Atmospheric Model (CAM). The new CP is designed to handle both shallow and deep convection and couples the two in a stochastic manner. It uses the SMCM to make decisions on the amount of various convection types that can co-exist in a grid column at any given time, and provides an adapted-variable (strength and vertical profile of) convective forcing at each instance and each grid column. The new CP is scale aware as it is based on a finite random number of plumes, which is capped by the number of SMCM microscopic lattice sites and its probability transition rates are inferred from radar data using machine learning techniques.

Boualem Khouider[1] [1]University of Victoria khouider@uvic.ca

MUL-Simulation of Mean state in the NCEP-CFSv2 through a Stochastic Multicloud Model calibrated through Indian Radar Data

Stochastic parameterizations are continuously providing promising simulations of unresolved atmospheric processes for global climate models (GCMs). To better represent organized convection in the Climate Forecast System version 2 (CFSv2), the SMCM parameterization is adopted in CFSv2 in lieu of the pre-existing simplified ArakawaSchubert (CTRL) cumulus scheme and has shown essential improvements in different large scale features of tropical convection. One of the features of earlier SMCM is to mimic the life cycle of the three most common cloud types (congestus, deep, and stratiform) in tropical convective systems. In this present study, a new cloud type, namely shallow cloud, is included along with the existing three cloud types to make the model more realistic. The cloud population statistics of four cloud types (shallow, congestus, deep, and stratiform) are taken from Indian (Mandhardev) radar observations and a Bayesian inference technique is used to generate key time scale parameters required for the SMCM as implemented in CFSv2 (hereafter CFSSMCM-4cloud). The 4- cloud simulation improves many aspects of the mean state climate compared to CTRL, and 3-cloud (CFSSMCM-3cloud, where the three most common cloud types are considered) simulation. Significant improvement is noted in the rainfall PDF over the global tropics. The global distribution of different clouds, mainly low-level and mid-level clouds, is also improved. The 4-cloud simulation shows significant improvement with respect to the double ITCZ (The Intertropical Convergence Zone) problem as well as overall organized convection. The convective and large-scale rainfall simulation is investigated in detail.

Kumar Roy[1], Parthasarathi Mukhopadhyay[2], R Phani Murali Krishna[2], MCR Kalapureddy[2], Boualem Khouider[1], Bidyut Bikash Goswami[3], G Pandithurai[2] [1]University

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Enhancing the analyses and applications of ocean observational and modelling data: Toward development of Made-in-Canada Digital Twins of the Ocean - Part 2 / Improving Ocean Accessibility in the Ocean Decade + Discussion

Thursday, June 1
14:30 - 16:00 EDT

(30 Mins) Model-based state of the ocean in Eastern Canada - Joël Chassé

(15 Mins) Explore CIOOS: Canada's home for ocean observing data - Jonathan Kellogg

(15 Mins) Towards Interoperable Freshwater Data in Canada - Jim M.C. Young

(30 Mins) Discussion on ideas and collaborations toward development of Canada's Digital Twins of the Ocean - Youyu Lu

Canada has a vast holding of ocean data from observations and numerical models (hindcast, forecast and future climate projections). Marine scientists from various disciplines have a long history of utilizing these data for quantifying, understanding and predicting the oceanic changes, developing applications in protecting the ocean environment, ecosystems and fishery resources, and for safe marine transportation and supporting offshore economy activities, etc. These activities well fit the recent international initiatives toward development of Digital Twins of the Ocean (DTO) under the framework of the United Nations Decade of Ocean Science for Sustainable Development. In fact, various projects toward developing DTOs in Canada have been supported in government, academia, NGOs, and the private sector. Besides the demands for data collection and management, and software technology, etc., data analysis and development of applications remain key components for DTO development. This work can greatly benefit from improving knowledge exchange and collaborations among different groups with different expertise. Through a combination of contributed and invited presentations, this session aims to bring together national and international researchers 1) to review the status of available and future development of ocean observation and modelling data; 2) to introduce classical and novel methodologies of ocean data analysis; 3) to present achievements in developing applications for ocean data including the effective presentation of ocean data to end users, and 4) to discuss the collaboration opportunities both nationally and internationally. We welcome both oral and poster presentations.

OCE-Model-based state of the ocean in Eastern Canada

Ocean monitoring is typically conducted during specific months and locations. Therefore large data gaps often exist in the observational system and numerical models are useful to fill data gaps to support the State of the Ocean reporting. This initiative draws on national and international modelling expertise to provide a four dimensional analysis, in space and time, of environmental variables from the atmosphere to the bottom of the ocean in Atlantic Canada. It aims to supplement the reporting based on observational systems which is traditionally conducted under DFOs Atlantic Zone Monitoring Program

(AZMP). Re-analysis from six atmospheric models were used to derive the atmospheric conditions over the ocean while seven ocean models were used to estimate ocean conditions. The covered time periods vary among models but range from 1948 to 2022. Ensemble results of the atmospheric and ocean variables as well as their anomalies from the long-term average will be presented. Biogeochemical conditions will also be presented when available from models.

Joël Chassé[1], Nicolas Lambert[1], David Brickman[2], Guoqi Han[3], Zeliang Wang[2], Diane Lavoie[4], Olivier Riche[4], Jacqueline Dumas[4] [1]Fisheries and Oceans Canada, Gulf Region [2]Fisheries and Oceans Canada, Maritimes Region [3]Fisheries and Oceans Canada, Pacific Region [4]Fisheries and Oceans Canada, Quebec Region Joel.Chasse@dfo-mpo.gc.ca

OCE-Explore CIOOS: Canada's home for ocean observing data

From the Beaufort Sea to the Bay of Fundy, the Canadian Integrated Ocean Observing System (CIOOS) is Canadas nucleus for integrated ocean science and observing activities. Our work with partners from coast to coast to coast is applying internationally recognized standards to consolidate data into a resource for all ocean people. CIOOS makes fully interoperable data available across Canadas ocean basins and, with continued development of new tools to explore the resources, it is now easier than ever to connect the dots and better manage our ocean resources. By improving access to past observations and present data streams, CIOOS is enabling ocean users to make place-based decisions for our ocean future. Join us to learn how CIOOS can help your planning efforts or data management legacy.

Jonathan Kellogg[1], Naomi Boon[2], Brad de Young[1], Andréane Bastien[3], Germain Sauvé[3], Shayla Fitzsimmons[4], Jeff Cullis[4], Pramod Thupaki[1] [1]CIOOS Pacific [2]CIOOS [3]St Lawrence Global Observatory [4]CIOOS Atlantic jonathan.kellogg@hakai.org

OCE-Towards Interoperable Freshwater Data in Canada

In 2019, the Government of Canada committed to establish a federal Canada Water Agency to work with the provinces, territories, Indigenous communities, and other stakeholders in order to find the best ways to keep Canadas water safe, clean, and well-managed.In 2021, Environment Climate Change Canada commenced foundational work to advance development of a national freshwater data management strategy, and in March 2023, a National Freshwater Data Strategy Framework was released. Some of the foundational work included leading a National Freshwater Data Engagement Workshop, and a compilation of a preliminary inventory of existing freshwater datasets. This presentation will describe a potential path forward on the way freshwater data is managed in Canada, with the goal of enabling every Canadian to determine what freshwater data exists, how to easily find and access the data they are looking for, and to support decision-making, innovation, and adaptation activities. With some foundational data principles such as FAIR, TRUST, and CARE, we propose the data strategy principles of quality data, findable accessible data, data stewardship and capacity building. These will serve to underpin the road map for the development of the National Freshwater Data Strategy in collaboration with key partners and stakeholders, including: federal departments, provinces and territories, Indigenous Peoples, non-governmental organizations, academia, and industry. We will map out how the Canada Water Agency plans to work jointly with partners and stakeholders to improve freshwater data discoverability and accessibility across existing platforms to better

develop value-added products and tools.

Jim M.C. Young[1], Daniel Ingram[1], Henry Jupe[1] [1]Enivronment & Climate Change Canada jim.young@ec.gc.ca

OCE-Discussion on ideas and collaborations toward development of Canada's Digital Twins of the Ocean

Under the framework of the United Nations Decade of Ocean Science for Sustainable Development, there are many initiatives related to development of the Digital Twins of the Ocean (DTO). Full development of DTO requires many aspects of work, including data collection and management, software technology, data analysis, and development of client oriented applications, etc. Here we invite participants of this session to discuss ideas and collaborations on enhancing the contributions to the development of Canadas DTO. To stimulate the discussion, we will briefly showcase some of the ongoing work in Canada that could contribute to digital twins, for example, data collection and management (expanded access to ocean data through the Canadian Integrated Ocean Observing System); data analysis (a new project to derive physical indices relevant to marine conservation and protection areas planning based on the results of high-resolution regional ocean models, led by DFO Maritimes).

Hui Shen[1], Youyu Lu[1], Corinne Bourgault-Brunelle[2], Fraser Davidson[3], Mike Smit[4], Pramod Thupaki[5] [1]Fisheries and Ocean, Maritime Science [2]Fisheries and Oceans, Service Desk for Operational Oceanography [3]ECCC [4]Dalhousie University [5]Hakai Institute hui.shen@dfo-mpo.gc.ca

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Gulf of St. Lawrence Tracer Release Experiment (TReX)

Thursday, June 1
14:30 - 16:00 EDT

(15 Mins) TReX Deep: a multidisciplinary, multisectoral and multinational investigation of subsurface waters in the Gulf of St. Lawrence - Douglas Wallace

(15 Mins) Initial tracer dispersion measurements in the TReX deep tracer release experiment - Samuel W. Stevens

(15 Mins) The water-following performance of various Lagrangian surface drifters measured in a dye release experiment - Rich Pawlowicz

(15 Mins) Estimating uncertainties in predicted buoy trajectories at the surface of the Estuary and Gulf of St. Lawrence - Maëla la Ménec

(15 Mins) Surface dispersion of dyed freshwater and drifting buoys in the lower St. Lawrence estuary - Cedric Chavanne

The Tracer Release Experiment (TReX) in the Gulf of St. Lawrence was designed to develop and demonstrate Canadian capacity for the forecasting of contaminant dispersal and biogeochemical transformation in coastal marine environments. It resulted in two field observational programs : a surface experiment in the lower St. Lawrence Estuary, involving the release of a fluorescent dye and Lagrangian drifters at the ocean's surface, and a deep experiment in the Gulf of St. Lawrence,

involving the release of an inert chemical tracer and Lagrangian drifters in deep waters, below the seasonal pycnocline, near Cabot Strait. These observational programs were complemented by numerical predictions of drift and dispersion in the Estuary and Gulf of St-Lawrence and by ancillary sampling of several biogeochemical properties. In this session we welcome theoretical, numerical, and experimental studies related to TReX, or more generally to drift and dispersion processes in coastal marine environments.

OCE-TReX Deep: a multidisciplinary, multisectoral and multinational investigation of subsurface waters in the Gulf of St. Lawrence

The TReX Deep Experiment was built around release of a few hundred grams of an inert, non-toxic chemical tracer (SF5CF3) in the subsurface waters of the Gulf of St. Lawrence, close to the entry point of Atlantic waters through Cabot Strait. The main goal was to examine advection timescales and mixing in subsurface waters that are warming and losing dissolved oxygen due to changing source water composition. The tracer was injected at 275 m in November 2021, and its spreading has been surveyed on three cruises that also allowed measurement of a wide variety of biogeochemical and physical parameters. The project was a joint iniatiative of MEOPAR and the Rseau Qubec Maritime (RQM) and received additional support from a number of other agencies including NRC and DFO. The presentation will explain the objectives of the experiment highlighting the broad diversity of parameters measured by various Canadian and international groups during the surveys. This included measurement of a number of redox-sensitive iodine, nitrogen and carbon compounds including greenhouse gases (N2O, CH4). It also included measurement of stable isotope tracers (H218O and DI13C) as well as oxygen, pH, DIC and alkalinity. The distribution of 129I originating from releases from nuclear waste reprocessing in Europe was measured in the Gulf for the first time.

Douglas Wallace[1], Toste Tanhua[2], Lennart Gerke[2], William Nesbitt[1], Sara Wong[1], Caroline Fradette[1], Chukwuka Orji[1], Adriana Reitano[3], Claire Normandeau[1], Qiang Shi[1], Huixiang Xie[4], Zhaozhao Li[4], Gwénaëlle Chaillou[4], Olivier Hérard[4], Ludovic Pascal[4], Rich Pawlowicz[5], Samuel Stevens[5], Joël Chassé[6] , Adam Drozdowski[6] , Simon Senneville[4], Núria Casacuberta[7], Lorenza Raimondi[7], Marjolaine Blais[6] , Nicolai von Oppeln-Bronikowski[8] [1]Dalhousie University [2]GEOMAR [3]Concordia Univ. [4]ISMER-UQAR [5]Univ. British Columbia [6] Fisheries and Oceans Canada [7]ETH-Zurich [8]Memorial University douglas.wallace@dal.ca

OCE-Initial tracer dispersion measurements in the TReX deep tracer release experiment

The Gulf of St. Lawrence tracer experiment (TReX) is a study that aims to model and observe dispersion and exchange pathways in the local marine environment. For the deepwater component of this project, an inert chemical tracer (SF5CF3) was injected north of Cabot Strait into the inflowing oceanic Gulf source waters on the =27.26 kg m-3 isopycnal (~275 m) during October 2021. Subsequent sampling missions were conducted in June and October 2022, where 205 stations were sampled in total to assess to what extent the tracer had spread through the Gulf. Here, I will present the results of these cruises that show a westward (i.e. inland) transport and general horizontal spreading of the tracer patch, in addition to a vertical spreading of the tracer that is variable in different regions of the Gulf. I will also show data from a handful of neutrally buoyant floats that were constructed to track the initial transport of the tracer

patch.

Samuel W. Stevens[1], Douglas W.R. Wallace[2], Lennart Gerke[3], William A. Nesbitt[2], Toste Tanhua[3], Rich Pawlowicz[1] [1]University of British Columbia [2]Dalhousie University [3]GEOMAR Helmholtz Centre for Ocean Research Kiel sstevens@eoas.ubc.ca

OCE-The water-following performance of various Lagrangian surface drifters measured in a dye release experiment

Recently many different ocean surface drifter designs have been developed to track near-surface currents, but the degree to which these drifters slip through the water due to mechanisms associated with the wind is poorly known. In the 2020 Tracer Release Experiment (TReX), 19 drifters of 8 different designs, both commercially available and home-built, were simultaneously released with a patch of rhodamine dye. Although winds were light, drifters moved downwind from the dye patch at speeds of 3-17 cm/s (0.8 to 4.5% of wind speed) depending on the design type. A simple boundary layer model is developed and used to find horizontal velocities at all heights between those of measured water column speeds and measured winds. Then, a steady-state drag model is used with this profile to successfully predict drifter slip. Drogued drifters are affected by Eulerian shear in the upper half-meter of the water column, as well as the Stokes drift, but undrogued drifters are in addition greatly affected by direct wind drag, and possibly by resonant effects. The dye is largely unaffected by all 3 factors, thus even perfect surface drifters dont move with the mixed layer.

Rich Pawlowicz[1], Cedric Chavanne[2], Dany Dumont[2] [1]University of British Columbia [2]Universite du Quebec a Rimouski rich@eos.ubc.ca

OCE-Estimating uncertainties in predicted buoy trajectories at the surface of the Estuary and Gulf of St. Lawrence

Improving the prediction of search and rescue areas at sea is a major issue. The trajectories of floating objects on the surface are usually predicted by oceanic, atmospheric and wave numerical models. However, the limited spatio-temporal resolution of these models does not resolve all scales of the turbulent flows that affect these trajectories. It is therefore necessary to estimate uncertainties in predicted trajectories to guide search and rescue operations. This is usually achieved by adding a stochastic component to the surface currents predicted by the oceanic model, assuming that the unresolved scales of motions and model errors are both random. Here, using a large number of GPS-tracked surface drifters released in September 2020 during the first surface TReX (Tracer Release Experiment) mission in the lower St. Lawrence estuary, we verify whether this assumption leads to efficient estimates of trajectory uncertainties, or whether some types of model errors need to be accounted for explicitly. Two numerical simulations are used to investigate the impact of the atmospheric model resolution. In both, the oceanic model has a horizontal resolution of 500 m and vertical resolution of 1 m near the surface, and is forced by atmospheric models of either 2.5 km or 250 m horizontal resolutions.

Maëla Le Ménec[1], Cédric Chavanne[1], Dany Dumont[1] [1]UQAR-ISMER Maela.LeMenec@uqar.ca

OCE-Surface dispersion of dyed freshwater and drifting buoys in the lower St. Lawrence estuary

Surface dispersion in the lower St. Lawrence estuary was studied using releases of dyed freshwater and drifting buoys in September 2020 and 2021 as part of the Tracer Release Experiment (TReX). On September 10, 2020, 162 drifting buoys (81 drogued between 10-60 cm depth and 81 undrogued) were released with initial separation distances ranging from 10 m to 30 km across the estuary offshore of Rimouski. On September 11, 2020, 680 L of rhodamine-WT at 2% concentration in a freshwater solution were released about 13 km offshore of Le Bic. Each day from September 5 to 9, 2021, 300 L of rhodamine-WT at 1% concentration were released between 1 and 8 km offshore of Rimouski. For each dye release, photographs of the rhodamine patch were taken from an aerial drone, and vertical profiles of rhodamine concentration were obtained with a Turner Cyclops fluorometer. The rhodamine always remained in the surface mixed-layer, which was less than 10 m deep. The intensity of the red channel in the aerial photographs was best correlated with the rhodamine concentration averaged over the top 4 m. A strain-diffusion model of the surface dye spreading is used to estimate both the turbulent horizontal diffusivity and the large-scale horizontal strain. Horizontal diffusivity values range from 0.7 to 1.3 m/s. In contrast, horizontal diffusivity estimated from the relative dispersion of drifting buoys initially separated by less than 150 m range from 2.2 m/s to 2.6 m/s.

Jean Clary[1], Cedric Chavanne[1], Dany Dumont[1], Rich Pawlowicz[2] [1]ISMER-UQAR [2]UBC
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Sharing lessons learned in collaborative environmental research with communities

Thursday, June 1
14:30 - 16:00 EDT

(15 Mins) Lessons learned from operating satellite-based remote automated weather stations in coastal Labrador - Robert Way

(15 Mins) Lessons learned working across Inuit and western scientific oceanographic knowledge in Nunatsiavut - Breanna Bishop

(15 Mins) Lessons learned in collaborative research with Sikusiutet: the Inuit management committee for SmartICE in Nain, Nunatsiavut - Shawna Dicker

(15 Mins) Community-based monitoring to understand the changing coast and ocean in Jones Sound, Nunavut - Bhatia Maya

(15 Mins) Coastal oceanographic monitoring through collaborations between government, First Nations, and industry in British Columbia - Laura Bianucci

Environmental information is increasingly important to access, use, and understand to support planning and decision making in communities. There are increasing calls for collaborative research with and for communities, with research being operationalized through myriad initiatives that are locally adapted and culturally relevant, such as community-based monitoring and observing programs. While many researchers are interested in working with communities, it can be overwhelming at times to know how to respectfully approach and engage

in this type of research. This can be particularly challenging given the broad spectrum of community-engagement that can take place in environmental research and the lack of an overarching approach that can be applied in diverse settings. Yet, there are novel approaches to conducting research with communities being implemented across Canada. While research with communities presents many opportunities, there are also inherent tensions that must be considered. Reflecting on challenges and opportunities offers valuable insights for researchers wanting to engage with this type of research. This session encourages presenters from diverse research programs that can share lessons learned in working with Indigenous and other local experts (i.e., fishers, and farmers) from communities across Canada.

MUL-Lessons learned from operating satellite-based remote automated weather stations in coastal Labrador

Ongoing and future climate change is predicted to negatively affect northern and Indigenous livelihoods, but current climate and weather observation programs do not adequately support northern Canada. In Labrador, northeastern Canada, isolated coastal communities have historically been significantly underrepresented in climate and weather observing programs. Only three of the regions eight remote fly-in communities have been serviced by Environment Canada weather stations, and many heavily used travel routes lack reliable meteorological coverage. Together with Indigenous, Government, and non-Government partners, the Coastal Labrador Climate and Weather Monitoring Program (CLCWMP) was initiated by the Northern Environmental Geoscience Laboratory to address these challenges by increasing weather observing infrastructure in the region. This project, originally funded through the Indigenous Community-Based Climate Monitoring Program from Crown-Indigenous Relations and Northern Affairs Canada, aimed to enhance weather and climate monitoring infrastructure in coastal Labrador by establishing remote automated weather stations (RAWS) in the vicinity of communities and along heavily used travel routes. Satellite-based RAWS were established in Summer 2019 near the communities of Black Tickle, North West River, Postville, Red Bay, and Rigolet, with a sixth station established along the Trans Labrador Highway in eastern Labrador. Weather observations are transmitted each hour via satellite and are uploaded to public facing web portals that are optimized for community member access. This work will present some of the successes and challenges with the implementation of this ambitious project while highlighting the importance of reliable weather and climate data for northern communities.

Robert Way[1], Rosamond Tutton[2], Eldred Allen[3], Jeffrey Keefe[4], Yifeng Wang[5], Jordan Beer[5], Victoria Colyn[5], Anika Forget[5], Caitlin Lapalme[6] [1]Northern Environmental Geoscience Laboratory, Department of Geography and Planning, Queen's University [2]Global Water Futures, Wilfrid Laurier University [3]Bird's Eye Inc. [4]NunatuKavut Community Council Guardians Program [5]Northern Environmental Geoscience Laboratory, Department of Geography and Planning [6] Independent researcher robert.way@queensu.ca

MUL-Lessons learned working across Inuit and western scientific oceanographic knowledge in Nunatsiavut

Coastal communities in Nunatsiavut, the Inuit self-governing region of northern Labrador, have deep ties to the marine environment. Sea ice acts as an extension of the land, providing critical infrastructure as a travelling and hunting platform for Labrador

Inuit during the sea ice season. Likewise, during the open water season the ocean has been used to travel, hunt, and harvest for millennia. Climate change impacts on oceanographic and sea ice conditions can significantly modify how and when Labrador Inuit are able to safely travel and access the land (inclusive of water and ice). Policy development and decision making in Nunatsiavut must account for these changes, which can be strengthened through including knowledge from both Inuit and western scientific perspectives. Bridging Inuit and oceanographic ways of knowing can offer a robust approach to understanding localized oceanographic processes and change. However, tensions are inherent to working across different ways of knowing, particularly when they stem from different values, interests, and languages of understanding. The ability to recognize and respond to these tensions appropriately is essential to support bringing together Inuit and western scientific oceanographic knowledge. Participatory mapping and interview workshops held in Rigolet, Makkovik, Postville, Hopedale, and Nain in 2019 and 2021 documented Inuit knowledge of ice and ocean conditions, travel routes, and ongoing environmental change. We reflect on lessons learned through these workshops, which over time have required that we adjust, adapt, and revise how we approach participatory research centred on the ice and coastal ocean in Nunatsiavut. An iterative approach to this work has been essential. This allows us to resolve tensions by creating multiple avenues to share perspectives and experiences, support research question identification, address spatial and temporal scales, and explore different approaches to bring diverse knowledges together in meaningful conversation.

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1Dalhousie University, Halifax, Canada
3World Maritime University, Malmö, Sweden

MUL-Lessons learned in collaborative research with Sikusiutet: the Inuit management committee for SmartICE in Nain, Nunatsiavut

SmartICE is an ice monitoring and information service that supports Indigenous communities to safely maintain their hunting and fishing practices during a time of significant environmental and social change (www.smartice.org). SmartICE trains local community members to operate ice monitoring equipment and map local ice conditions with the goal of augmenting - not replacing - Indigenous knowledge (IK). In response to community requests to mobilize their ice IK, the Sikumik Qaujimajjuti (a tool to know how the ice is) program has been co-developed. Indigenous youth are hired to work with local ice experts to learn, document, map, and share ice IK with the community. Youth are then trained to interpret satellite imagery using the ice IK theyve acquired to produce a weekly map of the regional ice conditions for the community. Over the past two years Shawna Dicker and Rex Holwell have worked with Sikusiutet, the Inuit management committee for SmartICE in Nain, Nunatsiavut. Sikusiutet means people of the ice, and is a group of sea ice experts in the community that self-selected their members, named the committee, and developed their own terms of reference. Sikusiutet are the decision-makers for SmartICE in Nain. They determine when and where the SmartICE operators should monitor the ice thoughout the season, and they have also been sharing their ice IK for the Sikumik Qaujimajjuti program in Nain. In this presentation, Shawna and Rex will share their collaborative research experiences with Sikusiutet, providing a unique perspective as they are both Nainumiut (Inuit from Nain).

Katherine Wilson[1], Shawna Dicker[1] [1]SmartICE katherine@smartice.org

MUL-Community-based monitoring to understand the changing coast and ocean in Jones Sound, Nunavut

Glaciers and sea ice are defining coastal features in the Canadian high Arctic. Rapid Arctic climate warming is dramatically altering the nature of these coastlines and adjacent waters through changing atmospheric forcing, declining sea ice and a lengthening open-water season, and accelerating glacier retreat. These changes have a broad range of impacts enhancing glacier meltwater discharge, shoreline erosion and sediment transport, shifting biological productivity patterns, and changing coastal ocean circulation. For the community of Aujuittuq (Grise Fiord), the place that never thaws, these impacts have critical implications for local infrastructure, travel safety and food security. Over the last decade, Aujuittuq community members have noted significant recession of glaciers and erosion of their local beaches, as well as changes in the fiords surrounding their home and hunting grounds. To better understand these changes, since 2021, we have been collaborating with the community to collect year-round coastal observations in Jones Sound, home of the Inuit of Aujuittuq. These observations span from the glacier watershed to the ocean, and include a range instruments (drones, time-lapse cameras, current profilers, multi-channel water column loggers, oceanographic moorings) and analyses (numerical models, water quality parameters, and phytoplankton characterization) to understand how meltwater contributions, the land surface, the shoreline, and the coastal ocean are changing. In 2022, we worked with 12 local youth, adults, and elders to make these observations. Our efforts aim to establish a long-term, community-led monitoring program centered around the co-consideration of Indigenous and scientific knowledge to understand ongoing change in high Arctic coastal environments.

Bhatia Maya [1], David Didier [2], Erin Bertrand[3], Terry Noah[4], Jimmy Qaapik [5], Andrew Hamilton[1], Stephanie Waterman[6] , Paul Myers[1], Charles Bonneau[2], Maria Cavaco[1], Danielle Halle[7], Ana Heras Duran[1], Claire Parrott[6] , Charlotte Stancu[2], Daniella Walch[2], Patrick White[1], Megan Roberts[3], Patrick Williams[1], Eric Brossier[8], France Pinczon du Sel[8], David Burgess[9], Jordan Eamer[9], Alexandre Normandeau[9], Luke Copland[10], Annie Eastwood[11] [1]University of Alberta [2]University of Quebec at Rimouski [3]Dalhousie University [4]Ausuittuq Adventures [5]Community of Aujuittuq [6] University of British Columbia [7]University of Waterloo [8]S/Y Vagabond [9]Geological Survey of Canada [10]University of Ottawa [11]Oceans North mbhatia

MUL-Coastal oceanographic monitoring through collaborations between government, First Nations, and industry in British Columbia

Monitoring ocean conditions is crucial to understand physical and biogeochemical dynamics and how these change with time. The observations resulting from monitoring programs can be studied and analyzed on their own and can also contribute to the initialization, forcing, and/or evaluation of ocean numerical models. Not only these ocean observations can support science, but also decision-making at many levels (local, regional, national). Unfortunately, even while technological progress has made instrumentation smaller, cheaper, and more accurate than ever, sampling the ocean still remains an expensive and challenging endeavour. The latter is particularly true for the coastal ocean, where the complex geography can lead to heterogenous dynamics within relatively small spatial scales, requiring more observations to provide meaningful coverage both in space and time. The west coast of Vancouver Island (WCVI) is a great example of such a region, where the glacially-modified coastline hosts a large array of fjords, inlets, and channels, some of which present different physical-biogeochemical dynamics despite their proximity (e.g., a seasonally hypoxic fjord neighbouring a normoxic one). It is prohibitively expensive and impractical for a government laboratory

or academic institution to design an ocean monitoring program where their staff go out and sample multiple coastal regions at least monthly. However, by collaborating with local communities and industries, higher resolution sampling of the coastal ocean can be envisioned, benefiting all partners. In this presentation, I will describe two ongoing efforts to achieve such collaborative monitoring in the WCVI, highlighting challenges, opportunities, and lessons learned along the way.

Laura Bianucci[1], Glenn Cooper[1] [1]Fisheries and Oceans Canada laura.bianucci@dfo-mpo.gc.ca

Posters

Below are abstracts and link to pdf copy of poster if available. Please adjust view size of posters to fit your device.

ATM1: Fine-scale factors associated with precipitation type transitions during a winter storm over southern Québec, Canada.

Forecasting freezing precipitation is challenging as it is formed at temperatures near 0C. The type of precipitation reaching the surface depends on the atmospheric conditions aloft, which can vary spatially and temporally during storms. The 2022 Winter Precipitation Type Research Multi-Scale Experiment (WINTRE-MIX) field campaign was held in the St. Lawrence Valley, Quebec, Canada, to document various precipitation types. During the campaign, which ran from 1 February to 15 March 2022, many types of winter precipitation were reported throughout a total of 11 Intensive Observations Periods. On 22-23 February 2022, a long-duration winter storm associated with many types of precipitation was documented. Mainly ice pellets were reported north of the domain, whereas the sites located approximately 80 km south of it only reported freezing rain. The study aims to investigate the fine-scale factors leading to precipitation type transitions along the St. Lawrence Valley during this event. Surface measurements and soundings from Sorel show an increase in both the 2-m temperature and the melting layer thickness. Furthermore, higher precipitation rates seemed to favour the production of ice pellets instead of freezing rain. Small ice crystal, such as needles and columns, were also observed throughout the event. This could imply secondary ice production. These findings suggest that the fine-scale processes were probably responsible for the precipitation type transitions, and highlights the degree of details needed to accurately forecast precipitation types when the temperature is near 0C.

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ATM2: Hailstorm Nowcasting with a Random Forest Model in the Midwestern United States

With approximately 5,000 hailstorms and $11 billion insured hail-related damages a year in the United States alone, timely and accurate hail prediction has significant societal and economic benefits. The nowcasting of hail events remains a challenge in operational meteorology due to the limitation of both extrapolation-based techniques and of existing numerical weather prediction (NWP) models on mesoscale convective weather and the complex interactions of factors relevant to the production of hailstorms. We investigated the possibility and skill of a machine learning method called Random Forests (RF) to nowcast hailstorms. This study applies the RF algorithm to nowcast hails in the Midwestern United States. Hail reports from NOAAs Storm Event Database between May and August from 1999 to 2003 are used to screen out 240 severe hail days. The hail nowcasting model is constructed with 35 relevant parameters and indices derived from the reanalysis data of the European Centre for Medium-Range Weather Forecasts (ECMWF) and the radar data from the Multi-Year Reanalysis of Remotely Sensed Storms (MYRORSS) project during the same period. The model computes the

Maximum Estimated Size of Hail (MESH) for three forecast horizons of 15-min, 30-min, and 60-min, as we expected that the most skillful predictors shifted from radar-derived to model-derived ones with increasing lead times. Initial results on the nowcasting skill and most valuable predictors will be presented.

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CLM1: Impact of Marine Heatwaves on Atmospheric Rivers along the Coast of California

The coastal climate of California is profoundly affected by the ocean, which moderates its hot summers and provides moisture for much-needed winter rain. Large-scale anomalies in the atmospheric circulation on seasonal to interannual timescales create persistent anomalous ocean conditions such as marine heat waves (MHWs), which subsequently influence aspects of weather patterns such as atmospheric rivers (ARs) on synoptic time scales. This study examines the dynamic and thermodynamic mechanisms that control these multi-scale coupled processes and evaluates their effects along the coast as well as in interior mountain regions of California. Here, we present a preliminary analysis based on observations and large-ensemble, high-resolution regional coupled model simulations targeting several landfalling ARs interacting with warm surface ocean anomalies during the prominent winter 2014/2015 MHW in the Northeast Pacific. Sensitivity simulations are conducted where the MHW feature in the upper ocean is removed in the oceanic component of the model to quantify the coupled impacts of MHWs on synoptic-scale precipitation, wind, clouds, and sea level. Initial results show that MHWs lead to a robust increase in rainfall intensity associated with landfalling ARs primarily via induced enhanced upward turbulent heat fluxes, increasing boundary layer convective available potential energy and thus ARs moisture transport. The initial results also indicate noticeable shifts in the landfalling locations of the ARs, although the statistical significance of the shift is yet to be evaluated from large ensemble simulations. Implications for short-term predictions of the California coastal climate will be discussed.
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CLM2: Mechanism and Predictability of the Gulf Stream Position Variability

Western boundary currents (WBCs) are regions of the largest ocean variability. WBC variability has been shown to impact many socioeconomically important aspects of the earth system, including extreme weather, sea-level rise, and coastal ecosystems. Despite the importance of WBC variability, some of the largest ocean biases in coupled ocean-atmosphere climate models are observed in these regions. One such WBC is the Gulf Stream, the WBC of the North Atlantic, which transports heat poleward along the east coast of North America. After its separation near Cape Hatteras, the Gulf Stream exhibits strong variability in the meridional shift of its path at interannual and decadal timescales. Standard resolution climate models encounter high biases over the Gulf Stream, ultimately translating to low prediction skill in climate prediction simulations. In this work we compare simulations from a standard resolution climate model (CESM1-Large Ensemble, nominal 1˚ resolution in the ocean and atmosphere) and a high-resolution climate model (CESM-High Resolution, 0.25˚ atmospheric resolution, 0.1˚ oceanic resolution) with the goal of investigating whether increased model resolution better captures Gulf Stream path variability. We then assess the prediction skill of each simulation against an SSH based observational Gulf Stream index at lead times up to 10 years, aiming to clarify the driving mechanisms of the Gulf Stream path variability and the sources of predictability in each model.

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CLM3: Stochastic Multicloud Model With Coupled non-precipitating Cumulus

Despite advances in computation, current global climate models fail to resolve variability associated with organized convection in the tropics. It is largely understood that this un-captured variability is to due to subgrid heating caused predominantly by clouds associated with tropical convection. Newly developed models have been shown to better capture large scale tropical instabilities using cloud heating profiles(Khouider, 2006; Waite, 2009) or cloud birth-death processes on subgrid lattices(Khouider, 2010). Both of these approaches only include stratiform, congestus and cumu- lonimbus cloud populations. A fourth cloud type, shallow, non-precipitating cumulus, have been shown to play a vital role in boundary layer pre-moistening for the development of precipitating congestus and cumulonimbus aside from non-negligible radiative feedback(Johnson, 1997). A new stochastic 4-multicloud model is proposed, with two baroclinic modes of vertical structure and incorporating fully coupled shallow cumulus, along with a new equation for boundary layer potential temperature. This allows for the differentiation between surface flux of sensible and latent heat suitable for the study of diurnal cycles in land regimes. A stability analysis of the new parameter space is conducted, including shallow cumulus coupling. Finally, linear stability analysis is conducted to identify various instabilities of the radiation convection equilibrium compared to previous multicloud models.

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CLM4: Tropospheric CO in the Indian Ocean region: An analysis of seasonal and long-term variability

The purpose of this project is to determine and explain the variability and long-term trends in tropospheric carbon monoxide (CO) in the region above the Indian Ocean. Variability on both seasonal and inter-annual time scales is investigated, with a focus on the potential driving factors such as horizontal and vertical transport, emissions from large events such as fires, as well as chemistry via the interactions of CO with water vapour. This analysis is conducted using CO data from the Measurement of Pollution in the Troposphere (MOPITT) satellite instrument, emissions from the Emissions Database for Global Atmospheric Research (EDGAR), fire counts from the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite instrument, and water vapour data from the Atmospheric Infrared Sounder (AIRS) satellite instrument. The Flexible Particle Dispersion Model (FLEXPART) transport model is used to examine the impacts of horizontal and vertical transport on the distribution of CO. Long-term trends of CO are derived for key regions in the Indian Ocean basin representing coastal and open ocean environments. We find that despite the continued increase in anthropogenic CO emissions from neighbouring landmasses, CO over the Indian Ocean continues to decrease, possibly due to changes in vertical transport and atmospheric loss processes.

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MUL1: A new satellite-based product for studying land-atmosphere interactions

Improving our understanding of the energy and water exchanges between the land surface and the lower atmosphere (i.e. land-atmosphere interactions), and how climate change may affect them, is crucial to analyze changes in temperature and precipitation extremes. Observations of energy and water fluxes at the land surface are typically retrieved from the eddy covariance method, which presents limitations related to spatial and temporal gaps, and the non-closure of the energy and water balances. Here, we aim to improve the spatial coverage of land-atmosphere interactions data ensuring the energy and water balance closure by exploring the combination of remote sensing data and a physical-based model. The High resolution Land Atmosphere Parameters from Space (HOLAPS) framework is a one dimensional modelling framework that solves the energy and water balance at the land surface using remote sensing data and reanalysis products as forcings. We used HOLAPS to produce hourly estimates of energy and water fluxes over Europe at 5km resolution. Preliminary results from the evaluation of HOLAPS outputs show an improvement in the simulation of latent heat flux when using remote sensing data in comparison with results using only reanalysis data as forcing. Additionally, we see a moderate improvement in HOLAPS latent heat flux estimates against energy-balance corrected eddy covariance measurements in comparison with other products that solve the energy and water balance equations, such as the ERA5Land product. These estimates can have several applications in the agriculture and forest management sectors and in the evaluation of weather and climate models over Europe.

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MUL2: A new scale-aware non-quasi-equilibrium mass flux scheme

The representation of clouds and organized tropical convection remains one of the biggest sources of uncertainties in climate and long - term weather prediction models. Some of the most common cumulus parameterization schemes, namely, mass - flux schemes, rely on the quasi - equilibrium (QE) closure proposed by Arakawa Schubert (1974), which assumes that convection consumes the large - scale instability and restores large - scale equilibrium instantaneously. However, the QE hypothesis has been challenged both conceptually and in practice, especially at so-called grey-scale horizontal resolutions of around 10km, where the cloud fraction can no longer be assumed small, and may vary significantly with time. Following Pan and Randall (1998), Khouider and Leclerc (2019) relaxed this hypothesis by couplingprognostic equations for the cloud work function (CWF) and the cumulus kinetic energy (CKE) to mean field equations for the cloud area fraction (CAF) derived from the stochastic multicloud model (SMCM) . Here, the resulting scale-aware and non-QE cumulus parameterization, comprising of the CWF-CKE evolution equations coupled to the SMCM mean field equations, is tested in an idealized single column climate model; a system of PDEs coupling the large-scale thermodynamic equations for static energy and water vapour to the new non-QE cumulus parametrization equations with evolving CAF. The equations are then analyzed numerically and analytically to explore their physical features and their potential to overcome the QE dilemma. Preliminary results from this analysis will be shown.

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MUL3: Artificial Neural Network Retrievals of Arctic Sub-Surface Temperature Profiles Using Passive Microwave Satellites

Passive microwave satellite measurements are an integral component to global weather forecast models and reanalysis products, but are difficult to incorporate effectively at high latitudes due to uncertainties in surface emissivities, especially over snow-covered surfaces. Microwave emissivities are typically retrieved assuming a single effective surface temperature for all frequencies. This causes emissivity bias if microwave penetration depth and surface temperature gradients are large, as is typically the case over snow-covered surfaces. An implementation of retrieving frequency-dependenteffective surface temperatures using artificial neural networks will be presented. Spatial and temporal features of the effective temperature profiles from this retrieval will be demonstrated, and a comparison to in-situ buoy measurements over Arctic sea ice will be used for validation of this approach.

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MUL4: Climatology of the synchronism of late spring frost with sensible phenological stages of five major horticultural crops in Quebec

Synchronism of late spring frost with sensible phenological stages may lead to significant damages to the major horticultural crops in Quebec. In order to prevent frost associated damages, irrigation is a commonly used practice requiring important volumes of water early in the growing season. This project aims to evaluate the climatology associated with flower-frost synchronism in order to provide an estimation of current and future water needs related to frost protection for strawberries, raspberries, blueberries, grapevines and cranberries. Different phenological models developed at AAFC, using calibrated models of thermal accumulation (degree-days), and gridded daily temperature values were used in order to determine the occurrence of flower-frost synchronism. Two historical climate dataset (NRCan, ANUSPLIN and the Canadian Regional Deterministic Reanalysis System v2.1) were evaluated to estimate the influence of the climate information on frost damage risks. We will present regional climatology statistics for the five major horticultural crops and trends observed in the recent climatic periods. Evaluation of the frost length using hourly values from a subset of weather stations was used as a proxy to determine the average water needs during an event. This approach allows to refine the agroclimatic indices relevant to the selection of crop varieties and appropriate protection methods in regions susceptible to spring frost damages. These results will be integrated in a tool destined to evaluate broader water needs (frost protection, irrigation, animal watering, washing water, etc.) in order to limit potential conflicts of water use.

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MUL5: Correlative Ground-based Observations at the St. Mary's University Atmospheric Observatory in Halifax, Nova Scotia

Air quality, weather and climate related variables are routinely monitored from space. Space-based earth observations require correlative measurements for calibration and validation purposes from sub-orbital and ground-based platforms. The Saint Marys University Atmospheric Observatory (SAO) was established, in part, to provide high quality and long-term data sets for this purpose. The observatory began operations in 2019 in Halifax in a coastal but urban setting with an Open-Path Fourier Transform InfraRed (OP-FTIR) spectrometer acting as its principal instrument. OP-FTIR spectroscopy is an established technique used to measure boundary layer trace gas concentrations (O3, CO, HCHO, CO2, CH4, N2O and other infrared-active species)

using an active IR source, a spectrometer and a retroreflector array separated by an atmospheric path. Complementing the trace gas measurements, aerosol concentrations are measured by a co-located PurpleAir sensor while a ground-based Micro-Pulse Lidar (mMPL) system is deployed at Sandy Cove (26 km south of SAO) and provides data on cloud and aerosol properties. The MPL is part of the MPLNET/MPLCAN lidar networks. This suite of measurements is under development to form a semi-autonomous ground-based observing system suitable for satellite validation. In particular, the active OP-FTIR measurements are well suited to validate current TROPOMI and upcoming geostationary TEMPO satellite measurements of HCHO and other species, while the active mMPL measurements are useful in future HAWC mission validation. HAWC stands for High Altitude Water vapour and Clouds and is scheduled to launch closer to 2031. We discuss results from SAO and Sandy Cove from September 2022 to April 2023.

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MUL6: Evaluation of hydrometeorological processes during the winter-spring transition using the Canadian regional climate model

In cold regions such as Quebec, modeling hydrological processes requires sophisticated land-surface schemes and very fine spatial resolution to well simulate local processes such as the depth of the snowpack and heavy precipitation events. Convection permitting models (CPMs) are promising tools to improve the representation of land-atmosphere interactions at small scales since they explicitly resolve deep convection and, due to their high horizontal resolution (4 km), they describe more accurately surface forcings including complex terrains. This study aims to evaluate the ability of the CPM version of the Canadian Regional Climate Model (CRCM) at 0.025 (~2.5 km) currently in development at the ESCER Center (UQAM, Quebec) to reproduce the main hydrometeorological processes responsible for winter-spring transition in southern Quebec (Canada). The focus is on the occurrence and phase of winter precipitation as well as snowpack accumulation and ablation during the transition into spring. A five-year simulation from September 2015 to August 2020 is compared to high-resolution data derived from weather stations, satellite data, and reanalysis products. Several variables are analyzed, such as temperature, precipitation, evapotranspiration, runoff, and snow water equivalent of the snowpack. Preliminary results show a positive bias in monthly mean temperatures from June to February leading to a late onset of snow cover and an underestimation of precipitation falling as snow during winter. As a result, the model underestimates the annual maximum of snow water equivalent of the snowpack, which leads to an early melt in spring and substantial issues with the timing of floods.

MUL7: Evaluation of precipitation over eastern Canada using explicit and parametrized representation of convection

Precipitation results from complex physical processes and interactions, in which atmospheric convection often plays a significant role. The representation of convection has been identified as one of the primary sources of incertitude in weather and climate models. Convection permitting models (CPMs) use a horizontal grid spacing finer than 4 km and are often run using an explicit representation of convective processes, by turning off the parametrization of deep convection. This study aims to assess the performance of two configurations of the CPM version of the Canadian Regional Climate Model (CRCM6/GEM5), one using an explicit representation of deep convection

and the other using a parametrization, to represent precipitation over eastern Canada. We assess errors in precipitation using a recently developed methodology, called environmental-conditioned intensity-frequency decomposition, which consists of separating frequency and intensity of precipitation errors according to different dynamical (vertical speed) and thermodynamical (vertically integrated water vapor) regimes. Our reference product is the Integrated Multi-satellitE Retrievals for GPM (IMERG). Preliminary results show that simulations produce precipitation too often and too weak for moderately dry regimes while the opposite occurs for wet regimes. Differences between the two configurations are mostly evident during summer months when the convection is dominant, with the explicit simulation showing a higher intensity of precipitation and a lower occurrence. The methodology seems promising to assess future changes in precipitation to quantify dynamical and thermodynamical contributions to the total precipitation changes.

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MUL8: McGill Real-time Ice Nucleation Chamber (MRINC): Deciphering Supercooled droplets from the Ice Crystals in Mixed-phase Cloud Regime

Clouds physicochemical processes influence the Earths radiative budget. Atmospheric ice-nucleating particles (INP) play an essential role in determining the optical thickness, lifetime, and phase of clouds (mixed-phase and cirrus clouds). Despite significant advancements in the fundamental understanding of different ice formation processes in the last decades, the ice phase in clouds still contributes to substantial uncertainty in climate model predictions of the radiative forcing. We introduce a newly developed portable McGill Real-time Ice Nucleation Chamber (MRINC) for studying ice nucleation processes of nano to micron-sized particles in situ in real-time. The MRINC allows measuring INP concentrations under conditions pertinent to mixed-phase cloud temperatures from about 10 C to about 38 C. The MRINC is coupled with aerosol sizers (6 nm to 10 m) and a Nano-Digital In-line Holographic Microscope (Nano-DIHM) to record the size distribution, phase, and shape of INPs. The characterization includes determining aerosol particles size, shape, morphology, phase, and surface properties. We have shown preliminary results as proof of concept, where Nano-DIHM coupled with MRINC successfully distinguished silver iodide nucleated ice crystals and supercooled droplets in real time. We also provide an example of real-time capturing of the growth of sodium chloride (NaCl) and ammonium sulphate ((NH4)2SO4) aerosol particles in controlled temperature and humidity conditions using MRINC. We will discuss the usage of MRINC for research on cloud condensation, ice nucleation analysis, and potential radiation properties.

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MUL9: Remaining carbon budget estimation under terrestrial nutrient limitation

The terrestrial carbon cycle representation in Earth system models is critical for accurately estimating the remaining carbon budget. On land, nutrient limitation has a core regulation on the amount of carbon fixed by terrestrial vegetation. It is therefore necessary to add nutrients such as nitrogen and phosphorus to land model structures in Earth system models. As a result, the estimation of the remaining carbon budget is significantly affected by the regulation of nutrient limitation in terrestrial ecosystems, but it is rarely taken into account. Here, we estimate the carbon budget and remaining carbon budget of a nutrient-limited Earth system model, using nitrogen and phosphorus cycles to limit vegetation productivity and biomass. We used the University of Victoria

Earth system Climate Model under terrestrial nitrogen and phosphorus cycle in various Shared Socioeconomic Pathways scenarios on three distinct model structures: 1) carbon cycle without nutrient limitation, 2) carbon cycle with terrestrial nitrogen limitation and 3) carbon cycle with terrestrial nitrogen and phosphorus limitation. Overall, we found that nutrient limitation reduced the carbon budget for all simulations compared to a carbon cycle without nutrient limitation. The nitrogen and nitrogen-phosphorus limited simulations reduce the remaining carbon budget by 9.5 and 15.7% for the 2 C target compared to the no nutrient limitation simulation. These results demonstrate the importance of considering terrestrial nutrient limitations when estimating or interpreting remaining carbon budgets and that nitrogen and phosphorus limitation are an integral uncertainty of carbon budgets in Earth system models.

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MUL10: The Great Dusty North?

We present results from analysis of multiple satellite-derived long-term aerosol datasets to identify the presence of mineral dust in the atmosphere over Canada. Datasets analysed include Dust Optical Depth (DOD) derived from MODIS Deep Blue AOD retrievals (L2, 0.1x 0.1), and both absorbing aerosol index (AAI) and aerosol layer height (ALH) from TROPOMI (L2, 3.5 km x 5.5 km). Our aims are twofold: firstly, to identify atmospheric regions where dust is most frequently detected; and secondly, to identify potential dust source areas at the surface. We examine maps of frequency of occurrence (FoO) wherein an indicator exceeds a specified threshold. This identifies dust hotspots that can otherwise be overlooked owing to temporal averaging, a consequence of the relatively low dustiness at high latitudes as compared to the lower latitude dust belt. Our analysis reveals multiple areas of relatively high FoO (> 5 % days in the multi-year study period) across most provinces. Isolated hotspots in northern regions are indicative of local sources, and we present case study images for some of these. Finally, we leverage the 20-year record from MODIS to evaluate temporal change in the frequency with which dust is present in the atmosphere above Canada. The results are of use both for guiding the study of dust aerosol impacts on air quality, weather, and climate in the atmosphere over northern Canada; and also for improved simulation of regional dust emissions.

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MUL11: The IceShark – an Answer to Effective Horizontal Plankton Tows Under the Sea Ice

With climate change increasing the unreliability of subarctic sea ice along the coast of Nunatsiavut, Labrador, communities are facing unprecedented uncertainties surrounding social, cultural, and economical sustainability. This is worsened by the current knowledge gaps surrounding ice loss and its effects on coastal ecosystems, given that field sampling and observations are limited by the physical barrier of the sea ice and weather extremes. This is especially problematic for plankton where collection methods have largely been limited to vertical plankton tows, which underrepresent the ice-seawater interface. This has restricted observations of zooplankton and their interaction with ice algae as well as the evolution of phytoplankton and ice algae composition as a function of sea ice condition. As part of the Sustainable Nunatsiavut Futures project, a battery-operated net-plankton sampler that has been developed to increase the understanding of plankton dynamics under the ice. Dubbed the IceShark, this apparatus imitates a horizontal plankton tow in surface waters whilst remaining

stationary, with minimal disruption to the ice-seawater interface. Here we present the design, development, and initial testing of the IceShark in several locations along the coast near Nain, Nunatsiavut. Keywords: Plankton, Sea Ice, Climate Change, Nunatsiavut, Nain

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OCE1-Drift modelling to estimate at-sea losses of Northern Gannets during the Highly Pathogenic Avian Influenza outbreak of 2022 (first wave)

During the spring and summer of 2022, a Highly Pathogenic Avian Influenza (HPAI) outbreak resulted in an unprecedented mass mortality event for seabirds across the Northern Hemisphere. In eastern Canada, tens of thousands of sick and dead Northern Gannets were reported on beaches and at breeding colonies. Comprehensive mortality estimates for Gannets are needed to assess population impacts, however, current estimates do not account for at-sea losses. We used drift modelling to estimate at-sea losses and thus generate a more comprehensive estimate of total mortality for Northern Gannets. Modelled drift trajectories were generated using operational atmospheric model forecasts, ocean model outputs (e.g. Coastal Ice-Ocean Prediction System for the East Coast of Canada (CIOPS-E)), and drift prediction tools (e.g. ModleLagrangiende Dispersion desParticulesdordren (MLDPn)) developed for operational applications within the Government of Canada.

OCE2: A model intercomparison provides new insights into carbon cycling in the water of the Canadian Arctic Archipelago

The Arctic Ocean is experiencing rapid changes in terms of sea ice seasonality and properties, freshwater inputs by ice melt and terrestrial runoff, stratification and mixing. These physical changes impact biogeochemical cycles in the Arctic Ocean, including the carbonate system. Numerical models are useful tools to assess these changes in the carbon system. However, the complexity of the models used varies, which might impact modelled results. To quantify these intra-model variations, we use three biogeochemical models, set up and run by different research groups. All models were forced with the Drakkar Forcing Set 5 (DFS5) atmospheric forcing for the year 2015 and run on the NEMO ocean modeling framework. The three carbon modules are Biogeochemistry with Light Iron Nutrients and Gases (BLINGv0+DIC), Canadian Ocean Ecosystem with Canadian Sea Ice Biogeochemistry (CANOE-CSIB) and the Pelagic Interactions Scheme for Carbon and Ecosystem Studies volume 2 (PISCESv2). Additionally, differences in the Louvain-La-Neuve sea Ice modules versions 2 and 3 (LIM2 and LIM3) are highlighted for the studied region.

We focus on the Gulf of Amundsen and Baffin Bay. The model results are compared to satellite-based chlorophyll-a, sea-ice concentration and temperature data for performance assessment. All models compare well with the satellite observations. Seasonal patterns in the carbonate system are similar between models. However, variations in each models carbon chemistry exist. We show differences in monthly carbon cycle dynamics, dissolved inorganic carbon (DIC), alkalinity (ALK) and partial

pressure of carbon dioxide (pCO2), to highlight impacts of each models complexity in their carbon modules.

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OCE3: Assessing pH as a master parameter for Monitoring, Reporting, and Verification of Ocean Alkalinity Enhancement

Ocean alkalinity enhancement (OAE) is a promising carbon dioxide removal (CDR) strategy requiring reliable carbon system parameter measurements through which the effectiveness of this CDR approach will be assessed. Monitoring, Reporting, and Verification (MRV) of OAE-CDR will require a well-constructed framework that combines direct field observation and regional-scale data-assimilative modeling. Of the four measurable carbon system parameters, pH shows promise as a master variable for MRV. First, pH distributions resulting from alkalinity addition can be measured from various observing platforms (AUVs, moorings, buoys) and utilized alongside discrete sampling to resolve the spatial and temporal scales needed to characterize alkalinity addition. Here we present the performance of different potentially suitable pH sensors in a number of experiments, including comparison against discrete samples for accuracy assessment. Furthermore, to assess the additionality effect of OAE, the perturbed conditions will have to be compared against a baseline constructed upon a variety of carbon system data collected over the years. To that effect, internal consistency, and discussion of the methodology of spectrophotometric pH measurement are presented by analysis of an overdetermined carbon system dataset collected in June 2022 as part of the Tracer Release Experiment (TReX) cruise in the Gulf of St. Lawrence. Characterization of pH sensor technology against discrete bottle samples will be addressed on the basis of controlled laboratory experiments and field work collected in the Bedford Basin during bimonthly surveys.

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OCE4: Autonomous eDNA Sampler for in situ Monitoring of Aquatic Environments

Climate change and industrialization have significantly impacted the Ocean. These impacts include a reduction in species population, increased frequency of harmful algae blooms and unusual species migration patterns. All of which can have devastating effects on the economy and the environment. These ecosystem effects can be limited if the changes are tracked and acted upon swiftly. eDNA analysis paired with an eDNA sampler provides a cost-effective solution to cover large geographical areas and perform a temporal analysis of microbial species. Here we present a novel autonomous eDNA sampler capable of performing long-term deployments with self-cleaning and sample preservation capabilities. There have been several deployments utilizing this eDNA sampler. One such deployment was conducted at multiple sites along Halifaxs Bedford Basin. This deployment directly compared the sampling ability of the eDNA sampler to the traditional Niskin bottle approach. The two collection methods returned the same top 10 families in near identical relative abundance, demonstrating that the sampler could capture the same community composition of common microbes as the Niskin. This system can be expanded to allow for wide-scale species monitoring on buoys and UAVs to survey species population changes due to climate change and industrial effects such as overfishes and construction.

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OCE5: Canada's marine carbon sink: An early career perspective on the state of research and existing knowledge gaps

Improving our understanding of how the ocean absorbs carbon dioxide is critical to climate change mitigation efforts. We, a group of early career ocean professionals working in Canada, summarized current research and identified steps forward to improve our understanding of the marine carbon sink in Canadian national and offshore waters in a perspectives paper submitted in the fall. We compiled an extensive collection of reported surface ocean air-sea carbon dioxide exchange values within each of Canadas three adjacent ocean basins. Here we highlight conclusions from that perspectives paper and identify major challenges limiting our understanding in the Pacific, the Arctic, and the Atlantic Ocean. We focus on ways of reducing uncertainty in estimating Canadas marine carbon sink to establish baselines for proposed marine carbon dioxide removal projects, and to inform ocean acidification mitigation and adaptation efforts. Future directions recommended by this group include enhanced collaboration between observation and modelling communities, maintaining and expanding continuous monitoring efforts to improve observational coverage, investing in training and development opportunities for early career ocean professionals, institutional restructuring to support diverse voices in our field, and strongly advocating for co-generation of knowledge with First Nations.

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OCE6: Canadian Atlantic Shelf Temperature-Salinity (CASTS) data product: A century of hydrographic observations in the Northwest Atlantic and Eastern Arctic

As part of the new Fisheries Act, Fisheries and Oceans Canada (DFO) has prioritized the dissemination of its data publicly. The Canadian Atlantic Shelf Temperature-Salinity (CASTS) data product supports this initiative by making openly available most of the historical temperature and salinity profiles collected in Atlantic Canada and the Eastern Arctic over the last century. This project does not aim to replace a potential database, but rather provide an easily accessible and quality-controlled product that can be easily utilized with minimal work by the user. The CASTS data product consists of approximately 750,000 individual casts collected in a geographical zone corresponding

to 35-80N and 42-100W between 1912 and 2022. Multiple data sources were combined to make this product, including regional archives at the Maurice-Lamontagne Institute (DFO-QC), the Bedford institute of Oceanography (DFO-MAR) and the Northwest Atlantic Fisheries Centre (DFO-NL). Other sources of data include DFO-NL Aquaculture, NEFSC, NCEI-GTSPP, CIOOS-ERDDAP, and the Polar Data Catalogue. This initiative can be used to inform fisheries management and supports DFO priorities such as the Ecosystem Approach to Fisheries Management, Marine Spatial Planning, and the Blue Economy. Such data products also offers new opportunities to review the changes in Atlantic Canadas ocean climate, which is another priority of the Government of Canada.

OCE7: Drift modelling to estimate at-sea losses of Northern Gannets during the Highly Pathogenic Avian Influenza outbreak of 2022 (first wave)

During the spring and summer of 2022, a Highly Pathogenic Avian Influenza (HPAI) outbreak resulted in an unprecedented mass mortality event for seabirds across the Northern Hemisphere. In eastern Canada, tens of thousands of sick and dead Northern Gannets were reported on beaches and at breeding colonies. Comprehensive mortality estimates for Gannets are needed to assess population impacts, however, current estimates do not account for at-sea losses. We used drift modelling to estimate at-sea losses and thus generate a more comprehensive estimate of total mortality for Northern Gannets. Modelled drift trajectories were generated using operational atmospheric model forecasts, ocean model outputs (e.g. Coastal Ice-Ocean Prediction System for the East Coast of Canada (CIOPS-E)), and drift prediction tools (e.g. ModleLagrangiende Dispersion desParticulesdordren (MLDPn)) developed for operational applications within the Government of Canada.

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OCE8: Exploring the definitions of predictive skill and loss in machine learning

Thompson and Sheng (1997) provide a measure of prediction skill (gamma-squared) that has been widely applied. The key aspect is the difference between a numerical forecast and observations, expressed as variance and normalized by observation variance. The same key aspect (i.e., prediction-obs difference) typically defines loss in neural network training. For all types of predictions (numerical forecast and neural network), we generally look for smaller prediction-obs differences as an indication of better predictive performance. However, perhaps moreso than for loss in machine learning, gamma-squared is amenable to exploration. We introduce a model of the prediction and observation measurements, and express gamma-squared in these terms. Predictions and observations are thus associated, but only by way of what they both measure. Specifically, linear association, nonlinear association, and a lack of association (i.e., numerically separable signal-and-noise terms, whose interpretation is based on signal) permit an interpretation of predictive skill to be explored in some detail. Thompson, K. R., and Sheng, J. (1997), Subtidal circulation on the Scotian Shelf: Assessing the hindcast skill of a linear, barotropic model, J. Geophys. Res., 102(C11), 24987 25003, doi:10.1029/97JC00368.

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OCE9: Exploring the vertical distribution of redox sensitive elements in a coastal anoxic basin (Whycocomagh Bay, Cape Breton)

Oxygen is fundamental to many processes in the ocean. Its decline can cause major changes in ocean productivity, biodiversity, and biogeochemical cycling. As more coastal waters become seasonally or permanently hypoxic or even anoxic, urgent questions arise about their changing biogeochemistry. Whycocomagh Bay is located within the Bras dOr Lake Biosphere (UNESCO) in Cape Breton, Nova Scotia. Its deep basin has been permanently anoxic below 20m depth (to the seabed at 48m) for at least half a century. It is an accessible site where the redox discontinuity can be studied in fine detail. We use novel technology to measure redox sensitive elements over a fine vertical distribution through and below the oxycline. Preliminary results from high-resolution sampling of inorganic iodine species, nitrous oxide, and sulfide reveal chemical gradients that inform hypotheses about biogeochemical and ecological effects of anoxia.

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OCE10: Interactive effects of temperature and iron on High Latitude North Atlantic phytoplankton communities and primary production

Phytoplankton growth is limited by iron availability in roughly a third of the worlds ocean. In areas of the High Latitude North Atlantic (HLNA) a pool of leftover macronutrients is regularly observed following the spring bloom, potentially reflecting seasonal iron limitation. Concurrently, sea surface temperatures are projected to increase in regions of the HLNA. As a site of deep water formation, the HLNA has far-reaching biogeochemical significance. How phytoplankton communities respond to changing environmental conditions in this region will ultimately impact preformed nutrients and primary productivity in the global ocean. Our work seeks to understand the interactive effects of iron limitation and temperature increases on HLNA phytoplankton in the Irminger Basin. Environmental sampling was used to characterize the baseline phytoplankton community. In addition, onboard manipulation experiments were conducted to assess responses to changes in iron and temperature in summer of 2021. We combined metaproteomics measurements with measurements of photophysiology, trace metals, uptake rates and 16S rRNA gene amplicon sequencing to assess the phytoplankton community responses to change and consequent biogeochemical impacts. Targeted metaproteomics measurements of Rubisco, a key protein in photosynthesis, coupled with measured primary productivity rates allowed us to conduct a detailed assessment of carbon fixation by the phytoplankton community. Our work shows that iron and temperature have interactive effects on summertime phytoplankton community productivity and composition.

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OCE11: Investigating microbial nitrogen cycling in the Northwest Arm, Halifax Harbour using natural abundance stable isotopes

Bioavailable or fixed nitrogen is an essential component of life in marine environments. While bioavailable nitrogen can at times be a limiting nutrient, when present at excess levels it can degrade water quality and harm ecosystems. The Northwest Arm is an inlet on the western side of Halifax Harbour measuring approximately 4.9 km long, 0.3 km wide and around 18 m deep with an average tidal range of 2 meters. The Northwest Arm is surrounded by residences, public parks, and major roadways. Nitrogen is added to the Arm through atmospheric deposition, land runoff, exchange with sediments and wastewater/stormwater systems, and removed through microbial processes. Each of these nitrogen sources and sinks are accompanied by a predictable isotope signature in 15N and 18O. Using a 3-year time series of nutrient concentrations (nitrate, nitrite and ammonium) and natural abundance nitrogen isotopes (15N in nitrite, nitrate and ammonium and 18O in nitrite and nitrate), this project identifies the major sources and sinks of nitrogen in the Arm. Overall, nitrate was the most abundant form of fixed nitrogen in the Arm, and it increased towards the inside of the inlet, away from Halifax Harbour. Ammonium showed the most intraseasonal variability of the three forms of nitrogen. We suspect that ammonium is the most affected by anthropogenic run-off during storm events and is highest in the inside of the inlet due to sediment-water exchange. We predict low tourism is the cause of 2020 and 2021 showing lower abundance of fixed nitrogen than 2019 and 2022.

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OCE12: Measurements of ocean biogeochemistry and air-sea exchanges on the Scotian Shelf from a Waveglider during two missions in 2022

Recently, Unmanned Surface Vehicles (USVs) have emerged as a new technology which can be utilized for taking autonomous measurements at the ocean surface. These platforms are operated by many groups and organizations for research including fish tracking, monitoring marine protected areas, and acoustic data offload, and can grant access to opportunistic data collection if equipped with proper instrumentation. Here we present data from a Waveglider USV that was deployed on the Scotian Shelf on two separate missions in 2022, equipped with sensors measuring ocean parameters including temperature, salinity, oxygen, pCO2, pH, and gas tension, as well as wind speed, atmospheric pressure, and wave height.

In spring 2022 the vehicle collected data between Nova Scotia and Sable Island during the spring bloom, which were used to characterize water column properties. Additionally, the data were used to calculate carbon dioxide fluxes across the air-sea interface both at the surface and at a nominal depth of 4.5m. From this, we will present conclusions regarding how stratification in the upper water column generates possible error in air-sea CO2 flux.

In September, the USV was deployed approximately 50km south of Halifax, and traveled eastward past Sable Island to sample in a box pattern near the Gully Marine Protected Area. After about two weeks, the vehicle was caught under Hurricane Fiona, and carried northward by about 100km by the storm. We will present data of several ocean properties that were affected by the passage of the storm, as well as estimates of air-sea fluxes of carbon.

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OCE13: Microbial eDNA Research to Facilitate the Management and Restoration of Coastal Blue Carbon Ecosystems

Protecting ecosystems that store carbon is critical for mitigating climate change impacts and is an important component of Maines goal to be climate neutral by 2045. Coastal and marine ecosystems that store carbon (AKA blue carbon ecosystems) such as salt marshes and seagrass beds can sequester a large amount of carbon relative to the amount of land cover. Building bridges and roads across tidal creeks in salt marsh habitats can restrict hydrologic flow and alter soil salinity as well as change patterns in dominant vegetation. Microbial communities, integral to the carbon cycling process, are also impacted by these changes. More research is needed to understand the connections between microbial communities, carbon sequestration and the severity of restriction impact. We investigated marsh soils of tidal marshes along restricted and unrestricted tidal creeks for metagenomic and carbon content to better understand the connections between carbon sequestration and tidal restrictions. Our work with stakeholders will help us integrate this research with management decisions to increase the carbon sequestration potential of Maines salt marshes.

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OCE14: Multi-year monitoring of organic carbon dynamics along the Line P program in the North Pacific

Dissolved organic carbon represents a major pool of reduced carbon in the ocean, much of it largely refractory in nature. This refractory pool of carbon can persist for thousands of years and as such is an important part of the oceans blue carbon sink. Refractory dissolved organic carbon (RDOC) is produced in the ocean interior via the microbial carbon pump that reworks the labile fraction and renders it unreactive. RDOC is also produced from the degradation sinking particles, sites of high microbial activity in the water column. Samples collected from along the Line P monitoring program in the North Pacific Ocean were analyzed to determine dissolved and total organic carbon (TOC) concentrations over a three-year period. Line P ranges over multiple oceanographic regions from the coastally influenced continental shelf to the pelagic North Pacific. The cruise typically covers three seasons, Winter, Spring, and Summer. The seasonal nature of the monitoring program allows for the tracking of organic carbon dynamics driven by phytoplankton blooms, temperature, and seasonal mixing/stratification processes. Further measurements of dissolved organic matter absorbance and fluorescence measurements were taken for select samples in an attempt to further characterize the nature of TOC and its sources and sinks in the North Pacific Ocean.

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OCE15: OCEAN ALK-ALIGN: a major, international research project to provide an independent assessment of Ocean Alkalinity Enhancement.

Of the various marine CDR technologies (mCDR) proposed to date, ocean alkalinity enhancement (OAE) has, arguably, the largest potential. OAE also has several advantages over other approaches in that it does not compete for nutrient-use, is applicable to large regions of the coastal and open ocean, can mitigate ocean acidification and should have a high degree of permanence. Consequently, a growing number of private-sector innovators are actively pursuing OAE. Given the rapidly growing interest, there is a risk that independent, non-profit oriented research will lag

behind in providing society with a balanced assessment of OAEs effectiveness, sustainability and environmental impact. The OCEAN ALK-ALIGN project is a newly funded, multi-year research effort involving an international consortium of researchers from Canada, Germany and Australia. The project seeks to increase knowledge on three research topics essential for OAE implementation: (1) efficiency and permanence of CO2 removal; (2) environmental safety; (3) monitoring and verification. The OCEAN ALK-ALIGN project will be application- and user-oriented, prioritizing research questions relevant for OAE implementation and will have a flexible research agenda that can be rebalanced as needed. The project includes a multi-scale combination of laboratory and mesocosm experimentation, and field observation coupled directly to regional and large-scale modelling. The OCEAN ALK-ALIGN team members cover the full range of expertise needed to address this broad research agenda. The presentation will summarize the OCEAN ALK-ALIGN research strategy and work packages, including early components that will be conducted in Bedford Basin, Nova Scotia.

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OCE16: Oceanographic conditions in the submarine canyons of Pointe-des-Monts (Quebec)

Submarine canyons are morphological incisions into continental margins that act as major conduits of sediments from shelf seas to the deep ocean. However, the exact mechanisms involved in sediment transfer within some submarine canyons are still a subject of investigation. We inspected the processes by which sediments are transported in the Pointe-des-Monts Canyon located near the northern shore of the Lower St. Lawrence Estuary. From October 2020 until October 2021 two ADCPs (Acoustic Doppler Current Profilers) (up and down looking) were deployed at 155 meters depth. Analysis of near-bottom horizontal and vertical velocities and backscatter signals provided a comprehensive view of the sediment transport mechanisms operating along this canyon. Two main sediment transport processes were identified. Firstly, turbidity currents, which have already been documented at Pointe-des-Monts, transport sediments down canyon. These events were initiated during storms and are associated with high values of backscatter signal and a sudden increase in down-canyon velocity. Secondly, internal tidal bores caused by the semidiurnal internal tide resuspend fine sediments, which are advected towards the canyon head with the up-slope propagation of the internal tidal bore. A regular occurrence of these internal tidal bores was recorded (391 identified during the one-year deployment 2020-2021). Their highest occurrence is within an hour of the low tide of the semidiurnal internal tide, irrespective of the season and the spring-neap phase of the surface tide.

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OCE17: Rapid identification of phytoplankton communities from coastal waters using long-read sequencing

As important primary producers and players of key biogeochemical processes, phytoplankton are emerging as a potential diagnostic tool to monitor ocean health and detect human impacts on the marine environment. Phytoplankton communities which are highly diverse, continually adapt to changes in the environment and likely impact the entire marine ecosystem. As a result, rapid identification of phytoplankton is critical to describe the structure of phytoplankton communities and create a baseline for future

research to determine phytoplankton response to environmental stressors. To date, the most common method used to describe the phytoplankton communities consist of short-read metabarcoding of variable regions of the 18S rRNA genes (~ 500bp). Here, we assess the use of long-read sequencing technology (e.g Oxford Nanopore Technologies) to target long fragment of the rRNA operon that includes both 18S and 28S taxon as a rapid diagnostics tool to profile the phytoplankton communities in the marine environments.

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OCE18: Remote detection of ocean sound speed profile using acoustic profiling techniques

The ocean Sound Speed Profile (SSP) directly affects how acoustic waves propagate in the ocean. So, knowing the SSP is essential in many underwater acoustic applications, such as sound propagation modeling, underwater acoustic imaging, acoustic localization, and acoustic tracking. Underwater sound speed also provides information about the temperature structure using the relationship between ocean temperature and sound speed. SSPs are usually measured by a Sound Velocity Profiler (SVP) or a Conductivity, Temperature, Depth (CTD) profiler. A significant part of the expense of these methods to estimate the SSP is the necessity to operate from a fixed platform for hours or even days.

Our presentation focuses on remote sound speed profile estimation using an underwater acoustic pulse-echo method. Our model uses a directional transmitter and a couple of receivers. The transducer transmits acoustic pulses to the medium, and SSP is estimated using received echo signals of marine organisms. To estimate a sound speed at each reflectors depth, the time-delay profile, which is determined theoretically, is compared to the one estimated experimentally. To show the approachs validity, using ray acoustics and an assumed sound speed profile, we model the signals reflected from the scatterers as received at the hydrophones. After estimating SSP using our synthetic received signals, the estimated sound speed associated with each reflector depth is compared to the assumed sound speed used in the modeling of echo signals.

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OCE19: Seasonal variability of biogeochemical cycling in the Labrador Sea in relation to phytoplankton blooms and regional deep mixing

The Labrador Sea is a key region for global carbon sequestration and export, due to its characteristic winter deep convection followed by a large-scale phytoplankton bloom in the spring and early summer. The timing and intensity of the bloom are linked to the winter preconditioning by establishing favourable conditions for phytoplankton growth, such as replenishment of nutrients and dissolved inorganic carbon through vertical mixing and/or lateral advection. However, little is known about the timing of setting up favorable conditions for spring bloom dynamics (i.e., timing, intensity, and duration) in the Labrador Sea. With a 30-years time series from a coupled physical-biogeochemical model, NEMO-PISCES, the seasonal trend of high resolution in situ observations in 2016 from a moored profiler has been contextualized. Despite the differences between the model and the observations, the model allows us to understand the link between temperature, stratification, winter-time deep convection intensity, and light limitation with the indices describing the temporal dynamics of the bloom. Then, approximate contextualization of in situ data suggests conditions favorable to the 2016 bloom

establishment. First results suggest that regional biogeochemical cycles showed strong temporal relationship with the timing of spring phytoplankton bloom and deepen mixing in the fall. As regional mixing is likely to be weaken in the future, the implication of nutrient and inorganic carbon supply to the efficiency of carbon export is remained uncertain. This study could be a starting point to understand the representation of mixing to the biological carbon pump by untangling the complexity of physical-biogeochemical interactions.

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OCE20: Simple models for carbon dioxide removal via ocean alkalinity enhancement in coastal environments

Ocean alkalinity enhancement (OAE) is a proposed method for mCDR by which alkalinity added to the surface ocean initiates a draw-down of atmospheric CO2, where it reacts to form bicarbonate. Although OAE shows promise as a mCDR technique, in-situ experiments and models are required to confirm theoretical predictions. I will present results from a general circulation model (MITgcm) that can be used to evaluate the effectiveness of CO2 storage via coastal OAE. In coastal environments, circulation patterns will determine the local distribution of an alkalinity addition. Using box models representing coastal embayments and fjords, we explore the impact of circulation, stratification (in particular mixed layer depth), and local wind conditions on the evolution of biogeochemical properties in the basin (e.g. pH) and CO2 uptake. Two simulations that nominally represent summer and winter conditions in Bedford Basin, a fjord-like estuary that is a likely site for future alkalinity release experiments, are discussed.

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OCE21: Subsurface nutrient variability on the Scotian Shelf

Marine primary production is strongly influenced by the supply of nutrient from subsurface waters. Subsurface nutrient variability on the Scotian Shelf (Northwest Atlantic), an ocean region close to the boundary between the subpolar and subtropical gyres, is believed to be chiefly modulated by shifts in ocean circulation in slope and shelf waters. We synthesized nutrient and hydrographic data over four decades to characterize and understand changes in subsurface (60-200 m) nutrient availability. An observed decline in subsurface temperature, salinity, and all macronutrients (i.e., nitrate, silicate, phosphate) in the eastern and central Scotian Shelf between the late 1970s and 2006 is consistent with a transition from Warm Slope Water to Labrador Slope Water as the dominant slope water mass. The western Scotian Shelf exhibited the same trend until 1985 when there was an abrupt shift in salinity, which increased thereafter, while temperature plateaued and nutrients followed the same trends as the rest of the shelf. This shift, as well as a doubling in the flow around Cape Sable Island, could be explained by a more intense coastal current. Since 2006, subsurface temperatures have been increasing sharply. This indicates a transition back from Labrador Slope Water to Warm Slope Water as suggested in other recent work. However, rapid warming was accompanied by only a slight increase in salinity together with little response in nutrients, which cannot be attributed to transitions in water masses alone but imply that the nature of water masses has also changed due to changes in circulation.

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OCE22: The Effects of Microplastic Fibers on the Aggregation of Diatoms

One important component of the biological carbon pump is marine snow, aggregates made of detritus and organic as well as inorganic matter. The aggregation of small particles to marine snow (>500m) enhances the sinking velocity of these particles and therefore the vertical flux. The sinking velocity of marine snow depends on various factors including density and composition. Microplastic are between one m and five mm in size, made from a variety of plastic types and have been found from the upper water column to sediments in the deep sea. Laboratory experiments have shown that microplastic particles can be incorporated into phytoplankton aggregates, however, not much is known about their effect on the aggregation characteristics and sinking velocity. Here we tested the effects of two different plastic types and one non-plastic type of microfibers on the aggregation of a diatom culture. We found differences in number and size as well as sinking velocity in the aggregates with fibers compared to the aggregates without fibers. In comparison, the material of the fibers influenced aggregate characteristics and sinking velocity less. Changes in sinking velocity potentially affect flux attenuation and the biological carbon pump.

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OCE23: Tracking a seasonal phytoplankton bloom in the Northwest Atlantic Ocean through the optical characterization of dissolved organic matter

Dissolved organic matter (DOM) is the largest reservoir of reduced carbon in the ocean and therefore has a significant impact on global carbon dynamics. Marine DOM is predominantly produced by phytoplankton through exudation, viral lysis, grazing and sloppy feeding. The microbial carbon pump has been recently recognized as an important mechanism whereby heterotrophic bacteria rework DOM in the ocean interior into extremely recalcitrant forms (RDOM). This RDOM accumulates and stores carbon for thousands of years in the deep oceans. The compounds present in DOM have complicated molecular structures, a wide range of chemical characteristics, various functional groups, and isomeric species. These factors make DOM characterisation a challenging analytical task. Optical properties such as absorbance and fluorescence have been extensively utilized to identify and trace various fractions of DOM, namely, colored dissolved organic matter (CDOM) and fluorescent dissolved organic matter (FDOM). In June 2022, aboard the R/V Celtic Explorer, we tracked a phytoplankton bloom in the Northwest Atlantic by characterizing the DOM produced during and after the bloom. The resulting dataset provides insight into the evolution of different fractions of DOM over the course of a spring phytoplankton bloom and their potential to be turned over by the microbial community or to be reworked into the recalcitrant pool via the microbial carbon pump. Preliminary results indicate the presence of fluorescent components of both reactive and recalcitrant forms of DOM during the spring bloom in the Northwest Atlantic.

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OCE24: Vertical Velocity Profiles of a Turbulent Tidal Channel

The Minas Passage, a tidal channel in the Bay of Fundy, presents an opportunity to apply classical turbulence theory to an oceanic flow. In addition to being sheltered from swell and wind driven waves, the site is effectively barotropic and unstratified because of its extremely energetic tidal flow regime (Re 1.4 108, M2 speeds 3.5 m/s). Using historical ADCP records collected in the relatively shallow tidal channel between 2008 and 2021, we fit the vertical velocity profiles using (1) a logarithmic law of the wall, and (2) an adapted logarithmic law of the wall which includes a wake function. The logarithmic dependence of velocity in the boundary layer, characterized by the law of the wall, is a well-established result. We find that although this model results in well-fitted estimations of the velocity profiles near the seabed (z 10 m), observational profiles consistently deviate from the fitted curves in the upper water column, measuring significantly faster flow speeds than predicted by the law of the wall. The addition of a wake term to the model captures flow in the outer layer and allows for reverse shear in the fitted profiles, resulting in significantly improved fits throughout the water column when compared to the original model. In addition to resulting in low error for both individual and ensemble-averaged vertical profiles, the physical quantities estimated from the adapted model, including drag coefficient, agree well with those computed from the law of the wall.

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SER1: Improvement to the impact-based storm surge forecast for the St. Lawrence River, Quebec

Coastal flooding represents one of major natural hazards that affects an important part of world population that lives in coastal areas. With sea level rise and strengthening of the intensity of tropical and extratropical storms expected in the future, the negative effects on the coastal communities will further increase. This situation calls for a better storm surge predicting and alerting system in order to prevent loss of life and property. The new impact-based Canada-wide costal flooding predicting and alerting program will be presented. We will concentrate on some examples to show how the storm surge warnings program currently works in Quebec. We will mention some recent improvements brought to this program by impact-based approach and finally, we will see how this new nation-wide approach will improve our forecast.

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SER2: Major Winter Storms Leading Up to Christmas 2022 in British Columbia

Traveling for holidays was particularly challenging for the week leading up to Christmas 2022 in British Columbia. Major winter storms arrived one after another and gave rise to many flight cancellations and travel risks. Each storm was unique in terms of atmospheric conditions, resulting in different outcomes for the public. This study aims to revisit these high-impact winter storms and validate the original analysis, diagnosis, and prognosis of these weather events. This will help improve confidence when a similar scenario sets up in the future.

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SER3: O'SALIS ; Saltwater intrusion, coastal groundwater quality and community health

Climate change affect coastal zones prone to salinity and seawater intrusion due to sea level rise and marine flooding increase. In the eastern region of Quebec, more than 50% of the inhabitants are located within the first 5 km from the shore and draw their drinking water mainly from groundwater. However, the coastal groundwater squeeze already leads to the salinization of private wells, which would represents a risk for people who have to adopt a low-salt diet, forcing citizens to turn to alternative freshwater supply sources or more expensive wells depths, which sometimes unknowingly expose them to even more harmful contaminants. In this poster, we present the structuring initiative O'Salis, an interdisciplinary project dedicated to assessing the vulnerability and risks of seawater intrusion of coastal groundwater related to sea-level rise and marine flooding in the Bas-Saint-Laurent and Gaspésie regions. The interdisciplinary project combines community health, geomorphology and geochemistry sciences embedded into risk management and communication strategies involving owners and legislators to explore all the facets of seawater intrusions and to propose adapted solutions to the communities. Here, we will expose our approaches, some of our results on sea-level rise projections and on groundwater quality, and we will propose some constructive feedback on the practice-based interdisciplinary research to address the risks in the coastal zones to enhance climate resilience in coastal communities. Furthermore, a scoping review identified about twenty solutions to mitigate or adapt to this risk that were presented to local at regional stakeholders to determine the most promising.

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Fine-scale factors associated with precipitation type transitions during a winter storm over southern Québec, Canada

Margaux Girouard[1], Mathieu Lachapelle[1], Julie M. Thériault[1], Ismail Gultepe[2] and Justin Minder[3]

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1. MAIN MOTIVATION

Freezing rain and ice pellets are generally formed when a melting layer aloft and a refreezing layer near the surface are present.

Ice pellets can form through 2 mechanisms:

- Partial melting of ice particles while falling through the melting layer
- Complete melting of ice particles while falling through the melting layer aloft

Other mechanisms can influence the type of precipitation reaching the surface:

- Type of ice crystals and degree of riming aloft
- Degree of saturation in the atmosphere
- Precipitation rate

Very few studies focused on the impact of precipitation rate on the type of winter precipitation reaching the surface.

2. OBJECTIVE

To study the processes associated with the precipitation type transitions at the surface.

3. METHODOLOGY

A. Experimental setup

The data used was collected during the WINTRE-MIX field campaign :

- Soundings
- Manual observations
- Macrophotography
- Automatic weather station

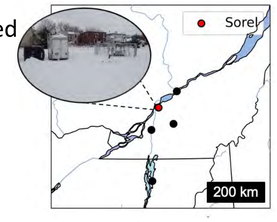


Fig 1. WINTRE-MIX domain in southern Quebec and northern New York

B. Hazardous precipitation 22-23 February 2022

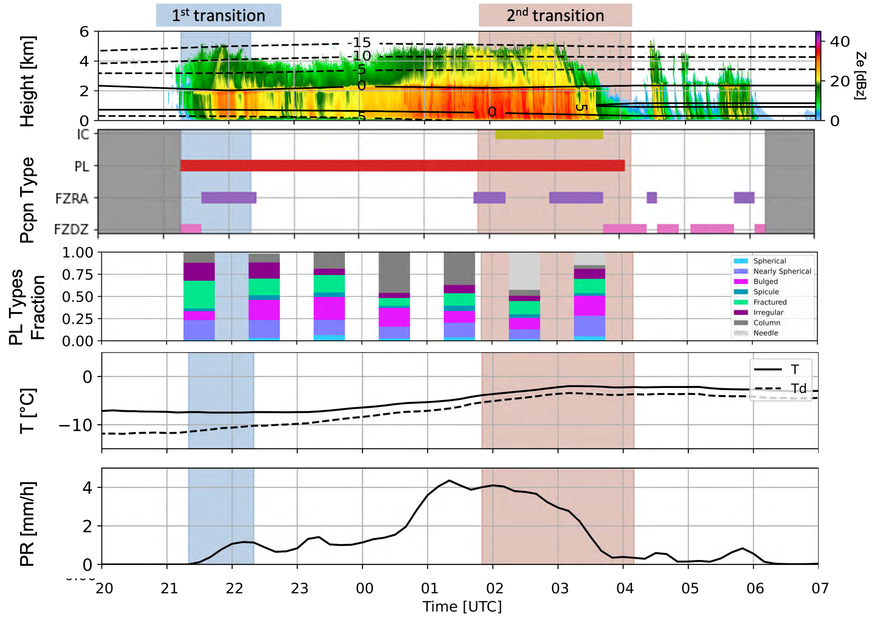
- A 7-hour ice pellet event occurred at Sorel, Québec
- Ice pellets occurred in 3 phases:

1) Ice pellets were mixed with freezing rain at the onset of the event
2) Ice pellets only
3) Ice pellets mixed with freezing rain/drizzle at the end of the event

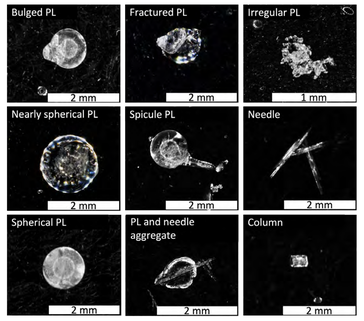
- The 2 precipitation type transitions that occurred during this event are investigated in this project.

4. OBSERVATIONS AND RESULTS

A. Overview of weather conditions

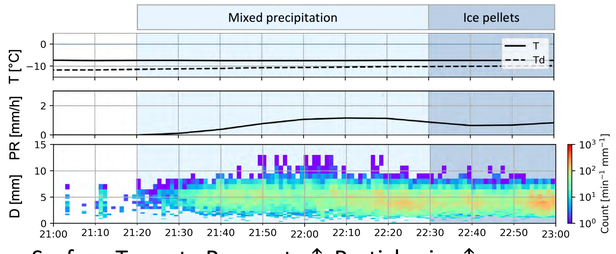


- Relatively thick (> 1.4 km) and warm (≈ 5°C) melting layer aloft throughout the event.
  → Similar ML can completely melt particles aloft (Stewart et al.,2015).
- 2 precipitation type transitions observed:
  → 1st transition: Mixed precipitation to ice pellets
  → 2nd transition: Ice pellets to mixed precipitation
- Different ice pellet shapes were observed throughout the event and were categorized based on Gibson and Stewart (2007).
- The surface temperature starts to increase after the 1st transition, but led to ice pellets instead of liquid phase precipitation
- The precipitation rate varies most during both precipitation type transitions, leading to higher collision rate (Carmichael et al., 2011)



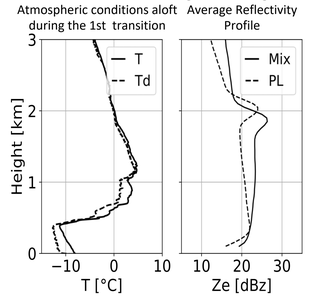
B. 1st transition : Mixed → Ice pellets

1. Surface atmospheric conditions



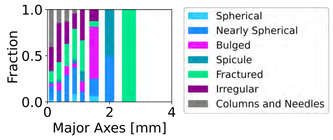
- Surface T ~ cst , Pcpn rate ↑, Particle size ↑

2. Vertical atmospheric profiles



- Relatively deep and warm melting layer → complete melting of particles
- Decrease in Ze at T min → refreezing particles

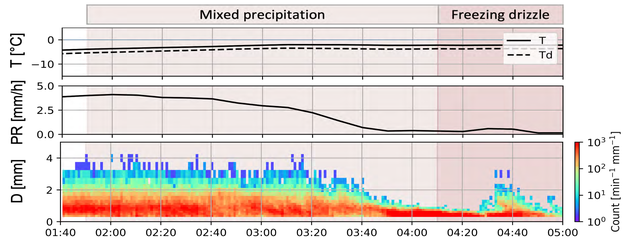
3. Ice pellets type observed



- Small ice crystals observed → secondary ice production
- Largest ice pellets are fractured

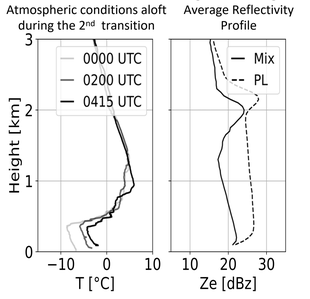
C. 2nd transition : Ice pellets → Mixed

1. Surface atmospheric conditions

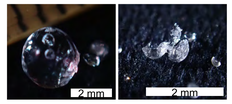


- Surface T ↑, Pcpn rate ↓, Particle size ↓

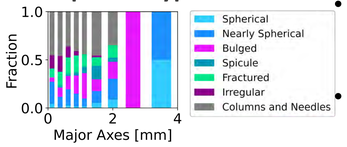
2. Vertical atmospheric profiles



- T profile increases with time -> refreezing rate of supercooled drops decreases
- Liquid core pellets were observed.



3. Ice pellets type observed



- Observed ice crystals → secondary ice production
- Larger particles w.r.t the 1st transition.

5. Summary

- During this event, ice pellets occurred despite a thick and warm melting layer and an increase in the T profile.
- The 2 precipitation type transitions aligned well with changes in the precipitation rate, suggesting that a higher precipitation rate favors the formation of ice pellets.

6. Next steps

Reproduce the transitions at both sites with 1D simulations to better understand the role of fine-scale factors in the elimination of freezing rain in the subfreezing layer during ice pellet events.

7. References

Carmichael, H. E., Stewart, R. E., Henson, W., & Thériault, J. M. (2011). Environmental conditions favoring ice pellet aggregation. *Atmospheric Research*, *101*(4), 844-851. https://doi.org/10.1016/j.atmosres.2011.05.015

Gibson, S. R., & Stewart, R. E. (2007). Observations of ice pellets during a winter storm. *Atmospheric Research*, *85*(1), 64-76. https://doi.org/10.1016/j.atmosres.2006.11.004

Stewart, R. E., Thériault, J. M., & Henson, W. (2015). On the Characteristics of and Processes Producing Winter Precipitation Types near 0°C. *Bulletin of the American Meteorological Society*, *96*(4), 623-639. https://doi.org/10.1175/BAMS-D-14-00032.1

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Random Forest Method for Hailstorm Nowcasting in the American Midwest

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Introduction

- The hyperlocal and abrupt nature of hail means it is a challenge to make accurate and advanced predictions on hail threat area and size of hail.
- Evidence of large hail (≥ 1") is a sufficient condition for the issuance[1] of a **Severe Thunderstorm Warning**.
- While nearly all severe thunderstorms produce hail aloft, whether the hailstones can reach the ground depend on several factors[2]:
  - Strong updraft to keep hailstones aloft
  - Deep vertical shear to separate the down/updrafts
  - High liquid water contents enhance hail growth
  - Low freezing levels minimize melting of hail
- Current approach to hail nowcasting relies on **radars** to detect imminent signs of hail (≥ 60 dBZ reflectivity and/or hail spike), paired with a knowledge of current atmospheric conditions via observations and **models**.
- Several recent studies[3,4] demonstrated high accuracy (≥ 91%) in hail nowcasting using **Random Forest (RF)**, a white-box ensemble supervised learning method.

Objective

Improve the existing hail warning systems by developing an RF-based hail nowcasting model with real-time radar data combined with model reanalysis data as its inputs. Generate outputs as the probability of hail occurrence and maximum estimated hail size for the next 0–2 hours.

Data

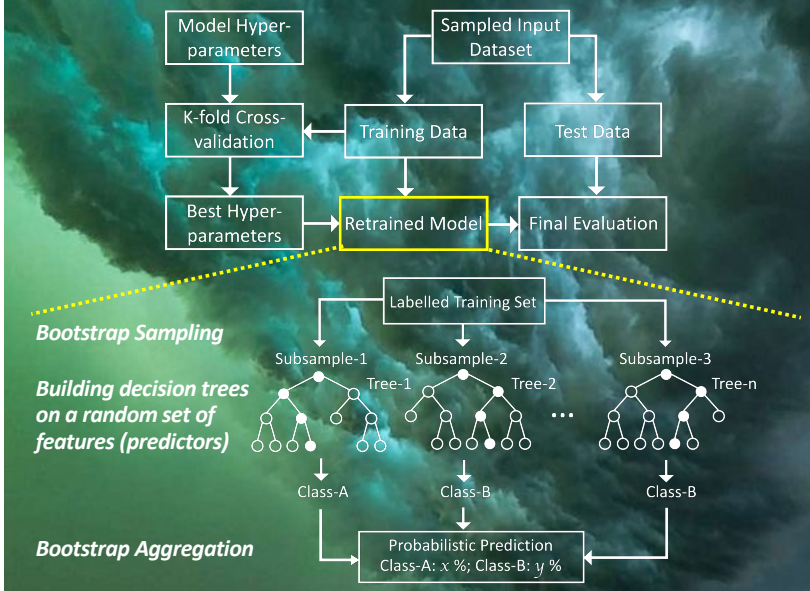
Data Type	Name (Source)	Lat/Lon Res.	Time Res.
Radar	MYRORSS (OU)	0.01° x 0.01°	5-min
Reanalysis	ERA5 (ECMWF)	0.25° x 0.25°	1-hr
Hail Report (nearest ¼")	Storm Event Database (SPC)	nearest 0.01°	nearest 5-min

- **Period of study**: 12:00 – 00:00 CST on all deep convective days from May to August 1999 – 2003
- **Domain of interest**: 39° – 49°N, 85° – 105°W (≃ 1100 km x 1600 km or 1.78M km^2)
- **Deep Convective Day**: ≥ 10 hail, wind or tornado reports within the domain of interest on a given day

We achieved **95% accuracy** in forecasting hail events up to **30 minutes** ahead.*

With improvements to our ensemble learning model, you could be even better prepared…

Random Forest Classifier for Hail Nowcasting



*(*Preliminary results for a 30-min forecast on hail size > 1 mm using radar parameters only.)*

Confusion Matrix

Real Label	Predicted: Negative	Predicted: Positive
Negative	Correct Rejection 47%	False Alarm 3%
Positive	Missed Prediction 2%	Correct Hit 48%

Feature Importance Table

Top Radar-derived Predictors	Score
Height of the 18 dBZ echo top	0.42
Reflectivity at -20°C	0.36
Vertically integrated liquid	0.13
Reflectivity at lowest altitude	0.06
Max. estimated size of hail	0.03

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Scan the QR code to access the full presentation PDF

Poster originally prepared for the CMOS-SCMO Congress 2023

Image courtesy of Nathen Erickson/@TwstdSkyStudios via Twitter

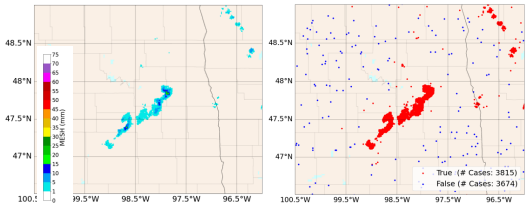
Methodology

1. Select a set of **hail predictors** (35 in total) based on their relevancy to hail nowcasting from literature.
2. Calculate the hail predictors for all gridded data from all Deep Convective Days (240 days in total).
3. Split the above dataset by their **Maximum Estimated Size of Hail (MESH)** into four classes: < 1 mm, 1–5 mm, 5–20 mm, and > 20 mm. Randomly sample each class to extract a maximized balanced mix of case samples from the four classes.
4. Split the samples above into the training and test set for the RF model, with MESH at the forecast validation time as the case label. Apply **k-fold cross-validation** to optimize the hyper-parameters.
5. Train the RF model. Evaluate its performance on the test set. Identify the top predictors for MESH at four forecast times (t = 15/30/60/120-min).

Preliminary Results

Maximum Estimated Size of Hail
(truth derived from radar dataset)

Deterministic Prediction of Hail
(for hail size > 1 mm, t = 15-min)



- *Preliminary results were obtained from a case study on a single Deep Convective Day – June 3, 1999 (training set size: 19,404; test set size: 6,654).
- Best model metrics achieved thus far: accuracy (proportion correct) = 0.95, precision (1 – false alarm ratio) = 0.95, recall (1 – miss ratio) = 0.96
- The model performs better with small hail sizes and short forecast times. Probabilistic predictions will replace this deterministic product in next iteration.

References

[1] *Hail forecasting*. NOAA National Severe Storms Laboratory. (n.d.). https://www.nssl.noaa.gov/education/svrwx101/hail/forecasting/
[2] US Department of Commerce, N. (2017, June 1). *Severe weather definitions*. National Weather Service. https://www.weather.gov/bgm/severedefinitions
[3] Czernecki, B., Taszarek, M., Marosz, M., Półrolniczak, M., Kolendowicz, L., Wyszogrodzki, A., & Szturc, J. (2019). Application of machine learning to large hail prediction - the importance of radar reflectivity, lightning occurrence and convective parameters derived from ERA5. *Atmospheric Research*, *227*, 249–262. https://doi.org/10.1016/j.atmosres.2019.05.010
[4] Yao, H., Li, X., Pang, H., Sheng, L., & Wang, W. (2020). Application of random forest algorithm in hail forecasting over Shandong Peninsula. *Atmospheric Research*, *244*, 105093. https://doi.org/10.1016/j.atmosres.2020.105093

McGill UNIVERSITY

NSERC CRSNG

Impact of Marine Heatwaves on Atmospheric Rivers along the Coast of California

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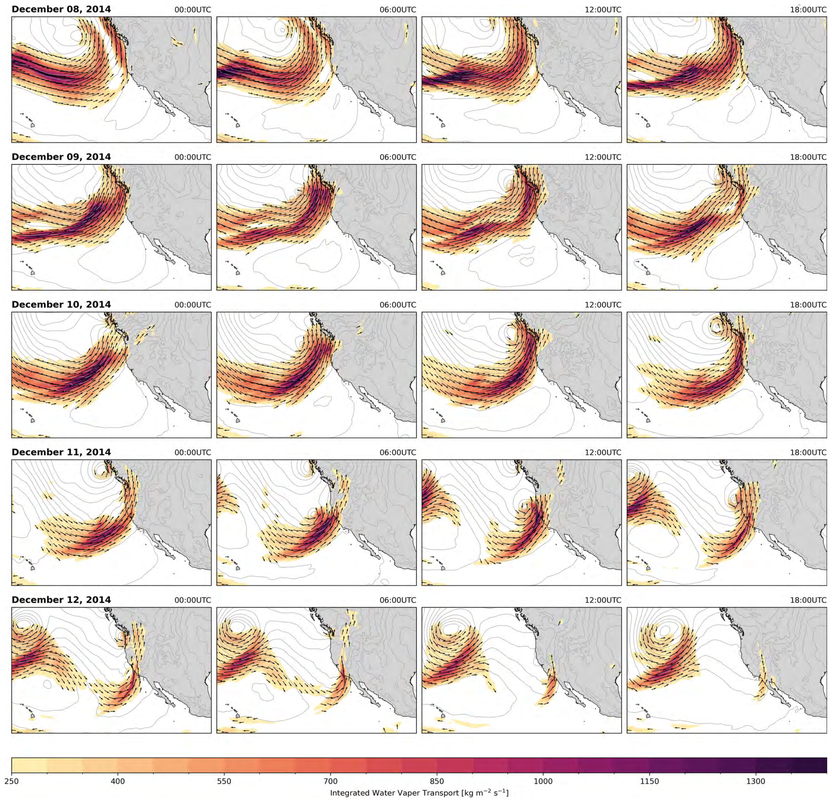
1. Introduction and Motivation

The coastal climate of California is profoundly affected by the ocean, which moderates its hot summers and provides moisture for much-needed winter rain. Large-scale anomalies in the atmospheric circulation on seasonal to interannual timescales create persistent anomalous ocean conditions such as marine heat waves (MHWs), which subsequently influence aspects of weather patterns such as atmospheric rivers (ARs) on synoptic time scales. This study examines the dynamic and thermodynamic mechanisms that control these multi-scale coupled processes and evaluate their effects along the coast as well as in interior mountain regions of California.

Here, we present a framework to analyze the impact of MHWs on synoptic-scale variability during the prominent winter 2014/15 surface ocean warm anomaly along the US West Coast using a high-resolution regional coupled modeling system.

2. Case Study: Atmospheric River December 8-12, 2014

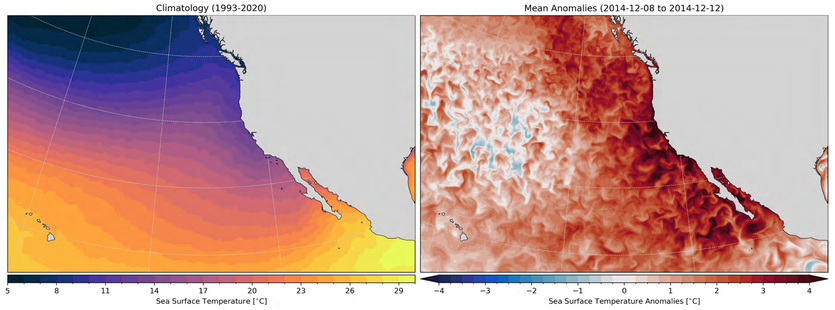


6-hourly snapshots of integrated water vapor transport (IVT) over the northeast Pacific and US west coast for the period December 8-12, 2014 based on ERA5 Reanalysis.

- Initial landfall over Oregon coast on December 10, 2014, northward propagation and dissipation
- Landfall of AR associated with secondary low pressure system over northern California
- Southward propagation across California and dissipation over the Baja California peninsula
- Extensive flooding and wind damage across US West Coast
- Maximum accumulated precipitation:
  - >350 mm in northern California and northwest Washington over 3 days
  - >50 mm (>20% of year-to-date precipitation) in central and northern California over 3 days
  - >200 mm in Sierra Nevada (inland) over 24 hours

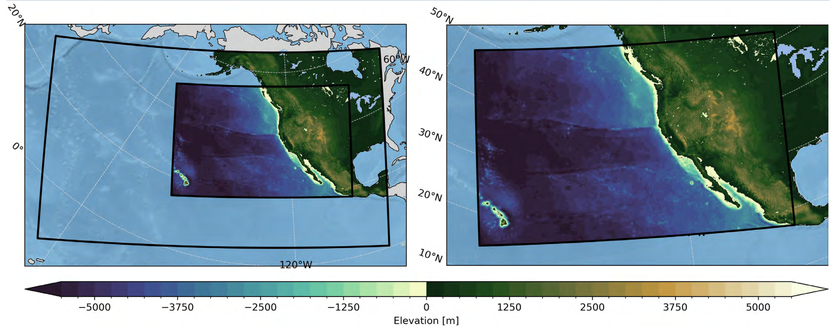
[Source: CW3E Synopsis by Marty Ralph and Brian Kawzenuk].

3. Northeast Pacific Warm Anomaly



Sea surface temperature (SST) climatology and mean anomalies for the period December 8-12, 2014 based on the GLORYS12v1 reanalysis. The ocean surface warming is part of the prominent SST anomaly in the North Pacific between 2013-2015 resulting from persistent anomalies in the large-scale atmospheric circulation (e.g., Amaya et al., 2016).

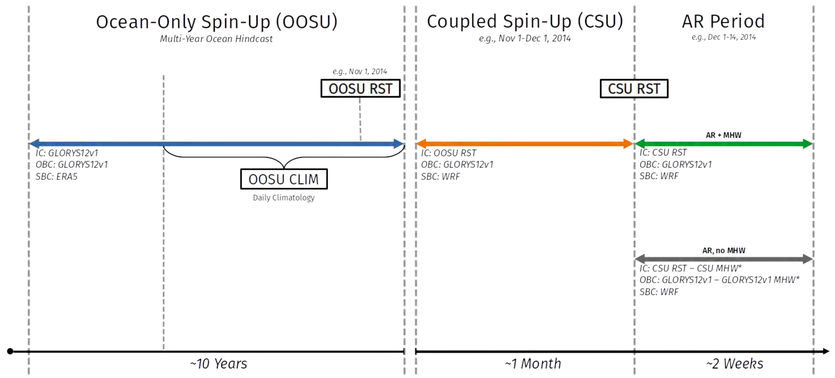
4. Scripps Coupled Ocean-Atmosphere Regional (SCOAR) Model



Domain 1 (Atmosphere Only):
- Weather Research & Forecasting Model (WRF)
- 30 km horizontal grid spacing
- 33 vertical levels
- ERA5 open boundary forcing

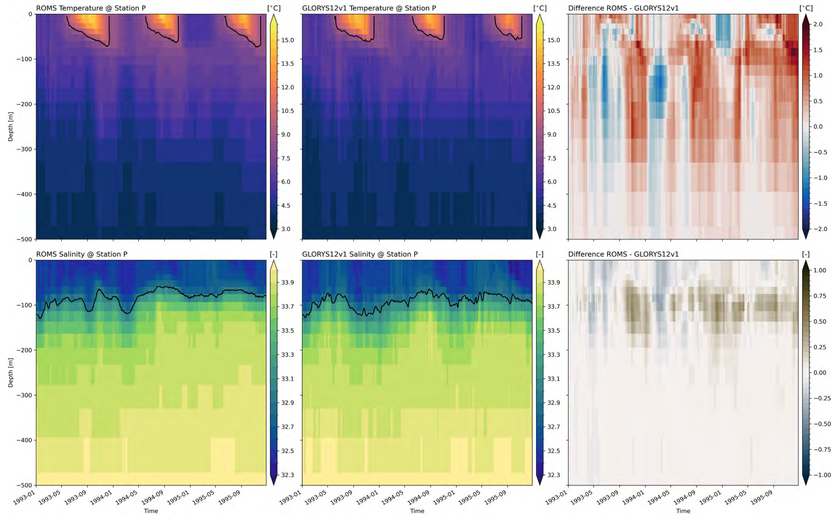
Domain 2 (Coupled Ocean & Atmosphere):
- Regional Ocean Modeling System (ROMS)
- Weather Research & Forecasting Model (WRF)
- Coupling via COARE3.5 bulk flux algorithm
- 7.5 km horizontal grid spacing
- ROMS: 30 vert. levels, WRF: 33 vert. Levels
- Matching Land-Sea Mask
- ROMS: GLORYS12v1 open boundary forcing

For more details see Seo et al. (2007, 2021).



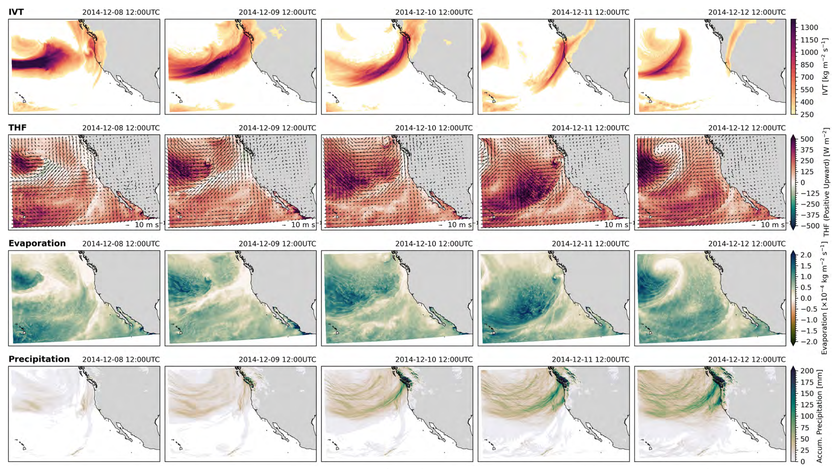
*** CSU MHW and GLORYS12v1 MHW:**
- Compute anomalies from respective daily climatologies
- Apply spatial box-car filter to anomalies on each model level to get large-scale anomaly, i.e., MHW
- Subtract large-scale MHW from total fields → high-pass filter to retain small wavenumbers

5. Ocean Model Validation



Temperature and salinity profiles in the top 500 m at Station P predicted by ROMS (uncoupled, forced with ERA5) and GLORYS12v1. ROMS is able to predict the seasonal variability of the surface ocean, but shows stronger stratification leading to a warm bias in the surface during summer.

6. Atmosphere-Only Simulation



Daily snapshots of IVT, turbulent heat fluxes (THF), moisture flux, and precipitation (accumulated from 0UTC on December 8, 2014) during case study period predicted by WRF. The uncoupled, nested simulation was initialized at 0UTC on November 1, 2014.

8. Summary and Future Work

- Framework to analyze the coupled impacts of MHWs on ARs along the coast of California
- Multi-year ocean hindcast to isolate warm anomalies with respect to model climatology
- SCOAR model components are able to capture observed variability

Next Steps:
- Large-ensemble coupled model simulations
- Quantification of coupled impacts of MHWs on synoptic-scale ocean and atmosphere variability
- Assessment of statistical significance of shifts in landfalling locations.

Stochastic Multicloud Model With Boundary Layer Cloud Feedback

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University of Victoria | Mathematics & Statistics

Abstract

It is largely understood that uncertainty in Global Circulation models (GCMs) is caused by poorly captured tropical convection. Newly developed 3-cloud stochastic models have been shown to better capture this organized convection. However, a fourth cloud type, shallow, non-precipitating cumulus, has been shown to play a vital role in boundary layer pre-moistening with non-negligible radiative feedback. A new stochastic 4-multicloud model is proposed, with two baroclinic modes of vertical structure and incorporating fully coupled shallow cumulus. A new synthetic cloud time series is presented along with preliminary model calibration results.

Keywords: Parametrization, Stochastic, Clouds

Introduction

Multicloud models capture organized convection by including cloud heating profiles projected onto the first and second baroclinic modes. However, due to crude vertical structure, these models have predominantly focused on precipitating clouds in the free troposhere, namely congestus, cumulonimbus and stratiform clouds[1].

A more complex Boundary Layer (BL) has been shown to capture additional tropical instabilities[2]. BL restricted shallow cumulus play a vital role in storm development through vertical mixing and moistening the lower troposphere. We are therefore motivated to include shallow cumulus as a fourth cloud type in the stochastic multicloud model, along with resolved BL bulk moisture.

The Model

A new BL potential temperature equation θ_b is coupled to the single column multicloud model[1]

$$\frac{\partial \theta_b}{\partial t} = \frac{D*}{h_b}\Delta_t\theta - \frac{D}{H_b}\Delta_m\theta + \frac{1}{\tau_e}\Delta_s\theta - \frac{E_c}{h_b}\Delta_t\theta - Q^0_{R,b}$$

Here $\Delta_i\theta$ are potential temperature fluxes across different atmospheric boundaries, i.e **S**-planetary surface, **t**-free troposphere, **M**-middle troposphere. D^* is the net flux between the BL and free troposphere, D downdrafts caused by evaporative cooling, E_c entrainment of cool air into BL, Q^0_{Rb} longwave radiative cooling, τ_e surface evaporation timescale and H_b, h_b heights of the free troposphere and BL respectively.

In the stochastic multicloud model cloud heating profiles are coupled to the bulk dynamics using cloud population fractions σ_i, across a subgrid lattice. Each lattice site behaves according to a Markov chain, with cloud states corresponding to all four cloud types and clear sky. Since the BL is not vertically resolved, we cannot couple shallow cumulus to the new model using a heating profile, so instead we allow the various model parameters to vary depending on the shallow cumulus cloud fraction σ_{sc}.

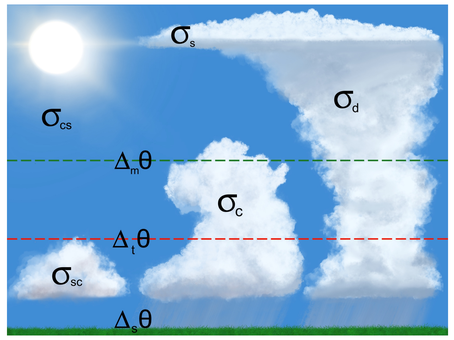


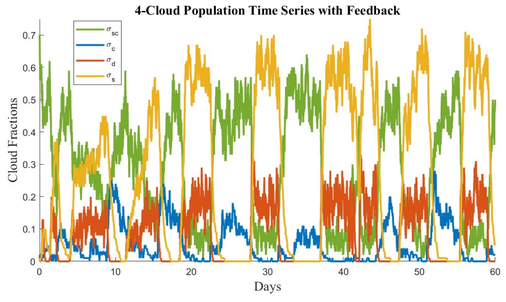
Figure 1: 4-Cloud Structure

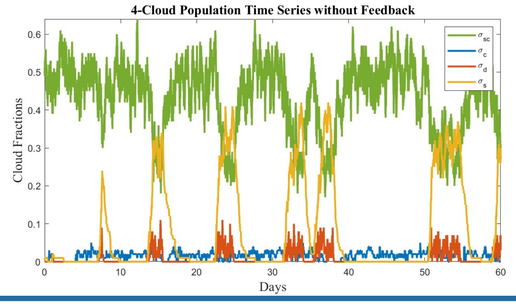
Stochastic Coupling

Given our new θ_b equation, we propose the following σ_{sc} coupling

$$D = D_0 e^{\sigma_{sc}/C_D}$$
$$\tau_e = \tau_0 e^{-\sigma_{cs}/C_e}$$
$$\theta_S = \theta_{s1}(1-\sigma_{cs}) + \sigma_{cs}\theta_{s2}$$
$$Q^0_{Rb} = Q_0 e^{\sigma_{cs}/C_Q}$$

Here, D_0, τ_0 and Q_0 represent the D, τ_e, θ_s and Q^0_{Rb} before forcing caused by shallow cumulus. σ_{cs} is the clear sky fraction. θ_{s1} and θ_{s2} represent surface potential temperature in cloudy or clear conditions respectively. Parameters C_j allow us to control the impact of σ_{sc} and are determined by the RCE stability or through sounding. Inclusion of shallow cumulus captures important BL moistening through enhanced upward flux D^*. The inclusion of the a separate θ_b equation allows the model to resolve sensible heat and better simulates drier, land-regimes.





Results

Figure 2 shows a model output cloud fraction time series for $T = 60$ days. The first series includes the new treatment of θ_b and shallow cumulus coupling, while the second includes a shallow cumulus Markov state, but without coupling or θ_b. With coupling, well distinguished active deep convective phases form. These phases follow well established hierarchies of succession, shallow cumulus σ_{sc} dominating inactive phases, followed by developing congestus σ_c, deep cumulonimbus σ_d and decaying stratiform σ_s. Without coupling, moisture and convection must be enhanced in order to observe active phases. The moist regime favors $\sigma_{sc} \to \sigma_d$ transitions, and shallow cumulus eclipses congestus in inactive phases.
The following Conclusions are drawn:

- A more complex boundary layer with coupled shallow cumulus and θ_b allows for the study of drier land regimes that still demonstrate the trimodal succession of multicloud convection.
- Inclusion of shallow cumulus better simulates cloud radiative feedback on the climate system.
- Inclusion of shallow cumulus and θ_b greatly increases the number of free parameters that must be tuned to produce accurate time series.
- Shallow cumulus adds four additional stochastic timescales that must be calibrated, increasing computational expense.
- A detailed stability analysis of the 4-cloud model should be conducted to identify potential new model instabilities.

References

[1] Boualem Khouider, Joseph Biello, and Andrew J Majda. A stochastic multicloud model for tropical convection. 2010.

[2] Michael L Waite and Boualem Khouider. Boundary layer dynamics in a simple model for convectively coupled gravity waves. *Journal of the atmospheric sciences*, 66(9):2780–2795, 2009.

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Tropospheric CO in the Indian Ocean region: An analysis of seasonal and long-term variability

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Introduction

Carbon monoxide (CO) is an air pollutant with both natural and anthropogenic sources. The majority of CO emissions are produced through anthropogenic means, such as fossil fuel combustion, biomass burning, and oxidation of methane (CH_4) and non-methane hydrocarbons[1]. The primary mechanism for removal of CO in the atmosphere is through the reaction with the hydroxyl radical (OH)[2] . Because of the reaction of CO with OH, CO has an indirect impact on the chemical lifetime of CH_4 and other greenhouse gases[2].

The indirect role that CO plays in the radiative budget of the atmosphere, as well as its negative impact on air quality make it an important species to study. This importance is especially highlighted in regions where emissions of CO continue to rise, such as in the Indian Ocean basin[3]. This project aims to examine the CO trend for key regions in the Indian Ocean representing coastal and open ocean environments to determine and explain the variability and long-term trends in tropospheric CO.

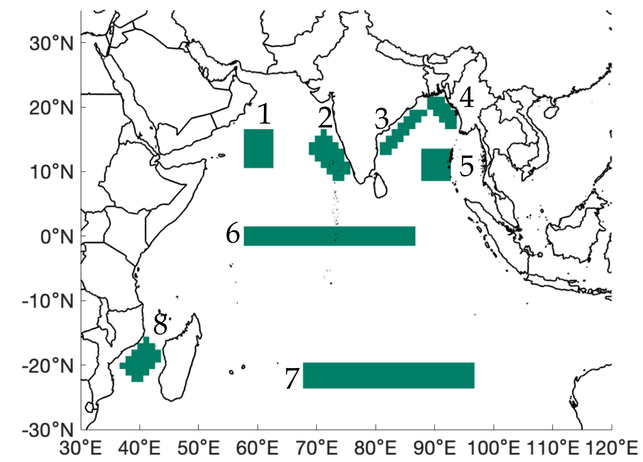

Figure 1: Regions for this analysis. 1: Remote Arabian Sea (RAS), 2: Coastal Arabian Sea (CAS), 3: Coastal Bay of Bengal (west) (BOBW), 4: Coastal Bay of Bengal (east) (BOBE), 5: Remote Bay of Bengal (RBOB), 6: Remote Equatorial Indian Ocean (REIO), 7: Remote Southern Indian Ocean (RSIO), 8: Western Indian Ocean near African Coast (WIO).

Objectives

- Determine trends in CO for each of the eight defined regions in the Indian Ocean basin using Measurements of Pollution in the Troposphere (MOPITT) data.
- Consider water vapour (H_2O) from the Atmospheric Infrared Sounder (AIRS), in addition to horizontal and vertical transport to explain long-term variability in the CO trends.
- Consider Global Fire Emissions Database (GFED) CO emissions to explain year-to-year variability in CO time series.

Methods

- To calculate trends (both in CO and H_2O), the seasonal cycle was removed from the data. MATLAB's fitlm function was used to calculate regression coefficients. The t-statistic was used to determine significance.
- A weighting function was obtained from the emission sensitivity (in units of sm^3kg^{-1}) from model runs with the FLEXible PARTicle dispersion model (FLEXPART). This function was applied to gridded GFED emissions to obtain time series for CO emissions from fires.

Trends in CO

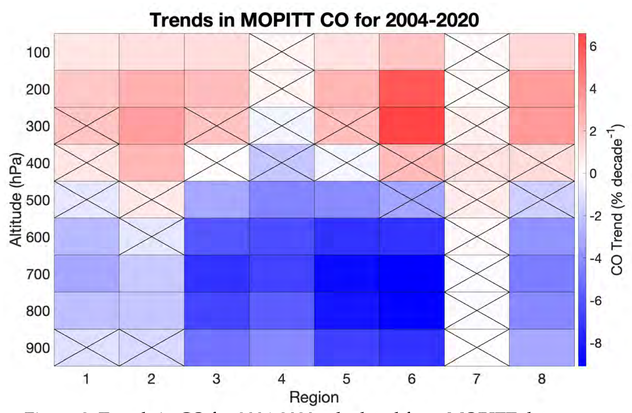

Figure 2: Trends in CO for 2004-2020 calculated from MOPITT data. Significance is defined for t > 2, and trends which do not meet this threshold are shown with an "x".

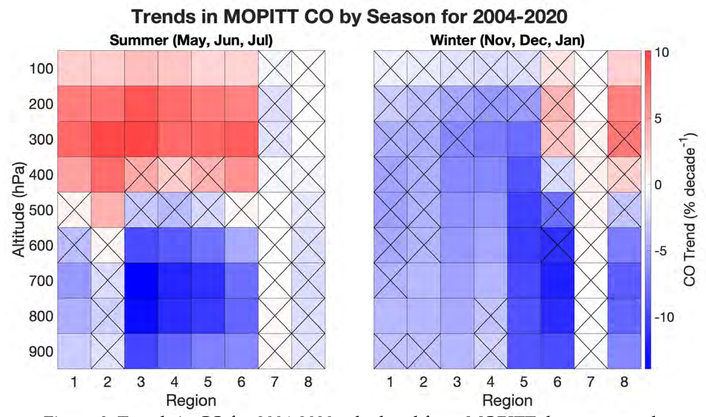

Figure 3: Trends in CO for 2004-2020 calculated from MOPITT data separated by season. Significance is defined for t > 2, and trends which do not meet this threshold are shown with an "x".

Across the regions, CO is decreasing in the lower troposphere (below 500 hPa) and increasing in the upper troposphere (above 500 hPa), with some seasonal variations.

Variability in the CO Time Series

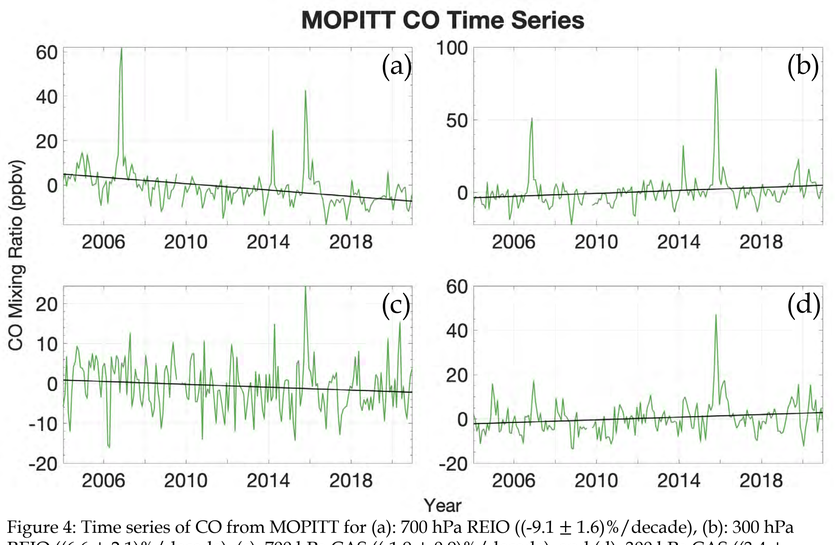

Figure 4: Time series of CO from MOPITT for (a): 700 hPa REIO ((-9.1 ± 1.6)%/decade), (b): 300 hPa REIO ((6.6 ± 2.1)%/decade), (c): 700 hPa CAS ((-1.9 ± 0.9)%/decade), and (d): 300 hPa CAS ((3.4 ± 1.2)%/decade).

The regions and altitude levels given here for CO time series present an overview of the trends and variability observed across the different regions for the upper and lower troposphere.

Peaks in CO Time Series and CO Emissions from Fires

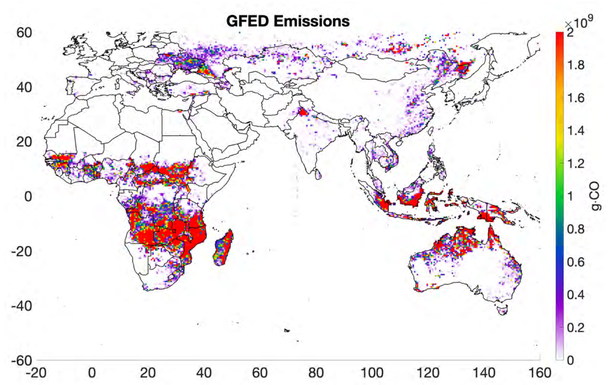

Figure 5: CO emissions from GFED summed over September 2015 to November 2015.

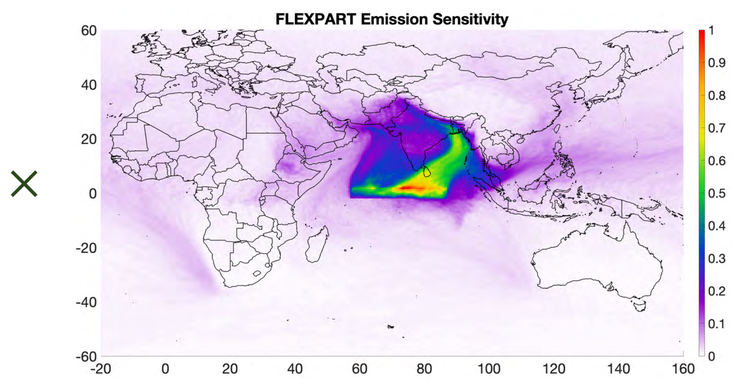

Figure 6: Weighting function for REIO for November 2015 to January 2016 (each region and season has its own unique function). To obtain this weighting function, the FLEXPART emission sensitivity for REIO was scaled by the largest value to obtain a grid of values between zero and one. This grid was then applied to the the gridded GFED emissions to obtain time series of CO emissions for each region.

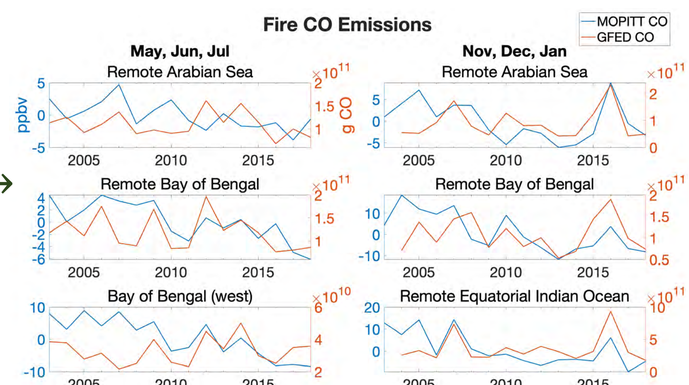

Figure 7: Time series of CO emissions from GFED and 900 hPa CO from MOPITT, separated by season for select regions. The GFED emissions for September, October, and November were used with the November, December, January emission sensitivity to account for the 1-4 month chemical lifetime of CO.

Large increases in CO observed in the MOPITT time series for winter 2007 and 2016 (November 2006/2015 to January 2007/2016) found to be linked to strong occurrences of El Niño, where drought conditions led to enhanced CO from fires[4], as shown with fire emissions from GFED.

Trends in Water Vapour

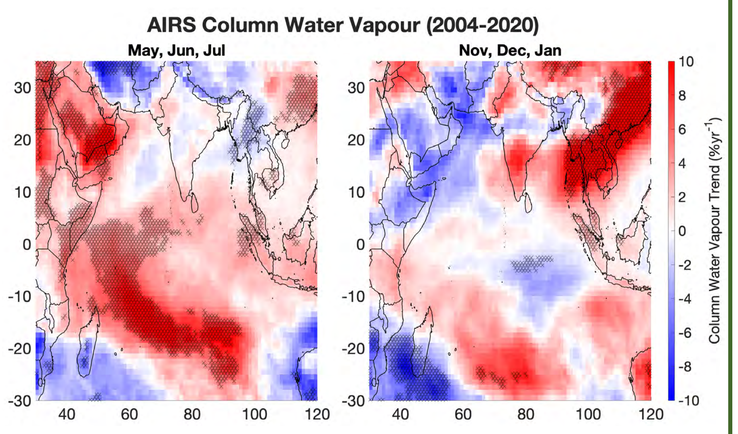

Figure 8: Trends in total column water vapour (CWV) calculated for 2004-2020 from AIRS data. The trend for each grid cell is shown as %/decade. Significance was defined for t > 2, with statistically significant cells shown with hatching.

Conclusions

- Boundary layer CO in the Indian Ocean region is found to be decreasing between 2004 and 2020, contrary to increasing CO emissions from surrounding land masses.
- Large increases in CO found for winter 2007 and 2016 can in large part be explained by the drought conditions caused by severe instances of El Niño, leading to increased fires.
- CWV is found to be increasing in many of the regions where decreases in boundary layer CO are found. Further work will examine the possible correlation between the increased CWV and decreased CO.

Future Work

- Examine the importance of transport versus emissions for atmospheric concentration of CO.
- Investigate the role of convection in CO variability.
- Continue to analyze CWV, as well as consider the impact of tropospheric ozone on CO.

References

1. Girach, I. A., & Nair, P. R. (2014). On the vertical distribution of carbon monoxide over Bay of Bengal during winter: role of water vapour and vertical updrafts. *Journal of Atmospheric and Solar-Terrestrial Physics*, *117*, 31-47.
2. Tegtmeier, S., Marandino, C., Jia, Y., Quack, B., & Mahajan, A. S. (2022). Atmospheric gas-phase composition over the Indian Ocean. *Atmospheric Chemistry and Physics*, *22*(10), 6625-6676.
3. Kurokawa, J., & Ohara, T. (2020). Long-term historical trends in air pollutant emissions in Asia: Regional Emission inventory in ASia (REAS) version 3. *Atmospheric Chemistry and Physics*, *20*(21), 12761-12793.
4. Huijnen, V., Wooster, M. J., Kaiser, J. W., Gaveau, D. L., Flemming, J., Parrington, M., ... & van Weele, M. (2016). Fire carbon emissions over maritime southeast Asia in 2015 largest since 1997. *Scientific reports*, 6(1), 1-8.

A new satellite-based product for studying land-atmosphere interactions

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Introduction

Information about the energy and water exchanges between the land surface and the lower atmosphere (i.e. land-atmosphere interactions) is necessary, for example, to improve our predictions and projections of temperature and precipitation extremes. Although there is a wide network of eddy-covariance towers providing observations of energy and water fluxes at the land surface over all continents, large spatial gaps remain. To improve the spatial coverage of land-atmosphere interactions data considering the energy and water balance closure, we combine remote sensing data and a physical-based model.

Data and Methods

We produce energy and water fluxes estimates at 5km resolution with the High-resolution land surface fluxes from satellite and reanalysis data (HOLAPS) framework. HOLAPS outputs of evaporation and sensible heat flux are compared against FLUXNET energy balance corrected estimates [1] and against evaporation estimates from the water balance method, using GRACE terrestrial water anomalies [2], GPCP precipitation [3] and E-RUN run-off [4]. We include in this comparison other evaporation and sensible heat flux products available for the community: GLEAM v3.6b [5], ERA5Land reanalysis [6] and two GLDAS products [7], using the CLM4 and the Noah land surface models.

Conclusion

- The HOLAPS framework shows a performance in reproducing FLUXNET data similar to GLEAM and better than the rest of products. HOLAPS is slightly better than all products in summer and during extreme temperature, precipitation and soil moisture conditions. However, some improvements are required to reproduce winter estimates, which can be related with HOLAPS limitations in simulating snow and freezing processes.
- Evaporation estimates from the water balance method disagree in winter climatologies with all products, showing a good agreement in inter-annual variability.
- The good performance of HOLAPS in summer and under extreme conditions together with its high spatial resolution support their use for agriculture and forest management activities and to evaluate the representation of land-atmosphere feedbacks in models.

References

[1] G. Pastorello, et al. The FLUXNET2015 dataset and the ONEFlux processing pipeline for eddy covariance data. *Scientific Data*, 7(1):225, 2020.

[2] F. W. Landerer and S. C. Swenson. Accuracy of scaled grace terrestrial water storage estimates. *Water Resources Research*, 48(4), 2012.

[3] R. F. Adler, et al. The version-2 global precipitation climatology project (gpcp) monthly precipitation analysis (1979–present). *Journal of Hydrometeorology*, 4(6):1147 – 1167, 2003.

[4] L. Gudmundsson and S. I. Seneviratne. Observation-based gridded runoff estimates for europe (e-run version 1.1). *Earth System Science Data*, 8(2):279–295, 2016.

[5] B. Martens, et al. Gleam v3: satellite-based land evaporation and root-zone soil moisture. *Geoscientific Model Development*, 10(5):1903–1925, 2017.

[6] J. Muñoz Sabater, et al. Era5-land: a state-of-the-art global reanalysis dataset for land applications. *Earth System Science Data*, 13(9):4349–4383, 2021.

[7] M. Rodell, et al. The global land data assimilation system. *Bulletin of the American Meteorological Society*, 85(3):381 – 394, 2004.

Evaluation against FLUXNET towers

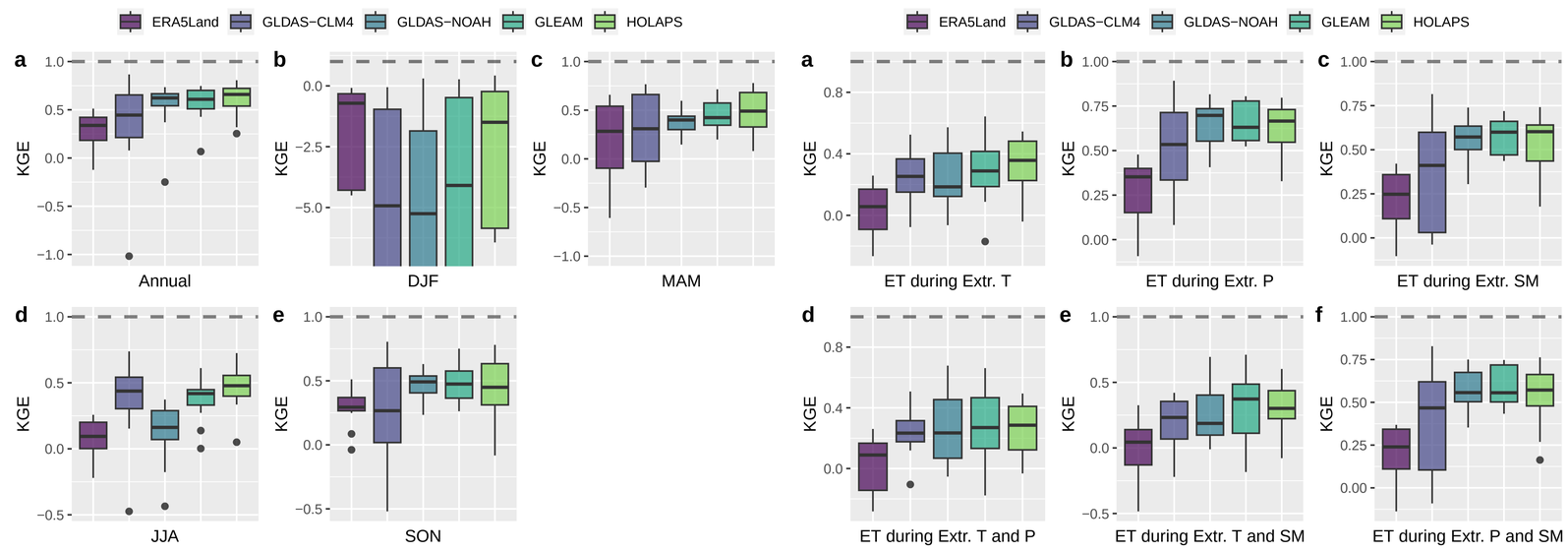

Figure 1: Annual and seasonal KGE metrics of evaporation (ET) products against eddy covariance measurements at daily scale (left). KGE metrics of evaporation products against eddy covariance measurements during extreme temperature (T), precipitation (P) and soil moisture (SM) conditions (right).

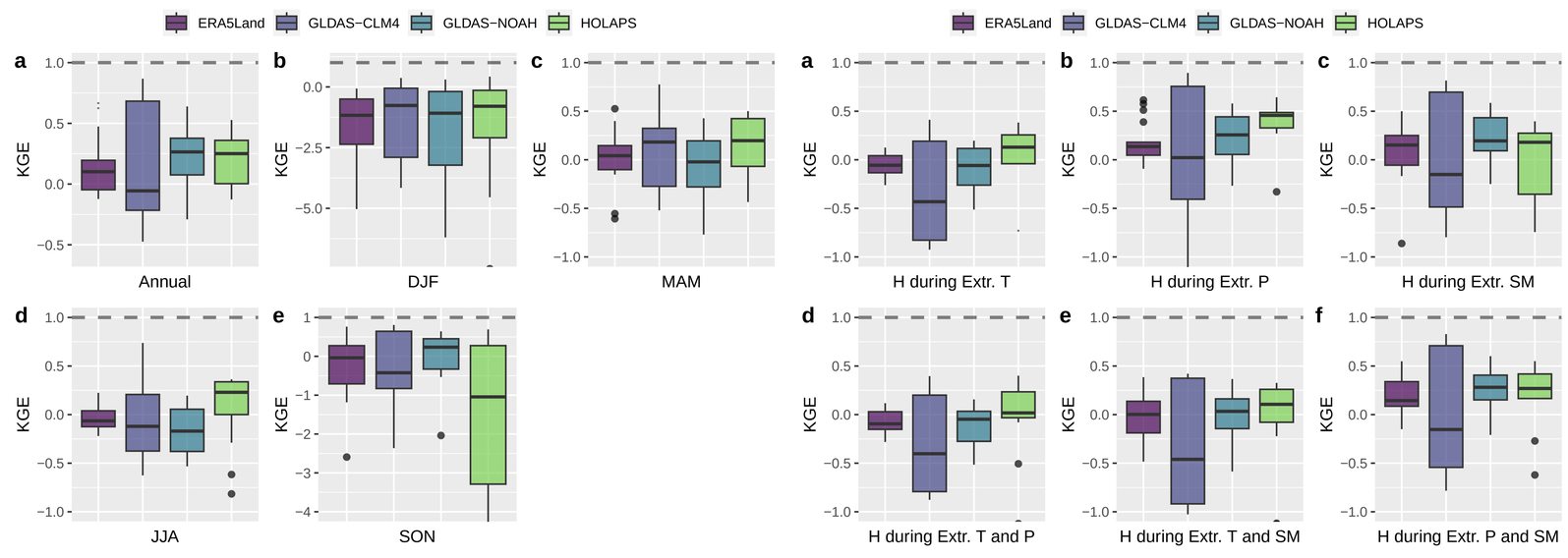

Figure 2: Annual and seasonal KGE metrics of sensible heat flux (H) products against eddy covariance measurements at daily scale (left). KGE metrics of H products against eddy covariance measurements during extreme temperature (T), precipitation (P) and soil moisture (SM) conditions (right).

Evaluation against the Water Balance method

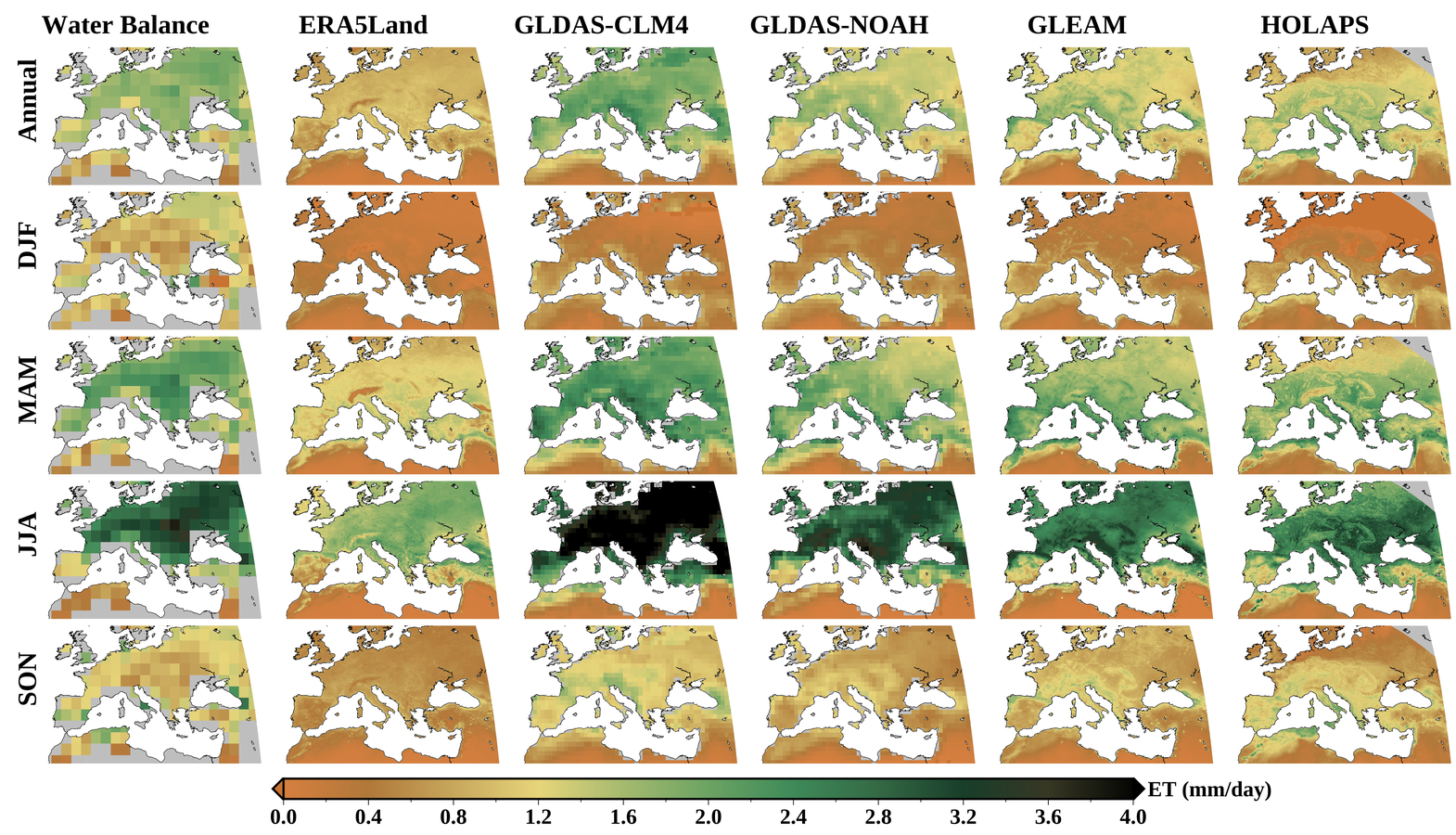

Figure 3: Annual and seasonal climatologies for the period 2003-2014 of evaporation estimates from the water balance method, ERA5Land, GLDAS-CLM4, GLDAS-NOAH, GLEAM and HOLAPS.

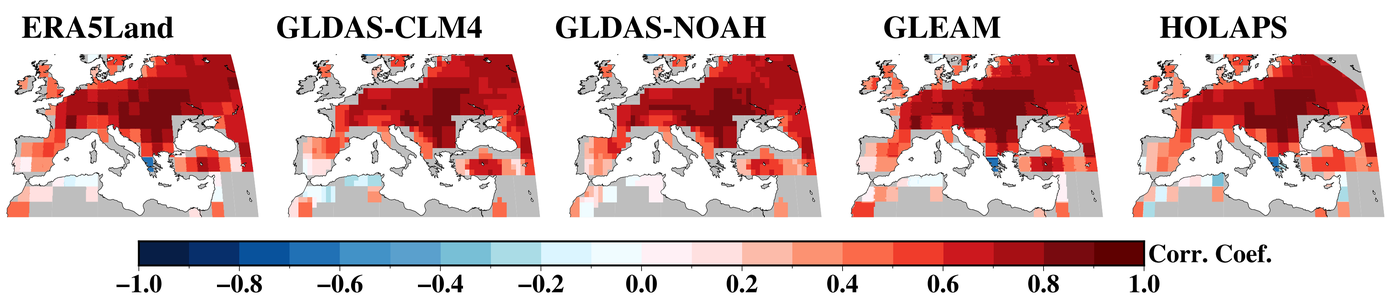

Figure 4: Pearson correlation coefficients between annual evaporation series derived from the water balance method and the ERA5Land, GLDAS-CLM4, GLDAS-NOAH, GLEAM and HOLAPS evaporation products.

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Climatology of the synchronism of late spring frost with sensible phenological stages of five major horticultural crops in Quebec

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[1] Agriculture and Agri-Food Canada, [2] Université de Sherbrooke, [3] Institut de recherche et développement en agroenvironnement (IRDA)

Key messages :

- Simple degree-day based phenological models can be used to evaluate the period at which plants may be vulnerable to frost damage;
- The RDRSv21 seems to better represent the conditions in northern latitudes than interpolated data (ANUSPLIN). However, the cumulative effect of a small cold bias has created an important underestimation of the numbers of irrigation events implemented by growers as crop protection measure;
- Phenological stage estimation needs to be re-evaluated using ground truthing information to assess the effect of possible bias and errors associated with a data source that differs from the data used to calibrate the models.

Rational and objectives

Synchronism of late spring frost with sensible phenological stages may lead to significant damages to the major horticultural crops in Quebec. Irrigation is a commonly used practice to prevent frost associated damages, requiring important volumes of water early in the growing season.

This project aims to evaluate the recent climatology associated with “flower-frost” synchronism in order to provide an estimation of current and future water needs related to frost protection for **strawberries, raspberries, cranberries, blueberries and grape vines**.

This objective is part of a broader project trying to estimate water needs and water availability for agricultural activities (irrigation, livestock, washing and crop protection), as a way to prevent potential conflicts over the resource.

Methodology

Calibrated phenological models developed at Agriculture and Agri-Food Canada (AAFC) based on thermal accumulation (degree-days) were used in order to determine the occurrence of “flower-frost” synchronism. These models reflect the relation between air temperature and available solar radiation mostly initiating the physiological response.

Frost tolerance thresholds were extracted from the literature and applied to the relevant phenological stages (Table 1).

Two climate datasets (NRCan-ANUSPLIN and the Canadian Regional Deterministic Reanalysis System-RDRS v2.1) are compared to estimate the influence of the climate information in the evaluation of frost damage risks.

Frost protection events were described based on hourly data from a selection of 15 weather stations.

Workflow

1. Find Days of Year (DoY) associated with the reaching of phenological stages (internal R version of CIPRA software, based on version 27.3);

2. Count the number of days where minimum air temperature (tasmin) < thresholds (literature and adjusted) between phenological stages;

3. Compute the frequency of “flower-frost” events of on 30-year period : ([1961-1990], [1971-2000], [1981-2010], [1991-2017], percentiles: 0.1-0.9)

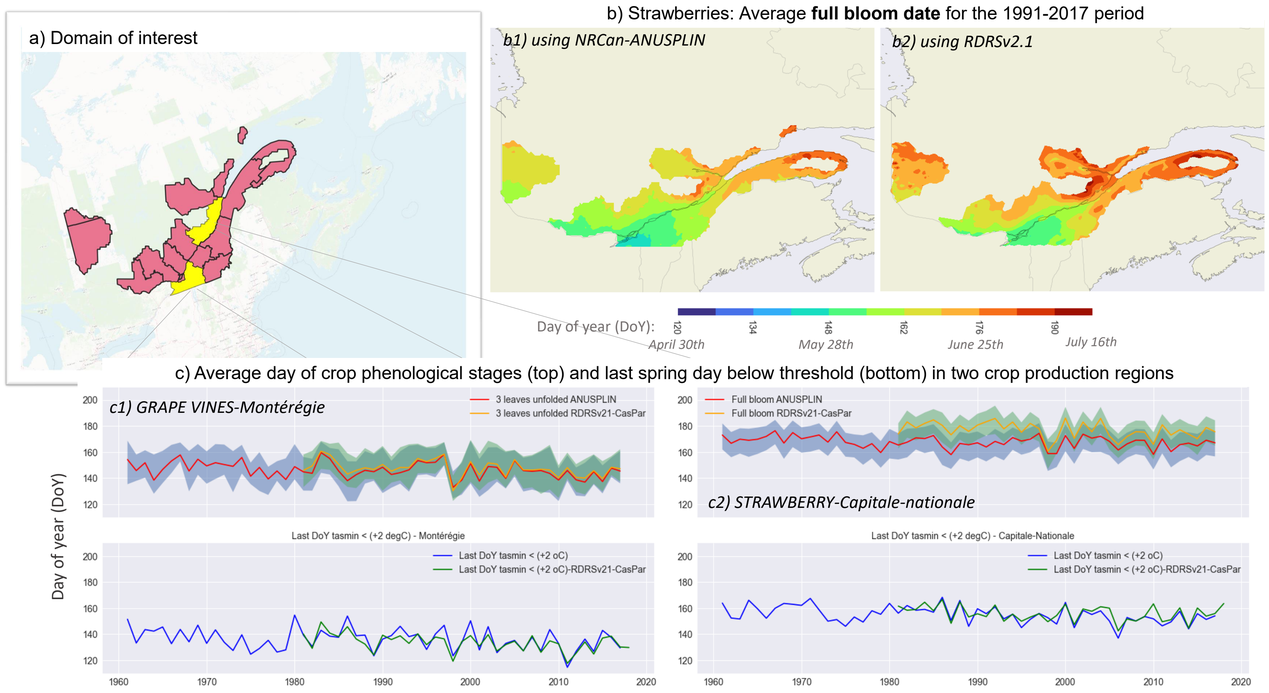
Table 1. Crop phenological stages and associated temperature thresholds for crop protection events

Crop	Variety	Degree-day (DD) computation method : (Start date, T°C-base, T°C-optimal)	Phenological stages [1] (DD for relevant phenological stages)	Frost tolerance temperature[2] (°C)	Adjusted frost tolerance temperature[3] (+2 °C)
Strawberry[2a]	*Jewel*	Simple sin (1st March, 0, 30)	1. Begin. leaf development (241)	NA	NA
			2. Beginning green bud (395)	-5.5	-3.0
			3. Advanced green bud (451)	-2.2	0.0
			4. Flowering (607)	0.0	2.0
			5. Green fruit (739)	-2.2	0.0
Raspberry[2b]	*Killarney*	Simple sin (1st March, 1.7, 30)	1. Green tip (189)	NA	NA
			2. Green buds tight (300)	NA (-20)	-18
			3. Green buds grouped (430)	NA (-10)	-8.0
			4. Green buds separated (513)	-1.0	1.0
			5. Flowering (686)	-1.0	1.0
Cranberry[2c]	ND	Simple sin (1st March, 5, 30)	1. Beginning of elongation (365)	-3.8	-1.0
			2. Beginning of flower hook (503)	-1.1	1.0
			3. 10 % flowering (663)	-1.1	1.0
			4. 10 % fruit set (777)	-1.1	1.0
			5. 95 % flowering (867)	-1.1	1.0
Lowbush blueberry[2d]	ND	Simple sin (1st March, 0, 28)	1. Flower buds emergence (285)	-7.0	-5.0
			2. Flower buds (358)	-5.0	-3.0
			3. Full bloom (498)	-2.0	0.0
			4. End of flowering (548)	-2.0	0.0
Grape vines[2e] (early varieties)	*Marquette, La Crescent, Baltica, E.S. 4-23- 60, DM 8521-1, Osceola Muscat*	Simple sin (1st March, 10, 30)	1. Wool stage (52)	-8.0	-6.0
			2. Green shoot (88)	-2.0	0.0
			3. 1 st leaf unfolded (102)	0.0	2.0
			4. 3 leaves unfolded (130)	0.0	2.0
			5. Flowers closely pressed together (218)	0.0	2.0

1. Plouffe et al., 2022. *CIPRA - Centre informatique de prévision des ravageurs en agriculture: guide des cultures*. ISBN 978-0-660-21483-2
2a. Martsoff and Gerber, *Ohio Strawberry Manual, Bulletin no 436* : cited in MAPAQ-Réseau d’avertissement phytosanitaire. 2022.
2b. Demchak, K. 2020 *Frost and Freeze Damage on Berry Crops*. PennState Extension.
2c. Workmaster *et al. 2009. Frost Hardiness of Cranberry Plant : A guide to manage the crop during critical periods in spring and fall.* University of Wisconsin
2d. Yarborough, D. 2015. *Flower primordia development stage. Fact Sheet no. 216*, University of Maine Extension no. 2003.
2e. Boivin, et coll. 2019. « Régie raisonnée de l’eau pour le bleuet nain cultivé dans un contexte de climat variable et en évolution », 170 pages.
3. Highlighted values represent the frost tolerance thresholds used to simulate initiation of for crop protection events using irrigation;

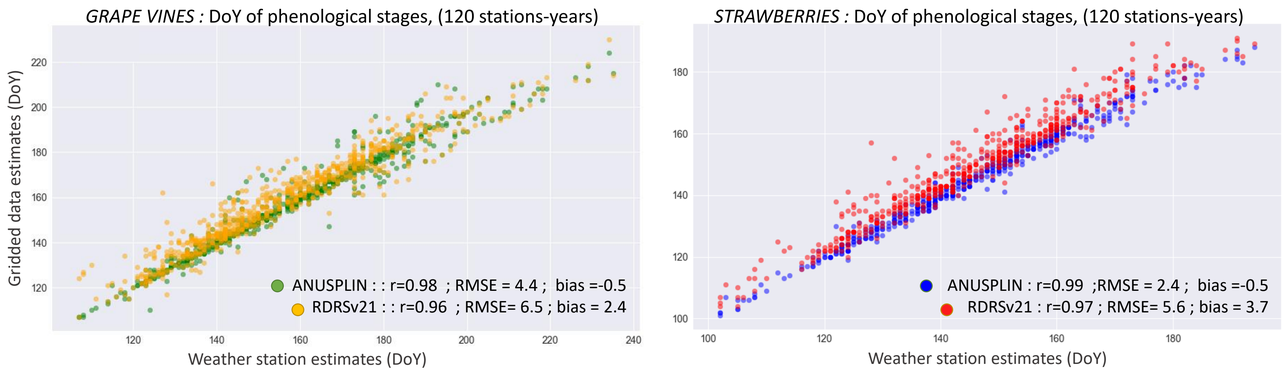
Results

The choice of the climatic dataset has an important effect on the estimated dates at which crops are sensible to late frost, especially in Northern regions.



Modeled date of crop phenological stages are **estimated 7 to 14 days later** in the Northern latitudes using RDRSv21 (fig. b2 and c2), while the shift in the last spring day below the temperature threshold is less pronounced (fig. c1 and c2). This has a strong effect on the estimated number of « flower-frost » events.

NRCan-ANUSPLIN has a greater success representing phenological stages as estimated using weather station data (used to calibrate the phenology models).



Comparison of model estimates with phenological observation dates is needed before using RDRSv21 to evaluate “flower-frost” synchronism.

The selection of appropriate return period of the frequency of “flower-frost” events is needed to estimate the volume of water needed for crop protection.

Nb of events/year during 1991-2017 period using ANUSPLIN (domain average)

Crop	1 in 2 years (C50)	1 in 5 years (C80)	1 in 10 years (C90)
Strawberry	1.3	2.7	3.6
Raspberry	0.0	0.5	0.8
Cranberry	0.0	0.0	0.2
Lowbush blueberry	0.7	1.7	2.3
Grape vines	2.6	4.7	6.1

Average length of a flower-frost event was 3.5 hours (+/- 2 hours).

Conclusion

- Calibrated phenological models provide useful information to evaluate the sensible stage of specific crops.
- Its utilization requires caution to the possible bias of climatic information versus the data used for calibration.
- Multiple models approach could help better represent the risk of late spring frost damage, which can then be interpreted to estimate the water resource needed by the agricultural sector.

Correlative Ground-based Observations at the St. Mary's University Atmospheric Observatory in Halifax, Nova Scotia

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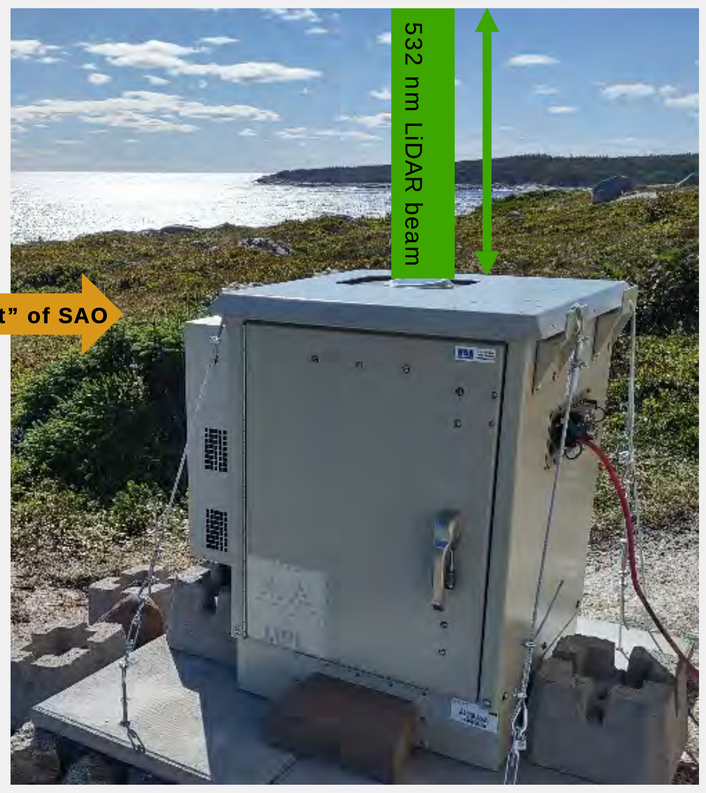
[1]St. Mary's University [2]Dalhousie University [3]University of Western Ontario

SMU Atmospheric Observatory

Infrared beam in open-path (450 m two-way)

IR beam retroreflector on neighbouring rooftop

Sandy Cove "Adjunct" of SAO



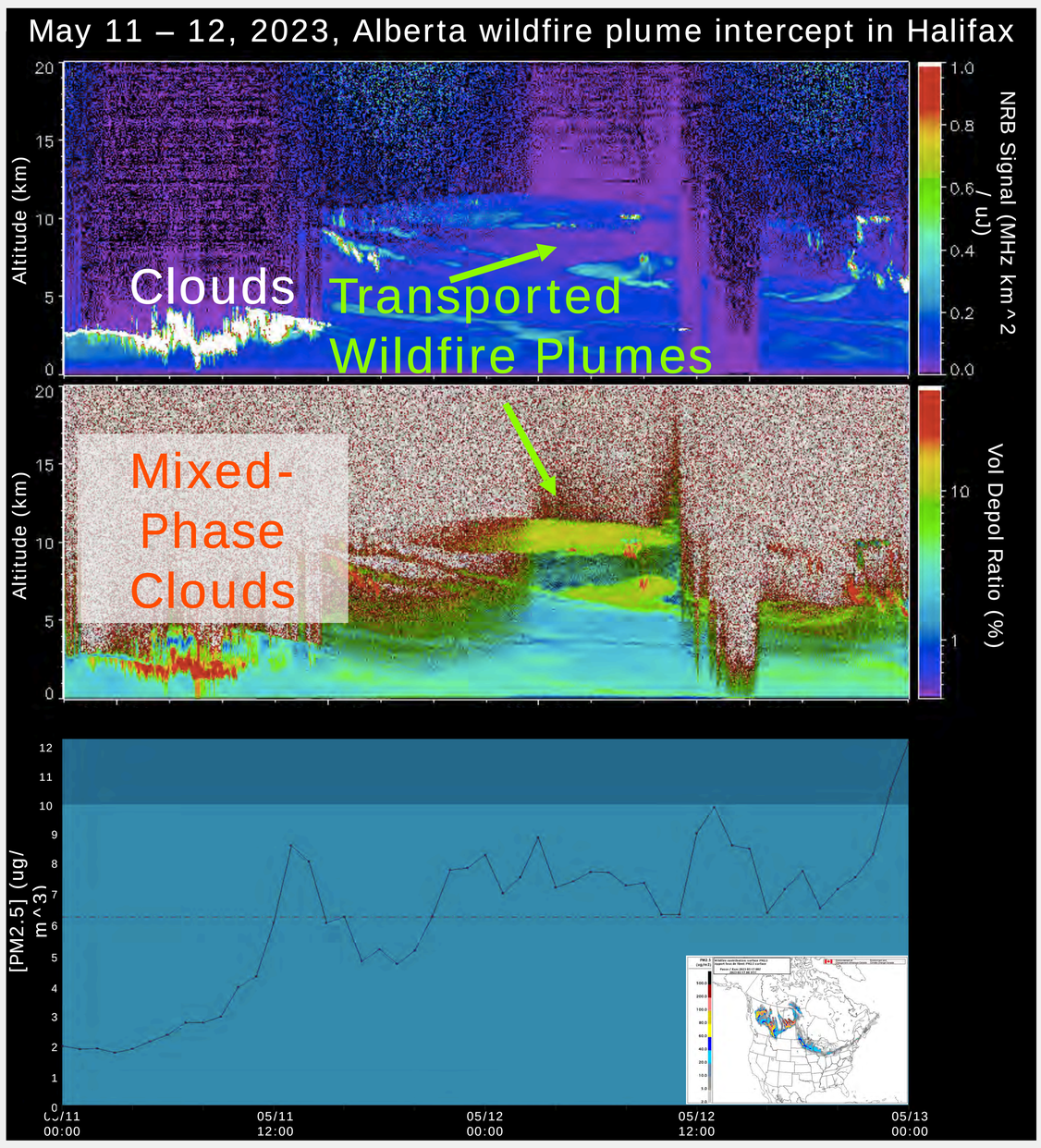
The SMU Atmospheric Observatory (SAO) is a newly established observatory designed for continuous monitoring of atmospheric trace gases, aerosols, meteorology, and cloud parameters. It comprises an urban Halifax site ~1 km from the coast and an "Adjunct" site right at the coast in nearby Sandy Cove. Instrumentation at SAO includes:

- Open-Path Fourier Transform InfraRed (**OP-FTIR**) spectrometer, currently sampling a horizontal two-way path of ~450 m, and recording active IR beam absorption spectra (day and night) of multiple trace gases, including VOCs like formaldehyde, at high temporal (4 min. to average 960 interferograms) and medium spectral resolution (0.5 cm^{-1}) with a sensitivity of ~1 ppb
- Mini Micro Pulse LiDAR (**mMPL**) deployed at Sandy Cove as part of the Canadian Lidar Network (a part of NASA's Lidar Network), currently probing the atmosphere up to an altitude of 20 km to provide vertical profile measurements of normalized relative backscatter (NRB) and volume depolarization ratio (VDR) to detect aerosols, clouds and their phase (solid vs. liquid)
- **PurpleAir** sensors at both SAO and Sandy Cove, providing surface aerosol concentration measurements of particulate matter with diameter, D, less than 2.5 µm ($PM_{2.5}$)
- **Davis Weather Station**, providing meteorological measurements (p, T, RH, wind direction and speed, rain rate, total solar irradiance and UV index)

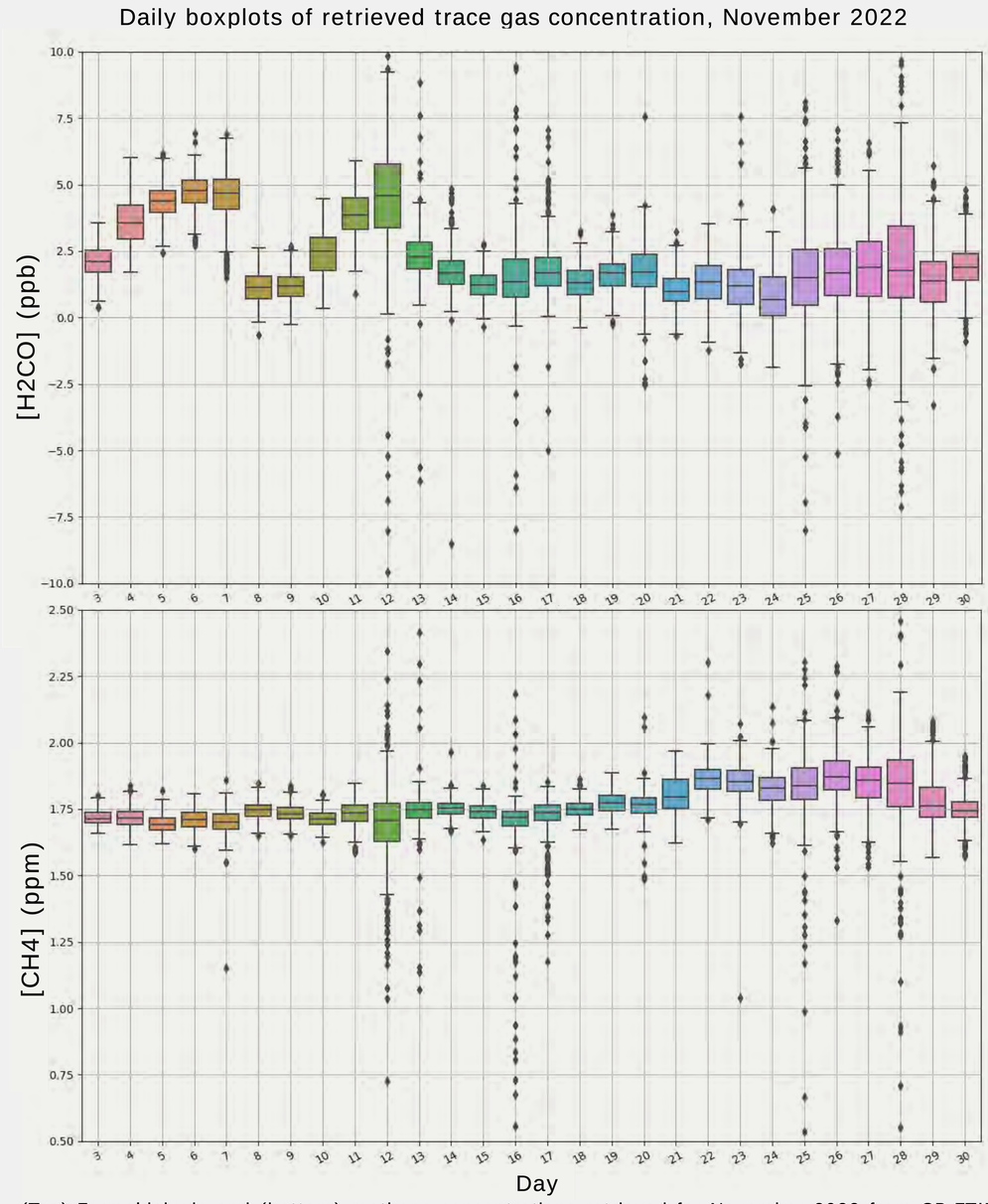
Reasons to monitor trace gases and aerosols in Halifax and at Sandy Cove:

- Halifax is the second largest Canadian coastal city with regular commercial and military ship presence in the port, which contributes criteria air contaminant emissions equivalent to placing a second automobile fleet on the roads [Wiacek et al., 2017, ACP]
- Shipping in Halifax is increasing, with the marine fleet changing to meet new regulations on fuel sulphur content and NO_x emissions, as well as to meet industry decarbonization goals that may increase methane (CH_4), methanol (CH_3OH), ammonia (NH_3) and nitrous oxide (N_2O) emissions (all detectable by the OP-FTIR system, along with many other mid-IR active gases)
- SAO provides vital data on shipping-related trace gas and aerosol concentrations, including unique gas species such as ammonia and oxygenated VOCs related to surface ozone and particulate matter production
- Halifax is subject to long-range transported (LRT) air pollution from upstream emission sources. The new observatory serves as an observation site for the newly-funded Canadian mMPL Network (MPLCAN), whose science goals include better tracking transported particulate pollution from anthropogenic sources as well as forest fires and volcanoes.
- SAO is well positioned to provide continuous ground-based measurements suitable for satellite validation and long-term trend analysis

First Results



(Top) Normalized relative backscatter and (middle) volume depolarization ratio measured by Sandy Cove LiDAR, with (bottom) surface $PM_{2.5}$ concentration from the SAO PurpleAir and (inset) a recent but non-coincident (May 17) FireSmoke forecast.



(Top) Formaldehyde and (bottom) methane concentrations retrieved for November 2022 from OP-FTIR absorption spectra recorded every 4 minutes. Boxplots show medians and 75th to 25th percentiles; upper and lower whiskers represent min and max values, with outliers shown as dots beyond the whiskers.

Future Work

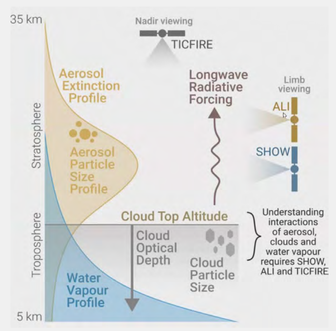
SAO is being upgraded to provide near-real time (NRT) trace gas concentrations automatically, as well as the co-located meteorology and (surface) PurpleAir $PM_{2.5}$ concentrations

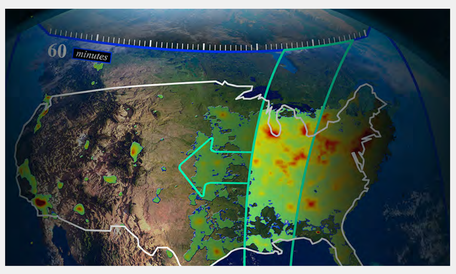
- Complementary low-cost sensors for surface [NO_x] are planned (not captured reliably by OP-FTIR at high humidity)
- MPLCAN data is already automated and accessible at https://mplnet.gsfc.nasa.gov/data?all&s=Sandy_Cove
- If you are interested in housing instrumentation at SAO please contact Project PI Aldona.Wiacek@smu.ca

OP-FTIR data (Halifax) will be used to validate the TEMPO instrument in geostationary orbit (April 07, 2023 launch), now making continuous daytime measurements over North America with a grating spectrometer that observes solar UV/VIS backscatter radiation

- Targets: NO_2 and O_3 (reported hourly, including 0-2 km O_3 comparable to OP-FTIR), HCHO, $C_2H_2O_2$, SO_2 (3 times / day)

Finally, long-term plans include the use of mMPL data (Sandy Cove) for validation of data products from the Canadian High-altitude Aerosol, Water vapor and Clouds (HAWC) mission, a part of NASA's Atmosphere Observing System (AOS), with a post-2028 launch.





(Left) HAWC mission goals and instruments, (right) TEMPO instrument coverage for NO_2.

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The Great Dusty North?

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For the first time, we use satellite data to highlight where and when mineral dust aerosol ("MDA") is present in the atmosphere over Canada.

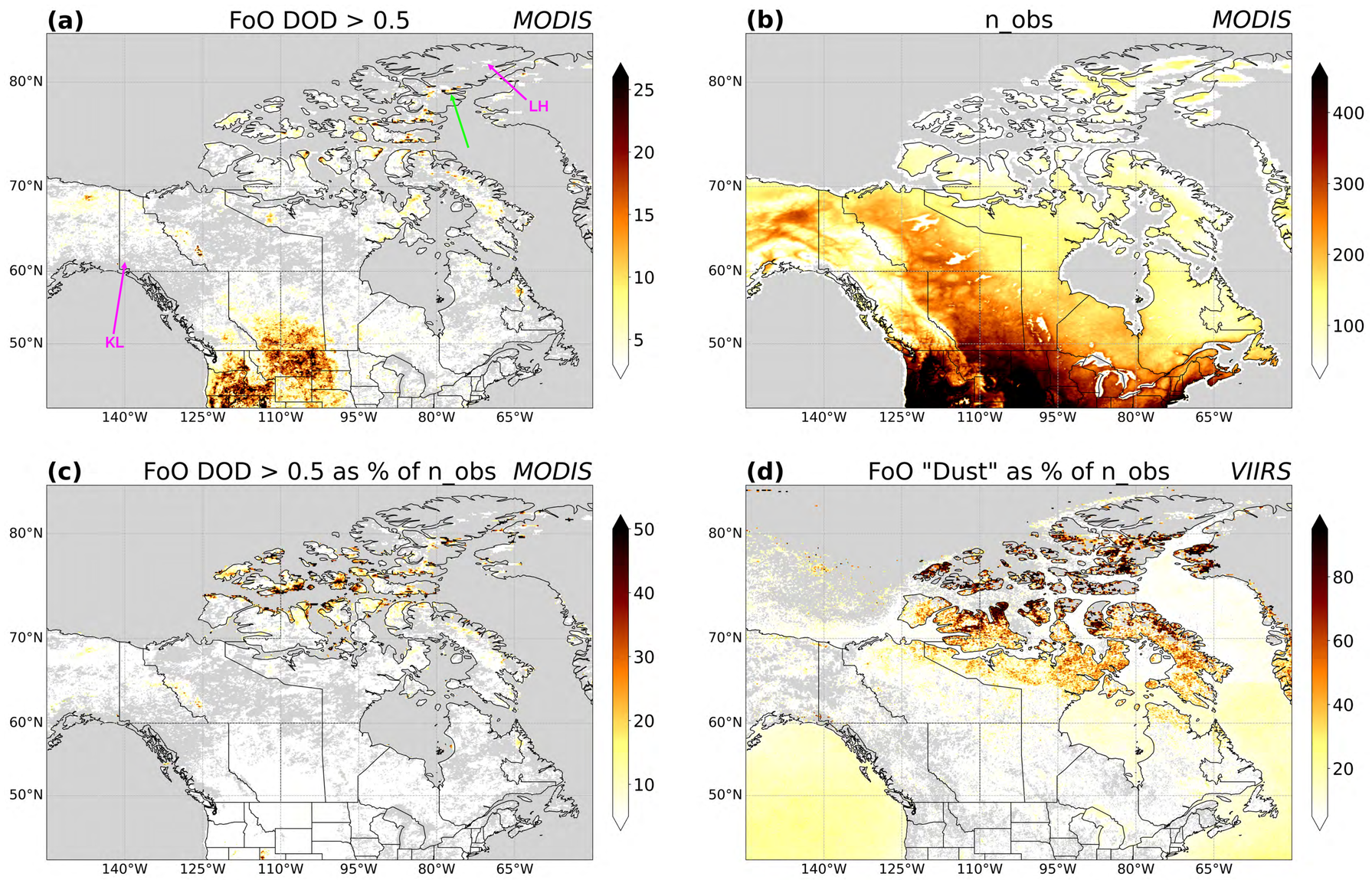


Fig. 1: a) Frequency of occurrence ("FoO") of MODIS dust optical depth ("DOD") > 0.5. Pink arrows = locations of previously documented Canadian MDA sources (KL = Kluane Lake; LH = Lake Hazen), green arrow = location of area shown in Fig. 3; **b)** Number of days with MODIS DOD retrievals ("n_obs"); **c)** FoO DOD > 0.5 expressed as a % of n_obs; **d)** As b but for aerosol type classification "dust" from VIIRS. Grey shading = no data in all cases. See text for more info.

Background

- MDA is an important component of the Earth System, impacting Earth's radiation budget, clouds, precipitation, biogeochemistry, and air quality.
- MDA sources are typically arid areas where erosion causes tiny (< 62.5 μm) particles to accumulate, such as dry lake beds and outwash plains. Hot deserts have long been recognized as MDA source hotspots, but emissions from high-latitudes are expected to increase owing to climate change, with e.g., deglaciated valleys rich in dust-sized particles (*Bullard et al.*, 2016, Rev Geophys.).
- MDA from high-latitude sources are especially important in the Arctic, with around one third of dust present here thought to have been sourced locally (*Groot Zwaaftink et al.*, 2016, JGR-Atmos.).
- Little research has focused on high-latitude MDA sources, with only two source areas having been documented in Canada's North (*Meinander et al.*, 2022, ACP; Kluane Lake & Lake Hazen, locations marked in Fig. 1a). There are likely many more.

Data & Methods

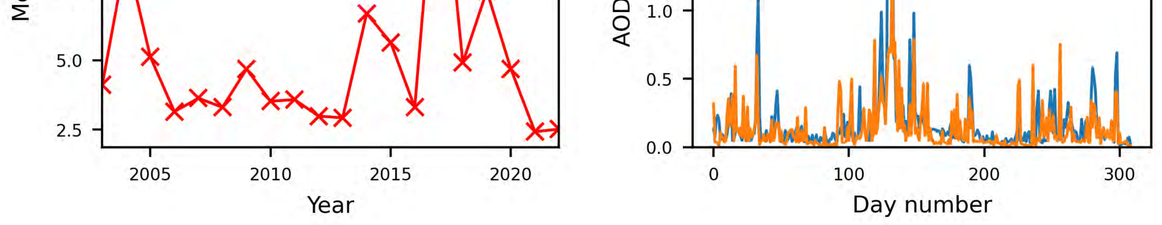
- Products from Table 1 were interpolated to a regular 0.1 x 0.1° grid at daily temporal resolution.
- Daily DOD (aerosol type) fields were screened for selected DOD thresholds (presence of aerosol type = "dust" flag). Frequency of occurrence ("FoO") was summed from these daily data. FoO fields were converted to a "% of n_obs" value by dividing by total number of days with data ("n_obs") for the respective product.
- DOD was compared to AOD (500nm) from the AERONET station at Kluane Lake (2018 – 2022 only).

Table 1: Satellite products analysed in this study.
[†1] From "Deep Blue" aerosol algorithm; [†2] From *Pu & Ginoux*, 2020, ACP

Product [†1]	Sensor (period)	Notes
Dust Optical Depth (DOD)	MODIS (2002 – 2020)	DOD = AOD x $(0.98 - 0.5089\alpha + 0.0512\alpha^2)$ [†2] L2 swath resolution = 10 x 10km @ nadir
Aerosol type = "Dust"	VIIRS (2020 – 2022)	L2 swath resolution = 6 x 6km @ nadir

Results

- There are hotspots of MDA presence scattered across northern Canada, in addition to a broader area to the south (Fig. 1a).
- Although number of days with data decreases to the north (Fig. 1b), these retrievals are more frequently indicative of higher DOD or "dust" than those to the south (Fig 1c & 1d, respectively).
- Preliminary analysis suggests dustiness may have increased in the north of the region from 2002 – 2020, on average (Fig. 2a).
- Peaks in MODIS DOD & AERONET AOD at Kluane Lake are aligned temporally (Fig. 2b), with moderate correlation across the time series (r = 0.58).
- Initial comparison with Google Earth imagery provides evidence that FoO hotspots presented here are proximal to geomorphological features (e.g., outwash plains) that are known MDA sources (Fig. 3). FoO hotspots from MODIS data are commonly used as indicators of MDA source areas at lower latitudes (e.g., *Ginoux et al.*, 2012, Rev. Geophys.).



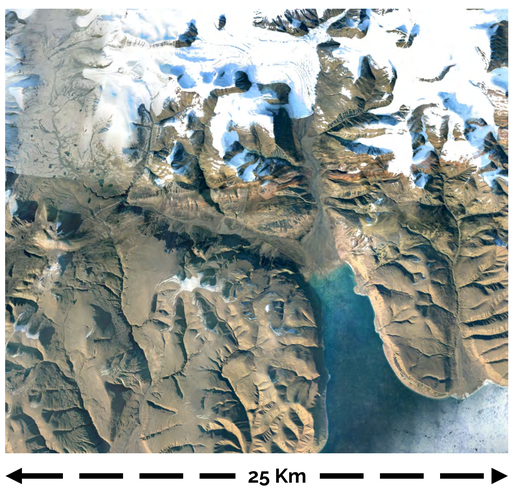


Fig. 2: (Above) **a)** Annual mean time series of FoO MODIS DOD > 0.5 expressed as % of n_obs, averaged north of 65° N; **b)** Time series comparison of daily maximum AERONET AOD from Kluane Lake vs maximum MODIS DOD in a 1° x 1° box centered on the AERONET site.

Fig. 3: (Left) Google Earth image of potential emission zone proximal to FoO hotspot marked with green arrow in Fig. 1a.

Results will be used to better understand and quantify the local Earth System impacts of MDA; and to evaluate and improve modelled dust emissions.

Canadian Atlantic Shelf Temperature-Salinity (CASTS) data product: A century of hydrographic observations in the Northwest Atlantic and Eastern Arctic

Fisheries and Oceans Canada
Pêches et Océans Canada

Jonathan Coyne[1], Frédéric Cyr[1], Sebastien Donnet[3], Peter Galbraith[2], David Hebert[5], Chantelle Layton [5], Andry Ratsimandresey[1], Stephen Snook[1], Nancy Soontiens[1] Wojciech Walkusz[4],

[1]DFO-NL, [2]DFO-QC, [3]DFO-PAC, [4]DFO-O&P, [5]DFO-MAR

Context

As part of the new Fisheries Act, Fisheries and Oceans Canada (DFO) has made a priority to disseminate publicly its data. The project proposed here is to create an open-access data product that include most of the historical temperature and salinity profiles collected in Atlantic Canada and the Eastern Arctic. This project does not aim to replace a potential database, but rather provide an easily accessible and quality-controlled product that can inform fisheries management and support DFO priorities such as the Ecosystem Approach to Fisheries Management, Marine Spatial Planning and the Blue Economy. The Canadian Atlantic Shelf Temperature-Salinity (CASTS; Coyne et al., 2023) data product consists of **782,133 individual casts** collected in a geographical zone corresponding to 35-80°N and 42-100°W since 1912. Data was gathered from multipled regional, national, and international sources in order to make this product. This data product also offers new opportunities to review the changes in Atlantic Canada's ocean climate, another priority of the Government of Canada.

Quality Assurance / Quality Control

Combining Sources

(A) - Gather Sources

- Northwest Atlantic Fisheries Center - Oceanography* *1912-2022*
- Climate Database (Gregory 2004) *1913-2010*
- Canadian Integrated Ocean Observing System *1996-2020*
- Northeast Fisheries Science Center *1981-2021*
- National Center for Environmental Information *1990-2021*
- Northwest Atlantic Fisheries Center - Aquaculture *2009-2020*
- Maurice Lamontagne Institute *1972-2022*
- Polar Data Catalogue *2002-2021*
- Bedford Institute of Oceanography - Ocean Monitoring & Modelling *2008-2018*
- European Union - Northwest Atlantic Fisheries Organization *2019-2021*

(B) - Prep for Combining

Bin-Average (1m), Remove Empties, Duplicates, Outliers

Bin-Average (1m) (separately)

(C) - Combine Sources

Combine Sources

Remove Duplicates, Outliers

Final Yearly Product

** Casts from NAFC - Oceanography had no previous QA/QC*

CASTS NetCDF Structure

Time Jan. 1912 → Dec. 2022

Depth 0m ↓ 2000m

Temperature (time, depth [1m bin-averaged])

0m ↓ 2000m

Salinity (time, depth [1m bin-averaged])

Latitude (time)

Longitude (time)

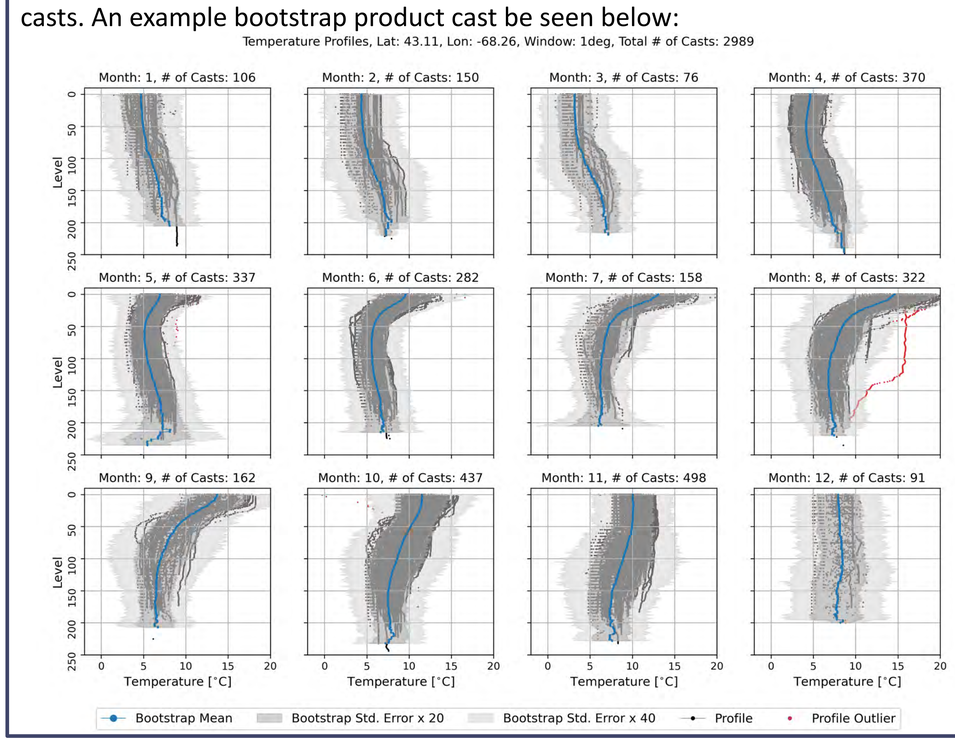
Instrument ID, File Name, Instrument Type, Station ID, etc. (time)

CASTS saved in yearly NetCDF files - load with one line of code!

Removing Outliers

Outliers: Casts are used to create a "climatology" for the entire domain. The gridded mean and standard deviation are determined for both temperature and salinity. This is then used to complete a bootstrap where boundaries are determined for each gridcell.

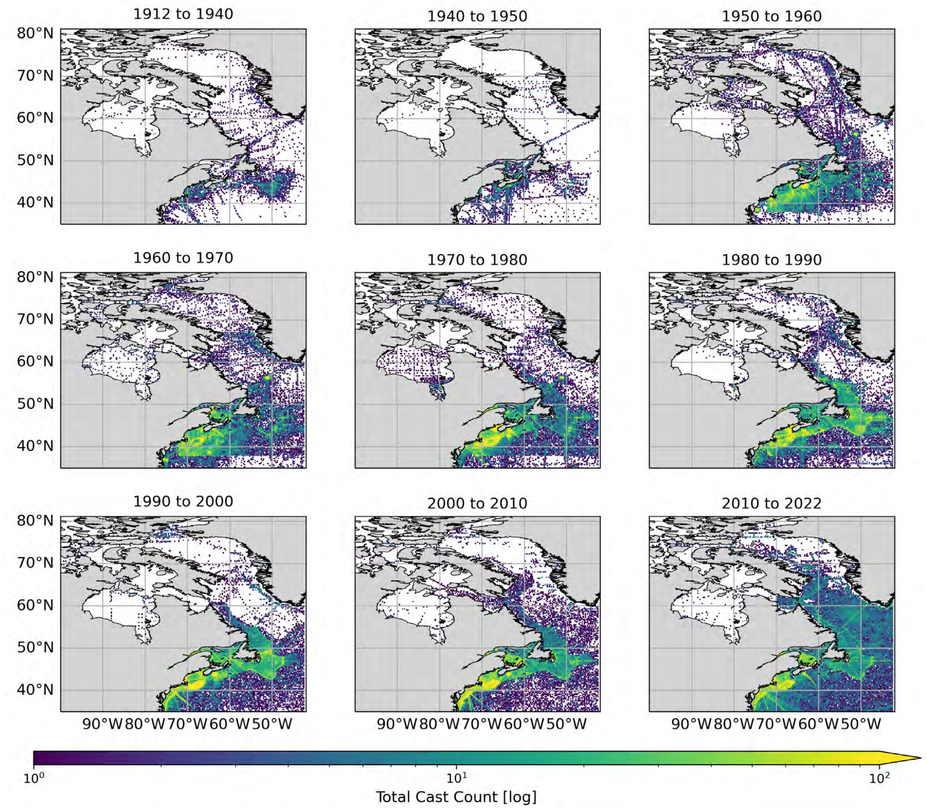
Each cast is then compared to the bootstrap product. If at least one measurement is outside the boundaries, it is flagged and plotted for visual inspection. We then decided whether to keep the cast, remove the outliers, or remove the entire casts. An example bootstrap product cast be seen below:



Gridded Density of Casts

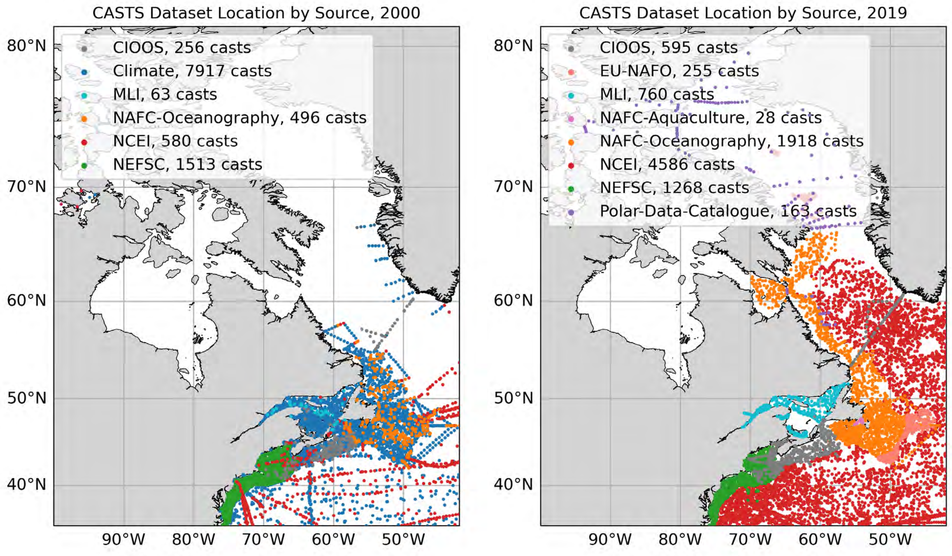
The number of casts that occur in 1 degree by 1 degree bins over a specified time period, plotted using a log scale. Starting in the 1950s, it is common to have at least 10 casts present along the Northwest Atlantic shelf.

Loaded in using one line: `ds = xr.open_mfdataset('*.nc')`

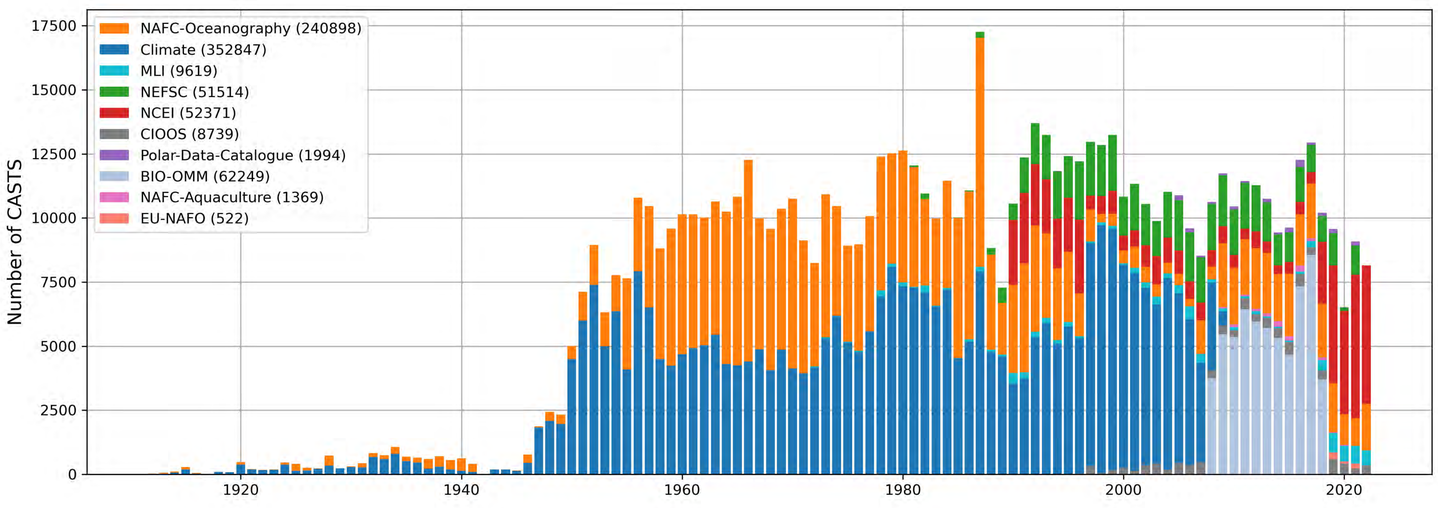


Typical Cast Location by Source

All cast locations from 2000 and 2019, plotted and coloured according to its source. Some sources have a typical area, like DFO sources isolating for their region, while other sources provide data throughout the domain (NEFSC, Climate, etc.).



Cast Source Count per Year



Acknowledgements and Contact Info

This work is possible in part due to contributions from the Atlantic Zone Monitoring Program (AZMP) of Fisheries and Oceans Canada (DFO). The authors thank the numerous scientists, technicians, captains, and crew members who have participated in the sampling and analysis effort since 1912. The authors also thank all national and international contributors who helped make this data product possible.

References

Gregory, D.N., (2008). Ocean Data Inventory (ODI): A Database of Ocean Current, Temperature and Salinity Time Series for the Northwest Atlantic

Coyne J., Cyr F., et al., (submitted). Canadian Atlantic Shelf Temperature-Salinity (CASTS). Federated Research Data Repository. https://doi.org/10.20383/102.0739

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Drift modelling to estimate at-sea losses of Northern Gannets during the Highly Pathogenic Avian Influenza outbreak of 2022 (first wave)

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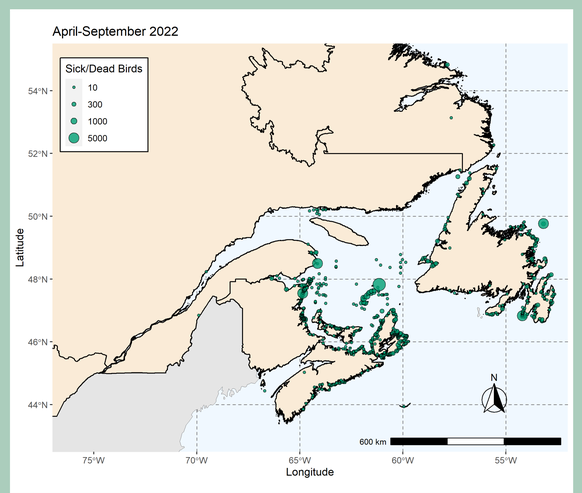
Introduction

In 2022, the Highly Pathogenic Avian Influenza (HPAI) virus had a devasting impact on Northern Gannets, a large seabird that breeds in eastern Canada. Throughout the summer, over twenty-four thousand dead gannets[1] were reported and many more were expected to have died at sea.

During this outbreak, we used operational ocean (CIOPS-East[2]) and weather (HRDPS[3]) forecasts to ask:

- What colony did dead gannets originate from?
- How many dead gannets were lost at sea?
- Where should ECCC focus survey efforts in 2023 to support migratory bird conservation?

Reported sick and dead gannets



Between April 1 and September 30, 2022 more than 24,500 sick and dead Northern Gannets were reported in eastern Canada, shown in green.

- These numbers are just a fraction of the total mortality because they do not include birds that died out of sight of people (i.e. in remote places or out at sea) or birds that were observed but not reported.

Numerical tools and drift modelling

For each colony:

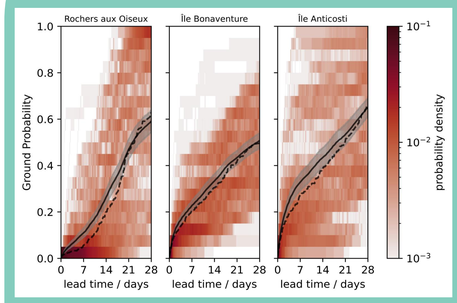
- 1000 particles deployed per day during outbreak within the foraging range and tracked for 28 days.
- Particles were normally distributed in space with a standard deviation equal to ¼ of the foraging radius.
- MLDPn[4,5] for particle tracking with
  - CIOPS-East ocean model for currents
  - HRDPS for 10 metre wind speeds with 3% windage.
- Random walk and horizontal diffusivity of 1 m^2/s to simulate turbulent dynamics.

Fate of the particles after n days

- Fraction washed ashore (grounded).

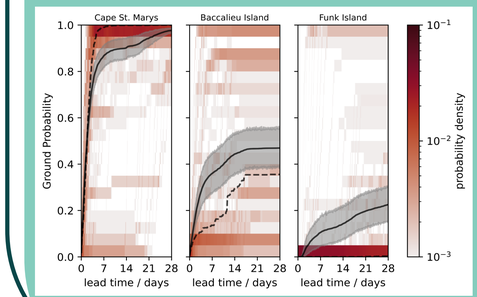
Modelled grounding rates driven by estimated ocean currents and winds can explain why some dead birds were observed in areas far away from colony sites and their foraging ranges (indicated by circles).

Grounding probability



Two-dimensional histogram of grounding probability as a function of lead time for Gulf of St. Lawrence colonies. Mean grounding probability with 95% confidence intervals also shown (black line, grey shaded area). The dashed line is the median grounding probability.

- At Bonaventure and Rochers aux Oiseaux, **nearly half** of the particles ground after 28 days.



As above but for Newfoundland colonies.

- At Funk Island, **almost no** particles ground, except during a few on-shore wind events.
- At Cape St. Marys, **nearly all** particles ground early.
- These scenarios indicate a need for careful monitoring at Funk Island in order to derive mortality estimates.

During mass mortality events, **drift modelling** can help identify the **source colony** of beached birds, **improve mortality estimates** by accounting for **at-sea losses,** and inform **survey planning.**

References

[1] Avery-Gomm et al., in prep
[2] Paquin et al. 2023, preprint; https://doi.org/10.5194/egusphere-2023-42
[3] Milbrandt et al. 2016; https://doi.org/10.1175/WAF-D-16-0035.1
[4] D'Amours et al. 2014; https://doi.org/10.1080/07055900.2014.1000260
[5] Chang et al. 2020; https://doi.org/10.1007/s42452-020-03808-6

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Exploring the definitions of predictive skill and loss in machine learning

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Introduction

Thompson and Sheng (1997) provide a measure of prediction skill (γ^2) that has been widely applied. The key aspect is the difference between a numerical forecast (***U***) and observations (***C***), expressed as variance and normalized by observation variance.

$$\gamma^2 = \frac{Var(U-C)}{Var(C)}$$

The same key aspect (i.e., prediction-obs difference) typically defines loss in neural network training. That is, we can consider a neural network (***N*** ≈ ***U***) as a surrogate prediction. Intuitively, we expect smaller prediction-obs differences to indicate better predictive skill, but as Thompson and Sheng (1997) remind us, there is invariably a limit, not just to how closely predictions (forecast models or neural networks) match the observations, but also how closely predictions and observations match the environment.

Predictive skill can be assessed when either predictions or observations improve, but how do iterative assessments depend on a model of the relationships among predictions, observations, and the environment itself? As we approach the limit of our improvements, we might expect all prediction-obs-environment relationships to become linear, but in the interim, should we be prepared to treat these relationships as nonlinear? Perhaps moreso than for loss in machine learning, γ^2 seems amenable to an exploration of preliminary improvements, incomplete representations by ***C*** and ***U***, and nonlinear relations in general. Below, we introduce a model of the environment via prediction and observation measurements, and express γ^2 in these terms.

Skill and Measurement Truth

Among the simplest measurement models that we could write, and one that we sometimes apply implicitly, takes that aspect of the environment (***T***) that observations capture (***t***) to be identical to the observations (***C***) themselves, without error. A linear calibration of the forecast model to observations is also allowed. To be precise, we write separate equations for the calibrated observations (***C***), an uncalibrated forecast model (***U***), and its predictive skill (γ^2) as

$$\begin{aligned} C &= t \\ U &= \alpha_U + \beta_U t + \epsilon_U \\ \gamma^2 &= \frac{(\beta_U-1)^2\sigma_t^2+\sigma_U^2}{\sigma_t^2} \end{aligned} \qquad [1]$$

Here, α_U and β_U are an additive and multiplicative calibration of ***U*** with respect to ***C***, ϵ_U is forecast model error, σ_U^2 is error variance, and σ_t^2 is the environmental variance that both ***C*** and ***U*** capture in some linear sense. Following Thompson and Sheng (1997), if ***C*** and ***U*** are in perfect agreement ($\beta_U = 1$), then there is greater predictive skill (smaller γ^2) when forecast error (σ_U^2) is small.

With the environment (***T***) taken to be only what can be measured by predictions and observations (***C*** is a *perfect* linear measure of ***t***), the interpretation of a prediction-obs difference seems easy. However, not only does this prohibit a nonlinear relationship between observations and environment, but there can be no correlation of nonlinear-environment relationships as well. This restriction is lifted in a subsequent framework. First, we anticipate that the environment ***T*** is not easily measured by either ***C*** or ***U***. A necessary step in lifting this restriction is to consider errors in both measures.

Skill and Measurement Error

Thompson and Sheng (1997) accommodate error in both ***C*** and ***U***. As they say, "One possible reason for low model skill or, equivalently, a high γ^2 is that the observations are dominated by measurement noise. Another possibility is that the dynamical model is deficient in some important way." With observation error (ϵ_C) and variance (σ_C^2) included, the corresponding equations are

$$\begin{aligned} C &= t + \epsilon_C \\ U &= \alpha_U + \beta_U t + \epsilon_U \\ \gamma^2 &= \frac{(\beta_U-1)^2\sigma_t^2+\sigma_C^2+\sigma_U^2}{\sigma_t^2+\sigma_C^2} \end{aligned} \qquad [2]$$

Predictions and observations may disagree because ***C*** and ***U*** are different representations, so we include α_U and β_U in [1] and [2]. This allows for *linear* prediction-obs-environment relationships, but nonlinear relationships are excluded. In this respect, [2] is identical to [1].

Improvements that we seek to assess using γ^2 are changes in either σ_U^2 or σ_C^2, but in the framework of [2], these error variances also determine β_U. A simple example of this dependence is given in Fig. 1, where the shallow slope is obtained when observation error is negligible (as in [1]), and the steep slope is obtained when prediction error is negligible. (In this simple example, $\beta_U = 1$ is known.) It follows that an interpretation of skill in [2] depends not just on σ_C^2 and σ_U^2, but also on σ_t^2 when β_U is different than one. Although greater skill (smaller γ^2) is expected with smaller forecast error (σ_U^2), we might also expect β_U to increase when we improve predictions, and decrease when we improve obs.

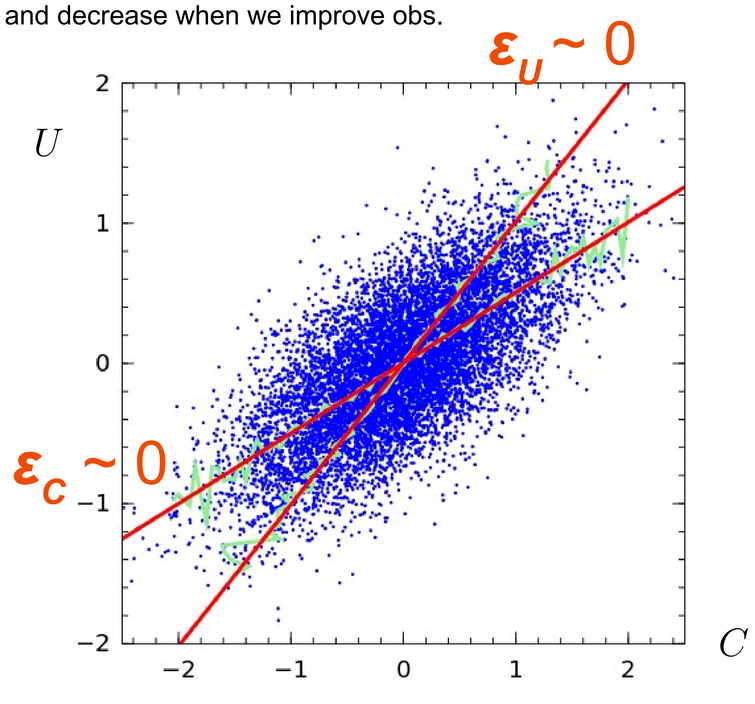

Figure 1. Slope of β_U (red lines) when $|\epsilon_C| >> |\epsilon_U|$ (steep) and $|\epsilon_U| >> |\epsilon_C|$ (shallow).

Conclusions

By way of what predictions (***U*** or ***N***) and observations (***C***) both measure, there seems to be an intimate connection between skill, performance, and association. If observations are essentially fixed and changes in predictive skill need to be assessed, then obs act as a *temporary* reference. Similarly, when improved observations need to be assessed, predictive models can also act as a *temporary* reference. Of course, the partially unknown, but *constant,* reference is our environment.

Thompson and Sheng (1997) provide a succinct measure of skill that can be used to assess both predictions or observations in a range of measurement modelling frameworks. It is notable that the value of γ^2 is identical in each framework; the only difference is our interpretation of the terms that define γ^2. Given that smaller values of γ^2 generally correspond to greater predictive skill, we find that different frameworks emphasize slightly different aspects of prediction-obs-environment relationships. Indeed, we anticipate that being flexible in our modelling framework may work to our advantage.

More Modelling

Our next step is to consider equations for ***C*** and ***U*** as the "primitive equations" of a measurement model, where each term on the RHS is a signal-and-noise term with an interpretation given by signal. (Note that the primitive equations of a forecast model are understood in the same way.) In turn, a definition of skill follows from *completing* a measurement model by including a separate term for nonlinear association (ϵ), as in

$$\begin{aligned} C &= t + \epsilon + \epsilon_C \\ U &= \alpha_U + \beta_U t + \epsilon + \epsilon_U \\ \gamma^2 &= \frac{(\beta_U-1)^2\sigma_t^2+\sigma_C^2+\sigma_U^2}{\sigma_t^2+\sigma_\epsilon^2+\sigma_C^2} \end{aligned} \qquad [3]$$

In effect, the forecast error (ϵ_U) of [1] and [2] is split into correlated and uncorrelated parts (Thompson and Sheng 1997), and so is observation error (ϵ_C).

The interpretation of observations (***C***) and predictions (***U***) can be given in terms of signal, so linear association is captured by terms involving ***t***, nonlinear association by ϵ, and lack of association by ϵ_C and ϵ_U. Observations and predictions are taken as only partially representative, and by extension partially nonlinear, measures of the environment (***T***). In other words, measurement is hard!

An interpretation of skill (γ^2) can also be given as the sum of variance in one or two aspects of the environment that are hard to measure, either by observations or predictions or both, and perhaps some aspect of the environment that is easy for both to measure (if $\beta_U \neq 1$). This sum is normalized by observation variance. By this *signal* interpretation, greater skill (smaller γ^2) refers to the use of observations and predictions that provide similar representations of the environment. However, it should be emphasized that noise is present in all terms of [3], and a lack of association (ϵ_C or ϵ_U) likely captures more noise than, say, linear association.

Reference

Thompson, K. R., and Sheng, J. (1997), Subtidal circulation on the Scotian Shelf: Assessing the hindcast skill of a linear, barotropic model, *J. Geophys. Res.,* 102(C11), 24987-25003, doi:10.1029/97JC00368.

Microbial eDNA Research to Facilitate the Management and Restoration of Maine's Saltmarsh Ecosystems

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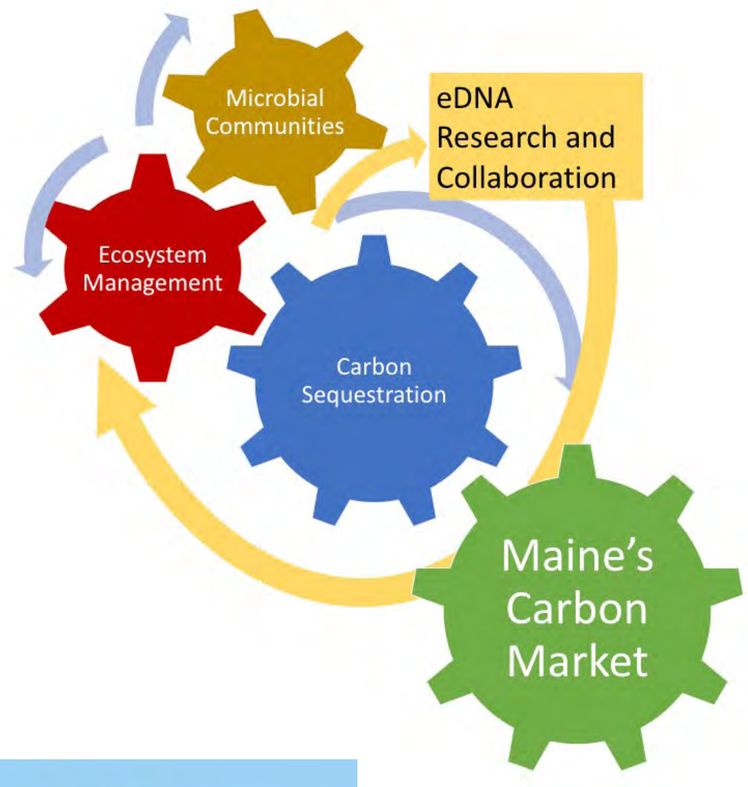
Supported by National Science Foundation award #OIA-1849227 to Maine EPSCoR at the University of Maine

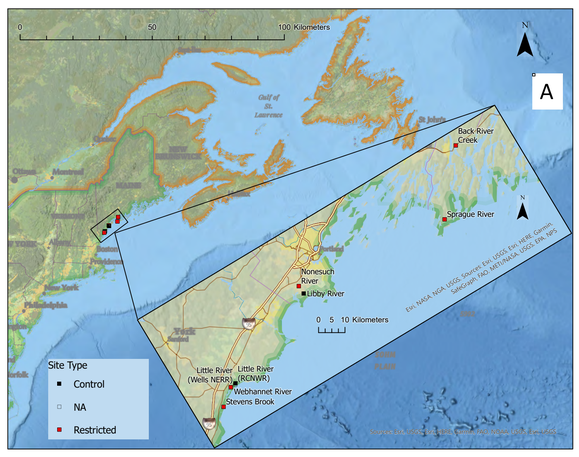
Abstract

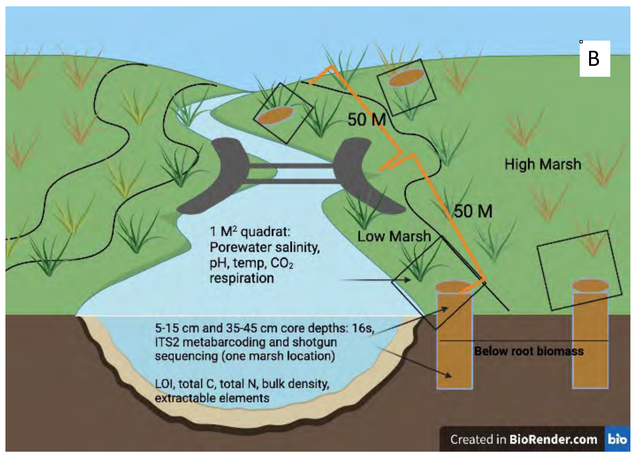
Environmental DNA (eDNA) methods such as metabarcoding and metagenomics have the potential to provide insight into biogeochemical processes that occur within soils, thereby elucidating how management decisions can increase or reduce carbon sequestration occurring within habitats. The aim of our research is to pilot the use eDNA methods to identify potential indices which might be useful for monitoring and assessing Maine saltmarsh habitats and further the understanding on microbial and fungal communities, greenhouse gas emissions, carbon storage and ecosystem management.

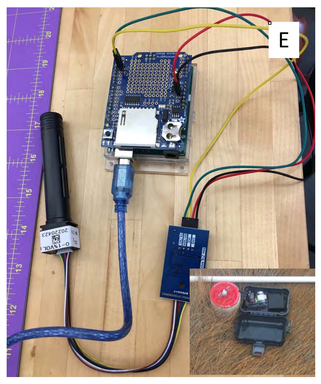
Sampling Design and Collection

We took sediment cores from eight different locations along the coast of Maine, USA **(Figure A)**. At each location we took sediment cores above and below hydrological restrictions (if present) along the marsh river at intervals of 100 M and at various elevations/vegetation zones. We collected soil samples from these cores from within and below the vegetation root zone, subsampling for genetic analysis and for physicochemical analysis **(Figure B)**.
For all but two sites, the main sampling was conducted in low and high marsh zones. Back River Creek (Woolwich, ME) was sampled prior to undergoing restoration, and will be part of a before and after study since the vegetation above and below were not comparable. Little Marsh (Part of the National Estuarine Research Reserve, NERR) was sampled along a hydrological gradient from the upland to the low marsh along with some exploratory sampling of algal mats in saltwater pools. The Little River (Rachael Carson National Wildlife Reserve, RCNWR) is a true unrestricted control site, whereas the Libby River (Scarborough, ME) had a nearby restriction, but was sampled along an unrestricted stretch of river **(Figure C)**.









At each core sampling location, soil temperature, pH, porewater salinity and CO_2 was measured at the surface within a 1 M^2 quadrat. Vegetation height and species were noted **(Figure D).**
CO_2 was measured every three seconds over a time period of 5-10 minutes using a small sensor purchased from Sandbox Electronics and connected to an Arduino computer outfitted with an Adafruit Data Logger Shield.[8] In the field, a PVC sleeve was installed 2-3 inches into the marsh and the sensor was placed inside and sealed with a lid **(Figure E).**
Soil cores were sectioned into two depths (5–15 cm and 35–45 cm) and the interior core sections were removed with a sterile knife (1x1x10 cm) and preserved on dry ice for genetic analysis at the University of New Hampshire. The remaining soil was dried for physicochemical analysis at the University of Maine **(Figure F).**

Background

Protecting ecosystems that store carbon is critical for mitigating climate change and is important for Maine's goal to be climate neutral by 2045.[1]

Coastal and marine ecosystems such as salt marshes and seagrass beds can sequester a large amount of carbon relative to the amount of landcover. These are known as "blue carbon" ecosystems.[2,3]

There has been increasing interest in monetizing blue carbon ecosystems using carbon credits to protect and restore these habitats.

Building bridges and roads across tidal creeks in salt marsh habitats can restrict hydrologic flow and alter soil salinity as well as change patterns in dominant vegetation. Microbial communities, integral to the carbon cycling process, are also impacted by these changes.[4–7]

eDNA could be a useful tool for assessing restoration potential of marsh habitats, however more research is needed to elucidate the link between microbial communities, carbon sequestration and the impacts of restrictions.

Analysis

16s and ITS2 metabarcoding was performed on extracted soil DNA for all samples along with three sterile sand blanks collected in the field as controls. In addition to metabarcoding, shotgun sequencing at a depth of ~25 million reads per sample occurred for all Back River Creek samples. All samples underwent chemical analysis for extractable nutrients and combustion analysis for Total C and Total N measurements. As of May 17th, 2023, all laboratory analysis is complete.

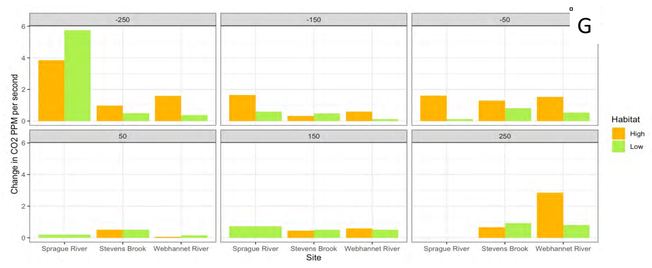
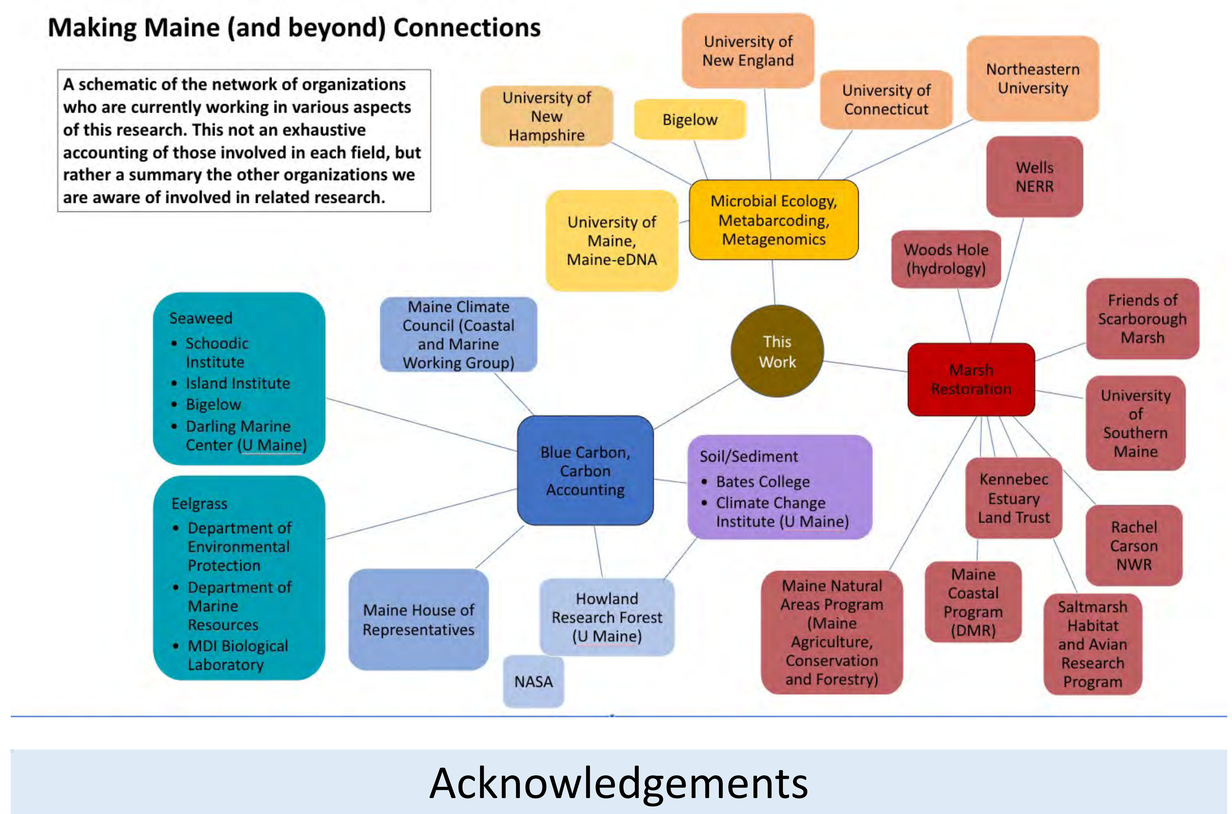


Figure G: Preliminary CO^2 emission data (y-axis, delta PPM per second) for selected marsh sites (x-axis)comparing low (green) and high (orange) marsh vegetation zones.

Planned Analysis: We plan on performing statistical analysis to assess bacterial and fungal alpha, beta and gamma biodiversity and compare Bray-Curtis dissimilarity along marsh creed gradients to assess if hydrological restrictions have a significant impact on biologic communities. We will rely on environmental niche modeling to better understand the relationship between measured environmental parameters and species diversity. We will use shotgun sequencing data to look at genes present in the environment before (data in hand) and after (not yet collected) hydrologic restoration and look at shifts in species and changes in Bray-Curtis dissimilarity measures.



Acknowledgements

This work was made possible by funding through the University of Maine's Marine Aligned Research, Innovation and Nationally-recognized Education initiative seed grant program 58822. Additionally, this work is supported by National Science Foundation award #OIA-1849227 to Maine EPSCoR at the University of Maine. All genetic lab work was performed by University of New Hampshire's Hubbard Center for Genome Studies. Soil chemical analysis was performed by University of Maine's Soil Testing Lab. Beverly Johnson, Ruth Indrick, Pete Avis, Lawrence Mayer, Kristen Puryear, Julia Guimond, Steve Pinette, Joe Staples, Anthony DeVecchis, Slade More, Jason Goldstein, Laura Crane, Jennifer Bowen and Beth Lawrence, Dan Hayes, Greg Zogg, Pam Morgan, Susie Arnold, Linden Rominger, Geneva York, Laurie Osher, Bruce Hoskins and Ivan Fernandez provided expert guidance and advice. Matt Tate, Madelyn Woods and Kate Macolini provided support with field sampling. Ayush Gyawali, Sam Bach, Ben Gutzler and the Hacker Space at University of Maine provided assistance for building and programming the CO_2 sensor, and Shawn Fraver and Zoe Read assisted with the design for capturing field measurements. The Bigelow and the Single Cell Genomics Center provided a scholarship for bioinformatics professional development. Catilin Cleaver, Scott Lindsay and Ryan Kleinert helped with site permitting.

References

1. MaineWontWait_December2020.pdf. Available: https://climatecouncil.maine.gov/future/sites/maine.gov.future/files/inline-files/MaineWontWait_December2020.pdf
2. Nellemann, C., & Corcoran, E. (Eds.). (2009). *Blue carbon: the role of healthy oceans in binding carbon: a rapid response assessment*. UNEP/Earthprint.
3. Kelleway, J. J., Serrano, O., Baldock, J. A., Burgess, R., Cannard, T., Lavery, P. S., ... & Steven, A. D. (2020). A national approach to greenhouse gas abatement through blue carbon management. *Global Environmental Change*, *63*, 102083.
4. Gerwing, T. G., Davies, M. M., Clements, J., Flores, A. M., Thomson, H. M., Nelson, K. R., ... & Plate, E. (2020). Do you want to breach an embankment? Synthesis of the literature and practical considerations for breaching of tidally influenced causeways and dikes. *Estuarine, Coastal and Shelf Science*, *245*, 107024.
5. Lynum, C. A., Bulseco, A. N., Dunphy, C. M., Osborne, S. M., Vineis, J. H., & Bowen, J. L. (2020). Microbial community response to a passive salt marsh restoration. *Estuaries and Coasts*, *43*(6), 1439-1455.
6. Zogg, G. P., Travis, S. E., & Brazeau, D. A. (2018). Strong associations between plant genotypes and bacterial communities in a natural salt marsh. *Ecology and Evolution*, *8*(9), 4721-4730.
7. Barry, A., Ooi, S. K., Helton, A. M., Steven, B., Elphick, C. S., & Lawrence, B. A. (2022). Vegetation zonation predicts soil carbon mineralization and microbial communities in southern New England salt marshes. *Estuaries and Coasts*, *45*(1), 168-180.
8. Joshi Gyawali, A., Lester, B. J., & Stewart, R. D. (2019). Talking SMAAC: a new tool to measure soil respiration and microbial activity. *Frontiers in Earth Science*, *7*, 138.

ID: 4626507
Theme: OCEAN
Session: Marine Carbon Dioxide Removal (mCDR)

Simple models for carbon dioxide removal via ocean alkalinity enhancement in coastal environments

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Context

Ocean alkalinity enhancement (OAE) is a proposed method for marine carbon dioxide removal (CDR) in which alkalinity added to the surface ocean initiates a draw-down of atmospheric CO_2, where it reacts to form bicarbonate[1] (Fig. 1). Numerical models are a convenient way to test how physical factors like wind, tides, and seasonal changes to mixed layer depth (MLD) affect turbulent diffusivity, κ_e, alkalinity dispersion, and the effectiveness of CDR.

We present 1) a simplified 1D OAE model to estimate vertical transport of total alkalinity (TA) and dissolved inorganic carbon (DIC), and 2) a 3D box model for OAE in an idealized estuary with tides, river inflow, and wind. The impact of seasonality (increased wind, mixed layer deepening, and surface cooling in winter compared to summer) is considered since it is likely to impact the efficiency factor (EF) of OAE, where

$$EF(t) = \int_0^t F_{pCO_2} dt \Big/ \int_0^{t\to\infty} F_{pCO_2} dt,$$

and F_{pCO_2} is the air-sea pCO_2 flux.

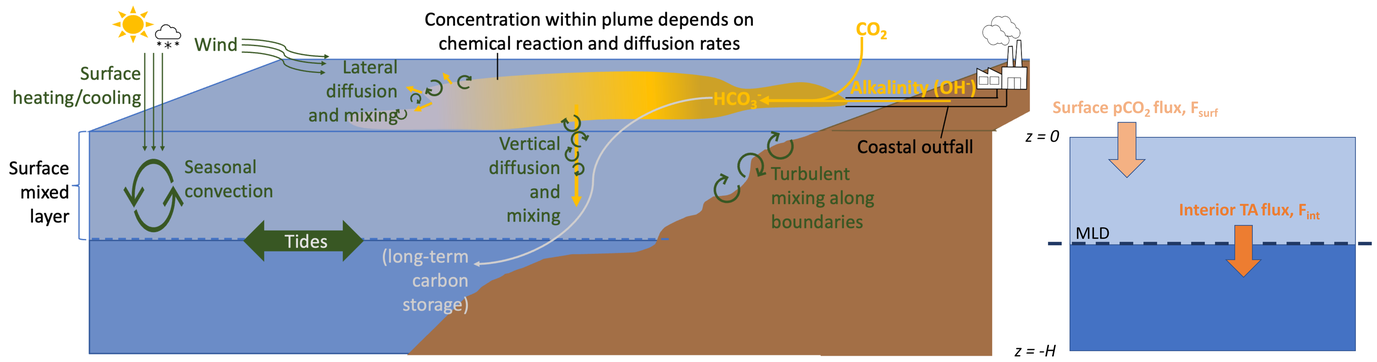
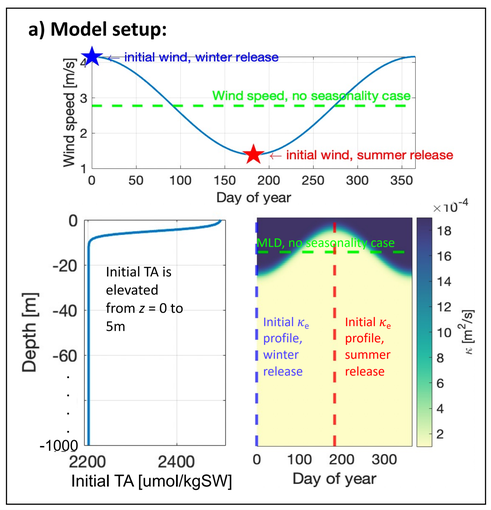


Fig. 1: Schematic of the physical processes that can impact surface and interior fluxes and, ultimately, the effectiveness of coastal OAE.

In general, *EF(t)* depends on fluxes (Fig. 1, right panel):

- ***EF(t)* increases as F_{surf} increases** → F_{surf} depends on wind and pCO_2 gradient between air and water
- ***EF(t)* decreases as F_{int} increases** → F_{int} depends on vertical κ_e and TA gradient between ocean layers

1D model



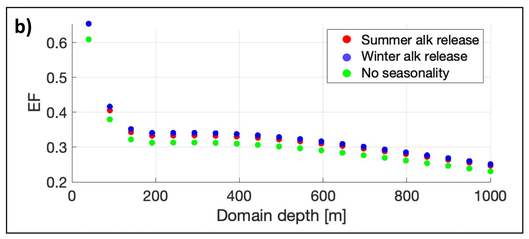


Fig. 2: Efficiency factor (EF) after 3 years as determined using the 1D model for several seasonal release cases and domain depths.

However, the 1D model does not account for horizontal gradients, which is limiting for coastal basins where OAE is likely to be implemented. The 1D model is extended to 3D to understand the impact of lateral effects.

For comparison, Fig. 3 was produced by the 1D model and uses the same initial conditions as the 3D model results in Fig. 5.

The 1D model solves the diffusion equation for TA and DIC:

$$\frac{\partial TA}{\partial t} = \frac{\partial}{\partial z}\kappa_e \frac{\partial TA}{\partial z}$$

$$\frac{\partial DIC}{\partial t} = \frac{\partial}{\partial z}\kappa_e \frac{\partial DIC}{\partial z}$$

DIC is then evolved using CO2SYS[2], with pCO_2 flux set by wind and air-sea gradient at z=0[3] and no flux at the bottom boundary. The MLD is set by prescribing a profile of κ_e (Fig. 2a).

Elevated *EF* for a winter versus summer release suggests that wind dominates over MLD in determining *EF; EF* also decreases as domain depth increases (Fig. 2b).

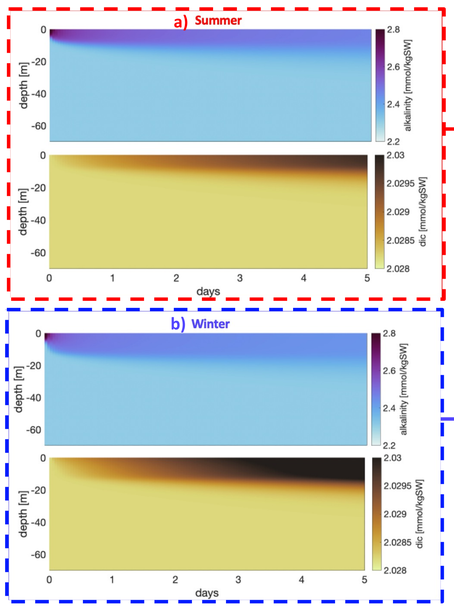


Fig. 3: Five-day progression of TA and DIC from the 1D model of a) summer and b) winter conditions.

3D idealized model

MITgcm[4] was used to model a TA addition in a rectangular basin with identical initial conditions to the 1D model (Fig. 4). Modelling in higher dimensions allows for the lateral effects of river inflow, tides, and wind stress to be included.

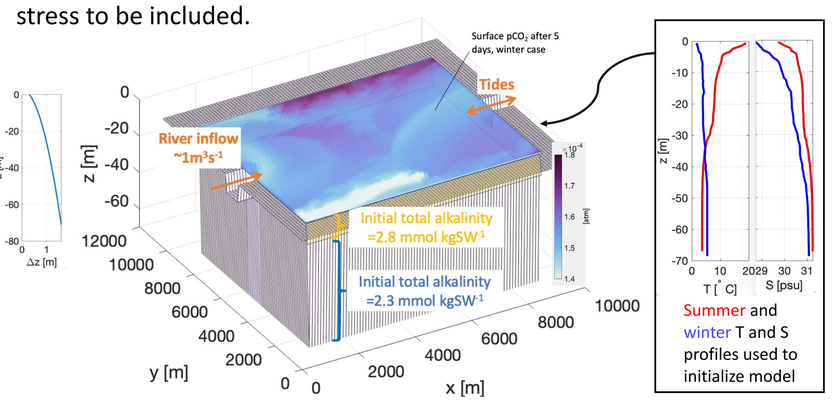


Fig. 4: Configuration of the 3D MITgcm model with idealized (rectangular) bathymetry.

- In the 3D model, physical forcings like tides and wind drive mixing via interactions with boundaries
- Tides and wind contribute to increased downward transport of TA and DIC
- DIC accumulates in mixed layer in the 1D cases
- In the 3D cases, sinking of cold river water in winter allows elevated DIC to reach the bottom of the domain ~0.75 days earlier than in summer

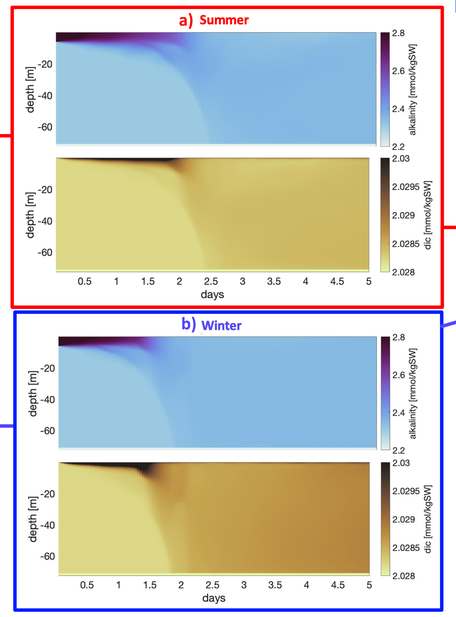


Fig. 5: Five-day progression of TA and DIC averaged over the entire box domain for a) summer and b) winter conditions.

3D Bedford Basin model

Next, we intend to model Bedford Basin, a fjord-type estuary at the head of Halifax Harbour[5], using realistic bathymetry (Fig. 7). Bedford Basin is proposed as a location for alkalinity release experiments by the company Planetary Technologies.

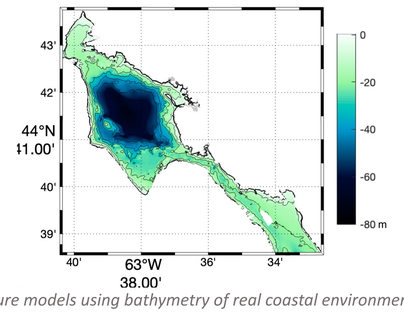


Fig. 7: Future models using bathymetry of real coastal environments (e.g. Bedford Basin, as shown) can be used to simulate more realistic alkalinity release conditions.

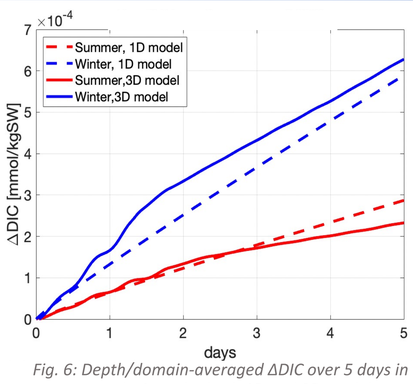


Fig. 6: Depth/domain-averaged ΔDIC over 5 days in summer and winter for both 1D and 3D models.

Domain-average ΔDIC is greatest for a winter TA addition (Fig. 6). Tides, river inflow, and wind introduce variability in ΔDIC that is not seen with the 1D model. In winter, these mechanisms increase DIC storage; in summer, after >3 days ΔDIC is lower in the 3D model, possibly due to downward mixing of TA before it can react with atmospheric CO_2.

Conclusions

1. Seasonal differences, especially in wind speed, can impact the CDR efficiency
2. Physical processes like tidal and wind-driven mixing were shown to impact vertical TA and DIC transport in the 3D model
3. ΔDIC since the time of TA addition is sensitive to the horizontal effects associated with wind, river inflow, and tides

Future work will focus on extending both 1D and 3D models to explore parameter space and the resulting impacts on CDR. We are interested in how the geometry and residence time of specific regions (e.g. Bedford Basin) impact carbon storage. Important physical processes will be identified using the 1D model, followed by a more detailed investigation using the 3D model. Eventually, the K-profile parametrization will be implemented to directly link forcings such as wind to vertical mixing[6].

Scan for surface-view animations of TA, DIC, pCO2, and pH!

References:
1. Renforth, P., and Henderson, G. 2017. Rev. Geophys. doi:10.1002/2016RG000533.
2. Lewis, E. et al. 1999. doi:10.2172/639712
3. Wanninkhof, R. 2014. Limnol. Oceanog-Meth. doi: 10.4319/lom.2014.12.351
4. Adcroft, A. et al. 2018. *MITgcm Documentation.*
5. Shan, S. et al. 2011. Ocea. Dyn. doi:10.1007/s10236-011-0398-3.
6. Large et al. 1994. Rev. Geophys. doi:10.1029/94RG01872

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Improvement to the impact-based storm surge forecast for the St. Lawrence River, Quebec

Maja Rapaic and Devon Telford, Environment and Climate Change Canada

Coastal flooding due to **wave** action, **storm surge** and **astronomical tide** is a common occurrence along the Canada's coasts: Atlantic, Pacific, Arctic, Great Lakes and St. Lawrence.

Project objectives: **To develop nation-wide warning system for the coastal flooding.**

- High percentage of word's population living in the coastal areas
- In the future climate:
  - global sea-level rise
  - increased intensity of extreme weather

} increased the risk of coastal flooding

A storm surge is **an abnormal rise of water generated by a storm**. Strong winds in a tropical cyclone or a sever mid-latitude storm are their primary cause… (WMO)

How is the storm surge warning issued now (Quebec):

1. When it is expected that the water level will reach a critical value, storm surge warnings is issued as a part of the public warning system.
2. The expected wave height is predicted as a part of the marine forecast (navigation).

   Not easy to collect the information for a particular municipality

3. Strom surge is not forecasted the same way across the country or not forecasted at all

A new approach:

- Uniform approach across the country
- Storm surge warnings and risks (waves) will be part of one program (information at the same place).
- Impact-based forecast: the critical water level value for which flooding occurs would be determined based on the vulnerability of each location

- **Collaboration with provinces and territories in order to collect the vulnerability information**

Vulnerability is a function of the severity of the weather and of what is on the coast

Also, for every particular site, **vulnerability varies with time:**

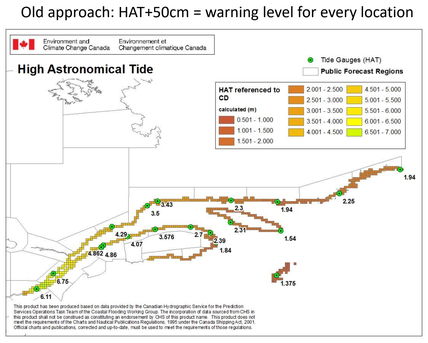
- New construction
- Erosion
- Climate change provoked mean sea-level rise
- Sea-ice coverage decline, etc.

There is a necessity of constant collaboration with provinces and territories to adjust our vulnerability threshold.

Where are we now? Challenges?

In the process of developing a closer collaboration with provincial, territorial and municipal partners as well as with the first nations governments.

Old approach: HAT+50cm = warning level for every location



Impact data collection from the revue of the past event

We have collected:

- reported storm surge **impacts**
- **observed/estimated/forecasted water level** for each event

This gives us a better estimate for a particular location of:

- **Vulnerability**
- **Warning threshold adjustments**
- **Forecast "correction"** towards something **more realistic**

Future plans

- Integration of the Northern Quebec in the program.
- Revue of the past events to establish the critical water-level values for Nunavik municipalities.
- Strengthening our relation with partners.

- **Nation-wide implementation of this new approach is expected in 2024.**

Major Winter Storms Leading Up to Christmas 2022 in British Columbia

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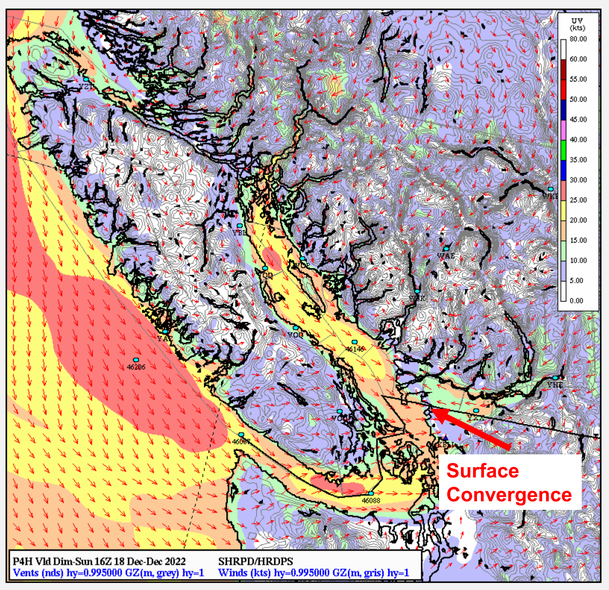
Environment and Climate Change Canada

INTRODUCTION

Traveling for the holidays was particularly challenging for the week leading up to Christmas 2022 in British Columbia. Major winter storms arrived one after another and gave rise to many travel cancellations and hazards. Each storm was unique in terms of the atmospheric conditions, thus causing slightly different impacts for the public. This poster aims to re-visit these high-impact winter storms and to provide a summary of the impacts. This will help improve forecast confidence when similar scenarios set up in the future.

Dec 18, 2022 – Arctic Front



Setup:
- An unstable airmass with thundersnow reported at the Vancouver international airport.
- Strong inflow from the Strait of Georgia and Juan de Fuca Strait and strong outflow from the interior created intense surface convergence in the Metro Vancouver region.
- An arctic front moving through the Metro Vancouver region and the convective atmosphere gave localized heavy snowfall accumulations.

Forecast Challenge:
Is the surface convergence sweeping through the Lower Mainland or gradually weakening?

Snowfall accumulations: 30 cm in Westwood Plateau in Coquitlam and 5-15 cm in the Metro Vancouver region.

Dec 20, 2022 – Low Pressure System

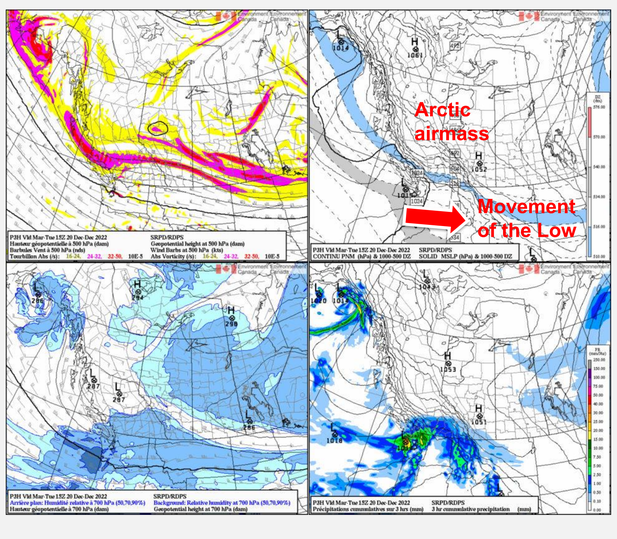
This system gave the HEAVIEST snowfall accumulations over the B.C. south coast.

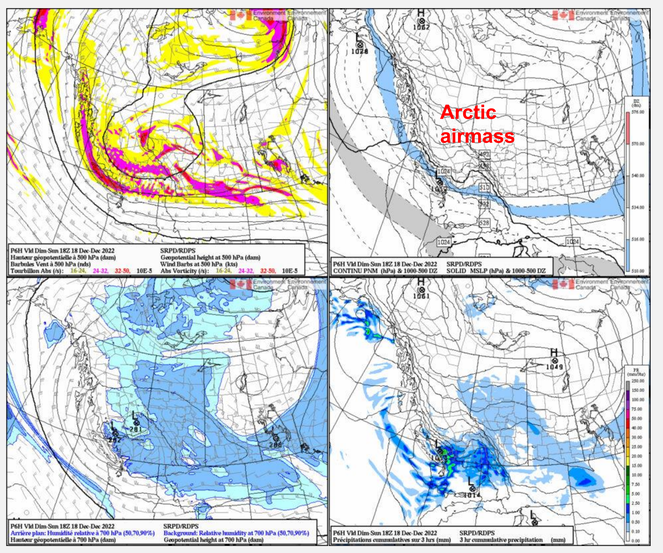
Setup:
- A low pressure centre moved towards Washington State.
- The arctic airmass persisted over the B.C. south coast due the strong outflow pattern.

Forecast Challenge: The location of the low pressure centre was slightly different in various models. If the low tracked south, it could have been a false alarm.

Snowfall accumulations:
- Widespread 30 cm of snow in the Lower Mainland and southern Vancouver Island.
- 44 cm of snow for Hope Slide.
- Delta Tsawwassen Beach had the second highest all-time daily total snowfall amount by 0.8 cm.

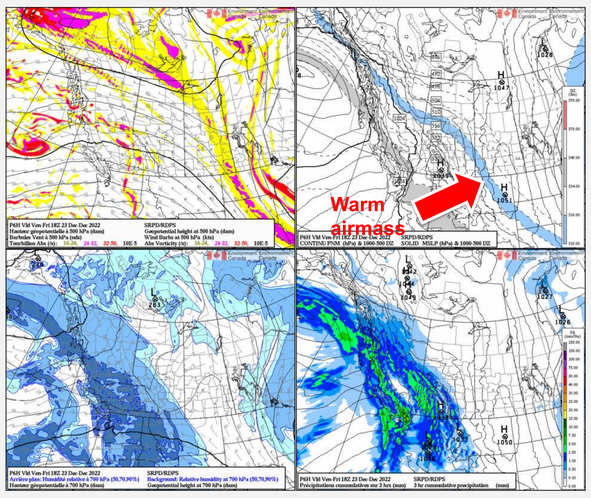
Impacts:
Many flight and BC ferry cancellations and delays disrupting holiday season travel.





Dec 22-24, 2022 – Precipitation Phase Shift

Malahat Highway received 37 cm of snow.



The first and the last observations of the 22 hours of steady freezing rain at the Abbotsford Airport:

2022/12/23 16:03:54 CYXX 231600
METAR 07006KT 2SM -FZDZ -SNPL BKN022 OVC030 M8/M9 A2995 RMK SN1NS6NS1 RIME ON INDICATOR /S02/ PRESRR SLP148=

2022/12/24 14:05:03 CYXX 241400
METAR 04006KT 010V080 3SM -FZRA OVC028 M0/M1 A2999 RMK NS8 SLP160=

A slow transition from snow to ice pellets and freezing rain, and finally to rain.

Setup:
- Moderate westerly flow brought a warm airmass from the Pacific Ocean and replaced the existing arctic airmass.

Forecast Challenge:
Snow and ice accumulations and the timing of the phase change.

Impacts:
- 12-24 hours of snow pellets and freezing rain giving ice accretion on existing slippery roads from previous snowstorms.
- Lower snowfall accumulations compared to the previous events. Approximately 5-10 cm.
- Ice build-ups were approximately 5 mm on southeast Vancouver Island and as much as 25 mm in the Fraser Valley.
- Major bridges were closed for the day (Port Mann and Alex Fraser bridges).
- Speed limits were strictly enforced in the Fraser Valley to prevent car collisions as some travelers used ground travel instead of flying.

CONCLUSION

It's obvious that each weather system had a different atmospheric setup from re-visiting the three major winter storms for the B.C. south coast in December 2022. The arctic front gave a wide range of snowfall accumulations due to the smaller-scale feature, a surface convergence, and the convective nature of the atmosphere on Dec 18, 2022. The low pressure system brushing through the B.C. south coast gave the highest amount of snowfall accumulations across the region on Dec 20, 2022. It's worthwhile to note this system produced approximately 30 cm of snow for the entire Lower Mainland and southern Vancouver Island. Lastly, ice accumulation from ice pellets and freezing rain was the biggest concern for the long-duration event from Dec 22 to 24, 2022.

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