CMOS 58th Congress

June 1 - 4, 2024 – Winnipeg MB (virtual)

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June 3-6, 2024 / 3-6 juin, 2024

Canadian Meteorological and Oceanographic Society

Société canadienne de météorologie et d'océanographie

58th Congress/58e congrès

Extreme Events in a Changing Climate

Événements extrêmes dans un climat changeant

Dear attendees,

It is the first time, as the new Assistant Deputy Minister of the Meteorological Service of Canada, that I have the pleasure of welcoming you to a Canadian Meteorological and Oceanographic Society (CMOS) Congress. Please allow me to share my best wishes for a successful Congress.

"Extreme Events in a Changing Climate" is a fitting and imperative theme for the 58th CMOS Congress after the record-breaking 2023 wildfire season and the consecutive landfall of post-tropical storms Fiona and Lee in Atlantic Canada which caused significant damages, negative health impacts, and tragically, loss of life. Year after year, we experience more frequent and more intense extreme weather events. Considering this, the importance of timely, accurate, and reliable forecasts and warnings for the health and safety of Canadians is clear. Given the need for life-saving information about weather, environmental, and climate-related risks and emergencies, both the federal government and broader scientific community stand to benefit tremendously from working together and sharing insights.

As such, I would like to commend you for participating in this Congress which brings together hundreds of participants from across Canada and the world to discuss the latest science and solutions related to the climate crisis, high impact weather, and many more important topics. The connections made here will be invaluable as we work together to mitigate and adapt to the environmental challenges ahead.

Once again, please accept my best wishes for a productive and engaging Congress. I look forward to exploring the opportunities that arise from this year's event.

Warm regards,

Siewe, Cecile

Digitally signed by Siewe, Cecile
Date: 2024.05.31 13:00:23 -04'00'

Cécile Siewe
Assistant Deputy Minister
Meteorological Service of Canada
Environment and Climate Change Canada

PREMIER
OF MANITOBA

Legislative Building
Winnipeg, Manitoba R3C 0V8
CANADA

A MESSAGE FROM THE PREMIER

On behalf of the Government of Manitoba, I want to welcome you all to the 58th Annual Scientific Congress of the Canadian Meteorological and Oceanographic Society.

This year's theme, Extreme Events in a Changing Climate, is of great significance. Over the past few years, Manitoba has seen an increase in extreme weather events such as droughts and wildfires. These climate crises pose an existential threat to our survival. We must take immediate action to mitigate their effects.

The work being done by scientists and other professionals involved in CMOS is critical to our fight against the climate crisis. I want to offer my sincere gratitude to each one of you for your efforts in research and creating innovative solutions. Your work will help create a more sustainable future. In particular, I want to thank all of the Manitoban researchers who are working to promote climate innovation right here in our province.

Our government knows the importance of listening to science and making evidence-based decisions. As we work to take bold action to transition to a low-carbon economy and invest in environmental protection, I recognize that it is your dedication to climate research that has made this possible.

I wish you an excellent Congress full of meaningful and productive conversations.

The Honourable Wab Kinew
Premier of Manitoba

A MESSAGE *from* PREMIER DAVID EBY

As Premier of British Columbia, I am pleased to extend greetings to everyone participating in the 58th Congress of the Canadian Meteorological and Oceanographic Society.

In British Columbia, we continue to see extreme weather events that are affecting all of us, from heat domes to atmospheric rivers to droughts. Through our CleanBC Roadmap to 2030, we are taking action to transition to a clean economy by lowering emissions by 40% by 2030, while our Climate Preparedness and Adaptation Strategy will better prepare us to respond to a changing climate and protect our environment.

Our government is bringing the province together to tackle these challenges. We are working with businesses large and small to reduce waste, develop new, clean technology and build a thriving clean economy that works for everyone. We are supporting local governments to develop critical infrastructure to both adapt to and mitigate the impacts of climate change, like investing in zero-emission vehicle charging stations that make it easier for people to switch to a low-carbon commute. We are also working collaboratively with First Nations to recognize their cultural connection to stewarding the land and water and ensuring that we always put people and the environment first.

It is imperative that our efforts to combat climate change are guided by reliable data and sound science, and we are fortunate to have skilled professionals with this expertise working alongside us. Thank you all for the critical work you do, and I wish you all the best for a productive congress.

Honourable David Eby, KC
Premier of British Columbia

Office of the Premier
PO Box 2703, Whitehorse, Yukon Y1A 2C6

June 3, 2024

Dear Delegate:

It is my pleasure to welcome you to the 58th Annual Canadian Meteorological and Oceanographic Society Scientific Congress. Climate change represents one of the biggest challenges of our generation, and the Yukon is seeing the impacts earlier and more intensely than other parts of the world. Given this year's Congress theme is "Extreme Events in a Changing Climate", I wanted to lend my voice to the important discussions that will take place over the next few days.

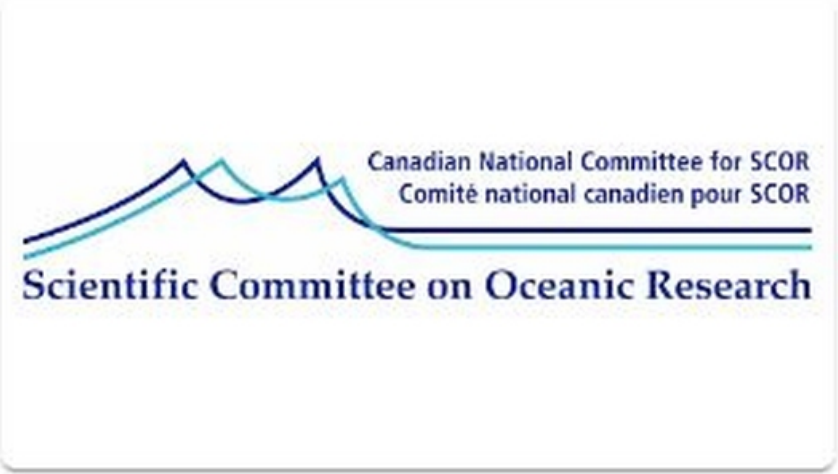
Due to changing conditions on the land, including changes to snow, water and ice and shorter frozen seasons with less predictable conditions, the Yukon is experiencing wildfires, floods, permafrost thaw and drought more frequently and with greater intensity. We have committed to ensuring the Yukon is highly resilient to the impacts of climate change by 2030. We recognize the threat that climate change poses to Indigenous cultures, ways of life and wellbeing and will continue to support Indigenous-led climate action.

We are adapting to climate change impacts by increasing our capacity to prepare for and respond to threats, by developing community protection plans, and by establishing an ambitious and achievable greenhouse gas reduction target for the territory. We recognize that more must be done, which is why we will continue to work with experts, stakeholders and partner governments across the territory and beyond, to identify opportunities to accelerate and intensify our efforts.

Rising to the challenge of climate change requires participation from all Canadians. We appreciate the significant contribution made by the scientific community, and want to thank you for taking part in these important conversations.

Best wishes for a successful Congress!

Ranj Pillai
Premier of Yukon



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

Time (EDT) Heures (HAE)	Monday June 3 Lundi 3 juin	Tuesday June 4 Mardi 4 juin	Wednesday June 5 Mecredi 5 juin	Thursday June 6 Jeudi 6 juin	Time (EDT) Heures (HAE)
1030 - 1100	Opening ceremony Cérémonie d'ouverture				1030 - 1100
1100 - 1200	Plenary 1 / Plénière 1 Laura Twidle (Catastrophe Indices & Quantification Inc.) Hailstorms and Tornadoes and Floods, oh my!	Plenary 2 / Plénière 2 Dr. Myrle Ballard (University of Calgary) What does Indigenous Science and Anishinaabe mowin say about Weather?	Plenary 3 / Plénière 3 Dr. Peter S. Galbraith (Fisheries and Oceans Canada) The Gulf of St. Lawrence, undergoing warming conditions and extreme events	Plenary 4 / Plénière 4 Dr. David Matthew Hall (NVIDIA) Tapping into the Explosive Growth of Artificial Intelligence to Tackle Extreme-Events in a Changing Climate	1100 - 1200
1200 - 1215	Coffee Break (on your own) / Pause café (à votre choix)				1200 - 1215
1215 - 1350	Parallel Sessions / Sessions parallèles (2010, 4010, 7030, 6010)	Parallel Sessions / Sessions parallèles (2040, 7020, 3010, 6013)	Poster Session Session d'affiches	Parallel Sessions / Sessions parallèles (7040, 2030, 5010, 6030)	1215 - 1350
1350 - 1405	Coffee Break (on your own) / Pause café (à votre choix)				1350 - 1405
1405 - 1540	Parallel Sessions / Sessions parallèles (2011, 4011, 7031, 6011)	Parallel Sessions / Sessions parallèles (2041, 7021, 3011, 8030)	Parallel Sessions / Sessions parallèles (2043, 4030, 3020, 5020)	Parallel Sessions / Sessions parallèles (8020, 2031, 5011, 6031)	1405 - 1540
1540 - 1555	Coffee Break (on your own) / Pause café (à votre choix)				1540 - 1555
1555 - 1730	Parallel Sessions / Sessions parallèles (2020, 4012, 7032, 6012)	Parallel Sessions / Sessions parallèles (2042, 7010, 8010, 3040)	Awards Prix	Parallel Sessions / Sessions parallèles (8021, 5012, 6040)	1555 - 1730
1730 - 1800	Coffee Break (on your own) / Pause café (à votre choix)			Closing Session / Séance de clôture	1730 - 1800
1800 - 1900	Public Lecture / Conférence publique Dr. L. Ruby Leung (Pacific Northwest National Laboratory) Extreme Weather Events and their Future Changes				1800 - 1900

TIME	SESSION	CHAIR
June 03, 2024	**Monday - Day 1**	
10:30 - 11:00 EDT	OPENING SESSION	Patrick McCarthy Peter Jackson Serge Desjardins
11:00 - 12:00 EDT	1003 Plenary - Hailstorms and Tornadoes and Floods, oh my!	John Hanesiak Peter Jackson
12:00 - 12:15 EDT	COFFEE BREAK	
12:15 - 13:50 EDT	2010 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 1	David Sills
12:15 - 13:50 EDT	4010 Coastal Oceanography and Inland Waters - Part 1	Shiliang Shan Guoqi Han
12:15 - 13:50 EDT	7030 Collaborative Earth System Modelling in Canada - Part 1	Clint Seinen
12:15 - 13:50 EDT	6010 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 1	Kaley Walker Alec Casey
13:50 - 14:05 EDT	COFFEE BREAK	
14:05 - 15:40 EDT	2011 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 2	John Hanesiak
14:05 - 15:40 EDT	4011 Coastal Oceanography and Inland Waters - Part 2	Guoqi Han Shiliang Shan
14:05 - 15:40 EDT	7031 Collaborative Earth System Modelling in Canada - Part 2	Paul Kushner
14:05 - 15:40 EDT	6011 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 2	Kaley Walker Alec Casey
15:40 - 15:55 EDT	COFFEE BREAK	
15:55 - 17:30 EDT	2020 Extreme Precipitation: Past, Present, Future	Neil Tandon Megan Kirchmeier-Young Xander Wang
15:55 - 17:30 EDT	4012 Coastal Oceanography and Inland Waters - Part 3	Guoqi Han Shiliang Shan
15:55 - 17:30 EDT	7032 Collaborative Earth System Modelling in Canada - Part 3	Paul Kushner

15:55 - 17:30 EDT	6012 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 3	Kaley Walker Alec Casey
17:30 - 18:00 EDT	COFFEE BREAK	
18:00 - 20:00 EDT	9020 Public Lecture - Extreme Weather Events and their Future Changes	Peter Jackson Patrick McCarthy John Hanesiak
June 04, 2024	**Tuesday - Day 2**	
11:00 - 12:00 EDT	1002 Plenary - What does Indigenous Science and Anishinaabe mowin say about Weather?	John Hanesiak Peter Jackson
12:00 - 12:15 EDT	COFFEE BREAK	
12:15 - 13:50 EDT	2040 Weather and Climate Extremes - General - Part 1	Elizaveta Malinina Nathan Gillett
12:15 - 13:50 EDT	7020 Developing Ocean Modelling Capacity in Canada - Part 1	Paul Myers
12:15 - 13:50 EDT	3010 Climate Variability and Predictability - Part 1	Hai Lin Bin Yu
12:15 - 13:50 EDT	6013 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 4	Kaley Walker Alec Casey
13:50 - 14:05 EDT	COFFEE BREAK	
14:05 - 15:40 EDT	2041 Weather and Climate Extremes - General - Part 2	Elizaveta Malinina Nathan Gillett
14:05 - 15:40 EDT	7021 Developing Ocean Modelling Capacity in Canada - Part 2	Susan Allen
14:05 - 15:40 EDT	3011 Climate Variability and Predictability - Part 2	Hai Lin Bin Yu
14:05 - 15:40 EDT	8030 Multidisciplinary- Community, Service and Education	Vanessa Foord
15:40 - 15:55 EDT	COFFEE BREAK	
15:55 - 17:30 EDT	2042 Weather and Climate Extremes - General - Part 3	Elizaveta Malinina Nathan Gillett
15:55 - 17:30 EDT	7010 Towards development of Canada's Digital Twin of the Ocean: Observations, Modelling, Forecasting, Analyses and	Youyu Lu Nancy Soontiens

	Applications	
15:55 - 17:30 EDT	8010 Changing Arctic: Science and Policy Studies	Matthew Asplin May Wang
15:55 - 17:30 EDT	3040 Climate - Community, Service and Education	Siraj ul Islam
June 05, 2024	**Wednesday - Day 3**	
11:00 - 12:00 EDT	1001 Plenary - The Gulf of St. Lawrence, undergoing warming conditions and extreme events	John Hanesiak Peter Jackson
12:00 - 12:15 EDT	COFFEE BREAK	
12:15 - 13:50 EDT	9010 POSTER SESSION	Peter Jackson Stephen Dery
13:50 - 14:05 EDT	COFFEE BREAK	
14:05 - 15:40 EDT	2043 Weather and Climate Extremes - General - Part 4	Elizaveta Malinina Nathan Gillett
14:05 - 15:40 EDT	4030 Ocean - Theoretical to applied science	Juliana Marson
14:05 - 15:40 EDT	3020 Atmosphere, Ocean, and Climate Dynamics	Michael Waite
14:05 - 15:40 EDT	5020 Atmosphere - Community, Service and Education	Serge Desjardins
15:40 - 15:55 EDT	COFFEE BREAK	
15:55 - 17:30 EDT	CMOS Awards Ceremony 2024	Gordon Griffith Serge Desjardins
June 06, 2024	**Thursday - Day 4**	
11:00 - 12:00 EDT	1004 Plenary - Tapping into the Explosive Growth of Artificial Intelligence to Tackle Extreme Events in a Changing Climate	John Hanesiak Peter Jackson
12:00 - 12:15 EDT	COFFEE BREAK	
12:15 - 13:50 EDT	7040 Simulation of weather and climate extremes using regional climate models	Dominique Paquin Alejandro Di Luca
12:15 - 13:50 EDT	2030 Advancing research on marine extremes - Part 1	Amber Holdsworth

		Hayley Dosser
12:15 - 13:50 EDT	5010 Atmosphere - Theoretical to applied science - Part 1	Kyle Ziolkowski
12:15 - 13:50 EDT	6030 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 1	Miguel Tremblay Ann Dacres
13:50 - 14:05 EDT	COFFEE BREAK	
14:05 - 15:40 EDT	8020 Multidisciplinary - Theoretical to applied science - Part 1	Rick Danielson
14:05 - 15:40 EDT	2031 Advancing research on marine extremes - Part 2	Amber Holdsworth Hayley Dosser
14:05 - 15:40 EDT	5011 Atmosphere - Theoretical to applied science - Part 2	Kyle Ziolkowski
14:05 - 15:40 EDT	6031 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 2	Miguel Tremblay Ann Dacres
15:40 - 15:55 EDT	COFFEE BREAK	
15:55 - 17:30 EDT	8021 Multidisciplinary - Theoretical to applied science - Part 2	Rick Danielson
15:55 - 17:30 EDT	5012 Atmosphere - Theoretical to applied science - Part 3	Kyle Ziolkowski
15:55 - 17:30 EDT	6040 Leveraging Artificial Intelligence for Enhanced High-Resolution Regional Climate Modeling of Extreme Events under Climate Change	Yanping Li
17:35 - 18:00 EDT	CLOSING SESSION	Peter Jackson Patrick McCarthy

Information and Legend for Sessions, Plenaries, Abstracts and Posters

Sessions and Abstracts are listed in the order presented.

Convenors and Session information precedes session abstracts and are **in bold**.

Plenaries and Public Lecture are in blue / bold

Poster Abstracts are listed in Day 3 and can be viewed using a marked link in **Poster Order**. Posters are in high-resolution pdfs and may need to be resized for best viewing.

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

Day 1 – 3 June 2024

Session: 1003 Plenary - Hailstorms and Tornadoes and Floods, oh my! Plénière - Tempêtes de grêle, tornades et inondations !

Laura Twidle
Catastrophe Indices & Quantification Inc.

Bio: Laura Twidle is the President and CEO at Catastrophe Indices & Quantification Inc. (CatIQ), Canada's loss and exposure indices provider. Laura is a meteorologist that specializes in catastrophe forecasting and providing stakeholders with knowledge and tools to make informed decisions. Laura also analyzes insured loss and exposure data to maintain the Canadian catastrophe and industry exposure databases which are housed on the CatIQ Platform. Since 2017, she has participated on the steering committee for the annual Canadian catastrophe conference. Laura holds a B.Sc. in meteorology from Central Michigan University, where she was on athletic and academic scholarships; and an M.Sc. in atmospheric and oceanic sciences from McGill University, where her research focused on extreme rainfall events. Her pastime is filled with soccer, coaching, hiking, pickleball, curling, golf, and hockey.

Session: 1003 Plenary - Hailstorms and Tornadoes and Floods, oh my! Plénière - Tempêtes de grêle, tornades et inondations ! **03/06/2024 11:00**

ID: 12128 Invited plenary speaker

Hailstorms and Tornadoes and Floods, oh my!
Laura Twidle [1]

[1] **Catastrophe Indices & Quantification Inc**

Presented by / Présenté par: ***Laura Twidle***
Contact: laura.twidle@gmail.com

Last year, Canadians were impacted by the most severe weather events, perhaps ever. There were 24 - what the insurance industry calls – catastrophes (CATs). A CAT is single event that results in at least $30 million of insured loss, affects multiple policy holders, and multiple insurers. Before 2023, the greatest number of annual CATs we had ever seen in Canada was 15. The increasing frequency of CATs is strongly represented by an increasing population (or increasing "exposure") and the effects of climate change. Last year posed a new challenge to the industry, when several CATs were occurring across the country simultaneously – Nova Scotia, the Northwest Territories, southern Ontario, and British Columbia. Now more than ever before, there is a need for a whole-of-society approach to minimize the impacts from extreme weather.

Session: 2010 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 1 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 1

Convenors:
John Hanesiak (University of Manitoba)
David Sills (Western University)

Many of Canada's most costly natural disasters are caused by severe and extreme 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 and extreme 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 will lead off the session.

Session: 2010 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 1 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 1 | 03/06/2024 12:15

ID: 11970 Invited session speaker

Hodographs and Skew-Ts of Hail-Producing Storms

John Allen [1] , Mateusz Taszarek [2]

1 Central Michigan University
2 Adam Mickiewicz University

Presented by / Présenté par: Cameron Nixon
Contact: cameron.nixon@noaa.gov

Environments associated with severe hailstorms, compared to those of tornadoes, are

often less apparent to forecasters. Understanding has evolved considerably in recent years; namely, that weak low-level shear and sufficient convective available potential energy (CAPE) above the freezing level is most favorable for large hail. However, this understanding comes only from examining the mean characteristics of large hail environments. How much variety exists within the kinematic and thermodynamic environments of large hail? Is there a balance between shear and CAPE analogous to that noted with tornadoes? We address these questions to move toward a more complete conceptual model. In this study, we investigate the environments of 92,323 hail reports (both severe and non-severe) using ERA5 modeled proximity soundings. By employing a self-organizing map algorithm and subsetting these environments by a multitude of characteristics, we find that the conditions leading to large hail are highly variable, but three primary patterns emerge. First, hail growth depends on a favorable balance of CAPE, wind shear, and relative humidity, such that accounting for entrainment is important in parameter-based hail prediction. Second, hail growth is thwarted by strong low-level storm-relative winds, unless CAPE below the hail growth zone is weak. Finally, the maximum hail size possible in a given environment may be predictable by the depth of buoyancy, rather than CAPE itself.

Session: 2010 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 1 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 1

03/06/2024 12:45

ID: 11996 Contributed abstract

ERA5 Alberta hail environments during the 2022-23 Northern Hail Project’s Field Season

John Hanesiak [1], Dylan Painchaud-Niemi [2], David Walker [3], Mateusz Taszarek [4], Julian Brimelow [5], Clinton Macadam [6]

1 University of Manitoba
2 Western University
3 University of Manitoba
4 Adam Mickiewicz University
5 Western University
6 University of Manitoba

Presented by / Présenté par: John Hanesiak
Contact: john.hanesiak@umanitoba.ca

Hail in Alberta is a major natural hazard that has profound impacts on municipalities and agricultural sector due to damage. For example, in 2020, Calgary experienced the first billion-dollar hailstorm and fourth costliest natural disaster ($1.2B) in Canadian history. In addition, the largest hailstone every recorded in Canada occurred in Alberta on 1 August 2022. Despite their impacts, we still do not fully understand the meteorological environments of hailstorms in Canada. One of the goals of the Northern Hail Project (NHP) is to address this issue. NHP conducted field observations in central Alberta during the summers of 2022-23 to identify hailstorms, hailswath areas, and measure hail sizes (via disdrometers, hailpads and actual samples), amongst other measurements. This study uses ERA5 proximity vertical profiles associated with 32 non-supercell (NSC) and 20 supercell (SC) NHP hailstorms to provide an initial meteorological analysis. On average, SC produced 30 mm larger hail than NSC. Preliminary results suggest that SC events have 600 J/kg larger MLCAPE, 200 J/kg

larger CAPE in the hail growth zone and >400 J/kg larger CAPE with temperatures colder than -10°C. Convective cloud depth is >1 km larger for SC cases due to higher cloud tops. The largest bulk shear differences between SC and NSC occur between 1-3 km followed by 0-1 km, however, the effective bulk shear and storm relative helicity between 3-6 km are also good discriminators. The most notable hodograph shape difference is in the lowest 1 km, with greater “looping” and shear taking place in SC events. Ongoing research of environments according to hail size is being examined to elucidate meteorological factors that control hail size. We intend on comparing results to other recent work in the U.S. and Europe, but also the large historical datasets produced during the Alberta Hail Project.

Session: 2010 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 1 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 1 | 03/06/2024 13:00

ID: 11912 Contributed abstract

Canadian Hail Data Developments at Weatherlogics

Scott Kehler [1], Matthieu Desorcy [2]

1 Weatherlogics
2 Weatherlogics

Presented by / Présenté par: Scott Kehler
Contact: info@weatherlogics.com

Weatherlogics has developed a suite of hail datasets for Canada. These include a database of over 21,000 ground truth hail reports, crop insurance claims data, and radar-based hail mapping. The data were acquired using a multi-channel approach, including new techniques such as crowd sourcing. This presentation will provide an overview of these new datasets and the techniques used to assemble them. Ongoing research efforts to further improve the data will also be described, including work to produce new algorithms with dual-polarization radar.

Session: 2010 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 1 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 1 | 03/06/2024 13:15

ID: 11963 Contributed abstract

Mesoscale Convective Systems and Extreme Precipitation in Northeastern North America: identification and evaluation with the Canadian Regional Climate Model (CRCM6).

Milena Alpizar [1], Philippe Gachon [2], Alejandro Di Luca [3]

1 UQAM
2 UQAM
3 UQAM

Presented by / Présenté par: Milena Alpizar
Contact: alpizar_tirzo.milena@courrier.uqam.ca

Extreme precipitation events are primarily associated with large-scale and mesoscale meteorological phenomena, including mesoscale convective storms (MCS). The introduction of convection-permitting models (CPMs), which operate at high spatial resolution and avoid the need for parameterization schemes, has provided a more realistic representation of the atmospheric processes involved in mesoscale phenomena. This study aims to provide a detailed analysis of MCS and associated extreme precipitation events in the northeastern region of North America during the period 2015-2022. A tracking algorithm is used to identify and characterize MCS using simulations from the Canadian Regional Climate Model, version 6 (CRCM6) at 12 and 2.5 km grid spacing, ERA5 reanalysis data, and IMERG and MERGIR satellite data. The spatial and temporal distribution of MCS in the study region are analyzed, along with a detailed analysis of key characteristics, including frequency, precipitation intensity, duration, propagation velocity, and area coverage. Furthermore, a comparison between MCSs obtained using different data sources is performed to assess the reliability and accuracy of the CRCM6 simulations. This investigation provides valuable insights into MCS and assesses potential changes in the associated probable maximum precipitation, particularly in a region with significant dam and hydroelectric infrastructure.

Session: 2010 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 1 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 1 | 03/06/2024 13:30

ID: 11986 Contributed abstract

Simulations of storms and precipitation types – The impacts of recent innovations to the Predicted Particle Properties (P3) microphysics scheme

Melissa Cholette [1], Jason Milbrandt [2], Hugh Morrison [3]

1
2
3

Presented by / Présenté par: Melissa Cholette
Contact: melissa.cholette@ec.gc.ca

Aspects that characterize many extreme weather events include the high accumulation of rain in a short period during convective storms and hazards related to the phase (solid, liquid, supercooled or mixed) of precipitation and its type (e.g., hail, freezing rain, ice pellets, wet snow). In the High Resolution (2.5 km) Deterministic Prediction System (HRDPS) of Environment and Climate Change Canada, the Predicted Particle Properties (P3) bulk microphysics scheme predicts the evolution of different hydrometeors (cloud droplets, rain and ice). This presentation describes recent innovations to P3 that have aimed at improving aspects related to the numerical guidance of precipitation. These innovations include: (1) The prediction of mixed-phase particles, necessary to parameterize important processes involved in the formations of hail, freezing rain, ice pellets and wet snow. (2) The triple-moment treatment of ice which improves the microphysical process rates in general and allows for a better simulation of hail. (3) The use of multiple free ice-phase categories for the

representation of secondary ice production (SIP) processes and mixtures of ice with different properties.
The impacts of these new features are examined with HRDPS hindcast simulations of high-impact weather events, including a freezing rain storm, a wet snow squall, a mid-latitude squall line and a severe hailstorm. The results show that the simulations of the precipitation phase at the surface as well as the particle properties aloft and the dynamics of the storm (e.g., propagation speed) are sensitive to these microphysics scheme improvements. An example is the large reduction of the overestimation of explicit freezing rain when SIP is allowed in the simulation. Ice pellets and snow are simulated instead when the temperature is <0°C. In some cases, it is important to include these scheme advances to improve the weather forecast of such high-impact weather events and associated precipitation types.

Session: 4010 Coastal Oceanography and Inland Waters - Part 1 Océanographie côtière et eaux intérieures - Partie 1

Convenors:
Jinyu Sheng (Dalhousie University)
Guoqi Han (Institute of Ocean Sciences)
Dan (Shiliang) Shan (Royal Military College of Canada)

In the context of the overarching theme, "Extreme Events in a Changing Climate," this session aims to provide a comprehensive exploration of 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, as well as the mixing and dispersion of materials. Contributions related to both observational and modelling aspects of biogeochemistry in coastal and inland waters are welcome. Papers can focus on improving our knowledge of physical and biogeochemical conditions over coastal and inland waters in the past and present climate, and/or on predictions of changes and extremes in marine conditions in response to climate change.

Session: 4010 Coastal Oceanography and Inland Waters - Part 1
Océanographie côtière et eaux intérieures - Partie 1 **03/06/2024 12:15**

ID: 11952 Contributed abstract

Ventilation of fjords by down-fjord winds

Jody Klymak [1], *Jennifer Jackson* [2], *Wiley Evans* [3]

[1] University of Victoria
[2] Institute of Ocean Science, Department of Fisheries and Oceans
[3] Hakai Institute

Presented by / Présenté par: ***Jody Klymak***
Contact: jklymak@uvic.ca

Wind blowing down a fjord or lake can cause deep layers in the fjord to be brought into contact with the atmosphere, leading to deep water re-oxygenation due to ventilation. Previous work has considered this problem in fjord stratifications idealized as two-layers. Here we consider the fully stratified case, and provide accurate scalings for the time scale of ventilation and the maximum depth that will be ventilated as functions of wind speed, stratification and length of the fjord (we find the effect of cooling to be secondary, and ignore that). The oxygen signal is more complex, depending on the time at the surface and the surface mixed layer depth, but can be inferred with a simple heuristic model.

Session: 4010 Coastal Oceanography and Inland Waters - Part 1
Océanographie côtière et eaux intérieures - Partie 1 **03/06/2024 12:30**

ID: 12090 Contributed abstract

Influence of wind-driven processes on seasonal and subseasonal variability patterns in the near-shore and shelf-break regions of Queen Charlotte Sound, British Columbia, Canada

Benjamin O'Connor [1], *Stephanie Waterman* [2], *Charles Hannah* [3], *Wiley Evans* [4], *Jennifer Jackson* [5], *Alex Hare* [6]

[1] University of British Columbia
[2] University of British Columbia
[3] Institute of Ocean Sciences, Fisheries and Oceans Canada
[4] Hakai Institute
[5] Institute of Ocean Sciences, Fisheries and Oceans Canada
[6] Hakai Institute

Presented by / Présenté par: ***Benjamin O'Connor***
Contact: boconnor@eoas.ubc.ca

The ecological and climatological role of the coastal ocean is closely related to key water properties and their variability in time. Understanding variability in coastal ocean water properties, the physical mechanisms that drive it, and the associated ecosystem implications is therefore critical to understanding the ecological and climatological function of coastal seas at present and in the future. Here, we analyze six years of near-continuous in situ measurements of temperature, salinity, dissolved oxygen concentration, and current velocity from the shelf-break and near-shore regions of Queen Charlotte Sound, British Columbia to characterize their variability on subseasonal-to-interannual timescales. We explore the physical processes that govern variability on these timescales by relating the observed variability patterns to fluctuations in forcing mechanisms such as wind-driven mixing, lateral advection, and coastal downwelling. Finally, we consider the implications for ecosystems by examining how oxygen and aragonite saturation state (a measure of ocean acidity; estimated here by applying an empirically derived predictive model to our direct observations) vary in relation to critical thresholds for ecosystem stress. We find that the near-shore region appears particularly sensitive to seasonal variations in vertical mixing and downwelling strength whereas the shelf-break region is sensitive to downwelling and alongshore advection. We further observe large variability on subseasonal timescales that is of particular interest. Notably, we document strong

fluctuations during wintertime in the shelf-break region between 40-150 metres depth which coincide with strong fluctuations in alongshore current strength and downwelling forcing. These fluctuations result in the injection of oxygen to intermediate depths and a transition from under-saturated to saturated conditions with respect to aragonite, which could have meaningful implications for local ecosystems. These results provide new insights into the processes that drive coastal ocean water property variability and reinforce the value of continuous timeseries data for studying issues such as coastal warming, deoxygenation, and acidification.

Session: 4010 Coastal Oceanography and Inland Waters - Part 1
Océanographie côtière et eaux intérieures - Partie 1

03/06/2024 12:45

ID: 12098 Contributed abstract

Controls on Exchange through a Tidal Mixing Hotspot at an Estuary Constriction

Susan Allen [1] , *Nancy Soontiens* [2] , *Michael Dunphy* [3] , *Elise Olson* [4] , *Douglas Latornell* [5]

[1] University of British Columbia
[2] University of British Columbia
[3] University of British Columbia
[4] University of British Columbia
[5] University of British Columbia

Presented by / Présenté par: ***Susan Allen***
Contact: sallen@eoas.ubc.ca

The Strait of Georgia is fresh due to the outflow of the Fraser and other rivers. As in most estuaries, this drives an estuarine flow with surface flow out toward the ocean, replaced by an intermediate depth inflow from the ocean. In the Salish Sea, however, the exchange needs to pass through the region of very strong tidal mixing in Haro Strait. The amount and depth of the estuarine exchange depends sensitively on this mixing and the densities of the water masses. Thus, the density, nutrient concentration, oxygen saturation, and dissolved inorganic carbon content of the incoming estuarine flow depend on local tidal mixing processes and large scale buoyancy dynamics. We have investigated this process using a numerical model (SalishSeaCast) of the Salish Sea. Using a four-year hindcast from the model we determine the amount, depth and position of the outflow and inflow. We show that 95% of the variance of the 4-day average baroclinic flux through the tidal mixing region can be explained by the density difference across the region and a Richardson Number based on the tidal velocities. The outgoing flux includes both surface and intermediate waters and the incoming flux includes both intermediate and deep waters. Laterally, fluxes into and out of the Strait of Georgia and across Victoria Sill show the impact of the Coriolis force and local bathymetry.

Session: 4010 Coastal Oceanography and Inland Waters - Part 1
Océanographie côtière et eaux intérieures - Partie 1

03/06/2024 13:00

ID: 12066 Contributed abstract

Rip Current Observations on the West Coast of Vancouver Island

Jamie Daniel [1] , *Johannes Gemmrich* [2] , *Jody Klymak* [3]

[1] University of Victoria
[2] University of Victoria
[3] University of Victoria

Presented by / Présenté par: ***Jamie Daniel***
Contact: jamiedaniel@uvic.ca

Rip currents are strong seaward-directed flows generated by the action of breaking waves. They are considered one of the most dangerous coastal hazards due to their ability to quickly transport swimmers and surfers into deeper waters. Since 1936, rip currents have been studied through a variety of methods including field observations, numerical modelling, and laboratory experiments. In order to better understand rip current occurrence and dynamics, field observations have taken place in several countries, including Australia, England, South Korea, and the United States. Results of previous studies have shown that, in general, rip current speed increases at or around low tide and with increasing wave energy.

Rip currents occur at Long Beach on the west coast of Vancouver Island, a popular surfing destination, and have necessitated water rescues and been responsible for injuries, and deaths. In spite of this hazard, no systematic field observations of rip currents have been made on Canada's west coast. This research will present preliminary results of observations of rip currents made in a wide range of sea states at multiple locations at Long Beach. These observations have been obtained utilizing in situ fixed-point instruments and Lagrangian wave drifters, and examined using time series and spectral analysis. A long-term coastal video monitoring system is also in place overlooking a section of Long Beach and rip currents are identified by examining 10 minute-averaged images of the surf-zone. Results of these observations will be used to determine how the local tidal conditions and wave field modulate the speed and occurrence of rip currents at Long Beach.

Session: 4010 Coastal Oceanography and Inland Waters - Part 1
Océanographie côtière et eaux intérieures - Partie 1 **03/06/2024 13:15**

ID: 12014 Contributed abstract

Estuarine exchange and tidally mixed flows through inter-connected pathways in the Salish Sea

Camryn Stang [1] , *Susan Allen* [2]

[1] UBC
[2] UBC

Presented by / Présenté par: ***Camryn Stang***
Contact: cstang@eoas.ubc.ca

The Salish Sea is a coastal ocean whose largest basin (Strait of Georgia) is connected to the north-eastern Pacific Ocean through regions with tight constructions and sills that cause intense tidal mixing. The Fraser River supplies substantial freshwater to the Salish Sea and flows into the Strait of Georgia, driving an estuarine circulation. The southward estuarine surface flow and northward deep flow are complicated through the tidally mixed region around then San Juan and Gulf Islands (SJGI), causing considerable reflux back into the Strait of Georgia. Thus, the dynamics in the SJGI region strongly influence the water properties and the transport of nutrients, carbon, etc. The SJGI region consists of three different straits, Haro Strait, Rosario Strait, and San Juan Channel. Haro Strait is the largest and deepest of the channels and as such, more exchange occurs through this Strait than the others. To examine the differences in water transport through the different channels, Lagrangian particle tracking simulations were performed for a 4-year hindcast (from 2018-2022) using 3-dimensional numerical model SalishSeaCast. The density difference between the two sides of the region is the most dominant factor driving water transport, accounting for ~ 80% of the variance in water flux. The tides are the next most prominent factor, accounting for 15% of variance, and as expected are negatively correlated with the baroclinic and barotropic water fluxes. While there is 2-layer flow through Haro Strait, water flow through the shallower Rosario Strait and San Juan Channel is typically only southward. However, the proportion of the southward flow carried by these straits is significant. The relative proportion of the southward flow through Rosario Strait increases at the onset of the Fraser River freshet, from ~ 20% in the winter to 30% in the summer.

Session: 4010 Coastal Oceanography and Inland Waters - Part 1
Océanographie côtière et eaux intérieures - Partie 1 **03/06/2024 13:30**

ID: 12113 Contributed abstract

Extreme sea levels on the Canadian Pacific coast in the 21st century

Guoqi Han [1] , *Jing Lu* [2] , *Tomas James* [3] , *Cornor Brierlry-Green* [4]

[1] Fisheries and Oceans Canada
[2] Fisheries and Oceans Canada
[3] Natural Resources Canada
[4] Natural Resources Canada

Presented by / Présenté par: ***Guoqi Han***
Contact: Guoqi.Han@dfo-mpo.gc.ca

We study extreme sea levels along the Pacific coast of Canada in the 21st century in consideration of mean sea level rise. First hourly sea level hindcasts over 1993-2021 are produced using a high-resolution Northeast Pacific Ocean Model (NEPOM). Then present-day extreme sea levels are derived from the hourly hindcasts by using the Gumbel approach. Afterwards future extreme sea levels in the 21st century are generated by adding the present-day extreme sea levels to the projected mean sea level rise under different climate change scenarios. Spatial differences of extreme sea levels and impacts of climate change are examined.

Session: 7030 Collaborative Earth System Modelling in Canada - Part 1
Modélisation collaborative du système terrestre au Canada - Partie 1

Convenors:
Paul Kushner (University of Toronto)
Matthew Toohey (University of Saskatchewan)
Clint Seinen (Environment and Climate Change Canada)

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

Session: 7030 Collaborative Earth System Modelling in Canada - Part 1 Modélisation collaborative du système terrestre au Canada - Partie 1

03/06/2024 12:15

ID: 11919 Invited session speaker

A New Estimate of the Climate Sensitivity in CMIP Earth System Models

Ivy Tan [1] , *Chen Zhou* [2] , *Aubert Lamy* [3] , *Catherine Stauffer* [4]

[1]

[2] Nanjing University
[3] McGill University
[4] McGill University

Presented by / Présenté par: ***Ivy Tan***
Contact: ivy.tan@mcgill.ca

The projected change in Earth's global mean surface air temperature in response to a doubling of atmospheric carbon dioxide concentrations --- known as climate sensitivity --- remains highly uncertain. Attempts to narrow Earth's climate sensitivity using Earth System Models (ESMs) have remained elusive in large part due to clouds. Previous studies have shown that exaggerating the proportion of ice in cold clouds in ESMs participating in the fifth phase of the Coupled Model Intercomparison Project (CMIP5) were linked to underestimated climate sensitivity values. A number of ESMs in the sixth phase of the Coupled Model Intercomparison Project (CMIP6) have since exaggerated the proportion of liquid in cold clouds that were potentially linked to high climate sensitivity values. Here, we analyze the CMIP5 and CMIP6 ESMs and find a linear relationship emerge between the change in cloud opacity in response to global warming and the proportion of liquid in cold clouds on the global scale. We use this relationship, which has underpinnings rooted in the physics of the climate system, along with the forcing-feedback framework and global satellite observations to derive a new estimate of the climate sensitivity of the CMIP5 and CMIP6 ESMs.

Session: 7030 Collaborative Earth System Modelling in Canada - Part 1 Modélisation collaborative du système terrestre au Canada - Partie 1

03/06/2024 12:30

ID: 12051 Contributed abstract

The Canadian Atmospheric Model version 5.2

Carsten Abraham [1], *Ayodeji Akingunola* [2], *Jason Cole* [3], *Ruth Digby* [4], *Michael Lazare* [5], *Jiangnan Li* [6], *Norman McFarlane* [7], *David Plummer* [8], *John Scinocca* [9], *Knut von Salzen* [10], *Cynthia Whaley* [11], *Barbara Winter* [12]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada
[4] Environment and Climate Change Canada
[5] Environment and Climate Change Canada
[6] Environment and Climate Change Canada
[7] Environment and Climate Change Canada
[8] Environment and Climate Change Canada
[9] Environment and Climate Change Canada
[10] Environment and Climate Change Canada
[11] Environment and Climate Change Canada
[12] Environment and Climate Change Canada

Presented by / Présenté par: ***Carsten Abraham***
Contact: carsten.abraham@ec.gc.ca

The Canadian Atmospheric Model (CanAM) is the atmospheric component of the Canadian Earth System Model (CanESM) and has been developed at the Canadian Centre for Climate modelling and analysis for over 50 years. Here we present the physics package updates and important changes for the latest version (5.2) of CanAM. In comparison to the previous version, CanAM-5.1, new parameterizations have been introduced for the solar and thermal radiative transfer, deep convection mass flux and

microphysics, vertical turbulent transports in the atmospheric boundary layer, and the bulk and PAM aerosol microphysics schemes. In addition, a new submodel for the land surface (CLASSIC) has been introduced, which will be described in a separate presentation. We will describe the features of these new physical parameterizations and illustrate model responses to these new parameterizations.

Session: 7030 Collaborative Earth System Modelling in Canada - Part 1 Modélisation collaborative du système terrestre au Canada - Partie 1

03/06/2024 12:45

ID: 11994 Contributed abstract

The new CanESM6 land surface component for CMIP7 simulations

Vivek Arora [1], *Ed Chan* [2], *Sian Kou-Giesbrecht* [3], *Gesa Meyer* [4], *Joe Melton* [5], *Libo Wang* [6], *Aranildo Lima* [7], *Luke Grant* [8]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Dalhousie Univ.
[4] Environment and Climate Change Canada
[5] Environment and Climate Change Canada
[6] Environment and Climate Change Canada
[7] Environment and Climate Change Canada
[8] Environment and Climate Change Canada

Presented by / Présenté par: ***Vivek Arora***
Contact: vivek.arora@ec.gc.ca

The Canadian Earth System Modelling (CanESM) framework developed and led by Environment and Climate Change Canada (ECCC) has regularly contributed to the past phases of the coupled model intercomparison project (CMIP). Experiments performed with various versions of CanESM, under the auspices of CMIP, have provided valuable scientific input for the past assessment reports of the Intergovernmental Panel on Climate Change (IPCC) and to inform global change science. ECCC is currently developing a new version of CanESM (CanESM6) for contribution to the seventh phase of CMIP (CMIP7). This presentation will summarize changes made to the land surface component of CanESM6 in preparation for CMIP7. The Canadian Land Surface Scheme Including Biogeochemical Cycles (CLASSIC) builds on the previous version of CanESM's land component in which physical processes were modelled using the Canadian Land Surface Scheme (CLASS) and biogeochemical processes were modelled using the Canadian Terrestrial Ecosystem Model (CTEM). CLASSIC includes several new improvements compared to CLASS-CTEM including 1) a finer discretization of soil layers in the top 4 m and a deeper bedrock going down to 62 m to more realistically simulate the spatial distribution of permafrost and its response to climate warming, 2) a representation of wildfires which simulates both natural and anthropogenic ignitions, and 3) a representation of terrestrial nitrogen cycle to simulate nutrient constraints on future carbon uptake more realistically. This presentation will show primary results for energy, water, and carbon fluxes from CLASSIC when implemented in the spectral CanESM model, and compare them to observation-based estimates, with a focus on the above mentioned three new processes.

Session: 7030 Collaborative Earth System Modelling in Canada - Part 1 Modélisation collaborative du système terrestre au Canada - Partie 1

03/06/2024 13:00

ID: 11971 Contributed abstract

Developing CanESM6 and preparing for Canada's CMIP7 contribution

Neil Swart [1] , *CanESM development team* [2]

[1] Environment and Climate Change Canada
[2]

Presented by / Présenté par: ***Neil Swart***
Contact: neil.swart@canada.ca

The Canadian Earth System Model (CanESM) and its predecessors have contributed to all five previous phases of the Coupled Model Intercomparison Project (CMIP), providing valuable scientific output to inform global climate change science and decision making. CanESM6 is being developed with the intention of contributing to CMIP7 over the coming few years. Here we describe the key features planned for CanESM6 - upgrades to the ocean (NEMO4) and sea-ice components (SI3), a significantly updated land surface scheme with terrestrial ecology (CLASSIC) and the replacement of the existing spectral dynamical core with the GEM dynamical core, while continuing to employ the CCCma climate physics package. We will describe the novel challenges in developing an energy conserving coupled global climate model using the semi-Lagrangian GEM dynamical core discretized on the Yin Yang grid, which is as far as we know the only one of its kind in the world. We will present milestones in CanESM6 development and performance, including analysis of model conservation and climate properties. Finally, we present the major decisions that lie ahead regarding the CanESM6 contribution to CMIP7. These decisions include what MIPs to participate in, and how to optimize the compromise between simulation years, process complexity and horizontal resolution in configuring the CanESM6 contribution. We end by raising the new opportunity that external scientists might become more actively involved in the CanESM contribution to CMIP7, by engaging with CCCma and leveraging the Collaborative Platform for CanESM (CP4C).

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03/06/2024 13:15

ID: 11920 Contributed abstract

The Collaborative Platform for CanESM (CP4C) – Progress in 2023-2024

Paul Kushner [1]

[1] Department of Physics, University of Toronto

Presented by / Présenté par: ***Paul Kushner***
Contact: paul.kushner@utoronto.ca

This presentation will summarize our ongoing work on CP4C, which is a computational platform developed, in partnership with the federal government, to enable use of Environment and Climate Change Canada's (ECCC's) Canadian Earth System Model (CanESM) in the academic community. In its third year of development, CP4C is now capable of providing reliable access and application of CanESM through several active earth system modelling projects. This year's activities focused on further development of i/o processing capability, bringing a recent update of CanESM to the CP4C, and training and workshop activities. We will discuss our working group structure, our user policy, and proposed technical liason support from ECCC to enable porting of CanESM to various platforms external to ECCC. Our efforts are continuing to foster easier collaboration with ECCC in R&D activities focused on CanESM.

Session: 6010 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 1 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 1

Convenors:
Kaley Walker (University of Toronto)
Matt Arkett (Environment and Climate Change Canada)

Satellite Earth observation (SEO) 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. Resourceful, Resilient, Ready: Canada's Strategy for Satellite Earth Observation provides a plan for Canada to more effectively leverage satellite earth observation (SEO) to address key priorities, including climate change mitigation and adaptation. This strategy will help to inform Canada's plans for SEO for the next decade and ensure Canada will maximize utilization and benefits of SEO. This session encourages contributions from across the full SEO value chain, upstream, midstream and downstream, to illustrate the activities currently underway in Canada, involving industry, academia and government. 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.

Session: 6010 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 1 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 1 **03/06/2024 12:15**

ID: 12046 Contributed abstract

The Atmospheric Chemistry Experiment MAESTRO spectrophotometer on CSA's SCISAT satellite in its 21st year

C. Thomas McElroy [1], *James R. Drummond* [2], *Kaley A. Walker* [3], *Jiansheng Zou* [4], *Paul Jeffery* [5]

[1] York U

[2] Dalhousie
[3] U Toronto
[4] U Toronto
[5] U Toronto

Presented by / Présenté par: ***C. Thomas McElroy***
Contact: TMcElroy@YorkU.ca

MAESTRO (Measurement of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation) has now been operating on the Canadian Space Agency's SCISAT satellite for more than 20 years. MAESTRO is one of two instruments on the satellite, the other one being the Atmospheric Chemistry Experiment, Fourier Transform Spectrometer (ACE FTS). MAESTRO was designed to measure NO2, water vapour, ozone and aerosol in the atmosphere. The instrument will be described briefly and the retrieval algorithms will be outlined. Some sample retrieved profiles of atmospheric constituents will be presented. A comparison to other satellite data sets will be presented in another contribution. The instrument development was funded by the Canadian Space Agency (CSA) and Environment Canada. The data analysis has been supported since the successful launch of the satellite in August 2003, by the CSA.

Session: 6010 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 1 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 1 **03/06/2024 12:30**

ID: 11983 Contributed abstract

Validation of the version 4 MAESTRO ozone and NO2 measurements

Paul Jeffery [1], *James R. Drummond* [2], *C. Thomas McElroy* [3], *Kaley Walker* [4], *Jiansheng Zou* [5]

[1] University of Toronto
[2] Dalhousie University
[3] York University
[4] University of Toronto
[5] University of Toronto

Presented by / Présenté par: ***Paul Jeffery***
Contact: paul.jeffery@mail.utoronto.ca

Launched aboard the Canadian satellite SCISAT-1 in August 2003, the Measurement of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation (MAESTRO) instrument has been measuring solar absorption spectra in the ultraviolet (UV) and visible part of the spectrum more than 20 years.

The UV measurements from MAESTRO are inverted to yield profiles of NO2 and ozone, while measurements made in the visible part of the spectrum are used to retrieve a separate ozone product. The two ozone products are thus deemed the UV-ozone and Vis.-ozone products. Recently, a new version of the maestro ozone and NO2 profile products, version 4 (v4), has been released, which nominally covers the

period from February 2004 to December 2023. However, due to the buildup of an unknown contaminant the UV-ozone and NO2 products are only viable during the first part of the mission, up to June 2009 for NO2 and December 2009 for UV-ozone.

The new v4 products require validation, to ensure their quality and characterize any biases they might have as compared to other datasets. To this end, this study presents comparisons of the v4 MAESTRO ozone and NO2 measurements against coincident, both spatially and temporally, measurements from an ensemble of 11 other satellite limb-viewing instruments: ACE-FTS, OSIRIS, SMR, MIPAS, GOMOS, SCIAMACHY, Aura-MLS, OMPS-LP, SAGE II, SAGE III/M3M, and SAGE III/ISS. The results will present these comparisons and indicate the regions of the atmosphere which have the best agreement.

The SCISAT satellite and this work is funded by the Canadian Space Agency.

Session: 6010 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 1 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 1 **03/06/2024 12:45**

ID: 12095 Contributed abstract

The Canadian Atmospheric Chemistry Experiment: 20 years of Validation and Science Results

Kaley Walker [1] , *Paul Jeffery* [2] , *Patrick Sheese* [3] , *Laura Saunders* [4] , *Jiansheng Zou* [5]

[1] University of Toronto
[2] University of Toronto
[3] University of Toronto
[4] University of Toronto
[5] University of Toronto

Presented by / Présenté par: ***Kaley Walker***
Contact: kwalker@atmosp.physics.utoronto.ca

The Canadian-led Atmospheric Chemistry Experiment (ACE) mission on board the SCISAT satellite has been making routine measurements of the Earth's atmosphere since February 2004. The long lifetime of ACE provides a valuable time series of composition measurements that contribute to our understanding of ozone recovery, climate change and pollutant emissions.

The SCISAT/ACE mission uses infrared and UV-visible spectroscopy to make its solar occultation measurements. The ACE Fourier Transform Spectrometer (ACE-FTS) is an infrared FTS operating between 750 and 4400 cm-1 and the Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation (ACE-MAESTRO) is a dual UV-visible-NIR spectrophotometer which was designed to extend the ACE wavelength coverage to the 280-1030 nm spectral region. From these measurements, altitude profiles of atmospheric trace gas species, temperature and pressure are retrieved.

The ACE data set can be combined with other data sets to provide the climate data

records required for long term monitoring of ozone and related species and for initialization and testing of chemistry-climate models. In order to do this, it is essential to quantify the biases between the different instruments and investigate their changes over the operational time period. Validation and comparison studies are a necessary component of this data assessment process. Highlights of validation and science results from the ACE mission will be presented in this paper along with mission and instrument status.

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ID: 12040 Contributed abstract

Time series analyses for the ACE-FTS and MIPAS CFC-11, CFC-12 data products

Jiansheng Zou [1] , *Kaley Walker* [2] , *Patrick Sheese* [3] , *Chris Boone* [4] , *Gabriele Stiller* [5]

[1] University of Toronto
[2] University of Toronto
[3] University of Toronto
[4] University of Waterloo
[5] Karlsruhe Institute of Technology

Presented by / Présenté par: ***Jiansheng Zou***
Contact: jzou@atmosp.physics.utoronto.ca

Two decades of the Atmospheric Chemistry Experiment - Fourier Transform Spectrometer (ACE-FTS) measurements of atmospheric composition have provided a rich dataset for studying ozone recovery, climate change, atmospheric dynamics, and pollutant emissions. This study carries out time series analyses of ACE-FTS version 5.2 CFC-11 and CFC-12 data – using zonally averaged monthly means covering 20-degree latitude bands from 90°S – 90°N. At the present time ACE-FTS is the only satellite instrument that measures profiles of CFCs, which are major ODSs (Ozone Depleting Substances). Continuing monitoring CFCs along with the assessment of the data quality of ACE-FTS data is important to ensure the continuing success of the Montreal Protocol. The early part of the ACE-FTS CFCs data is compared to the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) version 8 data (2005 – 2012) from the IMK/ISS (Institut für Meteorologie und Klimaforschung/Instituto de Astrofísica de Andalucía) processing by carrying out similar analyses. Because ACE-FTS and MIPAS employ different measurement techniques, the sampling patterns are quite different. Multivariate linear regression analyses are carried out for the time series constructed from coincident subsampled datasets as well as from the entire dataset from each instrument and separated by latitude band. Linear components as well as annual, semi-annual, and quasi-biennial oscillation (QBO) terms are derived from each data set. Comparisons of the coefficients derived from the coincident datasets enable the evaluation of the consistency between ACE-FTS and MIPAS. Further comparisons with the coefficients derived from the entire datasets reveal the impact of measurement sampling on the derivation of these modes. In addition, long-term trends for the ACE-FTS data are determined to take advantage of

the data set that spans 20 years.

Session: 6010 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 1 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 1 **03/06/2024 13:15**

ID: 12118 Contributed abstract

OSIRIS - Another Year of Data

Doug Degenstein [1] , *Adam Bourassa* [2] , *Daniel Zawada* [3] , *Taran Warnock* [4] , *Chris McLinden* [5]

[1] University of Saskatchewan
[2] University of Saskatchewan
[3] University of Saskatchewan
[4] University of Saskatchewan
[5] Environment and Climate Change Canada

Presented by / Présenté par: ***Doug Degenstein***
Contact: doug.degenstein@usask.ca

After 23 years the OSIRIS instrument onboard the Odin spacecraft continues to produce high quality optical measurements used to extract climate quality data records of ozone, nitrogen dioxide, stratospheric aerosols and now stratospheric temperature. This talk will update listeners on the current OSIRIS status and what the future holds for this long-lived Canadian earth observation venture. It will also introduce listeners to the new OSIRIS temperature data record. Results presented from this 23 year long record of stratospheric temperatures will indicate some of its utility for studying long term change in earth's atmosphere.

Session: 2011 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 2 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 2

Convenors:
John Hanesiak (University of Manitoba)
David Sills (Western University)

Many of Canada’s most costly natural disasters are caused by severe and extreme 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 and extreme 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 will lead off the session.

Session: 2011 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 2 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 2 **03/06/2024 14:05**

ID: 11948 Contributed abstract

Assessment of wind speeds along the damage path of the Didsbury, Alberta EF4 tornado on July 1, 2023

Connell Miller [1], *Gregory Kopp* [2], *David Sills* [3]

[1] Northern Tornadoes Project (Western University)
[2] Northern Tornadoes Project (Western University)
[3] Northern Tornadoes Project (Western University)

Presented by / Présenté par: ***Connell Miller***
Contact: connell.miller@uwo.ca

On July 1, 2023, a climatologically extreme tornado occurred in Didsbury, AB. The Northern Tornadoes Project, in collaboration with the ECCC Prairie and Arctic Storm Prediction Centre, conducted a thorough ground and drone survey. The survey team determined that the tornado should be rated as an EF4, with a maximum wind speed of 275 km/h. It is only the second tornado in Canada to have damage rated at EF4 on the Enhanced Fujita scale since it was implemented in this country in 2013, with the other being the Alonsa, MB EF4 that also had a maximum wind speed of 275 km/h. Twelve residences were hit by the tornado: 3 were destroyed, 4 were left uninhabitable, and a further 5 were damaged. This presentation details the ground and drone survey of that event and details the EF-scale rating process for individual buildings affected by this event.

Additionally, in the Didsbury event there were multiple instances of large compact debris (farming equipment, haybales, vehicles, etc.) that were lofted in the tornado. Currently, the Enhanced Fujita scale does not consider the wind-induced movement of various large compact objects that are often found in post-event damage surveys. One reason for this is that modelling debris in tornadoes comes with considerable uncertainties since there are many parameters to determine, leading to difficulties in using trajectories to analyze wind speeds of tornadoes. This presentation also details the development of a forensic tool using analytical tornado models to estimate lofting wind speeds based on trajectories of large compact objects, by using the Didsbury tornado as an example. This is accomplished by implementing a Monte Carlo simulation to randomly select the parameters and plotting cumulative distribution functions showing the likelihood of lofting at each wind speed.

Session: 2011 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 2 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 2 **03/06/2024 14:20**

ID: 11974 Contributed abstract

Synoptic scale patterns associated with the Didsbury AB tornado of 1 July 2023

Eric Van Lochem [1]

[1]

Presented by / Présenté par: ***Eric Van Lochem***
Contact: eric.vanlochem@ec.gc.ca

The EF-4 tornado which hit portions of Mountain View County, Alberta on Canada Day 2023 was the strongest to hit the province since the Edmonton tornado in July, 1987. In this work, a case study of the Didsbury EF-4 is presented, first putting the tornado into a historical context: it is only the third tornado of this intensity since 1915 in Alberta. It also occurred early in the day (of 101 significant tornadoes on the Prairies between 1978 and 2020, only 5 occurred before 19:45 UTC). Of 21 violent tornadoes (EF/F4+) recorded in Canada, Didsbury is only the 5th to occur and not result in loss of life. There is a quick overview of NWP performance in the lead-up to the event, and a comparison with the 14 July 2000 Pine Lake tornado – closer inspection reveals a number of similarities between Pine Lake and Didsbury, especially the synoptic pattern. Other antecedent factors in both cases include a severe drought over Palliser's Triangle, and a negatively tilted upper trough. Finally, the role of the upper pattern in significant tornadoes over Alberta is also discussed, using a series of plots from the North American Regional Reanalysis for hundreds of tornado events in western Canada.

Session: 2011 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 2 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 2 **03/06/2024 14:35**

ID: 11950 Contributed abstract

The detection and prediction of recent 'extreme' thunderstorm events in Canada

David Sills [1]

[1] Northern Tornadoes Project @ WesternU

Presented by / Présenté par: ***David Sills***
Contact: dave.sills@rogers.com

Thunderstorm events having climatologically extreme characteristics and/or extreme impacts make up five of the top ten natural disasters in Canada based on insured losses. Such events include the 2013 Toronto flash flood, the 2020 Calgary hailstorm, and the 2022 Ontario-Quebec derecho – all with close to or over $1B in insured losses and, in the case of the derecho, a large number of casualties. In 2023, a tornado hit the Didsbury area north of Calgary, achieving a rare EF4 rating though fortunately resulting in no casualties and far less insured losses than the other events listed. For each of these thunderstorm events, extreme impacts and/or intensity was not

anticipated. In most cases, the extreme nature of the event was not understood until after the event occurred. This presentation will examine our current ability to detect and predict such storms, and will discuss related implications, particularly in highly urbanized areas.

Session: 2011 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 2 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 2 **03/06/2024 14:50**

ID: 11916 Contributed abstract

Tornado Analysis using Artificial Intelligence and Treefall Patterns

Daniel Butt [1] , *Aaron Jaffe* [2] , *Connell Miller* [3] , *Gregory Kopp* [4] , *David Sills* [5]

[1] Northern Tornadoes Project, Western University
[2] Northern Tornadoes Project, Western University
[3] Northern Tornadoes Project, Western University
[4] Northern Tornadoes Project, Western University
[5] Northern Tornadoes Project, Western University

Presented by / Présenté par: ***Daniel Butt***
Contact: dbutt7@uwo.ca

In many regions of the world, tornadoes travel through forested areas with low population densities, making downed trees the only observable damage indicator. Current methods in the EF scale for analyzing tree damage may not reflect the true intensity of some tornadoes. However, new methods have been developed that use the number of trees downed or treefall directions from high-resolution aerial imagery to provide an estimate of maximum wind speed. Treefall Identification and Direction Analysis (TrIDA) maps are used to identify areas of treefall damage and treefall directions along the damage path. Until recently, TrIDA maps were generated manually, but this is labour-intensive, often taking several days or weeks. To solve this, a machine learning and image processing-based model was developed that automatically extracts fallen trees from large-scale aerial imagery, assesses their fall directions, and produces an area-averaged treefall vector map with minimal initial human interaction. Using the treefall vectors, tornadic and downburst damage can be separated, the tornado's convergence line fit (convergence of tree directions), and other factors such as path width can be determined. By examining transects of the tornado's path perpendicular to the convergence line, the area-averaged directions can be used to extract an observed treefall pattern. A vortex is then simulated travelling over the same location and in the same direction, with a resulting simulated treefall pattern being calculated. The observed pattern is then compared to the simulated pattern, with the similarity between these patterns taken as proportional to the similarity between the characteristics of the observed and simulated vortices. After the simulation of many patterns, the best matching patterns can be utilized to estimate the wind speed among other characteristics of the observed tornado, such as swirl ratio.

Session: 2011 Severe and Extreme Convective Storms : Detection, **03/06/2024**

Prediction, Climatology and the Future - Part 2 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 2 **15:05**

ID: 12034 Contributed abstract

Downburst Damage Assessments in Canadian Forests

Lesley Elliott [1] , *Aaron Jaffe* [2] , *David Sills* [3]

[1] Western University
[2] Western University
[3] Western University

Presented by / Présenté par: ***Lesley Elliott***
Contact: lesley.elliott@uwo.ca

The Northern Tornadoes Project (NTP) aims to detect, assess and document all tornadoes in Canada, with equal interest applied to heavily populated areas along our southern border and sparsely populated forested areas of the country. NTP efforts to detect tornadoes has led to the discovery of many downburst events as well. Satellite imagery review can reveal damage from both tornadoes and downbursts, and a significant portion of these events occur in forested regions where no structural damage indicators are present.

Using the “Trees” damage indicator in the Canadian implementation of the Enhanced Fujita scale, NTP developed a scalable box method for rating tornado damage in forested areas. The box method can be applied to the various types of remotely sensed imagery (satellite, drone and aircraft) gathered during NTP investigations. A reliable method for rating damage from downburst events in forested areas is also needed. The impact area of a downburst event can vary widely in scale and the intensity of damage within that impact area can also vary widely.

This presentation will focus on the challenges of developing a scalable box method for rating downburst tree damage. Progress made by NTP to date will be discussed, including using nearby structural damage to validate the box method applied to forest damage.

Session: 2011 Severe and Extreme Convective Storms : Detection, Prediction, Climatology and the Future - Part 2 Tempêtes convectives graves et extrêmes : Détection, prévision, climatologie et avenir - Partie 2 **03/06/2024 15:20**

ID: 11987 Contributed abstract

Update on the Meteorological Service of Canada’s Convective Alert Modernization project

Bradley Power [1]

[1]

Presented by / Présenté par: ***Bradley Power***

Contact: bradley.power@ec.gc.ca

The Convective Alert Modernization (CAM) project, initiated in early 2022, aims to modernize the production and delivery of convective warnings in Canada. The current practice of creating convective alerts for predefined zones results in areas being alerted where there is no actual threat expected. The project aims to reduce areal over-alerting of tornado and severe thunderstorm hazards by introducing forecaster defined free-form polygons. This change will more precisely represent the boundaries of the predicted convective threat areas. Internal evaluations have demonstrated potential service improvements and highlighted challenges with the introduction of this new threat boundary paradigm in Canada. This presentation will discuss the approaches being considered to address the challenges and will also provide a project update.

Session: 4011 Coastal Oceanography and Inland Waters - Part 2 Océanographie côtière et eaux intérieures - Partie 2

Convenors:
Jinyu Sheng (Dalhousie University)
Guoqi Han (Institute of Ocean Sciences)
Dan (Shiliang) Shan (Royal Military College of Canada)

In the context of the overarching theme, "Extreme Events in a Changing Climate," this session aims to provide a comprehensive exploration of 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, as well as the mixing and dispersion of materials. Contributions related to both observational and modelling aspects of biogeochemistry in coastal and inland waters are welcome. Papers can focus on improving our knowledge of physical and biogeochemical conditions over coastal and inland waters in the past and present climate, and/or on predictions of changes and extremes in marine conditions in response to climate change.

Session: 4011 Coastal Oceanography and Inland Waters - Part 2
Océanographie côtière et eaux intérieures - Partie 2 **03/06/2024 14:05**

ID: 11964 Contributed abstract

Quantifying hydrodynamic connectivity among existing and proposed Marine Protected Areas on the Scotian Shelf using the Lagrangian particle-tracking method

Kyoko Ohashi [1] , *Jinyu Sheng* [2] , *Bruce Hatcher* [3] , *Bo Yang* [4]

[1] Dalhousie University
[2] Dalhousie University
[3] Cape Breton University
[4] Ocean University of China

Presented by / Présenté par: ***Kyoko Ohashi***

Contact: kyoko.ohashi@dal.ca

The international “30 by 30” initiative aims to protect 30% of the Earth’s terrestrial and marine habitats by 2030. Marine Protected Areas (MPAs) are one component of Canada’s plans to reach this goal. The ecological benefits of MPAs to marine ecosystems under current and future climates, however, are still not fully clear and need to be examined. In this study, hydrodynamic connectivity among existing and proposed MPAs on the Scotian Shelf is quantified using the movement of virtual particles due to simulated three-dimensional (3D) currents, calculated using a Lagrangian particle-tracking program (ROMSPath, Hunter et al., 2022). The 3D currents and temperature/salinity over the eastern Canadian shelf during 2015-2018 are simulated using an ocean circulation model known as the Regional Ocean Modeling System (ROMS), coupled to a sea ice model known as the Community Ice CodE (CICE). Numerical experiments using ROMSPath are conducted with particles released initially from various depths over the existing or proposed MPAs of the Scotian Shelf bioregion (as defined by Fisheries and Oceans Canada) as well as existing MPAs in areas upstream from the Scotian Shelf (i.e., the Gulf of St. Lawrence and the Laurentian Channel). Particles in these experiments can be either purely passive, in which case their movements are determined only by the ocean currents, or active in that they include swimming behaviour depending on their life stage and habitat. The results of these experiments are used to construct maps of connectivity among different areas of the bioregion as well as between the bioregion and areas upstream of it. These maps have the potential to support decision making about conservation measures and to act as a tool for communication with stakeholders.

Session: 4011 Coastal Oceanography and Inland Waters - Part 2
Océanographie côtière et eaux intérieures - Partie 2 **03/06/2024 14:20**

ID: 11946 Contributed abstract

Storm-Induced Hydrodynamic Changes and Wave-Current Interaction over the Southeastern Canadian Shelf during Hurricane Fiona

Qiantong Pei [1] , *Jinyu Sheng* [2]

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Presented by / Présenté par: ***Qiantong Pei***
Contact: qn317878@dal.ca

Hurricane Fiona in late September 2022 was a large and destructive Category-4 Atlantic hurricane, with the wind gusts of about 180 km/h recorded at Arisaig of Nova Scotia. This storm was the most intense tropical/post-tropical cyclone to hit Atlantic Canada on record. A coupled wave-circulation model is used in this study to examine the storm-induced hydrodynamic changes and effects of wave-current interaction (WCI) during Hurricane Fiona. The coupled modelling system is based on the Regional Ocean Modeling System (ROMS) and the Simulating Waves Nearshore model (SWAN). Analysis of model results demonstrates very intense vertical mixing and currents generated by Hurricane Fiona in the surface mixed layer, both of which are biased to the right of the storm track. In addition to the strong wind forcing and large atmospheric pressure perturbations, the WCI plays a very important role in the

hydrodynamic changes in the top ~80 m over the eastern Scotian Shelf and adjacent waters. Over the offshore deep waters (coastal waters) of the study region, the maximum significant wave heights (SWHs) reach up to 21 m (16 m), biased to the right of the storm track.

Session: 4011 Coastal Oceanography and Inland Waters - Part 2
Océanographie côtière et eaux intérieures - Partie 2 **03/06/2024 14:35**

ID: 12022 Contributed abstract

A hydrologic model calibration and simulation of eastern Canadian freshwater discharge

Rick Danielson [1] , *Joël Chassé* [2] , *Will Perrie* [3]

[1] Fisheries and Oceans Canada
[2] Fisheries and Oceans Canada
[3] Fisheries and Oceans Canada

Presented by / Présenté par: ***Rick Danielson***
Contact: rick.danielson@dfo-mpo.gc.ca

Configuration of the National Center for Atmospheric Research (NCAR) WRF-Hydro model is sought for climate simulations of discharge from an eastern Canadian river network at two-km resolution. The river network is taken from an upscaled digital elevation model with well defined catchment boundaries. Perturbations of a subset of model parameters are examined using the parameter estimation tool (PEST), with reference to streamflow from 25 gauged catchments during the 2019 warm season. Agreement between observed and modelled streamflow improves for about half the individual catchments. With reference to 189 gauged catchments (1990-2022), further agreement is obtained at monthly and annual scales by neural network post-processing that targets all catchments at once as well as individual catchments. Using this configuration, we examine climate simulations of discharge.

Session: 4011 Coastal Oceanography and Inland Waters - Part 2
Océanographie côtière et eaux intérieures - Partie 2 **03/06/2024 14:50**

ID: 12030 Contributed abstract

Estimating uncertainties of predicted surface drifter trajectories in the Estuary and Gulf of St. Lawrence in Québec

Maëla Le Ménec [1] , *Cédric Chavanne* [2] , *Dany Dumont* [3]

[1] Institut des Sciences de la Mer de Rimouski
[2] Institut des Sciences de la Mer de Rimouski
[3] Institut des Sciences de la Mer de Rimouski

Presented by / Présenté par: ***Maëla Le Ménec***
Contact: Maela.LeMenec@uqar.ca

Extreme events come with necessities of more surveillance of the sea and its users. In particular, more frequent and stronger storms will increase the risk of maritime accidents, challenging search and rescue operations and oil spill mitigation measures. It is therefore important to have reliable predictive models of drift trajectories. These predictions are usually obtained from 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 in Quebec, 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. The oceanic model has a horizontal resolution of 500 m and a vertical resolution of 1 m near the surface. The atmospheric model has a horizontal resolution of 2.5 km and the wave model has a horizontal resolution of 1 km. Different simulations of drifter trajectories are realized to investigate the impact of the Stokes drift and the vertical shear of the currents on the predicted trajectories, and to determine the best stochastic model to use for estimating efficient trajectory uncertainties.

Session: 4011 Coastal Oceanography and Inland Waters - Part 2
Océanographie côtière et eaux intérieures - Partie 2 **03/06/2024 15:05**

ID: 12065 Contributed abstract

Models for aquaculture in Nova Scotia and SW New Brunswick

David Greenberg [1]

[1] Bedford Institute of Oceanography

Presented by / Présenté par: ***David Greenberg***
Contact: davidgreenberg@alumni.uwaterloo.ca

New Brunswick has moved heavily into aquaculture over the past several years and farm operators continue to explore opportunities. In Nova Scotia many farms are now established or exploring feasibility. In recent years several hydrodynamic models have been used for the purpose of evaluating sites and more are being developed. These models aid in the search for suitable locations and predicting interactions with other sites and the wider environment. This presentation reviews some of the sites and models and gives examples of how they are being used.

Session: 4011 Coastal Oceanography and Inland Waters - Part 2
Océanographie côtière et eaux intérieures - Partie 2 **03/06/2024 15:20**

ID: 12081 Contributed abstract

Interannual Variations of Upwelling along Coast of Nova Scotia

Jing Tao [1] , *Youyu Lu* [2] , *Hui Shen* [3] , *Michael Casey* [4]

[1] Fisheries and Oceans Canada
[2] Fisheries and Oceans Canada
[3] Fisheries and Oceans Canada
[4] Fisheries and Oceans Canada

Presented by / Présenté par: ***Jing Tao***
Contact: Jing.Tao@dfo-mpo.gc.ca

Coastal upwelling influences primary productivity in the ecosystem. The daily fields of sea surface temperature (SST) from a high-resolution global ocean data assimilative

reanalysis product (GLORYS12) are analyzed to derive upwelling indices along coast of Nova Scotia during 1993-2022. These indices include the upwelling area, intensity, and yearly start date and duration. The time variations of upwelling area and intensity show seasonal variations, and all parameters show variations at interannual and longer time scales. The relationships between the variations of these upwelling indices and the precondition represented by SST and the persistence of upwelling-favorable wind are explored.

Session: 7031 Collaborative Earth System Modelling in Canada - Part 2
Modélisation collaborative du système terrestre au Canada - Partie 2

Convenors:
Paul Kushner (University of Toronto)
Matthew Toohey (University of Saskatchewan)
Clint Seinen (Environment and Climate Change Canada)

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.

ID: 11968 Contributed abstract

Constraining Carbon Cycle Simulations Using Global Earth Observations and Machine Learning

Christian Seiler [1]

[1]

Presented by / Présenté par: ***Christian Seiler***
Contact: christian.seiler@queensu.ca

Effective climate policies demand reliable estimates of global carbon fluxes and trends. Every year, the Global Carbon Project provides new estimates for the global carbon budget. These calculations require knowledge of the strength of the terrestrial carbon sink, which relies on an ensemble of terrestrial biosphere models. Simulating the strength of the terrestrial carbon sink is subject to considerable uncertainties. One source of uncertainty is related to the choice of parameter values, which are difficult to constrain directly through observations. As a result, modelers select parameter values that fall within an approximate uncertainty range, while also producing outputs that are consistent with global earth observations. Traditionally, such model-tuning efforts rely on experience, expert judgment, and intuition. This presentation demonstrates the potential of machine learning for systematically tuning the land surface component of the Canadian Earth System Model. By employing a Genetic Algorithm, parameters are optimized across various statistical metrics, output variables, and biomes, while also considering observational uncertainties. Tuning does not only improve model performance, but it also affects the strength of the natural carbon sink. The framework can be adopted by other modeling groups seeking to improve their carbon cycle simulations in alignment with global observational data.

Session: 7031 Collaborative Earth System Modelling in Canada - Part 2 Modélisation collaborative du système terrestre au Canada - Partie 2

03/06/2024 14:20

ID: 11893 Contributed abstract

Upgrading the representation of soil carbon processes in the UVic ESCM

Claude-Michel Nzotungicimpaye [1] , *Andrew MacDougall* [2]

[1] St Francis Xavier University
[2] St Francis Xavier University

Presented by / Présenté par: ***Claude-Michel Nzotungicimpaye***
Contact: miklonzo.science@gmail.com

Most current Earth system models feature multiple soil carbon pools characterized as active, slow, and passive carbon pools. However, such carbon pools are not measurable in the natural world and present limitations when it comes to simulating soil carbon sequestration in the context of nature-based climate solutions on land. In our presentation, we describe a recent upgrade of soil carbon processes in version 2.10 of the University of Victoria (UVic) Earth System Climate Model (ESCM). The

model upgrade consists of a transition from a single soil carbon pool, in each soil layer, to five measurable soil carbon pools. Our presentation focuses on the model validation across spatial scales and sensitivity to poorly-constrained model parameters over the historical period. The upgraded model will be practical for studies on nature-based climate solutions in Canada and globally, as well as their implications for future climate.

Session: 7031 Collaborative Earth System Modelling in Canada - Part 2 Modélisation collaborative du système terrestre au Canada - Partie 2

03/06/2024 14:35

ID: 12026 Contributed abstract

Examining the climate system drivers of the local and non-local biogeophysical effects of afforestation

Pierre Etienne Banville [1] , *Alexander MacIsaac* [2] , *Kirsten Zickfeld* [3]

[1] Simon Fraser University
[2] Simon Fraser University
[3] Simon Fraser University

Presented by / Présenté par: ***Pierre Etienne Banville***
Contact: peb1@sfu.ca

Afforestation is an important component of global climate mitigation scenarios due to the significant carbon sink potential of forests. Land cover changes, such as afforestation, also have biogeophysical effects on climate, influencing surface temperature locally ("local effects") and at distant locations ("non-local effects"). Non-local effects are non-negligible and may lead to undesired and unintended consequences. However, local, and non-local effects remain uncertain and poorly understood. Our research seeks to quantify the local and non-local biogeophysical effects of afforestation on land surface temperature and determine the drivers of such effects using the UVic ESCM, an Earth System Model of intermediate complexity. We simulate an idealized afforestation scenario across the globe using the checkerboard approach where we alternate grid cells undergoing afforestation with grid cells remaining deforested. We separate local from non-local effects by comparing the idealized afforestation scenario to a control simulation where all grid cells remain deforested. To determine their drivers, we perform a surface energy balance decomposition over the local and non-local effects. To determine the ocean’s role in mediating non-local effects, we perform a simulation with prescribed sea surface temperatures (“SSTs”) that we compare to our idealized afforestation scenario. Our results show that afforestation leads to a local cooling, more pronounced in the Tropics, driven by an increase in sensible heat flux. Afforestation also leads to a non-local warming, more pronounced in northern latitudes, driven by an increase in incoming longwave radiation from increasing surface air temperature. We hypothesize that non-local effects are influenced by the increase in SSTs and the subsequent reduction in albedo from the melting of sea ice in northern latitudes. Identifying the processes driving local and non-local effects of afforestation increases our understanding of the interactions among Earth Systems components and can inform climate mitigation policies, particularly on afforestation’s role in limiting global warming.

Session: 7031 Collaborative Earth System Modelling in Canada - Part 2 Modélisation collaborative du système terrestre au Canada - Partie 2

03/06/2024 14:50

ID: 12110 Contributed abstract

Investigating scenario dependence of the biophysical impacts of reforestation

Tom Markland [1] , *Kirsten Zickfeld* [2]

[1] Simon Fraser University
[2] Simon Fraser University

Presented by / Présenté par: ***Tom Markland***
Contact: tom_markland@sfu.ca

Reforestation is a frequently suggested climate solution, yet the biophysical processes which govern its efficacy depend on alignment of several biogeochemical factors. Trees can influence temperature via both radiative (albedo) and non-radiative (surface roughness and evapotranspiration) biophysical processes. In the Tropics, it has been shown that reforestation can mitigate against temperature increase as carbon sequestration rates and evaporative cooling align. However, in Boreal regions the presence of forest can mask the reflectivity of the snow and lead to warming, potentially counteracting the benefits of carbon sequestration of forests in this region. We expect the magnitude of biophysical responses to be scenario dependent as different amounts of warming will affect non-radiative and radiative effects of reforestation, but this scenario dependence has not been investigated systematically. The goal of this research is to investigate the magnitude of biophysical effects of reforestation on global and regional temperatures under different Shared Socio-economic pathways (SSPs). We will use the UVic ESCM to investigate the biophysical impacts of reforestation under three different SSP scenarios. The UVic ESCM is an Earth System model of intermediate complexity, coupled with dynamic ocean and vegetation models with components representing sea-ice, the land surface and an energy-moisture balance model of the atmosphere. The different pathways are SSP1-1.9, SSP2-4.5 and SSP3-7.0 which represent a high mitigation, middle of the road and low mitigation scenario, respectively. To isolate the biophysical impacts of reforestation, we will run baseline simulations with consistent land-use change and reforestation scenarios which aim to reverse historical deforestation. Understanding the magnitude of biophysical effects in different regions and their potential to counter positive biogeochemical benefits of reforestation can help inform effective climate mitigation policies in the future.

Session: 7031 Collaborative Earth System Modelling in Canada - Part 2 Modélisation collaborative du système terrestre au Canada - Partie 2

03/06/2024 15:05

ID: 11981 Contributed abstract

Accounting for carbon cycle feedbacks when attributing global warming to emissions

Nathan Gillett [1] , *Isla Simpson* [2] , *Aranildo Lima* [3] , *Vivek Arora* [4]

[1] CCCma, Environment and Climate Change Canada
[2] National Center for Atmospheric Research, CO, USA
[3] CCCma, Environment and Climate Change Canada
[4] CCCma, Environment and Climate Change Canada

Presented by / Présenté par: ***Nathan Gillett***
Contact: nathan.gillett@ec.gc.ca

As well as assessing attribution of global mean warming to changes in concentrations of greenhouse gases and other atmospheric constituents, the IPCC Sixth Assessment Report also assessed contributions to global mean warming due to changes in emissions of greenhouse gases, changes in emissions of aerosols and aerosol precursors, and other factors. While the assessment considered interactions associated with tropospheric chemistry, it did not consider carbon cycle effects. Accounting for carbon-climate feedbacks, which are likely to be net positive, is expected to result in a stronger warming attributable to greenhouse gas emissions offset by a stronger cooling attributable to aerosol and aerosol precursor emissions, compared to results from an analysis omitting such effects. This talk will present results from new sets of CanESM5 simulations of the response to changes in greenhouse gases, aerosols, and natural forcings in which the CO2 concentration is simulated interactively. Based on a comparison of the simulated response with corresponding simulations with prescribed CO2 concentrations we will discuss the effects of carbon cycle interactions on the warming attributable to these sets of forcings. The talk will end with discussion of the implications of the results for climate policy, and for the experimental design of the Detection and Model Intercomparison Project (DAMIP) for the seventh Coupled Model Intercomparison Project (CMIP7), where there is expected to be a stronger emphasis on emissions-driven simulations compared to prior CMIPs.

Session: 6011 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 2 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 2

Convenors:
Kaley Walker (University of Toronto)
Matt Arkett (Environment and Climate Change Canada)

Satellite Earth observation (SEO) 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. Resourceful, Resilient, Ready: Canada's Strategy for Satellite Earth Observation provides a plan for Canada to more effectively leverage satellite earth observation (SEO) to address key priorities, including climate change mitigation and adaptation. This strategy will help to inform Canada's plans for SEO for the next decade and ensure Canada will maximize utilization and benefits of SEO. This session encourages contributions from across the full SEO value chain, upstream, midstream and downstream, to illustrate the activities currently underway in Canada, involving industry, academia and government. 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.

Session: 6011 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 2 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 2 **03/06/2024 14:05**

ID: 11945 Contributed abstract

The use of Satellite Imagery for Operational Forecasters: Observations and Future Needs

Kyle Ziolkowski [1]

[1] ECCC-SPC Winnipeg/National Lab-West

Presented by / Présenté par: ***Kyle Ziolkowski***
Contact: kziolkowski4404@gmail.com

Satellite images provide forecasters with a picture of the current state of the atmosphere at the beginning of and throughout a forecast shift. Forecasters also leverage various satellite derived products to further diagnose the state of the atmosphere and highlight features that are integral to issuing alerts for public safety. With the launch of the GOES-R series came increased spectral and spatial resolution. This has opened up the door to a host of new satellite products that forecasters can leverage to make more accurate forecasts and more timely alerts. Satellite RGBs in particular have been a major addition to the forecaster's toolbox. RGBs allow forecasters to examine weather phenomena in more detail and make it is easier to distinguish between different phenomena ranging from severe thunderstorms to tracking smoke plumes from wildfires. The increase in products has also introduced an increase in the amount of data that needs to flow into forecast operations and creates other challenges in navigating the large amounts of data available to forecasters. This presentation will examine how forecasters are leveraging the current suite of products along with the current and future needs and how the Meteorological Service of Canada is bringing this critical data too forecasters and other users of satellite data.

Session: 6011 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 2 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 2 **03/06/2024 14:20**

ID: 12033 Contributed abstract

Pre-launch broadband radiative closure assessment for the EarthCARE mission

Zhipeng Qu [1], *Jason Cole* [2], *Howard Barker* [3], *Meriem Kacimi* [4], *Shannon Mason* [5], *Robin Hogan* [6], *Ben Courtier* [7]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada

[3] Environment and Climate Change Canada
[4] Environment and Climate Change Canada
[5] European Centre for Medium-Range Weather Forecasts
[6] European Centre for Medium-Range Weather Forecasts
[7] University of Leicester

Presented by / Présenté par: ***Zhipeng Qu***
Contact: zhipeng.qu@ec.gc.ca

The EarthCARE satellite, launched in May 2024, will retrieve profiles of aerosol and cloud properties using its cloud-profiling radar (CPR), atmospheric backscatter lidar (ATLID), and passive multi-spectral imager (MSI). Co-located broadband thermal and solar radiative radiances will be measured by the broadband radiometer (BBR). Cloud and aerosol retrievals, along with additional geophysical properties, will serve as inputs for 1D and 3D broadband solar and thermal radiative transfer (RT) models that will compute radiances and fluxes. These will be compared with to estimates based on BBR measurements thereby defining a comprehensive, and continuous, radiative closure assessment of the retrievals. In preparation for EarthCARE's launch, an extensive evaluation was conducted utilizing observations from A-Train satellites. EarthCARE's synergistic retrieval algorithm (CAPTIVATE) was applied to A-Train measurements to retrieve cloud and aerosol properties, which were in turn used as inputs for the RT models. Output from the RT calculations were then compared with broadband radiative fluxes inferred from Clouds and the Earth's Radiant Energy System (CERES) mission. This study describes the 1D and 3D forward RT simulations, compares computed radiative fluxes to CERES's values, and highlights the importance of using 3D RT models for radiative closure assessments. The findings of this study will also support Canadian EarthCARE calibration/validation (val/val) activities.

Session: 6011 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 2 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 2 **03/06/2024 14:35**

ID: 12010 Contributed abstract

Progresses towards the Canadian HAWC/AVENIR Mission on NASA Atmosphere Observing System

Jean-Pierre Blanchet [1], *Adam Bourassa* [2], *Doug Degenstein* [3], *Yann Blanchard* [4], *Jeffrey Langille* [5], *Landon Rieger* [6], *Patrick Grenier* [7], *Yi Huang* [8], *Kaley Walker* [9]

[1] Université du Québec à Montréal (UQAM)
[2] University of Saskatchewan
[3] University of Saskatchewan
[4] Université du Québec à Montréal (UQAM)
[5] University of New Brunswick (UNB)
[6] University of Saskatchewan
[7] Université du Québec à Montréal (UQAM)
[8] McGill University
[9] University of Toronto

Presented by / Présenté par: ***Jean-Pierre Blanchet***
Contact: blanchet.jean-pierre@uqam.ca

Since 2019, a Canadian team has been working with CSA and NASA on the development of innovative satellite instruments to probe with greater sensitivity and higher resolutions the cold and dry region of the globe targeting a launch around 2031 for a 5-year mission. The nadir and limb viewing instruments will provide a 3D view of the UTLS region with fine vertical resolution (≤ 500 m) and tiny concentration of particulates (extinction of aerosols and thin clouds > 10-5 km-1) and water vapor (accuracy ≤ 15 %) concomitant with the vertical view of clouds and water vapor retrieved from spectral radiance images in 8 bands [4 to 73 µm] at kilometer resolutions.
Although this is a long-term program, considerable milestone advancements have been done so far. From the initial prototypes developed over nearly 15 years, to campaign deployments, including the recent ER-2 high-altitude (~21 km) flights last fall, the maturity of the design has made it to phase A of a full mission. It has been endorsed by the Minister Champagne with a budget over 200M$. As a result of the collaboration, workshops, and the contribution of 14 Canadian universities, research is well underway for scientific applications to build a more comprehensive picture of aerosol, cloud, water vapor and radiation for improving climate assessment and modelling with a wide range of interests and increasing efforts across the country. This talk will inform on the status and progresses of the mission and highlight research results from recent campaigns.

Session: 6011 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 2 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 2 **03/06/2024 14:50**

ID: 12058 Contributed abstract

Suborbital testing of the HAWC limb imaging instruments on the NASA ER-2 airplane

Landon Rieger [1] , *Jeff Langille* [2] , *Adam Bourassa* [3] , *Doug Degenstein* [4] , *Yann Blanchard* [5] , *Jean-Pierre Blanchet* [6]

[1] University of Saskatchewan
[2] University of Saskatchewan
[3] University of Saskatchewan
[4] University of Saskatchewan
[5] University of Sherbrooke
[6] University of Quebec in Montreal

Presented by / Présenté par: ***Landon Rieger***
Contact: landon.rieger@usask.ca

The High-altitude Aerosol, Water vapor and Cloud (HAWC) satellite mission will fill critical gaps in our knowledge of cloud processes and interactions, radiative forcing and aerosol and water vapour concentrations in the upper troposphere and lower stratosphere. These quantities, and in particular, their interactions are difficult to measure with current instruments, so to improve understanding HAWC will use a

unique suite of three instruments: The Aerosol Limb Imager (ALI) that will measurement aerosol extinction, particle size and thin cirrus clouds. The Spatial Heterodyne measurements of Water (SHOW) instrument will provide highly vertically resolved water vapour profiles and the Thin Ice Cloud in Far InfraRed Emissions (TICFIRE) instrument that will acquire nadir imagery in the far IR emission spectrum.

In the Fall of 2023, the ALI and SHOW instruments were flown on a series of high-altitude ER-2 flights. The ER-2 aircraft provides a unique platform to test instrument engineering and science, with three flights taking place near the west coast of the USA for this campaign. Several interesting meteorological conditions were observed, and flights were coordinated with both frost-point hygrometer releases and satellite overpasses for validation. Initial results of data quality, calibrations, and aerosol and water vapour retrievals are presented.

Session: 6011 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 2 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 2 **03/06/2024 15:05**

ID: 12000 Contributed abstract

Comparison Between Ground-based Lidar Measurements from MPLCAN and Simulated Retrievals from the Aerosol Limb Imager

Emily Tracey [1] , *Landon Rieger* [2] , *Victoria Pinnegar* [3] , *Bob Sica* [4]

[1] Western University
[2] University of Saskatchewan
[3] Western University
[4] Western University

Presented by / Présenté par: ***Emily Tracey***
Contact: etracey4@uwo.ca

I will present initial results of a comparison between simulated satellite measurements and ground-based lidar measurements from a network of micro-pulse lidars. The Aerosol Limb Imager (ALI) is a part of the High-altitude Aerosol, Water, and Clouds (HAWC) satellite, a Canadian mission which will help fill a critical gap in our understanding of the role of aerosol, water vapour, and clouds in climate forcing. ALI will measure limb-scattered radiance allowing for retrievals of aerosol extinction and particle size in the troposphere and stratosphere. The Canadian Micro-Pulse Lidar Network (MPLCAN) is a network consisting of five micro-pulse lidars (MPLs) across eastern and northern Canada. The MPLs can detect particulates produced from wildfire smoke, volcanic ash, and anthropogenic pollutants. They can also differentiate between water and ice in clouds by measuring the polarization state of the backscatter signal. Coincident measurements between the MPLCAN and ALI instruments have great potential to validate the ALI measurements, and to extend their vertical coverage. However, the ALI retrieved quantities are not directly comparable to the MPL backscatter coefficient measurements, so assumptions must be made about the constituents and optical properties of the atmosphere to compare them. The ALI retrieved quantities were converted to an MPL backscatter measurement for comparison using two methods. First, Mie scattering theory was used based on the ALI retrievals of aerosol particle size to calculate the backscatter coefficient. The second

method assumed a lidar ratio, the ratio of backscatter to extinction, appropriate for the assumed stratospheric aerosols. The ALI-derived backscatter coefficient from both methods yielded similar results as expected. Preliminary comparisons between both simulated and actual MPL measurements and the converted ALI retrieval show promising agreement. Future work will aim to model ALI passing over multiple MPLs for realistic HAWC satellite tracks to simulate wildfire smoke events.

Session: 2020 Extreme Precipitation: Past, Present, Future Précipitations extrêmes : Passé, présent, futur

Convenors:
Neil Tandon (York University)
John Gyakum (McGill University)
Megan Kirchmeier-Young (Environment and Climate Change Canada)
Xander Wang (University of Prince Edward Island)

As we have seen repeatedly in the news, extreme precipitation events are impacting many regions across Canada and around the globe, often contributing to devastating floods. The extreme precipitation leading up to the 2014 Alberta floods and the atmospheric rivers that hit British Columbia in 2021 are just some of the countless examples. Understanding extreme precipitation events is imperative for improved climate change projections and climate change adaptation. This session welcomes contributions addressing the range of topics relevant to extreme precipitation, including long-term changes, variability, physical drivers, climate change attribution, prediction, observing methods, modelling and impacts. These studies might examine events in the distant past, more recent events or projected future events. We encourage submissions of theoretical modelling studies as well as analyses of observations and model output. Regional case studies are welcomed, as well as studies examining extreme precipitation characteristics and mechanisms aggregated over larger spatial scales and longer temporal scales.

Session: 2020 Extreme Precipitation: Past, Present, Future
Précipitations extrêmes : Passé, présent, futur **03/06/2024 15:55**

ID: 11915 Contributed abstract

Pseudo Integrated Vapor Transport and Pseudo Moist Flow as Two Saturation-Adjusted Quantities for Atmospheric River Analysis

Ruping Mo [1] , *Eimile Botting* [2] , *Bruce Ainslie* [3] , *Kirk Torneby* [4] , *Roxanne Vingarzan* [5]

[1] Meteorological Service of Canada
[2] Meteorological Service of Canada
[3] Meteorological Service of Canada
[4] Meteorological Service of Canada
[5] Meteorological Service of Canada

Presented by / Présenté par: ***Ruping Mo***
Contact: ruping.mo@ec.gc.ca

Atmospheric rivers (ARs) are long, narrow, and transient corridors of strong horizontal water vapor transport that have the potential to produce heavy precipitation and some related hazards upon making landfall. Vertically Integrated water Vapor Transport (IVT) is often used to define and categorize AR intensity. It is generally believed that stronger IVT can lead to heavier precipitation. While this expectation may be justified based on simple physical principles, there is room for further improvement of this indicator. Here we show that, since precipitation efficiency is also dependent on the degree of saturation in the air column, applying a saturation adjustment to IVT can significantly enhance its association with precipitation. We propose a simple adjustment to define a pseudo IVT (PIVT), which is the IVT multiplied by the column relative humidity (a dimensionless variable ranging from 0 to 1). Based on a 45-year global reanalysis dataset, the Spearman (or Kendall) correlation coefficient of PIVT with total precipitation rate is about 0.41 (0.29), which is much higher than 0.28 (0.20) derived from IVT. Similar improved scores (Spearman: 0.43, Kendall: 0.31) can also be derived from an additional new variable called pseudo moist flow (PMF), which can be considered as the moisture-weighted column-average wind speed. PMF has the same units as wind speed, making it a convenient way to analyze moist low-level jets. We demonstrate that use of either PIVT or PMF has some advantages over IVT for determining AR intensity and could be used for detection of high-latitude and inland-penetrating ARs and refining AR scales.

Session: 2020 Extreme Precipitation: Past, Present, Future
Précipitations extrêmes : Passé, présent, futur **03/06/2024 16:10**

ID: 11931 Contributed abstract

Extreme convective rainfall over central Nova Scotia July 21-22, 2023: A case study

Alissa Steeves [1] , *Shunli Zhang* [2] , *Marc Verville* [3] , *Manon Faucher* [4]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada
[4] Environment and Climate Change Canada

Presented by / Présenté par: ***Alissa Steeves***
Contact: alissa.steeves@ec.gc.ca

A convective atmospheric river made landfall over Nova Scotia during the afternoon of July 21, 2023, and continued for the next 48 hours as it slowly shifted eastward. Rainfall amounts exceeding 200mm were observed along the Atlantic coast from Liverpool to Bedford, as well as inland across to Windsor and near Stewiacke. RADAR imagery suggests over 300mm fell south of Windsor. However, numerical weather prediction generally failed to predict such extreme amounts. This case study delves into the successes and failures of the numerical weather prediction, including some experimental, and considers elements such as terrain, convective parameterization, sea surface temperatures, and precipitable water assimilation.

ID: 11896 Contributed abstract

Influence of Rossby Wave and Jet Stream Patterns during Extreme Precipitation Regimes (EPRs) in eastern North America

Yeechian Low [1] , *John Gyakum* [2]

[1] McGill University
[2] McGill University

Presented by / Présenté par: ***Yeechian Low***
Contact: yeechian.low@mail.mcgill.ca

Extreme precipitation is often challenging to predict but can have substantial impacts through flooding and loss of life and property, especially when it is persistent and affects a large region. We analyze the Rossby wave and jet stream patterns and hypothesize the associated large-scale physical mechanisms contributing to the occurrence and persistence of extreme precipitation regimes (EPRs). EPRs are characterized by an unusually slow-moving and persistent large-scale pattern favorable for southerly flow of subtropical moisture into eastern North America. The strength of the southerly flow is critical in producing large precipitation rates. The pattern is set up by the start of the EPR, moves very slowly eastward until the middle of the EPR, and then moves faster eastward by the end of the EPR. The ridges' persistence, despite the lack of higher-latitude blocking, and the long-wavelength and slow-moving nature of the Rossby wave pattern are critical to the longevity of EPRs. The latent heat from moisture transport into cyclones provides a feedback mechanism contributing to the persistence. The Rossby wave speed spatial pattern and lack of high-latitude blocking indicates a succession of relatively quick-moving cyclones that track north of the persistent ridges.

ID: 12029 Contributed abstract

Cold-season subtropical air mass intrusions into eastern Canada: Dynamic and thermodynamic impacts on extreme precipitation

John Gyakum [1] , *Yeechian Low* [2]

[1] McGill University
[2] McGill University

Presented by / Présenté par: ***John Gyakum***
Contact: john.gyakum@mcgill.ca

During the past several decades, extreme weather events, particularly extreme precipitation, have been increasingly publicized in the media. Our objective in this study is to examine a possible thermodynamic basis for these events, namely

subtropical airmass intrusions into higher latitudes. Our focus is on such intrusions that occur during the Northern Hemisphere winter (December, January and February) during the years from 1979 through 2024.

We first define a subtropical airmass based upon a combination of temperature and water vapor, more precisely the maximum value of equivalent potential temperature (theta-e) in the 900-700 hPa layer that is at least 310 K. This threshold value of theta-e is associated with the climatological values observed in subtropical regions. Furthermore, this thermodynamic metric is particularly relevant in that it relates directly to well-established climate-change warming.

We next identify such large values of theta-e that are observed in the latitudinal range of 40 to 50 deg N latitude from the operational radiosondes of North America that exist in these latitudes. The value of using the equivalent potential temperature is its conservation in the absence of friction and convective processes. Additionally, identifying the maximum value of theta-e in the 900-700 hPa layer also identifies the base of coupling between the free atmosphere's lower level and the dynamic tropopause. This coupling may be characterized as the convective stability in the troposphere.

Our analyses of particularly extreme intrusions of subtropical air into extratropical latitudes reveal for eastern Canada an anomalously strong transport of water vapor from the Gulf of Mexico and the subtropical regions of the North Atlantic. Such strong water vapor transports often resemble an atmospheric river.

Perhaps the most compelling result of this study is the identification of especially extreme values of lower-tropospheric equivalent potential temperature also often identifies the most extreme amounts of 24-h precipitation.

Therefore, this purely thermodynamic metric, the equivalent potential temperature maximum in the lower troposphere, represents a significant diagnostic metric for extreme precipitation without explicit consideration of any dynamically based metric, such as vertical motion.

Case-study examples of the physical linkages between subtropical air mass intrusions and the associated dynamics of extreme precipitation events will be presented.

Session: 2020 Extreme Precipitation: Past, Present, Future
Précipitations extrêmes : Passé, présent, futur **03/06/2024 16:55**

ID: 11944 Contributed abstract

Differences between convection-parameterizing and convection-resolving simulations of future changes in extreme precipitation intensity over the subtropical Atlantic.

Thabo Mpanza [1] , *Neil Tandon* [2]

[1] York University
[2] York University

Presented by / Présenté par: ***Thabo Mpanza***
Contact: thbms17@gmail.com

Regional projections of extreme precipitation intensity (EPI) are strongly influenced by changes of “extreme ascent,” i.e. ascending air during periods of extreme precipitation. This influence is especially strong over the subtropical Atlantic, where most global climate models (GCMs) project decreased EPI due to weakened extreme ascent. Thus, the subtropical Atlantic is a prime study location for understanding dynamical influences on extreme precipitation. Previous controlled experiments using a cloud resolving model (CRM) have suggested that weakening of differential cyclonic vorticity advection (dCVA) drives these subtropical extreme ascent decreases. In the present study, we assess whether a single column model (SCM) that parameterizes convection produces similar results.
For our experiments, we picked three representative locations over the subtropical Atlantic Ocean. At each study location, four to ten pairs of 20-year-maximum precipitation events were simulated, with each pair consisting of an event during the historical period (1981–2000) and an event during the future period (2081–2100). Large-scale forcings for these events were derived from members of an initial condition ensemble of the Canadian Earth System Model version 2 (CanESM2).
These SCM experiments reveal that, over two of the study locations, increases in static stability are the key driver of decreased extreme ascent and EPI, in contrast with results of earlier CRM experiments. Interestingly, none of the EPI produced in the SCM experiments was due to parameterized precipitation, similar to the behaviour in most GCMs during extreme precipitation events. The SCM results more closely resemble those of earlier analyses of GCM output, suggesting that the mechanisms driving projected subtropical EPI decreases in GCMs are influenced by the unrealistic absence of subgrid-scale convection during extreme events.

Session: 2020 Extreme Precipitation: Past, Present, Future
Précipitations extrêmes : Passé, présent, futur **03/06/2024 17:10**

ID: 11935 Contributed abstract

Snowfall projections developed from the novel Canadian Downscaled Climate Scenarios – Multivariate CMIP6 dataset

Kenneth Kin Cheung Chow [1] , *Emilia Diaconescu* [2]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada

Presented by / Présenté par: ***Kenneth Kin Cheung Chow***
Contact: kenneth.chow2@ec.gc.ca

Snow is an important resource, especially in Canada, as it is a vital part of the freshwater supply, influences climate and weather over a range of spatial scales, and is associated with drought and flood events. It is also tied to a multi-billion dollar winter recreation industry in Canada. Users of future climate projections in Canada often request information on future snowfall projections for adaptation and decision-making in numerous sectors. However, most climate data portals provide downscaled projections for total precipitation only. Existing snowfall projections are primarily from GCM and RCM simulations, which have spatial scales too coarse for local and regional applications.

To address these data gaps, the Canadian Centre for Climate Services has developed

a multi-model ensemble of snowfall projections based on the Canadian Downscaled Climate Scenarios – Multivariate CMIP6 (CanDCS-M6) dataset. This ensemble consists of daily temperature and precipitation simulations from 26 CMIP6 GCMs, statistically downscaled using the Climate Imprints and the Multivariate Bias Correction N-probability density function transform methods. Snowfall and subsequent climate indices are derived from these daily temperature and precipitation simulations using the Auer polynomial method.

This talk will detail the methods used to estimate snowfall from daily temperature and precipitation variables, the evaluation of snowfall and snowfall climate indices derived using the CanDCS-M6 dataset, and present some of the snowfall projections at the end of the 21st century.

Session: 4012 Coastal Oceanography and Inland Waters - Part 3 Océanographie côtière et eaux intérieures - - Partie 3

Convenors:
Jinyu Sheng (Dalhousie University)
Guoqi Han (Institute of Ocean Sciences)
Dan (Shiliang) Shan (Royal Military College of Canada)

In the context of the overarching theme, "Extreme Events in a Changing Climate," this session aims to provide a comprehensive exploration of 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, as well as the mixing and dispersion of materials. Contributions related to both observational and modelling aspects of biogeochemistry in coastal and inland waters are welcome. Papers can focus on improving our knowledge of physical and biogeochemical conditions over coastal and inland waters in the past and present climate, and/or on predictions of changes and extremes in marine conditions in response to climate change.

Session: 4012 Coastal Oceanography and Inland Waters - Part 3 Océanographie côtière et eaux intérieures - - Partie 3 **03/06/2024 15:55**

ID: 11899 Contributed abstract

Evolving relationship of Nares Strait ice arches on sea ice along the Strait and the North Water, the Arctic's most productive polynya

Kent Moore [1], *Stephen Howell* [2], *Mike Brady* [3]

[1] University of Toronto
[2] ECCC
[3] ECCC

Presented by / Présenté par: ***Kent Moore***
Contact: gwk.moore@utoronto.ca

Nares Strait, the waterway that separates northwest Greenland from Ellesmere Island,

is a major pathway along which sea ice leaves the Arctic, including the planet's oldest and thickest sea ice that is experiencing an accelerated loss. Ice arches that develop during the winter at the Strait's northern or southern terminus can remain stable for months at a time during which the transport of sea ice ceases. The Arctic's most productive polynya, the North Water (NOW) or Pikialasorsuaq (West Greenlandic for 'great upwelling') forms at the Strait's southern end. There is evidence that a warming climate and the concomitant thinning of Arctic sea ice is weakening the arches and it has been proposed that this may impact the stability of NOW and the complex ecosystem that it sustains. Here we employ a categorization of recent winters with respect to the presence or absence of ice arches to explore their impact on sea ice along the Strait and over the NOW. We find that winters during which a southern ice arch is absent are associated with a reduced and thinner ice cover along the Strait with ice conditions over the NOW similar to that during winters with a southern arch. In winters, without a southern arch, there is also an acceleration of the winds along the Strait that contributes to the presence of reduced ice cover. Ocean color remote sensing data suggests that current levels of primary productivity over the NOW are independent of the presence or absence of an ice arch. The results suggest more research is needed to assess the stability of the NOW, with respect to reduced ice cover and primary productivity, in a future where ice arches cease to form along Nares Strait.

Session: 4012 Coastal Oceanography and Inland Waters - Part 3
Océanographie côtière et eaux intérieures - - Partie 3 **03/06/2024 16:10**

ID: 11901 Contributed abstract

An Examination of the Wrangel Island Sea Ice Thickness Dipole

Spenser Ross [1] , *Kent Moore* [2]

[1] University of Toronto
[2] University of Torontorsity

Presented by / Présenté par: ***Spenser Ross***
Contact: gwk.moore@utoronto.ca

The Beaufort Sea High is a high-pressure system located in the Beaufort Sea and influences ocean circulation in the western Arctic known as the Beaufort Gyre. Wrangel Island, located in the western Chukchi Sea, typically experiences easterly sea ice motion due to the Beaufort Gyre. We find that under these climatological conditions, moving ice is blocked by the island and piles up on its eastern side, while ice on its western side continues to drift. This results in an ice thickness dipole across the island. A reversal in the sense of the oceanic and atmospheric circulation across the western Arctic results in a dipole with the opposing sign. We find the dipole is present throughout the year and is strongest in January when the ice thickness difference is approximately 1m. During the spring, it is associated with the transient opening of a polynya to the west of the island. The dipole is the result of opposing ice divergence and convergence across the western Arctic and may impact ocean circulation and ecosystems within the Chukchi Sea.

ID: 11907 Contributed abstract

Wind-Driven Transient Polynyas along Kennedy Channel

Kevin Joshy [1] , *Kent Moore* [2]

[1] University of Toronto
[2] University of Toronto

Presented by / Présenté par: ***Kevin Joshy***
Contact: gwk.moore@utoronto.ca

Nares Strait, the waterway situated between northwest Greenland and Ellesmere Island that joins the Lincoln Sea to Northern Baffin Bay, is one of the major export pathways for Arctic sea ice. Nares Strait also hosts several islands, such as those present within Kennedy Channel – one of the narrowest parts of the strait. The impact of these obstacles on the ice flow along the Strait has not been investigated. Here, we show that as sea ice is carried through Nares Strait via wind and water currents, these islands can shield downstream regions from becoming ice-covered resulting in the formation of hitherto unknown transient polynyas. To accomplish this, we use satellite-derived sea ice concentration data from the AMSR-E and ASMR2 instruments alongside 10m wind speed, wind direction, and sea-level pressure fields from the Copernicus Arctic Regional Reanalysis (CARRA) to map the spatial sea ice distributions and atmospheric conditions in the region. The size and extent of these polynyas were correlated with the wind's strength and direction through Kennedy Channel. These polynyas likely impact the regional meteorology and oceanography through enhanced fluxes of heat, moisture, momentum and carbon dioxide.

ID: 12109 Contributed abstract

Tidewater Glacier Influence on the Marine Environment in the Canadian Arctic Archipelago

Claire Parrott [1] , *Patrick White* [2] , *Jenifer Spence* [3] , *Maya Bhatia* [4] , *Erin Bertrand* [5] , *Andrew Hamilton* [6] , *David Didier* [7] , *Terry Noah* [8] , *Eric Brossier* [9] , *Paul G. Myers* [10] , *Stephanie Waterman* [11]

[1] University of British Columbia
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Presented by / Présenté par: ***Claire Parrott***
Contact: cparrott@eoas.ubc.ca

Tidewater glaciers, numerous in the Canadian Arctic Archipelago (CAA), are an important and variable source of freshwater, sediment, and nutrients to the coastal ocean. Subglacial discharge can produce meltwater plumes that promote upwelling and enhance mixing near glacier termini, impacting water column structure, freshwater distribution, and other biogeochemical properties in the proximate ocean. Despite their abundance, knowledge is lacking on glacier-ocean systems across the CAA, specifically how glacial meltwater is influencing and modifying the marine environment in the near-coastal ocean. Further, as glaciers continue to retreat, their impact on the unique ecosystems stimulated from the presence of these glaciers is unknown. In this study, we examine the spatial and temporal variability of physical and biogeochemical water properties at a variety of sites in Jones Sound, a tidewater glacier-rich region in the CAA, to better understand the influences of glacier meltwater inputs on the marine environment, specifically water column structure and marine biogeochemistry. We use in situ? water column observations along coast-to-open ocean transects at a variety of locations across the region that contrast glacierized and non-glacierized sites. This novel dataset was obtained using the sailing yacht Vagabond and local vessels operated by community members from Ausuittuq (Grise Fiord, NU) each summer from 2019-2023 and provides multi-year, fjord-scale-resolution observations of physical and chemical water column properties from glacier terminus to open ocean. Results show sites with tidewater glaciers often have a nutrient-enhanced upper water column with decreased stratification, likely a result of plume-induced upwelling near these sites. Sites with weaker tidewater glacier influence have a similar water column structure with less nutrient enhancement and stronger stratification. There is significant interannual variability across all sites. As tidewater glaciers continue to retreat, these results suggest this will cause a reduction in nutrient delivery to the surface ocean, which may impact marine ecosystems existing near tidewater glacier sites.

Session: 4012 Coastal Oceanography and Inland Waters - Part 3
Océanographie côtière et eaux intérieures - - Partie 3 **03/06/2024 16:55**

ID: 11961 Contributed abstract

Tidal-induced Extreme Bottom Current Resuspension in the Halifax Harbour

Sarwesh Mali [1] , *Shiliang Shan* [2] , *Jennifer Shore* [3] , *Anna Crawford* [4]

[1] Royal Military College of Canada
[2] Royal Military College of Canada
[3] Royal Military College of Canada
[4] DRDC – Atlantic Research Centre

Presented by / Présenté par: ***Sarwesh Mali***
Contact: malisarwesh@gmail.com

Halifax Harbour, a crucial Atlantic Canadian port, has extensive commercial, environmental and strategic value to Canadians. Despite thorough hydrographic research, knowledge about the influence of the bottom currents on the resuspension of

sediments within the harbour is lacking. To address this knowledge gap, we utilized a high-resolution, three-dimensional, barotropic finite volume coastal ocean model (FVCOM) to simulate the tidal-driven extreme bottom currents in the harbour. We used the critical Shields parameter, a threshold for sediment movement, to quantify the areas at risk for sediment resuspension. Our results indicate regions in the Narrows and west of McNabs Island are susceptible to sediment resuspension due to the interaction of extreme bottom currents and sediment grain sizes. These findings are important for detecting sediment changes in the harbour, and potentially improving existing monitoring and management practices.

Session: 7032 Collaborative Earth System Modelling in Canada - Part 3
Modélisation collaborative du système terrestre au Canada - Partie 3

Convenors:
Paul Kushner (University of Toronto)
Matthew Toohey (University of Saskatchewan)
Clint Seinen (Environment and Climate Change Canada)

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.

- Partie 3

ID: 12071 Contributed abstract

Millennial timescale climate change in the Canadian Earth System Model

Jake Eager-Nash [1] , *Colin Goldblatt* [2] , *Carsten Abraham* [3] , *Andrew Weaver* [4] , *Michael Eby* [5]

[1] University of Victoria
[2] University of Victoria
[3] Environment and Climate Change Canada
[4] University of Victoria
[5] University of Victoria

Presented by / Présenté par: ***Jake Eager-Nash***
Contact: jeagernash@uvic.ca

We apply CanESM for the first time to look at the millennial scales consequences of anthropogenic climate change. CanESM is a state of the art, fully coupled, Atmosphere-Ocean Global Climate Model. We run simulations with abrupt forcings of 0.5, 2,4 and 8 times preindustrial CO2 levels, using two variants of CanESM5.1. We focus on how the atmosphere, including cloud and moisture, is impacted by the warming of the deep ocean on millennial time scales.

Session: 7032 Collaborative Earth System Modelling in Canada - Part 3 Modélisation collaborative du système terrestre au Canada - Partie 3

03/06/2024 16:25

ID: 12080 Contributed abstract

How does tropospheric VOC chemistry affect climate? Investigations using the Community Earth System Model Version 2

Noah Stanton [1] , *Neil Tandon* [2]

[1] York University
[2] York University

Presented by / Présenté par: ***Noah Stanton***
Contact: nstant@my.yorku.ca

Comprehensive tropospheric chemistry models, traditionally run with fixed sea surface temperatures (SSTs), have recently advanced to include fully coupled oceans, enhancing their ability to simulate climate responses. The Community Earth System Model version 2 (CESM2) with the Whole Atmosphere Community Climate Model version 6 (WACCM6) exemplifies this progress, incorporating interactive tropospheric chemistry with 231 chemical species and a coupled ocean. This marks a notable shift from earlier CESM versions that used a simplified “SOAG scheme” for secondary organic aerosol (SOA) formation, to a more detailed simulation of volatile organic compounds (VOCs) responsible for tropospheric aerosol formation. We conducted 211-year preindustrial control simulations using two configurations: (1) the standard

CESM2-WACCM6 with comprehensive atmospheric chemistry (WACtl), and (2) a modified version with simplified tropospheric chemistry (MACtl). While middle-atmospheric chemistry was the same in both configurations, the tropospheric chemistry varied, and we examined the difference between WACtl and MACtl. This analysis revealed regional SST changes ranging from −4 to 4 K and significant extratropical tropospheric cooling, which appear to be due to increased sulfate aerosols and cloud feedbacks. In WACtl, interactions with SOAs led to reductions in black carbon (BC) and primary organic matter (POM), contributing to further cooling relative to MACtl, particularly in the Northern Hemisphere. This cooling also influenced atmospheric dynamics, causing shifts in midlatitude jets and alterations in cloud and precipitation patterns. In the tropical upper troposphere, cloud-related changes appear to affect the Hadley circulation, impacting precipitation in tropical and subtropical regions. Additional simulations comparing a 2000 baseline climate to the preindustrial simulations reveal sensitivity to prescribed land emissions. This research, most of which was recently published in Atmospheric Chemistry and Physics (doi:10.5194/acp-23-9191-2023), underscores important climate influences of comprehensive tropospheric chemistry in Earth system models and the need for strong collaborations to further develop these capabilities.

Session: 7032 Collaborative Earth System Modelling in Canada - Part 3 Modélisation collaborative du système terrestre au Canada - Partie 3

03/06/2024 16:40

ID: 11977 Contributed abstract

Most CMIP6 models do not capture the signature of Pacific Water in the Canadian Basin

Erica Rosenblum [1] , *Robert Fajber* [2]

[1] University of Toronto
[2] McGill University

Presented by / Présenté par: ***Erica Rosenblum***
Contact: erica.j.rosenblum@gmail.com

In observations, the Canadian Basin has three distinct water masses in it: a layer of cold, fresh, Arctic water above a seasonal halocline over the first 100m, a layer of Pacific water with a local thermal maximum below the seasonal halocline, and layer of warm, salty, Atlantic water below that, separated by a strong thermocline. The layer of Pacific water represents a significant source of thermal energy relatively close to the surface, with the potential to melt much of the sea ice in the Canadian basin.

By contrast, most CMIP6 models do show a distinctive signal of a thermal maximum below the seasonal halocline associated with Pacific water in the Canadian basin. Instead the models either show a well mixed temperature profile, or a more or less constant thermocline that extends towards start of the Atlantic later. The majority of these models also underestimate the seasonal and interannual variability of the temperature and salinity profiles in the Canadian Basin. The exception to this behavior are the EC-Earth family of models, which have a vertically resolved mixing scheme. The results of this study emphasize the importance of the subgrid-scale vertical mixing scheme for the performance of ocean models in the Canadian basin.

ID: 12057 Contributed abstract

Towards Modernization of Surface and Atmospheric Components of the Short-Range ECCC's Numerical Weather Prediction System

Sylvie Leroyer [1], *Marc Verville* [2], *Maria Abrahamowicz* [3], *Marc Beuhner* [4], *Bernard Bilodeau* [5], *Marco Carrera* [6], *Dorothée Charpentier* [7], *Manon Faucher* [8], *Syed Zahid Husain* [9], *Dominik Jacques* [10], *Thomas Milewski* [11], *Danahé Paquin-Ricard* [12]

[1] ECCC
[2] ECCC
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[9] ECCC
[10] ECCC
[11] ECCC
[12] ECCC

Presented by / Présenté par: ***Sylvie Leroyer***
Contact: sylvie.leroyer@ec.gc.ca

ECCC is currently undertaking a coordinated effort to modernize both the surface and atmospheric components of the short-range Numerical Weather Prediction System (HRDPS) simultaneously, covering a grid that encompasses the majority of Canada and the northern part of USA. The primary goal of this project is to develop a robust and integrated system capable of accurately predicting weather and environmental variables in a coherent manner. This involves revisiting some of the modelling and data assimilation methods, as well as deepening verification approaches in the context of validating terrestrial models. To achieve this objective, this project leverages recent advances in land surface and sub-surface forecasting withing the framework of hydrology forecasting. In particular, the land-surface model used for the dominant landscape in Canada is the Soil, Vegetation and Snow scheme (SVS). It permits a better representation of physical processes at the surface, including water and energy budgets, and the snow evolution. It is initialized with the Canadian Land Data Assimilation System (CaLDAS), incorporating satellite remotely-sensed soil moisture and temperature. Concurrently, atmospheric physical processes in the Global Environmental Multiscale Model (GEM) in convection-permitting mode are being revisited, such as turbulence and mixing length formulations, microphysics, and cloud-radiation interactions. Overall, results will emphasize modelling of surface-atmosphere interactions.
The challenges posed by such a project include the need for high levels of coordination across the scientific, technical, and human resources, but the expected outcomes include enhanced operational activities, improved provision of integrated services for both weather and hydrology, and increased understanding of the earth system modelling.

ID: 12126 Contributed abstract

Representation of Clouds and Precipitation in NWP, RCMs, and GCMs – Thoughts on the Future of Cloud Microphysics Parameterization in Atmospheric Models in Canada (and Beyond)

Jason Milbrandt [1] , *Hugh Morrison* [2] , *Melissa Cholette* [3]

[1] ECCC
[2] MMM, NCAR
[3] ECCC

Presented by / Présenté par: ***Jason Milbrandt***
Contact: jason.milbrandt@ec.gc.ca

With continuously increasing computer power, the resolution of numerical weather prediction (NWP) models, regional climate models (RCMs), and global climate models (GCMs) has increased over the past decades. One of the many components of atmospheric models is the grid-scale cloud/precipitation (i.e. microphysics) parameterization. As model resolution increases, so does relative importance of the model microphysics and as models approach the km scale, the microphysics scheme becomes one of the largest sources of model uncertainty.

Ten years ago, we proposed a new approach to represent ice-phase hydrometeors in models and developed a new microphysics parameterization, the Predicted Particle Properties (P3) scheme. Since its inception, P3 has become operational in the ECCC's HRDPS, it is the official scheme of PNNL's GCM, and it has been implemented in several other models (LESs, mesoscale models, and GCMs) around the world for research. Active development of P3 by the core development team and collaborators continues; within the next 2 year, we expect to have a the most complete and state-of-the-art framework amongst bulk microphysics schemes. P3, therefore, is useful for current operational and research needs and provides an excellent framework for ongoing improvement to individual microphysical processes as we continue to increase our understanding of the fundamental physics of in-cloud processes.

This presentation will provide an overview of the current state of the art in techniques to represent cloud microphysics in atmospheric models and a prediction of the future roles of microphysics schemes in operational and research models. An argument will be made for the international modeling community at large to adopt P3 as a "community" scheme for use in weather/climate prediction modeling systems – with full awareness of the disruption of AI/ML for operational NWP -- in Canada (and elsewhere).

Convenors:
Paul Kushner (University of Toronto)
Matthew Toohey (University of Saskatchewan)
Clint Seinen (Environment and Climate Change Canada)

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Session: 7032 Collaborative Earth System Modelling in Canada - Part 3 Modélisation collaborative du système terrestre au Canada - Partie 3

03/06/2024 15:55

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Jake Eager-Nash [1], *Colin Goldblatt* [2], *Carsten Abraham* [3], *Andrew Weaver* [4], *Michael Eby* [5]

[1] University of Victoria
[2] University of Victoria
[3] Environment and Climate Change Canada
[4] University of Victoria
[5] University of Victoria

Presented by / Présenté par: ***Jake Eager-Nash***

Contact: jeagernash@uvic.ca

We apply CanESM for the first time to look at the millennial scales consequences of anthropogenic climate change. CanESM is a state of the art, fully coupled, Atmosphere-Ocean Global Climate Model. We run simulations with abrupt forcings of 0.5, 2,4 and 8 times preindustrial CO2 levels, using two variants of CanESM5.1. We focus on how the atmosphere, including cloud and moisture, is impacted by the warming of the deep ocean on millennial time scales.

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03/06/2024 16:25

ID: 12080 Contributed abstract

How does tropospheric VOC chemistry affect climate? Investigations using the Community Earth System Model Version 2

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[1] York University
[2] York University

Presented by / Présenté par: ***Noah Stanton***
Contact: nstant@my.yorku.ca

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03/06/2024 16:40

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Most CMIP6 models do not capture the signature of Pacific Water in the Canadian Basin

Erica Rosenblum [1] , *Robert Fajber* [2]

[1] University of Toronto
[2] McGill University

Presented by / Présenté par: ***Erica Rosenblum***
Contact: erica.j.rosenblum@gmail.com

In observations, the Canadian Basin has three distinct water masses in it: a layer of cold, fresh, Arctic water above a seasonal halocline over the first 100m, a layer of Pacific water with a local thermal maximum below the seasonal halocline, and layer of warm, salty, Atlantic water below that, separated by a strong thermocline. The layer of Pacific water represents a significant source of thermal energy relatively close to the surface, with the potential to melt much of the sea ice in the Canadian basin.

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03/06/2024 16:55

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Contact: sylvie.leroyer@ec.gc.ca

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Session: 7032 Collaborative Earth System Modelling in Canada - Part 3 Modélisation collaborative du système terrestre au Canada - Partie 3

03/06/2024 17:10

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Jason Milbrandt [1] , *Hugh Morrison* [2] , *Melissa Cholette* [3]

[1] ECCC
[2] MMM, NCAR
[3] ECCC

Presented by / Présenté par: ***Jason Milbrandt***
Contact: jason.milbrandt@ec.gc.ca

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Session: 6012 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 3 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 3

Convenors:
Kaley Walker (University of Toronto)
Matt Arkett (Environment and Climate Change Canada)

Satellite Earth observation (SEO) 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. Resourceful, Resilient, Ready: Canada’s Strategy for Satellite Earth Observation provides a plan for Canada to more effectively leverage satellite earth observation (SEO) to address key priorities, including climate change mitigation and adaptation. This strategy will help to inform

Canada's plans for SEO for the next decade and ensure Canada will maximize utilization and benefits of SEO. This session encourages contributions from across the full SEO value chain, upstream, midstream and downstream, to illustrate the activities currently underway in Canada, involving industry, academia and government. 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.

Session: 6012 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 3 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 3 **03/06/2024 15:55**

ID: 12045 Contributed abstract

Detection of methane emissions from permafrost peatlands with TROPOMI XCH4 observations

Ray Nassar [1], *Joseph Mendonca* [2], *Qindii Shafi* [3], *Sabour Baray* [4], *Peter Morse* [5], *Oliver Schneising* [6], *Michael Buchwitz* [7]

[1] ECCC
[2] ECCC
[3] University of Waterloo
[4] ECCC
[5] Natural Resources Canada
[6] University of Bremen
[7] University of Bremen

Presented by / Présenté par: ***Ray Nassar***
Contact: ray.nassar@ec.gc.ca

Permafrost across the northern circumpolar region is a vast carbon reservoir that holds nearly twice the mass of carbon in Earth's atmosphere. Some fraction of this carbon will be released as CH4 or CO2 when permafrost thaws in the coming years. Recent column-averaged methane (XCH4) observations (2018-2023) from the Tropospheric Monitoring Instrument (TROPOMI) on the Sentinel-5 Precursor satellite are assessed for evidence of CH4 emissions from permafrost regions. TROPOMI XCH4 anomalies north of 50°N are calculated and averaged bi-monthly onto a high spatial resolution (0.09°x0.18° ≈ 10 km) grid and soil temperature anomaly maps (down to 1.5 m depth) are also generated from reanalysis data. Considering the XCH4 and soil temperature anomalies along with information on soil carbon content and wind variability leads to a focus on Canada's Hudson Bay Lowlands (HBL). The HBL is an area of wetlands and peat underlain by continuous through to isolated permafrost, containing very high soil carbon content. With the HBL on the southern edge of the permafrost zone, it has been identified as vulnerable to thaw and high carbon emissions. Wind conditions in the HBL are also favorable for the detection of surface emissions from space. We find strong evidence in TROPOMI XCH4 of enhanced CH4 emissions correlated with elevated summer soil temperature for the HBL permafrost peatlands, although the attribution of CH4 emissions to a specific geophysical process is difficult.

ID: 11956 Contributed abstract

Extreme carbon monoxide emission events observed by MOPITT

Paul Jeffery [1] , *James Drummond* [2] , *Jiansheng Zou* [3] , *Kaley Walker* [4]

[1] University of Toronto
[2] Dalhousie University
[3] University of Toronto
[4] University of Toronto

Presented by / Présenté par: ***Paul Jeffery***
Contact: paul.jeffery@mail.utoronto.ca

Since March 2000, the Measurements Of Pollution In The Troposphere (MOPITT) instrument aboard NASA's Terra satellite has been measuring upwelling thermal and near-infrared radiance in a nadir-viewing geometry. These measurements are used to retrieve profile and total column estimates of carbon monoxide (CO) concentration. MOPITT achieves global coverage, spanning from 82 degrees N to 82 degrees S every 3 days, with an exact revisit cycle of 16 days. The resultant MOPITT CO dataset constitutes the longest satellite-based record of global CO measurements available to date.

The MOPITT CO dataset makes it well-suited for a variety of applications, including trend analysis and the construction of CO budgets. However, large, irregularly timed emissions of CO, often associated with extreme events such as large wildfires or other biomass burnings, can introduce complexities in utilizing CO measurements for such analyses.

This work will report on recent work including the presentation of a recently developed technique aimed at identifying large episodic emission events in the MOPITT daily-mean total column CO measurement dataset. It involves empirically determining the expectation density function (EDF) that describes the departure of daily-mean CO observations from the baseline behaviour of CO, as described by its periodic components and trends.

This method provides an objective method to determine whether events are usual, cyclic, or ‘extreme’. Examples from this analysis will be provided.

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.

Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 3

ID: 12048 Contributed abstract

Arctic Observing Mission (AOM): An update on progress and partnerships

Ray Nassar [1], *Alec Casey* [2], *Geneviève Gariépy* [3], *Matt Arkett* [4], *Chris Sioris* [5], *Joseph Mendonca* [6], *Josep Aparicio* [7], *Shen-En Qian* [8], *Isabelle Jean* [9], *Alexander Trishchenko* [10]

[1] ECCC
[2] ECCC
[3] Canadian Space Agency
[4] ECCC
[5] ECCC
[6] ECCC
[7] ECCC
[8] Canadian Space Agency
[9] Canadian Space Agency
[10] Natural Resources Canada

Presented by / Présenté par: ***Ray Nassar***
Contact: ray.nassar@ec.gc.ca

The Arctic Observing Mission (AOM) is a satellite mission concept currently under study by the Canadian Space Agency (CSA), Environment and Climate Change Canada (ECCC) and Natural Resources Canada (NRCan). AOM would use two satellites in a Highly Elliptical Orbit (HEO) to make geostationary-like observations of meteorological variables, greenhouse gases (GHGs), air quality (AQ) and space weather over northern regions (~45-90°N). These observations are important for operational weather forecasts, environmental monitoring, situational awareness and scientific research aligned with key priorities of the Government of Canada and our prospective US and European partners.

AOM meteorological observations would extend the capabilities of the National Oceanic and Atmospheric Administration (NOAA) geostationary meteorological imager to more northerly latitudes to improve Numerical Weather and Environmental Prediction (NWEP) in the Arctic. Northern GHG observations would improve our ability to detect and monitor changes in northern carbon cycles, including CO2 and CH4 emissions from permafrost thaw or anthropogenic sources. AQ observations would enhance our ability to monitor northern emissions and pollution transport from mid-latitudes and improve air quality forecasts. Space weather observations would support operational space weather forecasting to protect valuable space-based assets and improve our scientific understanding of solar-terrestrial interactions.

AOM is currently undergoing a pre-formulation study (PFS) to be completed by late 2024 as a step toward a future funding request. A key component of the PFS is a mission design contract in which an industry team is assessing payload and orbit options, updating conceptual designs for the GHG and AQ imaging spectrometers and estimating costs for the mission. Activities to advance new technologies required for AOM and science studies to guide mission requirements and assess AOM benefits continue in parallel with the mission design. This presentation will give an overview of AOM's status, progress on the pre-formulation study and updates on international partnership scenarios.

Session: 6012 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 3 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 3 **03/06/2024 16:40**

ID: 11988 Contributed abstract

The GHGSat constellation: Land and offshore methane detection and quantification

Jean-Philippe MacLean [1], *Marianne Girard* [2], *Dylan Jervis* [3], *David Marshall* [4], *Jason McKeever* [5], *Antoine Ramier* [6], *Mathias Strupler* [7], *Ewan Tarrant* [8], *David Young* [9]

[1] GHGSat Inc
[2] GHGSat Inc
[3] GHGSat Inc
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[8] GHGSat Inc
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Presented by / Présenté par: ***Jean-Philippe MacLean***
Contact: jmaclean@ghgsat.com

GHGSat operates a constellation of small satellites specifically designed and optimized for imaging and quantification of methane plumes down to 25 m resolution and 100 kg/h source rates. In 2023, the constellation expanded to 12 satellites with the launch of three additional satellites, including the introduction of the first CO2 sensing instrument.

Here, we report on our latest efforts to characterize system performance from several perspectives.

On land, we present a comprehensive analysis of the performance across the constellation, demonstrating consistent column precision levels (interquartile range: 1% to 3%) influenced primarily by ground reflectance. To assess the detection threshold, a series of controlled releases were self-organized and performed on a single-blind basis. Fitting our results to a probability-of-detection model we obtain a 50% probability of detection at 3 m/s wind of 102 kg/h.

Offshore, we present a variety of examples of methane plumes, including the largest single emission at (84, 000 ± 24, 000) kg/h observed by GHGSat from the Nord Stream 2 pipeline leak in 2022 and the smallest offshore emission measured from space at (180 ± 130) kg/h in the Gulf of Mexico. In addition, we provide an overview of the constellation's offshore measurement capabilities. We measure a median column precision of 2.1% of the background methane column density and estimate a detection limit, from analytical modelling and orbital simulations, that varies between 160 kg/h and 600 kg/h depending on the latitude and season.

Session: 9020 Public Lecture - Extreme Weather Events and their Future Changes Conférence publique - L'une des conséquences les plus importantes du réchauffement climatique pour

Dr. L. Ruby Leung
Pacific Northwest National Laboratory

L. Ruby Leung is a Battelle Fellow at Pacific Northwest National Laboratory. Her research broadly cuts across multiple areas in modeling and analysis of climate, water cycle, and extreme events. Ruby is the Chief Scientist of the U.S. Department of Energy's Energy Exascale Earth System Model (E3SM), a major effort involving over a hundred earth and computational scientists and applied mathematicians to develop state-of-the-art capabilities for modeling human-Earth system processes on DOE's next generation high performance computers. Ruby is an elected member of the National Academy of Engineering and Washington State Academy of Sciences. She is also a fellow of the American Meteorological Society (AMS), American Association for the Advancement of Science (AAAS), and American Geophysical Union (AGU). She is the recipient of the AGU Global Environmental Change Bert Bolin Award and Lecture in 2019, the AGU Atmospheric Science Jacob Bjerknes Lecture in 2020, and the AMS Hydrologic Sciences Medal in 2022. She was awarded the DOE Distinguished Scientist Fellow in 2021. She received a BS in Physics and Statistics from Chinese University of Hong Kong and an MS and PhD in Atmospheric Sciences from Texas A&M University. Ruby has published over 500 papers in peer-reviewed journals.

Session: 9020 Public Lecture - Extreme Weather Events and their Future Changes Conférence publique - L'une des conséquences les plus importantes du réchauffement climatique pour

03/06/2024 18:00

ID: 12131 Invited plenary speaker

Extreme Weather Events and their Future Changes

L. Ruby Leung [1]

[1] **Pacific Northwest National Laboratory**

Presented by / Présenté par: ***L. Ruby Leung***
Contact: ruby.leung@pnnl.gov

Some of the most consequential outcomes of global warming for societies and ecosystems are changes in extreme weather events. Comparing 2000-2019 with 1980-1999, extreme temperature and flood events have more than doubled globally while the number of disastrous storms and droughts has increased by 30-50%. While the nonlinear increase in latent energy with warmer surface air temperature may explain the global increasing trends in weather extremes, credible projections of the regional changes in extreme events remain challenging. In this seminar, I will discuss some recent advances in modeling extreme weather events and their future changes. Using a combination of modeling approaches, I will provide examples of projections of future changes in flood-producing winter storms and their characteristics, mesoscale convective systems that produce wind damages and floods, and the risk of landfalling hurricanes. These projections underscore the need for adaptation

planning for a weather and climate resilient society.

Day 2 – 4 June 2024

Session: 1002 Plenary - What does Indigenous Science and Anishinaabe mowin say about Weather? Plénière - Que disent la science autochtone et le mowin anishinaabe à propos de la météo ?

Dr. Myrle Ballard
University of Calgary

Bio: Dr. Myrle Ballard is an Associate Professor in the Department of Earth, Energy, and Environment at the University of Calgary. She stood-up the new Indigenous Science Division at Environment and Climate Change Canada. Anishnaabe from Lake St. Martin First Nation, Dr. Ballard's latest research explores Three-eyed seeing and how her fluency in Anishinaabe mowin can transform approaches to water resource management using Anishinaabe mowin baseline indicators for monitoring. Dr. Ballard also serves on a number of committees and working groups, two of which are recent appointments as Scoping expert for the second IPBES global assessment of biodiversity and ecosystem services; and Expert for the IPBES task force on Indigenous and local knowledge. She currently holds NSERC (Natural Sciences and Engineering Research Council of Canada) and CIHR (Canadian Institutes for Health Research) grants. Her other research interests include, but are not limited to, climate, species at risk, sustainability of flooding/displacement.

Session: 1002 Plenary - What does Indigenous Science and Anishinaabe mowin say about Weather? Plénière - Que disent la science autochtone et le mowin anishinaabe à propos de la météo ? **04/06/2024 11:00**

ID: 12129 Invited plenary speaker

What does Indigenous Science and Anishinaabe mowin say about Weather?
Myrle Ballard [1]

[1] **University of Calgary**

Presented by / Présenté par: ***Myrle Ballard***
Contact: myrle.ballard@ucalgary.ca

Indigenous peoples knowledge and Indigenous science of the land (aki) has sustained them and enabled them to survive since time immemorial. Their knowledge of weather and environmental conditions were important. Aki has changed but their knowledge still prevails. The weather and how language plays a role are important to understand and it is this knowledge of the land and its characteristics that has sustained them.

Session: 2040 Weather and Climate Extremes - General - Part 1 Extrêmes météorologiques et climatiques - Généralités - Partie 1

Convenor:
Elizaveta Malinina (Environment and Climate Change Canada)

This session is for topics related to extremes that are not covered by other sessions in Theme 2.

Session: 2040 Weather and Climate Extremes - General - Part 1
Extrêmes météorologiques et climatiques - Généralités - Partie 1 **04/06/2024 12:15**

ID: 12027 Invited session speaker

Attribution of the severity of the the 2023 Canadian fire weather season

Clair Barnes [1]

[1]

Presented by / Présenté par: ***Clair Barnes***
Contact: c.barnes22@imperial.ac.uk

Canada's 2023 fire season was one of the most extreme on record: by the end of July, just halfway through the season, around 13.1 million hectares had burned, already representing the most intense fire season in recent history. In August 2023, World Weather Attribution (WWA) produced a rapid attribution study evaluating the impact of climate change on the severity of the fire weather in Québec during this part of the season, and found that increased temperatures and reduced humidity due to human-induced climate change have significantly increased the likelihood of experiencing such extreme fire weather. In this talk I will introduce the WWA approach to extreme event attribution, and present some findings from the rapid study, along with updated results for the cumulative severity of the fire season as a whole.

Session: 2040 Weather and Climate Extremes - General - Part 1
Extrêmes météorologiques et climatiques - Généralités - Partie 1 **04/06/2024 12:45**

ID: 12006 Contributed abstract

Attribution of area burned and other characteristics of the 2023 Canadian wildfire season

Megan Kirchmeier-Young [1] , *Elizaveta Malinina* [2] , *Quinn Barber* [3] , *Karen Garcia Perdomo* [4] , *Piyush Jain* [5] , *Nathan Gillett* [6] , *Marc-Andre Parisien* [7] , *Yan Boulanger* [8] , *Alex Cannon* [9] , *Yongxiao Liang* [10] , *Aranildo Lima* [11] , *Laura Van Vliet* [12]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Canadian Forest Service, Natural Resources Canada
[4] Environment and Climate Change Canada
[5] Canadian Forest Service, Natural Resources Canada
[6] Environment and Climate Change Canada
[7] Canadian Forest Service, Natural Resources Canada
[8] Canadian Forest Service, Natural Resources Canada
[9] Environment and Climate Change Canada
[10] Environment and Climate Change Canada
[11] Environment and Climate Change Canada
[12] Environment and Climate Change Canada

Presented by / Présenté par: ***Megan Kirchmeier-Young***
Contact: megan.kirchmeier-young@ec.gc.ca

Canada experienced an extreme wildfire season in 2023, with the almost 15 million hectares burned more than doubling the previous record based on satellite-era observations. Many provinces/territories across the country set local records for area burned as well. The fire season started early and high fire weather conditions lasted for several months. We use a probabilistic event attribution framework to analyze several characteristics of the fire season, including the extreme fire weather, start and length of the fire season, and measures of the spatial extent of the high fire risk. We also develop simple statistical models to predict the area burned and investigate changes in the likelihood/magnitude.

Session: 2040 Weather and Climate Extremes - General - Part 1
Extrêmes météorologiques et climatiques - Généralités - Partie 1 **04/06/2024 13:00**

ID: 12083 Contributed abstract

Canada’s Extreme 2023 Wildfire Smoke season and addressing lessons learned

Celine Audette [1]

[1]

Presented by / Présenté par: ***Celine Audette***
Contact: celine.audette@ec.gc.ca

The extreme 2023 wildfire season follows multiple years for wildfires and wildfire smoke in Canada impacting all forecast regions and major cities. Climate change impacts result in frequent and intense hot temperatures that increase the severity of heatwaves and contribute to increased drought and wildfire risks. Fire-prone conditions are predicted to increase across Canada. The 2023 wildfires resulted in 7 times (over 15 million hectares) the national average of area burned (2.5 million hectares). Wildfire smoke in this past season impacted close to all forecast areas in Canada, in addition to the US eastern seaboard. Over 4600 Special Air Quality bulletins were issued in

2023, compared to a range of 280 to 1577 since 2017. The Air Quality Health Index (AQHI) is used to communicate the level of air quality using an index from 1 to 10+ with associated health messaging. The 10+ value was triggered for over 7000 hours (133 days) with most in British Columbia, Saskatchewan, Manitoba and Alberta. A total 867 smoke days were reported for provinces and territories. This presentation will present analysis of PM2.5, AQHI and bulletin data as well as lessons learned from previous seasons which led to service improvements.

Session: 2040 Weather and Climate Extremes - General - Part 1
Extrêmes météorologiques et climatiques - Généralités - Partie 1 **04/06/2024 13:15**

ID: 12008 Contributed abstract

Atmospheric Blockings over North Atlantic, their characteristics and links with forest fire risks.

Dipanwita Ghosh Sarkar [1] , *Philippe Gachon* [2] , *Clémence Benoit* [3]

[1] ESCER (Etude et Simulation du Climat à l'Échelle Régionale) centre, University of Quebec in Montreal, QC, Canada
[2] ESCER (Etude et Simulation du Climat à l'Échelle Régionale) centre, University of Quebec in Montreal, QC, Canada
[3] ESCER (Etude et Simulation du Climat à l'Échelle Régionale) centre, University of Quebec in Montreal, QC, Canada

Presented by / Présenté par: ***Dipanwita Ghosh Sarkar***
Contact: ghosh_sarkar.dipanwita@uqam.ca

Atmospheric blockings are large-scale patterns in atmospheric circulation, often associated with a persistent area of high pressure, where the zonal west-east flow is temporarily suppressed and replaced by a meridional flow. Some atmospheric blockings take place over North Atlantic and can be associated with the occurrence of heat waves and/or dry conditions over northeastern Canada. Abnormal warm and dry weather conditions might lead to extreme forest fire episodes, as it was the case during 2023 across eastern Canada. The 500 hPa geopotential heights anomaly, column-averaged potential vorticity anomaly (PV), and 500 hPa geopotential height gradient (AGP) are the key factors to detect atmospheric blockings. Using these fields from the ERA5 reanalysis data over North Atlantic (0-100o W) for the 1950-2023 period, atmospheric blockings are computed to identify trends in their features (occurrence, duration, extent and intensity), and evaluate compound warm and dry conditions over Québec province associated with blockings. This study focusses not only on daily mean temperature and precipitation anomalies, but also on Fire weather Index (FWI) ones. The results emphasize a significant decrease in total number of blockings per year, smaller total number of blocked days for fall, winter, and spring, whereas mean intensity exhibits a significant negative trend for fall and spring. However, spring of 2023 has an exceptionally high number of total blocked days that favors warm and dry conditions across northeastern Canada. In general, a combination of positive/negative correlation of temperature/precipitation with blocking occurrence and duration eventually leads to a strong positive correlation of FWI especially during spring, and fall. Three case studies of 2010, 2015 and 2023, with different characteristics of blockings, demonstrate that FWI increases abruptly with the number of consecutive days of blocking.

Session: 2040 Weather and Climate Extremes - General - Part 1
Extrêmes météorologiques et climatiques - Généralités - Partie 1 **04/06/2024 13:30**

ID: 12063 Contributed abstract

A brief look into the development of a wildfire simulator

Daniel Guerin [1]

[1] The Co-operators

Presented by / Présenté par: ***Daniel Guerin***
Contact: daniel_guerin@cooperators.ca

As an insurer, The Co-operators interests on the impacts of severe weather events on the Canadian landscape in the context of climate changes. The 2016 Fort McMurray fire was the costliest catastrophic event in the history of the country. With years like 2021 and 2023 having had unprecedented wildfire activity, the Co-operators is driven to better understand the risk that wildfire poses both to the insured and insurers.
To better understand exposure and enhance our communications with partners, a project was started to internally develop a Canada-wide wildfire simulator to estimate probable maximum losses (PML). To realize these objectives, we needed to develop a flexible approach around different spatial, temporal, and weather conditions to ensure the whole country was modeled under multiple weather conditions and possible scenarios over many theoretical years. This enables us to better understand wildfire risk across multiple provinces and climate scenarios.
This presentation will explore the motivations and context for the development of a simulator. The simulator is composed of three modules, i) an ignition module, which models when and where a wildfire is likely to start, ii) a spread module, which grows an ignition point using cellular automaton to predict a fully developed wildfire footprint, and iii) a loss calculation module, which assigns a dollar amount loss caused by fire, smoke, and embers.
These three modules result in 50 000 simulated years with millions of simulated fires. All those fires cause losses that can be aggregated to better understand individual risks, but most importantly the dependencies between locations.

Session: 7020 Developing Ocean Modelling Capacity in Canada - Part 1
Développer la capacité de modélisation des océans au Canada - Partie 1

Convenors:
Paul Myers (University of Alberta)
Susan Allen (University of British Columbia)
Juliana Marson (University of Manitoba)
Frederic Dupont (Fisheries and Oceans Canada)

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.

Session: 7020 Developing Ocean Modelling Capacity in Canada - Part 1 Développer la capacité de modélisation des océans au Canada - Partie 1 **04/06/2024 12:15**

ID: 12120 Contributed abstract

Military Oceanography – A Collaborative Way Forward

Martin Taillefer [1]

[1]

Presented by / Présenté par: ***Martin Taillefer***
Contact: martin.taillefer2@forces.gc.ca

Operational oceanography in Canada and in particular the RCN has long been concepts of keen understanding and at times prowess. It was not until 1939 when the allied navies were faced with flighting a global war in all oceans where not a single navy were trained to evaluate ocean data to transform this information into the type of strategical and tactical intelligence required for military operations. Yet, since then, the western navies gained a vast amount of scientific knowledge, through the help of government labs, universities and the private sector - to advance the application of oceanographic data to military operations – known as Military Oceanography. But then something happened … the cold war ended, global terrorism took center stage - and the “threat” of submarine warfare seemed to have disappeared. Since the early 2000’s the RCN and many navies in the world began a period of “ASW doldrum”. The threat seemed to have gone and so the need for oceanographic knowledge waned. In this new era an opportunity exists to improve the competencies and capabilities in the tactical analysis of ocean data. The military oceanographic community has been challenged by a global shift in focus, making support to the fleet difficult. Compound this with the need to understand climate change and its geo-political impacts and navy operations that may have adverse impacts on animals and sea life in vulnerable eco-systems. The challenge to develop and improve the efficiency, timeliness, robustness and product quality of military oceanography to support fleet operations. I will provide to you my vision as the Chief Oceanographer to address key scientific challenges and research priorities for the next 5–10 years. I will discuss areas of modelling and forecasting technology and how Artificial Intelligence (AI) in military oceanography will be a game changer.

Session: 7020 Developing Ocean Modelling Capacity in Canada - Part 1 Développer la capacité de modélisation des océans au **04/06/2024 12:30**

Canada - Partie 1

ID: 11973 Contributed abstract

Updating to NEMO4 and CICE6 in CONCEPTS prediction systems

Frederic Dupont [1], *Philippe Blain* [2], *Oleksandr Huziy* [3], *François Roy* [4], *Gregory Smith* [5], *Jean-Philippe Blain* [6], *Youyu Lu* [7], *Jean-François Lemieux* [8]

[1] ECCC
[2] ECCC
[3] ECCC
[4] ECCC
[5] ECCC
[6] ECCC
[7] DFO/BIO
[8] ECCC

Presented by / Présenté par: ***Frederic Dupont***
Contact: frederic.dupont@ec.gc.ca

The Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) has developed a suite of ocean prediction systems from global to coastal scales. They are all based on NEMO v3.6 coupled to CICE v4.0. This year, the system sea ice component was updated to CICE v6.2.0 and we are in the process of testing the v4.2.2 NEMO component. CICE6 finally offers dynamic array allocation and new physics such as mushy layer, and NEMO4 is expected to improve on the run time, new bulk formulae, turbulence below sea ice and offers new features such as wetting and drying. This presentation will show early results using NEMO4 and CICE6 at different scales and the challenges faced when introducing these new component versions, coupling them together and to the GEM atmospheric model.

Session: 7020 Developing Ocean Modelling Capacity in Canada - Part 1 Développer la capacité de modélisation des océans au Canada - Partie 1

04/06/2024 12:45

ID: 12091 Contributed abstract

Updates of GIOPS and RIOPS operational systems at ECCC

Dorina Surcel Colan [1], *Charlie Hébert-Pinard* [2], *Audrey-Anne Gauthier* [3], *Kamel Chikhar* [4], *Gregory Smith* [5], *Philippe Blain* [6], *Francois Roy* [7], *Frederic Dupont* [8]

[1] CCMEP/ECCC
[2] CCMEP/ECCC
[3] CCMEP/ECCC
[4] CCMEP/ECCC
[5] MRD/ECCC
[6] CCMEP/ECCC
[7] MRD/ECCC
[8] CCMEP/ECCC

Presented by / Présenté par: ***Dorina Surcel Colan***

Contact: dorina.surcel-colan@ec.gc.ca

For the last 10 years CCMEP updates all operational systems at the same time during the innovation cycles. This allows not only to test separate innovations for each system but also to see the impact on the downstream systems.
The last innovation cycle (IC4) started in July 2022 and will be completed in Juin 2024. GIOPS and RIOPS innovations included in IC4 were related to the change of the ice model CICE from version 4 to version 6, the use of new Mean Dynamic Topography file, the change of the radiation scheme to Delta Eddington and the addition of two new altimeter datasets.
All these innovations have a positive impact on the quality of the ocean analyses especially in the Arctic regions. A better representation of the mean surface height has a significant impact on the surface currents and the volume transports through main Arctic gateways.
The impact of these innovations on the coastal prediction systems will also be presented.

Session: 7020 Developing Ocean Modelling Capacity in Canada - Part 1 Développer la capacité de modélisation des océans au Canada - Partie 1 **04/06/2024 13:00**

ID: 12079 Contributed abstract

Investigation of the Addition of Alkalinity to an Outfall Plume in the Strait of Georgia

Susan Allen [1] , *Jake Tao* [2]

[1] University of British Columbia
[2] University of British Columbia

Presented by / Présenté par: ***Susan Allen***
Contact: sallen@eoas.ubc.ca

Motivated by the need to understand the impact of adding alkalinity to the ocean, we used a coupled ocean model of the Salish Sea to follow an outfall plume. The model is SalishSeaCast, a 3-dimensional NEMO configuration with coupled biological (nutrients, phytoplankton and zooplankton) and chemical (carbon and oxygen) models. The outfall plume we investigated is the main outfall of Metropolitan Vancouver: the Iona Outfall which discharges into the Strait of Georgia at about 100 m depth. We first characterized the present plume, adding it, a passive dye and its temperature, salinity and chemical signatures. Second we added alkalinity for a month, simulating a pilot project. In this talk we will present the fate of the outfall plume, how it travels and mixes in the Salish Sea, its contact with the atmosphere and the impact of the alkalinity on the carbon concentrations. Tracking such small signals through an ocean model requires subtracting two nearly identical runs, the only difference being the change in alkalinity. We will discuss some of the technical difficulties in making these very identical model experiments.

Session: 7020 Developing Ocean Modelling Capacity in Canada - Part 1 Développer la capacité de modélisation des océans au Canada - Partie 1 **04/06/2024 13:15**

ID: 12015 Contributed abstract

Evaluations of a 3D numerical model of the Salish Sea in small river plume regions

Cassidy Donaldson [1] , *Susan Allen* [2]

[1] University of British Columbia
[2] University of British Columbia

Presented by / Présenté par: ***Cassidy Donaldson***
Contact: cassidy.donaldson@gmail.com

The Salish Sea in British Columbia, Canada, is an ecologically, economically, and culturally important coastal sea. Understanding it as a dynamic system is a priority to be able to address questions about its dynamics, chemistry, biology, hazards, and resilience in the face of a changing climate and extreme weather events. Riverine freshwater is significant in this system, and changes in river flow and timing will consequently have systemic impacts. Previous studies of freshwater in the Salish Sea have mainly focused on the largest river, the Fraser River, while this work focuses on smaller rivers to enhance the breadth of overall understanding and build local insights. SalishSeaCast is a three-dimensional numerical model that is built upon the NEMO modeling framework and has the capacity to resolve freshwater dynamics from smaller rivers that enter the Salish Sea. In this research, SalishSeaCast is evaluated not just on its overall model performance, but in specific small river plume (SRP) regions. SRP-regional evaluations can provide insight into not only what regions yield better performance metrics, but also as to why. Comparisons between model versions indicate how changes in bathymetry, river input geometry, and river forcing impact performance. To perform SRP evaluations, observational data was compiled to increase data coverage around river mouths and then matched with a corresponding time and location in the model. These matched datasets were evaluated by numerous statistical metrics. SRP datasets were split by season and sub-region to assess seasonality and sub-regional patterns in the metrics. Results of the SRP analysis generally show that the model tends to perform worse closest to the river mouths, where salinity is the lowest, but that changes between SalishSeaCast model versions have different and sometimes opposite effects between SRP regions. Examples of these effects will be discussed and their hypothesized causes explored.

Session: 7020 Developing Ocean Modelling Capacity in Canada - Part 1 Développer la capacité de modélisation des océans au Canada - Partie 1

04/06/2024 13:30

ID: 11959 Contributed abstract

Sensitivity of Arctic Ocean Model Simulations to River Runoff and Temperature Forcing From Hydrological Models

Tahya Weiss-Gibbons [1] , *Andrew Tefs* [2] , *Tricia Stadnyk* [3] , *Paul Myers* [4]

[1] University of Alberta
[2] University of Calgary
[3] University of Calgary
[4] University of Alberta

Presented by / Présenté par: ***Tahya Weiss-Gibbons***

Contact: weissgib@ualberta.ca

The Arctic is warming faster than the rest of the planet, impacting the Arctic Ocean and its sources of freshwater. River runoff in particular is increasing in both amounts and temperature with climate change, with potential far reaching effects. While most general circulation models include freshwater volume flux from river input, though often from older climatological data sources, the heat flux associated with this river water is generally not represented. This river water can be a significant source of seasonal heat, especially in coastal regions. We investigated the impacts of this heat flux on the Arctic Ocean using runoff scenarios produced for the Arctic Ocean with the Swedish Hydrological Predictions for the Environment (HYPE) hydrological model that now extend to the present day. We find impacts on sea ice formation and mobility in key coastal regions, as well as changes in ice flux out of major Arctic gateways. Investigating the model sensitivity to temporal changes in runoff and the inclusion of riverine heat flux can improve the understanding of the role river runoff plays in sensitive Arctic coastal regions.

Session: 3010 Climate Variability and Predictability - Part 1 Variabilité et prévisibilité du climat - Partie 1

Convenors:
Hai Lin (Environment and Climate Change Canada)
Bin Yu (Environment and Climate Change Canada)

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, polar and stratospheric processes, and impacts of these processes on predictability and predictions. We welcome contributions on extended- and long-range weather forecasts, especially those related to extreme events, 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.

Session: 3010 Climate Variability and Predictability - Part 1
Variabilité et prévisibilité du climat - Partie 1 **04/06/2024 12:15**

ID: 12028 Contributed abstract

Extending Multi-parameter Pattern Scaling to Interpret Polar Amplification in Earth System Models

Paul Kushner [1], *Luke Fraser-Leach* [2], *Stephanie Hay* [3], *Alexandre Audette* [4]

[1] University of Toronto
[2] University of Toronto
[3] University of Exeter
[4] University of California, Santa Cruz

Presented by / Présenté par: ***Paul Kushner***
Contact: paul.kushner@utoronto.ca

In earth system model protocols that induce polar amplification by, for example, imposing sea ice loss, a key question is how to cleanly separate signals attributable to polar amplification from the rest of radiatively forced climate change. We have developed multi-parameter pattern scaling (MPPS), which diagnoses these experiments in combination with free-running radiatively forced ESM experiments, to address this question. MPPS posits that the pattern of forced response in climate change can be decomposed into partial responses ("sensitivity patterns") that are separately proportional to scaling variables such as global mean surface temperature, Arctic and Antarctic sea ice extent, high- and low-latitude lapse rates, top-of-atmosphere radiative forcing, etc.. Here we show how MPPS can be used to separate the effects of polar and low-latitude influences on atmosphere-ocean responses attributable to low-latitude, Arctic, and Antarctic warming, how theoretical support for MPPS can be found in an idealized energy balance model framework, and how scaling variables for MPPS can be strategically chosen to correct for spurious warming effects in coupled sea ice loss experiments. MPPS permits exploitation of the wide range of ESM experiments that have been developed to probe polar amplification along with existing archived radiatively forced ESM simulations. But the limitations of MPPS need to be more fully fleshed out, particularly given evidence of nonlinearity in some aspects of responses to induced polar amplification. In addition, less heuristic methods for determining scaling variables need to be identified. One promising approach to this is to explicitly link artificially induced polar amplification through, for example, sea ice loss, to an effective radiative forcing.

Session: 3010 Climate Variability and Predictability - Part 1
Variabilité et prévisibilité du climat - Partie 1 **04/06/2024 12:30**

ID: 11884 Contributed abstract

Diagnosing Observed Extratropical Stationary Wave Changes in Boreal Winter

Lei Wang [1], *Wanying Sun* [2]

[1] Department of Atmospheric and Oceanic Sciences and Institute of Atmospheric Sciences, Fudan University, Shanghai, China
[2] Department of Atmospheric and Oceanic Sciences and Institute of Atmospheric Sciences, Fudan University, Shanghai, China

Presented by / Présenté par: ***Lei Wang***
Contact: wanglei_ias@fudan.edu.cn

Stationary waves are time-averaged zonally asymmetric component of the climatological mean atmospheric circulation, primarily due to the unevenly distributed topography and diabatic heating. Stationary waves are subject to influence from long-term external forcing. In this study, the temporal evolution of the winter (January) Northern Hemisphere (NH) stationary waves during 1961–2020 is diagnosed with the fifth generation ECMWF (European Centre for Medium-range Weather Forecasts) reanalysis data (ERA5), which shows an overall strengthening in amplitude and an eastward shift in phase. A stationary wave model (SWM) is used to attribute the stationary wave response to changes in the zonal mean basic state (ΔZM) and the

zonally asymmetric diabatic heating forcing (Δq^*). The pattern of stationary wave changes is well captured by the response to ΔZM alone, whereas the contribution of Δq^* to the amplitude increases in height and becomes dominant in the stratosphere. Δq^* is also found to be important in driving stationary wave changes in the North Pacific and Western Europe regions. Furthermore, changes in tropospheric stationary waves are probably a result of internal variability, whereas stratospheric changes are more likely to be driven by external forcing.

Session: 3010 Climate Variability and Predictability - Part 1
Variabilité et prévisibilité du climat - Partie 1 **04/06/2024 12:45**

ID: 11887 Contributed abstract

Interannual variability of the wintertime Asian-Bering-North American teleconnection linked to Eurasian snow cover and Maritime Continent sea surface temperature

Wogu Zhong [1] , *Zhiwei Wu* [2]

[1]
[2]

Presented by / Présenté par: ***Wogu Zhong***
Contact: wgzhong19@fudan.edu.cn

Recent studies propose that the Asian-Bering-North American (ABNA) teleconnection is a distinct atmospheric pattern that is related to Eurasian and North American winter climate besides the Pacific-North America (PNA) pattern, while its origin remains elusive. This study investigates the interannual variability of the ABNA during the past 42 winters (1979-2020) and the associated prior surface boundary forcings. The ABNA explains coherent surface air temperature changes in northern Asia, Eastern Siberia-Alaska, and eastern North America, even after removing the impacts of the PNA, the Arctic Oscillation, the North Atlantic Oscillation, and the North Pacific Oscillation. Surface boundary conditions linked to the ABNA could be traced back to a Eurasian snow cover dipole pattern (ESCDP) and a Maritime Continent sea surface temperature anomaly (MCSST) in November. The ESCDP leads to a displacement of the Arctic stratospheric polar vortex via troposphere-stratosphere coupling. The anomalous polar vortex propagates downwards in the following winter and generates the tropospheric ABNA pattern. The MCSST induces a diabatic heating anomaly, which is associated with a tropical western Pacific precipitation anomaly (TWPP) in winter. The TWPP excites a poleward Rossby wave train that propagates across the North Pacific and directly strengthens the ABNA. The above physical processes can be well reproduced by a linear baroclinic model (LBM). Based on the ESCDP and MCSST predictors, an empirical model is established and shows a promising prediction skill of the ABNA during the hindcast period. This can provide a useful strategy for seasonal prediction of winter climate in the Northern Hemisphere extratropics.

Session: 3010 Climate Variability and Predictability - Part 1
Variabilité et prévisibilité du climat - Partie 1 **04/06/2024 13:00**

ID: 11891 Contributed abstract

Unprecedented 2021 Heatwave over Western North America: Increasing Intensity and Frequency of Humidex and Temperature Extremes in a Warming Climate

Dae Il Jeong [1] , *Bin Yu* [2] , *Alex J. Cannon* [3]

[1] Climate Research Division, Environment and Climate Change Canada
[2] Climate Research Division, Environment and Climate Change Canada
[3] Climate Research Division, Environment and Climate Change Canada

Presented by / Présenté par: ***Dae Il Jeong***
Contact: jeong.daeil@ec.gc.ca

The 2021 heatwave over Western North America (WNA) led to record-breaking air temperatures and human-perceived heat stress (humidex) values. The event was accompanied by drier conditions driven by prolonged atmospheric blocking. During the heatwave, the maximum 6-day means of humidex and temperature (HX-6 and TX-6) exhibited larger anomalies (6.70 and 5.57°C) compared to the 95th percentiles (HX95 and TX95) (4.12 and 3.73°C), relative to 1981-2021 extended summer (June-September) averages. Extreme indices of humidex show faster and larger increases than those of temperature, reflecting the nonlinear positive relationship between humidex and temperature. Future projections from a multi-model ensemble of 19 Coupled Model Intercomparison Project Phase 6 (CMIP6) Global Climate Models (GCMs) clearly show an increase in humidex and temperature extremes, especially under intermediate and high emissions scenarios. Humidex indices (HX-6 and HX95) show faster and larger increases than temperature indices (TX-6 and TX95) for the same future years and global warming levels. Controlling for differences in GCM climate sensitivity to greenhouse gas forcing yields robust projections at various global warming levels, reducing the ranges of projected changes from the multi-model ensemble. At 3.0°C global warming from pre-industrial, the multi-model ensemble projects occurrences of HX-6, TX-6, HX95, and TX95 over WNA that exceed 2021 levels to occur every 3.9, 1.7, 1.4, and 2.2 years, respectively, increasing to almost annually at 4.0°C. This study also highlights potential uncertainties in the projections linked to the range of climate sensitivity of GCMs to greenhouse gas emissions.

Session: 3010 Climate Variability and Predictability - Part 1
Variabilité et prévisibilité du climat - Partie 1 **04/06/2024 13:15**

ID: 11890 Contributed abstract

Projected changes of the warm Arctic-cold North American pattern

Bin Yu [1] , *Hai Lin* [2]

[1] ECCC
[2] ECCC

Presented by / Présenté par: ***Bin Yu***
Contact: bin.yu@canada.ca

The Warm Arctic - Cold North American (WACNA) pattern is characterized by opposing surface air temperature anomalies centered over the Chukchi - Bering Seas (CBS) and the North American Great Plains. CanESM5, the Canadian Earth System Model participated in Coupled Model Intercomparison Project Phase 6 (CMIP6), reasonably well simulates this pattern and its formation mechanism. Projections from CanESM5 simulations under the Shared Socioeconomic Pathway 8.5 (SSP585) suggest a significant weakening of the WACNA pattern in response to global warming.

Projected changes in the intensity and spatial structure of the pattern are apparent, primarily a reduction in the strength of the CBS action center. These changes are attributed to global warming and its featured Arctic amplification, particularly the influence of warming on the WACNA associated meridional heat transport over CBS.

Session: 6013 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 4 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 4

Convenors:
Kaley Walker (University of Toronto)
Matt Arkett (Environment and Climate Change Canada)

Satellite Earth observation (SEO) 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. Resourceful, Resilient, Ready: Canada's Strategy for Satellite Earth Observation provides a plan for Canada to more effectively leverage satellite earth observation (SEO) to address key priorities, including climate change mitigation and adaptation. This strategy will help to inform Canada's plans for SEO for the next decade and ensure Canada will maximize utilization and benefits of SEO. This session encourages contributions from across the full SEO value chain, upstream, midstream and downstream, to illustrate the activities currently under way in Canada, involving industry, academia and government. 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.

Session: 6013 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 4 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 4 **04/06/2024 12:15**

ID: 12001 Contributed abstract

Using RADARSAT observations to investigate Arctic lake ice phenology

Alex Cabaj [1], *Laura Brown* [2], *Stephen Howell* [3], *Mike Brady* [4]

[1] University of Toronto Mississauga
[2] University of Toronto Mississauga
[3] Environment and Climate Change Canada
[4] Environment and Climate Change Canada

Presented by / Présenté par: ***Alex Cabaj***
Contact: alex.cabaj@mail.utoronto.ca

Lakes in polar regions are evolving rapidly as the Arctic warms. The timing of lake ice

freeze-up and break-up are experiencing changes which reflect global warming impacts. Understanding lake ice phenology and its evolution is of importance both to further current understanding of climate change, as well as for local communities which rely on the lakes for transportation and local food sources. In situ observations of lakes are challenging in remote northern regions, since many of these lakes are situated far from local communities. Remote sensing observations can provide a supplemental source of information for understanding the evolution of lakes, particularly when in situ observations are not available.

The RADARSAT Constellation Mission (RCM) is a constellation of three identical satellites in a low earth orbit, equipped with C-band synthetic aperture radar instruments. The backscatter measurements provide high-resolution imagery at a resolution of up to 50 km, enabling detailed observations of lake ice. Using RCM backscatter data, we examine the seasonal evolution of lake ice at Eleanor Lake on Cornwallis Island, Nunavut. We identify freeze-up and break-up dates, and examine the seasonal evolution of backscatter, with supplemental data obtained from ERA5 and the nearest Environment and Climate Change Canada weather station (Resolute Bay, 80 km away). We also qualitatively assess lake ice motion and evolution following the initial break-up, validated with daily ground-based camera imagery. This work will serve as a basis for further analysis of other lakes in the Northern Hemisphere.

Session: 6013 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 4 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 4 **04/06/2024 12:30**

ID: 11895 Contributed abstract

Application of daily VIIRS clear-sky composites for monitoring seasonal cycle of freshwater ice over Canada

Shaheen Ghayourmanesh [1], *Alexander Trishchenko* [2], *Calin Ungureanu* [3], *Yi Luo* [4]

[1] Canada Centre for Remote Sensing, Natural Resources Canada
[2] Canada Centre for Remote Sensing, Natural Resources Canada
[3] Canada Centre for Remote Sensing, Natural Resources Canada
[4] Canadian Ice Service, Environment and Climate Change Canada

Presented by / Présenté par: ***Shaheen Ghayourmanesh***
Contact: shaheen.ghayourmanesh@nrcan-rncan.gc.ca

The Visible Infrared Imaging Radiometer Suite (VIIRS) is an operational imager for global observations from the NOAA polar-orbiting satellites S-NPP, JPSS-1, and JPSS-2. In many aspects, the VIIRS imager is comparable to the Moderate Resolution Imaging Spectroradiometer (MODIS) operated by NASA since 2000. To continue the long-term time series of MODIS surface properties over Canada, the Canada Centre for Remote Sensing (CCRS) develops and operates the VIIRS data processing system to generate output products fully compatible with MODIS. Among other VIIRS products derived at CCRS, the daily snow and ice masks from the I- and M-bands are created at 250-m and 500-m spatial resolutions. We analyzed these daily masks to assess their utility for monitoring the seasonal cycle of freshwater ice over Canada. An analysis will be presented for several years to assess the dynamics of freeze-up and break-up dates, as well as the duration of the ice cover period as functions of latitude and

climate zone. Validation against alternative sources of ice maps and satellite imagery will be presented to evaluate the accuracy and uncertainties of VIIRS 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 at CCRS, NRCan.

Session: 6013 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 4 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 4 **04/06/2024 12:45**

ID: 11900 Contributed abstract

Summer Snowfall Amounts and Minimum Snow/Ice Variations in Canadian Arctic

Alexander Trishchenko [1] , *Calin Ungureanu* [2]

[1] Canada Centre for Remote Sensing, NRCan
[2] Canada Centre for Remote Sensing, NRCan

Presented by / Présenté par: ***Alexander Trishchenko***
Contact: alexander.trichtchenko@nrcan-rncan.gc.ca

The warm season's Minimum Snow/Ice extent (MSI) is an important climatic and hydrological parameter for polar latitudes and alpine regions. The satellite data processing technology developed at the Canada Centre for Remote Sensing (CCRS) has been utilized to produce the MSI extent time series at 250-m spatial resolution from satellite observations acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) since 2000, and the Visible Infrared Imaging Radiometer Suite (VIIRS) since 2017. The spatial extent is derived from the snow/ice probability maps generated for the April-September season using 10-day clear-sky composite products.
The analysis of MSI extent time series shows that semipermanent or seasonal snowpack plays an important role in the cold Arctic and alpine regions. It can contribute more than 30% to its interannual variability. To better understand the mechanisms supporting these variations, we analyzed the solid precipitation data in the Canadian Arctic available from the Environment and Climate Change Canada climate archive and the ERA5-Land reanalysis. The analysis showed that warm-season snowfall is a typical phenomenon in the Arctic Canada region. The average summer spatial distribution of snowfall amounts from the ERA5-Land dataset exhibits a strong correlation with surface elevation and correlates well with the MSI extent derived from MODIS ($R>0.7$). These results indicate that above-average seasonal snowfall is a common occurrence during summer months in the cold-climate Arctic region and can potentially sustain the snow cover during the melt season.
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 at CCRS, NRCan.

Session: 6013 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 4 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 4 **04/06/2024 13:00**

ID: 12085 Contributed abstract

Assimilation of synthetic SWOT Observations for the Canadian East Coast using the Regional Ice Ocean Prediction System

Gregory Smith [1], *Guoqiang Liu* [2], *Audrey-Anne Gauthier* [3], *Will Perrie* [4], *Charlie Hebert-Pinard* [5]

[1] ECCC
[2] Dalhousie Univ.
[3] ECCC
[4] DFO
[5] ECCC

Presented by / Présenté par: ***Gregory Smith***
Contact: Gregory.Smith@ec.gc.ca

The SWOT satellite mission was launched in December 2022. This innovative wide-swath altimeter has the potential to provide a significant improvement in the constraint on fine-scale features in operational coastal ocean analysis systems. Here we use an Observing System Simulation Experiment (OSSE) framework to assess the potential impact of SWOT on the quality of analyses from the Regional Ice Ocean Prediction System (RIOPS). RIOPS is running operationally at the Canadian Centre for Environmental Prediction and providing numerical guidance for the Canadian Coast Guard for search and rescue and environmental emergency response efforts (among other applications). RIOPS combines three analysis systems: a multivariate reduced-order Kalman filter for the ocean, a 3DVar scheme for bias correction of temperature and salinity profiles, and a 3DVar approach for sea ice concentration. We aim to assess the extent to which SWOT data may improve RIOPS surface currents along the Canadian east coast. Results show that assimilation of SWOT observations in addition to conventional altimetry leads to a significant reduction in errors in sea surface height. Improvements in surface salinity and surface currents are also found. Early results from the assimilation of real SWOT observations will also be presented.

Session: 6013 Satellite Earth Observation: A unique view of our planet and a critical need for Canada - Part 4 Observation de la Terre par satellite : Une vue unique de notre planète et un besoin critique pour le Canada - Partie 4 **04/06/2024 13:15**

ID: 11976 Contributed abstract

Earth Observations and Water-Food connections in the Red River Basin

Richard Lawford [1]

[1] GEO

Presented by / Présenté par: ***Richard Lawford***
Contact: rlawford@gmail.com

The Red River, which brings water from as far south as South Dakota northward to Lake Winnipeg, drains some of the flattest topography in North America. The Red River valley also is characterized by fertile soils and a continental mid-latitude climate that affects the basin’s predominately agricultural economy.

This presentation considers the information needs of farmers and water managers in the basin and reviews the types of Earth Observations that are available for serving those needs. Challenges for water managers include spring flooding while many farmers are concerned about getting melt waters and, on some farms, flood waters off their fields through the use of tile drainage. Water quality is also an issue because Lake Winnipeg's water quality is affected by pollutants such as phosphorous originating in the upstream part of the basin.
This paper identifies some steps that could be taken to make better use of satellite and in-situ Earth observations to monitor and manage these challenges. It is based to some degree on a GEO (Group on Earth Observations) workshop held University of North Dakota in the fall of 2023.

Session: 2041 Weather and Climate Extremes - General - Part 2 Extrêmes météorologiques et climatiques - Généralités - Partie 2

Convenor:
Elizaveta Malinina (Environment and Climate Change Canada)

This session is for topics related to extremes that are not covered by other sessions in Theme 2.

Session: 2041 Weather and Climate Extremes - General - Part 2
Extrêmes météorologiques et climatiques - Généralités - Partie 2 **04/06/2024 14:05**

ID: 11938 Contributed abstract

The 2021 heatwave was less rare in Western Canada than previously thought

Elizaveta Malinina [1] , *Nathan Gillett* [2]

[1] Environment and Climate Change Canada (ECCC)
[2] Environment and Climate Change Canada (ECCC)

Presented by / Présenté par: ***Elizaveta Malinina***
Contact: elizaveta.malinina-rieger@ec.gc.ca

The 2021 Pacific Northwest heatwave resulted in record temperatures observed across the Canadian provinces of British Columbia, Alberta and Saskatchewan as well as the US states of Washington and Oregon. Previous studies of extreme temperatures over predominantly rectangular regions covering parts of Oregon, Washington and British Columbia have estimated return periods of 200–100 000 years, generally based on data since 1950, with some analyses suggesting that the event would have been considered impossible based on statistical fits to pre-2021 data. Consistently with those studies, we estimate a return period of 1152 (126-∞) years for the 2021 event averaged over British Columbia, based on a generalized extreme value distribution (GEV) with a location parameter a function of global mean surface temperature fitted to 1950–2021 ERA5 data, However, we show that this return period is reduced to 236 (52-∞) years when the analysis period is extended back to 1940, using newly-available ERA5 data, owing to an extreme heatwave observed in 1941. While the 1941 event was 1.7 °C cooler than the 2021 event in British Columbia, it was a rarer event relative to the cooler climatology of the time, with an estimated return period of 735 (135-∞) years. Over this longer period, we also find that almost all CMIP6 models underestimate variability in annual maximum

temperatures over British Columbia and overestimate it over other regions, in particular Saskatchewan. While the 2021 event was an unprecedented and extremely intense heatwave whose likelihood was much increased by human-induced climate change, our results indicate that this event was not as rare as previously thought in Western Canada. Hence, as the climate continues to warm, the recurrence of such a heatwave in the coming decades is not as unlikely as suggested by previous analyses.

Session: 2041 Weather and Climate Extremes - General - Part 2
Extrêmes météorologiques et climatiques - Généralités - Partie 2 **04/06/2024 14:20**

ID: 11930 Contributed abstract

A rapid event attribution system for heatwaves in Canada

Nathan Gillett [1], *Elizaveta Malinina* [2], *Megan Kirchmeier-Young* [3], *Yongxiao Liang* [4], *Karen Garcia Perdomo* [5], *Xuebin Zhang* [6]

[1] CCCma, CRD, Environment and Climate Change Canada
[2] CCCma, CRD, Environment and Climate Change Canada
[3] CDAS, CRD, Environment and Climate Change Canada
[4] CDAS, CRD, Environment and Climate Change Canada
[5] CCCma, CRD, Environment and Climate Change Canada
[6] PCIC, University of Victoria

Presented by / Présenté par: ***Nathan Gillett***
Contact: Nathan.Gillett@ec.gc.ca

In recent years, heatwaves in Canada have had major impacts on ecosystems and society, with the western Canada heatwave of 2021 causing the death of more than 600 people, and heatwaves in early 2023 being associated with the start of that year's exceptional fire season. In Canada, as elsewhere, there is a desire for quantitative information on the contribution of anthropogenic climate change to the probability of occurrence of observed extreme events, including heatwaves, to inform rebuilding and recovery efforts, and to improve public understanding of climate change impacts. Such information is much more impactful if it is available days after an event, rather than months or years later. This talk will describe the development and application by Environment and Climate Change Canada of a prototype quasi-operational probabilistic event attribution system for hot extremes which runs automatically on a daily basis, and provides estimates of how much the probability of heatwaves has been increased by human influence over sub-regions of Canada shortly after they occur. Observed events are characterized using ERA5 reanalysis, and risk ratios are calculated from large ensembles of CMIP6 simulations of the present-day climate compared to simulations of an 1850-1900 base period. It will end by discussing the next steps in the development of the system, including extensions to other types of extremes.

Session: 2041 Weather and Climate Extremes - General - Part 2
Extrêmes météorologiques et climatiques - Généralités - Partie 2 **04/06/2024 14:35**

ID: 11937 Contributed abstract

Probability estimation for long return period hot extremes using a large ensemble of model simulations

Yongxiao Liang [1], *Megan Kirchmeier-Young* [2], *Xuebin Zhang* [3]

[1] Environment Canada
[2] Environment Canada
[3] University of Victoria

Presented by / Présenté par: ***Yongxiao Liang***
Contact: Yongxiao.Liang@ec.gc.ca

Accurately estimating the probability of hot extreme events with long return periods is crucial for understanding the impacts of climate change. In particular, using event attribution to determine the change in likelihood of an extreme event due to anthropogenic forcing requires robust estimates of the event probability. Increasing demand for event attribution results in an operational context further strengthens the need for reliable methods. Estimates of the probability of hot extremes are commonly derived by fitting samples of annual maxima to generalized extreme value (GEV) distributions. A large ensemble of climate model simulations offers a large sample of extremes to evaluate the goodness of fit within a model-simulated climate and to quantify the impact of method choices on the estimation of return periods and risk ratios for very rare events. We discuss how the fit of annual maxima affects the estimation of return periods and risk ratios and how we can improve the goodness of fit for long return period hot extremes at the regional level.

Session: 2041 Weather and Climate Extremes - General - Part 2
Extrêmes météorologiques et climatiques - Généralités - Partie 2 **04/06/2024 14:50**

ID: 12107 Contributed abstract

Extreme temperature events in the Pacific Northwest

Matthew Pereira-Wilson [1] , *Nathan Gillett* [2] , *Adam Monahan* [3]

[1] University of Victoria
[2] CCCma
[3] University of Victoria

Presented by / Présenté par: ***Matthew Pereira-Wilson***
Contact: mhpereir@uvic.ca

The accumulation of anthropogenic emissions of greenhouse gases has led to a measurable increase in the average global temperature and a higher incidence of extreme weather events. Among them, heatwaves have begun to pose significant dangers to human societies and the ecosystems they depend on. Earth System Models are the primary tool for investigating how these complex weather events will evolve, in frequency and magnitude, with the changing climate. However, there are still some reservations in the scientific community about how well these simulations are reproducing the relevant physical processes involved in heatwave dynamics. Our work will focus on the analysis of extreme temperature events occurring in the Pacific Northwest (PNW) region of North America, where two historical heatwaves are of particular interest. A recent heatwave during the summer 2021 exceeded previous records by 5 degrees in some places, a margin which was largely unexpected for the current climate conditions. Since then, a previous heatwave during the summer of 1941 of similar magnitude has been identified in the ERA5 data, strongly suggesting that extreme temperature events in the PNW may be more frequent than previously thought. We are utilizing the CanESM and CanRCM large ensemble datasets to

examine the frequency and magnitude of heatwaves in the PNW region, with particular emphasis on heatwaves of similar magnitude to those of 1941 and 2021. We are comparing the observed vs simulated relationship between atmospheric blocking events and extreme temperature events, while exploring the question of why only some blocking events result in heatwaves. With this work, we hope to ensure that climate simulations are "fit-for-purpose" as the principal tool guiding decision-making processes in the years to come.

Session: 2041 Weather and Climate Extremes - General - Part 2
Extrêmes météorologiques et climatiques - Généralités - Partie 2 **04/06/2024 15:05**

ID: 12089 Contributed abstract

The Role of Near-Solstice Solar Radiation on the Pacific Northwest Heatwave of 2021

Shauna Ndoping [1], *Jamie Robson* [2], *Lualawi Admasu* [3], *Tim Chui* [4], *Rosie Howard* [5], *Rachel White* [6]

[1] University of British Columbia
[2] University of British Columbia
[3] University of British Columbia
[4] University of British Columbia
[5] University of British Columbia
[6] University of British Columbia

Presented by / Présenté par: ***Shauna Ndoping***
Contact: shauna.ndg@gmail.com

In late June 2021, the Pacific Northwest was hit with a severe heatwave that broke national temperature records and made worldwide news. Studies published after the event attribute high temperatures to a “perfect storm” of rare events. We investigate the impact of the maximized near-surface incoming solar radiation resulting from the proximity of the summer solstice on the event’s extreme temperatures. Using a regional weather model over the Pacific Northwest, we model the dynamics of the heatwave event, changing the levels of incoming solar radiation to match those in August, July, and May. A model run simulating the actual conditions in June 2021 is used as the control. We investigate differences in surface temperatures, surface heat fluxes, geopotential heights, and upper- and lower-level temperature differences between the experiments. June simulations break local temperature records over a wide region and by a larger margin than August simulations. The radiation differences increase surface heat fluxes as well as impact upper-level dynamics and temperature profiles. However, the response of surface temperature largely follows the timing of direct solar heating, indicating little feedback influence from upper-level changes. Sensitivity tests show that the temperature responses are consistent across various model parameterizations. These results indicate that the temperatures were influenced by several degrees Celsius by peak radiation due to the summer solstice, although records would still have been broken under August solar radiation conditions.

Session: 2041 Weather and Climate Extremes - General - Part 2
Extrêmes météorologiques et climatiques - Généralités - Partie 2 **04/06/2024 15:20**

ID: 12019 Contributed abstract

Comparing Indices of Heatwave Frequency and Intensity in the Pacific Northwest

Stephen Sobie [1] , *Charles Curry* [2]

[1] Pacific Climate Impacts Consortium
[2] Pacific Climate Impacts Consortium

Presented by / Présenté par: ***Stephen Sobie***
Contact: ssobie@uvic.ca

Heatwaves have been increasing in frequency and intensity over recent decades, a trend that is expected to continue under future projected warming. The experience in British Columbia and the Pacific Northwest US of the unprecedented heatwave of 2021 illustrated the hazardous nature of severe heat events. Rather than a single, common metric for describing heatwaves, a number of index types are commonly used, depending on regional characteristics and the impact of interest. We explore how different indices identify and characterize historical heatwave events in BC and the Pacific Northwest, including the 2021 event, at regional and local scales. We evaluate indices defined using historic daily maximum and minimum temperatures from stations, gridded observations (Daymet), and reanalysis (ERA5). Index types considered include fixed-temperature thresholds, spatially varying percentile thresholds, and acclimatization-based indices.

Comparing different heatwave indices computed from the same observed datasets reveals the sensitivity of indices to source dataset and to small changes in heatwave definition. Variations in percentile thresholds (e.g. 90th vs 95th) or persistence criteria (e.g. 2-days vs 3-days) can lead to notable differences in heatwave occurrence and intensity. The sensitivity of a given index of occurrence or intensity to the different observational datasets is also explored. Results from these comparisons are presented regionally and at specific sites within southern British Columbia and the Pacific Northwest. Finally, we evaluate the performance of the same indices in the context of future climate simulations, with particular attention to the property of “saturation” of occurrence frequency as temperatures continue to increase.

Session: 7021 Developing Ocean Modelling Capacity in Canada - Part 2
Développer la capacité de modélisation des océans au Canada - Partie 2

Convenors:
Paul Myers (University of Alberta)
Susan Allen (University of British Columbia)
Juliana Marson (University of Manitoba)
Frederic Dupont (Fisheries and Oceans Canada)

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.

Session: 7021 Developing Ocean Modelling Capacity in Canada - Part 2 Développer la capacité de modélisation des océans au Canada - Partie 2

04/06/2024 14:05

ID: 12037 Contributed abstract

Impacts of Arctic anticyclones on the freshwater content in the Beaufort Sea

Zhenxia Long [1] , *Will Perrie* [2] , *Minghong Zhang* [3]

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2

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Presented by / Présenté par: ***Zhenxia Long***
Contact: longz@dfo-mpo.gc.ca

Observations show that there is a significant increase in the freshwater content in the Beaufort Sea, and the changes can affect local ecosystems and ocean circulation in North Atlantic. To understand the decadal variations of freshwater content, NEMO 3.6 is implemented in the Arctic Ocean, forced by PHC temperature and salinity, GLORYS currents and JRA-55 atmospheric surface fields (1958-2021). Compared to observations, NEMO can reproduce the spatial patterns of ocean salinity and freshwater content in the Beaufort Sea. In addition, the simulations suggest that there is an increasing trend in the freshwater content, consistent with the observations. The increases in the freshwater content are mostly related to the enhanced anticyclone activity in the Beaufort Sea. When there is an increased frequency of anticyclone occurrence in the Beaufort Sea, anticyclone wind anomalies dominate the Beaufort Sea which accelerate the Ekman convergence of surface water in the Arctic Ocean, and the freshwater content in the Beaufort Sea tends to increase. Finally, the increased anticyclone frequency is related to the warming troposphere and associated weakening polar vortex.

Session: 7021 Developing Ocean Modelling Capacity in Canada - Part 2 Développer la capacité de modélisation des océans au Canada - Partie 2

04/06/2024 14:20

ID: 12116 Contributed abstract

Year-round perspective on marine physical dynamics and sea ice in Jones Sound, Nunavut, based on observations and model.

Ana Belen HERAS DURAN [1] , *Andrew Hamilton* [2] , *Stephanie waterman* [3] , *erin bertrand* [4] , *eric brossier* [5] , *terry noah* [6] , *Paul G Myers* [7] , *Maya P Bhatia* [8]

[1] University of Alberta

[2] University of Alberta
[3] University of British Columbia
[4] Dalhousie university
[5] S/Y Vagabond
[6] Ausuittuq Adventures
[7] University of Alberta
[8] University of Alberta

Presented by / Présenté par: ***Ana Belen HERAS DURAN***
Contact: herasdur@ualberta.ca

The Canadian Arctic Archipelago (CAA) is a crucial gateway connecting the North Atlantic to the Arctic Ocean. Pacific water masses enter the Arctic Ocean via the Bering Strait and undergo transformation and mixing in the channels of the archipelago on their route to Baffin Bay, leading to a complex structure of the water column in the region. The deep layers contain warmer, more saline waters from the North Atlantic, above which are waters from the Pacific, and the seasonal mixed water at the surface. In Baffin Bay, Atlantic Water (AW) flows northward along the western side of the bay and southward along the eastern side, recirculating around the North Water Polynya and entering Jones Sound, a major waterway in the CAA and home to the Inuit hamlet of Aujuittuq (Grise Fiord), who are partners in our data collection.
The Arctic is warming up to four times faster than the rest of the planet, and thus, rapidly evolving. In the CAA, climate change is dramatically altering the physical oceanographic environment, including sea-ice formation, the stratification of the water column and the AW heat content, which could in turn affect sea ice melt and submarine tidewater glacier melting.

Over 2019-2022 and in collaboration with the hamlet of Aujuittuq, we have collected measurements of physical and biogeochemical properties at different oceanographic stations in Jones Sound. Here, we present this data as well as data from an oceanographic mooring deployed for 1-year (from August 2021-2022) within 5-km of a large tidewater glacier in the Sound. By combining these two novel datasets we attempt to answers questions related to sea ice formation and brine rejection, and how it leads to deep winter mixed layers. Since the AW is an important component in Arctic climate change processes, we will also examine which specific mechanisms drive its penetration into the Jones Sound region and the pathway it follows. The main investigated mechanisms are the atmospheric conditions (wind stress) and the North Water Polynya influence. Insight into this would help to understand the role AW heat might play on submarine melting of tidewater glaciers, and whether it could affect the local sea-ice. To gain a broader perspective on sea ice and AW evolution over the last two decades, outputs from a high-resolution ocean circulation model, NEMO (Nucleus for European Modelling of the Ocean) are analyzed after being evaluated using the observational CTD datasets.

Session: 7021 Developing Ocean Modelling Capacity in Canada - Part 2 Développer la capacité de modélisation des océans au Canada - Partie 2

04/06/2024 14:35

ID: 12035 Contributed abstract

Canada's Three Oceans multi-decade ocean – sea-ice hindcast: A Hudson's Bay sea-ice study.

Sarah MacDermid [1] , *Youyu Lu* [2] , *Li Zhai* [3] , *Xianmin Hu* [4] , *David Brickman* [5]

[1] DFO/ECCC
[2] DFO
[3] DFO
[4] Dalhousie University
[5] DFO

Presented by / Présenté par: ***Sarah MacDermid***
Contact: sarahbeth.macdermid@gmail.com

We will briefly report on the progress of a collaboration project entitled “Assessing on-going ocean climate change: A high-resolution climate simulation for Canada's Three Oceans from 1958-to-Present day” supported by the Competitive Science Research Fund of Fisheries and Oceans Canada.

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 45°N in the North Pacific, the Arctic, and north of 7°N in the North Atlantic Oceans. The model includes tides, and is driven by hourly ERA5 atmospheric forcing and monthly lateral boundary conditions, provided by ORAS5. Monthly varying river runoff and Greenland ice sheet meltwater is also included.

While the project will be completed using a grid with a nominal horizontal resolution of 1/12° in longitude/latitude and 75 z-levels in the vertical, we make use of a coarser model resolution of ¼° to make testing and parameter tuning quicker. We will be presenting results from a 64 year simulation of this coarser model, concentrating on possible trends and historical changes in sea-ice phenology in the Hudson’s Bay.

Session: 7021 Developing Ocean Modelling Capacity in Canada - Part 2 Développer la capacité de modélisation des océans au Canada - Partie 2

04/06/2024 14:50

ID: 11998 Contributed abstract

Exploring Western Labrador Sea Dynamics for Ocean and Climate Implications

Pouneh Hoshyar [1] , *Clark Pennelly* [2] , *Paul G. Myers* [3]

[1] Earth and Atmospheric Sciences, University of Alberta, Canada
[2] Earth and Atmospheric Sciences, University of Alberta, Canada
[3] Earth and Atmospheric Sciences, University of Alberta, Canada

Presented by / Présenté par: ***Pouneh Hoshyar***
Contact: hoshyar@ualberta.ca

The Labrador Sea (LS) holds significant interest in oceanographic and climatological studies owing to its important role in global thermohaline circulation. The formation of Labrador Sea Water during wintertime convection contributes directly to the Atlantic Meridional Overturning Circulation (AMOC), which regulates Earth’s climate system by facilitating the transport of heat and dissolved gases. Additionally, the LS is characterized by the dynamic influence of oceanic eddies, which play a critical role in modulating its circulation patterns, preconditioning for the convection process, restratificating the convected water, and driving exchange into the LS interior. Our understanding of boundary current eddies shed from the Labrador Current (LC),

remains relatively limited. Previous studies using low-resolution models suggested that these eddies appear to exert only minor influence on preconditioning and restratification, and have little exchange into the LS interior. In this study, we aim to explore the dynamics of the LC and its associated instabilities, particularly within the western LS region. By using a 1/60º AGRIF nested configuration, we examine the extent of the exchange between the LC and the LS interior to determine whether these results align with the previous studies' findings. This eddy-rich configuration enables detailed analysis of the LS and its dynamics by resolving small-scale processes, that are critical for reliable model predictions. We present comprehensive analysis on the significance of boundary current eddies that originate from the LC instabilities and their role in modulating convection and stratification within the LS using the 1/60º configuration. Furthermore, we investigate the seasonal and interannual variability of these instabilities and the potential impact of sea ice on their dynamics. Our findings contribute to a deeper understanding of LS dynamics, the mechanisms behind the formation of mode water in its interior, and provide valuable insights into the broader implications for the AMOC and the global climate system.

Session: 7021 Developing Ocean Modelling Capacity in Canada - Part 2 Développer la capacité de modélisation des océans au Canada - Partie 2

04/06/2024 15:05

ID: 12125 Contributed abstract

Freshwater exchange from the Labrador Current into the sub-polar North Atlantic

Paul Myers [1] , *Elena Gebauer* [2] , *Clark Pennelly* [3] , *Pouneh Hoshyar* [4] , *Frederic Cyr* [5]

[1] University of Alberta
[2] University of Alberta
[3] University of Alberta
[4] University of Alberta
[5] Department of Fisheries and Oceans

Presented by / Présenté par: ***Paul Myers***
Contact: pmyers@ualberta.ca

The Labrador Current carries freshwater from the Arctic, Greenland and Canadian north south along the western margin of the sub-polar gyre. Given the proximity of the region of deep water formation in the Labrador Sea to this fresh boundary current, many have speculated on the role high-latitude freshwater may have on the formation of Labrador Sea Water and the meridional overturning circulation. However, other studies have suggested that there is little offshore exchange along the Labrador margin, with most freshwater being mixed offshore in the region of Flemish Cap and the Grand Banks, impacting the sub-polar gyre. We here focus on the question of how does this freshwater leave the boundary current system and where is it taken up into the Atlantic Ocean. We carry out Nucleus for the European Modelling of the Ocean (NEMO) simulations incorporating two AGRIF (adaptive grid refinement in Fortran) nests to achieve 1/60° 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. Another question is if we can quantify the impact of Greenland melt over the past decade. We evaluate the model using observations from the Atlantic Zonal Monitoring Program run

by Fisheries and Oceans Canada.

Session: 7021 Developing Ocean Modelling Capacity in Canada - Part 2 Développer la capacité de modélisation des océans au Canada - Partie 2

04/06/2024 15:20

ID: 11990 Contributed abstract

Quantification of Constrained Scales with an Ensemble Analysis

Kenneth Andrew Peterson [1], *Gregory C Smith* [2], *Andrea Storto* [3], *Kamel Chikhar* [4]

[1] RPN-EM, ECCC
[2] RPN-EM, ECCC
[3] CNR, Italy
[4] MSC, ECCC

Presented by / Présenté par: ***K. Andrew Peterson***
Contact: andrew.peterson@ec.gc.ca

Ocean models have unconstrained processes and scales, usually associated with processes that cannot be constrained by the model resolution or model physics, but for systems initialized to observations, this may also include scales that cannot be constrained by the observational network. Ensemble systems, through accessing the full parameter space with Monte Carlo methods, are one method to remove these unconstrained scales -- or at least the uncertainty related to these scales. In the process, the spread of the ensemble then becomes a proxy for model uncertainty -- and therefore it is important that model uncertainty match as best as possible, the errors with respect to observation in the system. The ultimate goal being that uncertainty between observation and system should match uncertainty within the system: The observations should be as suitable an outcome as any member of the ensemble. Using analyzed outcomes for sea surface height and velocities from an ensemble version of the ECCC GIOPS system, we show that the ensemble spread is a good representation of error in the system, and that the ensemble is capable of removing scales associated with unconstrained mesoscale activity not suitably constrained by the observations or the model.

Session: 3011 Climate Variability and Predictability - Part 2 Variabilité et prévisibilité du climat - Partie 2

Convenors:
Hai Lin (Environment and Climate Change Canada)
Bin Yu (Environment and Climate Change Canada)

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, polar and stratospheric processes, and impacts of these processes on predictability and predictions. We welcome contributions on extended- and long-range weather forecasts, especially those related to extreme events, 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.

Session: 3011 Climate Variability and Predictability - Part 2
Variabilité et prévisibilité du climat - Partie 2 **04/06/2024 14:05**

ID: 12072 Invited session speaker

CanSIPSv3: ECCC's next-generation seasonal to interannual prediction system

Bill Merryfield [1], *Hai Lin* [2], *Gulilat Diro* [3], *Ryan Muncaster* [4], *Woo-Sung Lee* [5], *Slava Kharin* [6], *John Scinocca* [7]

[1] ECCC/CCCma
[2] ECCC/RPN
[3] ECCC/CCMEP
[4] ECCC/RPN
[5] ECCC/CCCma
[6] ECCC/CCCma
[7] ECCC/CCCma

Presented by / Présenté par: ***Bill Merryfield***
Contact: bill.merryfield@ec.gc.ca

Environment and Climate Change Canada (ECCC) has issued seasonal forecasts since the mid-1990s, first based on global atmospheric models forced by persisted SST anomalies, and since 2011 on coupled global climate models that predict future ocean/sea ice/land conditions in addition to atmospheric variables. This presentation describes ECCC's new Canadian Seasonal to Interannual Prediction System version 3 (CanSIPSv3), which is scheduled to become operational at the end of June 2024. Like its predecessors, CanSIPSv3 forecasts seasonal climate anomalies out to a range of 12 months from multiple models: GEM5.2-NEMO, developed at Recherche en prévision numérique (RPN), and CanESM5.1p1, developed at the Canadian Centre for Climate Modelling and analysis (CCCma). GEM5.2-NEMO features updates to its atmospheric physics parameterizations that enable it to realistically simulate the Quasi-Biennial Oscillation (QBO) in the tropical stratosphere, as well as updates to its real-time land surface initialization that improve consistency with the historical hindcast period. CanESM5.1p1 features the novel application of tendency corrections that substantially reduce biases in its atmospheric and ocean variables. Both models, as well as their combined forecasts, generally improve upon the skill of the current version of CanSIPS and its constituent models. Seasonal forecast products currently offered by CanSIPS and that are under development are also briefly reviewed.

Session: 3011 Climate Variability and Predictability - Part 2
Variabilité et prévisibilité du climat - Partie 2 **04/06/2024 14:35**

ID: 12050 Contributed abstract

Seasonal Forecast Skill of Sea Ice in version 3 of the Canadian Seasonal to Interannual Prediction System (CanSIPS)

Joseph Martin [1], *Adam Monahan* [2], *Robert Payne* [3], *Michael Sigmond* [4]

[1] Royal Canadian Navy
[2] University of Victoria
[3] University of Victoria
[4] Canadian Centre for Climate Modelling and Analysis

Presented by / Présenté par: ***Joseph Martin***
Contact: joeymartin888@gmail.com

The improvements to sea ice forecasting systems have continued as the importance of seasonal sea ice forecasting increases for the operations of regional stakeholders. The Canadian Seasonal to Interannual Prediction System (CanSIPS) looks to achieve a more skillful forecasting system through the replacement of one of its two constituent models, CanCM4i, with the CanESM5.1 model with runtime bias correction and the updating of the other constituent model to GEM5.2-NEMO. This work assesses the skill of the new forecast system, due for release in the summer of 2024, using hindcasts for the period of 1990-2020 of both pan-Arctic and regional sea ice extent. In several instances, substantially less skill is noted when considering the more recent time period of 1990-2020 as opposed to the 1980-2010 and 1980-2018 periods used for hindcasting in previous studies. Further, features from previous versions of CanSIPS as well as other seasonal sea ice forecasting systems such as greater skill in the Atlantic when compared to the Pacific and the presence of a spring predictability barrier persist in CanSIPS version 3. We also consider the effect of the runtime bias correction applied to atmosphere and ocean components of CanESM5.1 to address, among other phenomena, a high sea ice bias in the Labrador Sea, and find that it leads to enhanced regional skill at lead times of 5-11 months. Generally, the skill of CanSIPS version 3 continues to improve as compared to previous versions, however, the change of hindcast assessment period from 1980-2010 to 1990-2020 has resulted in substantial changes to the quantity and quality of seasonal skill in the forecast system.

Session: 3011 Climate Variability and Predictability - Part 2
Variabilité et prévisibilité du climat - Partie 2 **04/06/2024 14:50**

ID: 12023 Contributed abstract

Investigating hybrid seasonal streamflow forecasting using dynamical seasonal forecasts and long short-term memory (LSTM) neural networks.

Taylor Swift-LaPointe [1], *Rachel White* [2], *Valentina Radic* [3]

[1] University of British Columbia
[2] University of British Columbia
[3] University of British Columbia

Presented by / Présenté par: ***Taylor Swift-LaPointe***
Contact: tswiftlapointe@eoas.ubc.ca

Over 85% of British Columbia’s power is produced through hydroelectricity, and thus skillful forecasting of streamflow is extremely important for dam management, with widespread economic and environmental impacts. On seasonal timescales, prediction skill of temperature and precipitation, which influence streamflow, is derived from climate modes of variability, like the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). We evaluate how the phases of these climate

modes affect inflow into the Kinbasket Reservoir in British Columbia. El Niño and PDO positive phases produce greater streamflow than La Niña and PDO negative phases from April to mid-June, with the opposite true from July to October. We use this connection to investigate whether ENSO and PDO can improve seasonal streamflow predictions. Previous studies have demonstrated the functionality of long short-term memory (LSTM) neural networks for streamflow forecasting. We develop a hybrid seasonal streamflow forecast methodology to use dynamical seasonal forecasts of temperature and precipitation as input to a LSTM. We find using monthly averages of the prior 36 months rather than daily averages of the prior 365 days, as used in previous studies, increases the model's ability to capture interannual variability in streamflow volume. In the Kinbasket Reservoir region, dynamical forecasts of average temperature have more skill past one month lead time than forecasts of minimum and maximum temperatures. We determine that a LSTM trained on average temperatures has skill in predicting streamflow volume (with Nash-Sutcliffe Efficiency >0.9 and R^2>0.5). For the model to learn biases present in the dynamical forecasts, we use the forecasts as forcing when training a LSTM. Finally, we investigate what forcings are required for a skillful streamflow forecast by using combinations of reanalysis and climatology for the prior 36 months. We also investigate whether including ENSO and PDO indices as forcing improves the forecasts.

Session: 3011 Climate Variability and Predictability - Part 2
Variabilité et prévisibilité du climat - Partie 2 **04/06/2024 15:05**

ID: 11934 Contributed abstract

Monthly forecast system at CMC

Juan Sebastian Fontecilla [1] , *Lin Hai* [2]

[1] ECCC
[2] ECCC

Presented by / Présenté par: ***Juan Sebastian Fontecilla***
Contact: juansebastian.fontecilla@ec.gc.ca

The operational monthly forecast at Environment and Climate Change Canada (ECCC) has been based on the Global Ensemble Prediction System (GEPS) since 2015.

It is a 32-day extension of the 16-day GEPS forecast, and it runs once a week, and as such, it benefits from all the innovations of GEPS.

The model climatology that is used for calculating forecast anomalies comes from a set of reforecasts of past 20 years with a hindcast system which is almost identical to the one that makes the forecast, except that it uses a reanalysis as initial conditions.

A new version of the monthly forecast system has recently been developed for Innovation Cycle 4 (IC-4) of the Canadian Centre for Meteorological and Environmental Prediction (CCMEP) of ECCC and is being implemented in operations in early summer 2024. The main innovations of the new system are:
-Increase in horizontal resolution from 39 km to 25 km
-GEM version from 5.1 to 5.2
-Improved representation of Markovian disturbance fields used in SPP and SKEB schemes

-Modified SPP scheme to improve excess dispersion in the tropics, as well as to improve the skill of the MJO in monthly forecasts.
-Monthly forecast extended to 39 days for a 5th week of forecast
-Addition of a second monthly forecast per week at 0 lead time
We will show the improvement in performance compared to the current system, as well as the relevance of the extension to 5 weeks and the addition of a second forecast per week.

Session: 3011 Climate Variability and Predictability - Part 2
Variabilité et prévisibilité du climat - Partie 2 **04/06/2024 15:20**

ID: 11947 Contributed abstract

Skillful long-lead seasonal predictions in the summertime Northern Hemisphere middle latitudes

Hai Lin [1], *Ryan Muncaster* [2], *Jacques Derome* [3], *Bill Merryfield* [4], *Gulilat Diro* [5]

[1] RPN-A, ECCC
[2] RPN-A, ECCC
[3] Department of Atmospheric and Oceanic Sciences, McGill University
[4] CCCma, ECCC
[5] CCMEP, ECCC

Presented by / Présenté par: ***Hai Lin***
Contact: hai.lin@ec.gc.ca

In contrast to boreal winter when extratropical seasonal predictions benefit greatly from ENSO-related teleconnections, our understanding of forecast skill and sources of predictability in summer is limited. Based on 40 years of hindcasts of the Canadian Seasonal to Inter-annual Prediction System version 3 (CanSIPSv3), this study shows that predictions for the Northern Hemisphere summer are skillful more than six months in advance in several middle latitude regions, including eastern Europe−Middle East, central Siberia−Mongolia−North China, and the western United States. These midlatitude regions of statistically significant predictive skill appear to be connected to each other through an upper tropospheric circum-global wave train. Although a large part of the forecast skill for the surface air temperature and 500 hPa geopotential height is attributable to the linear trend associated with global warming, there is significant long-lead seasonal forecast skill related to interannual variability. Two additional idealized hindcast experiments are performed to help shed light on sources of the long-lead forecast skill using one of the CanSIPSv3 models and its uncoupled version. It is found that tropical ENSO related SST anomalies contribute to the forecast skill in the western United States, while land surface conditions in winter, including snow cover and soil moisture, in the Siberian and western United States regions have a delayed or long-lasting impact on the atmosphere, which leads to summer forecast skill in these regions. This implies that improving land surface initial conditions and model representation of land surface processes is crucial for further development of a seasonal forecasting system.

Session: 8030 Multidisciplinary- Community, Service and Education
Multidisciplinaire- Communauté, Services et Éducation

Convenor: Vanessa Foord

Related to multidisciplinary environmental studies and/or information sharing , which includes, but not limited to Arctic studies, wildfire fires, hydrology, and cryology using various approaches.

This session covers many topics, including but not limited to education, community science and data collection, data dissemination, and other activities as well as all environmental topics that are not addressed in the atmosphere, ocean, and climate sessions.

Session: 8030 Multidisciplinary- Community, Service and Education Multidisciplinaire- Communauté, Services et Éducation

04/06/2024 14:05

ID: 11904 Contributed abstract

WMO Initiative on the Environmental Sustainability of Observing Systems and Methods: Advancing Ideas Through International Engagement

Paige Aldridge [1] , *Shannon Allen* [2] , *Michael Earle* [3] , *Roya Ghahreman* [4] , *Jeff Anderson* [5] , *Peter Leibiuk* [6] , *Alicia Campbell* [7] , *Shannon Kaya* [8]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada
[4] Environment and Climate Change Canada
[5] Environment and Climate Change Canada
[6] Environment and Climate Change Canada
[7] Environment and Climate Change Canada
[8] Environment and Climate Change Canada

Presented by / Présenté par: ***Paige Aldridge***
Contact: paige.aldridge@canada.ca

Earth system observations are foundational to global numerical weather and environmental prediction. The World Meteorological Organization (WMO) sets requirements for its members to provide the type, frequency, and spatial resolution of observations to meet the needs of global prediction via its Global Basic Observing Network (GBON) programme. Meeting these requirements, however, can result in significant environmental impacts, such as new station installations with additional maintenance requirements or more radiosonde launches. To address this challenge, the WMO launched a dedicated initiative to promote and advance the environmental sustainability of observing systems and methods, with Canada in a leadership role. The Objective of this initiative is to develop practical recommendations for WMO Members and industry to reduce their environmental impacts through engagement, and collaboration. The initiative covers meteorological (surface and upper air), marine, hydrological, and atmospheric chemistry observational domains. While new emerging technologies to enhance the environmental sustainability of observing systems are a point of interest, the initiative considers factors from across the observing system life cycle (e.g. from network design and planning to decommissioning).

This presentation builds upon a dedicated science session “Environmental

Sustainability of Observing Systems and Methods: A Paradigm Shift for Weather and Climate Observational Programs and Policies" held at the 57th annual CMOS in 2023. This was the first session of its kind at CMOS, providing an avenue to kick start the conversation in Canada. Presentations at CMOS 2023 included an overview of the WMO initiative, results from an international benchmarking survey, and others. Since then, the initiative has progressed and achieved many milestones. Key milestones that will be highlighted are a multi-disciplinary virtual international workshop, and a dedicated international forum at the Meteorological Technology World Expo (MTWE) in Geneva 2023. Collectively, these activities continue to advance the awareness and consideration of environmental sustainability across the observing system life cycle, with outcomes feeding directly into practical and pragmatic recommendations for WMO Members, and industry. Next steps for the initiative will also be addressed, including the implementation of recommendations from WMO Commission for Observation, Infrastructure, and Information Systems meeting (INFCOM-3), and an event to be hosted at the 2024 WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO). Additional future activities include the potential for a follow-up survey to measure international progress, and initiating Phase 2 of the initiative to address the domains of Hydrology and Atmospheric Chemistry.

Session: 8030 Multidisciplinary- Community, Service and Education Multidisciplinaire- Communauté, Services et Éducation

04/06/2024 14:20

ID: 11911 Contributed abstract

Recent Advancements in Canadian Operational Radar Production and Services Post CWRRP (Canadian Weather Radar Replacement Program)

Rabah Hachelaf [1], *Ahmed Mahidjiba* [2], *Corinne Simard* [3], *Ilyass Hajji* [4], *Sudesh Boodoo* [5]

[1] CMC-MSC-ECCC
[2] CMC-MSC-ECCC
[3] CMC-MSC-ECCC
[4] CMC-MSC-ECCC
[5] CMC-MSC-ECCC

Presented by / Présenté par: ***Rabah Hachelaf***
Contact: rabah.hachelaf@ec.gc.ca

With the recent and successful completion of the Canadian Weather Radar Replacement Program (CWRRP), a transformative chapter in meteorological advancements has unfolded. This significatif project, overseen by the Meteorological Service of Canada (MSC), culminated in the successful installation of all new radars. The MSC's strategic objective aimed to enhance radar product capabilities, achieved through the incorporation of cutting-edge features, including dual-polarization technology.

Throughout the CWRRP's duration, several pivotal milestones marked the journey toward improved radar capabilities. Notable achievements encompass a substantial reduction in the radar network scan strategy cycle, ensuring more efficient and timely data. Furthermore, the extension of Doppler coverage has significantly enhanced the accuracy and range of meteorological observations. The introduction of innovative

dual-polarization products represents a significant advancement in radar data sophistication, providing valuable insights into precipitation types and intensity.

This presentation seeks to delve into the specifics of the operational radar production improvements resulting from the CWRRP, among other contributing factors. Going beyond a retrospective analysis, we will explore the future directions that await, focusing on elevating the quality of products and services.

Session: 8030 Multidisciplinary- Community, Service and Education Multidisciplinaire- Communauté, Services et Éducation

04/06/2024 14:35

ID: 11908 Contributed abstract

Validation of actual reported cases of drifting vessels

Laura Lam [1] , *Kuo-Hsien Chang* [2] , *Serge Trudel* [3] , *Guillaume Marcotte* [4]

[1] ECCC
[2] ECCC
[3] ECCC
[4] ECCC

Presented by / Présenté par: ***Laura Lam***
Contact: laura.lam@ec.gc.ca

The Environmental and Climate Change Canada (ECCC) Environmental Emergency Response Section (EERS) has been preparing its capacity to respond operationally to drift modelling upon request by the National Environmental Emergency Center (NEEC). EERS drift modelling, part of the Canadian Oil Spill Modelling Suite (COSMoS) uses the 9 parameters leeway downwind and crosswind method developed by the U.S. Coast Guard; the Leeway Table currently available to EERS contains 110 objects.
Fishing vessels and large vessels, such as bulk carriers and cargo ships, are amongst the most frequently reported drifting objects in NEEC heads-up and advisories reports over the past few years. In the Leeway Table, there are eight objects referring to fishing vessels and three referring to large vessels. One of our goals is to know how well the drift modelling could have done for real past events to have an idea of the level of service that can be given when becoming operational; also, this validation could open the discussion with clients, level the expectations on both sides and could orient future works to improve EERS product as a whole.
A summary of the events reported and explored to find potential cases for validation will be shown. A number of cases have been selected and studied; the drift modellings with best fit objects from the Leeway Table compared to the ship trajectory, i.e., Automatic Information System (AIS) data, will be presented for selected cases.

Session: 8030 Multidisciplinary- Community, Service and Education Multidisciplinaire- Communauté, Services et Éducation

04/06/2024 14:50

ID: 11923 Contributed abstract

Consumers and citizens making impact on Canada’s Net Zero challenge

Charles Lin [1] , *James Lin* [2] , *Stephen Phoon* [3] , *Shu Yi Chu* [4] , *Veronika*

Kosova [5]

[1] Retired
[2] University of Alberta alumnus
[3] Seneca Polytechnic
[4] University of Oxford alumnus
[5] Comenius University alumnus

Presented by / Présenté par: ***Charles Lin***
Contact: charles.augustin.lin@gmail.com

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. The city of Toronto aims to reduce its community-wide emissions to net zero by 2040 – 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. 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 green initiatives we started within grassroots organizations in the city of Toronto, and advocacy actions with the Toronto City Council. We assess the city’s progress in emission reductions to reach its net zero goals. We also discuss the importance of narratives and story- telling in communicating climate change to the public to create engagement and to spur action.

Session: 8030 Multidisciplinary- Community, Service and Education Multidisciplinaire- Communauté, Services et Éducation

04/06/2024 15:05

ID: 12052 Contributed abstract

Expanding Horizons and Expectations: Lessons from innovations in adaptation

Stephanie Arnold [1] , *Meagan Moynagh* [2] , *Heather Harris* [3]

[1] CLIMAtlantic, UPEI
[2] PEI Federation of Agriculture
[3] CLIMAtlantic

Presented by / Présenté par: ***Stephanie Arnold***
Contact: stephanie.arnold@climatlantic.ca

Pursuing the goal of reducing climate risks, without consideration of other risks, has been shown to lead to climate change adaptation actions that could mitigate climate hazards in the short term but exacerbate other problems or create new ones. Fortunately, recognition of the need to stop artificially isolating climate risks as discreet problems is increasing at the international level. Working Group II’s contribution to the Sixth Assessment Report of the IPCC (2022) embedded social and environmental challenges in its chapter on climate change impacts, vulnerability, and adaptation of food systems, feed, fibre and other ecosystem products. The international conference Adaptation Futures (2023) highlighted research and practice on the limits of adaptation, cascading risks, and the need for Indigenous Knowledge and equitable

and just approaches. What could this look like in practice at the local or regional level?

The Prince Edward Island Federation of Agriculture is developing a provincial climate change adaptation plan for the agriculture sector. A hybrid research- and participatory-based approach was chosen to capture a wider variety of knowledge and perspectives. Producer and stakeholder engagement included discussions on climate, regulatory, economic, social, and environmental risks as well as adaptation responses that could address multiple, interconnected issues and priorities. The co-development of adaptation pathways to address multiple needs and risks helped to identify actions that address immediate priorities and build climate resilience over time. Not only has the positioning of adaptation within a broader context increased engagement and buy-in, it is changing the expectations of risk reduction initiatives, programs, and policies. The methodology, findings, lessons, and surprises of this process will be shared.

Session: 8030 Multidisciplinary- Community, Service and Education Multidisciplinaire- Communauté, Services et Éducation

04/06/2024 15:20

ID: 11999 Contributed abstract

The Ripple Effect Caused by the Establishment of a Permanent Cell Within the Congress Scientific Program Committee / L'effet de Vague Provoqué par la Mise En Place d'une Cellule Permanente Au Sein du Comité Du Programme Scientifique du Congrès

Serge Desjardins [1]

[1] retraité (MSC/ECCC)

Presented by / Présenté par: ***Serge Desjardins***
Contact: sergio.desjardins1@gmail.com

One of the most important parts of a CMOS congress is its scientific program. This year is our 58th Congress, and it seems that for all this time, this task has fallen to the local Congress organizers, and in particular to its Scientific Program Committee (SPC), which reinvents itself at each Congress to accomplish this task. Is this the most efficient and least burdensome way for the Congress organizers (volunteers) to achieve the desired goal of hosting a good Congress, and how can we envision a well-established, simple, standard process, also developed with longer-term thinking in mind, to facilitate the organization of this important annual event for our Society?
In this oral presentation, we will discuss current efforts to establish a permanent cell in future congress SPCs that would lighten the load of preparing the congress scientific program and enable us to develop and standardize a process for organizing our annual congress. We will conclude our presentation with a visionary look at the presence of this permanent feature within CMOS. This permanence has the potential to structure our approach by enabling better communication, exchange and planning between us, and ultimately to better target and frame ideas, initiatives, projects, etc. within CMOS, which operates in a scientific, multidisciplinary environment requiring a spectrum of expertise to make and share this science within our Society and in society.

L'une des parties les plus importantes d'un congrès de la SCMO est son programme scientifique. Cette année, nous en sommes à notre 58e congrès, et il semble que depuis tout ce temps, cette tâche incombe aux organisateurs locaux du congrès, et en particulier à son comité du programme scientifique (CPS), qui se réinvente à chaque

congrès pour accomplir cette tâche. Est-ce la manière la plus efficace et la moins contraignante pour les organisateurs (bénévoles) du congrès d'atteindre l'objectif souhaité, à savoir l'organisation d'un bon congrès, et comment pouvons nous envisager la mise en place d'un processus bien établi, simple, standard, et aussi élaborer avec une pensée à plus long terme pour faciliter l'organisation de cet important événement annuel pour notre Société ?
Dans cette présentation orale, nous discuterons des efforts actuels visant à établir une cellule permanente dans les futurs CPS du congrès qui allégerait la charge de la préparation du programme scientifique du congrès et nous permettrait de développer et de normaliser un processus d'organisation de notre congrès annuel. Nous conclurons notre présentation par un regard visionnaire sur la présence de cet élément permanent au sein de la SCMO. Cette permanence a le potentiel de structurer notre approche en permettant de meilleurs communication, échange et planification entre nous, et finalement de mieux cibler et encadrer les idées, les initiatives, les projets, etc. au sein de la SCMO, qui opère dans un environnement scientifique et multidisciplinaire nécessitant un spectre d'expertise pour faire et partager cette science au sein de notre Société et dans la société.

Session: 2042 Weather and Climate Extremes - General - Part 3 Extrêmes météorologiques et climatiques - Généralités - Partie 3

Convenor:
Elizaveta Malinina (Environment and Climate Change Canada)

This session is for topics related to extremes that are not covered by other sessions in Theme 2.

Session: 2042 Weather and Climate Extremes - General - Part 3
Extrêmes météorologiques et climatiques - Généralités - Partie 3 **04/06/2024 15:55**

ID: 11957 Contributed abstract

Heatwaves, streamflow, and climate change: Where and when will the streamflow response to warm anomalies change most rapidly?

Sam Anderson [1] , *Shawn Chartrand* [2]

[1] Simon Fraser University
[2] Simon Fraser University

Presented by / Présenté par: ***Sam Anderson***
Contact: anderson.sam.lucas@gmail.com

Persistent warm temperature anomalies, from warm spells to heatwaves, can drive streamflow throughout the year. Such streamflow responses can drive downstream flooding and damage infrastructure; however, as climate change continues to warm Canadian basins, it is not well understood how the streamflow response to warm anomalies will change. Here we ask: when, where, and for what magnitude of temperature anomalies will the streamflow response change most rapidly under climate warming? Will the streamflow response to heatwaves change differently than the response to less extreme warm anomalies? We use observed streamflow and temperature for >800 basins across Canada to quantify the streamflow response to warm temperature anomalies and how such responses vary in space, time, and by

anomaly magnitude. We first identify two temporal modes of the streamflow response: one in autumn and one in spring, the relative strength and timing of which varies by climate. We then use analytical approximations of temperature variability to characterize the key controls of these two modes, as well as the sensitivity of such modes to changes in annual temperature. We find that the streamflow response to more extreme warm events is more sensitive to changes in mean annual temperatures as compared to the response to less extreme warm events, and this sensitivity is greatest in the coastal, southern, and Prairie regions of Canada. Our results describe how even linear and uniform warming can drive non-linear and non-uniform changes to the streamflow response to warm anomalies, that strongly vary by the relative magnitude of the driving warm anomaly. Our findings imply that the hydrological impacts of extreme events will change more rapidly relative to the impacts of less extreme events.

Session: 2042 Weather and Climate Extremes - General - Part 3
Extrêmes météorologiques et climatiques - Généralités - Partie 3 **04/06/2024 16:10**

ID: 11925 Contributed abstract

Moisture Fluxes during Three Atmospheric Rivers in September and October 2021 in British Columbia's Upper Nechako Watershed

Tamar Richards-Thomas [1] , *Spencer Woyke* [2] , *Stephen Dery* [3]

[1] University of Northern British Columbia
[2] University of Northern British Columbia
[3] University of Northern British Columbia

Presented by / Présenté par: ***Stephen Dery***
Contact: sdery@unbc.ca

Atmospheric rivers (ARs) that influence the hydroclimatology of British Columbia (BC) are concentrated streams of water vapor associated with extratropical cyclones originating over the Pacific Ocean. ARs making landfall in BC undergo orographic lifting along the Coast Mountains, leading to intense precipitation and strong winds. To better understand ARs making landfall in north-central BC, the Tahtsa Ranges Atmospheric River Experiment (TRARE) collected detailed hydrometeorological data in BC's upper Nechako Watershed in September and October 2021. This study aims to quantify moisture fluxes and understand the impact of three ARs (Events 3, 5, and 10) recorded during TRARE on the upper Nechako Watershed over the event duration. Hydrometric stations showed sharp peaks in runoff (~45 mm/day) in Event 3 that correspond to a surge of intense rainfall (~80 mm/day) and strong winds (~15 m/s). Major variations in the integrated water vapour transport (IVT) defining ARs were observed over the upper Nechako, owing to geographical and hydrometeorological differences between Events 3, 5, and 10. Events 3 (~600 kg/m/s) and 5 (~500 kg/m/s) surpassed and Event 10 lagged behind a minimum IVT threshold of 250 kg/m/s, indicating ARs near the TRARE study area. Event 10 originated after a historical bomb cyclone southwest of BC, where air pressure dropped up to 50 hPa/day, breaking the record for the lowest sea-level pressure (942 hPa). ARs associated with Events 3 and 5 experienced southwestern paths with IVT steadiness factor (ISF) >80% and consequently similar wind direction due to the presence of a single low-pressure center located off the coast of northern BC and Alaska. Event 10 experienced a northeastern path with ISF <80% due to the enhanced water vapour caused by the passage of a historical bomb cyclone.

ID: 11995 Contributed abstract

Modelling in a Warming World: Marine Heatwave Drivers in James Bay, Canada

Hannah Louis [1], *Zou Zou Kuzyk* [2], *Jens Ehn* [3], *Paul Myers* [4]

[1] University of Alberta
[2] University of Manitoba
[3] University of Manitoba
[4] University of Alberta

Presented by / Présenté par: ***Hannah Louis***
Contact: hlouis@ualberta.ca

Arctic average temperatures are increasing four times as quickly as the global average temperature as the effects of climate change are being amplified in high-latitude regions. The overall higher atmospheric and ocean temperatures are exacerbating extreme anomalous warm-water events known as marine heat waves (MHW). In the Hudson and James Bay (HBC), Canada, these events not only affect marine life but also the surrounding Cree and Inuit communities whose way of life rely heavily on their connection to the Arctic marine environment. In the late 1990s, Indigenous peoples in the region reported numerous drastic changes in the marine environment and ecology, such as a dramatic decline in eelgrass meadows, and erratic and unpredictable weather and sea ice patterns. Coinciding with these reports, an extreme MHW event occurred in James Bay in 1998. Since then, there have been other recorded MHW events in James Bay.

Given the sparse observational data in the region, we ask how high-resolution numerical modelling of the ocean can be used to help understand the forcing of and help predict MHW events in JB. We use the Nucleus for European Modelling of the Ocean (NEMO) model coupled to the Louvian-la-Nueve sea ice model version 2 (LIM2) with the Arctic and Northern Hemisphere Atlantic ¼ degree resolution (ANHA4) configuration to examine the processes associated with MHWs and parse out which mechanisms are most important in JB. Shorter winters and earlier ice retreat dates may indicate that air-sea heat flux may play an important role in driving MHW events in Hudson Bay. Given the overall cyclonic circulation of Hudson Bay, horizontal advection from southwestern Hudson Bay may furthermore drive MHWs in northern JB. Once the mechanisms that drive MHW in the HBC are known, oceanographic model simulations will be performed to predict the stability of the future HBC ecosystem.

ID: 12078 Contributed abstract

Exploring meteorological drought trends in British Columbia and potential relationships with climate variability.

Vanessa Foord [1] , *Bryan Mood* [2] , *Norman Shippee* [3] , *Lukas Cheung* [4] , *Katherine Pingree-Shippee* [5]

[1] British Columbia Ministry of Forests
[2] Stantec/University of Saskatchewan
[3] Stantec
[4] Stantec
[5] Stantec

Presented by / Présenté par: ***Vanessa Foord***
Contact: veggin@telus.net

Recent meteorological drought in British Columbia (BC), such as 2017, 2018, 2021 and 2023 are causing impacts to BC's forests such as mortality, increased susceptibility to pests, increased wildfire risk, and challenges to reforestation. There is a need to understand these drought events in the context of long-term trends and potential relationships to climate variability to assess future forest risks. Trends in drought for each of BC's natural resource districts were analyzed from 1951-2023 using the Standardized Precipitation and Evapotranspiration Index (SPEI), calculated in timesteps of 1, 3, 6, and 12 months, using data from ERA5-Land. Potential hydroclimatic drivers of drought events, defined as SPEI < -1.5, were explored with the Arctic Oscillation (AO), the Pacific North American Oscillation (PNA), the Pacific Decadal Oscillation (PDO), the Multivariate ENSO Index (MEI), and the Oceanic Niño Index (ONI). Preliminary results show some significant trends towards drought, primarily in winter months, as well as significant relationships with climate variability, primarily with the MEI and the PDO. However, both the trends and correlations with hydroclimatic drivers were quite variable with geography and seasonality across the province.

Session: 2042 Weather and Climate Extremes - General - Part 3
Extrêmes météorologiques et climatiques - Généralités - Partie 3 **04/06/2024 16:55**

ID: 12075 Contributed abstract

Comparison of the association between waviness metrics and extreme temperature values, and future trends of association

Eliott Roocroft [1] , *Rachel White* [2]

[1] University of British Columbia
[2] University of British Columbia

Presented by / Présenté par: ***Eliott Roocroft***
Contact: eroocroft@eoas.ubc.ca

With increasing global temperatures, there has been an observed increase in the quantity and intensity of extreme weather events, particularly heat extremes in the mid-latitude regions. Some recent studies have attributed this increase at least partially to an amplification in the waviness of the upper tropospheric jet stream. Whilst there is

significant scientific uncertainty over causes of recent trends in jet stream waviness, the impact atmospheric waves have on extreme events is clear. Currently there is a wide variety of methods for measuring the waviness of the jet stream, with a recent study suggesting that trends in waviness may depend on the metric chosen. Using ERA5 reanalysis data, we compare five popular metrics of waviness to identify which are most closely associated with summertime-hot and wintertime-cold temperature extremes in the northern hemisphere mid-latitudes. We use the odds ratio to quantify the likelihood of co-occurring high waviness values in the atmospheric region above a grid point and temperature extremes at that gridpoint. We show relatively large differences between metrics, with metric performance (i.e. the strength of the connection between waviness and temperature extremes) heavily dependent on geographical location and season. Overall, the local wave activity (LWA) metric appears to have the strongest connection to extreme temperatures over the majority of regions.

We then calculate the LWA with the CESM2 Large Ensemble (LENS2) to compare model accuracy, as well as trends and variability, in both the LWA and the association between high LWA and surface extremes between the historical period (1980-2015) and the future (2065-2100). By calculating projected changes in both the LWA and its association with surface extremes, we analyse the effect that forced dynamical changes to the waviness of the jet stream will have on the changing nature of extreme temperature events by the end of the century.

Session: 7010 Towards development of Canada’s Digital Twin of the Ocean: Observations, Modelling, Forecasting, Analyses and Applications Vers le développement du jumeau numérique de l'océan du Canada : Observations, modélisation, prévisions, analyses et applications

Convenors:
Youyu Lu (Fisheries and Oceans Canada, Maritimes)
Nancy Soontiens (Fisheries and Oceans Canada, Newfoundland)
Di Wan (Fisheries and Oceans Canada, Pacific)
Hui Shen (Fisheries and Oceans Canada, Maritimes)

Data and knowledge from ocean observations, modelling, prediction, and analyses support a great range of applications, such as fishery and ecosystem protection and management, safe navigation, search and rescue, and climate change adaptation etc. Impacts and outcomes of these activities would be amplified by the application of an international framework for Digital Twins of the Ocean (DTO). In Canada, there is a tremendous amount of activity relevant to DTO development in government departments, academia, and the private sector. To be successful in building DTO for oceans around Canada, there are imminent needs to enhance the knowledge and technology exchanges, coordination and collaboration among management and researchers in various organizations and also with the international community, including the various activities under the United Nations Decade of Ocean Science for Sustainable Development. To this end, this session aims to bring together national and international researchers and managers to 1) share the client needs and plans of relevant projects and activities; 2) review existing resources (data, models, technology and knowledge); 3) present achievements in research and development; and 4) discuss collaboration opportunities. The session will consist of a mixture of invited and contributed presentations, and in both oral and poster formats.

Session: 7010 Towards development of Canada's Digital Twin of the Ocean: Observations, Modelling, Forecasting, Analyses and Applications Vers le développement du jumeau numérique de l'océan du Canada : Observations, modélisation, prévisions, analyses et applications

04/06/2024 15:55

ID: 12092 Contributed abstract

Multi-scale variations of ocean temperature off the coast of Nova Scotia and their potential relevance ecosystem and fishery

Youyu Lu [1], *Michael Casey* [2], *Li Zhai* [3], *Xianmin Hu* [4], *Jing Tao* [5], *Brian Petrie* [6], *David Brickman* [7], *Hui Shen* [8]

[1] Bedford Institute of Oceanography
[2] Bedford Institute of Oceanography
[3] Bedford Institute of Oceanography
[4] Bedford Institute of Oceanography
[5] Bedford Institute of Oceanography
[6] Halifax
[7] Bedford Institute of Oceanography
[8] Bedford Institute of Oceanography

Presented by / Présenté par: ***Youyu Lu***
Contact: Youyu.Lu@dfo-mpo.gc.ca

Ocean temperature variations off the coast of Nova Scotia are quantified through analyses of data from in situ and satellite remote sensing observations, and high-resolution numerical ocean models. The analyses reveal significant variations at various time-space scales, including: 1) rapid cooling in nearshore waters associated with extreme cold-air outbreaks; 2) frequent cold spells at seabed along the coast from late fall to early spring; 3) large-scale cooling or warming spanning over a season or longer; 3) extensive upwelling along the coast from late-spring to fall; 4) space-time (seasonal and interannual) variations of marine heat waves and cold spells at surface and in the water column; and 5) interannual variations of upwelling along the coast. The forcing mechanisms and predictability of these variations are explored through analysis of atmospheric forcing and ocean model solutions. This presentation will present updates of selected aspects listed above, and discuss their potential relevance to applications in marine ecosystems and fishery is discussed.

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04/06/2024 16:10

ID: 12084 Contributed abstract

Cold temperature spikes in near-bottom water off Halifax during late fall to early spring

Michael Casey [1], *David Hebert* [2], *Youyu Lu* [3], *Hui Shen* [4], *David Brickman* [5]

[1] Department of Fisheries and Oceans Canada
[2] Department of Fisheries and Oceans Canada
[3] Department of Fisheries and Oceans Canada
[4] Department of Fisheries and Oceans Canada
[5] Department of Fisheries and Oceans Canada

Presented by / Présenté par: ***Michael Casey***
Contact: mpcasey70@gmail.com

Coastal areas off Halifax on the Scotian Shelf are largely dominated by two water sources: colder/fresher waters in the top layers (< 100 m depth) delivered by the Nova Scotia Current, and warmer/saltier Scotian Slope waters in the deeper layers (> 120 m) originating from the shelf break. A decade-long record of bottom-mounted CTD sensors at the 150 m isobath off the coast of Halifax show the occurrence of frequent colder/fresher water spikes lasting several days during late fall to early spring. High-resolution ocean models show reasonable agreement with the observed signals, and also elucidate their horizontal coverage and depth coverage. Model results further show that the occurrence of the spikes is related to weather-driven short-term intensifications of the Nova Scotia Current delivering colder/fresher water to greater depths. The potential impacts of the spikes on fishery are discussed.

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04/06/2024 16:25

ID: 12074 Contributed abstract

Importance of ocean observations in ECCC's Global Ocean Analysis GIOPS: The SynObs Project

Kamel Chikhar [1] , *Dorina Surcel-Colan* [2] , *Brayden Zheng* [3] , *Andrew Peterson* [4] , *Gregory C. Smith* [5]

[1] Meteorological Service of Canada
[2] Meteorological Service of Canada
[3] Meteorological Service of Canada
[4] Meteorological Research Division
[5] Meteorological Research Division

Presented by / Présenté par: ***Kamel Chikhar***
Contact: kamel.chikhar@ec.gc.ca

The Synergistic Observing Network for Ocean Prediction (SynObs) project (https://oceanpredict.org/synobs) seeks to find synergies between ocean observations and ocean prediction through a multi-system approach to an Observing System Experiment (OSE). Here we use an operational ocean prediction system in a digital twin framework to investigate "what if ?" scenarios for the global ocean observing system. Best estimates and predictions of the location of eddies, ocean sound speed

profiles, ocean currents and ocean water masses are important ocean diagnostics for a variety of ocean and/or coupled NWP applications. Skillful estimates of these diagnostics is presumably determined by the quantity and quality of ocean observations used in the ocean state estimation, but the exact value of the observations, and in particular, which observations are most crucial is unknown. Through OSE experiments performed by Environment and Climate Change Canada's system the Global Ice Ocean Prediction System (GIOPS) for the SynObs project, we will investigate the effect of observation withholding experiments on these diagnostics. Particular attention is paid experiments withholding ARGO observations, but other experiments withholding altimeter, or only assimilating SST observations also prove interesting.

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04/06/2024 16:40

ID: 12117 Contributed abstract

Enhancing End-User Engagement in Ocean Observation and Ocean Forecasting Systems: Development of a Visualization and Access Application

Vanessa Sutton-Pande [1]

[1]

Presented by / Présenté par: ***Vanessa Sutton-Pande***
Contact: vanessa.sutton-pande@dfo-mpo.gc.ca

The Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS) represents a collaborative effort among various federal government departments aimed at establishing operational coupled atmosphere-ice-ocean-wave assimilation, analysis, and prediction capabilities for Canada. CONCEPTS has matured significantly, now hosting operational ocean forecasting systems operationalized daily at Environment and Climate Change Canada (ECCC). However, the sustained utilization of these systems for societal benefit hinges upon accessible visualization and user-friendly interfaces.
Addressing this need, an application is under development at the Department of Fisheries and Oceans (DFO), Newfoundland and Labrador (NL) Region, to facilitate and enhance end-user engagement with ocean forecasting systems. Leveraging a client-driven approach, the application is crafted to cater to a range of end users requirements including scientific research and operational use cases. Built upon a web-accessible server system, the application combines front-end web interface (JavaScript), analysis tools (Python), and data archive (SQL database and NetCDF files) to offer intuitive access and visualization capabilities. This application is designed to incorporate various types of models for ingestion.
End users can interactively access and visualize ocean forecasting systems, with functionalities enabling data subsetting along transects, point coordinates, and specified areas (e.g., virtual moorings, Hovmöller diagrams, etc.). Moreover, the application facilitates data download in various user-friendly formats, streamlining integration into end users' operational processes. Verification of model output is

provided against in situ observations by leveraging datasets from regional and global monitoring programs such as GODAE OceanView and RIOPS Assimilated Observations.
Collaboration, knowledge exchange, end user engagement are drivers for the development and utilization of tools and applications contributing to the advancement of ocean science and sustainable management practices.

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04/06/2024 16:55

ID: 11958 Contributed abstract

CIOOS: Developing a strong foundation for Canada's digital ocean

Jonathan Kellogg [1], *Brad de Young* [2], *Stéphane Lapointe* [3], *Anne-Sophie Ste Marie* [4], *Shayla Fitzsimmons* [5]

[1] Tula Foundation
[2] CIOOS Pacific
[3] St Lawrence Global Observatory
[4] St Lawrence Global Observatory
[5] CIOOS Atlantic

Presented by / Présenté par: ***Jonathan Kellogg***
Contact: jonathan.kellogg@hakai.org

The foundation of any digital twin of the ocean are data that are findable, accessible, interoperable, and reusable. The Canadian Integrated Ocean Observing System (CIOOS) is dedicated to this purpose and is developing into a one stop shop for Canadian ocean data and has recently been recognized as a regional association of the Global Ocean Observing System. Since 2019, CIOOS has been improving access to data from federal agencies, academic departments, non-profit organizations, industry, and coastal communities for the benefit of all. We're working with our partners to make CIOOS even more useful and improve our functionality for researchers and recreational users alike. The continued development of CIOOS will help democratize the access to ocean information and improve the foundation for the digital twins of the future. This presentation will be a chance to highlight recent advances and new tools within CIOOS, explain our near-term objectives, and be an opportunity to hear from users what additional features and data should be targeted for integration next.

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04/06/2024 17:10

ID: 12093 Contributed abstract

Discussion on ideas and collaborations toward development of Canada's Digital Twins of the Ocean: Observations, Modelling, Forecasting, Analyses and Applications

Youyu Lu [1], *Nancy Soontiens* [2], *Di Wan* [3], *Hui Shen* [4], *Patricia Pernica* [5], *Mike Smit* [6], *Pramod Thupaki* [7], *Naomi Boon* [8], *Isabelle Gaboury* [9], *Fraser Davidson* [10]

[1] Bedford Institute of Oceanography
[2] Northwest Atlantic Fishery Center
[3] Institute of Ocean Sciences
[4] Bedford Institute of Oceanography
[5] DFO HQ
[6] Dalhousie University
[7] OMS Research and Consulting Ltd
[8] Hakai Institute
[9] DFO HQ
[10] ECCC

Presented by / Présenté par: ***Youyu Lu***
Contact: Youyu.Lu@dfo-mpo.gc.ca

Information from ocean observations, modelling, prediction, and analyses support a great range of applications such as fishery and ecosystem protection and management, safe navigation, search and rescue, coastal engineering, and climate change adaptation etc. Impacts and outcomes of these activities would be amplified by the application of an international framework and development of open standards for Digital Twins of the Ocean (DTO). In Canada, there is a tremendous amount of activities relevant to DTO development in government departments, academia, and the private sector. To build successful DTO for oceans around Canada that are fit-for-purpose, there are imminent needs to enhance the knowledge and technology exchanges, coordination and collaboration among management, professionals and researchers in various organizations and also with the international community, including the various activities under the United Nations Decade of Ocean Science for Sustainable Development. Here we invite participants of this session to discuss collaborations and future step to enhance the contributions to key components in the development of Canada's DTO.

Session: 8010 Changing Arctic: Science and Policy Studies L'Arctique en mutation : études scientifiques et politiques

Convenor:
Matthew G. Asplin (ASL Environmental Sciences)

This interdisciplinary session aims to showcase recent scientific findings related to the rapidly evolving Arctic and northern environment. Significant changes have occurred in the physical environment of the Arctic in recent decades, particularly in the cryosphere, oceanography, hydrology, and meteorology. Various scientific approaches are being employed to understand the underlying causes of these changes. The session will explore the application of scientific

results in addressing policy issues, particularly those related to the federal government and Indigenous-led management initiatives.

The relevance of Arctic research and its implications for the future is of great importance. This is especially timely for informing northern communities, the public, and contributing to a range of policy issues in this strategically significant part of Canada. The session welcomes contributions from research, scientific, and policy activities that are either nearing Completion, currently underway, or in the planning stage.

Session: 8010 Changing Arctic: Science and Policy Studies
L'Arctique en mutation : études scientifiques et politiques **04/06/2024 15:55**

ID: 11905 Contributed abstract

Impacts of climate variability on terrestrial and freshwater systems in the Arctic: lessons from the past

Konrad Gajewski [1]

[1]

Presented by / Présenté par: ***Konrad Gajewski***
Contact: gajewski@uottawa.ca

Long-term impacts of Arctic warming on the terrestrial and freshwater ecosystems have critical influence on wildlife populations and resources such as water supply; but these are only beginning to be understood through monitoring and experimental studies. However, the Arctic has experienced warm periods in the recent past (Holocene) lasting centuries to millennia and these can help understand climate change impacts at a scale needed for planning. Paleo-studies from lake sediments indicate how warming affected terrestrial and freshwater systems across the Arctic in response to previous warm periods. The invasion of new species into the Arctic can be rapid. Fossil pollen analyses indicate the arrival of the flora occurred nearly instantaneously following deglaciation although this may differ in the future as human-mediated invasions are more likely. Major impacts of warming on the vegetation occurred through increases in plant production more than through changes in biodiversity. These changes in the vegetation changes are widespread, although there are longitudinal gradients as well as the expected latitudinal ones. The impact of climate variability on freshwater systems is more regional, depending on conditions such as lake bathymetry, bedrock, and landscape factors, which influence water chemistry.

Session: 8010 Changing Arctic: Science and Policy Studies
L'Arctique en mutation : études scientifiques et politiques **04/06/2024 16:10**

ID: 11928 Contributed abstract

Analysis of Thirty Years of Sea-ice Velocities in the Canadian Beaufort Sea using Upward Looking Sonar Instruments, 1990 to 2020

David Fissel [1] , *Matthew Asplin* [2] , *Keath Borg* [3] , *Humfrey Melling* [4]

[1] ASL Environmental Sciences Inc.
[2] ASL Environmental Sciences Inc.
[3] ASL Environmental Sciences Inc.
[4] Institute of Ocean Sciences / DFO

Presented by / Présenté par: ***David Fissel***
Contact: dfissel@aslenv.com

Nearly continuous measurements of sea-ice velocities, spanning 30 years in duration, have been obtained at two sites in the eastern Canadian Beaufort Sea using subsurface continuous upward looking sonar instruments. Over the period from April 1990 to Sept. 2020, sea-ice velocities were measured at both a mid-shelf and an outer-shelf location, with only a few data gaps. Sea ice velocities exhibit a very large seasonal cycle ranging from the largest velocities in the fall during the onset of sea ice, to the lowest velocities from early winter to early spring, with frequent episodes of no-motion. There are more no-motion days at the mid-shelf site (28%) vs. the outer-shelf site (21%). As well as seasonal variability, ice motion is characterized by large variability at synoptic and interannual time scales. There is evidence of a trend to increased sea ice velocities which is obscured by the large levels of interannual variability.
Sea ice motion is dominated by wind forcing in the fall and spring to early summer months. In the winter to mid-spring period, the magnitude of the wind-driven motion is reduced due to the development of an internal ice force which impedes motion. Internal ice forces develop under westerly (shoreward convergent) winds and generally abate under easterly (shoreward divergent) winds. However, internal ice forces can persist for days after the onset of easterly winds.

Session: 8010 Changing Arctic: Science and Policy Studies
L'Arctique en mutation : études scientifiques et politiques **04/06/2024 16:25**

ID: 11902 Contributed abstract

Modulation of Convective Overturning in the Labrador Sea by Large-Scale Modes of Atmospheric Variability

Romina Piunno [1], *Kent Moore* [2]

[1] University of Toronto
[2] University of Toronto

Presented by / Présenté par: ***Romina Piunno***
Contact: gwk.moore@utoronto.ca

During the winter season, stratification in the central Labrador Sea is eroded by surface heat fluxes causing convective overturning exceeding depths of 2km. This is one of the few locations globally in which deep convection occurs making it an important feature of the climate system and ocean ventilation. It also plays a role in the global carbon budget as the convected water brings with it dissolved gases, including Carbon Dioxide, which are in constant flux between the ocean and the atmosphere. The rate at which buoyancy is lost depends heavily on large-scale atmospheric

circulation patterns, such as the North Atlantic Oscillation (NAO). Here we investigate the process by which weather patterns driven by the NAO, and its northern centre of action, the Icelandic Low modulate convective depths. A one-dimensional ocean model is used to quantify the mixed layer depth's response to various atmospheric forcing conditions. We find that while net heat flux is the strongest modulating factor of mixed layer depth's seasonal maximum, it is also strongly affected by the NAO. The Icelandic Low, despite its proximity to the Labrador Sea, does not affect mixed layer entrainment as strongly. From geospatial correlation fields with heat flux, NAO, and Icelandic Low time series, it is evident that the NAO better drives strong, cold, westerly winds from over the North American continent, which are more effective at cooling the ocean surface boundary layer. These correlations are supported by a compositing approach with a peak-over-threshold technique.

Session: 8010 Changing Arctic: Science and Policy Studies
L'Arctique en mutation : études scientifiques et politiques **04/06/2024 16:40**

ID: 11951 Contributed abstract

Establishing a new community-based sea ice monitoring site in coastal Nunatsiavut (Kaipokok Bay)

May Wang [1] , *Maurice Jacque* [2] , *Samantha Pilgrim* [3] , *Clark Richards* [4] , *Eric Oliver* [5]

[1] Dalhousie University
[2]
[3] Nunatsiavut Government
[4] Fisheries and Oceans Canada
[5] Dalhousie University

Presented by / Présenté par: ***May Wang***
Contact: may.wang@dal.ca

Amid climate warming, two pressing concerns in coastal Nunatsiavut are emerging: increasing severity of anomalously low ice years and growing unpredictability of ice conditions. For example, the extreme winters of 2010 and 2021 experienced remarkably lower ice levels than any other year in lived history. This significantly restricted people's access to the landfast ice for travel and subsistence hunting, leading to adverse effects on their mental well-being. The drivers of extreme years and interannual variability are poorly understood, mainly due to the lack of long-term in-situ observations. In this talk, we present our methods for establishing a new community-based sea ice monitoring program in coastal Nunatsiavut. In January 2024, we launched an "ice monitoring site" on the landfast sea ice in Kaipokok Bay, located near the community of Postville, Nunatsiavut, Labrador. The site includes a suite of ice-tethered scientific instruments set to collect data on the sea ice, ocean, and atmosphere over the 2024 ice season (January to April 2024). In addition, local team members visit the site each week to supplement the monitoring site with in situ ice thickness measurements and under-ice CTD casts and to incorporate local knowledge on weather and ice conditions. The project's central focus is to examine the heat balance between ice, ocean, atmosphere, and rivers, and the role each component plays in yearly ice conditions. Our methodology emphasizes ongoing collaboration with community members from inception to completion. Through this approach, we can

obtain a more detailed and holistic understanding of the local sea ice environment.

Session: 8010 Changing Arctic: Science and Policy Studies
L'Arctique en mutation : études scientifiques et politiques **04/06/2024 16:55**

ID: 12099 Contributed abstract

Insights on the 2022-23 Ice Season Using Ice Profiling Sonar in the Coastal Waters of Nunatsiavut, Newfoundland and Labrador, Canada

Matthew Asplin [1], *Rodd Laing* [2], *Michelle Saunders* [3], *Dawn Sadowy* [4], *James Bartlett* [5], *Keath Borg* [6]

[1] ASL Environmental Sciences Inc.
[2] Nunatsiavut Government
[3] Nunatsiavut Government
[4] ASL Environmental Sciences Inc.
[5] ASL Environmental Sciences Inc.
[6] ASL Environmental Sciences Inc.

Presented by / Présenté par: ***Matthew Asplin***
Contact: masplin@aslenv.com

A comprehensive understanding of the ocean's and sea ice's role in climate moderation and the sustenance of intricate food webs is essential to support ocean stewardship and protection initiatives led by Indigenous communities along Canada’s coastlines. The traditional territorial waters of the Nunatsiavut in the Labrador Sea harbor a diverse marine ecosystem intricately regulated by physical oceanography and seasonal sea ice cover, influenced by wind patterns and ocean currents. To facilitate effective environmental management, the Nunatsiavut Government has established an expanding research program aimed at comprehending and monitoring this complex biophysical system.

As part of this research endeavor, ongoing efforts include the fifth-year monitoring of over-winter ocean and sea ice conditions at an offshore location near Nain, Labrador. Measurements encompass water temperature, salinity, dissolved oxygen, turbidity, currents, and ice drafts and velocities. In Fall 2022, the program expanded to include two additional sites near the communities of Rigolet and Hopedale, with a specific focus on sea ice observation.

Preliminary analysis of data collected during the 2022-2023 over-winter deployment has yielded invaluable insights into the sea ice dynamics of the region. This paper delves into the differences in the evolution of the sea ice cover between Nain and Rigolet, examines the atmospheric (wind) and oceanic (currents) forcings on the ice, and contextualizes the season within the long-term sea ice climatology for each site. These two sites were also selected for their contrast between a northern coastal location (Nain) and a southern location subject to strong tidal currents and estuarine freshwater output from Lake Melville (Rigolet). The establishment of long-term data records at all sites aims to enable the assessment of high-resolution spatial time series of sea ice cover, informing ocean and coastal management and protection policy development in Nunatsiavut.

ID: 12112 Contributed abstract

The Nunatsiavut Sea Ice Observers Program: Community-based monitoring of environmental change and social impacts in Nunatsiavut, northern Labrador

Emma Harrison [1], *Eric Oliver* [2], *Susan Ziegler* [3], *James Jacque* [4], *Ronald Webb* [5], *Derrick Pottle* [6], *Maurice Jacque* [7], *Reuben Flowers* [8], *Ross Flowers* [9], *Todd Broomfield* [10], *John Winters* [11]

[1] Dalhousie University
[2] Dalhousie University
[3] Memorial University
[4] Dalhousie University
[5]
[6]
[7]
[8]
[9]
[10]
[11] Dalhousie University

Presented by / Présenté par: ***Emma Harrison***
Contact: ej.harrison@dal.ca

Climate change is producing dramatic and rapid changes in seasonality, sea ice coverage, and species distribution in Nunatsiavut. These changes significantly impact the food security and traditional lifeways of Inuit communities in this region. Community-based observational monitoring plays a particularly important role in the North, where instrumental monitoring systems (e.g., weather stations) are sparse and historic data is incomplete. In contrast, Inuit have a long history of monitoring, interpreting, and adapting to environmental change. Traditional Inuit Knowledge integrates observations of the animals, environment, and human well-being over generations. As Inuit spend much of their time on the land, ice, and sea, they are often the first observers of environmental change and have unique, localized methods for producing new observations of their environment.

The Nunatsiavut Sea Ice Observer program is a community-based environmental monitoring program established in 2021 with a focus on sea ice conditions. Its goal is to support knowledge-holders from each of the five Nunatsiavut communities to record observations of environmental conditions while they are out on the land. The Observers create narrative, qualitative observations including photographs and annotated maps that document ice conditions, travel conditions, ice thickness, weather systems, water conditions, animal sightings and behavior, and information about harvesting or hunting. This unique record preserves the voices and perspectives of knowledge holders and sheds light on the local impacts of rapidly changing sea ice conditions. We will describe (i) our approach for creating this program (ii) examples of environmental observations and (iii) our work engaging Nunatsiavut youth through a curricular toolkit in development for local schools.

Session: 3040 Climate - Community, Service and Education Climat - Communauté, Services et Éducation

Convenor: Siraj ul Islam

Related to scientific studies and/or information sharing about the climate, including studies on slowly varying aspects of the Earth's systems, as well as past and future conditions, using various approaches.

This session covers many topics, including but not limited to education, community science and data collection, data dissemination, and other activities such all studies related to climate services and communicating climate change-related risks.

Session: 3040 Climate - Community, Service and Education Climat - Communauté, Services et Éducation **04/06/2024 15:55**

ID: 11932 Contributed abstract

The Climate Crisis – A Way Forward

G.S. Strong [1]

[1] Canadian Association of Club of Rome (CACOR)

Presented by / Présenté par: ***G.S. Strong***
Contact: geoff.strong45@gmail.com

Climate change is now in crisis mode, despite the confidence of most governments that believe they can solve the crisis with new technology. During 2023, global warming exceeded the IPCC target to keep warming below 1.5°C, the maximum warming that the world should allow. Participating countries submitted climate plans to keep to that level, but virtually every country has surpassed their targets to date.

We are now on our way to the next level, 2°C warming, which many believe could lead to irreversible and catastrophic impacts around the globe. Governments hope that technology such as Carbon Capture and Storage (CCS) will rescue the world from this fate. They unwisely pour billions of dollars into CCS, fully controlled and operated by the fossil fuel industry. We review latest disappointing results of CCS and other technologies, and discuss a way of implementing renewable clean energy in a timely fashion that could salvage a liveable climate for all Earth.

Session: 3040 Climate - Community, Service and Education Climat - Communauté, Services et Éducation **04/06/2024 16:10**

ID: 12094 Contributed abstract

Bridging the gap between climate science and adaptation practitioners

Emma Poirier [1] , *Stephanie Arnold* [2]

[1] CLIMAtlantic
[2] CLIMAtlantic

Presented by / Présenté par: ***Emma Poirier***
Contact: emma.poirier@climatlantic.ca

As climate change continues to intensify, the scientific community continues to produce a wealth of valuable scientific knowledge, frameworks, and data. This increased production, however, has widened the gap between the science available and adaptation practitioners' capacity to use it. As a result, the additional outputs do not automatically make a difference on the ground. As communities continue to grapple with impacts from extreme events, their already limited capacity and resources are further strained as expectations for them to sort through the plethora of information available to design and implement adaptation actions increase.

In response to the gap between the growing volume of scientific research produced and the stagnant or declining capacity and resources communities have available to make use of it, climate service organizations are emerging as a potential solution. They inject extra capacity and technical expertise into communities needing to adapt, and support other intermediaries doing related work. Services such as training, skill building, and engagement help facilitate mutual understanding; creating connections among experts and stakeholders enables work across disciplines; creating public-facing interfaces make data and information more approachable and useful; and making space for non-traditional collaborators in adaptation to participate in projects help increase impacts, resources, and access to funding sources. This presentation will highlight local and regional examples of how climate services have helped communities and supporting organizations make use of scientific research, frameworks, and data. As a result, more individuals see themselves as collaborators in research and adaptation practitioners, helping to build meaningful and creative adaptation approaches at the community level.

Session: 3040 Climate - Community, Service and Education
Climat - Communauté, Services et Éducation **04/06/2024 16:25**

ID: 12047 Contributed abstract

A brief history of surface observations in Canada since 1871 and their Usage

Charles Paterson [1]

[1]

Presented by / Présenté par: ***Charles Paterson***
Contact: ckpaterson5@gmail.com

This presentation will give a brief overview of the history of surface weather observations in Canada in light of their use; “real-time” and non-real-time. Before the assimilation of this data into numerical weather models began in the 1960s and 1970s; weather observations were transmitted by telegraph and later teletype on a near-real-time basis to Toronto and other world meteorological centres for the plotting of weather maps and prediction of storms for marine users. When civil aviation began in the

1930s and during WW II, surface aviation sites expanded to nearly 300, whilst the collection of daily or twice-daily climate observations continued at around 1000 sites. Starting from the 1970s, automatic stations, both for aviation and for climate became dominant and many observations continue to increase from MSC, Nav Canada, Canadian Forces, and many other agencies including those in provincial and territorial governments.

Other purposes of the data have included climate statistics, agriculture, and legal. The presentation will discuss the many of the uses of this data over the years, and in particular, the exercise once per decade of creating Climate Normals. This work has been occurring over the last 70 years, and that work has prompted many key changes in how observational data is handled.

Day 3 – 5 June 2024

Session: 1001 Plenary - The Gulf of St. Lawrence, undergoing warming conditions and extreme events Plénière - Le golfe du Saint-Laurent, soumis à des conditions de réchauffement et à des événements extrêmes

Dr. Peter S. Galbraith (Fisheries and Oceans Canada)

Bio: Dr. Peter Galbraith is a DFO research scientist in physical oceanography whose main interest is the climate of the Gulf of St. Lawrence. He is chair of the Atlantic Zone Monitoring Program and is responsible for delivering State of the Ocean advice. He produces the annual state of the ocean report for the physical oceanography of the Gulf of St. Lawrence and leads the production of the zonal environmental overview. He contributes to DFO's monitoring program by running a helicopter-based winter survey of the temperature and salinity conditions in the Gulf of St. Lawrence.

Session: 1001 Plenary - The Gulf of St. Lawrence, undergoing warming conditions and extreme events Plénière - Le golfe du Saint-Laurent, soumis à des conditions de réchauffement et à des événements extrêmes **05/06/2024 11:00**

ID: 12127 Invited plenary speaker

The Gulf of St. Lawrence, undergoing warming conditions and extreme events

Peter Galbraith [1]

[1] **Fisheries and Oceans Canada**

Presented by / Présenté par: ***Peter Galbraith***
Contact: Peter.Galbraith@dfo-mpo.gc.ca

The Gulf of St. Lawrence is a semi-enclosed sea that is subject to rising

temperatures. Sea surface temperatures have been increasing; the May-November averages of the last three years were the warmest of the satellite record and marine heat waves have been stronger and more frequent. In winter, the Gulf can become completely covered by sea ice and nearly half of its volume of water usually gets cooled to temperatures below -1C within the winter mixed layer. But winter air temperatures have been warming at nearly twice the rate of other seasons. In the 15-year period since 2010, 10 of the 15 weakest recorded sea ice seasons have occurred. In the historical records, the Gulf has been nearly free of sea ice during 6 winters, and 4 of them have occurred in this 15 year time span. The winter mixed layer gets capped in spring, creating a cold intermediate layer that persists until late fall that determines the bottom temperature habitat over large areas. This layer has been warming and decreasing in volume since 1990 with large inter-annual variability. On two recent occasions, post-tropical storms Dorian and Fiona have disrupted the water column and mixed heat down to 45 m. Changes deeper in the water column have been even more startling. Waters deeper than roughly 150 to 200 m are entrained inwards from the continental slope by estuarine circulation, taking several years to reach the heads of the Gulf deep channels while mixing and diffusion occurs. This layer has been warming since 2009 at 300 m depth to reach 100-year record highs, up to 7.1C in 2022.

Poster Session

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11949 Contributed abstract

Poster Order: 2010P01

Our changing understanding of Canada's tornado climatology

David Sills [1]

[1] Northern Tornadoes Project @ WesternU

Presented by / Présenté par: ***David Sills***
Contact: dave.sills@rogers.com

The tornado climatology of Canada has been studied at the national level for decades, and it has evolved significantly over that time due to developing scientific knowledge (e.g. tornadoes vs downbursts), an increase in available data (e.g. high-resolution satellite imagery), and concerted efforts to update and improve our national tornado database. The latest such effort, the Northern Tornadoes Project, has used new assessment techniques and the latest technologies, social media-based crowdsourcing, and a nationally consistent approach to achieve a high-quality data set and a closer approximation of the 'true' climatology, increasing the annual tornado count by more than 60% and improving the characterization of tornado damage. Several trends in occurrence, location and timing have begun to emerge and appear to be similar to that predicted by climate modelling studies for North America (with some important caveats). Lastly, new open-access data and tools are coming online that will assist with the determination of long-term trends.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 12053 Contributed abstract

Poster Order: 2020P01

Framing Extreme Precipitation Events in the Context of Cumulative Emissions

Travis Roger Moore [1]

[1] Concordia University

Presented by / Présenté par: ***Travis Roger Moore***
Contact: rain1290@aim.com

Extreme precipitation events are often-destructive forms of weather that, despite their infrequency, can lead to significant losses of human life and infrastructural damage. Such events are expected to increase in a warmer world as cumulative carbon emissions rise. However, this increase varies considerably across scenarios and spatial scales, especially with respect to the most extreme precipitation events. The Transient Response to Cumulative CO2 Emissions (TCRE) has proven to be a powerful metric to characterize the linear response of global mean temperature to

cumulative carbon emissions, and previous research has shown its potential applicability to other climate indicators, such as regional temperature and precipitation, and heat extremes. Using Coupled Model Intercomparison Project Phase 5 (CMIP5) model simulations, I quantify extreme precipitation indices of one-day maximum (Rx1day) and five-day maximum (Rx5day) events as a function of cumulative CO2 emissions. I first determine whether precipitation extremes respond linearly to cumulative CO2 emissions, at global to sub-global scales, using simple linear regression modelling. I then conduct a Generalized Extreme Value analysis to model the behavior of the most extreme values of Rx1day and Rx5day and show whether location parameter estimates and specified return levels can be approximated by regional TCRE values. Finally, I extend this analysis to estimate remaining carbon budgets for avoiding particular extreme precipitation levels. Overall, my results suggest that extreme precipitation work well within a TCRE framework, and that global and sub-global changes can be well approximated by a linear response to cumulative CO2 emissions, though with less robustly linear trends locally. My results further showed that location parameter estimates and return levels of Rx1day and Rx5day scale approximately linearly to increasing cumulative carbon emissions. My findings also show that remaining carbon budgets are generally small to avoid specified present-day 20-year and 100-year return levels, becoming commonplace events with global warming.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 12124 Contributed abstract

Poster Order: 2020P02

Estimation non-stationnaire des courbes intensité-durée-fréquence basée sur les précipitations simulées à haute résolution / Non-stationary estimation of Intensity-Duration-Frequency curves based on high-resolution simulated precipitation

Charles Marois [1]

[1]

Presented by / Présenté par: ***Charles Marois***
Contact: charles.marois@polymtl.ca

Les ingénieurs et professionnels en climatologie utilisent les courbes intensité-durée-fréquence (IDF) pour concevoir des infrastructures résistantes aux aléas hydrométéorologiques. Les courbes IDF décrivent la relation entre l'intensité, la durée et la période de retour des précipitations intenses en un lieu donné pour des durées d'accumulations s'échelonnant typiquement entre 5 minutes et 24 h.

De façon générale, l'incorporation des effets des changements climatiques s'effectue à l'aide de simulations climatiques. Dans le cas des courbes intensité-durée-fréquence (IDF) des précipitations, les données simulées par des modèles numériques de climat, intégrant les scénarios d'émissions de gaz à effet de serre, pourront être analysées jusqu'à la fin du 21e siècle. Cependant, ces données sont souvent biaisées, en partie à cause d'une résolution spatiale et temporelle trop grossière qui empêche une simulation précise des processus physiques. Par conséquent, elles ne peuvent pas être directement utilisées pour produire des courbes IDF.

D'abord, différents scénarios non-stationnaires sont étudiés. Le modèle incorporant le CO2 cumulé sous un scénario RCP 8.5 au paramètre d'échelle présente le meilleur ajustement aux données. Ensuite, les méthodes de post-traitement des précipitations simulées spécifiquement pour les extrêmes tels que Quantile Matching, Quantile Delta Matching et XCDF-t seront étudiées et comparées afin de réduire les biais. Enfin, les incertitudes pour chacune des méthodes seront combinées pour produire des courbes IDF et leurs incertitudes en climat futur.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11936 Contributed abstract

Poster Order: 2040P01

From Mild to Extreme Heatwaves: Examining Trends in North America

Élise Comeau [1] , *Alejandro Di Luca* [2]

[1] Université du Québec à Montréal (UQÀM)
[2] Université du Québec à Montréal (UQÀM)

Presented by / Présenté par: ***Élise Comeau***
Contact: comeau.elise@courrier.uqam.ca

Several studies have shown that North American heatwaves have become more intense and more frequent over the course of the 20th century and early 21st century, and projections show further increases in the following decades. So far, limited research has focused on how the magnitude of these trends relates to the severity of heatwaves. In this study, we compare the trends of the most severe heatwaves (top tier) against those of less severe heatwaves (middle and bottom tiers). We use three heatwave intensity metrics (daily average, accumulated and daily maximum) for the whole of North America between 1940 and 2022, and we separate the analysis by season. We find that the magnitude of the trends of the most severe heatwaves is 2 to 4 times larger than that of the least severe heatwaves. We also find that the trends of the most severe heatwaves are more likely to be statistically significant than those of the least severe heatwaves by a factor of 2. This reveals that studies on simulations of future heatwaves should consider the severity of heatwaves in their projections.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11960 Contributed abstract

Poster Order: 2040P02

Characteristics of three exceptional atmospheric rivers impacting British Columbia's Nechako River Basin

Bruno Sobral [1] , *Stephen Dery* [2]

[1] University of Northern British Columbia
[2] University of Northern British Columbia

Presented by / Présenté par: ***Bruno Sobral***
Contact: sdery@unbc.ca

Atmospheric rivers (ARs) are known for their potential to cause or enhance natural hazards worldwide. In western Canada, ARs contribute chiefly to water replenishment, although specific AR events also cause great damage to the region. The Nechako River Basin (NRB) is in the geographic center of British Columbia (BC) and is regularly affected by ARs, which prevail in the fall and winter. Therefore, this study analyzes the climatology associated with high AR-related precipitation events affecting the NRB. Historical data are sourced from ERA5, ERA5-Land (hourly) and SIO-R1 (six-hourly) from 1950 to 2021. A criteria-based ranking system is employed to select ARs that resulted in elevated average precipitation totals in the NRB and the Upper Nechako sub-basin, where the Nechako Reservoir is managed for hydropower production and ecological flows. The three most significant events, with precipitation totals exceeding 70 mm in the Upper Nechako and 40 mm in the NRB, are chosen for further analysis. The selected AR events are: (1) 12-14 December 1952, (2) 28 October – 1 November 1978, and (3) 28-31 October 2009. Using data from the ERA5 and ERA5-Land Reanalysis products, a climogram and accumulation maps for each event are created. The AR event of 1952 lasted 54 hours in winter conditions and precipitation in the Nechako Reservoir was 87% snow, compared to 81% snow in 1978 and 55% in 2009 occurred in the fall. Peak convergence and precipitation tend to occur at the same time in all events with 1978 and 2009 possibly impacted by two sequential ARs, while 1952 had one. The findings are expected to provide insights into the regional climatology of AR events that cause extreme precipitation in the region, thereby enhancing awareness and preparedness for these phenomena affecting the NRB and to guide Nechako Reservoir water management during extreme hydrometeorological events.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11939 Contributed abstract

Poster Order: 2040P03

Human-induced climate change has increased the risk of extreme winds like those observed in post-tropical storm Fiona in Atlantic Canada

Elizaveta Malinina [1], *Nathan Gillett* [2], *Karen Garcia Perdomo* [3], *Chris Fogarty* [4]

[1] Environment and Climate Change Canada (ECCC)
[2] Environment and Climate Change Canada (ECCC)
[3] Environment and Climate Change Canada (ECCC)
[4] Environment and Climate Change Canada (ECCC)

Presented by / Présenté par: ***Elizaveta Malinina***
Contact: elizaveta.malinina-rieger@ec.gc.ca

In late September 2022, the Atlantic Hurricane Fiona transitioned to a post-tropical cyclone making a landfall in the Canadian Maritime provinces, setting a new national lowest pressure record and causing more than 800m CAD in insured damage, making it the most expensive storm of its kind in Canadian history. While the landfall of Fiona in Canada was associated with precipitation, a commonly used variable in event attribution, most destruction associated with the event was caused by high winds. This talk describes an event attribution of extreme windspeed using CMIP6 high resolution atmosphere model (HighResMIP) simulations and ERA5 reanalysis data, including a discussion of the choice of the appropriate windspeed frequency and variable for the analysis along with the method we used to address these issues. Based on our best

estimate using ERA5 data, the maximum hourly windspeed associated with Fiona was approximately a 1 in 100 year event in Atlantic Canada. HighResMIP simulations exhibit a statistically significant increase in the probability of extreme maximum windspeeds in the Maritimes in the current climate (2008-2037) in comparison to the climate of 1950-1979, indicating that human-induced climate change has increased the probability of extreme windspeeds, like those observed in post-tropical storm Fiona, in Atlantic Canada.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 12069 Contributed abstract

Poster Order: 3010P01

Subseasonal Prediction of Quasi-stationary Rossby waves during Winter

Lualawi Mareshet Admasu [1] , *Rachel White* [2]

[1] University of British Columbia
[2] University of British Columbia

Presented by / Présenté par: ***Lualawi Mareshet Admasu***
Contact: ladmasu@eoas.ubc.ca

Quasi-stationary Rossby Waves (QSWs) have been shown to modulate the strength of temperature extremes in the midlatitude regions. QSWs tend to last in one region for several days, providing a unique opportunity to improve subseasonal forecasts of extreme events. Here, we evaluate the predictability of QSWs and their relation to potential sources of predictability such as sea surface temperatures in the ECMWF dynamical forecast model in the midlatitude region winter months. As expected, the forecast skill shows a large decline with increasing lead time; however, some skill remains at the subseasonal timescale, particularly over the Pacific region. Furthermore, the skill shows large interannual variability that has some linkage with potential predictors. Building on this, we construct a statistical forecast model that predicts QSW amplitude in North American winter at 14-28 days lead time using identified predictors. The model outputs are evaluated against observed data using different skill scores and compared against the skill of dynamical forecast models.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11967 Contributed abstract

Poster Order: 3040P01

Elevating Awareness: Encouraging the Uptake of National Hydrometeorological Standards

Ted Weick [1] , *Adrienne Yuen* [2] , *Kristine Confalone* [3] , *Ire Oluwasola* [4]

[1] BC Ministry of Environment and Climate Change Strategy
[2] Climate Resilience & Sustainability, Standards Council of Canada
[3] MSC, ECCC
[4] Data Governance & AI, Standards Council of Canada

Presented by / Présenté par: ***Ted Weick***

Contact: ted.weick@gov.bc.ca

Four national standards to support hydrometeorological monitoring have been developed and represents a major step forward for support of regional, provincial and national hydrometeorological monitoring operations. Developed under a project described in Weick et al. (2021) and funded by the Standards Council of Canada (SCC), the four national standards outline how Canadian hydrometeorological networks should approach siting and operations, make data available, report metadata and initiate a quality assurance program. The standards are meant as guidance for network operators and data users to improve the understanding of data quality and fitness for use.

Adoption of these standards will take time and require concerted efforts by existing network operators. It's likely that the practical information will be adopted first (i.e., sensor siting and operation, and data transmission standards) and the more qualitative information adopted last. Improving awareness of the standards both within the public and private sectors is important to ensure adoption and currency. In this session four awareness posters developed SCC to help existing network/station operators and those agencies that wish to undertake monitoring information about the standards and how they can help for efficient operations.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11954 Contributed abstract

Poster Order: 4010P01

A call for improved monitoring in small systems across the northern peat and boreal environment

Kavi Heerah [1] , *Kailee Clarke* [2] , *Heather Reader* [3]

[1] Memorial University of Newfoundland
[2] Memorial University of Newfoundland
[3] Memorial University of Newfoundland

Presented by / Présenté par: ***Kavi Heerah***
Contact: kmheerah@mun.ca

Canada is home to boreal and peat environments; regions that act as significant stores of carbon holding 28 Pg across soil, biomass and organic matter. These regions serve as sources of carbon and metals to the coastal environment through the numerous rivers draining the lands. Carbon export has been increasing from boreal regions due to warming, changing land use, and reduced acidification. Hurricanes have been making their way further north with Hurricane Larry arriving to the shores of Newfoundland in 2021. While storms are normal to Newfoundland, Larry made landfall at a time not typically associated with storm events. Storm events can transport a significant amount of the annual budget of rivers affecting annual dynamics. The well predicted path of Hurricane Larry allowed us to sample three catchments of varying size and landcover before and after the storm. We saw increases in carbon, colour and iron exported from all three rivers but the changes in export varied due to subtle landcover differences. South River, with a smaller amount of peat and wetlands experienced the greatest increase exporting 4.32 times its baseflow export. Due to

poor road conditions and the timing of the storm we were unable to sample during the initial peak in discharge or sample peaks occurring after sampling. This prevented a full understanding on the fate of carbon exported following the storm. Automatic sensors are used to monitor large systems, but recent research has highlighted the importance of small systems leading to underestimations of fluxes. These small systems experience greater increases in storm fluxes due to their small size and lower catchment complexity. As storms become more frequent and reach further north it is essential that Canada has a robust monitoring system to monitor the numerous small systems draining into the coastal environment.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11962 Contributed abstract

Poster Order: 4010P02

Shelf-Slope Front north of the Gulf Stream: An Objective Detection Method

Shiliang Shan [1] , *Francois Rivest* [2] , *Blair Greenan* [3] , *Junsung Lee* [4]

[1] Department of Physics and Space Science, Royal Military College of Canada
[2] Department of Mathematics and Computer Science, Royal Military College of Canada
[3] Bedford Institute of Oceanography, Fisheries and Oceans Canada
[4] Department of Physics and Space Science, Royal Military College of Canada

Presented by / Présenté par: ***Shiliang Shan***
Contact: Shiliang.Shan@rmc.ca

Ocean fronts exhibit intensified motion and sharp thermal/salinity gradients. The Shelf-Slope Front (SSF) north of the Gulf Stream functions as a narrow boundary that separates the colder and less-saline subpolar waters from the warmer and more-saline subtropical waters. Understanding and forecasting the SSF is imperative for environmental monitoring, fisheries management, and climate research. An analysis of the latitudinal positions of the SSF from 1973 to 2017 based on satellite remotely sensed sea surface temperature was produced by the Atlantic Zone Monitoring Program (AZMP) at Fisheries and Oceans Canada. In this study, we propose an objective detection method for the SSF using the ARMOR3D sea surface temperature data product (Multi Observation Global Ocean Analysis) to obtain the monthly positions of the SSF. The objective detection method is validated and refined by comparing the SSF visually determined for the period of 1992-2017 from the AZMP program. Furthermore, we explore the trend and variability of the SSF based on the newly extended dataset covering the past 50 years (1973-2023).

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11985 Contributed abstract

Poster Order: 4010P03

Surface drift and dispersion in the Laurentian Channel during the passage of Hurricane Dorian

Graig Sutherland [1]

[1] ECCC

Presented by / Présenté par: ***Graigory Sutherland***
Contact: graigory.sutherland@ec.gc.ca

In August of 2019, 10 surface drifters were deployed in the Laurentian channel to investigate the drift and dispersion in the region. One week after deployment, Hurricane Dorian happened to track very close to this deployment with the centre of the hurricane passing about 500 km to the west of the drifter deployment. Hurricane Dorian brought wind gusts over 100 km/h and significant wave heights of 10 m to the region. These drifters offer a unique opportunity to study drift and dispersion in a coastal region during a high-wind event. Presented are analyses of the drift and dispersion characteristics of the surface drifters before and after the passage of Hurricane Dorian.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 12021 Contributed abstract

Poster Order: 4010P04

Dynamical shifts in the California Current System as drivers of biogeochemical variability in a semi-enclosed coastal sea.

Becca Beutel [1] , *Susan Allen* [2] , *Parker MacCready* [3]

[1] University of British Columbia, Earth Ocean and Atmospheric Science
[2] University of British Columbia, Earth Ocean and Atmospheric Science
[3] University of Washington, School of Oceanography

Presented by / Présenté par: ***Becca Beutel***
Contact: bbeutel@eoas.ubc.ca

The Salish Sea is a semi-enclosed coastal sea between Vancouver Island and the coast of British Columbia and Washington State, invaluable from both an economic and ecologic perspective. Pacific inflow to the Sea, strongly influenced by the California Current System (CCS), is the main contributor of many biologically important constituents. Climate change induced changes to CCS dynamics, such as alterations in California Undercurrent depth, upwelling and downwelling strength and timing, and Pacific Subarctic Upper Water intrusion, have direct implications for Salish Sea inflow. However, the extent of this connection and the Salish Sea's vulnerability to specific changes remain unknown. This study explores the contribution of Pacific water masses to Salish Sea inflow in relation to variability of CCS dynamics. We conducted quantitative Lagrangian particle tracking experiments to 3D physical-biogeochemical ocean models of the Salish Sea and surrounding coastal waters. Water parcels were integrated backwards in time to assess water mass path (and their biogeochemical properties while on this path) from the shelf region to the Salish Sea with unprecedented accuracy. Our study aims to identify the main drivers of Salish Sea biogeochemical variability in the context of CCS changes. By doing so, we contribute valuable insights to the understanding of the intricate interplay between physical and biogeochemical processes in this coastal sea, with implications for upwelling systems worldwide.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 12062 Contributed abstract

Poster Order: 4010P05

Characterizing cold intermediate layer variations on seasonal timescales on the Newfoundland and Labrador Shelf

Heather Andres [1] , *Nancy Soontiens* [2] , *Jared Penney* [3] , *Frederic Cyr* [4]

[1] Fisheries and Oceans Canada
[2] Fisheries and Oceans Canada
[3] Fisheries and Oceans Canada
[4] Fisheries and Oceans Canada

Presented by / Présenté par: ***Heather Andres***
Contact: heather.andres@dfo-mpo.gc.ca

Across the Newfoundland and Labrador (NL) Shelf, water temperatures at intermediate depths remain below 0C throughout the summer, even when the surface is much warmer. This cold intermediate layer (CIL) is a characteristic feature of summer-time conditions in many sub-Arctic seas and their continental margins. Intermediate water properties are established via winter mixing and are preserved during the spring and summer after restratification isolates these waters from the atmosphere. CIL water at a given site may have been formed locally, or it may have been formed remotely and advected there. In the second case, the water properties are primarily determined by the remote location's winter mixed layer, which may or may not differ from local winter conditions. How the balance between local formation versus advection, as well as differences in winter conditions at local and remote formation regions, contributes to variations in CIL area, depth and extent across the NL shelf throughout a year has not been investigated previously. We use the GLORYS12 global ocean reanalysis and Atlantic Zone Monitoring Program data to assess their importance to seasonal variations in CIL properties at multiple locations on the NL shelf. A better understanding of these seasonal variations is fundamental for optimizing long-term monitoring efforts and interpreting their results.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 12043 Contributed abstract

Poster Order: 5010P01

On the impact of the latent heat release on the accumulated freezing rain at the surface

Sujan Basnet [1] , *Julie M. Thériault* [2]

[1]
[2]

Presented by / Présenté par: ***Sujan Basnet***
Contact: basnet.sujan@courrier.uqam.ca

Near-surface temperatures at near 0°C can lead to various forms of winter

precipitation. The type of precipitation that reaches the surface can influence the hydrology, snowpack variability to flooding. One such precipitation type is freezing rain, which is both dangerous and difficult to forecast. The forecasting challenge arises because it requires a particularly narrow range of temperature profiles in which it can form and its “self-limiting” nature. The latent heat generated from freezing of supercooled drops on subfreezing surface warms the atmospheric air near the surface. The goal of this study is to simulate the impact of the latent heat released associated with the freezing of supercooled drops at the surface during freezing rain on the type of precipitation reaching the surface. To do so, the Global Environmental Multiscale (GEM) 5.1.1 model coupled with the Predicted Particle Properties (P3) bulk microphysics scheme and the Canadian land surface scheme (CLASS) is used. To illustrate the impact of latent heat released from freezing rain, the 1998 Ice storm was simulated with and without the latent heat release during freezing rain. Since the latent heat is distributed between the surface and the atmosphere, adjustments to both components in the model were applied. For the surface, we incorporated the latent heat released into the surface energy balance in CLASS. For the atmosphere, we represented the increased in air temperature in the lowest model levels. Preliminary findings from the modification at the Gatineau airport, for example, showed a reduction in freezing rain accumulation from 81.3 mm to 66.1 mm, accompanied by an increase in rainfall from 6.26 mm to 21.73 mm. Also, the simulated 2-m air temperature exhibited an average increase of approximately 1°C over the freezing rain event. Furthermore, in regions experiencing significant cold air advection, no discernible alteration in precipitation type was observed. Overall, these findings underscore the importance of considering latent heat dynamics in atmospheric models.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 12123 Contributed abstract

Poster Order: 5020P01

Severe storms from the “Ring-of-Fire” weather pattern

Haizhen Sun [1]

[1]

Presented by / Présenté par: ***Haizhen Sun***

Contact: haizhen.sun@ec.gc.ca

A stagnant warm-core mid-level anticyclone dominated the central United States from Aug. 20th to Aug. 25th of 2023, which is known as the ‘’Ring-of-Fire” weather pattern associated with the dome of hot air east of the Rockies. A few stable waves tracked along a wavy frontal boundary to the northern periphery of the anticyclone, providing continuous forcing mechanisms to the development of repetitive severe thunderstorms over southwestern Ontario on Aug. 23 to 24th. A record-high moist and hot airmass further fueled these storms into well-organized nocturnal mesoscale convective system (MCS) and tornadic squall lines, resulting in damaging wind gusts and microbursts, significant flooding, and tornado over the Windsor-Essex county during the two-day period. This talk will mainly focus on the prediction of different thunderstorm types, their propagation, and associated threats, as well as how numerical weather models performed under this extreme convective weather event.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11933 Contributed abstract

Poster Order: 6030P01

GEMnet : sensitivity to hyperparameters, architecture and ensemble size

Vikram Khade [1] , *Alain Beaulne* [2]

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Presented by / Présenté par: ***Vikram Khade***
Contact: vikram.khade@ec.gc.ca

A Convolutional Neural Network (CNN) based simulator (GEMnet) for the 39 km resolution GEM model performing a 1.5-meter temperature 6-hour forecast is presented. The GEPS archives ensemble members (1-10) from January to July 2017-2023 are used for training and testing. These ensemble forecasts are produced by GEM. The analysis and 6-hour trials of the 1.5-meter temperature are extracted for the four synoptic hours every day and a dataset is prepared for training/validation (2017-2022) and testing (2023). Two different architectures for the CNN are explored. GEMnet 1.0 has 775K tunable parameters and GEMnet 2.0 has 3.3 million tunable parameters. Depending on the architecture, the training MSE loss converges after about 100 epochs.
The test RMSE for GEMnet 1.0 and GEMnet 2.0 are 1.6 and 1.45 degree celsius respectively. The RMSE on ocean is much lower than that over land. The training times for these are 5.6 and 6.6 minutes per epoch respectively on a single NVIDIA GPU. The training time for GEMnet 2.0 with 200 epochs is 21 hours. After training, GEMnet 2.0 executes 1240 6-hour forecasts in 13 seconds. The sensitivity of the results to hyperparameters like learning rate, the type of optimizer, activation, batch size and kernel size are presented. It is shown that though GEMnet is able to mimic the pattern of the temperature forecast from GEM it tends to smooth the forecast. Three separate training and testing experiments are run with different amount of data by using ensemble sizes of 10, 5 and 1. It is found that the GEMnet using only 1 ensemble member tends to overfit. It is shown that GEMnet forecasts are able to outperform persistence and climatology. Some future directions like using different loss function are discussed.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11941 Contributed abstract

Poster Order: 6030P02

Global Lightning Prediction with Ensemble Decision Trees Trained on a Large Dataset

Jerry Su [1] , *Dominique Brunet* [2] , *Robert Crawford* [3] , *John Hanesiak* [4] , *Mateusz <> Taszarek* [5]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada
[4] University of Manitoba

[5] Adam Mickiewicz University

Presented by / Présenté par: ***Jerry Su***
Contact: Dominique.Brunet@ec.gc.ca

Recent advancements in the field of machine learning (ML) have become a motivating factor for its applications to the complicated problem of lightning prediction. Unlike in the past where statistical models were trained with data associated with particular regions (such as countries or continents), we will present a baseline for global-scale lightning prediction using gradient boosting trees trained on data collected from locations all around the world. The dataset consists of 217 convective parameters computed from ERA5 reanalysis on 137 levels over 4230 global locations every 3 hours between 2014 and 2022 with associated lightning occurrence. The white box nature of simpler machine learning techniques like gradient boosting trees allows us to explore the most important convective features for lightning detection; and from such exploration, offer new insights into understanding the conditions for lightning occurrence. Lastly, we describe the limitations of this simpler modelling technique, this dataset and the general knowledge on how lightning occurs (in the tropics for instance); and how, with a proven baseline and new insights, this newly uncovered information can guide new machine learning-based solutions to better solve global-scale lightning prediction.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11942 Contributed abstract

Poster Order: 6030P03

Quality control of crowd-sourced hail reports with ensemble decision trees and Large Language Models

Hokyung Lee [1], *Dominique Brunet* [2], *Robert Crawford* [3]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada

Presented by / Présenté par: ***Hokyung Lee***
Contact: Dominique.Brunet@ec.gc.ca

The project showcases innovative approaches for enhancing the quality control of crowd-sourced hail reports with ensemble decision trees and Large Language Models (LLMs). In a first application, an XGBoost ensemble decision tree is trained on lightning observations, convective parameters derived from ERA5 reanalysis and a database of crowd-sourced hail reports. Binary and categorical classification for hail occurrence and severity are performed and the AI models are examined to highlight important features contributing to hail occurrences. For the second application, free-form notes gathered from crowd-sourced hail reports are processed by LLMs to automatically extract, validate or anonymize important information. The information extracted includes storm location, hail size (or reference object) and reported hail damage. Extracted storm locations are validated through a combination of GPT-4 and Google Maps API. A key aspect of the project is its focus on confidentiality, employing the Mistral-7B LLM run locally to filter out personal information from the dataset, ensuring privacy through automated data processing techniques. For these

applications, the use of AI-based techniques enhances both the quality of hail data and the efficiency of its preparation for downstream meteorological applications. Finally, the project provides an opportunity to explore the capabilities of closed-source and open-source LLMs to accurately process textual data for extracting information.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11943 Contributed abstract

Poster Order: 6030P04

CamWxAI: Opportunistic use of webcams for present weather detection with computer vision

Hokyung Lee [1] , *Dominique Brunet* [2] , *Robert Crawford* [3]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada

Presented by / Présenté par: ***Hokyung Lee***
Contact: Dominique.Brunet@ec.gc.ca

The CamWxAI project represents an automated image analysis technique employing state-of-the-art computer vision models to classify the precipitation type in webcam images. A dataset of images from 37 NavCanada cameras over 13 months with co-located manual observations was used to train and validate a MobileNet2 computer vision model. As a pre-processing step, webcam imagery was matched with METAR/SPECI reports and dark or unavailable images were filtered out to ensure data quality. This preliminary work sets the stage for the application of AI in identifying patterns in webcam images caused by weather. This was done by testing the flexibility of pre-trained models through fine-tuning for various weather phenomena. The project emphasizes explainable AI, aiming to make AI-driven predictions transparent and understandable through relevance maps and confidence levels. Experimental analysis of the AI's performance across different conditions and of its ability to generalize across camera observations were performed, aiming to determine robustness and adaptability in real-world forecasting scenarios. For future deployment, CamWxAI envisions integrating real-time predictions into a developmental website for the tens of thousands of airport and highway cameras across Canada.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11984 Contributed abstract

Poster Order: 6040P01

Changes in future convective storms over expansive lake areas in western Canada

Fei Huo [1] , *Yanping Li* [2] , *Zhenhua Li* [3]

[1] University of Western Ontario
[2] University of Western Ontario
[3] University of Western Ontario

Presented by / Présenté par: ***Fei Huo***
Contact: fhuo2@uwo.ca

Mesoscale convective systems (MCSs) induce intense winter precipitation in western Canada, contributing to a global trend of escalating economic damages from extreme weather events. The inadequate representation of MCSs in climate models with coarse resolutions has left the response of MCSs to a warming climate unknown. Here we employ convection-permitting climate model simulations to evaluate the impact of climate change on winter MCSs in western Canada. Under a high-emissions scenario, we observe a more pronounced increase in precipitation at the storm center compared to the overall rain system. Particularly noteworthy are MCSs exhibiting a substantial surge in storm center precipitation, primarily concentrated over expansive lake areas in western Canada. Canada is known for its abundant surface fresh waters as a percentage of area. These identified changes substantially elevate the risk of future flooding over these expansive lake areas.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 12067 Contributed abstract

Poster Order: 7010P01

Combining population models and larval dispersal – a tool for sea lice management

John Phelan [1] , *Philip Gillibrand* [2] , *Alexander Murray* [3] , *Meadhbh Moriarty* [4] , *Tom Adams* [5] , *Keith Davidson* [6] , *Michael Burrows* [7]

[1] Univsersity of Highlands and Islands
[2] MOWI
[3] Scottish Government
[4] Scottish Government
[5] Scottish Sea Farms
[6] Univsersity of Highlands and Islands
[7] Univsersity of Highlands and Islands

Presented by / Présenté par: ***John Phelan***
Contact: jpphelan@tcd.ie

Control of sea lice, Lepeophtheirus salmonis, is one of the key management priorities for salmon aquaculture operators. The dispersal of sea lice larvae is driven by local hydrodynamic conditions. Understanding this movement is essential when looking at how aquaculture sites may be connected, with consequent impacts on the population dynamics of sea lice on their farmed salmon hosts.

We developed a sea lice population model which integrates on-farm dynamics with dispersal driven by local hydrodynamics, with the goal of investigating and disentangling the many factors affecting population development. Connectivity between sea lice populations on farms is driven in part by dispersal patterns and biological constraints. Infection rates derived from this dispersal model have been included in models of sea lice populations at farms at three interconnected sites as an example of a small network. The abundances of sea lice at each stage on farm sites were used to calculate the daily number of viable larvae being released from each site. The total number of larvae and the relative abundances of infective lice arriving in the

vicinity of each site were used to infer an absolute infection pressure. Analysis of deviance gives insight into model performance, estimating development rates of stages, mortalities, and successful attachment rates for sites. Understanding the rates of arrival (and subsequent attachment) of larvae using quantitative predictions will help identify key points in the production cycle where preventative measures would be best applied.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 12073 Contributed abstract

Poster Order: 7040P02

Development of MESH-CLASSIC and assessment of the model's water and carbon cycling capability in a catchment in Ontario

Daniel Mutton [1] , *M. Altaf Arain* [2] , *Dan Princz* [3] , *Bruce Davison* [4]

[1] McMaster University
[2] McMaster University
[3] Environment and Climate Change Canada
[4] Environment and Climate Change Canada

Presented by / Présenté par: ***Daniel Mutton***
Contact: muttond@mcmaster.ca

The MESH-CLASSIC model is a coupling of the Modélisation Environmentale Communautaire Surface and Hydrology system (MESH) hydrologic model, and the Canadian Land Surface Scheme Including Biogeochemical Cycles (CLASSIC) land surface model. It was developed for the purpose of investigating the impact of hydrologic processes on biogeochemistry at the site and catchment scale and builds upon previous work to couple the Canadian Terrestrial Ecosystem Models (CTEM) to MESH, with the ultimate goal of succeeding the MESH (with CLASS physics) hydrologic model for use within ECCC and by the Canadian hydrological modelling community. To evaluate model performance, MESH-CLASSIC has been run at four flux tower sites in Southern Ontario, including three different-age managed conifer forest sites, one deciduous forest site and an agricultural site in the Big Creek catchment area. MESH-CLASSIC's model performance will be compared with the observed flux data at site level and the simulations from the uncoupled MESH model for carbon, water and energy at catchment scale.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 11955 Contributed abstract

Poster Order: 7040P03

Revisiting the physical explanation behind the Saguenay 1996 flood and analysis of added value from convection-permitting regional climate model

SOUMIK GHOSH [1] , *Philippe Lucas-Picher* [2] , *Philippe Roy* [3] , *Philippe Gachon* [4] , *Alejandro Di-Luca* [5]

[1] Centre for the Study and Simulation of Regional-Scale Climate (ESCER Centre),

University of Quebec in Montreal (UQAM), Montreal, QC, Canada.
[2] Centre for the Study and Simulation of Regional-Scale Climate (ESCER Centre), University of Quebec in Montreal (UQAM), Montreal, QC, Canada.
[3] Institut de recherche d'Hydro-Québec, Montreal,QC, Canada
[4] Centre for the Study and Simulation of Regional-Scale Climate (ESCER Centre), University of Quebec in Montreal (UQAM), Montreal, QC, Canada.
[5] Centre for the Study and Simulation of Regional-Scale Climate (ESCER Centre), University of Quebec in Montreal (UQAM), Montreal, QC, Canada.

Presented by / Présenté par: ***Soumik Ghosh***
Contact: soumik.ghosh@fulbrightmail.org

Investigating the 'Saguenay 1996 flood,' one of Canada's most destructive natural disasters, has sparked our curiosity in understanding the interplay between large-scale and local meteorological factors during this extreme event. Employing the high-resolution (2.5km) CRCM6/GEM5 model developed at UQAM (ESCER), our objectives encompass unraveling the mechanisms behind this calamitous event and determining the added value of utilizing a convection-permitting climate model. Our primary aim is to discern the impact of large-scale meteorological phenomena versus local-scale factors on the characteristics of this flood event. Initially, we concentrate on configuring the climate model over the extended North American CORDEX Domain at a 12km resolution, with a smaller domain centered over Quebec at a 2.5km resolution. Subsequently, we assess the CRCM6/GEM5 model's performance in replicating the flood event, incorporating the P3 microphysics scheme, ERA5 initial conditions, and surface boundary conditions from ERA5 reanalysis or a pre-existing CRCM6/GEM5 long-term simulation at 12 km. Simulations, with and without spectral nudging, are conducted. Additionally, we evaluate the 2.5km resolution's added value by validating the model against Environment and Climate Change Canada weather stations, ERA5, and ERA5-Land data. This comprehensive validation process aims to identify the optimal model configuration demonstrating superior accuracy in reproducing the catastrophic flood event. Our scrutiny extends to examining the impact of spectral nudging on simulating precipitation extremes and its influence on the representation of large-scale atmospheric circulation patterns during this summer flood.

Session: 9010 POSTER SESSION AFFICHES

05/06/2024 12:15

ID: 12036 Contributed abstract

Poster Order: 8020P01

Deriving Gridded Ocean Surface Currents from Observed Drifting Buoys to Evaluate GLORYS12 on the Newfoundland and Labrador Shelf

Jennifer Holden [1] , *Heather J. Andres* [2] , *Nancy Soontiens* [3]

[1] Fisheries and Oceans Canada
[2] Fisheries and Oceans Canada
[3] Fisheries and Oceans Canada

Presented by / Présenté par: ***Jennifer Holden***
Contact: jennifer.holden@dfo-mpo.gc.ca

Drifting buoys provide a low-cost means of evaluating the ability of ocean models to accurately predict the paths that drifting objects will take in the ocean. While the use of

data from drifting buoys is currently an active area of research, the best way to reconcile differing Lagrangian and Eulerian perspectives is still unclear. Systematically comparing gridded observational data against gridded model equivalents can help address this challenge. Yet, in the case of velocities derived from observed drifting buoys, uncertainty exists about the most effective means of carrying out these comparisons. This study introduces a novel method for gridding observed drifter velocities as a complement to existing approaches. The method computes effective velocities based on the straight-line distance and time between observed drifter entry and exit points within model grid cells allowing for direct comparisons with modelled velocities. To validate the method, we applied it to SVP drifting buoys off the Newfoundland and Labrador Shelf and compared the observed velocities to gridded model output from the GLORYS12 ocean model. The results offer insights into regional currents during the study period while also exploring the usefulness of gridded drifter velocity products in validating ocean model currents.

Session: 2043 Weather and Climate Extremes - General - Part 4 Extrêmes météorologiques et climatiques - Généralités - Partie 4

Convenor:
Elizaveta Malinina (Environment and Climate Change Canada)

This session is for topics related to extremes that are not covered by other sessions in Theme 2.

Session: 2043 Weather and Climate Extremes - General - Part 4
Extrêmes météorologiques et climatiques - Généralités - Partie 4 **05/06/2024 14:05**

ID: 12049 Contributed abstract

Modulating the urban heat island by synoptic patterns and their intensification with heat waves over Mexico Basin.

Lourdes Aquino [1], *Beatriz Ortega* [2], *Arturo Quintanar* [3], *Carlos Ochoa-Moya* [4], *Fernando Durango* [5], *Erika López* [6], *Yanet Díaz* [7], *Yosune Miquelajauregui* [8]

[1] ENCiT UNAM
[2] ENCiT UNAM
[3] ICAyCC UNAM
[4] ICAyCC UNAM
[5] FI UNAM
[6] ICAyCC UNAM
[7] Heinrich-Böll-Stiftung
[8] IE LANCIS UNAM

Presented by / Présenté par: ***Lourdes Aquino***
Contact: lourdesaquino@atmosfera.unam.mx

Heat waves (HW), combined with the heat island phenomenon (UHI), pose a serious threat to human health. Therefore, under climate change, it is relevant to investigate

the combined modulation of synoptic patterns and urbanization for the Valley of Mexico, in this region one of the most populated cities in the world is located. Under heatwave conditions the combined UHI and HW events can alter the heat stored in the valley, the partitioning of surface flows, and the ventilation in the valley. In this research, by using surface observations, simulations, and an objective classification of synoptic patterns (WT), we analyze which synoptic pattern allows the maximum intensification of the UHI, and the combined effect of UHI-HW during the dry season of the year for 1990-2019 and the impact on thermal comfort under an urbanization scenario for 2060. Three WTs dominate the intensification of UHI events. These WTs leave subsidence, clear skies, large amounts of surface radiation, and calm winds. The combined effect of UHI-HW intensifies in the synoptic patterns associated with the displacement of a Rossby wave in mid-latitudes that allows warm advection from the southeast of the country and intensification of 0.5°C degree concerning the events without HW for these WT and usually occur in the warm dry season (March to May) of the year. The urban effect on the combined UHI-HW phenomena, when considering urban growth by 2060, injects 50% more heat into the atmosphere into the atmospheric boundary layer during the afternoon, associated with the warming rate, the height of the boundary layer increases, leading to more ventilation and greater risk of fire dispersion. The hotter and dryer environment reduces thermal comfort conditions.

Session: 2043 Weather and Climate Extremes - General - Part 4
Extrêmes météorologiques et climatiques - Généralités - Partie 4 **05/06/2024 14:20**

ID: 11979 Contributed abstract

Efficacy of gridded datasets in representing climate extremes across British Columbia.

Aseem Raj Sharma [1] , *Colin Mahony* [2]

[1] FFEC, FCCSB, OCF, BC Ministry of Forests
[2] FFEC, FCCSB, OCF, BC Ministry of Forests

Presented by / Présenté par: ***Aseem Raj Sharma***
Contact: Aseem.Sharma@gov.bc.ca

British Columbia (BC) is experiencing extreme climate events including flooding, heatwaves, droughts, and devastating wildfires that pose substantial risks to ecosystems and ecological processes. Access to reliable and consistent climate data is crucial for understanding and adapting to climate extremes. This is especially important in BC, where paucity of observed data occurs due to challenging topography and remote locations. Consequently, gridded climate data emerge as alternatives for comprehending historical and anticipated changes in climate extremes. While various gridded climate datasets are available, their performance evaluation, especially in accurately representing spatial variations in climate extremes, is constrained. In this study, we aim to address this gap by investigating (i) the extent to which gridded datasets depict mean and extreme climates in BC, (ii) the efficacy of gridded datasets in representing elevational climate gradients in the region, and (iii) the influence of spatial resolution on the accuracy of gridded data.
We evaluate the performance of five commonly used, relatively high-resolution gridded datasets, namely ERA5Land, Daymet, MSWX, WRF-CTL, and CHELSA that consist daily minimum and maximum temperatures and precipitation data for BC. We calculate

mean and extreme climate indices for observed and gridded datasets. Utilizing statistical analysis, visual tools, and multi-criteria decision analysis, we evaluate the performance and rank each dataset against observations across different elevation bands and for BC as a whole. Preliminary findings indicate variations among datasets in representing climatology and extremes. MSWX performs better at higher elevation bands, while Daymet exhibits enhanced accuracy at lower elevations. This study provides valuable insights to assist climate data users in selecting appropriate gridded datasets based on their specific region of interest and the purpose of their work.

Session: 2043 Weather and Climate Extremes - General - Part 4
Extrêmes météorologiques et climatiques - Généralités - Partie 4 **05/06/2024 14:35**

ID: 11993 Contributed abstract

Using observations and newspapers to distinguish between extreme and disruptive weather events in Southern Quebec

Victoria Slonosky [1], *Frédéric Fabry* [2], *Renée Sieber* [3], *Gordon Burr* [4], *Yumeng Zhang* [5], *Alyssa Conlon* [6], *Munchen Wang* [7], *Antoine Rehberg* [8]

[1] McGill University
[2] McGill University
[3] McGill University
[4]
[5]
[6]
[7]
[8]

Presented by / Présenté par: ***Victoria Slonosky***
Contact: frederic.fabry@mcgill.ca

Do extreme events, as determined from meteorological observations, necessarily correspond to the disruptive events that affect day-to-day lives? Extreme events, as defined by their rarity or percentile level of the meteorological data, may or may not be disruptive, whereas some ordinary events can nevertheless cause considerable inconvenience or damage. An example of a non-extreme disruptive event would be repeated winter freeze-thaw cycles leading to dangerously icy surfaces and the accidents these cause. In the absence of a recognized database for disruptive events, we postulate that they can be determined by the extent with which they are being commented upon in the media. We hence sought to compare and contrast extreme and disruptive events in Southern Quebec. We also wanted to see how perceptions of and responses to disruptive events evolved over time by contrasting a period in the past (1880-1899) with the present (1995-2014).

We briefly discuss the steps to construct a database of disruptive events using keyword analysis on newspaper articles. We then compare timelines of disruptive events to time series of extreme events as determined by statistical analysis of meteorological station observations.

The combination of both social and meteorological information creates a comprehensive view of disruptive, high impact and extreme weather events from both the meteorological, data-driven view and the human, social angle. We examine case

studies of disruptive events to look in more detail at the meteorological conditions and descriptions of their effects. In these case studies, changes in impacts, vulnerabilities and resiliencies are seen through the vocabulary of the newspaper articles. Analysis of the newspaper records suggests that flooding events are the most written about and have the highest disruptive impact in both historical and modern times. Winter storms, while of comparable severity, seem to be more disruptive in modern times than in the past.

Session: 2043 Weather and Climate Extremes - General - Part 4
Extrêmes météorologiques et climatiques - Généralités - Partie 4 **05/06/2024 14:50**

ID: 12016 Contributed abstract

AI for past and future glimpses into vulnerabilities and resilience related to newspaper reports of disruptive weather

Renee Sieber [1], *Frédéric Fabry* [2], *Victoria Slonosky* [3], *Muchen Wang* [4], *Yumeng Zhang* [5]

[1] McGill University
[2] McGill University
[3] McGill University
[4] McGill University
[5] McGill University

Presented by / Présenté par: ***Renee Sieber***
Contact: renee.sieber@mcgill.ca

We use artificial intelligence (AI) to automatically identify trends in vulnerabilities and resilience to disruptive weather events. The AI is used to classify two 20-year tranches of articles (1880-1899 and 1995-2014) from Southern Quebec newspapers. Our assumption is that automation can reveal insights without applying preconceived ideas about how people coped in the past, cope in the present and how those coping mechanisms change over time.

Classification algorithms look for patterns in data, transforming them into concepts that improve situational awareness. They also require large volumes of digitized text. We encountered issues arising from digitization and optical character recognition of print newspapers (historical and current). Obtaining sufficient volume of relevant and quality digitized output proved to be an unexpected obstacle that complicated our analysis.

With the corpora, we can identify types of vulnerabilities and resilience. We began with unsupervised classification, Latent Dirichlet Allocation (LDA). Unsurprisingly LDA generated considerable noise (metaphoric use of weather) and hockey. Because of data sparsity issues, we moved to generative pretrained transformers (GPTs). We started with the Bidirectional Encoder Representations from Transformers (BERT), which is one of the first and most widely-used large language models, BERT is pretrained on natural languages before we began exploring GPT 3.5.

Our results thus far include the type and predictability of events, and responses to and changes in responses to events. Compared to winter weather, floods were more frequently discussed in the newspapers. Snow/thaw/freeze sequences were examples of impactful events (e.g., hospital power outage, snow removal, use of indoor heaters,

time to change tires) for which society is often unprepared. In terms of vulnerabilities, results show consistencies across time (e.g., to agriculture, impacts on ice fishing) and differences (e.g., reliance on energy grids, use of ice bridges). We see new normals emerging, which suggest resilience.

Session: 2043 Weather and Climate Extremes - General - Part 4
Extrêmes météorologiques et climatiques - Généralités - Partie 4 **05/06/2024 15:05**

ID: 11989 Contributed abstract

Canadian Weather of the Past: Observations and Analyses of Past Weather and Climate Extremes from Historical Weather Records

Victoria Slonosky [1] , *Rachel Black* [2] , *Antoine Rehberg* [3]

[1] Open Data Rescue
[2] Halifax Provincial Archives
[3] McGill University

Presented by / Présenté par: ***Victoria Slonosky***
Contact: victoria.slonosky@mail.mcgill.ca

The Canadian Weather of the Past (CWP) project is, after over four years, coming to a close. The project is centred on discovering, safeguarding, and transforming into machine readable data Canadian weather records from past centuries. We catalogue and track the information with traceability and transparency built into the process. Over 1.9 million data records from 46 stations were entered, checked, and transformed into ISO units. The data records include not only standard weather and climate measurements, but also comments on the state of the environment. The process and extent of the project has been described previously; here the focus is on the uses of this data collection. We will explore the applications of this newly transcribed historical data set and what it has to tell us about past weather through weather mapping and statistical analysis.

Using these newly acquired data, we can start to look at the weather of the past and evaluate how it compares to that of today, giving us an indication of centuries-long climate change and variability. Variables collected and transcribed include pressure, temperature, precipitation, wind direction, cloud cover, humidity and wet bulb temperatures, and weather. These data are especially important when evaluating the frequency, or any changes in frequency, to extreme events. Although many of the records are fragmentary, there are enough instances of pressure and wind observations to take a preliminary look at the atmospheric dynamics associated with past extreme events. These new data will be compared to the existing 20CR analyses and will in turn be used to improve further the next generation of reanalysis products.

Session: 2043 Weather and Climate Extremes - General - Part 4
Extrêmes météorologiques et climatiques - Généralités - Partie 4 **05/06/2024 15:20**

ID: 12103 Contributed abstract

Understanding Extreme Weather Events in the Context of Climate Change: Analysis of MSC Public Alerts Data from 2012 to Present

Melissa MacDonald [1]

[1]

Presented by / Présenté par: ***Melissa MacDonald***
Contact: melissa.macdonald@ec.gc.ca

With the ever-increasing frequency and intensity of extreme weather events, there are attempts to correlate these events with climate change impacts. This presentation examines the Meteorological Service of Canada's (MSC) public and air quality alerts from 2012 to the present to show the trends of weather alerts in relation to climate change. What began as a visualization of the changing landscape of public alerts under the Health and Air Quality Forecast Services Program (Air Quality Alerts, mainly due to wildfire smoke, Heat Warnings, and Extreme Cold Warnings) evolved into analysis of all public weather alerts since 2012. MSC is faced with ever increasing demands for public alert information in support of climate change related research and public health, environmental health, and emergency management decision makers' climate change resilience and emergency response planning. It is assumed that by analyzing trends in alert issuance over time, trends can be used to plan for and explain the dynamics of extreme weather events and their potential connections to broader climatic shifts, such as increasing wildfire intensity and extreme heat events. However, simply correlating public alert data with climate change indicators may not always provide conclusive insights due to the evolution of public alert criteria, forecast practices over time, and the variation in potential impacts and severity associated with public alerts. Through examples, we will demonstrate how changes in alert thresholds and forecast practices have influenced the observed trends in alert frequency. These examples will highlight the challenges of working with MSC public alert data and how the data can support researchers and partners seeking information in relation to extreme weather events and climate change. Moving forward, the adoption of impact-based forecasting and tiered alert systems within the MSC offers promising avenues to enhance our understanding of event rarity and severity correlated with climate change. By integrating the assessment of societal impacts into alerting processes, we can better capture the complexities of extreme weather events and their changing nature, ultimately advancing our ability to adapt and respond to the challenges posed by a changing climate.

Session: 4030 Ocean - Theoretical to applied science Océan - De la théorie à la science appliquée

Convenor: Juliana Marson

Related to scientific studies and/or information sharing about the ocean, including studies in physical, chemical, and biological oceanography, ocean waves and storm surge using various approaches.

This session covers many topics, including, but not limited to, theoretical research, model development, observation techniques, real-time monitoring, databases, diagnostic methods, data analysis and artificial intelligence.

ID: 12055 Contributed abstract

Modelling Wave-Ice Interactions in Three-Dimensions in the Marginal Ice Zone of the Beaufort Sea

Will Perrie [1], *Michael Meylan* [2], *Bechara Toulany* [3], *Michael Casey* [4], *Yongcun Hu* [5]

[1] DFO, Bedford Institute of Oceanography
[2] School of Information and Physical Sciences, University of Newcastle, Australia
[3] DFO, Bedford Institute of Oceanography
[4] DFO, Bedford Institute of Oceanography
[5] DFO, Bedford Institute of Oceanography

Presented by / Présenté par: ***Will Perrie***
Contact: william.perrie@dfo-mpo.gc.ca

This study is about wave-ice interactions in the marginal ice zone (MIZ). We compare simulations using recent three-dimensional formulations for wave-ice interactions and the scattering of ocean surface waves by flexible ice floes, with older parameterizations and field observations. These parameterizations are implemented in a modern version of the wave model WAVEWATCH III®, as source terms in the action balance equation. Field observations consist of wave characteristics collected during the Arctic Sea State Boundary Layer Experiment of 2015 in the Beaufort Sea. Comparisons focus wave heights, 1-dimensional and 2-dimensional wave spectra and wave attenuation as the waves propagate into the MIZ. Results show that the new wave-ice formulations for wave-ice interactions provide an improvement compared to previous parameterizations, in the simulations of observation cases. Test cases include collinear winds and waves, and crosswinds to the waves, propagating into the MIZ.

Session: 4030 Ocean - Theoretical to applied science Océan - De la théorie à la science appliquée **05/06/2024 14:20**

ID: 11997 Contributed abstract

An overview of CONCEPTS Coupled Environmental Prediction Systems and their applications

Hal Ritchie [1], *Greg Smith* [2], *Fraser Davidson* [3]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada

Presented by / Présenté par: ***C. Harold Ritchie***
Contact: elritchie@bellaliant.net

Over the past few years, we have seen a significant maturing of the ocean prediction enterprise in Canada. Assisted by the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS), ice-ocean forecasting systems are progressing through research and development, technology transfer and operational

implementation at the Canadian Centre for Meteorological and Environmental Prediction (CCMEP). A fully coupled atmosphere-ice-ocean (AIO) forecasting system for the Gulf of St. Lawrence (GSL) was first implemented at CCMEP in June 2011. The GSL system was subsequently adapted for the Laurentian Great Lakes and coupled to a hydrological model. Global applications are supported by the Global Ice-Ocean Prediction System (GIOPS) that has been running in real-time at CCMEP since January 2013 and upgraded to operational status in August 2015. GIOPS was coupled with the operational atmospheric Global Environmental Multi-scale (GEM) model in November 2017 to become the first fully coupled AIO model used for operational medium-range weather forecasting. More recently there has been a full rollout of higher resolution systems: Regional Ice-Ocean Prediction System (RIOPS), Coastal Ice-Ocean Prediction System (CIOPS), Canadian Arctic Prediction System (CAPS), Water Cycle Prediction System (WCPS) and port-scale systems. New means of disseminating data to users are provided by the Ocean Navigator and Geomet. Ensemble prediction systems are also being developed and implemented, particularly with lower resolution AIO versions being used for coupled monthly and seasonal predictions.

Originally a collaboration amongst Environment and Climate Change Canada (ECCC), Department of Fisheries and Oceans (DFO), and the Department of National Defence (DND), the scope of CONCEPTS has been expanded with the inclusion of the Canadian Space Agency (CSA) and the National Research Council (NRC) as new partners.

Here we present an overview of recent developments and plans for these systems including their use in near-shore applications and ensembles for uncertainty estimates. Connections to related international activities will also be highlighted.

This presentation will be made on behalf of our colleagues in CONCEPTS, many of whom will be giving further details in companion presentations.

Session: 4030 Ocean - Theoretical to applied science Océan - De la théorie à la science appliquée **05/06/2024 14:35**

ID: 12096 Contributed abstract

Impact of Assimilation of Absolute Dynamic Topography on Arctic Ocean Circulation

Charlie Hebert-Pinard [1], *Gregory Smith* [2], *Audrey-Anne Gauthier* [3], *Francois Roy* [4], *Andrew Peterson* [5], *Pierre Veillard* [6], *Yannice Faugere* [7], *Sandrine Mulet* [8], *Miguel Morales Maqueda* [9]

[1] ECCC
[2] ECCC
[3] ECCC
[4] ECCC
[5] ECCC
[6] Collecte Localisation Spatiale
[7] Collecte Localisation Spatiale
[8] Collecte Localisation Spatiale
[9] University of Newcastle

Presented by / Présenté par: ***Charlie Hebert-Pinard***
Contact: Charlie.Hebert-Pinard@ec.gc.ca

The ocean circulation is typically constrained in operational analysis and forecasting systems through the assimilation of sea level anomaly (SLA) retrievals from satellite altimetry. This approach has limited benefits in the Arctic Ocean and surrounding seas due to data gaps caused by sea ice coverage. Moreover, assimilation of SLA in seasonally ice-free regions may be negatively affected by the quality of the Mean Sea Surface (MSS) used to derive the SLA. Here, we use the Regional Ice Ocean Prediction System (RIOPS) run operationally at the Canadian Centre for Meteorological and Environmental Prediction to investigate the impact of assimilating Absolute Dynamic Topography (ADT) fields on the circulation in the Arctic Ocean. This approach avoids the use of a MSS and additionally provides information on sea level in ice covered regions using measurements across leads.

RIOPS uses a coupled ice-ocean model on a 3-4 km grid-resolution pan-Arctic domain together with a multi-variate reduced-order Kalman Filter. The background error is modified to match the spectral characteristics of the ADT fields, which contain fewer small scales than traditional SLA due to filtering applied to reduce noise originating in the geoid product used. A series of four-year reanalyses demonstrate significant reductions in innovation statistics with important impacts across the Arctic Ocean. Results suggest that the assimilation of ADT can improve circulation and sea ice drift in the Arctic Ocean, and intensify volume transports through key Arctic gateways and resulting exchanges with the Atlantic Ocean. This study highlights the large uncertainties that exist in present operational ocean forecasting systems for the Arctic Ocean due to the relative paucity and reduced quality of observations compared to ice-free areas of the Global Ocean.

Session: 4030 Ocean - Theoretical to applied science Océan - De la théorie à la science appliquée **05/06/2024 14:50**

ID: 12042 Contributed abstract

Modeling the Baffin Bay Seasonal Freshwater Content and Budget

Luiz Henrique da Silva [1] , *Juliana Marson* [2] , *Paul Myers* [3]

[1] University of Manitoba
[2] University of Manitoba
[3] University of Alberta

Presented by / Présenté par: ***Luiz Henrique da Silva***
Contact: dasilvlh@myumanitoba.ca

Baffin Bay significantly contributes to transporting and transforming freshwater from the Arctic Ocean to the North Atlantic Ocean. Nevertheless, our understanding remains incomplete regarding the mechanisms involved in storing and dispersing of this freshwater within the bay before it leaves through Davis Strait. In order to investigate the freshwater content (FWC) seasonal variability in Baffin Bay, we used the Nucleus for European Modelling of the Ocean (NEMO, version 3.6) model coupled with The Louvain-La-Neuve sea ice model (LIM2) – at 1/4o horizontal spatial

resolution. We have analyzed the FWC annual budget within Baffin Bay, as well as its sources and sinks, and determined that there is a surplus influx of freshwater into the bay from May to September, while there is a FWC decrease in the remaining months. This cycle is primarily influenced by sea ice growth and melt. After considering all sources and sinks, we have found a residual positive value of 156.2 (± 86) km3, suggesting a gradual freshwater accumulation throughout the years. We have also applied the Empirical Orthogonal Function (EOF) analysis to examine the FWC variability in Baffin Bay. The first EOF represents 82.8% of the FWC's total variance and likely results from the melting of sea ice in central Baffin Bay and land runoff near coastal areas. Along the Baffin Island Current pathway, this mode appears to be predominantly driven by freshwater transport out of the bay associated with the current. The second mode, which accounts for 12.1% of the FWC's total variance, exhibits a heterogeneous spatial pattern, suggesting that various local physical forces such as wind-ice stress and inflow of Atlantic Water influence it.

Session: 4030 Ocean - Theoretical to applied science Océan - De la théorie à la science appliquée **05/06/2024 15:05**

ID: 12104 Contributed abstract

Modeling Iceberg Severity on the East Canadian Coast

Madhurima Chakraborty [1], *Juliana Marson* [2], *Paul Myers* [3]

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Presented by / Présenté par: ***Madhurima Chakraborty***
Contact: chakra12@myumanitoba.ca

Icebergs calved mainly from Greenland cross the shipping lanes in the Grand Banks (off the Newfoundland coast) and thus are considered threats to navigation. The observed iceberg occurrence in this region is highly variable, and the factors that might drive this variability include iceberg calving rates, environmental conditions along the icebergs' trajectory, and their deterioration rate. Existing studies are not unanimous about which of those factors plays a key role in determining the season severity (number of icebergs reaching Grand Banks). Moreover, the lack of observations outside of the International Ice Patrol's (IIP) reconnaissance region (approximately 30°N to 60°N, 35°W to 65°W) makes it difficult to determine what affects the icebergs' drift upstream of that region. In this study, we use simulation results from Nucleus for European Modelling of the Ocean (NEMO, version 3.6), an ocean-sea ice-iceberg coupled model (with a spatial resolution of 1/4°) to address that problem. First, we evaluate the model's representation of iceberg severity at the Grand Banks, the Labrador Shelf ocean temperature, and sea ice conditions over the Newfoundland coast and in Baffin Bay. Then, we analyze the relationship between those variables and the IIP-observed number of icebergs crossing 48°N. If a significant correlation is found, we will conduct a sensitivity study by switching off the influence of those variables in the modeled icebergs' drift and decay. This work is expected to highlight the parameterization(s) that should be prioritized when improving iceberg models that can be used to project the severity of the next iceberg season.

Session: 4030 Ocean - Theoretical to applied science Océan - De la théorie à la science appliquée **05/06/2024 15:20**

ID: 12111 Contributed abstract

Bring out your data! A new hydrographic data compilation for the Canadian Arctic and surrounding seas

Andrew Hamilton [1] , *Paul Myers* [2]

[1] University of Alberta
[2] University of Alberta

Presented by / Présenté par: ***Andrew Hamilton***
Contact: akhamilt@ualberta.ca

To understand the past and present state of the ocean in the Canadian Arctic and surrounding seas requires access to any and all available oceanographic observations. These observations are required to understand ocean climate trends, the spatial distribution of water masses, and changes to ocean properties and stratification in an era of rapid climate warming, and provide the essential means for ocean and climate model evaluation. To date, the challenge has been that what sparse observations do exist from the relatively poorly sampled Arctic regions have been archived across multiple different databases, in various formats, with varying degrees of quality control, or have simply not been made publicly accessible. We aimed to rectify this issue by searching for, acquiring, and compiling all available in situ ocean temperature and salinity profiles collected in the Canadian Arctic and surrounding seas over the past century. We present progress on the creation of a comprehensive, quality-controlled, standardized, and accessible database, which at present contains >90,000 ocean temperature and salinity profiles collected in the Canadian Arctic and Baffin Bay between 1908 and 2022. The database fills a persistent regional gap in observational data archives, and when combined with other regional data compilations contains >450,000 profiles spanning the pan-Arctic. We continue to solicit new data contributions to expand the ever-growing database which is becoming a valuable resource for ocean studies and model evaluation.

Session: 3020 Atmosphere, Ocean, and Climate Dynamics La dynamique de l'atmosphère, de l'océan et du climat

Convenors:
Mike Waite (University of Waterloo)
Marek Stastna (University of Waterloo)
Ron McTaggart-Cowan (Environment and Climate Change Canada)

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.

Session: 3020 Atmosphere, Ocean, and Climate Dynamics La dynamique de l'atmosphère, de l'océan et du climat **05/06/2024 14:05**

ID: 12013 Contributed abstract

Tagging water in an idealized aquaplanet model: the sensitivity of long range transport to dynamics an ocean heat transport

Robert Fajber [1]

[1]

Presented by / Présenté par: ***Robert Fajber***
Contact: robert.fajber@mcgill.ca

Water tags are Eulerian tracers that can be added to a model that partition water vapor by the source regions where it is evaporated from. Adding this diagnostic to a model allows a direct quantification of the effects of both resolved and parameterized dynamics on the distributions of atmospheric water vapor and precipitation, and the interactions between atmospheric dynamics and the hydrologic cycle. While previous studies have focused on including these diagnostics to realistic atmospheric circulation models, in this presentation I will discuss the addition of water tags to the Isca model, an idealized atmospheric dynamics model which can run with physical parameterizations and boundary conditions of varying complexity.

In the control simulation the water tags show an import role for long range transport; in the poles while the precipitation is sourced locally, the water vapor is sourced from remote sources of evaporation, revealing vertically separated polar air masses. Sensitivity tests show that the long range transport of water vapor is sensitive to the choice of convective parameterization, although the overall distribution of water vapor stays the same, suggesting that caution needs to be used when diagnosing long range transport. Changing the ocean heat transport impacts both the surface temperatures and the Hadley cell, which both act to reduce the transport distance of high altitude tropical water vapor, but increase the transport distance of water vapor evaporating in subtropics and midlatitudes. These prototype experiments provide a basis for understanding the effects of different circulation biases on the hydrological cycle in more complex models, and provide a platform for testing new hypotheses about the dynamical controls on the atmospheric water cycle.

Session: 3020 Atmosphere, Ocean, and Climate Dynamics La dynamique de l'atmosphère, de l'océan et du climat **05/06/2024 14:20**

ID: 12009 Contributed abstract

Backscatter in Radiative-Convective Equilibirum

Kwan Tsaan "Donald" Lai [1] , *Michael Waite* [2]

[1]

[2] University of Waterloo

Presented by / Présenté par: ***Kwan Tsaan "Donald" Lai***
Contact: ktlai@uwaterloo.ca

Subfilter energy transfer analysis at a filter scale of 4 km is performed in an idealized radiative-convective equilibrium simulation. A 1-km horizontal resolution simulation is filtered to a horizontal scale of 4 km to perform a priori analysis of subfilter energy transfer. Three filters are used for the calculation of the subfilter energy transfer: the box filter, the Gaussian filter, and the spectral cutoff filter. The results of the subfilter energy transfer calculated by the three filters will be discussed. The kinetic energy spectrum resembles the -5/3 spectrum in both the upper troposphere and the lower stratosphere. In the upper troposphere, the energy gain in buoyancy flux is balanced by the energy loss in the vertical flux. In the lower stratosphere, the energy gain in vertical flux is balanced by the energy loss in the transfer term. There is a direct inverse energy transfer in the upper troposphere and inverse energy transfer in the lower stratosphere.

Session: 3020 Atmosphere, Ocean, and Climate Dynamics La dynamique de l'atmosphère, de l'océan et du climat **05/06/2024 14:35**

ID: 11926 Contributed abstract

Climate Change and the Changing Dynamics of the Beaufort Gyre

Rosalie Cormier [1] , *Francis Poulin* [2]

[1] University of Waterloo
[2] University of Waterloo

Presented by / Présenté par: ***Rosalie Cormier***
Contact: rosaliecormier17@gmail.com

The Beaufort Gyre (BG) is one of the two major currents in the Arctic Ocean and is driven anti-cyclonically by surface winds. The transfer of momentum from the winds to the gyre is partially damped by the seasonally-fluctuating sea-ice cover, which has, on average, dramatically declined over recent decades. Wind forcing mixes the uppermost layer of the BG and skews the gyre’s isopycnal surfaces to create a strong vertical shear below the mixed layer. The baroclinic instability associated with this shear generates baroclinic eddies, which stir the water column and lift warm water from depth. Field measurements of the BG and data-assimilation models reveal that an increased upward heat flux correlates with recent sea-ice retreat in the BG region. This talk will explore the changing dynamics of the BG through two complementary approaches. First, we will chronicle the dynamics of the BG over the past several decades via an analysis of ECCO (Estimating the Circulation and Climate of the Ocean) model data. We will focus on how the temperature, density, and velocity profiles of the BG have changed, and how these changes correlate with the loss of sea ice. Second, we will present an idealized model of the BG, informed by our ECCO-data analysis, that can be simulated numerically using the Julia-language library Oceananigans.jl. We discuss how this model is used to more precisely parameterize baroclinic phenomena in the BG.

Session: 3020 Atmosphere, Ocean, and Climate Dynamics La dynamique de l'atmosphère, de l'océan et du climat **05/06/2024 14:50**

ID: 12101 Contributed abstract

Is the winter Beaufort High weakening under warming climate scenarios?

Minghong Zhang [1] , *Will Perrie* [2] , *Zhenxia Long* [3]

[1] Bedford Institution of Oceanography
[2] Bedford Institution of Oceanography
[3] Bedford Institution of Oceanography

Presented by / Présenté par: ***Will Perrie***
Contact: minghong.zhang@dfo-mpo.gc.ca

Using CMIP6 results and regional climate model simulations with climate scenarios SSP5-8.5 and SSP2-4.5, we show that the average sea level pressure (SLP) of the winter Beaufort High (BH) decreases by about 5hPa and 2hPa, respectively, by the end of the 21st century. These decreases are associated with reductions in the background SLP over the western Arctic. For example, the Arctic warming increases the surface evaporation and turbulent heat flux, and the resulting increase in the diabatic heating at the surface leads to rising motion and convergence, contributing to SLP reduction. However, the vorticity of the BH tends to intensify, which is associated with a northeastward displacement of the ridge over the Western Arctic, suggesting that the BH itself becomes stronger under warming scenarios such as SSP5-8.5. We suggest that it is necessary to take into account the dynamic aspects of the BH, such as vorticity.

Session: 3020 Atmosphere, Ocean, and Climate Dynamics La dynamique de l'atmosphère, de l'océan et du climat **05/06/2024 15:05**

ID: 11978 Contributed abstract

Analyzing North American Cyclones in Climate Models Through an Eulerian Approach

Alejandro Di Luca [1] , *Victorien De Meyer* [2]

[1] UQAM
[2] UQAM

Presented by / Présenté par: ***Victorien De Meyer***
Contact: de_meyer.victorien@uqam.ca

Global Climate Models (GCMs) are commonly used to provide lateral boundary conditions for Regional Climate Models (RCMs). While GCMs can accurately simulate large-scale and synoptic-scale conditions, they often struggle to represent fine-scale variables. This study proposes a novel method for selecting GCMs for dynamical downscaling, specifically focusing on studying wet extreme events over North America. The selection process is based on variables that reflect the model's ability to reproduce

large-scale and synoptic-scale conditions associated with extratropical storms that can lead to extreme precipitation or winds. An Eulerian approach is employed to identify synoptic-scale storms using the global reanalysis ERA5, 27 CMIP6 models, and a high-resolution regional climate model developed at the ESCER center at UQAM (CRCM6-GEM5), utilizing anomalous mean sea level pressure and anomalous near-surface humidity. These variables provide insights into the dynamics and thermodynamics of the extraopical storms, enabling the evaluation of the models' capability to accurately capture synoptic forcing and water vapor content. Additionally, a new theoretical model is developed to approximate the time series around the minimum pressure of the strongest storms at each grid point, allowing for the derivation of a simple error metric. The results show that the proposed method can effectively identify the best GCMs for replicating storm-related atmospheric conditions. This method can be applied to other regions, providing a more robust approach for the selection of GCMs for dynamical downscaling.

Session: 3020 Atmosphere, Ocean, and Climate Dynamics La dynamique de l'atmosphère, de l'océan et du climat **05/06/2024 15:20**

ID: 12002 Contributed abstract

Historical and Future Projections of the North American Jet Stream in Regional Climate Models

Yoandy Alonso [1] , *James King* [2] , *Biljana Music* [3] , *Hélène Côté* [4]

[1]

[2] Université de Montréal
[3] Ouranos
[4] Ouranos

Presented by / Présenté par: ***Yoandy Alonso***
Contact: yoandy.alonso@umontreal.ca

The jet stream, a critical component of atmospheric circulation, plays a central role in shaping regional and global climate patterns, affecting weather phenomena, air travel routes, and environmental conditions, including air quality. This study examines the future behavior of the jet stream using regional climate models.

In the North American domain, the CanESM2-CRCM5-OURANOS, CNRM-CM5-CRCM5-OURANOS, MPI-ESM-LR-CRCM5-OURANOS, and GFDL-ESM2M-CRCM5-OURANOS are compared with ERA5 to evaluate the frequency distribution of the jet stream and wind speed during 1980-2010. In addition, the study examines the position and intensity of the jet stream under future climate conditions by analyzing model output from NA-CORDEX under Representative Concentration Pathway (RCP) scenarios, specifically RCP4.5 and RCP8.5 for the period 2011-2100.

The preliminary results show that CRCM5-OURANOS exhibits high agreement with the reanalysis regarding the jet stream position and intensity. Analyses of the jet stream position and intensity under future climate conditions are currently under way.

Session: 5020 Atmosphere - Community, Service and Education Atmosphère - Communauté, Services et Éducation

Convenor: Serge Desjardins

Related to scientific studies and/or information sharing about the atmosphere, including weather, meteorology, clouds and precipitation, air quality, atmospheric dynamic and extreme events, using various approaches.

This session covers many topics, including but not limited to education, community science and data collection, data dissemination, and other activities such as forecasting and communicating weather-related risks.

Session: 5020 Atmosphere - Community, Service and Education
Atmosphère - Communauté, Services et Éducation **05/06/2024 14:05**

ID: 11914 Contributed abstract

The case of DRAW (Data Rescue: Archives and Weather): How a weather data rescue project became a participatory science archives by engaging student communities

Gordon Burr [1]

[1] McGill University School of Information Studies

Presented by / Présenté par: ***Gordon Burr***
Contact: gordon.burr@mcgill.ca

Created in 2015, the Data Rescue: Archives and Weather (DRAW) project has been using crowdsourcing to transcribe on our custom-built website millions of historical weather observations housed in handwritten ledgers found in the archives of the McGill Observatory in Montreal. Citizen scientists contribute their skills as interpreters and problem solvers when transcribing data. DRAW also acts as a participatory science archive working to engage the community through its social media presence and local crowdsourcing. A key element of the project focuses on DRAW as a pedagogical tool for junior colleges and in university courses.

As citizen scientists become more engaged in the DRAW project, some move towards a participatory science role. Knowledge exchange occurs more frequently and extensively where citizen scientists ask more in-depth questions about the historical context and impact of the weather. The participants took part in the creation of an online archive experience tied to a researcher generated narrative based on archival sources created directly by the user. Everyone who participates in DRAW makes the records they created available for weather research but also keeps under their username any data they have rescued.

University students were asked to do background research on participatory archives, transcribe scientific weather data on the DRA W website, as well as produce a blog entry with a related Instagram message tied to a weather-related theme.

In the participatory science level, DRAW citizen scientists ask about recorded casual phenomena (for example, notable events like Convocation days at McGill University or weather events such as aurora borealis. Citizen scientists have then added related historical information from other sources, or they work with one of the project leaders to define a new problem. The participatory science level leads to the bringing together of the weather (natural sciences) and history (social sciences) that augment the value

of the transcribed data.

Session: 5020 Atmosphere - Community, Service and Education
Atmosphère - Communauté, Services et Éducation **05/06/2024 14:20**

ID: 12102 Contributed abstract

MSC/COMET Applied Numerical Weather Prediction (NWP) Course: investing in the meteorologists of today, preparing for the impact and probability based forecasting of the future.

Robyn Dyck [1], *Rares Gheti* [2], *Bryan Guarente* [3], *Michelle Hardy* [4], *Adam Hirsch* [5], *Lee-ann Simpson* [6], *Andrea Smith* [7], *Alissa Steeves* [8], *Camilly Wong* [9]

[1] ECCC
[2] MSC
[3] The COMET Program
[4] MSC
[5] The COMET Program
[6] The COMET Program
[7] The COMET Program
[8] MCS
[9] MSC

Presented by / Présenté par: ***Robyn Dyck***
Contact: robyn.dyck@ec.gc.ca

A changing climate and increasing societal impacts from weather events demands forecasting the weather in new and innovative ways. The weather industry has historically focused on using Deterministic Prediction System (DPS) models for hazard identification in alerting the public, but with the changing clientele and their evolving needs, probabilistic forecasting using Ensemble Prediction System (EPS) models will need to be normalized and that requires training. To fill this training gap, the Meteorological Service of Canada and The COMET® Program collaborated to create the Applied NWP Course: Being Confident in Uncertainty. Two rounds of synchronous online courses were offered to MSC and international meteorologists from 14 different weather agencies. These synchronous courses were then packaged into an asynchronous online format published on COMET's MetEd website for anyone to access. Learners are introduced to a framework encompassing NWP topics from resolvability to post-processing to distribution characteristics. The course culminates in a synthesis exercise where meteorologists practice adding value to the DPS and EPS forecast outputs to confidently communicate uncertainty to clients.

Session: 5020 Atmosphere - Community, Service and Education
Atmosphère - Communauté, Services et Éducation **05/06/2024 14:35**

ID: 11965 Contributed abstract

The new Canadian Weather Radar Network – from Project to Operations

Qian Li [1] , *Sylvain Laramée* [2] , *Steven Brady* [3] , *Michael Romaniuk* [4]

[1] Canadian Weather Radar Replacement Program & National Radar Operations, Meteorological Service of Canada, Environment and Climate Change Canada
[2] Canadian Weather Radar Replacement Program, Meteorological Service of Canada, Environment and Climate Change Canada
[3] National Radar Operations, Meteorological Service of Canada, Environment and Climate Change Canada
[4] National Radar Operations, Meteorological Service of Canada, Environment and Climate Change Canada

Presented by / Présenté par: ***Qian Li***
Contact: qian.li@ec.gc.ca

Since 2017, the Canadian Weather Radar Network (CWRN) has undergone significant transformation through the Canadian Weather Radar Replacement Program (CWRRP). By the conclusion of 2023, all 33 new radars have been successfully installed nationwide, with 32 currently operational. This presentation offers an insightful overview of the accomplishments in renewing the radar network, highlighting key lessons learned from the project's implementation. Additionally, we will discuss operational challenges encountered and outline future endeavors aimed at further enhancing the effectiveness and reliability of Canada's weather radar infrastructure.

Session: 5020 Atmosphere - Community, Service and Education
Atmosphère - Communauté, Services et Éducation **05/06/2024 14:50**

ID: 11888 Contributed abstract

The Canadian Hurricane Centre - Forecast Product Improvements

Chris Fogarty [1]

[1] Canadian Hurricane Centre

Presented by / Présenté par: ***Chris Fogarty***
Contact: chris.fogarty@ec.gc.ca

Skill and accuracy in the prediction of tropical cyclone track, intensity and structure has improved steadily at the Canadian Hurricane Centre (CHC) since its inception in 1987. Resources remain in place for improving accuracy and detail of numerical weather prediction overall, meanwhile gains are being made in the way in which we as meteorologists communicate these forecasts. As the Meteorological Service of Canada (MSC) continues to focus on developing an impact-based warning system (vice the current hazard threshold-centric one), the CHC is also enhancing its service in line with the MSC efforts. Several projects currently taking place as they relate to the CHC's mandate will be discussed in this presentation, including simplification of the warnings system to reduce confusion of the message, expanded graphical products beyond the traditional forecast track and error 'cone', and the introduction of storm surge and wave impact graphics which will greatly improve our ability to communicate the coastal hazards associated with hurricanes and post-tropical storms impacting Eastern Canada.

ID: 12041 Contributed abstract

A record-breaking wildfire smoke event over Southern Ontario from 2023 June 6 to June 7

weiqing Zhang [1]

[1] Meteorological Service of Canada

Presented by / Présenté par: ***weiqing Zhang***
Contact: weiqing.zhang@ec.gc.ca

A significant smoke event happened in Southern Ontario from June 6 to June 7 in 2023 due to the unprecedented wildfires in Quebec. Dense smoke plums transported from Quebec to Southern Ontario were advertised by Canadian wildfire model FireWork three days in advance. The observed smoke traveled as far south as New York State and the surface PM2.5 in Ottawa and Kingston reached a record-breaking level of 500+ µg/m3. In this study, the forecast performance will be reviewed from the perspectives of operation, model guidance and risk communication.

Day 4 – 6 June 2024

Session: 1004 Plenary - Tapping into the Explosive Growth of Artificial Intelligence to Tackle Extreme-Events in a Changing Climate Plénière - Tirer parti de la croissance explosive de l'intelligence artificielle pour faire face aux événements extrêmes dans un climat en mutation

Dr. David Matthew Hall (NVIDIA)

Bio: Dr. Hall is a Senior Solution Architect and Data Scientist at NVIDIA, where he specializes in AI applications for weather and climate. Prior to joining NVIDIA, he gained extensive experience as a computational climate scientist at the National Center for Atmospheric Research (NCAR) and as a research professor in the Computer Science Department at the University of Colorado Boulder. Dr. Hall holds a PhD in theoretical physics from the University of California, Santa Barbara. Throughout his career, he has made significant contributions to the fields of computational physics, climate model development, and artificial intelligence, including co-authoring the Nonhydrostatic atmospheric dynamical core on the Energy Exascale Earth System Model (E3SM) and the High-Order Methods Modeling Environment (HOMME) nonhydrostatic atmospheric model for the Community Earth System Model (CESM).

Artificial Intelligence to Tackle Extreme-Events in a Changing Climate Plénière - Tirer parti de la croissance explosive de l'intelligence artificielle pour faire face aux événements extrêmes dans un climat en mutation **11:00**

ID: 12130 Invited plenary speaker

Tapping into the Explosive Growth of Artificial Intelligence to Tackle Extreme-Events in a Changing Climate

David Hall [1]

[1] NVIDIA

Presented by / Présenté par: ***David Hall***
Contact: dhall@nvidia.com

In this talk, we'll explore the explosive growth of AI and its potential to revolutionize the prediction of extreme weather events in a changing climate. We'll showcase state-of-the-art data-driven weather and climate models, discuss their strengths, weaknesses, and the intuition behind their incredible speedups. We'll highlight NVIDIA's Earth-2 Inference Microservices (NIMs), which enable efficient AI model integration and deployment. Together, we'll delve into emerging trends in AI for weather and climate, such as generative modeling, learning from earth-observations, foundation models, adaptive learning, and AI agents. Time permitting, we'll speculate on potential impacts of AGI on society and the environment, as we consider whether we're on the cusp of this pivotal technology.

Session: 7040 Simulation of weather and climate extremes using regional climate models Extrêmes météorologiques et climatiques à l'aide de modèles régionaux du climat

Convenors:
Dominique Paquin (Ouranos)
Alejandro Di Luca (UQAM)

Regional climate models, in both parameterized and resolved convection modes, can simulate weather and climate extremes more realistically than global models. Several scientific questions can be asked about these extremes. What are the different types of extreme? How does climate change influence them? How can we assess the quality of simulated extremes with limited observations? What influence do model configurations have on extremes? How can large ensembles of regional models be used to explore extremes? How can we compare extremes from different types of models (including regional models)? This session invites contributions based on regional modeling, which address both the above questions and any other related scientific questions.

Session: 7040 Simulation of weather and climate extremes using regional climate models Extrêmes météorologiques et climatiques à l'aide de modèles régionaux du climat **06/06/2024 12:15**

ID: 12038 Invited session speaker

High-Resolution Regional Climate Modeling and Projection over Western Canada using a Weather Research Forecasting Model with a Pseudo-Global Warming Approach

Yanping Li [1] , *Zhenhua Li* [2]

[1] Western University
[2] Western University

Presented by / Présenté par: ***Yanping Li***
Contact: yli4972@uwo.ca

Climate change poses great risks to western Canada's ecosystem and socioeconomical development. To assess these hydroclimatic risks under high-end emission scenario, this study used the Weather Research Forecasting (WRF) model at a convection-permitting (CP) 4 km resolution to dynamically downscale the mean projection of a 19-member CMIP5 ensemble by the end of the 21st century. The CP simulations include a retrospective simulation (CTL, 2000–2015) for verification forced by ERA-Interim and a pseudo-global warming (PGW) for climate change projection forced with climate change forcing (2071–2100 to 1976–2005) from CMIP5 ensemble added on ERA-Interim. Precipitation changes in PGW over CTL vary with the seasons: in spring and late autumn precipitation increases in most areas, whereas in summer in the Saskatchewan River basin and southern Canadian Prairies, the precipitation change is negligible or decreased slightly. With almost no increase in precipitation and much more evapotranspiration in the future, the water availability during the growing season will be challenging for the Canadian Prairies. WRF-PGW shows an increase in high-intensity precipitation events and shifts the distribution of precipitation events toward more extremely intensive events in all seasons. Due to this shift in precipitation intensity to the higher end in the PGW simulation, the seemingly moderate increase in the total amount of precipitation in summer east of the Canadian Rockies may underestimate the increase in flooding risk and water shortage for agriculture. The high-resolution downscaled climate simulations provide abundant opportunities both for investigating local-scale atmospheric dynamics and for studying climate impacts on hydrology, agriculture, and ecosystems.

Session: 7040 Simulation of weather and climate extremes using regional climate models Extrêmes météorologiques et climatiques à l'aide de modèles régionaux du climat

06/06/2024 12:45

ID: 12024 Contributed abstract

Comparing the simulation of hourly precipitation using 2.5 and 12-km versions of the Canadian Regional Climate Model

Kim Lahaie [1] , *Alejandro Di Luca* [2]

[1] Université du Québec à Montréal
[2] Université du Québec à Montréal

Presented by / Présenté par: ***Kim Lahaie***
Contact: miklahaie@gmail.com

The spatial resolution of climate models is a critical factor that determines their ability to resolve precipitation. The inability of coarser resolution climate models to represent small-scale atmospheric processes, mountain-valley circulations and fine scale surface properties lead to important uncertainties representation of precipitation on the regional and local scale, particularly short-duration intense convective precipitation events. The use of extremely high-resolution models despite the requirement of large computational resources, holds promises in improving precipitation. The aim of this study is to assess the impact of increasing resolution from 12 km to 2.5 km on the simulation of hourly precipitation using many different configurations of the Canadian Regional Climate Model (CRCM6/GEM5). To do so, we analyze precipitation errors using a methodology known as "environment-conditioned intensity-frequency decomposition". This methodology, based on two successive decompositions, allows us to categorize rain events based on their dynamic and thermodynamic characteristics and to approximate precipitation using three terms that describe distinct aspects of the precipitation field: large-scale environmental conditions, frequency, and intensity of precipitation. Results indicate that all three error terms (frequency, intensity, and environment) collectively influence total precipitation errors and exhibit strong compensations, underscoring the importance of this methodology. All 12 km simulations produce precipitation too frequently and too weakly for most regimes. Similarly, the 2.5 km simulations produce precipitation too frequently and too weakly but only moderately dry regimes, because the opposite occurs for wet regimes. Our results show a weak sensitivity to changes in the model configurations at 2.5 km. As we found little sensitivity to change in configuration at 2.5 km, we find that they perform significantly better than their 12 km counterparts.

Session: 7040 Simulation of weather and climate extremes using regional climate models Extrêmes météorologiques et climatiques à l'aide de modèles régionaux du climat

06/06/2024 13:00

ID: 12086 Contributed abstract

A Dynamically Downscaled Convection-Permitting Reanalysis and Pseudo-Global Warming Dataset for British Columbia

Timothy C. Y. Chui [1], *Rosie Howard* [2], *Alex J. Cannon* [3], *Colin R. Mahony* [4], *Roland Stull* [5]

[1] University of British Columbia
[2] University of British Columbia
[3] Environment and Climate Change Canada
[4] BC Ministry of Forests
[5] University of British Columbia

Presented by / Présenté par: ***Timothy C. Y. Chui***
Contact: colin.mahony@gov.bc.ca

Reanalysis products like the ECMWF Reanalysis v5 (ERA5) are often used to provide a historical gridded dataset for weather and climate research. These reanalysis datasets can be perturbed with a climate-change delta from global climate models (GCMs), to then be downscaled using a regional climate model to achieve a pseudo-global warming (PGW) simulation. PGW simulations can provide information on how

the downscaled weather could change in a future climate regime, which is important in the study of how extreme weather events can be exacerbated by climate change. We use the Weather Research and Forecasting (WRFv4) model to downscale ERA5 reanalysis data to a convection-permitting domain (3-km grid spacing) over British Columbia, to produce a multi-decadal gridded dataset over the province. Initial verification against surface stations and the Canadian Precipitation Analysis (CaPA) for the 2020-2021 water year shows an improvement in skill against ERA5 for 10-m winds and daily precipitation overall, while 2-m temperature errors are comparable in flat terrain but are an improvement against ERA5 for daytime highs during the June 2021 heatwave event. ERA5 is also the starting point and basis for PGW perturbation. We use an ensemble of Coupled Model Intercomparison Project Phase 6 (CMIP6) GCMs to produce monthly climate deltas for +2 and +3 degree warming levels, under the Shared Socioeconomic Pathways 5-8.5 scenario (SSP585). These PGW perturbations are then ingested into WRF, to produce convection-permitting PGW datasets parallel to the ongoing downscaling of the base ERA5 reanalyses. We find that the PGW simulations intensify the severity of the June 2021 event, leading to warmer daytime highs and nighttime lows. After the completion of the multi-decadal reanalysis and PGW datasets, we will make the output available to enhance decision-making in a changing climate, as well as to provide a new gridded dataset for researchers to use.

Session: 7040 Simulation of weather and climate extremes using regional climate models Extrêmes météorologiques et climatiques à l'aide de modèles régionaux du climat

06/06/2024 13:15

ID: 12068 Contributed abstract

Blue in Green: Forestation Mitigates European Heat Extremes by Turning Blue Water Green

Olivier Asselin [1], *Martin Leduc* [2], *Dominique Paquin* [3], *Nathalie de Noblet-Ducoudré* [4], *Diana Rechid* [5], *Ralf Ludwig* [6]

[1] Ouranos
[2] Ouranos
[3] Ouranos
[4] Laboratoire des Sciences du Climat et de l'Environment
[5] GERICS, Helmholtz-Zentrum Hereon
[6] Ludwig-Maximilians University,

Presented by / Présenté par: ***Olivier Asselin***
Contact: asselin.olivier@ouranos.ca

Afforestation and reforestation, herein combined as forestation, offer a strong technical potential for reducing atmospheric concentration of carbon. However, large-scale implementation of such mitigation strategies would not only impact the chemical composition of the atmosphere, but also the energy and water exchanges between the land and the atmosphere. Replacing grassland with forests, for instance, may lower albedo, increase surface roughness and affect evapotranspiration rates, with important effects on the regional climate. Since forestation is expected to contribute about a quarter of mitigation efforts pledged under the Paris agreement, it is essential that these so-called biophysical effects are accounted for when assessing their mitigation

potential.
In this study, we analyze the impacts of land-use change in Europe under the sustainability scenario (SSP1-2.6) using an ensemble of regional climate simulations. We find that land-use change, primarily broadleaf forestation, reduces summertime heat extremes significantly over continental Europe. In fact, cooling from land-use change trumps warming by greenhouse gases under SSP1-2.6, resulting in reduced heat extremes by 2100 compared with today. Forestation shifts the partition of turbulent energy fluxes away from sensible and towards latent heat fluxes. This evaporative cooling affects daily temperature locally, especially during hot summer days. Impacts on the water cycle are then assessed. The forestation-driven boost of evapotranspiration (green water flux) is found to be unmatched by precipitation recycling, such that run-off (blue water flux) is reduced. Some regions experience severe drying in response. In other words, forestation turns blue water green, bringing heat relief at the expense of water availability. The implications of this blue-green trade-off are discussed.

Session: 7040 Simulation of weather and climate extremes using regional climate models Extrêmes météorologiques et climatiques à l'aide de modèles régionaux du climat

06/06/2024 13:30

ID: 12056 Contributed abstract

The effect of climate change on the simulated streamflow of six Canadian rivers based on the CanRCM4 regional climate model

Vivek Arora [1] , *Aranildo Lima* [2] , *Rajesh Shrestha* [3]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada

Presented by / Présenté par: ***Aranildo Lima***
Contact: aranildo.lima@ec.gc.ca

The effect of climate change is investigated on the hydro-climatology of six major Canadian rivers (Mackenzie, Yukon, Columbia, Fraser, Nelson, and St. Lawrence), in particular streamflow, by analyzing results from the historical and future simulations (RCP 4.5 and 8.5 scenarios) performed with the Canadian regional climate model (CanRCM4). Streamflow is obtained by routing runoff using river networks at 0.5° resolution. Of these six rivers, Nelson and St. Lawrence are the most regulated. As a result, the streamflow at the mouth of these rivers shows very little seasonality. Mean annual precipitation (P), evaporation (E), runoff (R), and temperature increase for all six river basins considered and the increases are higher for the more fossil fuel-intensive RCP 8.5 scenario. The only exception is the Nelson River basin for which the simulated runoff increases are extremely small. The northerly Mackenzie and Yukon River basins show a decrease in evaporation ratio (E/P) and an increase in runoff ratio (R/P) since the increase in precipitation is more than enough to offset the increase in evaporation associated with increasing temperature. For the southerly Fraser and Columbia River basins, the E/P ratio increases, and the R/P ratio decreases due to an already milder climate in the Pacific north-western region. The seasonality of simulated monthly streamflow is also more affected for the southerly Fraser and Columbia Rivers than for the northerly Mackenzie and Yukon Rivers as snow amounts decrease and

snowmelt occurs earlier. The streamflow seasonality for the Mackenzie and Yukon rivers is still dominated by snowmelt at the end of the century even in the RCP 8.5 scenario. The simulated streamflow regime for the Fraser and Columbia Rivers shifts from a snow-dominated to a hybrid/rainfall-dominated regime towards the end of this century in the RCP 8.5 scenario.

Session: 2030 Advancing research on marine extremes - Part 1 Faire progresser la recherche sur les extrêmes marins - Partie 1

Convenors:
Amber Holdsworth (Institute of Ocean Science)
Hayley Dosser (Institute of Ocean Science)

Anthropogenic greenhouse gas emissions are altering conditions across the global ocean, driving more frequent and extreme ocean states of anomalously high temperature, low oxygen, and/or low pH (acidification). Multiple ecosystem stressors occurring concurrently or consecutively can adversely affect marine biota to a greater extent than a single stressor in isolation. This session will highlight recent advances in research on marine extremes, for either single or multiple stressors. We welcome experimental, observational, and modelling investigations of marine extremes and their impacts for both open ocean and coastal waters. Of particular interest are studies focused on developing and implementing clear and consistent definitions of extremes that allow for comparisons between regions and on varying time scales. We welcome insights into improving monitoring programs, with a focus on better characterizing the ranges and distributions of relevant variables, investigating ecological responses to extremes, and assessing how such programs can support modelling efforts. We encourage studies that consider the past and current states of the ocean as well as those that consider future projections.

Session: 2030 Advancing research on marine extremes - Part 1
Faire progresser la recherche sur les extrêmes marins - Partie 1 **06/06/2024 12:15**

ID: 12087 Invited session speaker

Site-specific Assessments of Multiple Stressor Extremes in GFDL's Earth System Model 4.1 with Comparisons to Historical Observations and Future Projections

Elise M. Olson [1] , *Jasmin G. John* [2] , *John Dunne* [3] , *Charles Stock* [4] , *Elizabeth J. Drenkard* [5] , *Adrienne J. Sutton* [6]

[1] Princeton University
[2] NOAA/OAR/AOML
[3] NOAA/OAR/GFDL
[4] NOAA/OAR/GFDL
[5] NOAA/OAR/GFDL
[6] NOAA/OAR/PMEL

Presented by / Présenté par: ***Elise Olson***
Contact: eo2651@princeton.edu

As oceans respond to rising CO2, previously infrequent environmental conditions are becoming commonplace, and the characteristics of statistically rare events are shifting. At a local level, marine ecosystems may be impacted by warming and ocean acidification, and knowledge of current and anticipated stressor conditions could inform marine resource management. However, the Earth system models (ESMs) that form the basis for climate projections are resolution-limited and may not capture important modes of variability that contribute to extreme events. In the context of extreme event diagnosis, we compared daily GFDL-ESM4.1 model output with surface observation time series at sites across a range of ocean environments, including several within marine protected areas (MPAs). Despite limited model representation of sub-monthly variability, model and observation-based assessments of the fraction of days experiencing temperature-pH and temperature-aragonite saturation multistressor conditions showed reasonable agreement (Pearson correlation coefficient of 0.6 to 0.9), depending on the stressor combination and threshold definition. Projected multiple stressor conditions vary by location, stressor event definition, and scenario. While shifts in annual ocean acidification extremes in excess of historical variability are near-ubiquitous across scenarios, corresponding shifts in temperature extremes are regionally confined under low emissions and only prevalent in the high scenarios. In this context, US MPAs exhibit varying environmental vulnerability in a changing climate.

Session: 2030 Advancing research on marine extremes - Part 1
Faire progresser la recherche sur les extrêmes marins - Partie 1 **06/06/2024 12:45**

ID: 12070 Contributed abstract

Clustering to characterize extreme marine conditions for the benthic region of Northeastern Pacific continental margin

Amber Holdsworth [1] , *James Christian* [2] , *Andrew Shao* [3]

[1] Fisheries and Oceans Canada
[2] Fisheries and Oceans Canada
[3] Hewlett Packard Enterprises

Presented by / Présenté par: ***Amber Holdsworth***
Contact: northpacificbgc@gmail.com

Anthropogenic CO2 emissions lead to warming, deoxygenation and acidification of the oceans. Superimposed on these long-term trends are episodic extremes of temperature, pH and oxygen, but these are not well understood. To address this, we present an innovative method for assessing single and multiple stressor extremes using a regional ocean model. The method is applied to a high-resolution model of the Northeastern Pacific Ocean. Focusing on benthic habitats, we assume that organisms are adapted to local environments and use an unsupervised clustering approach (machine learning) to isolate regions with similar environmental conditions assuming that the extremes in the different clusters may be influenced by different mechanistic drivers.
We define extreme thresholds seasonally using a fixed baseline (1996 to 2020). Of the six clusters, we analyze two of them to quantify the fraction of waters that exceed these thresholds in the recent past ; for both single and compound stressors. The

Shallows cluster includes the open waters east of Haida Gwaii and some of the shallow banks in Queen Charlotte Sound. The Canyons cluster includes the deep channels of Dixon Entrance north of Haida Gwaii, the troughs of Queen Charlotte Sound and connected waters along the edge of the continental shelf. The Canyons and Shallows have contrasting climatological conditions with the Shallows having more seasonal variability, relatively high oxygen and low AOU, lower dissolved inorganic carbon and warmer temperatures.

A substantial number of single stressor extremes occur annually, but compound extremes are rare with most of the compound extremes involving low oxygen and high acidification. The signatures of large-scale climate variability (e.g., North Pacific Gyre Oscillation) are apparent in time series of the fraction of extreme waters in each cluster. For the clusters examined here , ocean upwelling and basin-scale climate variability have a strong influence on extreme conditions.

Session: 2030 Advancing research on marine extremes - Part 1
Faire progresser la recherche sur les extrêmes marins - Partie 1 **06/06/2024 13:00**

ID: 11910 Contributed abstract

Quantifying variability in the Northeast Pacific Ocean hypoxic boundary and saturation horizons from ocean glider data along Line P

Hayley Dosser [1] , *Tetjana Ross* [2] , *Debby Ianson* [3]

[1] DFO
[2] DFO
[3] DFO

Presented by / Présenté par: ***Hayley Dosser***
Contact: hayley.dosser@dfo-mpo.gc.ca

Ocean acidification and hypoxia have been worsening in the Northeast Pacific Ocean for decades as anthropogenic climate change progresses. Further, carbonate system variability in this region is poorly constrained on sub-annual timescales and on sub-mesoscale spatial scales, limiting our ability to put observed changes into context. To address this issue, we use high-resolution ocean glider data from 2019 to 2023 in order to quantify sub-mesoscale spatial variability in the depth of the calcite and aragonite saturation horizons and in the hypoxic boundary at the top of the oxygen minimum zone. To achieve this goal, we have developed multiple linear regression (MLR) models for Line P in the Northeast Pacific using a 30-year time series of ship-based carbonate and hydrographic data. These robust empirical models estimate dissolved inorganic carbon (DIC) and total alkalinity (TA) using in-situ observations of temperature (T), salinity (S), and dissolved oxygen (O2) from the near-surface to 750m depth (roughly the top of oxygen minimum zone). We applied the MLR models to the glider data, which allowed us to determine how the magnitude of these spatial variations compare with the seasonal and interannual variations seen in the ship-based calibration data; thus providing new context for those presumed temporal changes. Finally, we suggest a method to update the MLR models to account for the anthropogenic trends detectable in Northeast Pacific waters and validate them annually using ship-based Line P data, improving their long-term applicability.

Session: 2030 Advancing research on marine extremes - Part 1
Faire progresser la recherche sur les extrêmes marins - Partie 1 **06/06/2024 13:15**

ID: 12064 Contributed abstract

Ocean acidification is not a slow burn in some coastal regions: rapid modulation of corrosive conditions in the northern Strait of Georgia

Wiley Evans [1] , *Justin Del Bel Belluz* [2] , *Katie Campbell* [3] , *Carrie Weekes* [4] , *Jessy Barrette* [5] , *Eva Drew Jordison* [6] , *Kimberly Bedard* [7] , *Jonathan Bergshoeff* [8] , *Ian Giesbrecht* [9] , *Alex Hare* [10] , *Colleen Kellogg* [11] , *Jennifer Jackson* [12]

[1] Tula Foundation / Hakai Institute
[2] Tula Foundation / Hakai Institute
[3] Tula Foundation / Hakai Institute
[4] Tula Foundation / Hakai Institute
[5] Tula Foundation / Hakai Institute
[6] Tula Foundation / Hakai Institute
[7] Tula Foundation / Hakai Institute
[8] Tula Foundation / Hakai Institute
[9] Tula Foundation / Hakai Institute
[10] Tula Foundation / Hakai Institute
[11] Tula Foundation / Hakai Institute
[12] Fisheries and Oceans Canada

Presented by / Présenté par: ***Wiley Evans***
Contact: wiley.evans@hakai.org

There is a perception that ocean acidification (OA) is a gradually intensifying phenomenon; however, recent studies have illustrated large rates of change in weakly-buffered seawater within the ocean interior and in the Arctic. Rapid changes in marine CO2 chemistry are also likely to occur in many coastal regions that exhibit a weak capacity to buffer natural and anthropogenic CO2 additions. Rapid abatement in adverse conditions may also occur, leading to short-lived extremes that manifest on time scales dictated by the nature of physical and biogeochemical forcings. The Strait of Georgia, on the northeast Pacific coast, is one such region that has exhibited short-lived extremes in marine CO2 chemistry. Here, we evaluate inter-annual physical and biogeochemical variability using an 8-year record of bi-weekly measurements from an oceanographic station to show how the seasonal manifestation of extremely corrosive, low-pH, and hypercapnic conditions in the northern terminus of this region is related to wintertime wind and summertime productivity season intensities.

Session: 2030 Advancing research on marine extremes - Part 1
Faire progresser la recherche sur les extrêmes marins - Partie 1 **06/06/2024 13:30**

ID: 11980 Contributed abstract

Anomalies in the Salish Sea due to Exceptionally Low Fraser River Flow in July 2023: SalishSeaCast View

Susan Allen [1]

[1] University of British Columbia

Presented by / Présenté par: ***Susan Allen***
Contact: sallen@eoas.ubc.ca

Historically low Fraser River flow occurred in July 2023, with the lowest values since recording started in 1905. Using SalishSeaCast, a real-time coupled bio-chem-physical model of the Salish Sea, we compared July 2023 to the hindcast from 2007-2022, looking for anomalies greater than two standard deviations from mean which we term “exceptional”. In 2023 we see higher surface salinity throughout the sea with exceptionally high in the salinity in the Southern Strait of Georgia (SoG). This change in surface salinity reduced the salinity gradient and led to stronger mixing. This stronger mixing brought exceptional levels of nitrate to the surface and led to an exceptional diatom bloom. In the Northern SoG, the system was more stable than usual due to weak winds and higher solar energy. The nanoflagellates formed an exceptionally deep chlorophyll maximum, leading to high Z1 zooplankton and deeper than usual Z2 zooplankton. With caveats, there is evidence that the higher surface salinities in the southern SoG decreased the typical deep water renewal.

Session: 5010 Atmosphere - Theoretical to applied science - Part 1 Atmosphère - De la théorie à la science appliquée - Partie 1

Convenor: Kyle Ziolkowski

Related to scientific studies and/or information sharing about the atmosphere, including weather, meteorology, clouds and precipitation, air quality, atmospheric dynamic and extreme events, using various approaches.

This session covers many topics, including, but not limited to, theoretical research, model development, observation techniques, real-time monitoring, databases, diagnostic methods, data analysis and artificial intelligence.

Session: 5010 Atmosphere - Theoretical to applied science - Part 1 Atmosphère - De la théorie à la science appliquée - Partie 1 **06/06/2024 12:15**

ID: 12004 Contributed abstract

Étude qualitative de la réponse d’un modèle de qualité de l’air dans un contexte de réduction linéaire de la pollution anthropogénique canadienne

Annie Duhamel [1] , *Ivana Popadic* [2] , *Sandrine Trotechaud* [3] , *Dominic Beaudet* [4] , *Craig Stroud* [5]

[1] ECCC
[2] ECCC
[3] ECCC
[4] ECCC
[5] ECCC

Presented by / Présenté par: ***Annie Duhamel***
Contact: annie.duhamel@ec.gc.ca

Le but de cette étude est d'analyser qualitativement la réponse du modèle canadien de qualité de l'air à savoir si sa variation est linéaire ou non pour différentes villes canadiennes. Pour faire cette analyse, le modèle GEM-MACH (Global Environnemental Multi-échelle – Modélisation de la qualité de l'Air et de la Chimie) a été utilisé. Six simulations annuelles d'un modèle de qualité de l'air sur l'Amérique du Nord ont été effectuées à une résolution de 10 km. Une simulation de référence a été effectuée pour représenter le niveau de pollution valide pour l'année de référence, soit 2015. Pour chaque autre simulation, la pollution anthropogénique canadienne a été réduite également sur tout le territoire selon un pourcentage différent entre chaque simulation. La météorologie, les émissions biogéniques et les émissions anthropogéniques des États-Unis et du Mexique sont restées identiques dans chacune des simulations annuelles. Les feux de forêt ne sont pas inclus. Ensuite, avec l'aide des sorties horaires du modèle GEM-MACH de trois polluants importants, trois métriques ont été calculées soit : la moyenne annuelle des particules fines (PM2.5) et du dioxyde d'azote (NO2) ainsi que la moyenne annuelle des maximums journaliers de l'ozone (O3). Les résultats de ces trois métriques ont été utilisés pour analyser la variation de la pollution dans quelques villes canadiennes plus ou moins populeuses. Les résultats démontrent que dans les villes où la pollution est moindre que dans les grandes, la variation est plutôt linéaire. Toutefois dans le cas des grandes villes, la réponse est plus complexe.

Session: 5010 Atmosphere - Theoretical to applied science - Part 1 Atmosphère - De la théorie à la science appliquée - Partie 1 **06/06/2024 12:30**

ID: 11892 Contributed abstract

Comparing measured and inventoried methane emissions estimates from waste facilities in Southwestern Ontario

Lawson Gillespie [1], *Sebastien Ars* [2], *Siyar Urya* [3], *Tim Khoo* [4], *David Pomeroy* [5], *Felix Vogel* [6], *Debra Wunch* [7]

[1] University of Toronto & Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada & University of Waterloo
[4] Environment and Climate Chage Canada & University of Waterloo
[5] Environment and Climate Change Canada & University of Guelph
[6] Environment and Climate Change Canada
[7] University of Toronto

Presented by / Présenté par: ***Lawson Gillespie***
Contact: lgillespie@physics.utoronto.ca

The waste sector is a significant source of methane emissions in Southwestern Ontario. We estimated methane emission rates from observed concentration enhancements downwind of solid waste and water resource recovery facilities in Southwestern Ontario. Using a Gaussian plume model inversion scheme, we calculate emissions estimates for at least 15 active landfills, 10 closed landfills, 10 water resource recovery facilities, 3 compost facilities, 1 organic waste processing facility, and 3 combined sewage overflow storage basins. Additionally, we compare these

results against several spatially resolved and facility-level methane emissions inventories in the region.

Session: 5010 Atmosphere - Theoretical to applied science - Part 1 Atmosphère - De la théorie à la science appliquée - Partie 1 **06/06/2024 12:45**

ID: 11897 Contributed abstract

Air quality modeling study assessing the impact of NOx Tier III regulations on coastal emissions in Canada

Mourad Sassi [1], *Wanmin Gong* [2], *Hui Peng* [3], *Sandrine Trotechaud* [4]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada
[4] Environment and Climate Change Canada

Presented by / Présenté par: ***Sandrine Trotechaud***
Contact: sandrine.trotechaud@ec.gc.ca

The Government of Canada is actively addressing air pollution through various means including the implementation of regulatory policies. The anticipated growth of the transport sector and subsequent air pollutant emissions represent an increased risk for public health and highlight the need for effective regulatory measures. In this study, the impact on air quality over Canadian waters of the NOx Tier III regulations, established by the International Maritime Organization, is investigated. Numerical simulations have been run using the Global Environmental Multiscale-Modelling Air quality and Chemistry model, GEM-MACH, with emission sets created using the Marine inventory Tool from the Cross Sectoral Energy Division of Environmental Protection Branch at Environment and Climate Change Canada. Three scenarios are run with different percentage of compliance to the NOx Tier III standards over Canadian waters: current (1%), partial (30%), and full (100%) compliance. The numerical simulations predict decreasing NO2, O3 and PM2.5 levels along coastal areas of Canada. Of the three analyzed air pollutants, the biggest impact is found on NO2 concentration. The reduction on NO2 and PM2.5 concentrations remain local and confined along shipping routes whereas the impact on O3 concentration penetrates more significantly inland.

Session: 5010 Atmosphere - Theoretical to applied science - Part 1 Atmosphère - De la théorie à la science appliquée - Partie 1 **06/06/2024 13:00**

ID: 12059 Contributed abstract

Investigating Urban Air Quality Using Surface NO2 Derived from Column Measurements

Darby Bates [1], *Ramina Alwarda* [2], *Kimberly Strong* [3], *Xiaoyi Zhao* [4], *Vitali Fioletov* [5], *Sum Chi Lee* [6], *Yushan Su* [7]

[1] University of Toronto

[2] University of Toronto
[3] University of Toronto
[4] Air Quality Research Division, Environment and Climate Chance Canada
[5] Air Quality Research Division, Environment and Climate Change Canada
[6] Air Quality Research Division, Environment and Climate Change Canada
[7] Ontario Ministry of the Environment, Conservation, and Parks

Presented by / Présenté par: ***Darby Bates***
Contact: darby.bates@mail.utoronto.ca

Atmospheric trace gases near the Earth's surface can have important human and environmental health impacts. In particular, the trace gas nitrogen dioxide (NO2), which is commonly emitted by traffic, biomass burning, and industrial sources, can be a major threat to human respiratory health, leading to increased rates of asthma, lung cancer, and overall mortality. In the Greater Toronto Area (GTA), NO2 and other trace gases are being monitored by six ground-based Pandora UV-visible spectrometers that are part of the Pandonia Global Network. We present NO2 surface volume mixing ratios derived from Pandora direct sun total column measurements to monitor air quality using the conversion method from Zhao et al. (2019). Their method uses three inputs in addition to the Pandora total columns: the stratospheric NO2 column from the Ozone Monitoring Instrument (OMI), the free troposphere NO2 column from the GEOS-Chem chemical transport model, and the ratio of NO2 surface volume mixing ratio to planetary boundary layer column from Environment and Climate Change Canada's regional air quality forecast model, Global Environmental Multi-scale-Modelling Air quality and Chemistry (GEM-MACH). The derived estimates of surface NO2 are compared with in situ measurements, and their level of agreement is tested for dependence on meteorological conditions, including wind speed and direction, temperature, and surface pressure. This presentation will provide an overview of this column-to-surface conversion method, a summary of preliminary results for each site in the GTA, and an outline of plans toward using this approach to improve and validate satellite estimates of surface NO2.

Zhao, X., et al., Retrieval of total column and surface NO2 from Pandora zenith-sky measurements, Atmos. Chem. Phys., 19, 10619–10642, https://doi.org/10.5194/acp-19-10619-2019, 2019.

Session: 5010 Atmosphere - Theoretical to applied science - Part 1 Atmosphère - De la théorie à la science appliquée - Partie 1 **06/06/2024 13:15**

ID: 11975 Contributed abstract

On the evaluation of the performance of a new automated atmospheric transport and dispersion modelling system for wildfire smoke across Canada and northern USA: initial results of PM2.5 concentration forecast verification

Paul Bovis [1] , *Alain Malo* [2] , *Philippe Barnéoud* [3]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada

Presented by / Présenté par: ***Paul Bovis***

Contact: paul.bovis2@ec.gc.ca

Especially during the spring and summer months, forest fire smoke can cause episodes of poor air quality. Many clients rely on frequently updated numerical model guidance of forest fire smoke dispersion to provide timely evacuations and mitigate impacts to public health. The Meteorological Service of Canada's (MSC) Canadian Meteorological Centre (CMC) uses the Modèle lagrangien de dispersion de particules (MLDP), a Lagrangian atmospheric transport and dispersion model, to provide clients with timely fine particulate matter PM2.5 dispersion guidance. The MLDP model is run four times daily, as well as on-demand, and uses (1) satellite-based hotspot detection algorithms to identify the location of forest fires and derive PM2.5 emissions and (2) high-resolution meteorological forecasts from the numerical weather prediction system HRDPS (High Resolution Deterministic Prediction System).

Using Emet, CMC's database-driven observation point verification system, this study is the first large-scale attempt at verifying MLDP PM2.5 dispersion guidance against observations. Focusing on Canada and the northern United States, this verification study aims to improve the accuracy of MLDP's dispersion guidance over regional and local scales.

Initial results indicate a strong diurnal pattern in the magnitude of the error between modelled near-ground air concentrations and PM2.5 air concentration measurements at air quality stations. Additionally, when many forest fire hotspots are near each other, these errors can be several orders of magnitude larger.

As this verification process continues to evolve, its results will be used to improve the parameterizations and configurations of the MLDP automated model forecasts to provide more accurate PM2.5 dispersion guidance to emergency managers, warning preparedness meteorologists, public health authorities, and provincial wildfire stakeholders.

Session: 5010 Atmosphere - Theoretical to applied science - Part 1 Atmosphère - De la théorie à la science appliquée - Partie 1 **06/06/2024 13:30**

ID: 12060 Contributed abstract

Aerosols contribution to fog life cycle during the FATIMA fog study in the Northwest Atlantic Ocean

Gianina Giacosa [1], *Lauren Robinson* [2], *Phillipe Gauvin-Bourdon* [3], *Leyla Salehpoor* [4], *Leigh Crilley* [5], *Trevor VandenBoer* [6], *David G. Ortiz-Suslow* [7], *Ryan Yamaguchi* [8], *Qing Wang* [9], *Ed Creegan* [10], *Harindra J. S. Fernando* [11], *Rachel Chang* [12]

[1] Dalhousie University
[2] Dalhousie University
[3] Dalhousie University
[4] York University
[5] York University
[6] York University
[7] Naval Postgraduate School
[8] Naval Postgraduate School

[9] Naval Postgraduate School
[10] US Army Research Laboratory
[11] University of Notre Dame
[12] Dalhousie University

Presented by / Présenté par: ***Gianina Giacosa***
Contact: gianina.giacosa@dal.ca

Atmospheric aerosols, such as sea salt particles and those derived from air pollutants, can act as cloud condensation nuclei and contribute to fog formation in the lower atmosphere. These interactions across a wide range of scales present a challenge to fully understanding and forecasting the fog life cycle. The objective of this work is to improve our understanding of how aerosol properties, like size distribution, can affect fog properties such as droplet size distribution and liquid water content. Temporal evolution of these properties can provide insight on how the fog develops at different stages of its life cycle. As part of the Fog And Turbulence Interactions in the Marine Atmosphere (FATIMA) project, we characterized marine aerosols and their interaction with fog droplets over the Northwest Atlantic Ocean offshore of Eastern Canada during a research cruise on July 2022. The aim of the cruise was to sample sea fog formation over the Grand and Sable Banks, which frequently forms due to warm air advection from over the Gulf Stream across the cold Labrador Sea waters on the continental shelf.
This analysis is focused on aerosols and fog size distributions measured with a scanning mobility particle sizer and with a fog monitor, respectively. For all the events sampled, the average aerosol number concentration, across all particle diameters, decreased during fog, as compared to no fog conditions. In some fog cases, a bimodal aerosol size distribution was recorded, while during other events, the distribution was unimodal. Aerosol size distribution before, during and after fog will be compared for different fog events to understand how condensation onto aerosols affects temporal evolution of aerosols size distribution during fog life cycle.

Session: 6030 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 1 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 1

Convenors:
Miguel Tremblay (Environment and Climate Change Canada)
Ann Dacres (Environment and Climate Change Canada)

We invite the meteorological community to contribute to an exciting session on the integration of Artificial Intelligence (AI) in meteorology. This session aims to explore how AI, especially Machine Learning (AI/ML) and high-performance computing, is revolutionizing modern meteorology. == Potential Topics == * AI in Weather Forecasting Enhancement: * Application of AI algorithms to improve the accuracy of weather forecasts. * Case studies on the integration of AI in national meteorological services. * Climate Change Modeling with AI: * The role of AI in predicting long-term climatic trends. * Using machine learning to understand and mitigate the effects of climate change. * Public Engagement and Weather Information Dissemination: * AI-driven platforms for better communication of meteorological information to the public. * Social media and AI in raising awareness about meteorological events. * Innovations in Meteorological Data Collection: * The use of AI to enhance the quality and scope of meteorological data collection. * Innovations in sensor technology and data acquisition methods

driven by AI. Additional Topics to Explore: * The use of AI for the forecasting, management, and impact analysis of environmental emergencies, including natural disasters and extreme meteorological phenomena. * Data-driven modeling in meteorology. * Hybridization of meteorological models. * AI/ML for immediate forecasting (Nowcasting). * Improvements in S2S (sub-seasonal to seasonal) forecasts. * Operationalization of AI/ML. * Ethical and responsible AI. * Improving AI literacy.

Session: 6030 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 1 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 1 **06/06/2024 12:15**

ID: 12044 Contributed abstract

The state of the art in AI weather forecasting and ECCC's research plans

Christopher Subich [1] , *Ervig Lapalme* [2]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada

Presented by / Présenté par: ***Christopher Subich***
Contact: csubich@gmail.com

In the past two years, the role of artificial intelligence in weather prediction has dramatically grown. Once seen as a specialized tool for post-processing or empirically fitting under-constrained physics parameterizations, a number of publications have shown that it is capable of directly producing global atmospheric forecasts at least as skillful as those produced by the best conventional forecast models. We expect artificial intelligence may become even more useful over time, and this tool might transform weather prediction as deeply as computational methods did, beginning seventy years ago.

The field of artificial intelligence is moving very quickly, and the first portion of this talk will review the state of the art in its application to numerical weather prediction. We will briefly cover the leading AI forecast models, the development of foundation models, downscaling/nowcasting applications, and post-processing.

The second portion of this talk will review the research plans and activities of the Meteorological Research Division and Meteorological Service of Canada. In Spring 2024, ECCC prepared our first "AI Roadmap" that sets out our research goals and priorities in the short and medium term. We will review the highlights of this roadmap, and we will briefly describe some of our ongoing, early-stage research projects.

Session: 6030 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 1 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 1 **06/06/2024 12:45**

ID: 11906 Contributed abstract

NWP AI-based models verifications against observations

Ervig Lapalme [1]

[1] Environnement et Changement Climatique Canada

Presented by / Présenté par: ***Ervig Lapalme***
Contact: ervig.lapalme@ec.gc.ca

Publications showing merits and verifications of AI-based models all show verifications against analyses. Some show verifications against observations but only at the surface.

At ECCC, we made a full set of verifications to compare AI-based forecasts against radiosondes observations in altitude up to 10 hPa and on an extensive period.

We show that AI-based models outperform the physics-based operational Canadian model for several variables in the troposphere. We also compare the performance of AI-based models initialized with the operational global analysis giving the same conclusions.

Those results also show that AI-models deteriorate forecasts upper than 150 hPa which earlier publications didn't mention clearly.

This indicates some weakness in the AI-based models training. Weighting is applied differently in the vertical and how this affects the forecast performance according to the vertical level.

We think those results are important for the community to guide future developments in the domain of data-driven forecasts models.

Session: 6030 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 1 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 1 **06/06/2024 13:00**

ID: 11924 Contributed abstract

Leveraging Data-Driven Weather Emulators to Guide Physics-Based NWP Models: A Fusion of Forecasting Paradigms

Syed Zahid Husain [1], *Leo Separovic* [2], *Jing Yang* [3], *Christopher Subich* [4], *Rabah Aider* [5]

[1] RPN-A, Environment and Climate Change Canada
[2] RPN-A, Environment and Climate Change Canada
[3] RPN-A, Environment and Climate Change Canada
[4] RPN-A, Environment and Climate Change Canada
[5] RPN-A, Environment and Climate Change Canada

Presented by / Présenté par: ***Syed Zahid Husain***
Contact: syed.husain@ec.gc.ca

Numerical weather prediction (NWP) models that rely on a physics-driven approach to

simulate atmospheric processes have long been the gold standard for meteorological forecasting. However, the advent of data-driven models inspired by artificial intelligence (AI) has recently started to seriously challenge this well-established paradigm. These AI models are generally based on some form of deep neural network architecture. A number of these models and their trained weights have recently been made open-source, e.g., GraphCast by Google's DeepMind, Pangu-Weather by Huawei, and FourCastNest by NVIDIA.

By training on the ERA5 reanalysis dataset from ECMWF (European Centre for Medium-Range Weather Forecasts), the weights of these models are calibrated to make predictions that emulate ERA5. As a result, models like GraphCast and Pangu-Weather can even surpass the accuracy of ECMWF's Integrated Forecasting System (IFS) in certain metrics. More importantly, they can make predictions with computational efficiency that is orders of magnitude higher than any NWP model.

Despite their advantages, AI models can suffer from excessive smoothing of fine-scale features that may progressively worsen over longer lead times, affecting resolutions up to 1000-1500 km. To address this limitation, efforts are underway at Environment and Climate Change Canada (ECCC) to combine the AI and NWP modelling efforts through well-designed spectral nudging of NWP forecasts towards the large-scale states predicted by an AI model. Such an approach may help to improve NWP guidance while eliminating fine-scale smoothing and give operational meteorologist access to all the prognostic and diagnostic variables they are used to. A pertinent study at ECCC in this regard is aiming to identify the strengths and limitations of both AI and NWP models, with preliminary findings indicating higher spectral coherence in AI models over a wide range of scales. The detailed results from this ongoing comparative study will be shared at the conference.

Session: 6030 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 1 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 1

06/06/2024 13:15

ID: 11966 Contributed abstract

On the development of artificial intelligence downscaling applications for medium-range forecasts of weather elements at CCMEP

Christian Saad [1], *Dominique Brunet* [2], *Madalina Surcel* [3], *Johannes Schmude* [4], *Daniel Salles Civitarese* [5], *S. Karthik Mukkavilli* [6], *Jorge Luis Guevara Diaz* [7], *Maria Fernanda Fernandes Rezende* [8], *Simon Corbeil-Létourneau* [9], *Sébastien Fortier* [10]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada
[4] IBM Research
[5] IBM Research
[6] IBM Research
[7] IBM Research
[8] IBM Research
[9] Environment and Climate Change Canada
[10] Environment and Climate Change Canada

Presented by / Présenté par: ***Madalina Surcel***
Contact: madalina.surcel@ec.gc.ca

Given the high computational cost of dynamical downscaling, the Canadian Center for Meteorological and Environment Prediction (CCMEP) could greatly benefit from efficient and performant Artificial Intelligence (AI) downscaling techniques. These techniques could be applied both to extend the range of high-resolution forecasts, and to develop high-resolution ensembles.
Through a collaboration with IBM, an AI downscaling toolbox is currently being developed at CCMEP, consisting of a modular Python software package applicable to medium-range forecasts of various weather elements (surface winds, surface temperature and precipitation) from CCMEP's global model, the Global Deterministic Prediction System (GDPS; 15-km resolution). This toolbox will be used to downscale forecasts to a grid-spacing of 2.5 km, the resolution of CCMEP's High-Resolution Deterministic Prediction System (HRDPS). Considering future development beyond the IBM-CCMEP collaboration and an eventual operational implementation of this downscaling application, certain computational requirements need to be fulfilled. A tuned version of the toolbox, i.e., an AI downscaling model, will be trained and validated using data from GDPS and HRDPS.
This presentation will describe preliminary results of training the AI downscaling model for surface winds using GDPS data as the low-resolution dataset, and HRDPS data as the high-resolution dataset. Two different AI architectures are explored: a small AI model based on Generative Adversarial Networks (GAN) and a large AI model based on combining a trained foundation model with a vision Transformer backbone and an adapter layer to use for downscaling. GANs have been proven successful for downscaling applications and thus represent a reasonable benchmark to validate the large AI model.

Session: 6030 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 1 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 1

06/06/2024 13:30

ID: 12105 Contributed abstract

Deep learning-based bias adjustment of Arctic sea ice forecasts from version 3 of the Canadian Seasonal to Interannual Prediction System (CanSIPSv3)

Reinel Sospedra-Alfonso [1] , *Parsa Gooya* [2] , *Michael Sigmond* [3] , *Joseph Martin* [4]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada
[4] University of Victoria

Presented by / Présenté par: ***Reinel Sospedra-Alfonso***
Contact: reinel.sospedra-alfonso@ec.gc.ca

We propose a deep learning-based approach to post-process seasonal forecasts of Arctic sea ice concentration (SIC) produced with version 3 of the Canadian Seasonal to Interannual Prediction System (CanSIPS). CanSIPS is the Environment and Climate Change Canada's (ECCC's) operational seasonal forecasting system based on two

global climate models initialized at the start of every month to produce a 20-member ensemble of 12-month range predictions. While CanSIPSv3 SIC forecasts have improved from previous versions, biases remain particularly over the latest 1991-2020 hindcast period. We use Convolutional Neural Network (CNN) based architectures to adjust Arctic SIC. The CNN-based model is trained on retrospective SIC forecasts targeting observation-based data to map erroneous forecasts into more accurate predictions. The CNN-based SIC adjustments are shown to outperform the standard bias and trend correction methods for pan-Arctic and regional sea ice extent (SIE), sea ice area (SIA), and the location of the sea ice edge. We further examine the potential of deep learning-based models to adjust sea ice products such as freeze-up date (FUD) and ice-free date (IFD). ECCC's sea ice forecasts are being used for research and operational planning purposes by various end users, including the government, the private sector, and the northern communities.

Session: 8020 Multidisciplinary - Theoretical to applied science - Part 1 Multidisciplinaire - De la théorie à la science appliquée - Partie 1

Convenors: Rick Danielson

Related to multidisciplinary environmental studies and/or information sharing , which includes, but not limited to Arctic studies, wildfire fires, hydrology, and cryology using various approaches.

This session covers all studies related to environmental topics that are not addressed in the atmosphere, ocean, and climate sessions. For example, all models other than atmospheric, ocean, and climate models.

Session: 8020 Multidisciplinary - Theoretical to applied science - Part 1 Multidisciplinaire - De la théorie à la science appliquée - Partie 1

06/06/2024 14:05

ID: 12076 Contributed abstract

Using weather and microclimate measurements to assess wildfire risk in different forest stand types.

Vanessa Foord [1] , *Rulan Xiao* [2] , *Phil Burton* [3] , *Joseph Shea* [4] , *Rebecca Bowler* [5]

[1] British Columbia Ministry of Forests
[2] University of Northern British Columbia
[3] University of Northern British Columbia
[4] University of Northern British Columbia
[5] British Columbia Ministry of Forests

Presented by / Présenté par: ***Vanessa Foord***
Contact: veggin@telus.net

Observations from recent wildfires in the central interior of British Columbia (BC) have shown juvenile lodgepole pine plantations unburned or with low burn severity where neighbouring forests were burned, sometimes severely. The existence of these potential fire skips on the land base warrants further investigation; one area we

explored is the role microclimate has on wildfire risk in different stand types. We found 6 locations in BC's central interior with adjacent clear-cut openings, juvenile lodgepole pine plantations, and mature sub-boreal spruce forest and made measurements of air temperature, relative humidity, rainfall, wind speed, wind direction, surface temperature, soil temperature, and soil moisture in each of the three stand types. We compared these measurements between different stand types and postulate how they may increase or reduce wildfire risk. Additionally, we calculated Canadian Forest Fire Danger Rating System variables, such as Fine Fuel Moisture Code, Duff Moisture Code, Drought Code, Build Up Index, Initial Spread Index, and Fire Weather Index from our in-stand measurements and compared them to nearby BC Wildfire Weather stations. Initial results show reduced wind speed in the juvenile stands which could be a factor in reducing wildfire severity. Project design, methods, and preliminary results from the three field seasons of monitoring and analysis thus far will be presented.

Session: 8020 Multidisciplinary - Theoretical to applied science - Part 1 Multidisciplinaire - De la théorie à la science appliquée - Partie 1

06/06/2024 14:20

ID: 11889 Contributed abstract

The Topographic Random Cascade Approach for Downscaling and Extreme Event Modeling of Coarse-Scale Precipitation Products over Complex Terrain Regions. Study case: the metropolitan area of Mexico City.

Victor Manuel Peñaranda-Vélez [1] , *Carlos A. Ochoa* [2] , *Arturo I. Quintanar* [3] , *Enrique R. Vivoni* [4]

[1] Postdoctoral Research Scientist
[2] Titular Research Scientist at ICAyCC
[3] Titular Research Scientist at ICAyCC
[4] Fulton Professor of Hydrosystems Engineering in the School of Sustainable Engineering and the Built Environment at Arizona State University

Presented by / Présenté par: ***Victor Manuel Peñaranda-Vélez***
Contact: victor.penaranda@atmosfera.unam.mx

The orographic effect on the spatial structure of precipitation is a fundamental problem in hydrometeorology, as it interacts with several physical atmospheric processes that manage the development of atmospheric precipitation and the emergence of spatial complex patterns. In addition to the above, some regions, mostly in the tropics, do not account for good-distributed and high-quality measurements, causing the modeling of precipitation and its prediction to be quite challenging nowadays. In response to this problem, satellite precipitation products offer opportunities to understand how spatial precipitation fields behave over time; however, the functionality of these precipitation products presents limitations with spatial scale for water management applications. This research introduces an innovative approach to tackling the problem of downscaling precipitation products in regions with complex topography. This approach, called the Topographic Random Cascade, is an integrated modeling protocol to generate high-resolution precipitation fields from coarse-scale precipitation products. This approach includes in its methodology the application of a time-adaptive random cascade generator for the downscaling process, a topographic enhanced function for the description of the altitudinal variability of precipitation, and a numerical diffusion

filter to minimize the blockiness problem of random cascades. The suggested approach and the precipitation products CHIRP and IMERG were applied to analyze some long-term precipitation statistics in the metropolitan area of México City. Based on the results obtained, the mean-field statistics of simulated fields and precipitation products agree quite well, but there also exist some improvements in the extreme event statistics of locations influenced by orographic constraints. This research shows that this approach is an alternative to obtain high-resolution precipitation fields with less computational effort than the fields derived from dynamic downscaling techniques, and its use can be performed in urban hydrology or in the analysis of climate change of small watersheds, which are settled in regions with complex orography.

Session: 8020 Multidisciplinary - Theoretical to applied science - Part 1 Multidisciplinaire - De la théorie à la science appliquée - Partie 1

06/06/2024 14:35

ID: 11969 Contributed abstract

Future changes in consecutive ice-influenced and open-water streamflow extremes in a subarctic river basin

Rajesh Shrestha [1] , *Alex Cannon* [2] , *Spyros Beltaos* [3]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada

Presented by / Présenté par: ***Rajesh Shrestha***
Contact: rajesh.shrestha@ec.gc.ca

Floods in the Arctic/subarctic regions are compound hydrometeorological events of extreme water levels and flows, occurring under ice-influenced and open-water conditions, respectively, whose frequency and intensity can be expected to alter with the climate-induced changes in temperature, precipitation and snowpack. Here, we analyze future changes in the consecutive ice-influenced and open-water streamflow extremes for the Liard River basin in subarctic Canada using streamflow simulations from the variable infiltration capacity hydrologic model and ice thickness simulations from a conceptual model. The models are driven by statistically downscaled CMIP6 and CMIP5 GCMs, and future projections are analyzed under 1.5 to 4.0 °C global mean temperature increases above the preindustrial period. We use a nonstationary extreme value analysis framework to relate extreme streamflow changes to antecedent precipitation, temperature and snowpack. Our results indicate intensification of extreme streamflow with global mean temperature increases, with progressively higher flow magnitudes under both ice-influenced and open-water conditions. The projections driven by CMIP6 GCMs generally show larger increases in extreme flow compared to CMIP5 GCMs. The analysis of the hydroclimatic drivers indicate associations of different control mechanisms with ice-influenced and open-water flood events.

Session: 8020 Multidisciplinary - Theoretical to applied science - Part 1 Multidisciplinaire - De la théorie à la science appliquée -

06/06/2024 14:50

Partie 1

ID: 12003 Contributed abstract

Modelling Northern Hemisphere lake ice phenology using the Canadian Lake Ice Model

Alex Cabaj [1] , *Laura Brown* [2]

[1] University of Toronto Mississauga
[2] University of Toronto Mississauga

Presented by / Présenté par: ***Alex Cabaj***
Contact: alex.cabaj@mail.utoronto.ca

As global temperatures rise, the timing of lake ice freeze-up and break-up are impacted. In-situ monitoring of lake ice is commonly performed by local communities proximate to lakes, but remote lakes pose observational challenges. Thermodynamic lake ice models, such as the Canadian Lake Ice Model (CLIMo), can provide hemisphere-wide estimates of lake ice freeze-up, break-up, and seasonal thickness evolution. Many uncertainties remain in modelled representations of lake ice, particularly from snow cover on lakes, which is challenging to quantify due to redistribution across the lake surface, as well as uncertainties in reanalysis representations of precipitation.

In this work, we make use of the Canadian Lake Ice Model (CLIMo), forced with input from the ERA5 and ERA5-Land reanalysis products, to produce hemispheric estimates of lake ice freeze-up and break-up timing from 1980-2020, at a 0.25 degree grid resolution. The simulations are run using the most suitable version of CLIMo (Northern or Temperate region CLIMo) for multiple lake mixing depths and snow cover scenarios, with snow estimated from snow depths from ERA5-Land interpolated over lake areas. To validate the model, we compare output from CLIMo driven with observations from ground-based meteorological stations against the reanalysis-driven model runs and ground-based observations where available. Lake ice changes are evident over the time series, with shifts in the freeze-up and breakup timing, particularly in high-latitude regions.

Session: 8020 Multidisciplinary - Theoretical to applied science - Part 1 Multidisciplinaire - De la théorie à la science appliquée - Partie 1

06/06/2024 15:05

ID: 12005 Contributed abstract

Assessing the impact of differing snow inputs to reanalysis-based snow-on-sea-ice reconstructions

Alex Cabaj [1] , *Paul Kushner* [2] , *Alek Petty* [3]

[1] University of Toronto Mississauga
[2] University of Toronto
[3] University of Maryland, College Park

Presented by / Présenté par: ***Alex Cabaj***
Contact: alex.cabaj@mail.utoronto.ca

Snow on Arctic sea ice plays a key role in multiple feedbacks between sea ice and the global climate. Snow has many seasonally-varying and sometimes contrasting influences on sea ice thickness and extent. Furthermore, estimates of snow depth on Arctic sea ice are necessary for estimating sea ice thickness from satellite lidar altimetry measurements, such as those from the NASA Ice, Cloud, and land Elevation Satellite, 2 (ICESat-2). Snow-on-sea-ice models, such as the NASA Eulerian Snow On Sea Ice Model (NESOSIM), can produce basin-wide estimates of snow depth and density on Arctic sea ice. NESOSIM version 1.1 is a 2-layer model with simple representations of snow accumulation, densification through wind packing, loss due to blowing snow, and snow redistribution due to sea ice motion.
A key uncertainty in reanalysis-based snow-on-sea-ice reconstructions such as NESOSIM is the choice of reanalysis product used for snowfall input. In this work, snowfall from ERA5, JRA-55 and MERRA-2 are used as input to NESOSIM. A Markov chain Monte Carlo approach is used to automatically calibrate free parameters for NESOSIM run for 1980-2022 with these different snowfall inputs, constraining the model output to snow depth and density observations. The resulting outputs from NESOSIM are compared to two sets of existing output from SnowModel-LG, a Lagrangian snow-on-sea-ice model, which can be driven by ERA5 or MERRA-2 snowfall. Basin-average and regional snow trends are examined, and inter-forcing and inter-model differences are investigated. The impact of changing sea ice on trends in snow depth is also assessed. NESOSIM snow depths are found to be consistent with SnowModel-LG in the central Arctic Ocean, but inter-model differences are larger in the peripheral Arctic seas. The magnitude of snow depth trends produced by both NESOSIM and SnowModel-LG is found to be sensitive to the choice of snowfall input dataset.

Session: 2031 Advancing research on marine extremes - Part 2 Faire progresser la recherche sur les extrêmes marins - Partie 2

Convenors:
Amber Holdsworth (Institute of Ocean Science)
Hayley Dosser (Institute of Ocean Science)

Anthropogenic greenhouse gas emissions are altering conditions across the global ocean, driving more frequent and extreme ocean states of anomalously high temperature, low oxygen, and/or low pH (acidification). Multiple ecosystem stressors occurring concurrently or consecutively can adversely affect marine biota to a greater extent than a single stressor in isolation. This session will highlight recent advances in research on marine extremes, for either single or multiple stressors. We welcome experimental, observational, and modelling investigations of marine extremes and their impacts for both open ocean and coastal waters. Of particular interest are studies focused on developing and implementing clear and consistent definitions of extremes that allow for comparisons between regions and on varying time scales. We welcome insights into improving monitoring programs, with a focus on better characterizing the ranges and distributions of relevant variables, investigating ecological responses to extremes, and assessing how such programs can support modelling efforts. We encourage studies that consider the past and current states of the ocean as well as those that consider future projections.

Session: 2031 Advancing research on marine extremes - Part 2
Faire progresser la recherche sur les extrêmes marins - Partie 2 **06/06/2024 14:05**

ID: 11903 Contributed abstract

The impact of retreating sea ice on extremes in air-sea heat fluxes across the marginal seas of the North Atlantic Ocean and adjoining Arctic Ocean

Kent Moore [1]

[1]

Presented by / Présenté par: ***Kent Moore***
Contact: gwk.moore@utoronto.ca

The spatial and temporal variability in sea ice across the subpolar North Atlantic Ocean plays an important role in modulating the air-sea sensible and latent heat fluxes across the region. Typically, these fluxes are highest downstream of the marginal ice zone where cold and dry Arctic first encounters the open ocean. By their nature, polynyas are also regions where these contrasts are large and, as a result, they are often characterized by elevated fluxes. The retreat of sea ice or changes in polynya characteristics can, therefore, result in shifts in where these fluxes are large, impacting phenomena in both the atmosphere and ocean. The spatial complexity of these changes in sea ice can make it a challenge to resolve the resulting impacts on air-sea fluxes. Here, we use a high spatial resolution, 2.5km, regional reanalysis of the subpolar North Atlantic spanning the period from 1991 to the present that extends from the Canadian Arctic Archipelago, northern Baffin Bay and the Labrador Sea eastwards to the Norwegian Sea and Svalbard to characterize this impact. We find that the retreat of sea ice is dramatically impacting the spatial distribution of both median and extreme air-sea fluxes across the region. The changes are most pronounced near the North Water Polynya, the Labrador and Greenland Seas, as well as around Svalbard. Increases in the air-sea heat fluxes are also identified over the Arctic Ocean to the north of Ellesmere Island and north Greenland, the so-called Last Ice Area, which is associated with thinning ice. The impact of these changes on the atmosphere and ocean will be discussed.

Session: 2031 Advancing research on marine extremes - Part 2
Faire progresser la recherche sur les extrêmes marins - Partie 2 **06/06/2024 14:20**

ID: 12011 Contributed abstract

A new high-resolution view of the structure and evolution of Cape Farewell tip jets

Adrien Delespaul [1] , *Kent Moore* [2] , *Sergey Gulev* [3]

[1] University of Toronto
[2] University of Toronto
[3] University of Grenoble

Presented by / Présenté par: ***Adrien Delespaul***
Contact: gwk.moore@utoronto.ca

Tip jets, narrow regions with enhanced easterly or westerly winds in part generated due to Greenland's steep topography, are responsible for the oceans surrounding Cape Farewell being amongst the windiest marine locations worldwide. The elevated air-sea fluxes of heat and moisture associated with these jets are responsible for deep water formation in the Irminger Sea, a contributor to the abyssal return flow of the Atlantic Meridional Overturning Circulation. There has been a steady increase in our knowledge of the structure and impact of these tip jets that has occurred with increasing resolution of atmospheric reanalyses. However, the small-scale nature of these tip jets, with length scales on the order of 100km, suggests that even the ERA5 Reanalysis with a resolution of ~30km may not fully capture these phenomena. Here, we use the recently introduced C3S Arctic Regional Reanalysis (CARRA), with a grid resolution of 2.5km, covering the period from 1991 onwards, to provide a new high spatial resolution of the structure and evolution of Cape Farewell tip jets and their impact on the ocean. Results indicate that the higher spatial resolution of the CARRA provides new details on the fine-scale structure of these jets, including higher wind speeds and enhanced spatial gradients as compared to ERA5. There is also an increase in the magnitude of the air-sea heat fluxes associated with these jets, which suggests that deep ocean convection in the Irminger Sea may be more vigorous than previously thought.

Session: 2031 Advancing research on marine extremes - Part 2
Faire progresser la recherche sur les extrêmes marins - Partie 2 **06/06/2024 14:35**

ID: 11898 Contributed abstract

The characterization and impact of extreme winds along Nares Strait

Alexandra Stephens [1] , *Kent Moore* [2]

[1] University of Toronto
[2] University of Toronto

Presented by / Présenté par: ***Alexandra Stephens***
Contact: gwk.moore@utoronto.ca

Extreme winds in the Arctic can affect sea ice flow, the formation of open-water areas called polynyas, ocean convection, and maritime and aviation activity. This work aims to study a severe wind event that occurred along Nares Strait in April 2005 that demolished an ice camp established to investigate the oceanography of the region. Our aim is to determine whether the event was extreme or typical for the region and quantify its exceptionality. Nares Strait is a long, narrow body of water between Ellesmere Island (Nunavut, Canada) and Greenland. There are steep mountains on both sides, which significantly impact meteorological phenomena and make it difficult to accurately model weather events in the area. Therefore, we used the new Copernicus Arctic Regional Re-analysis (CARRA) data which has 2.5 km horizontal resolution, 21 height levels in the lower 2 km of the atmosphere, and covers the period 1991-2022 to characterize the wind climate of the region. Our results indicate that the winds are extreme at specific points in space and time during the April 2005 storm, briefly exceeding the 95th percentile, but most winds did not exceed this mark. Additionally, the re-analysis generally concurs with the oceanography camp's

description of events, although some of the highest observed wind speeds were not captured in the dataset.

Session: 2031 Advancing research on marine extremes - Part 2
Faire progresser la recherche sur les extrêmes marins - Partie 2 **06/06/2024 14:50**

ID: 12031 Contributed abstract

Variations of marine heatwaves and cold spells in Northwest Atlantic during 1993-2022

Li Zhai [1] , *Youyu Lu* [2] , *Gilles Garric* [3]

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2
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Presented by / Présenté par: ***Li Zhai***
Contact: Li.Zhai@dfo-mpo.gc.ca

Parameters of marine heatwaves (MHWs) and cold spells (MCSs) in the Northwest Atlantic during 1993-2022 are derived from the ocean temperatures from the data-assimilative global ocean reanalysis product GLORYS12V1. At sea surface, the parameters obtained from GLORYS12V1 and that from satellite remote sensing data show similar spatial contrast between shelf and deep oceans, and inter-annual variations. On Scotian Shelf, years with extremely high total days of MWHs and MCSs are identified, which are related to the occurrence of abnormally warning and cooling lasting more than a season in these years. The MHWs and MCSs parameters in the water column, including at the seabed, are derived from GLORYS12V1. The space-time variations of the derived parameters are linked to the interannual anomalies of water temperature from the model, which are evaluated with the ship-based observations of the annual surveys of the Atlantic Zone Monitoring Program of Fisheries and Oceans Canada. Finally, “heat maps” of MHWs and MCSs are produced based on the analysis results, and are provided for applications in ecosystem and fishery in Atlantic Canada.

Session: 2031 Advancing research on marine extremes - Part 2
Faire progresser la recherche sur les extrêmes marins - Partie 2 **06/06/2024 15:05**

ID: 12061 Contributed abstract

The 2023 Summer Marine Heat Wave over the Newfoundland and Labrador Shelf

Nancy Soontiens [1] , *Heather J. Andres* [2] , *Jonathan Coyne* [3] , *Frederic Cyr* [4] , *Peter S. Galbraith* [5] , *Jared Penney* [6]

[1] Fisheries and Oceans Canada
[2] Fisheries and Oceans Canada
[3] Fisheries and Oceans Canada
[4] Fisheries and Oceans Canada

[5] Fisheries and Oceans Canada
[6] Fisheries and Oceans Canada

Presented by / Présenté par: ***Nancy Soontiens***
Contact: nancy.soontiens@dfo-mpo.gc.ca

Using the GLORYS12v1 ocean model reanalysis, we describe the evolution of a summer heat wave over the Newfoundland and Labrador shelf in 2023. In the weeks preceding this heat wave, spring sea surface conditions were unusually cold with spatially averaged temperature anomalies (relative to a reference period of 1993-2022) as low as -0.7 ˚C in June. From mid-July to early August, however, spatially averaged sea surface temperature anomalies peaked at +3.6 ˚C, representing a moderate to strong heat wave. Locally, such as over parts of the Grand Banks, heat wave conditions reached strong to severe levels with temperature anomalies of more than +6 ˚C. Anomalously warm conditions persisted throughout the rest of the summer and moderate heat waves were again detected in September (~2 week duration) and October (~1.5 week duration). During the late fall, sea surface temperatures returned to normal when vertical mixing was established due to increased winds, storms, and surface cooling. In this talk, we explore several factors that contributed to the intensity of the heat wave, including stratification, winds, and advection of fresh water. In addition, we compare the GLORYS12v1 reanalysis with in-situ data collected under the Atlantic Zone Monitoring Program (AZMP).

Session: 5011 Atmosphere - Theoretical to applied science - Part 2 Atmosphère - De la théorie à la science appliquée - Partie 2

Convenor: Kyle Ziolkowski

Related to scientific studies and/or information sharing about the atmosphere, including weather, meteorology, clouds and precipitation, air quality, atmospheric dynamic and extreme events, using various approaches.

This session covers many topics, including, but not limited to, theoretical research, model development, observation techniques, real-time monitoring, databases, diagnostic methods, data analysis and artificial intelligence.

Session: 5011 Atmosphere - Theoretical to applied science - Part 2 Atmosphère - De la théorie à la science appliquée - Partie 2 **06/06/2024 14:05**

ID: 11918 Contributed abstract

Global modelling of lightning and wildfires in a changing climate

Cynthia Whaley [1], *Montana Etten-Bohm* [2], *Courtney Schumacher* [3], *Ayodeji Akingunola* [4], *Kerry Anderson* [5], *Vivek Arora* [6], *Jason Cole* [7], *Jack Chen* [8], *Mike Lazare* [9], *Paul Makar* [10], *David Plummer* [11], *Knut von Salzen* [12]

[1] Environment and Climate Change Canada (ECCC)
[2] Department of Atmospheric Science, University of North Dakota
[3] Department of Atmospheric Sciences, Texas A&M University
[4] ECCC
[5] ECCC

[6] ECCC
[7] ECCC
[8] ECCC
[9] ECCC
[10] ECCC
[11] ECCC
[12] ECCC

Presented by / Présenté par: ***Cynthia Whaley***
Contact: cynthia.whaley@ec.gc.ca

Wildfires are a complex but important process to include in Earth system models. They have major impacts on climate via emissions of greenhouse gases and short-lived climate forcers; changes to weather and clouds; deposition of particulate matter to ice and snow; and changes to vegetation. In turn, climate change impacts wildfires to a large degree with impacts on fire weather, lightning ignition, and fuel availability. These feedbacks require processed-based, interactive modelling between the land surface and the atmosphere in order to answer the questions ``How will wildfires change in future climates?'' and ``How will those changing fires impact air quality and climate?'' Lightning is also expected to change in frequency and location with the changing climate. Until now, the Canadian Earth System Model (CanESM) did not contain an interactive lightning parameterization, nor did it utilize fire emissions from its land model component. The fire parameterization in CanESM5.1 was designed to use prescribed monthly climatological lightning, and the vertical distribution of fire emissions was constant, depending only on location.

In this study, we improved CanESM5.1 by adding a logistical regression lightning parameterization that predicts lightning occurrence interactively based on three environmental variables and their interactions. This created the capacity to interactively model lightning, allowing for future projections under different climate scenarios. We have also added fire energy and plume rise parameterizations from the Canadian Forest Fire Emission Prediction System, creating more variable fire plume heights that will respond to changing fire projections. The modelled lightning, burned area, and plume heights were evaluated against satellite measurements over the historical period. The modified version of CanESM5.1 was then used to simulate two future climate scenarios to assess how lightning and fires change in the future.

Session: 5011 Atmosphere - Theoretical to applied science - Part 2 Atmosphère - De la théorie à la science appliquée - Partie 2 **06/06/2024 14:20**

ID: 12097 Contributed abstract

Cloud-Ground Lightning Trends in Canada: A Look at 26 Years of Data from the Canadian Lightning Detection Network

Gabor Fricska [1] , *William R. Burrows* [2] , *Bohdan Kochtubajda* [3]

[1]
[2] ECCC
[3] ECCC (retired)

Presented by / Présenté par: ***Gabor Fricska***

Contact: gabor.fricska@canada.ca

Environment and Climate Change Canada's Canadian Lightning Detection Network has been collecting lightning data since1999. Trends in cloud-ground lightning activity during this period show that lightning in Canada has been trending downward nationally, especially in the southern part of the country, while northern areas including the three Territories have shown an increase.

Session: 5011 Atmosphere - Theoretical to applied science - Part 2 Atmosphère - De la théorie à la science appliquée - Partie 2 **06/06/2024 14:35**

ID: 12007 Contributed abstract

Roles of Planetary Waves during Fast and Slow Sudden Stratospheric Warming Events

Yucheng Zi [1] , *Zhenxia Long* [2] , *Jinyu Sheng* [3] , *Ziniu Xiao* [4] , *Will Perrie* [5] , *Gaopeng Lu* [6]

[1] Dalhousie University
[2] Bedford Institute of Oceanography
[3] Dalhousie University
[4] School of Earth and Space Sciences, University of Science and Technology of China
[5] Bedford Institute of Oceanography
[6] School of Earth and Space Sciences, University of Science and Technology of China

Presented by / Présenté par: ***Yucheng Zi***
Contact: ziyucheng520@lasg.iap.ac.cn

Major Sudden Stratospheric Warming (MSSW) is defined as an event in which the stratospheric polar vortex (SPV) at 10hPa reverses from the westerly to the easterly during a short period. The warming rates of 48 MSSW events during 1940-2021 are examined using the ERA5 reanalysis in this study. Those MSSW events are separated into 27 fast-warming events (FWEs) and 21 slow-warming events (SWEs) based on the decay rates of the SPV's intensity. Our composite analysis shows that the average time scale of FWEs (SWEs) is about 20 (32) days. The early stage of the FWE (SWE) is accompanied by a strong (normal) SPV, which suppresses (inspires) the upward motion of planetary waves, leading to the accumulation (release) of planetary waves, and ultimately leading to the fast (slow) decay of SPV. Within ~40 days before the FWE, blocking high events (BHs) occur over Greenland, the North Atlantic east coast, the Nordic and Ural Mountains, and Alaska regions. This spatial distribution of BHs can significantly enhance climatological planetary wave-1 and wave-2 (linear effects). However, in the SWE, BHs just occur over Greenland, the North Atlantic east coast, and near Bering Strait. This can only enhance planetary wave-1 (linear effects), but not wave-2. In comparison with the SWE, more frequent and stronger BHs in the FWE lead to stronger baroclinicity and transient eddy effects (nonlinear effect), causing the SPV to weaken rapidly and faster tropospheric response.

ID: 11991 Contributed abstract

Weather driven complementarity between daily energy demand at one location and renewable supply at another: Adding the time dimension

Frédéric Fabry [1] , *Véronique Meunier* [2]

[1] McGill University
[2] McGill University

Presented by / Présenté par: ***Frédéric Fabry***
Contact: frederic.fabry@mcgill.ca

In a previous work (Fabry et al. 2023, https://doi.org/10.1175/JAMC-D-22-0153.1), we studied how weather patterns such as high- and low-pressure systems not only shape where and when more energy is needed for warming or cooling, but also where one can find more wind and solar energy in periods of greater need. One of our key conclusions was that while local solar power is often naturally slightly correlated with heating or cooling demand, local wind energy sources often provide more of their power in periods of lesser need. A consequential finding was that distant wind production sites east of consumption centers would naturally have better timing in winter than nearby ones. We may, however, have committed an injustice: the storms that are raging east of us when we are cold in winter were often on top of us a day or two before. Hence, instead of having to transport the wind power of the day over great distances, it may be simpler to store energy for a day or two before it is needed in greater quantity.

We hence completed our previous study by seeking potential sites of renewable energy production that are not only better timed with the demand of the day but also with the demand of the next day or two. Daily averaged time series of weather-related energy needs and of wind and solar energy potential from 1959 to 2022 were reanalyzed by also considering how energy production a day or two before from nearby and distant sites could partially match the energy consumption fluctuations associated with enhanced heating need in winter and cooling need in summer. We found that wind energy in winter and solar energy in summer tend to slightly precede periods of greater need, illustrating the value of storing energy for short periods.

ID: 11992 Contributed abstract

Why is there less convection in elevated areas?

Maxim Couillard [1] , *Frédéric Fabry* [2]

[1] McGill University
[2] McGill University

Presented by / Présenté par: ***Maxim Couillard***

Contact: frederic.fabry@mcgill.ca

Conventional meteorological wisdom dictates that mountains provide a favorable environment for convection initiation: There exists an expansive body of knowledge on mountains being regions of preferred convective initiation and enhancement via orographic lift, thermal circulations, and other mechanisms. However, our analysis shows that some mountainous areas (such as the Appalachians and the Laurentians) are convection minima, while intersecting valleys (such as the Appalachians and the Laurentians) are convection minima, while local maxima in convection occurrence are more often observed in intersecting valleys such as the Richelieu-St-Lawrence. This suggests that mountains either hamper cell maintenance or the formation of new cells. There is limited previous research into mountains having a negative effect on convective storms. This project investigates processes in which mountains disrupt pre-existing storms and inhibit convective initiation. Using lightning, radar, and ERA5 reanalysis data, we first sought for clues characterizing the convection minima such as its timing and the thermodynamic atmospheric properties associated with it. To further investigate processes contributing to the convective minimum, we conducted high-resolution simulations of some events using the WRF model. Processes possibly contributing include a variety of scales from synoptic frontal delays and CAPE reduction in orography to interactions between storm cold pool and complex terrain affecting storm maintenance.

Session: 5011 Atmosphere - Theoretical to applied science - Part 2 Atmosphère - De la théorie à la science appliquée - Partie 2 **06/06/2024 15:20**

ID: 11894 Contributed abstract

Performance assessment of the Low Porosity Double Fence wind shield configuration for improving solid precipitation measurement

Amber Ross [1] , *Connor Johnson* [2] , *Craig Smith* [3]

[1] ECCC
[2] ECCC
[3] ECCC

Presented by / Présenté par: ***Amber Ross***
Contact: amber.ross@ec.gc.ca

Precipitation measurements in operational networks, including in the Environment and Climate Change Canada networks, evolves with changing technology and infrastructure requirements. This has the potential to create inhomogeneity in long-term climate records. Measurement errors from wind-induced undercatch of solid precipitation is of notable concern for flood and water resource forecasting, hydrological modelling, and climate change analysis. To conduct performance intercomparisons and error assessments of the variety of automated precipitation gauge configurations, the WMO Solid Precipitation Intercomparison Experiment (SPICE) introduced the Double Fence Automated Reference (DFAR) consisting of an automated gauge inside a large wooden double octagonal wind fence. Although the DFAR wind fence is capable of significantly reducing this measurement bias due to wind, the structure is expensive to install, has a large footprint (12 m wide), is subject

to degradation, and is difficult to maintain (especially in remote locations). This makes the DFAR unfeasible for use in operational networks. Because of this, the ECCC Climate Research Division is examining the performance of a new wind shield termed the Low Porosity Double Fence (LPDF) that has been developed and tested by NOAA for use in the U.S. Climate Reference Network (USCRN). The LPDF has a substantially smaller footprint (4.9 m wide) than the DFAR and is constructed of off-the-shelf chain link fencing material that is virtually maintenance free and relatively easy to install, making this configuration deployable at almost any station in the operational network. Intercomparisons of the LPDF at test sites in the United States showed very satisfactory performance for solid precipitation measurement. For assessment in conditions more typical of the Canadian Prairies and Arctic (i.e. high exposure and elevated wind speed during snowfall events), the LPDF was installed at the Bratt's Lake (SK) supersite in the fall of 2023. Through the winter of 2023-2024, the performance of the LPDF was assessed against the DFAR reference precipitation measurements as well as against other gauge configurations currently and previously employed in the ECCC measurement networks. This presentation will share the preliminary results of the wind shield intercomparison along with future project plans.

Session: 6031 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 2 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 2

Convenors:
Miguel Tremblay (Environment and Climate Change Canada)
Ann Dacres (Environment and Climate Change Canada)

We invite the meteorological community to contribute to an exciting session on the integration of Artificial Intelligence (AI) in meteorology. This session aims to explore how AI, especially Machine Learning (AI/ML) and high-performance computing, is revolutionizing modern meteorology. == Potential Topics == * AI in Weather Forecasting Enhancement: * Application of AI algorithms to improve the accuracy of weather forecasts. * Case studies on the integration of AI in national meteorological services. * Climate Change Modeling with AI: * The role of AI in predicting long-term climatic trends. * Using machine learning to understand and mitigate the effects of climate change. * Public Engagement and Weather Information Dissemination: * AI-driven platforms for better communication of meteorological information to the public. * Social media and AI in raising awareness about meteorological events. * Innovations in Meteorological Data Collection: * The use of AI to enhance the quality and scope of meteorological data collection. * Innovations in sensor technology and data acquisition methods driven by AI. Additional Topics to Explore: * The use of AI for the forecasting, management, and impact analysis of environmental emergencies, including natural disasters and extreme meteorological phenomena. * Data-driven modeling in meteorology. * Hybridization of meteorological models. * AI/ML for immediate forecasting (Nowcasting). * Improvements in S2S (sub-seasonal to seasonal) forecasts. * Operationalization of AI/ML. * Ethical and responsible AI. * Improving AI literacy.

Session: 6031 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 2 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 2

06/06/2024 14:05

ID: 11953 Contributed abstract

Why are AI forecasting models so fast?

Christopher Subich [1]

[1]

Presented by / Présenté par: ***Christopher Subich***
Contact: csubich@gmail.com

Over the past two years, NVidia, Google, and others have reported breakthroughs in generating global atmospheric forecasts with data-driven AI approaches, using a variety of model architectures. Each of these leading models generates quarter-degree global forecasts at lead times from 6 hours to several days with accuracy comparable to that of ECMWF's IFS forecast system with model runtimes that are orders of magnitude faster than "conventional NWP methods."

Why is this the case? What do AI models do differently to explain such a large disparity in runtimes? Have these models found a more efficient representation of the Earth system, or are AI systems just a better way of taking advantage of accelerator architectures?

This talk compares the computational cost of a quarter-degree forecast produced by Environment & Climate Change Canada's GEM forecasting model with the cost of an equivalent forecast made by GraphCast, the open-source model from Google Deepmind. With performance instrumentation and a 'roofline' model of system performance, we look inside these models to see exactly where AI-NWP models gain their runtime advantages over traditional NWP, and we conclude with thoughts about the future direction of NWP systems on modern computing hardware.

Session: 6031 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 2 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 2

06/06/2024 14:20

ID: 11940 Contributed abstract

Towards state-of-the-art nowcasting with a foundational AI model: an ECCC-IBM collaboration

Dominique Brunet [1], *Didier Davignon* [2], *Ahmed Mahidjiba* [3], *Karthik Mukkavilli* [4], *Daniel Salles Civitarese* [5], *Johannes Schmude* [6]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada
[4] IBM
[5] IBM
[6] IBM

Presented by / Présenté par: ***Dominique Brunet***
Contact: Dominique.Brunet@ec.gc.ca

Recent progress in AI for nowcasting precipitation (e.g. NowcastNet) and other surface variables (e.g. MetNet-3) has been staggering. The move from advection-based nowcasting using PySteps to the state-of-the-art AI-based nowcasting methods requires an expertise not currently found in ECCC. We present here some results from a collaborative endeavour between ECCC and IBM. As a baseline, we initially compare a high-resolution operational ECCC PySteps-based radar reflectivity nowcasting with a version of NowcastNet specifically optimized for the Canadian domain. Then, we explore how the coupling of NowcastNet with a foundational AI model such as AtmoRep can enhance and expand the nowcasting capabilities by providing guidance on the large-scale dynamic. Finally, we lay the vision on how this approach can be expanded to other predictands (geostationary satellite, lightning, and surface observations) and more predictors (surface variables and clouds). The goal is thus not only to move towards the operationalization of state-of-the-art radar precipitation nowcasting algorithms, but also to push further the nowcasting state-of-the-art with cutting edge AI research.

Session: 6031 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 2 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 2

06/06/2024 14:35

ID: 11927 Contributed abstract

Investigation of a Deep Learning based simulator to increase the ensemble size in an EnKF with the recentering technique : experiments with the Lorenz 1996 model

Vikram Khade [1]

[1] ECCC

Presented by / Présenté par: ***Vikram Khade***
Contact: Vikram.khade@ec.gc.ca

In this work the efficacy of using a Deep learning (DL) based forecast model simulator to increase the ensemble size is demonstrated using two simulators (SIM1 and SIM2) with different levels of simulation errors. Typically, training a DL simulator is very expensive – but running a trained model is relatively cheap. It is convenient to use a simulator to increase the size of the ensemble in an EnKF. I demonstrate the utility of such DL based ensembles in increasing the ensemble size in EnKF thereby allowing a longer localization radius resulting in lower analysis RMSE using the 40 dimensional Lorenz 1996 (L96) model.
I trained two DL simulators, SIM1 and SIM2 using 1 million and 10 million samples of L96 model respectively. I ran EnKF experiments with all members coming from the L96 model, whose analysis RMSE is the baseline for comparison with the hybrid ensemble in which some members are from L96 and some from the simulator. The hybrid ensemble experiments are of two types – one in which SIM1 is used and the other in which SIM2 is used. In the hybrid EnKF, I used 10 L96 members and ran several EnKF

experiments with increasing size of the simulator ensemble. It is demonstrated that the hybrid EnKF closely approximates the analysis RMSE for the EnKF experiment with all L96 members. The hybrid EnKF using SIM1 approximates within 10% while SIM2 approximates within 6%. In the hybrid EnKF experiments the prior simulator ensemble is recentered on the mean of the L96 ensemble. This has the effect of correcting the simulator error.

Session: 6031 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 2 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 2 **06/06/2024 14:50**

ID: 11929 Contributed abstract

Extending the skillful range of hub-height wind forecasts using self-organizing maps

Jill Psotka [1] , *Greg West* [2] , *Roland Stull* [3]

[1] University of British Columbia
[2] BC Hydro
[3] University of British Columbia

Presented by / Présenté par: ***Jill Psotka***
Contact: jpsotka@eoas.ubc.ca

The accuracy of numerical weather prediction decreases with lead time due to the propagation of initial and boundary condition uncertainties as well as the chaotic nature of the atmosphere. This deterioration of skill is inversely proportional to the scale of the phenomenon that is being forecasted; large patterns of upper-level geopotential heights have been found to be skillful out to >10 days lead time, yet turbine hub-height wind forecasts are skillful only out to ~6 days. Additionally, many studies have shown that significant correlations exist between upper-level patterns and near-surface winds. This research aims to leverage the longer lead-time skill advantage of upper-level forecasts and their correlation to hub-height wind speed to extend the accuracy range of hub-height wind forecasts. This is tested using observations from wind farms in British Columbia and forecasts from the US Global Ensemble Forecast System (GEFS). Self-organizing maps, an unsupervised machine learning technique, are trained to cluster past patterns of upper-level (500-hPa) geopotential heights and their associated wind speed observations. Forecasts of geopotential height are then matched to the trained map patterns, and the associated hub-height wind distributions can be used as probabilistic wind forecasts. This method is evaluated against the climatology for the region as well as raw wind forecasts from the GEFS. Secondarily, we experiment with averaging over different forecast and observation window lengths from 12 hours to 7 days, to explore trade-offs between forecast skill and temporal resolution. This research will contribute to understanding the predictability of wind power at the 1-2 week forecast horizon, which is valuable for optimizing power generation and transmission planning.

Session: 6031 Advances and Applications of Artificial Intelligence **06/06/2024**

ID: 12108 Contributed abstract

Using Machine Learning to model severe weather risk in insurance

Jonathan Gadoury [1]

[1] Intact Financial Corporation

Presented by / Présenté par: ***Jonathan Gadoury***
Contact: jonathan.gadoury@intact.net

Insurance companies are at the forefront of the impacts caused by climate change. Every Canadian needs to have insurance for their properties and vehicles, so when severe weather hits, the cost can be quite severe. Insurers traditionally look at past claims history to anticipate insured loss for the following year and price their policies accordingly. However, this framework is failing to properly model risk since the environment and climate are changing at a rapid pace. We're seeing more and more weather events in regions that weren't previously impacted.

The private sector has been increasingly relying on data science and AI to capture patterns in their data, and insurance is no exception. Intact Financial Corporation (IFC), the biggest property insurer in Canada, has developed the capability to better anticipate the impacts of severe weather in a changing climate and take concrete adaptative actions, such as more accurate and fair pricing, as well as supporting communities becoming more resilient. The presentation will highlight how climate scientists from IFC have been using machine learning models over the years to better model risk of perils such as wildfire, flood and hail.

Session: 6031 Advances and Applications of Artificial Intelligence (AI) in Meteorology - Part 2 Progrès et applications de l'intelligence artificielle (IA) en météorologie - Partie 2 **06/06/2024 15:20**

ID: 12017 Contributed abstract

Analyzing Public Engagement with Official Weather Alerts in Northern Climates to Develop New Computational Approaches to Improving Communication

Renee Sieber [1], *Andrei Romascanu* [2], *Martin Pleynet* [3], *Zander Bamford-Brown* [4], *Frida Buitron* [5], *Drew Bush* [6]

[1] McGill University
[2] MILA
[3] McGill University
[4] McGill University
[5] Independent
[6] Mount Washington Observatory

Presented by / Présenté par: ***Renee Sieber***
Contact: renee.sieber@mcgill.ca

Meteorological information, conveyed through official alerts, is a daily presence in people's lives, aimed at enhancing preparedness and situational awareness. The needs of forecasters and crisis managers in providing this information and managing weather events has been well-studied. However, little attention has been paid to how the public engages with expert messages and how weather affects the public, especially regarding winter weather. Funded by Environment and Climate Change Canada, our research leveraged Natural Language Processing (NLP), a form of machine learning, to analyze social media (X/Twitter) that we scraped in December 2021 and January 2022 during various disruptive winter events in Canada, notably a historic blizzard that hit Toronto in January 2022. Engagement, which we operationalized as replies, quotes, retweets, and likes, served as a proxy for activities related to weather effects. We had two goals. First, by investigating the engagement of both the lay public and experts with the top-down broadcasting of weather information on social media, we break with the top-down classification schemes predominant in the crisis informatics literature to instead propose a bottom-up approach to analyzing weather information on social media that informs decision-making for the public and helps crisis managers more effectively communicate. Second, we use NLP to develop a classification scheme for citizens impacted by winter weather in Northern climates like Canada, which differs from the traditional crisis informatics schema trained on earthquakes and floods. We argue that the complex relationship Canadians hold with weather in cold regions, especially on social media where winter storms generate fun (i.e., dogs in snow mazes, stocking up on special foods) and disruption to daily life (i.e., school closures, infrastructure damage), necessitates unique computational methods.

Session: 8021 Multidisciplinary - Theoretical to applied science - Part 2
Multidisciplinaire - De la théorie à la science appliquée - Partie 2

Convenors: Rick Danielson

Related to multidisciplinary environmental studies and/or information sharing , which includes, but not limited to Arctic studies, wildfire fires, hydrology, and cryology using various approaches.

This session covers all studies related to environmental topics that are not addressed in the atmosphere, ocean, and climate sessions. For example, all models other than atmospheric, ocean, and climate models.

Session: 8021 Multidisciplinary - Theoretical to applied science - Part 2 Multidisciplinaire - De la théorie à la science appliquée - Partie 2

06/06/2024 15:55

ID: 11885 Contributed abstract

A look back at a 41 year career at MSC.

Gérard Croteau [1]

[1]

Presented by / Présenté par: ***Gérard Croteau***

Contact: gbcroteau@gmail.com

Having retired recently from the Meteorological Service of Canada I look back at a 41 year career and share some thoughts and observations, both on the spectacular scientific progress and subjective reactions. For example, during that time I have seen operational numerical resolution over North America go from 381.5KM to 2.5KM, a factor of 152. The number of operational models and systems at CMC went from one to 39. After this, what to expect in the future? (Even though I'm no reference on this.) I also look at precipitation type forecasting, a special case due to my involvement with SCRIBE matrices. Then, a few personal considerations: Why wait so long to retire? And why now? And concluding notes.

Session: 8021 Multidisciplinary - Theoretical to applied science - Part 2 Multidisciplinaire - De la théorie à la science appliquée - Partie 2 **06/06/2024 16:10**

ID: 12082 Contributed abstract

Highlights of the Next Innovation Cycle at the Meteorological Service of Canada: Innovation Cycle 4

Benoit Archambault [1], *Normand Gagnon* [2], *Marko Markovic* [3], *Rabab Mashayekhi* [4], *Wei Yu* [5], *Daniel Figueras-Nieto* [6]

[1] Environment and Climate Change Canada
[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada
[4] Environment and Climate Change Canada
[5] Environment and Climate Change Canada
[6] Environment and Climate Change Canada

Presented by / Présenté par: ***Benoit Archambault***
Contact: benoit.archambault@ec.gc.ca

The Canadian Centre for Meteorological and Environmental Prediction and the Atmospheric Science and Technology Directorate of Environment and Climate Change Canada are planning to complete a very large-scale improvement and innovation project in Spring 2024. The Innovation Cycle 4 (IC-4) will enable the implementation of numerous modifications to the operational systems, which will result in improvements to the various numerical guides and to the overall quality of the forecasts and services offered by the Meteorological Service of Canada. In total, tens of innovations in more than 30 atmospheric, oceanic, air quality, hydrological, and land prediction systems will be implemented in operations.
In this presentation, we will give an overview of the IC-4 project and highlight the main improvements and changes to our systems, including world and Canadian premieres.

Session: 8021 Multidisciplinary - Theoretical to applied science - Part 2 Multidisciplinaire - De la théorie à la science appliquée - **06/06/2024 16:25**

Partie 2

ID: 11909 Contributed abstract

Automatic weather station temperature measurement uncertainties using thermistor probes

Kai Wong [1] , *Jeffery Hoover* [2] , *Annie Chow* [3]

[1]

[2] Environment and Climate Change Canada
[3] Environment and Climate Change Canada

Presented by / Présenté par: ***Kai Wong***
Contact: kai.wong@ec.gc.ca

The Meteorological Service of Canada (MSC) operates a surface network of approximately 590 Automatic weather stations (AWS) across Canada. These measurements are critical for weather, climate, hydrology, transportation, and validation of remote sensing products. One of the parameters that are measured at these stations is air temperature, which is currently measured using a YSI44212 temperature probe with a thermilinear network of three thermistors and three fixed resistances. As the YSI44212 temperature probe is no longer in production, the MSC is investigating alternative technologies and approaches for a potential replacement probe. Understanding and quantifying the measurement uncertainty for the new temperature probe is important to deliver on MSC's mandate to provide data of known quality and meeting user needs. Also important, is the characterization of the measurement performance at extreme temperatures above 40 °C, which are becoming increasingly prevalent, even in Canada. The present study investigates the measurement uncertainty for a thermistor temperature probe arising from various datalogger, electrical, and thermistor sensor sources using different configurations and calibration program approaches. Also considered are the uncertainties in various situations such as the difference in uncertainty when the datalogger enclosure is heated or unheated, when the Steinhart-Hart coefficients for an individual thermistor are used versus the universal coefficients for a class of manufactured thermistors, and the influence of aspiration and radiation errors. Results from the study indicate significant improvements in the linearity and interchangeability can be obtained where Steinhart-Hart coefficients are derived for each temperature probe based on calibration test results.

Session: 8021 Multidisciplinary - Theoretical to applied science - Part 2 Multidisciplinaire - De la théorie à la science appliquée - Partie 2

06/06/2024 16:40

ID: 11972 Contributed abstract

Characterizing large-scale migrations of a boreal forest pest using a combination of moths trapping and atmospheric transport and dispersion modelling

Philippe Barnéoud [1] , *Alain Malo* [2] , *Jean-Noël Candau* [3]

[1] Environment and Climate Change Canada

[2] Environment and Climate Change Canada
[3] Canadian Forest Service - Natural Resources Canada

Presented by / Présenté par: ***Philippe Barnéoud***
Contact: philippe.barneoud@ec.gc.ca

Eastern spruce budworm (SBW) moth (Choristoneura fumiferana (Clem.)) mass outbreaks have widespread economic and ecological consequences. A key explanation for the large-scale dynamics of these outbreaks is the long-range transport (up to 450 km) of moths. These events have proved to be difficult to detect and analyze because dispersal flights occur only a few times a year and have no consistent routes. Since 2018, the Canadian Forest Service (CFS) and its provincial partners have deployed a network of traps to monitor the movement of spruce budworm moths across Eastern Canada. In 2021, a collaboration was established between CFS and the Environmental Emergency Response Section (EERS) of the Meteorological Service of Canada. In the framework of this collaboration, EERS provided modelling guidance when SBW specimens were captured in significant numbers in automated traps, which could involve cases of long-range insect migrations. The Modèle lagrangien de dispersion des particules (MLDP) was run to simulate the dispersal of SBW. MLDP is a Lagrangian stochastic Atmospheric Transport and Dispersion Model (ATDM) that simulates advection and diffusion processes by mean 3D winds and atmospheric turbulence, respectively, using millions of fluid air parcels. MLDP was driven using meteorological data from the numerical weather prediction model High Resolution Deterministic Prediction System (HRDPS), which has a spatial resolution of 2.5 km over Canada. In this study, we present several modelling results performed over the past three years. ATDM simulations provide an independent source of support to distinguish if captured SBW moths are from a local source or the result of a long-range migration. When the latter is suspected, backward simulations can identify the location of potential sources of immigrants. Future improvements could include a better account of biological traits and integration with other independent sources of detection, such as stable isotopes and weather radars.

Session: 8021 Multidisciplinary - Theoretical to applied science - Part 2 Multidisciplinaire - De la théorie à la science appliquée - Partie 2

06/06/2024 16:55

ID: 12054 Contributed abstract

Urban and Non-Urban Environmental Components and their impacts on Vector-Borne and Human Infectious Disease risks via effects on local Climate in Canada

SUKANYA GHOSH [1] , *Philippe Gachon* [2] , *Nicholas H. Ogden* [3]

[1]

[2] Professeur - Dir. centre insti. de recherche ou création
[3] Public Health Agency of Canada, St-Hyacinthe, Québec, Canada

Presented by / Présenté par: ***SUKANYA GHOSH***
Contact: ghosh.sukanya@uqam.ca

Climate change driving global warming is due to human-induced activities that include modification of Land-Use and Land Cover (LULC) alongside the continuous emission of greenhouse gases into the atmosphere. As a result, agricultural and forestry lands are partially converted to increased impermeable surfaces and non-vegetated space, which exacerbates the urban heat island (UHI) and its effects on local temperature. The effects of warming and other climate change indicators, such as altered precipitation and humidity patterns, may have a significant impact on vectors (mosquitoes, fleas, and ticks), as well as our capacity to prevent and control vector-borne diseases. Many vector-borne illnesses are currently a threat to North America, including Canada. Variability and changes in the daily, seasonal, or annual climate can lead to the adaptability of vectors and pathogens, as well as changes in their geographic locations. Thus, this study aimed to find the association between climate-change, the impact of LULC change, and potential changes in UHI on the transmission of vector-borne diseases in North America. Furthermore, it is important to comprehend and manage the historical and existing LULC characteristics to evaluate the association between the climate and vector-borne diseases.
The study concentrated on the major Urban (and non-Urban) Environmental Components (UEC) that include LULC, vegetation and build-up indices, land surface temperature (LST), UHI along with the on-going climate change (i.e. effects on temperatures and precipitation) affecting the spatial and seasonal distribution of vector-borne populations and diseases in North America.
Satellite Images are used to identify the spatial correlation between UEC and climate fields that influence the distribution of vector-borne populations. Landsat-8 series and MODIS available datasets covering a period from 2003-2023 are used and investigated using geospatial techniques. The UHI, derived from LST obtained from satellite images, is strongly associated with changes in LULC over the past 20 years. This evaluation or relationship has been made possible by the application of cutting-edge analysis techniques, improvements in computing power, and the freely available five-decade archival remotely sensed datasets. Those include different study area characteristics, LULC classification, normalized difference vegetation index (NDVI) and normalized difference built-up index (NDBI) with the association of spatial and temporal changes of LST and climate modifications of UHI. The results obtained from satellite data for climate modifications are validated using the reanalysis ERA-5 land datasets. The following steps will be to develop a model-based infectious and vector-borne diseases over North America using these geospatial information and regional climate model simulations to evaluate the changes in the risks of infectious and emerging diseases in Canada under future climate conditions.

Keywords: Urban Environmental (and non-Urban) Components (UEC), Urban Heat Island (UHI), Satellite Imageries, Vector-borne diseases, Geospatial Technology, and Climate change.

Session: 8021 Multidisciplinary - Theoretical to applied science - Part 2 Multidisciplinaire - De la théorie à la science appliquée - Partie 2

06/06/2024 17:10

ID: 12115 Contributed abstract

A study of dependence among environmental measures

Rick Danielson [1]

Presented by / Présenté par: ***Rick Danielson***
Contact: rick.danielson@dfo-mpo.gc.ca

Does it matter if growth rate (of a fish or a cyclone) is defined by a single measure? Is linearity ensured by taking a logarithm (or declaring a unit)? What if a measure is partly confounded (insensitive, oversensitive, or a bit of both)? And exactly what would it imply for a measurement to be "nonlinear"? It follows from such questions that polling scientific communities about whether (and how) their measurements might be nonlinear is an interesting exercise.

One might encounter these questions in the context of a simple measurement model, or at least, one that involves a trichotomy of associations: linear, nonlinear, and lack-of association. However, simple models are often the basis for more sophisticated approaches to data assimilation and machine learning. For example, challenges of data assimilation in the presence of autocorrelation are well known, but challenges of cross correlation, including a reliance on independent (IID) processes that R. Kalman was adamant should be explored, are less so. Similarly, when neural networks are employed to calibrate satellite retrievals or hydrologic models, for example, are forecasters expected to be comfortable using such products? It is suggested that an accommodation of nonlinearity in models of such products (i.e., a demonstration that nonlinearity is not too apparent) would allay some concerns. A few geophysical applications to date are shown, and we echo our informal poll, by asking whether measurements of various kinds can be characterized as nonlinear. What might this mean for quantities like growth rate and environmental correlates?

Session: 5012 Atmosphere - Theoretical to applied science - Part 3 Atmosphère - De la théorie à la science appliquée - Partie 3

Convenors: Kyle Ziolkowski

Related to scientific studies and/or information sharing about the atmosphere, including weather, meteorology, clouds and precipitation, air quality, atmospheric dynamic and extreme events, using various approaches.

This session covers many topics, including, but not limited to, theoretical research, model development, observation techniques, real-time monitoring, databases, diagnostic methods, data analysis and artificial intelligence.

Session: 5012 Atmosphere - Theoretical to applied science - Part 3 Atmosphère - De la théorie à la science appliquée - Partie 3 **06/06/2024 15:55**

ID: 11922 Contributed abstract

Review of recent progress and future outlook for the NWEP systems at CCMEP

Sébastien Chouinard [1]

[1] Director, Canadian Meteorological Center - Operations Environment & Climate Change Canada / Government of Canada

Presented by / Présenté par: ***Sébastien Chouinard***
Contact: sebastien.chouinard@ec.gc.ca

The Canadian Centre for Meteorological and Environmental Prediction (CCMEP), a directorate of the Meteorological Service of Canada (MSC), is the central hub for developing and delivering continuous real-time weather and environmental forecasts. This presentation will provide an overview of CCMEP's ongoing key projects and initiatives focused on enhancing continuously its modeling prediction capabilities.

Starting in Winter 2023, CCMEP launched one of its extensive modeling improvement projects, known as the 4th Innovation Cycle (IC-4). This large project involves integrating over 100 scientific and technical innovations into more than 30 numerical prediction systems, covering atmospheric, oceanic, hydrological, land surface and air quality applications. The implementation of these innovations in operations is scheduled for Spring 2024.

Additionally, CCMEP is making efforts to support applications of Artificial Intelligence (AI) and Machine Learning (ML) and to identify how such applications may improve numerical weather and prediction at CCMEP. This center is involved in different projects centered around the implementation of ML/AI techniques in NWEP. It is also involved in ongoing research endeavors utilizing AI techniques exploring their potential and efficacy in diverse modelling applications. Concurrent with the novel research and development projects, work is underway on the deployment and objective-evaluation of open-source AI-based models in a quasi-operational setting. Further, forecasters are conducting subjective evaluations of these AI-based models to discern their performance against traditional NWP models. A dedicated team has been assembled to solidify CCMEP's organizational vision for making use of these new technologies. Crucially, various training initiatives for employees across the organization are in progress.

Session: 5012 Atmosphere - Theoretical to applied science - Part 3 Atmosphère - De la théorie à la science appliquée - Partie 3 **06/06/2024 16:10**

ID: 11913 Contributed abstract

Automatic detection of layers within Arctic mixed-phase clouds

Emily M. McCullough [1] , *Robin Wing* [2] , *James R. Drummond* [3]

[1] Dalhousie University
[2] Leibniz Institute for Atmospheric Physics
[3] Dalhousie University

Presented by / Présenté par: ***Emily McCullough***
Contact: emily@purplecrowlidar.ca

We have previously shown that the spatial distribution of hydrometeors within Arctic mixed-phase clouds clouds can be interpreted as alternating layers of ice and water particles (``laminations") . Candac Rayleigh-Mie-Raman Lidar (CRL) shows layer thicknesses on order of tens of metres. Clouds with such laminations are strongly

correlated with precipitating snow conditions at ground level.

In those studies, the laminated regions were identified by human classifiers examining and measuring plots of lidar data. Presently, we have developed an automatic method to detect laminated regions by computer.

The approach is inspired by the residuals method of identifying gravity waves: separating desired fluctuations (here, laminations) from a background state (here, the rest of the cloud). 1. The attenuated backscatter measurements are smoothed to create a background state which is then subtracted from the original, leaving the residuals R1. Laminations become more distinct, but vertical shapes due to snow fall streaks remain. 2. Procedure is repeated on R1, to obtain R2. The remaining variations in the plot illustrate the laminations. 3. Positive and negative stripes are defined as contiguous collections of pixels which are above +0.2sigma and below -0.2sigma respectively in the R2 plot. 4. Each pixel is tested to determine whether is part of a set of laminations meeting criteria for number of stripes within a threshold vertical extent (here, 3 stripes within 40 bins, about 300 m) and duration (10 minutes). 5. Morphological closing of contiguous patches of pixels identified in (4) determines the regions of laminated cloud.

We will present this method, its limitations, and the value it adds to the investigations of mixed-phase clouds.

Session: 5012 Atmosphere - Theoretical to applied science - Part 3 Atmosphère - De la théorie à la science appliquée - Partie 3 **06/06/2024 16:25**

ID: 12106 Contributed abstract

Radiation closure experiment and retrieval of ice cloud properties from ground-based, end-to-end simulator and numerical weather model perspectives

Yann Blanchard [1], *Jean-Pierre Blanchet* [2], *Atif Taoussi* [3], *Rodrigo Munoz-Alpizar* [4], *Patrick Grenier* [5]

[1] ESCER - UQAM
[2] ESCER - UQAM
[3] UQAM
[4] ECCC
[5] ESCER - UQAM

Presented by / Présenté par: ***Yann Blanchard***
Contact: blanchard.yann@uqam.ca

Ice clouds play a crucial role in the Earth's weather systems, water balance, and energy budget by modulating radiation, precipitation, and atmospheric composition. Yet, their representation in current weather and climate models remains challenging, and processes and feedback mechanisms in which they are involved represent large sources of uncertainty. To study ice clouds and other related critically important atmospheric constituents, Canada has proposed the High-altitude Aerosols, Water vapor, and Clouds (HAWC) observation system, composed of three instruments including TICFIRE, a nadir-viewing imaging radiometer covering the mid- to far-infrared.

This work presents results from a campaign in the Autumn of 2023 when an ER-2 aircraft flew over an ARM site deployed at La Jolla (California). Ground-based observations and numerical weather simulations based on the Canadian Model GEM were used as inputs to feed an end-to-end simulator and perform ice cloud retrievals. Results suggest that radiation closure can be assessed using an AERI for clear and cloudy periods. The retrieved ice cloud properties are compared with ground-based active instruments complemented by ER-2 observations.

Session: 5012 Atmosphere - Theoretical to applied science - Part 3 Atmosphère - De la théorie à la science appliquée - Partie 3 **06/06/2024 16:40**

ID: 11917 Contributed abstract

A note on saturation transitions between water vapor and cloud droplets

Peter Taylor [1]

[1] York University

Presented by / Présenté par: ***Peter Taylor***
Contact: pat@yorku.ca

In warm clouds and fog there are transitions between water vapor and cloud droplets. Within an air parcel these saturation adjustments can often be assumed to occur rapidly relative to other processes and we can use a simple mass and heat conserving transition to determine the change in temperature, and mixing ratios for water vapor and liquid water in the parcel. This note describes and tests a simple one-moment BMP (Bulk Microphysical Parameterization) procedure that we use in fog and stratus cloud modelling situations in order to avoid detailed micro-physics schemes. We compare it with several other methods. Our procedure uses the specific heat of an air parcel with water vapor and droplets included and, though small, includes specific heat and latent heat variation with temperature. The saturation adjustments that we discuss are only a minor variation on methods that have been used, in various ways, for 60 years. The aim here is to present different saturation adjustment methods in a simple manner and to illustrate the results and impacts of our variation, which includes iteration and contributions of water vapor and liquid water mixing ratios to the specific heat of an air parcel. The impacts are relatively small but can make order 10% differences in temperature change and liquid water conversions. They could be easily implemented in any warm cloud models that uses saturation adjustment.

Session: 5012 Atmosphere - Theoretical to applied science - Part 3 Atmosphère - De la théorie à la science appliquée - Partie 3 **06/06/2024 16:55**

ID: 12077 Contributed abstract

A Spring and Summer of Fogs in Urban Halifax

Joelle Dionne [1] , *Felicity Merrick* [2] , *Baban Nagare* [3] , *Cameron Power* [4] , *Aldona Wiacek* [5] , *Wanmin Gong* [6] , *Rachel Chang* [7]

[1] Department of Physics and Atmospheric Science, Dalhousie University, Halifax, Canada
[2] Environment and Climate Change Canada, Edmonton, Canada
[3] Department of Physics and Atmospheric Science, Dalhousie University, Halifax, Canada
[4] Department of Astronomy & Physics, Saint Mary's University, Halifax, Canada
[5] Department of Astronomy & Physics, Saint Mary's University, Halifax, Canada and Department of Environmental Science, Saint Mary's University, Halifax, Canada
[6] Air Quality Research Division, Environment and Climate Change Canada, Toronto, Canada
[7] Department of Physics and Atmospheric Science, Dalhousie University, Halifax, Canada

Presented by / Présenté par: ***Joelle Dionne***
Contact: j.dionne@dal.ca

Coastal and marine fogs in Atlantic Canada have been relatively well-studied, but less is known about coastal urban fog in this region.The Halifax Fog and Air Quality Study (HaliFAQS) ran from May 28 – August 20, 2019. This study examines the measured droplet size distributions from 2-50 μm. We used the FLEXible PARTicle dispersion model (FLEXPART) to examine the potential source regions of particles that were present over the study site during fog events.

Unusually for the region compared to the historical climatology, most of the fog events were radiation fogs as opposed to advection fogs. We found differences in fog microphysical properties based on the fog type, which may have implications for improving fog modelling. The observed seasonality differed somewhat from the historical climatology as well, with fewer fog events during summer compared to spring. Fogs in urban Halifax appear to differ from other fogs studied in Atlantic Canada, possibly due to the urban nature of this location.

Session: 6040 Leveraging Artificial Intelligence for Enhanced High-Resolution Regional Climate Modeling of Extreme Events under Climate Change Tirer parti de l'intelligence artificielle pour améliorer la modélisation climatique régionale à haute résolution des événements extrêmes dans le cadre du changement climatique

Convenors:
Yanping Li (University of Saskatchewan)
Fei Huo (Western University)
Zhenhua Li (Western University)

The economic losses from weather-related extremes have been rising steadily under climate change, which causes global concerns. Specifically, extreme precipitation is expected to surge more than mean precipitation. Recognizing the significance of high-resolution modeling in understanding extreme events under climate change, especially at local and regional scales, there is a growing emphasis on its role in providing more accurate forecasts of climate variability impacts on extreme weather conditions. Artificial Intelligence (AI) methods have progressively augmented traditional weather and climate modeling, aiming to address substantial challenges in climate science. AI offers promising potentials in refining predictions of increasingly frequent extreme weather events driven by climate change at much lower computation cost than traditional models. Machine

learning enables the handling of vast, complex datasets, facilitating analysis and comprehension of high-resolution climate data. Additionally, deep learning applications can help forecast disruptive and damaging extreme rainfall events under future climate conditions. Considering these advancements, we cordially invite presentations discussing AI methodologies and their enhanced contributions to high-resolution regional climate modeling of extreme events under climate change.

Session: 6040 Leveraging Artificial Intelligence for Enhanced High-Resolution Regional Climate Modeling of Extreme Events under Climate Change Tirer parti de l'intelligence artificielle pour améliorer la modélisation climatique régionale à haute résolution des événements extrêmes dans le cadre du changement climatique **06/06/2024 15:55**

ID: 12018 Invited session speaker

Calibration of Parameters of Distributed Land Surface Models Using a Deeping Learning Technique

Qingyun Duan [1] , *Ruochen Sun* [2]

[1] Hohai University
[2] Hohai University

Presented by / Présenté par: ***Qingyun Duan***
Contact: qyduan@hhu.edu.cn

Land surface models (LSMs) are an important component of the Earth system models (ESMs), playing the role of simulating various land surface processes, including water, energy and carbon cycles over land. Calibration of LSM parameters presents an enormous challenge due to the compression of information inherent in model outputs and observations into a single-value objective function, which leads to uneven spatiotemporal performance of the model. We propose the use of a deep learning technique to fully utilize spatiotemporal information from the model outputs, observations as well as from land surface characteristics. Here, we presents a generative adversarial network-based Parameter Optimization (GAN-PO) method, which leverages a deep neural network to discern model spatial biases to produce spatially consistent parameter fields and minimizes the differences between simulations and observations. We applied GAN-PO to the Variable Infiltration Capacity (VIC) model to simulate evapotranspiration (ET) over China's Huaihe basin. We will show that GAN-PO can diminish errors in simulated ET across nearly all grid cells within the study region. Notably, due to the discriminator's explicit identification of model spatial biases, GAN-PO excels in maintaining spatial consistency, outperforming the state-of-the-art differentiable parameter learning (dPL) method in terms of model spatial performance.

Session: 6040 Leveraging Artificial Intelligence for Enhanced High-Resolution Regional Climate Modeling of Extreme Events under Climate Change Tirer parti de l'intelligence artificielle pour améliorer la modélisation climatique régionale à haute résolution **06/06/2024 16:25**

des événements extrêmes dans le cadre du changement climatique

ID: 12088 Contributed abstract

Practical Applications of Deep-Learning Based Climate Downscaling

Kiri Daust [1] , *Nicolaas Annau* [2] , *Adam Monahan* [3] , *Colin Mahony* [4]

[1] University of Victoria/BC Ministry of Forests
[2] ECCC
[3] University of Victoria
[4] BC Ministry of Forests

Presented by / Présenté par: ***Kiri Daust***
Contact: kiridaust@uvic.ca

Accurate local-scale climate information is important for ecological applications and climate adaptation strategies. Recently, deep learning has been successful at increasing the resolution of digital images, and it shows promise as a statistical downscaling method for spatially complex climate variables. Specifically, Generative Adversarial Networks (GANs), which can be trained on pairs of low- and high-resolution climate fields, can downscale by sampling from the high-resolution distribution conditional on low-resolution fields. Our work investigates the adaptations necessary for the application of GANs to practical downscaling problems. We will discuss two main areas of research: generalisability to multiple climate variables, and generalisability over space.

Most research to date has investigated downscaling of single climate variables, whereas many applications for downscaled data (e.g. fire weather predictions, extreme event forecasts) require multiple high-resolution variables. We investigated the ability of GANs to downscale five important variables (zonal and meridional wind, temperature, specific humidity, and precipitation) in both univariate and multivariate settings. With the correct input covariates, we find that the model is able to produce realistic downscaling for all variables, and that there is no loss of individual image quality in moving to a multivariate setting. Furthermore, multivariate downscaling leads to improved dependence structures between variables compared to the univariate setting.

Training GANs requires substantial graphical processing unit (GPU) memory, and this footprint increases quickly as the size of the region increases. We investigated spatial generalisability of GANs, and show that a single network can successfully downscale multiple regions, if it is given training data from each region. Based on this, we introduce a tiling algorithm for GAN training that allows downscaling of much larger areas for a given amount of memory.

Session: 6040 Leveraging Artificial Intelligence for Enhanced High-Resolution Regional Climate Modeling of Extreme Events under Climate Change Tirer parti de l'intelligence artificielle pour améliorer la modélisation climatique régionale à haute résolution des événements extrêmes dans le cadre du changement climatique **06/06/2024 16:40**

ID: 12020 Contributed abstract

Detecting Canadian wetland surface water extent: integrating deep learning, remote sensing techniques and high-resolution land surface model

danqiong dai [1] , *Zhenhua Li* [2] , *Yifan Yang* [3] , *Lauren Bortolotti* [4] , *Vanessa Harriman Harriman* [5] , *Yanping Li* [6]

[1] Western University Ontario
[2] Western Univeristy Ontario
[3] Colorado State University
[4] Ducks Unlimited Canada
[5] Ducks Unlimited Canada
[6] Western Univeristy Ontario

Presented by / Présenté par: ***danqiong dai***
Contact: daidq@tea.ac.cn

Wetlands provide essential ecosystem services such as water purification, carbon sequestration, wildlife habitat, and climate regulation. However, mapping the wetland extent and location is a challenge, due to the fine scale of the wetland water body and their vast distribution in remote areas. The traditional estimates of wetland extent rely on census data from literature reviews or remote sensing tools, yet the wetland extent products still have inconsistent information. Recently, deep learning techniques for the semantic segmentation of images have shown promise in addressing these challenges. In this paper, we will present a novel framework that employs surface water from satellite imagery and soil moisture output from a high-resolution Noah-MP land surface model to train a deep learning model. In particular, the proposed deep learning framework is composed of two deep convolutional neural networks (CNNS) that are designed for wetland extent detection and quantification. We aim to eliminate the costs of collecting manual annotations of radar images and census data through fieldwork, further monitoring surface water dynamics well.

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ID: 12100 Contributed abstract

ClimatExML: Designing AI Software for the Computational Demands of High-Resolution Climate Models

Nicolaas Annau [1] , *Kiri Daust* [2] , *Alex J. Cannon* [3] , *Adam Monahan* [4] , *Colin Mahony* [5]

[1] Environment and Climate Change Canada
[2] University of Victoria
[3] Environment and Climate Change Canada
[4] University of Victoria
[5] The Province of British Columbia, Ministry of Forests

Presented by / Présenté par: ***Nicolaas Annau***
Contact: nicolaas.annau@ec.gc.ca

The rapid integration of artificial intelligence (AI) methodologies in earth system research presents significant challenges in data preparation, model development, and software optimization. Deploying these systems on high-performance computing (HPC) clusters and leveraging graphical-processing units (GPUs) introduces further complexities. Moreover, scaling such systems for operational use is difficult as HPC resources available to Canadian researchers are typically modest and cannot easily deal with large datasets. Working around these limitations is a challenging computational problem full of bottlenecks and technical hazards. The ClimatEx project -- a multi-institutional collaboration between the BC Ministry of Forests, Environment and Climate Change Canada, University of British Columbia, and University of Victoria – is one such project that requires a scalable and optimized AI software system. With a particular focus on the climate extremes of variables associated with fire weather across Western Canada, ClimatEx aims to develop bespoke high-resolution (3-km grid spacing) Weather Research and Forecasting (WRF) runs for the region. Using this WRF output as training data, the AI research component of ClimatEx aims to conditionally emulate high-resolution fire weather patterns from WRF using Super-Resolution Generative Adversarial Networks (SRGANs). SRGANs show impressive skill at statistical downscaling tasks, however, training them can be computationally involved since two convolutional neural networks are trained simultaneously. While previous SRGAN applications focused on smaller regions and limited variables, ClimatEx expands this scope to encompass a larger domain covering BC (512 x 512 grid cells) and multiple variables (near surface temperature, relative humidity, wind components, and precipitation). In this presentation, I introduce “ClimatExML” -- a Python-based software package designed to manage the project’s computationally intensive datasets. Although the implementation of ClimatExML revolves around SRGAN models and the ClimatEx datasets, I aim to provide insights for successfully navigating the challenges of developing AI applications with limited computational resources and demanding datasets.

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ID: 11982 Contributed abstract

Bias-Correction of Convection-Permitting Climate Simulations Using Machine-Learning and Multivariate Quantile Mapping

Zhenhua Li [1] , *Yanping Li* [2] , *Fei Huo* [3] , *Danqiong Dai* [4]

[1] Western University
[2] Western University
[3] Western University
[4] Western University

Presented by / Présenté par: ***Zhenhua Li***

Contact: zhenhua.li@uwo.ca

Convection-permitting regional climate models (CPM) offer improved representations of physical processes, particularly in convection and surface heterogeneity. CPMs enable more detailed climate projections with higher temporal and spatial resolution for hydrological applications. Despite these advantages, biases persist in high-resolution regional climate model (RCM) simulations due to deficiencies in representing sub-grid processes and inherent parameterization schemes. Therefore, bias correction is essential for the effective application of RCM dynamical downscaling in agriculture and hydrological modeling. One challenge of bias correction for high-resolution modeling is the lack of high-resolution observational benchmarks. The resolution mismatch between convection-permitting simulations and observations can result in degraded simulations when bias-corrected to low-resolution observations. This mismatch may also distort climate change signals when applied to future projections. To address this issue, we introduce a novel method for bias-correcting dynamically downscaled climate projections using convection-permitting WRF. This method, which integrates multivariate quantile mapping and machine learning, preserves large-scale features observed in reanalysis while incorporating additional details from RCM simulations.

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Our Changing Understanding of Canada's Tornado Climatology

David M. L. Sills
Northern Tornadoes Project

david.sills@uwo.ca
uwo.ca/ntp

Western Engineering

1. Motivation

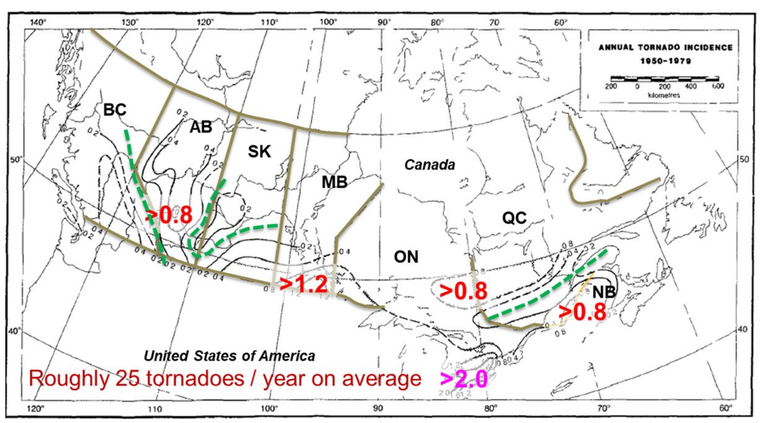
- Of the 10 highest insured loss events due to disasters in Canada from 2004-2023, severe convective storms (SCS) account for more than half
- High-quality, long-term, event-based SCS data sets are needed to help determine how the threats related to these disasters are changing
- There has been some progress on hail and downburst data sets, less for flash flooding – the greatest effort so far has been with tornado data sets

Rank	Year	Event	Insured Loss ($M unadj)
1	2016	Fort McMurray Wildfires	3600
2	**2013**	**Southern AB Floods**	**1500**
3	**2022**	**ON/QC Derecho**	**1200**
4	**2020**	**AB Hailstorms**	**1100**
5	**2013**	**GTA Flooding**	**900**
6	2022	Hurricane Fiona	900
7	**2005**	**Toronto Flood**	**800**
8	2018	ON Windstorm	700
9	**2021**	**Calgary Hail and Flooding**	**600**
10	2021	BC Flood	600
		Total	**11900**
		Total SCS	**6100**

Table showing ranked insured losses covering 2004-2023 based on data from CatIQ

2. First Tornado Climatology

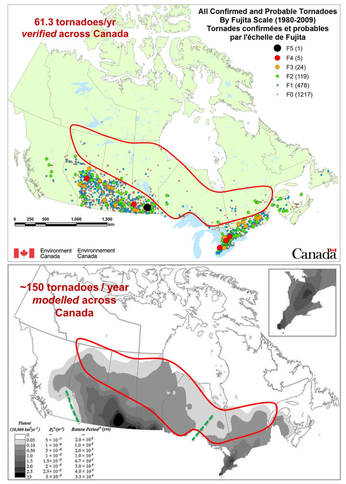
- First attempt at a Canadian tornado climatology was by Newark (1984)
- Tornado events 1950-1979 plus some extrapolation led to the first annual tornado incidence map (tornadoes per 10,000 sq km / year)
- Roughly 25 tors / year overall, maximum frequency > 2.0 in southern ON, some odd elongated minima (green dashed lines in AB / SK / QC)



Annual tornado incidence map from Newark (1984) with annotations (described in text)

3. A 30-year Update + Modelling

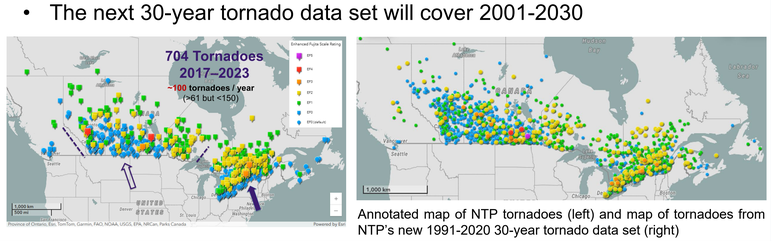
- To identify tornado-prone regions in Canada, researchers at ECCC created a new tornado data set that covered the years after the Newark study – 1980-2009 (Sills et al. 2012)
- Based on that data set, Canada's tornado frequency increased to 61 tors / year (rounded)
- However, it was recognized that to get a clear national picture the large gaps in tornado events in Canada's massive forested areas (red outline) needed to be filled
- A statistical modelling study by Cheng et al. (2013) did fill the gaps and suggested that Canada should see upwards of 150 tors / year with a max. frequency in southern SK



Annotated tornado maps from the Sills and Cheng studies

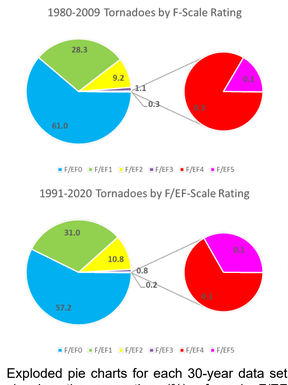
4. The NTP Era

- The Northern Tornadoes Project (NTP, Sills et al. 2020) began a focused effort identifying and documenting every tornado that occurred in Canada starting in 2017 with the support of ImpactWX
- Between 2017 and 2023, NTP's tornado frequency for Canada increased to 101 tors / year (rounded) – but unlike the statistical model results, the maximum frequency has been in southern ON / QC rather than southern SK (in 2023, only 1 tornado was recorded in SK)
- The NTP is also working to build historical data sets in order to better assess long-term trends – we recently completed an updated 30-year tornado data set covering the years 1991-2020, and have made numerous additions and revisions to the 1980-2009 data set, resulting in a high-quality database that extends from 1980 to 2023
- A new Advanced Dashboard has also been created as an interactive interface to these data and is open/accessible once an account is set up.
- The next 30-year tornado data set will cover 2001-2030

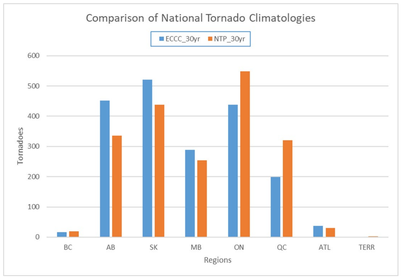


Annotated map of NTP tornadoes (left) and map of tornadoes from NTP's new 1991-2020 30-year tornado data set (right)

5. Comparing Climatologies



Exploded pie charts for each 30-year data set showing the proportion (%) of each F/EF rating; F/EF4-5 proportions are shown at right



Bar graph showing the number of tornadoes for each region in Canada and for each 30-year data set

- The 1980-2009 and 1991-2020 30-year data sets have effectively the same number of tornadoes (1949 and 1939, respectively)
- The mean number of tornadoes per year for both data sets is 65 (rounded)
- However, the new NTP 30-year data set has fewer EF0 tornadoes and more EF1/EF2 tornadoes – EF2s increase from 179 to 209 (annual frequency increase from 6.0 to 7.0)
- The average path length (all / just EF2+) *decreases* with the new data set – 10.6 / 19.7 km vs 8.6 / 16.2 km, respectively
- The average path width max. (all / EF2+) *increases* with the new data set – 348 / 582 m vs 354 / 667 m, respectively
- The most active province changes from SK (17.4 tors / year) to ON (18.2 tors / year)
- There is a notable *decrease* in the number of Prairie tornadoes (AB / SK / MB) with the new data set, and a similar *increase* in the number of tornadoes in ON / QC
- It's not yet clear if this is due to improved NTP methods, a real east-to-west shift as is being observed in the US, or both.

6. Summary

- Canada's tornado climatology is gradually becoming more accurate (though there will always be fewer EF0 tornadoes recorded than actually occurring since – when they do cause damage – it is typically beyond the detection capacity of remote sensing such as satellite imagery)
- At the same time, regional changes to the climatology are likely occurring (possibly in response to anthropogenic climate change) and more data are required to make trends clearer

Acknowledgements / References

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Framing Extreme Precipitation Events in the Context of Cumulative Emissions

Author: Travis R. Moore (PhD candidate) [1]
Supervisor: Dr. Damon Matthews[1]
[1]Department of Geography, Planning and Environment, Concordia University

Introduction: What is extreme precipitation?

- Can be thought of as all forms of condensed water that fall at rates that well exceed some climatological norm
- Most common with (deep) convective systems, such as strong to severe thunderstorms
- Often destructive due to their flooding potential, and the ability to trigger other extremes
- Flooding linked to these events rank among the deadliest events, with about 5000 fatalities globally (WMO, 2022)
- Growing concern in light of the expectation that such events will intensify and become more frequent as emissions continue to rise (e.g. Moore et al. 2015)
- Often in the form of sub-daily to multi-day events. Most studied as:

-One-day events (Rx1day)
-Five-day events (Rx5day)

Motivation for research & research area

- Response of the most extreme precipitation events to cumulative emissions is sparsely represented in the literature
- Weather events are realistically complex
- Accentuated uncertainty in the response of extreme events to cumulative emissions at sub-global scale
- Offers a venue to quantify trends in extreme precipitation

Primary Research Objectives

- Assess the extent to which Rx1day and Rx5day events can be approximated by the TCRE
- Determine robustness of linearity between precipitation extremes and cumulative carbon emissions

Photo credit: Travis R. Moore

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Methodology

- Extreme precipitation data from 9 Coupled Model Intercomparison Project Phase 5 (CMIP5) Earth System model simulations
- Used model interpolation procedure to place model simulation data onto a common grid system (CanESM2 – ~2.8 x 2.8 grid system)
- For each model, three scenarios considered:

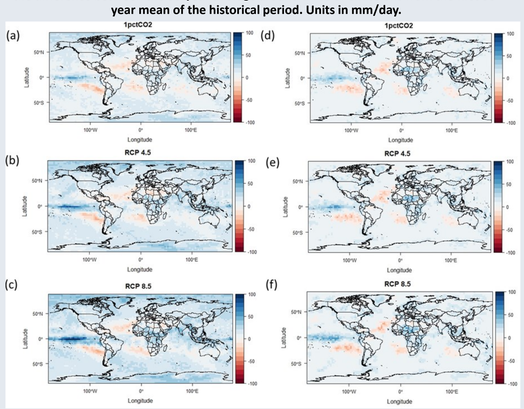
-1pctCO2 (140 years), RCP4.5 (90 years) and RCP8.5 (90 years)

- Also used historical cumulative emissions (145 years)
- Two variables used in this study: Rx1day & Rx5day
- Linear regression and correlation testing used to assess robustness of linearity globally, regionally and locally, with a focus on land areas

Transient climate response to cumulative emissions (TCRE)

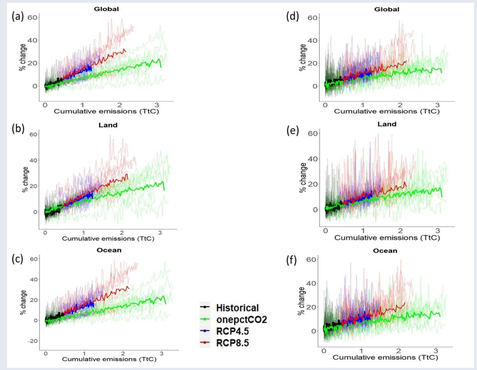
- The TCRE represents the ratio of average global warming to cumulative CO_2 emissions (Matthews et al., 2009; Gillett et al. 2013)
- TCRE is useful in guiding climate change mitigation policy-making because of its ability to directly relate warming to emissions
- Also has been shown to have applications regionally (e.g. Leduc et al. 2016)
- Previous studies have found TCRE estimates of other climate indicators, such as for sea ice extent (e.g. Zickfield et al., 2012)
- TCRE estimates of regional precipitation (Partanen et al., 2017), heat extreme indicators (Chavaillaz et al., 2019), and indicators of precipitation extremes (e.g. Moore et al., 2023)

Global extreme precipitation percent changes of Rx1day (left) and Rx5day (right) based on the difference between the 30-year average around 1 TtC of emissions from the first 30-year mean of the historical period. Units in mm/day.



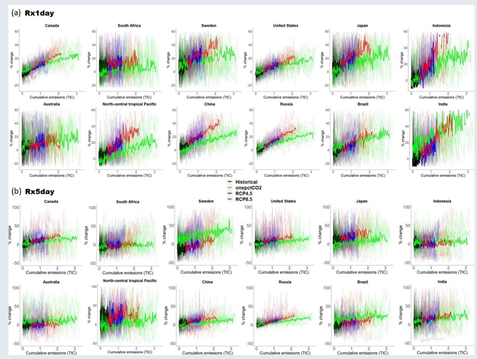
Moore et al. (2023)

Global, Land & Ocean TCRE patterns of median Rx1day and Rx5day across scenarios



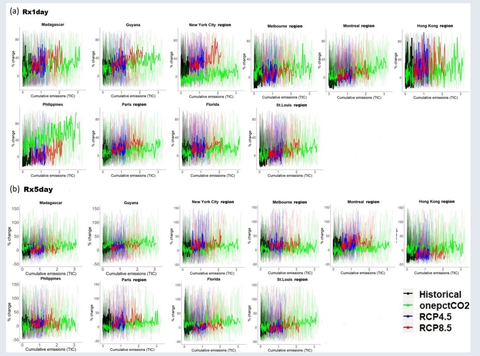
Moore et al. (2023)

Regional TCRE patterns of median Rx1day and Rx5day across scenarios



Moore et al. (2023)

Local TCRE patterns of median Rx1day and Rx5day across scenarios



Moore et al. (2023)

Primary Results

- TCRE estimates were found at all spatial scales
- However, linearity most robust at the global, land and ocean scale
- May still be a functional linear relationship at national to local scales where Pearson correlation coefficients are less than designated threshold (i.e. <0.75)
- Precipitation extremes increases are largely shown to be statistically significant at all spatial scales

Conclusions

- Rx1day and Rx5day can be approximated by the TCRE
- This shows how precipitation extremes may respond to higher cumulative emissions over time/historically
- Linearity strongest globally, for land and for ocean scale, and for largest nations
- Could still be a linear relationship at national/local scales despite the extent of noise at finer scales
- Precipitation extremes generally increase significantly at all spatial scales
- Findings provide a framework for better adapting to a world with more intense/frequent precipitation extremes

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Photo credit: Travis R. Moore

Travis R. Moore
E-mail: rain1290@aim.com

UNIVERSITÉ Concordia UNIVERSITY

CMOS Canadian Meteorological and Oceanographic Society

SCMO Société canadienne de météorologie et d'océanographie

Estimation non-stationnaire des courbes intensité-durée-fréquence basée sur les précipitations simulées et post-traitées à haute résoluton - 12124

Charles Marois, Graduate Student, Polytechnique Montréal

POLYTECHNIQUE MONTRÉAL
UNIVERSITÉ D'INGÉNIERIE

INTRODUCTION

- Extreme precipitation can cause large accumulations of rainfall over short periods and damage public or private infrastructures.
- Engineers, hydrologists and urban planners need models that take **climate change effects** in account to mitigate and plan futur risks.
- Extreme Value Theory provides a statistical framework to infer the probability of rare and extreme events.
  - Return values are defined as a value that is expected to be equaled or exceeded on average **once every interval of time (T) with a probability of 1/T**.
- **Intensity-duration-frequency (IDF) curves** are graphical tools that describe the likelihood of a range of extreme rainfall events.
  - Historical or simulated rainfall intensity data.
  - Coarse spatial and temporal resolution prevents accurate simulation of physical processes especially for sub-hourly durations.
  - Non-stationarity allows the evolution of model parameters as a function of covariates.

METHODS

ECCC Montreal Trudeau 702S006 Station:
Annual maxima series between 1955 and 2021 for 5 min to 24h rainfall intensities.

ClimEx (Ouranos): An ensemble of 50 transient runs of the Canadian general circulation model CanESM2 (±200km resolution) from 1955 to 2100. The CanESM2 then drives the regional climate model **CRCM5** (±11km resolution).

$$G(z) = \exp\left\{-\left[1+\xi\left(\frac{z-\mu}{\sigma}\right)\right]^{-1/\xi}\right\}$$

Figure 1: Cumulative density function (CDF) of the Generalized Extreme Value (GEV) distribution.

$$z_p = \begin{cases} \mu - \frac{\sigma}{\xi}\left[1-\{-\log(1-p)\}^{-\xi}\right], & \text{for } \xi \neq 0, \\ \mu - \sigma\log\{-\log(1-p)\}, & \text{for } \xi = 0, \end{cases}$$

Figure 2: Return value with GEV estimated parameters

Extreme Value Theory

- Most common distribution to model extremes. It unifies Gumbel, Fréchet and Weibull families.
- Maximum likelihood parameter estimation.
- Non-stationarity models on location or scaleparameters with covariates (time, cumulative CO2 in the atmosphere according to the RCP 8.5 scenario.)

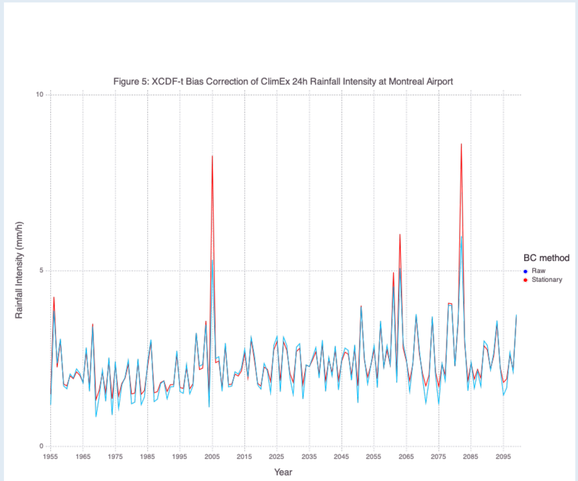
$$\hat{x} = F_Y^{-1}(F_X(x))$$

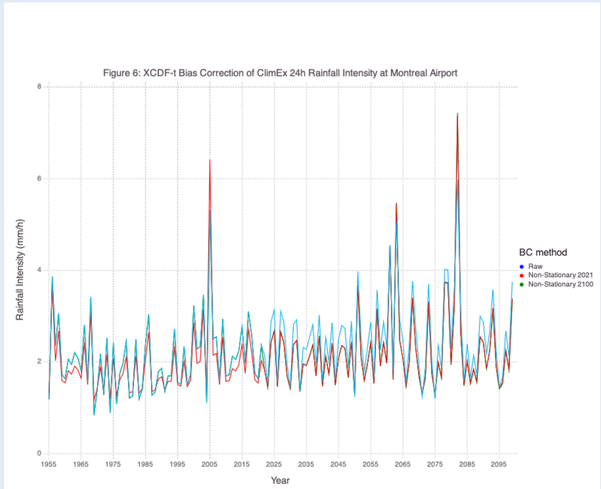
Figure 3: Quantile matching adjusts the distribution of model outputs to align with observed data by matching quantiles between the model CDF and the observed CDF.

$$F_{Y_P}(x) = T(F_{X_P}(x)) = F_{Y_C}(F_{X_C}^{-1}(F_{X_P}(x)))$$

Figure 4: XCDF-t is the adaptation of the CDF-t approach to the downscaling of extremes. Y and X are respectively observed and simulated timeseries. P and C stand respectively for projected and calibrated data.

RESULTS





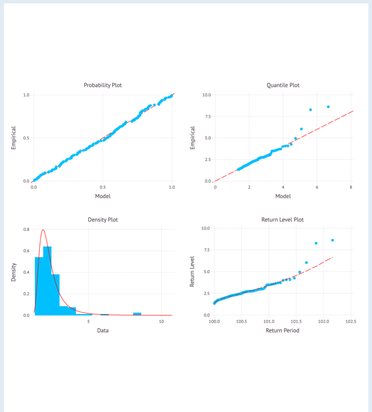


Figure 7: Diagnostic plots for the 24h stationary and corrected GEV model.

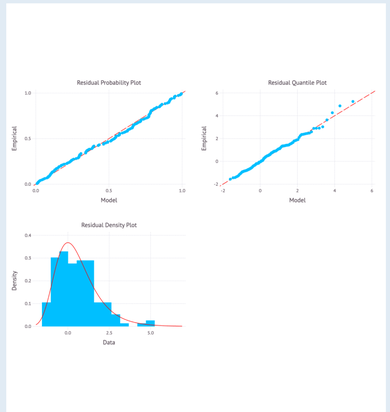


Figure 8: Diagnostic plots for the 24h non-stationary and corrected GEV model.

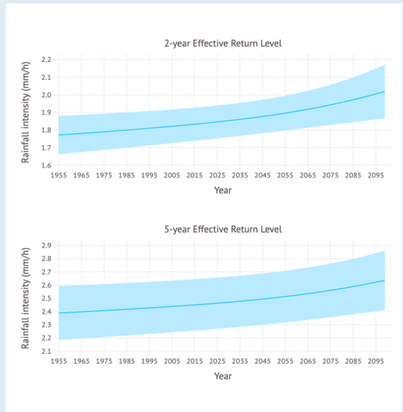
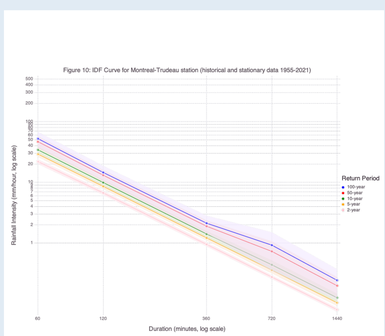
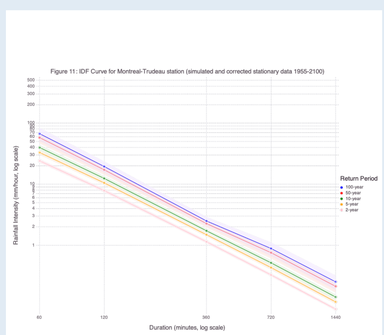
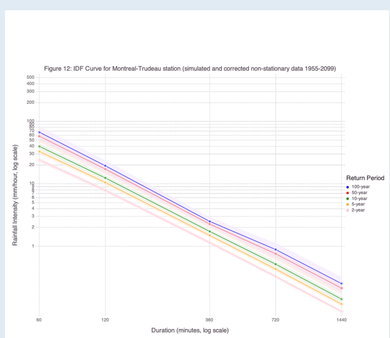


Figure 9 : 2 and 5-year effective return levels for a 24h non-stationary GEV model with cumulative C02 location covariate.







GOALS

1. Include the effects of climate change in IDF curves by analyzing a non-stationary model that integrates cumulative CO2 in the atmosphere according to the RCP 8.5 scenario.
2. Compare Quantile Matching, Quantile Delta Matching and XCDF-t correction methods under stationary and non-stationary models.
3. Estimate non-stationary and bias corrected IDF curves for return periods 2, 5, 10, 50, and 100 years.

NEXT STEPS & LIMITATIONS

- Fit the data under a general scaling GEV model (d-GEV) to take into account the dependency between durations in a stationary context.
- Adapt the d-GEV model for a non-stationary context.
- Consider all ClimEx ensemble members for more precise parameter estimates and bias correction analysis.
- Consider analyzing more stations to investigate province-wide significance.

CONCLUSION

The present study shoes that cumulative CO2 as a covariate on the location parameter of the non-stationary GEV model increases the model's overall performance.

An analysis of bias correction methods was done on this selected model. It is shown that the parametric XCDF-t method performs better than the quantile matching and quantile delta matching methods. The corrected time series can be fit under a new GEV model for every duration of interest (1, 2, 6, 12 and 24h).

Probability and quantile plots for the 24h corrected GEV model show good accuracy. Return evel plots under the corrected models show significant increase over time for 2, 5, 10, 50 and 100-year return periods..

Finally, stationary and non-stationary IDF curves are compared. While the non-stationary IDF curve shoes slightly decreased expected rainfall intensities, the differences are not significant under 95% confidence intervals.

From Mild to Extreme Heatwaves: Examining Trends in North America

Élise Comeau & Alejandro Di Luca

UQÀM Université du Québec à Montréal

CENTRE ESCER POUR L'ÉTUDE ET LA SIMULATION DU CLIMAT À L'ÉCHELLE RÉGIONALE

1. Introduction:

- Previous studies show heatwaves becoming ...
  - ... more frequent,
  - ... longer,
  - ... and more intense,

  in North America.
- Similar trends expected in the future.
- Few studies on trends according to heatwave severity.

What if mild, moderate and extreme heatwaves have been intensifying at different rates in North America?

2. Defining heatwaves, intensity and severity:

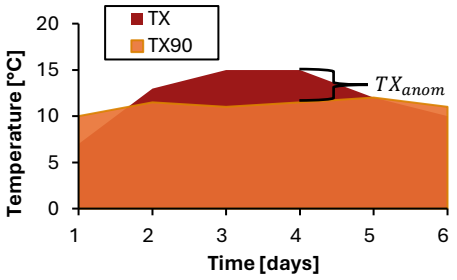
2.1 Heatwave definition:

- Heatwave if ...

$TX > TX_{90}$

(TX: daily max temperature (ERA5, 1940-2022); TX_{90}: 90th percentile of TX (ERA5, 1940-1969))

... for at least 3 consecutive days.



Example time series of daily maximum temperature (TX) and the 90th percentile of TX (TX_{90}).

2.2 Heatwave intensity definitions:

- Heatwave duration:

$HW_d = HW_e - HW_s + 1$

(HW_e: end date; HW_s: start date)

- Different intensity metrics, based on TX_{anom} (see Figure on the left):
  1. Cumulative intensity:

$$HW_{ci} = \sum_{HW_s}^{HW_e} TX_{anom}$$

  2. Average intensity:

$$HW_{ai} = \frac{HW_{ci}}{HW_d}$$

  3. Maximum intensity:

$$HW_{Xi} = \max\left(TX_{anom}\Big|_{HW_s}^{HW_e}\right)$$

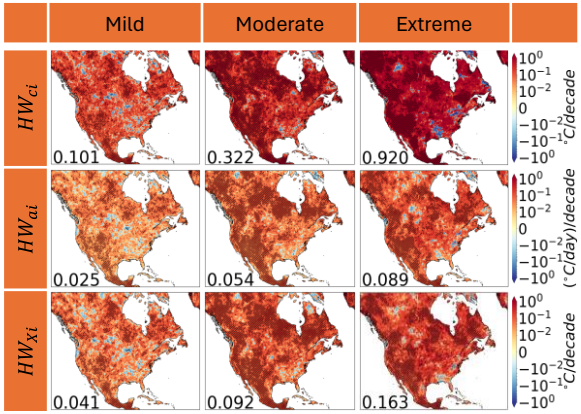
2.3 Heatwave severity definition:

- Severity depends on intensity, relative to other heatwaves ...
  1. Mild : bottom tier intensity
  2. Moderate : middle tier intensity
  3. Extreme : top tier intensity

... at the same location and in the same 5 year slice.

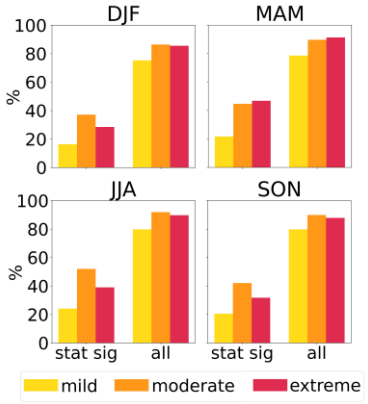
3. Results:

3.1 Mean heatwave intensity trend:



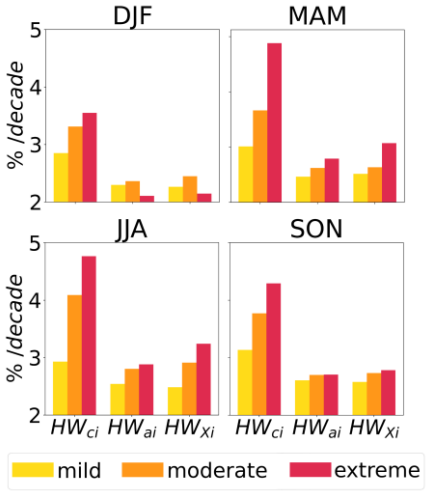
Summer (JJA) trends. Hatching indicates statistically significant trends (95% level). Value in bottom left corner represents mean over North America.

3.2 Fraction of North America with a positive trend:



Results for the HW_{ci} metric. Statistical significance is at the 95% level.

3.3 Mean relative heatwave intensity trend:



4. Discussion and Conclusions:

1. Extreme heatwaves intensified faster than moderate and mild heatwaves between 1940 and 2022, regardless of season or intensity metric.
2. Cumulative intensity intensified faster than the average and maximum intensity metrics, regardless of season or severity. This is because the cumulative metric is the only one that takes into account the duration of heatwaves.
3. Differences between mild, moderate and extreme heatwaves could be the result of a widening of the TX distribution over most of North America. Future studies should explore what physical processes could explain these differences.

5. Data:

Interested in seeing the heatwave data? Check out the U-HEAT catalog, publicly available on the Borealis Repository (https://doi.org/10.5683/SP3/Z4Y0LK).

Exploring the Climatology and Hydrological Response of Exceptional Atmospheric Rivers in British Columbia's Nechako River Basin

Bruno Sobral[1] , Stephen Déry[2]

[1] PhD Candidate, Natural Resources and Environmental Studies (NRES) Graduate Program, University of Northern British Columbia, BC, V2N 4Z9
[2]Department of Geography, Earth and Environmental Sciences, University of Northern British Columbia, BC, V2N 4Z9

sobral@unbc.ca

INTRODUCTION

- Atmospheric rivers (ARs) are key to water resources in temperate climates, with both hazardous and beneficial effects.
- British Columbia (BC) faces AR risks and benefits due to its location on the west coast of Canada.
- AR impacts in BC include heavy precipitation, floods, landslides and disruptions in transportation, energy, and food supply.
- The 47,200 km^2 Nechako River Basin (NRB) in central BC relies on the Nechako Reservoir for water supply, affected by ARs contributing to precipitation, particularly in the fall and winter.

OBJECTIVE

To characterize the climatology, spatial distribution and hydrological response of three exceptional AR events impacting the NRB.

DATA & METHODS

The study uses data from multiple sources:

1. SIO-R1-AR Catalogue (Guershunov *et al*. 2017) for tracking AR events impacting the west coast of North America;
2. ERA5 (Hersbach *et al*. 2020), and ERA5-Land data (Muñoz-Sabater *et al*. 2021) for hydroclimate variables.

Selection criteria for exceptional AR events affecting the NRB include **(1)** Average Integrated Water Vapour Transport (IVT), **(2)** Maximum IVT, **(3)** Average precipitation intensity, **(4)** Average precipitation in the broader NRB, and **(5)** Average precipitation in the Upper Nechako sub-basin. The intersection of the top AR events by ranking criteria reduces 2179 AR events to a shortlist of 10. A scoring mechanism of 1-10 is then assigned to the shortlisted AR events for each criterion, and the highest sums define the top three AR events assessed by this study.

STUDY AREA

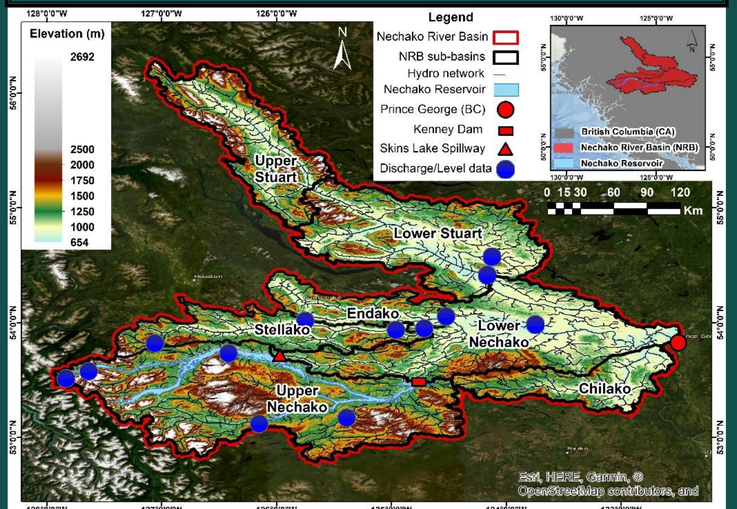


Figure 1 – Map of the NRB with sub-basins, elevation (m), hydrological network, the Nechako Reservoir (922 km^2), Kenney Dam, Skins Lake Spillway, Prince George (BC) and discharge or water level monitoring points within the NRB. Inset map with the location of the NRB in BC and the Nechako Reservoir.

RESULTS & DISCUSSION

- Top three exceptional AR events selected: **(1)** 12-14 December 1952, **(2)** 28 October – 1 November 1978, and **(3)** 27-31 October 2009.
- Positions located west of the NRB observe higher concentrations of IVT (Figures 2b, 4b and 6b), which is notably lower on the leeward side of the Coast Mountains.
- West of the NRB, the 1952 AR event brought 86% of the total precipitation (172 mm) as snow due to lower average temperatures compared to the other AR events.
- The 1952 AR event is located south of the NRB (Fig 3b) compared to the 1978 and 2009 AR events, which are concentrated southwest of the NRB (Figures 5b and 7b).
- Discharge (Fig. 8) across the NRB varies in intensity during all AR events, with abrupt increases in the unregulated portion of the NRB compared to the regulated portion.
- A historically slight increase in the water level of the Nechako Reservoir (Figure 9 – black dashed line) in early November is observed as a hydrological response to the "AR season," corroborating the findings of Sobral & Déry (2023) regarding the intensity of ARs peaking over the NRB in November.
- The AR events of 1978 and 2009 precipitated 1.2 km^3 and 1.0 km^3 of water to the Upper Nechako, respectively.
- In 1978 and 2009, the AR events contributed to elevated water levels of the Nechako Reservoir at least until the end of the year in both cases (Figure 9).
- In all AR events, the average temperatures (Figures 2f, 4f and 6f) in the NRB increase with the storm's passage over the region.
- Runoff (Figures 3h, 5h and 7h) is higher at the windward side of the Coast Mountains in all AR events due to the orographic barrier formed by the Coast Mountains and higher temperatures.

12-14 December 1952

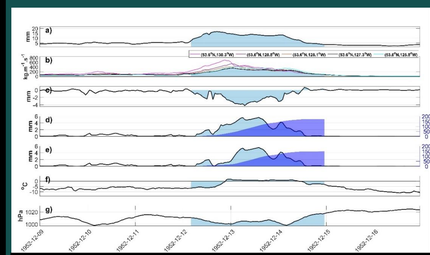


Figure 2 – Time series of meteorological conditions during the AR event from 12-14 December 1952. The panels show (a) the total column of water vapour (mm), (b) integrated water vapour transport (kg.m^{-1}.s^{-1}) at five positions along a longitudinal transect, (c) moisture divergence (negative values mean convergence) (mm), (d) total precipitation in light blue (mm) and cumulative precipitation in dark blue (mm), (e) snowfall in light blue (mm) and cumulative snowfall in dark blue (mm), (f) mean 2-metre temperature (°C), and (g) mean sea-level-pressure (hPa) during the AR event occurred on 12-14 October 1952 at (53.6°N, 127.3°W), located west of the NRB.

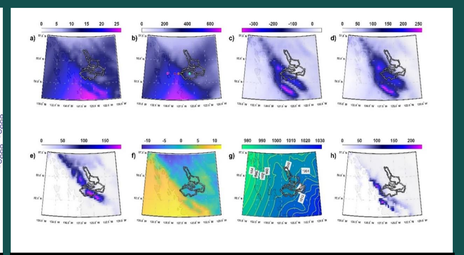


Figure 3 – Maps for (a) mean total column of water vapour (mm), (b) mean integrated water vapour transport (kg.m^{-1}.s^{-1}) and the location of the five positions along the transect, (c) moisture divergence (negative values mean convergence) (mm), (d) total precipitation (mm), (e) snowfall (mm), (f) mean 2-metre temperature (°C), (g) sea-level-pressure (hPa) during the peak of moisture convergence with contour lines and (h) accumulated runoff (mm) during the AR event occurred on 12-14 October 1952.

28 October – 1 November 1978

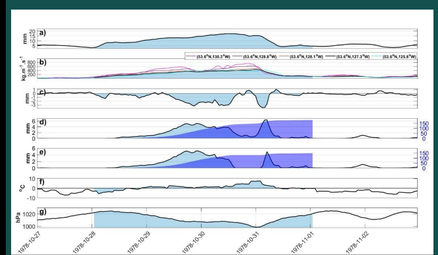


Figure 4 – Time series of meteorological conditions during the AR event AR event from 28 October to 1 November 1978. The panels show (a) the total column of water vapour (mm), (b) integrated water vapour transport (kg.m^{-1}.s^{-1}) at five positions along a longitudinal transect, (c) moisture divergence (negative values mean convergence) (mm), (d) total precipitation in light blue (mm) and cumulative precipitation in dark blue (mm), (e) snowfall in light blue (mm) and cumulative snowfall in dark blue (mm), (f) mean 2-metre temperature (°C), and (g) mean sea-level-pressure (hPa) during the AR event occurred on 28 October to 1 November 1978 at (53.6°N, 127.3°W), located west of the NRB.

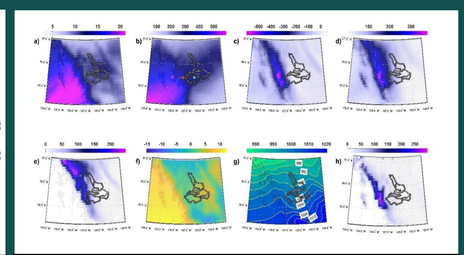


Figure 5 – Maps for (a) mean total column of water vapour (mm), (b) mean integrated water vapour transport (kg.m^{-1}.s^{-1}) and the location of the five positions along the transect, (c) moisture divergence (negative values mean convergence) (mm), (d) total precipitation (mm), (e) snowfall (mm), (f) mean 2-metre temperature (°C), (g) sea-level-pressure (hPa) during the peak of moisture convergence with contour lines and (h) accumulated runoff (mm) during the AR event occurred on 28 October to 1 November 1978.

27-31 October 2009

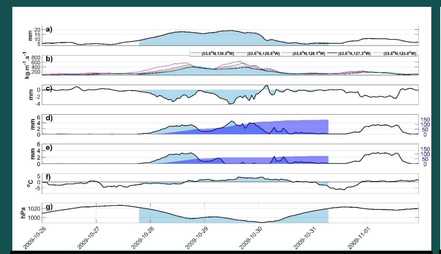


Figure 6 – Time series of meteorological conditions during the AR event of the AR event from 27-31 October 2009. The panels show (a) the total column of water vapour (mm), (b) integrated water vapour transport (kg.m^{-1}.s^{-1}) at five positions along a longitudinal transect, (c) moisture divergence (negative values mean convergence) (mm), (d) total precipitation in light blue (mm) and cumulative precipitation in dark blue (mm), (e) snowfall in light blue (mm) and cumulative snowfall in dark blue (mm), (f) mean 2-metre temperature (°C), and (g) mean sea-level-pressure (hPa) during the AR event occurred on 27-31 October 2009 at (53.6°N, 127.3°W), located west of the NRB.

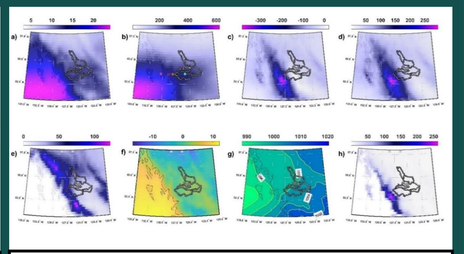


Figure 7 – Maps for (a) mean total column of water vapour (mm), (b) mean integrated water vapour transport (kg.m^{-1}.s^{-1}) and the location of the five positions along the transect, (c) moisture divergence (negative values mean convergence) (mm), (d) total precipitation (mm), (e) snowfall (mm), (f) mean 2-metre temperature (°C), (g) sea-level-pressure (hPa) during the peak of moisture convergence with contour lines and (h) accumulated runoff (mm) during the AR event occurred on 27-31 October 2009.

Hydrological Response

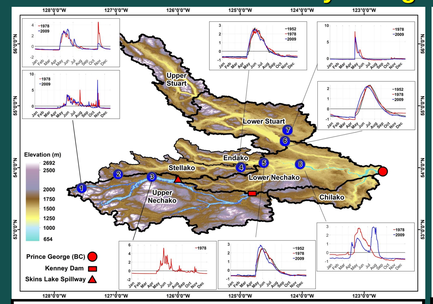


Figure 8 – Standardized water level or discharge data in monitored points of the NRB for the 1952, 1978 and 2009 exceptional AR events.

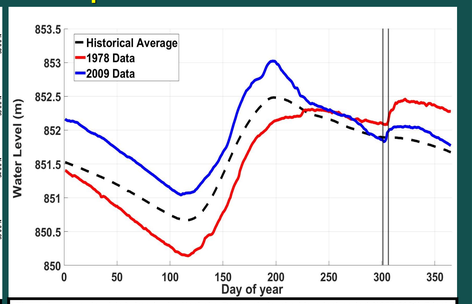


Figure 9 – Water level (m) data in the Nechako Reservoir for the historical period (1955-2021) (black dashed line) in days of the calendar year (1-365), for the 1978 AR event (red line) and the 2009 AR event (magenta line). The gray vertical lines represent the occurrence period of the exceptional AR events in 1978 and 2009. No data are available for the Nechako Reservoir during the exceptional AR event in 1952.

FINAL REMARKS

- ARs are commonly associated with natural hazards in BC but also play an important role in replenishing the region's water resources.
- ARs are one of the drivers affecting the hydrological cycle of the NRB, but exceptional AR events can be quite detrimental, especially west of the watershed.
- Exceptional ARs striking the coast of BC have the potential to abruptly increase discharges west of the NRB and expressively elevate water levels of the Nechako Reservoir.
- AR events of 1978 and 2009 elevated the Nechako Reservoir by 38 and 23 cm, equivalent to volume increases of 0.35 km^3 and 0.21 km^3 in mid-November, respectively.

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HUMAN-INDUCED CLIMATE CHANGE HAS INCREASED THE RISK OF EXTREME WINDS LIKE THOSE OBSERVED IN POST-TROPICAL STORM FIONA IN ATLANTIC CANADA

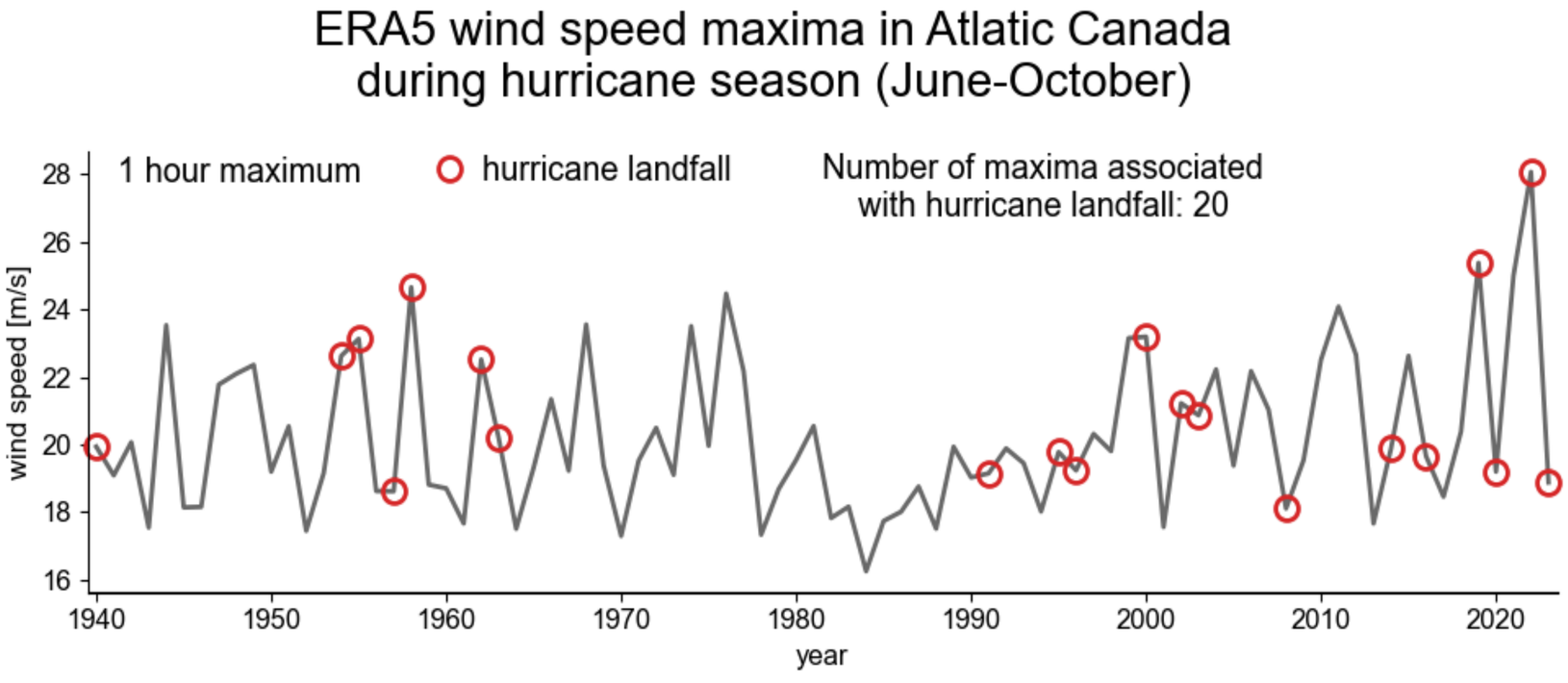
Elizaveta Malinina, Karen Garcia Perdomo, Nathan Gillett, Chris Fogarty

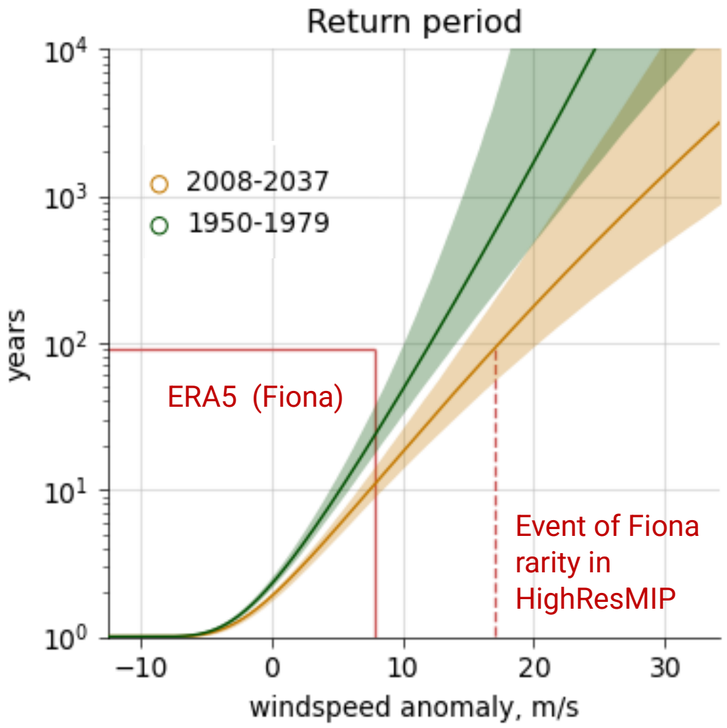
Environment and Climate Change Canada (ECCC)

Fiona was approximately a **1 in 100 year** event based on ERA5 maximum hourly wind data.

Daily maximum winds of the same rarity as Fiona have **become more likely** due to human-induced climate change since 1950-1979.

- Using ERA5 reanalysis, we analyzed hurricane season (June-October) maxima of 1 hour, 3 hour and daily windspeeds in any grid cell in the Atlantic Canada. It was shown that 1hour maxima are he best hurricane proxy.
- Several hurricanes, including Fiona (2022) and Lee (2023) are responsible for all three maxima (1hr, 3hr, and day).
- Based on the non-stationary GEV fit, the return periods from ERA5 are 91 (CI: 37-937) years for 1hr maxima, 108 (CI: 39-1529) years for 3hr and 118 (CI: 41-1823) years for the daily maxima, indicating that Fiona was approximately 1 in 100 event based on all three metrics.





- To provide attribution analysis we've analyzed an ensemble of daily maximum winds (sfcWindmax) in June-October from HighResMIP models, which are able to resolve hurricanes (Roberts et al, 2020).
- Since HighResMIP models provide daily maximum timestep-average winds, while ERA5 provides 1-hour averages, we analyzed an event of the same rarity (1 in 91 year event) as Fiona.
- The probability of the winds of the same rarity as those observed during Fiona increased 6.2 times (CI: 1.6-12) in comparison to the 1950-1979 climate.

SUBSEASONAL PREDICTION OF QUASI-STATIONARY ROSSBY WAVES DURING WINTER

Lualawi Mareshet Admasu and Rachel White

University of British Columbia

INTRODUCTION

Quasi-stationary Rossby waves (QSWs) modulate long-lasting (one week or longer) atmospheric ridges and troughs, and thus are related to blocking weather and temperature extremes[1] in the midlatitudes.

QSWs provide a unique opportunity to improve subseasonal forecast of extreme events because of their long lasting behavior and known relationship with extreme events.

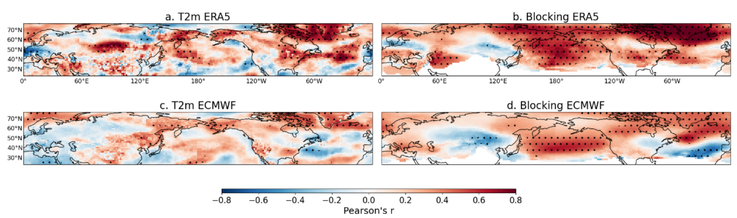


Fig 1. Correlation between spatially smoothed QSWs and (a) 2meter temperature and (b) blocking weather in the North America region in ERA5.(c,d) same as a and b respectively, but for ECMWF Black dots indicate grid points significant at p=10% level.

The ECMWF weather forecast model replicates the observed relationship between QSWs and blocking/temperature extremes with slight underestimation in certain regions (fig 1). This implies that a good forecast skill of QSWs could possibly translate to skill in rhe respective extremes.

In this study, we evaluate the subseasonal forecast skill of QSWs in dynamical weather forecast model in Winter season. By doing this, we aimed to identify the presence of potential information in weather models that can help improve extreme event forecast skill.

METHODOLOGY

The evaluation is performed on the ECMWF operational weather forecast acquired from the subseasonal to seasonal (S2S) project. For skill evaluation, three more models were anaysed to identify the inter-model relationship in skill. The models are CMA, HMCR and Meteo-France.

QSWs are identified using the 15 day low-pass filtered anomales in meridional wind at 300HPa. The method uses the hilbert transform to identify wave envelopes [2].

Model evaluation was performed using the anomally correlation coefficient (ACC):

$$ACC = \frac{\sum_{i=1}^{N}(f_i - \bar{f})(o_i - \bar{o})}{\sqrt{\sum_{i=1}^{N}(f_i - \bar{f})^2}\sqrt{\sum_{i=1}^{N}(o_i - \bar{o})^2}}$$

MIDLATITUDE SKILL

Improved subseasonal skill is seen in the north Pacific region (fig 2) and found to be consistent three other dynamical models (not shown). There is hardly any skill remaining in other regions at these lead times.

We further analyse the interannual variability of skill in the North Pacific region (boxed region in fig 2a).

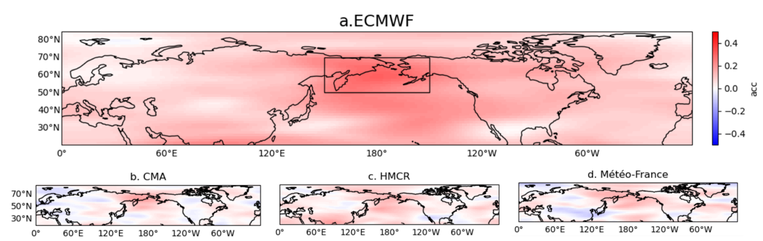


Fig 2. QSW skill in the midlatitude winter averaged over14-28days lead time in (a) ECMWF, (b) CMA and (c) MeteoFrance. Black box in (a) shows the area with relatively high skill and analyzed further.

CONNECTION WITH POTENTIAL SOURCES

High amplitude QSWs in the North pacific region correlate with sst patterns mimicing a cold PDO pattern. Zonal winds in the region show dipole pattern where stron winds are seen in high latitude.

ECMWF is mostly able to replicate the relationship observed in ERA5 data with some underestimated regions.

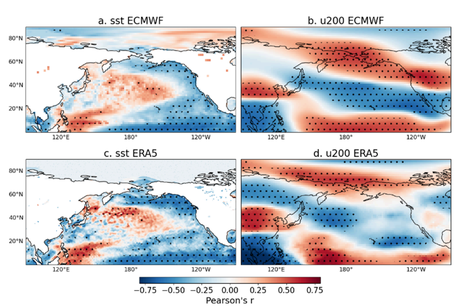


Fig 4. Correlation between North Pacific QSW amplitude and (a) sea surface temperature, (b) zonal wind at 200 HPa in ECMWF and (c,d) same as a and b but for ERA5 data. Black dots indicate grid points significant at p=10% level.

CONCLUSIONS

QSWs show some subseasonal skill in the North Pacific consistent across models. The models mostly replicate QSW relationships with blocking, temperature and potential sources like sst and zonal wind with some underestimation of the linkage. The skill shows large inter-annual variability that has some link with SST patterns, upper level zonal wind and MJO indices.

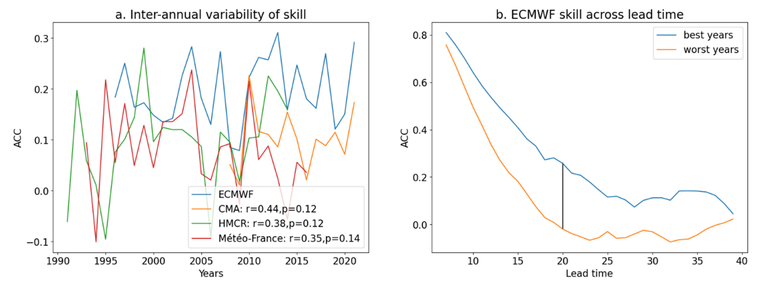


Fig 3. (a) Inter-annual variability of skill in the North Pacific region in four dynamical models and (b) QSW skill in the North pacific in best vs. worst skill years in the ECMWF model. The values in the legend of (a) indicate correlation between ECMWF and the remaining models. Black line in (b) indicates the largest difference between best and worst skill years.

The North Pacific region has large inter-annual variability that shows some consistency across models. ECMWF shows a pearson's correlation coefficient of 0.4 (p=~0.1) with all three models.

The largest difference between best skill years versus worst years is seen at the subseasonal timescale (around 21 days lead).

The skill of QSWs show some relationship with SST patterns and upper level zonal wind. Higher skill in the North Pacific is related to equatorward shft of zonal wind upstream.

MJO also influences the skill (r=0.3, p= ~0.1) where high amplitude events promote improved skill to a limited extent.

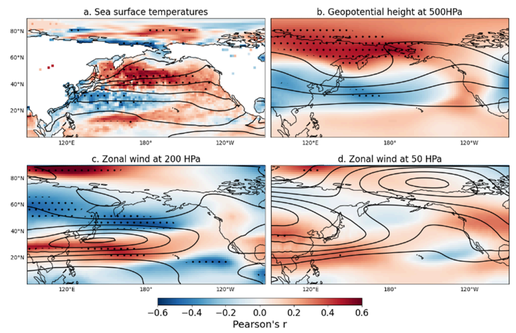


Fig 5. Correlation between North Pacific QSW skill and (a) sea surface temperature, (b) geopotential height at 500 HPa, (c) zonal wind at 200HPa and (d) 50 HPa. Black dots indicate grid points significant at p=10% level.

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Elevating Awareness: Encouraging the Uptake of National Hydrometeorological Standards

E.J.Weick[1], A.Yuen[2], K.Confalone[3], I.Oluwasola[2]

1. BC Ministry of Environment and Climate Change Strategy, 2. Standards Council of Canada, 3. Meteorological Services of Canada

Four national standards to support Hydrometeorological monitoring have been developed and represent a major step forward for support of regional, provincial, and national monitoring operations. Developed under a project described in Weick *et al.* (2021) and funded by the Standards Council of Canada (SCC), the four national standards outline how Canadian hydrometeorological networks should approach siting and operations, make data available, report metadata and initiate a quality assurance program. The standards are meant as guidance for network operators and data users to improve the understanding of data quality and fitness for use. Adoption of these standards will take time and require concerted efforts by existing network operators. It's likely that the practical information will be adopted first (i.e., sensor siting and operation, and data transmission standards) and the more qualitative information adopted last. Improving awareness of the standards both within the public and private sectors is important to ensure adoption and currency. In this session four awareness posters developed SCC to help existing network/station operators and those agencies that wish to undertake monitoring information about the standards and how they can help for efficient operations.

Poster design was undertaken by a committee with representatives from the SCC, the Meteorological Service of Canada (MSC) and BC's Ministry of Environment and Climate Change Strategy (BC ENV). Both MSC and BC ENV representatives participated in the development of the standards. All prototyping and idea development were undertaken using the collaboration tool Mural (mural.co).

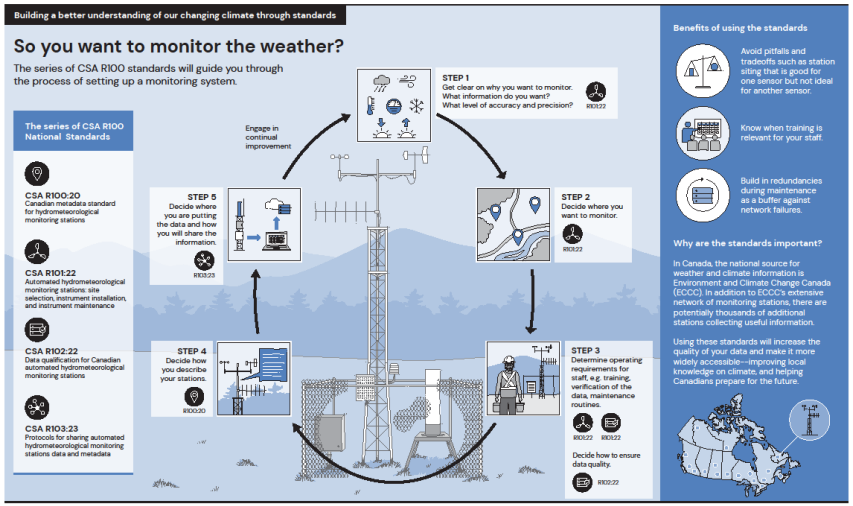
Four target archetype characters were developed – new and existing network administrators and operators. Context for the positions, their roles, motivations, and behaviours were developed that would assist the group in defining the key aspects of each audience, how to best sell the standards and what questions each archetype may be looking to answer.

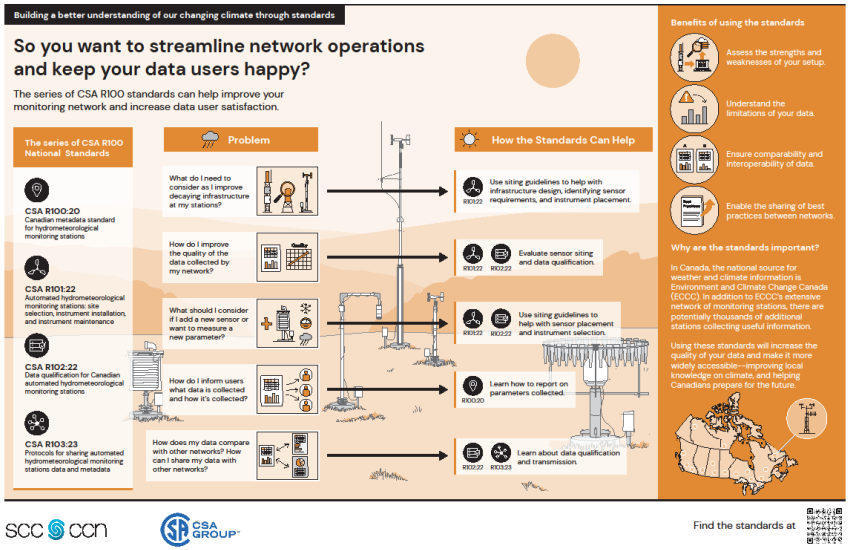
Background images for the posters were crafted from images of stations across Canada and British Columbia to ensure that the stations had some representation of reality. Once versions are finalized in English, French translation will be undertaken for a release in both languages. Posters are equipped with a QR code to a resource site operated by CSA Group (CSA Group standards for hydrometeorological monitoring stations). This site is populated with links to the standards and resource aids (to be developed).

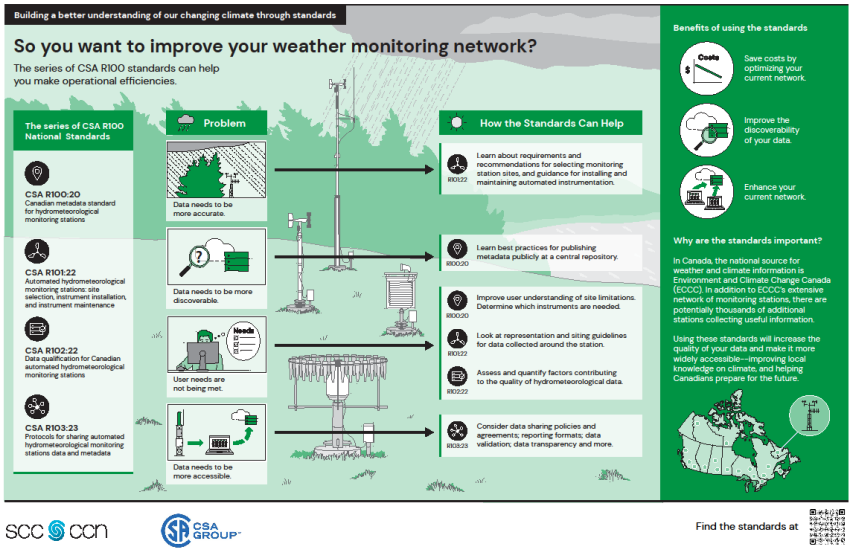
Concepts and final designs were created by KAP Designs (kapdesign.ca) with revisions made based on the committee's input.

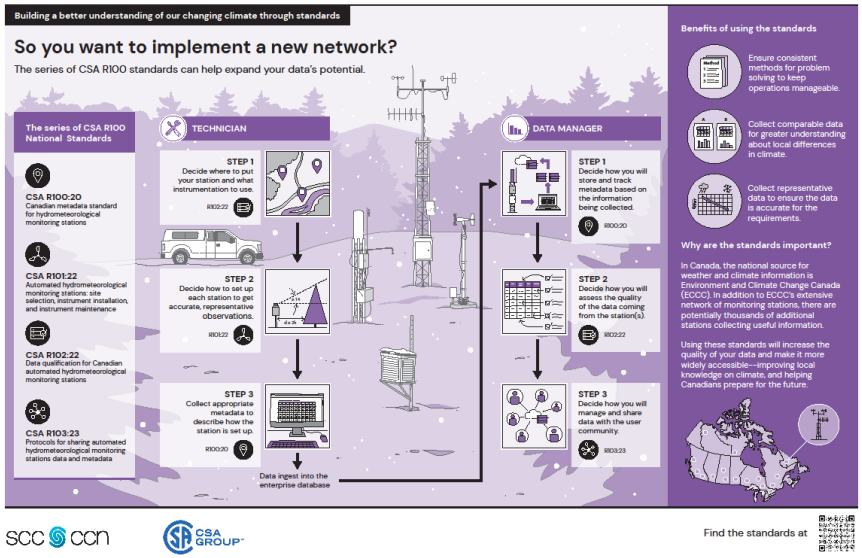
Reference Cited

Weick, E.J., I.Russell, F.Weber, P.Steenhof, M.Pinatton,S.Lindsay, A.Yuen, and F.Lenormand (2021), Development of Canadian Hydrometeorological Standards for description, siting and operation, data qualification and transmission, CMOS 2021 Virtual Congress.









A call for improved monitoring in small systems across the northern peat and boreal environment

Kavi Heerah[1], Kailee Clarke[2] and Heather Reader[2]

kmheerah@mun.ca, [1] Interdisciplinary Programs, Faculty of Science Memorial University of Newfoundland, [2] Department of Chemistry, Memorial University of Newfoundland

Background

Canada's peat and boreal regions hold an estimated 208.1 billion tonnes of carbon. With a third of the world's peatlands present in Canada and 54 % of the world's intact boreal forest present the export of material from Canada is of great importance to global carbon and iron budgets [1]. Peat and boreal landscapes produce dissolved organic matter (DOM) with a higher concentration of iron (Fe) ligands. Fe is a limiting nutrient for up to 50% of the ocean being essential for phytoplankton cellular functions[2]. Recent research has shown that through complexation with ligands present in DOM more Fe from the land can be transported into the ocean[3,4].There has been ongoing research into understanding the composition of these ligands, controls on their production, quantification , and their ultimate faith in the marine environment.

The Role of storms in river exports[12–14]

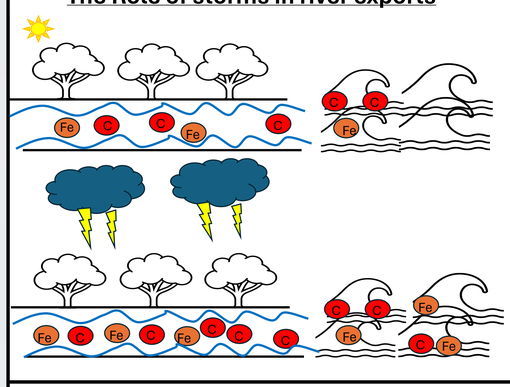


Figure 1: Simple diagram showing the effect of storms in riverine exports

The need for research and how we tackled it

Storms have been increasing with climate change and warming oceans as well reaching further north[5,7]. This can affect the export from peat and boreal landscapes present on Canada's coast which can have global implications on coastal carbon budgets. Current research has focused on large estuarine systems[8,9]. Small systems dominate the boreal environment and neglecting their influence leads to underestimations in global budgets[10,11]. In September 2021 Hurricane Larry made landfall on the Avalon Peninsula of Newfoundland as a category 1 hurricane. It followed a well predicted path allowing us to sample before and after the hurricane.

What did we do?

We sampled three catchments all under 100km^2 on the Avalon Peninsula. We measured the carbon (DOC), iron (Fe) concentration, lability (BOD/DOC), and colour(a_{350}). We also accessed the discharge and water level from Environment and Climate Change Canada[12] to calculate the difference in fluxes before and after the storm. Landcover was compared between three catchments to help explain the differences in response between the three catchments[13].

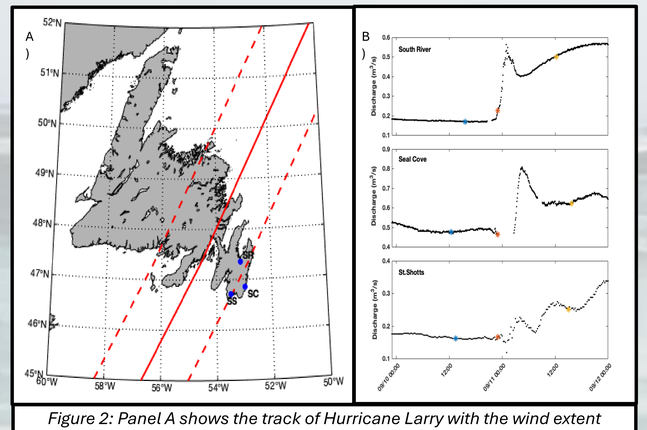


Figure 2: Panel A shows the track of Hurricane Larry with the wind extent indicated by dashed lines. The three samples' sites are South River(SR), Seal Cove(SC), and St. Shott's(SS). Panel B shows the discharge 24 hours before and after Hurricane Larry. Sampling time are shown as a blue and yellow asterisk. The landfall of Hurricane Larry is indicated by an orange asterisk.

What did we find ?

Small catchments can have significant increases in export contributing to global carbon dynamics. Negative relationships between specific landcovers and the export of material point to a buffering effect, where a large amount of natural landcover can reduce the severity of increased export. SC was the largest catchment and was thus able to better incorporate the increased water from Larry[14]. SS with more peat and wetland present had a buffered effect[15,16] from the storm with high connectivity already established in these environments due to NL's high-water table and shallow soils[17] the storm does not significantly alter exports from SS. SR with a more forested landscape had less connectivity and higher exports.

Table 1: Catchment characteristics and flux increases for sample sites

River	Total Area (km^2)	Peat (%)	Forest (%)	Wetland (%)	Richard Baker Index	Carbon Flux Increase	Iron Flux Increase
South River	17.3	44.84	39.90	1.28	0.3872	4.3X	1.6X
Seal Cove Brook	53.6	33.63	50.76	1.95	0.3722	1.3X	2.0X
St. Shott's River	15.5	62.96	13.02	10.04	1.5719	2.4X	5.5X

Figure 3: Bar graphs showing the change in concentration before and after the storm for three parameters measured; DOC, Fe and a_{350}.

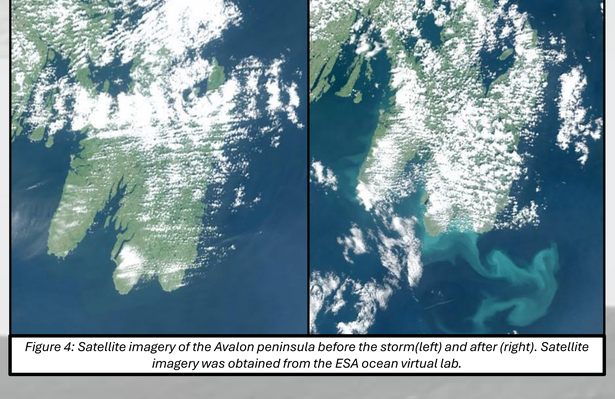
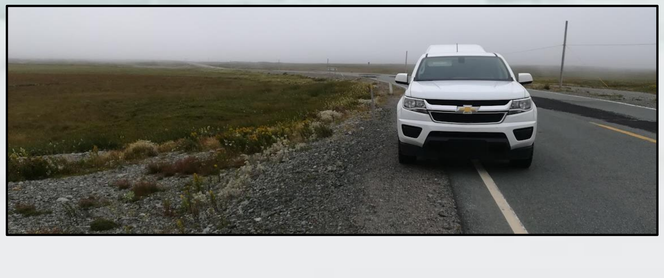
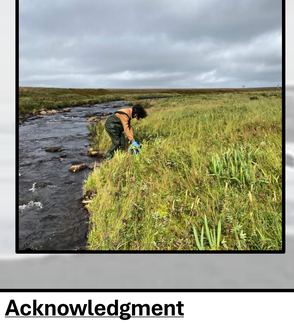


Figure 4: Satellite imagery of the Avalon peninsula before the storm(left) and after (right). Satellite imagery was obtained from the ESA ocean virtual lab.





The call for better sensors

Our initial study suggests that storms affecting the Avalon peninsula will contribute to long-term carbon storage on the coast. We were unable to sample the initial peak in discharge or peaks occurring after sampling. Current literature shows the initial peak in storm discharge can transport DOM that can be quickly mineralized[18]. Satellite imagery show a phytoplankton bloom occurred after the storm. While sediment resuspension is a likely cause[19], the effect the initial flux of DOM had is unknown. Currently, our results do not support the influence of terrestrial storm exports from NL. This result is severely limited by the lack of high frequency sampling achievable through automated samplers. As climate change intensifies and storms reach further north, the Canadian environment will undergo regime shifts. Canada's boreal forest and coasts will be impacted and in order to prepare for these changes a robust monitoring system should be put in place that accounts for both small systems and major systems.

Acknowledgment

We are grateful to Dr. Sean Leroux for allowing us the use of their field trucks, without which we would not be able to carry out this work. This study was funded by the Natural Sciences and Engineering Council of Canada (NSERC), [RGPIN-2019-04947] and the Canada Research Chairs program

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Shelf-Slope Front north of the Gulf Stream: An Objective Detection Method

Shiliang (Dan) Shan[1], Francois Rivest[1], Blair Greenan[2], and Junsung Lee[1]
[1]Royal Military College of Canada; [2]Fisheries and Oceans Canada
Email: shan@rmc.ca

1. Introduction

Ocean fronts are regions characterized by intensified motion and sharp thermal/salinity gradients. The Shelf-Slope Front (SSF), situated to the north of the Gulf Stream, serves as a narrow boundary that separates the colder and less-saline shelf waters from the warmer and more-saline slope waters. The SSF is dynamically complex, influenced by the remote large-scale ocean current systems of the Gulf Stream and Labrador Current, as well as local small-scale ocean processes (**Figure 1**, Bisagni et al., 2016).

Understanding and predicting the SSF is essential for environmental monitoring, fisheries management, and climate research.

A long-term dataset of latitudinal positions of the SSF from 1973 to 2017, based on traditional visual frontal analysis of the satellite remotely sensed sea surface temperature, was produced by the Atlantic Zone Monitoring Program (AZMP) at Fisheries and Oceans Canada (Drinkwater et al., 1994; Peterson et al., 2017).

In this study, we assess an objective method to extract the latitudinal position of the thermal SSF, extend the dataset over the past six years (2018-2023), and examine its seasonal and interannual variability based on a multi-observations reprocessing product from 1993 to 2023.

2. Methods

The objective front detection method described by Watelet et al. (2017) and Chi et al. (2019) is used to determine the Shelf-Slope Front (SSF) using sea surface temperature (SST) data from the multi-observations reprocessing ARMOR3D product (Multi Observation Global Ocean Analysis, Guinehut et al., 2012).

Front detection is achieved by identifying the latitude of maximum SST gradient at 26 equally spaced zonal positions at intervals of 1° longitude, spanning from 75°W to 50°W. The latitude of maximum SST gradient is objectively determined by fitting the SST to an error function. This approach allows us to obtain the monthly positions of the SSF spanning the years 1993 to 2023.

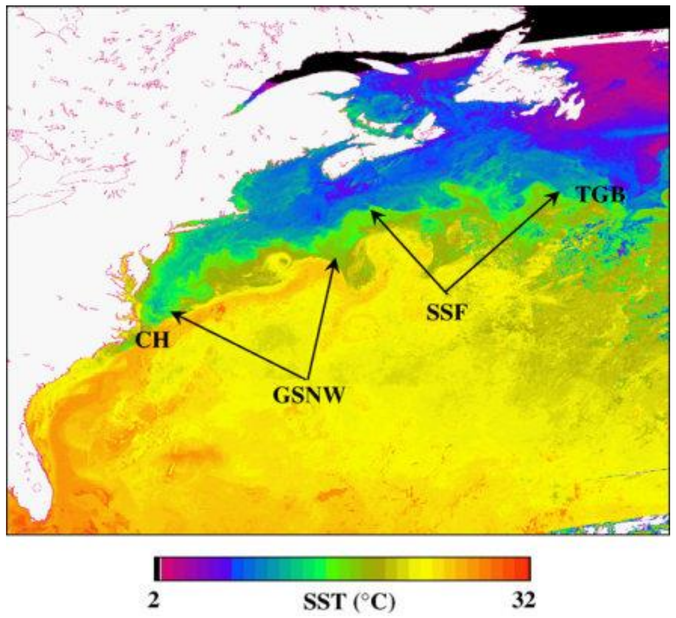

Figure 1. Sea surface temperature satellite image showing the Shelf-Slope Front (SSF) and Gulf Stream north wall (GSNW) during the week of 18 May, 1998 (from Bisagni et al., 2016).

3.1 Results: Validation

The objective detection method is validated and refined by comparing the Shelf-Slope Front (SSF) visually determined for the period of 1993-2017 from the AZMP program:

- The SSF (green zonal band) and Gulf Stream (red zonal band) are visible in the 31-year time-mean of sea surface temperature (**Figure 2**).
- The time-mean position of the objectively-determined SSF (blue line) is correctly located along the centre of the SSF (green band).
- The objectively-determined SSF is nearly identical to the AZMP-determined SSF (red line) off the Scotian Shelf (66°W-57°W), but underestimates the front position south/west of Georges Bank and overestimates it off the Grand Banks.
- **Figure 3** shows the variability of the latitudinal position of the SSF in the three distinct regions.
- **Figure 4** summarizes the quantitative comparison of the objectively-determined SSF with the AZMP-determined SSF in a Taylor diagram. The points with better statistical fits, located off the Scotian Shelf (66°W-57°W), are highlighted in red.

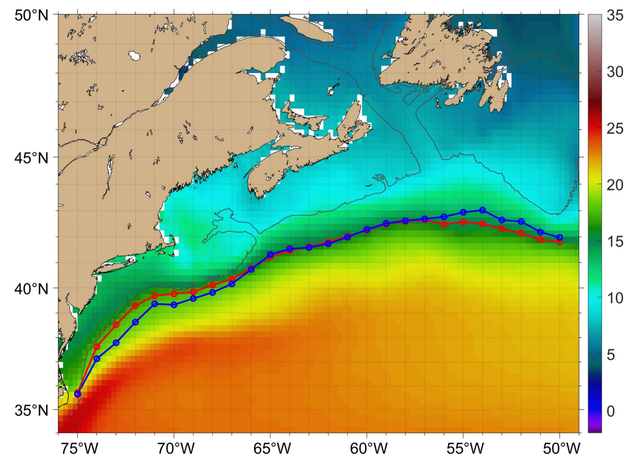

Figure 2. Time-mean latitudinal position of SSF from the AZMP dataset (red line) and objectively-determined positions (blue lines).

Figure 3. Time-series of the SSF position in three distinct regions.

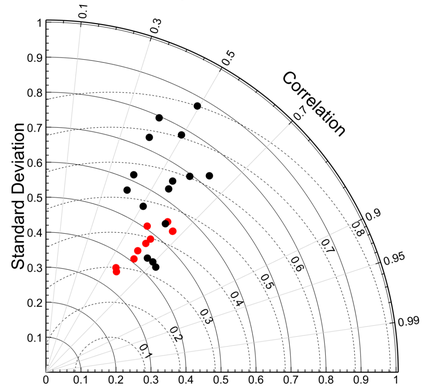

Figure 4. Taylor diagram: comparison of the objectively-determined SSF with the AZMP-determined SSF.

3.2 Results: Variability

The objectively-determined monthly positions of the Shelf-Slope Front (SSF) for the period from 1993 to 2023 are used to examine the latitudinal variability of the front. Both seasonal and interannual variability are evident:

- Seasonally, the front moves from an offshore location (negative anomaly) during the winter to a maximum onshore position in the summer (**Figure 5**). On average, the range of seasonal cycle is ~50 km.
- Interannually, the front reaches its maximum northward (onshore) location around 1993 and 2015 (**Figure 6**). It retreats to its maximum southward (offshore) location around 2004. The range of interannual variability in frontal displacement is ~70 km.

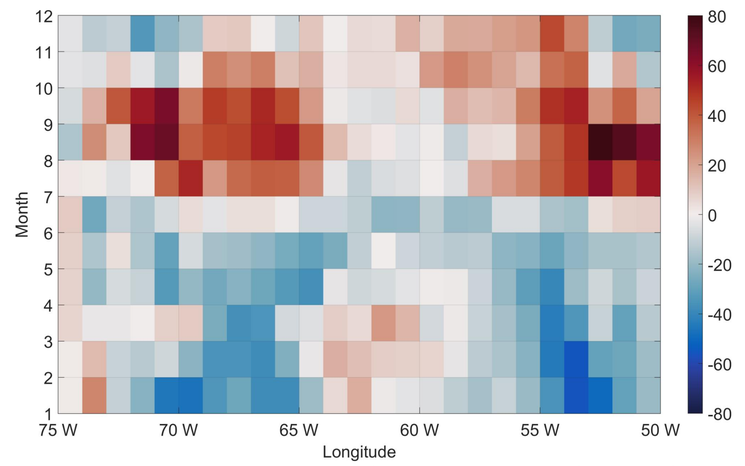

Figure 5. Monthly mean anomalies of the SSF position as a function of longitude, with position anomaly in kilometers (km).

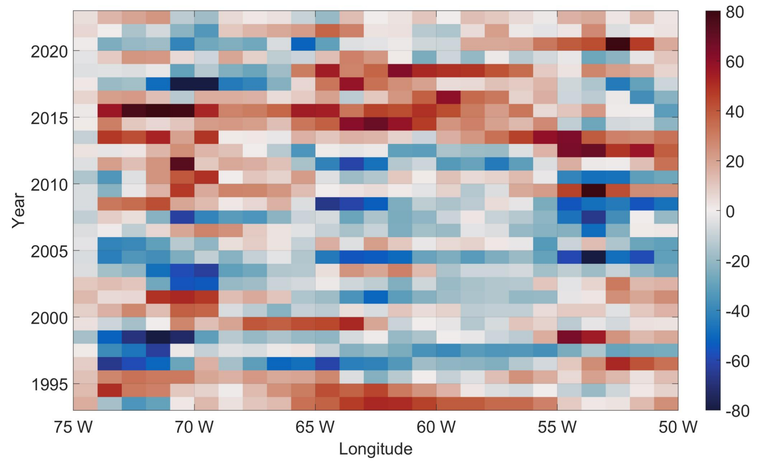

Figure 6. Annual mean anomalies of the SSF position as a function of longitude from 1993 to 2023, with position anomaly in kilometers (km).

4. Conclusions

- An objective method is developed to effectively determine the position of the Shelf-Slope Front (SSF) north of the Gulf Stream.
- The variability of the latitudinal position of the SSF from 1993 to 2023 is analyzed, revealing both seasonal and interannual variability over this 31-year period.
- The results of this study provide valuable insights into the dynamics of the SSF north of the Gulf Stream.
- In the future, the spatiotemporal variability of the SSF in recent years will be further explored in terms of the wind stress curl, and the transports of the Gulf Stream and Labrador Current.

Contact

Shiliang (Dan) Shan
Department of Physics and Space Science
Royal Military College of Canada
Kingston, Ontario, Canada
Email: shan@rmc.ca

Acknowledgements

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Dispersion in the Laurentian Channel

Observations from surface drifters during Hurricane Dorian

Graig Sutherland

Environment and Climate Change Canada

email: graigory.sutherland@ec.gc.ca

1. Introduction

- Ten surface drifters (OSKER) were deployed in the Laurentian Channel on 29 August 2019 and recorded up to 22 September 2019.
- Hurricane Dorian passed through the region on 09 September 2019.
- Offers a rare opportunity to analyse horizontal dispersion in a hurricane environment.

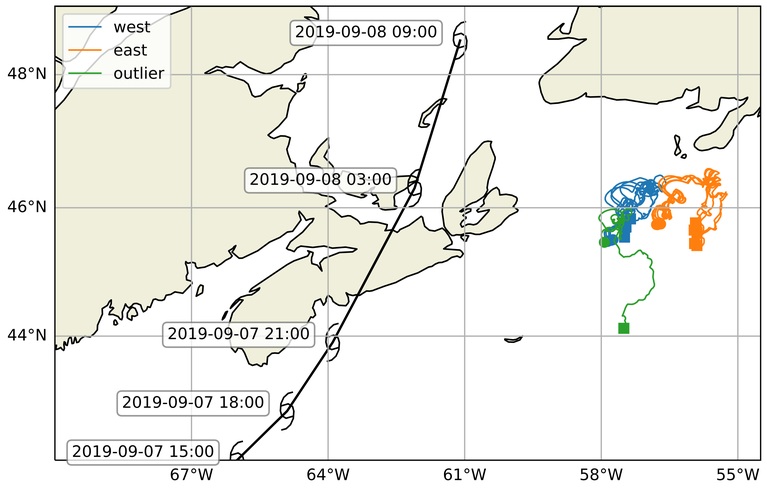

FIG. 1: Drifter tracks during the experiment period. Drifter clusters are organized as a west and east cluster. One of the drifters in the west cluster is labelled "outlier" as the drift pattern is significantly different from all the other drifters.

2. Absolute dispersion

- Absolute dispersion (A^2) is related to motion relative to starting location.
- $A^2 = \left\langle [\mathbf{x}(t) - \mathbf{x}(0)]^2 \right\rangle$ where $\mathbf{x}(t)$ is the location of the drifter at time t.
- The absolute dispersion diffusivity is $\kappa = \frac{1}{2}\frac{\partial A^2}{\partial t}$.

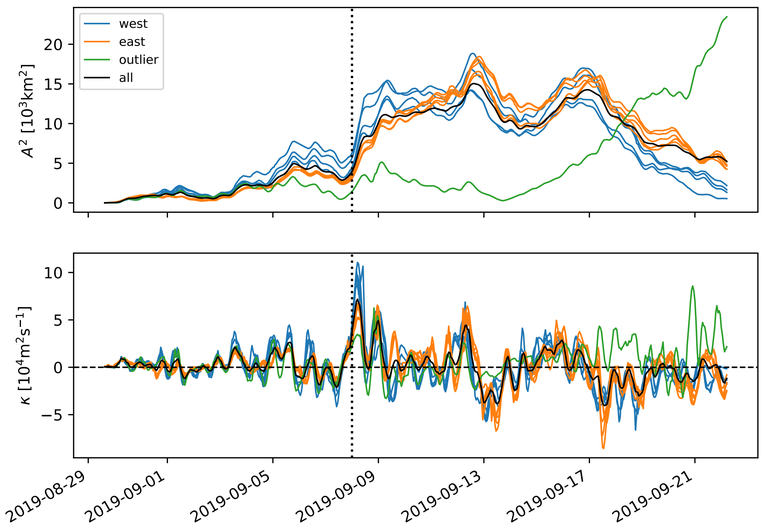

FIG. 2: Absolute dispersion (top) and diffusivity (bottom) for each of the drifters including the mean over all drifters (black). The colour denotes individual clusters of drifters.

3. Diffusion tensor

- Can estimate the full diffusion tensor if mean field is removed.
- Reynolds decomposition $u = \bar{u} + u'$ where:
- Diffusion tensor is then $K_{ij} = \overline{u_i' x_j'}$
- Decompose K_{ij} into:
  - Symmetric $S_{ij} = (K_{ij} + K_{ji})/2$
  - Anti-symmetric $A_{ij} = (K_{ij} - K_{ji})/2$
- S_{ij} is diffusive and symmetric so it can be diagonalized with eigenvalues λ_1 and λ_2.
- Numerical experiments show $\lambda_1 > 0$ and $\lambda_2 < 0$, which has never been shown using Lagrangian drifters [2, 3].
- Will also define two other metrics for qualitative analysis:
  - Mean diffusivity $< \lambda >= (\lambda_1 + \lambda_2)/2$
  - Mean absolute diffusivity $< |\lambda| >= (|\lambda_1| + |\lambda_2|)/2$
- Mean component is calculated using a rolling mean gaussian filter with a total width of 120 hours (σ = 1/2 width) for each trajectory.
- Residual velocities are approximately Gaussian, required for diffusivity estimates.

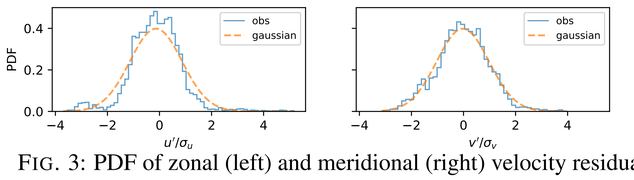

FIG. 3: PDF of zonal (left) and meridional (right) velocity residuals.

4. Mean and turbulent components

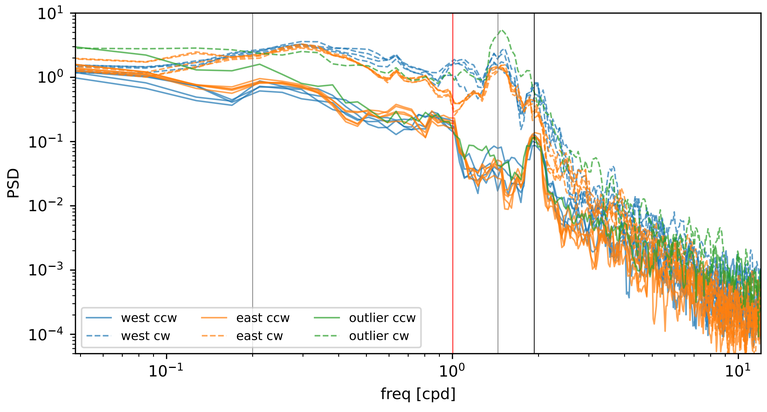

FIG. 4: Rotary spectra of drifter velocity. Energy is relatively constant at frequencies below 0.2 cpd (120 hours). More energy in cyclonic (ccw) with a clear peak at inertial frequency, compared to anti-cyclonic (cw).

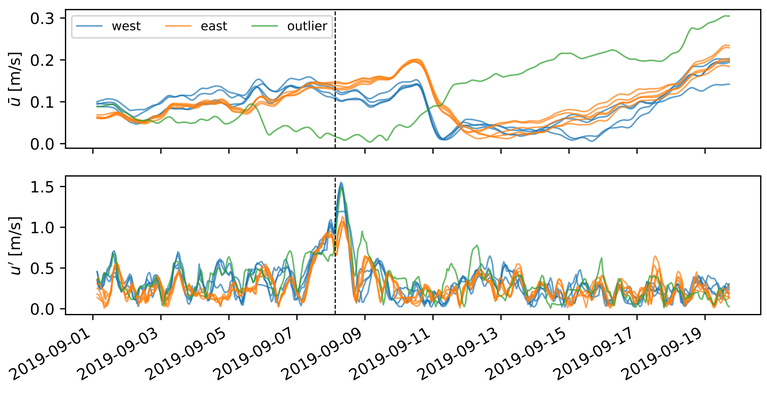

FIG. 5: Time series of mean (top) and turbulent (bottom) velocity scales respectively.

5. Diffusion eigenvalues

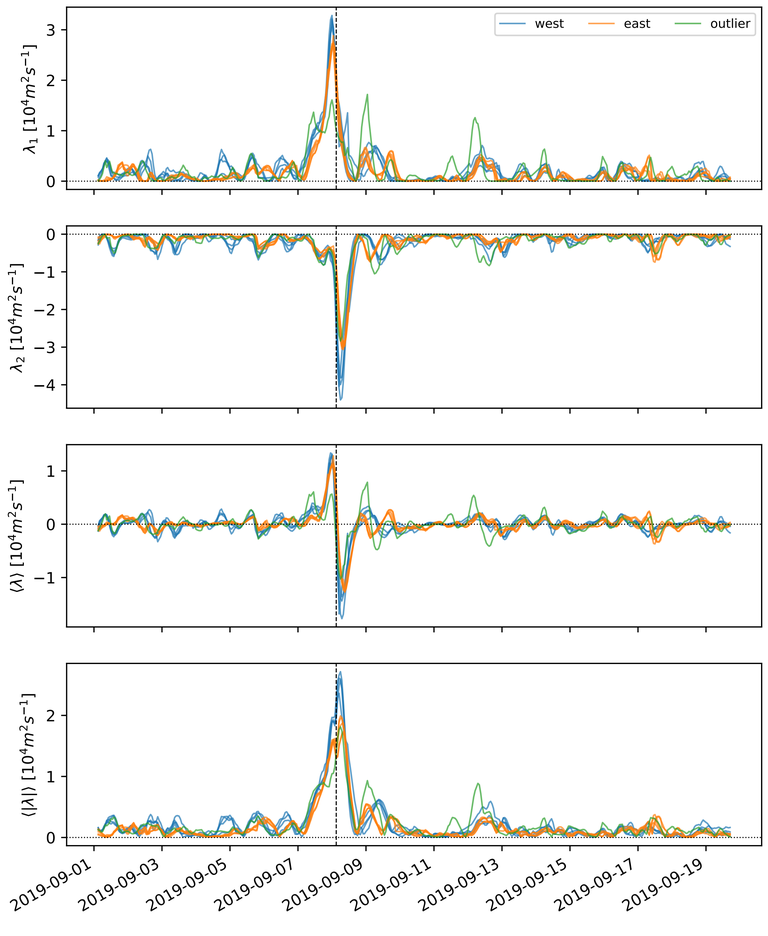

FIG. 6: Eigenvalues along principal λ_1 and orthogonal λ_2 axes. At all times $\lambda_2 < 0$. Clear dipole in $< \lambda >$ with strong values associated with the passage of Hurricane Dorian.

6. Summary

- Absolute dispersion is similar for each drifter with the exception of one outlier.
- Absolute dispersion and diffusivity show a strong impact from the passage of Hurricane Dorian, which persists for 4 days afterwards.
- Peak diffusivity is between 4 and 10 $\times 10^4$ m^{2}s^{-1}, which is consistent with the peak value of 5.6 $\times 10^4$ m^{2}s^{-1} measured during Hurricane Isaac [1].
- Developed a new technique to estimate diffusivity from single Lagrangian trajectories.
- Mean motion is estimated using a convolution of a Gaussian window with width 120 hours and standard deviation of 60 hours.
- This method allows for the full diffusivity tensor to be calculated.
- Can diagonalize symmetric component of diffusivity tensor and calculate eigenvalues.
- Eigenvalues $\lambda_1 > 0 > \lambda_2$ consistent with filament type diffusion [2].
- Passage of hurricane shows a strong dipole in $< \lambda >$ consistent with numerical estimates of tracer diffusion in the presence of strong jets [2].
- Method shows promise to estimate horizontal diffusivity from sparse drifter trajectories.

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Acknowledgements

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Dynamical shifts in the California Current System as drivers of biogeochemical variability in a semi-enclosed coastal sea

Becca Beutel[1], Susan Allen[1], Parker MacCready[2]
[1]University of British Columbia, Department of Earth Ocean and Atmospheric Science
[2]University of Washington, School of Oceanography

Problem:

How does variability and future changes in large scale ocean circulation impact marginal seas?

Approach:

- The Salish Sea, a semi-enclosed coastal along the northern California Current System (CCS), as a case study.
- Quantitative Lagrangian tracking backwards in time from the entrance to the Sea to determine the sources
  - Using six years of output (January 2017 to May 2023) from a 3D physical-biogeochemical model of the Salish Sea and surrounding coastal waters (LiveOcean)
- Property analysis along Line P to assess the influence of dynamical variability and alterations in source water properties over a longer time-period

Acknowledgements:

The authors are thankful for the opportunity to conduct research on the coast of and about the Salish Sea, the traditional, ancestral, and unceded territory of the Coast Salish peoples. We recognize their enduring presence on these waters and express our gratitude for their stewardship of this territory.

Get in touch!

If you have any questions, think it could be fun to collaborate, or just want to say hello, I would love to hear from you.
Here's a link to my personal research website:
https://sites.google.com/view/beutel

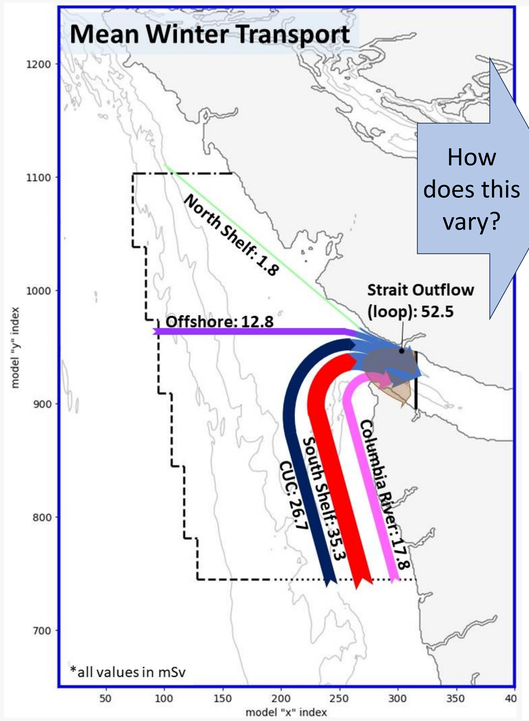
Interannual Variability

Typical winter – 174±29 days[a], 147 mSv. Inflow from CUC and South-shelf. Strong poleward winds drive intermittent inflow from the Columbia River.

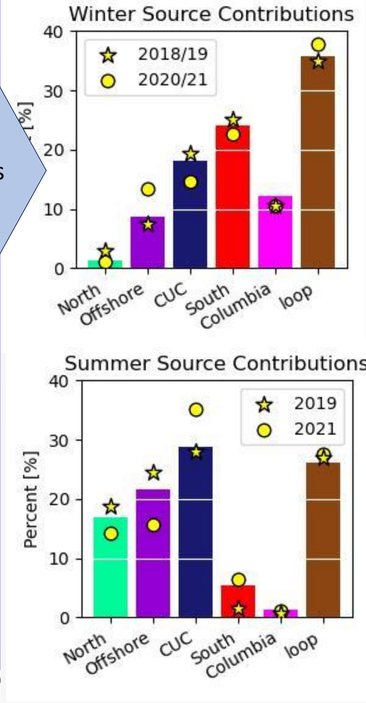
Typical summer – 191±29 days[a], 166 mSv. Inflow from CUC, Offshore, and North-shelf.

2019 - **High DO** summer[b]. Strong/persistent downwelling, weak upwelling with high north shelf and offshore contribution.

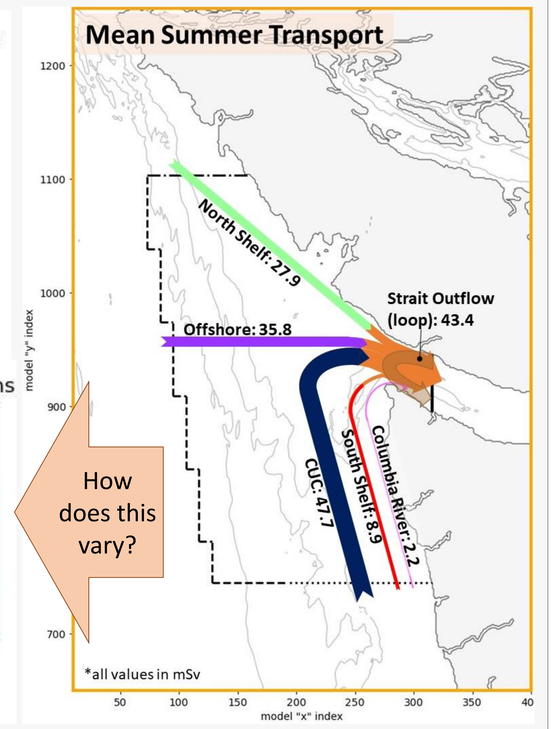
2021 – **Low DO** summer[b]. Weak and short downwelling period and strong upwelling with anomalously high CUC contribution (low DO high nutrient)

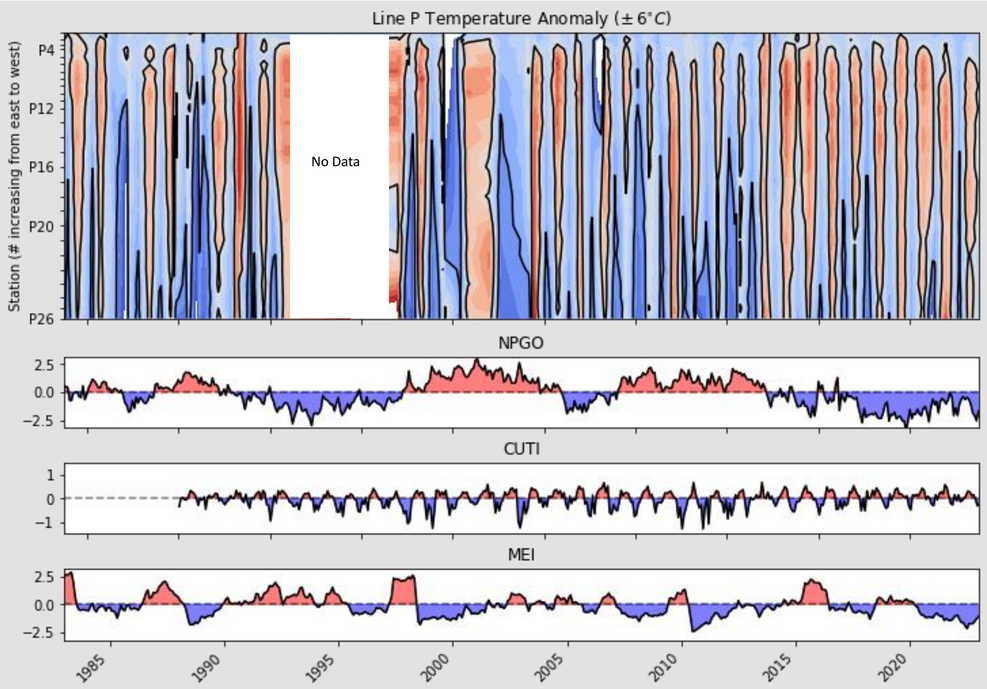


How does this vary?



How does this vary?





Decadal Variability & Climate Change

Warmer Line P surface (averaged over the top 50 m) should indicate a poleward shift of North Pacific Gyre (NPG)[c] = Sources shifted to more PEW (warm, salty, low DO, high nutrients) and less PSUW (cold, fresher, high DO, low iron) + longer, stronger upwelling

NPG Oscillation (NPGO) – Related to strength and position of the NPG, positive = intensification and poleward shift

Coastal Upwelling Transport Index (CUTI) – estimate of vertical transport along the west coast, positive = upwelling cold high nutrient, low DO, water to the coast

Multivariant ENSO Index (MEI) – measure of ENSO strength, negative = La Niña = increased influence of PSUW in the California Current (colder and fresher transport from the north)

A warmer Line P, strong and positive CUTI, and negative NPGO in the last decade are **contradictory signals**.

Takeaways:

1. On interannual timescales dynamical changes (ie. variation in source contributions) have a larger impact than variations in source properties.
2. Contradicting signals in the last decade indicate that future changes are complex, changes in dynamics and source water properties combine to confuse our current understanding of variability in the region.

Implications:

- In the future, changes in source water properties (eg. oxygen and nutrients[d]) may have a larger impact on coastal biogeochemistry than dynamical variability.
- The length and strength of upwelling has increased since 1980[a] and may continue to increase[e] – potentially leading to a higher frequency of conditions like 2021
- Shelf and inflow conditions are not a perfect match (ex. unexpected increase CUC inflow during strong downwelling[a]) – highlighting that the connection of marginal seas to large scale changes is not direct, further complicating the analysis.

References:

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Characterizing cold intermediate layer variations on seasonal timescales on the Newfoundland and Labrador Shelf

H. J. Andres (heather.andres@dfo-mpo.gc.ca), N. Soontiens, J. Penney, F. Cyr

2024 CMOS Congress
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Abstract 12062

Problem Statement

The **cold intermediate layer (CIL)** is a common summertime feature on sub-Arctic continental shelves. On the Newfoundland and Labrador (NL) shelf, it is defined by the 0°C isotherm, and characterized by two seasonally varying branches of the Labrador Current system[1,2].

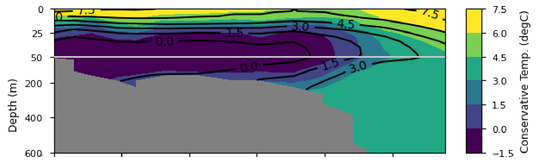


Figure 1: NL summer transect with observations in colours and model data in lines

Production mechanisms:

- Local[3] – winter convectively mixed water capped near surface by spring restratification, protecting the CIL from summer warming
- Advective[4,5] – intermediate-depth water produced via local mechanism upstream and advected to current location

Eroded by mixing from above or below with warmer water

PROBLEM: Identifying seasonal evolution of CIL on NL transects not possible given current frequency of observations

OBJECTIVE: Describe seasonal CIL variations in GLORYS12 model data on NL Shelf and connect to physical mechanisms

Data

Atlantic Zone Monitoring Program (AZMP)

- DFO environmental monitoring program for Atlantic coast of Canada since 1998[6]
- Sampling 3 times a year (not at all transects): April-May, July-August, and November-December
- Analyse 6 transects on NL Shelf
- T and S accessed via the CASTS data product[7]

GLORYS12 global ocean reanalysis

- Produced by Mercator Océan International[8]
- NEMO3.1 ocean and sea ice general circulation model beginning January, 1993
- Bathymetry: merged product using ETOPO1 and GEBCO8
- Tides neglected
- Forcings
  - ERA-Int on 3-hr timesteps (ERA5 hourly after January 1, 2019)
  - Climatological river runoff[9]
  - Prescribed increasing trend in meltwater from Greenland into open ocean
- Assimilates
  - Sea level anomalies (satellite)
  - Sea surface temperatures (satellite)
  - Sea ice concentration (satellite)
  - In situ T and S profiles (CORA 4.1 database)

Figure 2: AZMP transects marked with red lines. Transect acronyms are as follows: BI = Beachy Island, MB = Makkovik Bank, SI = Seal Island, WB = White Bay, BB = Bonavista Bay, FC = Flemish Cap

Key Take-aways:

- **Stratification: determines how insulated the CIL is from surface heating throughout the summer and its properties (volume, temperature…) are preserved**
- **Advection: summer CIL properties in the south determined by CIL formation properties in the north**

Seasonal CIL Variations

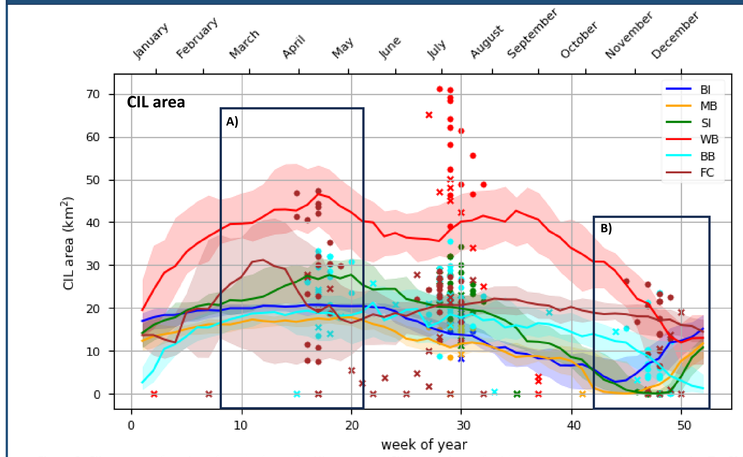
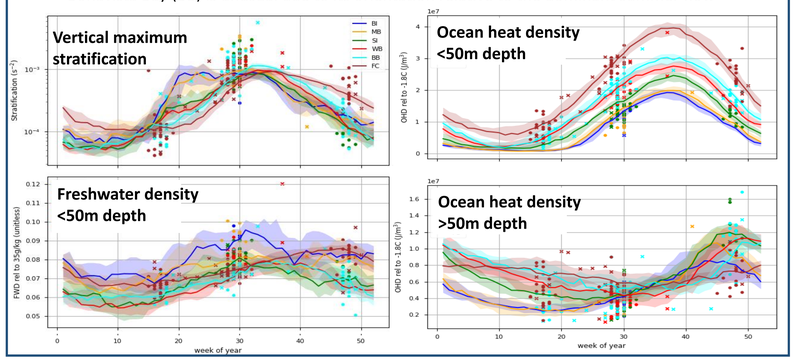
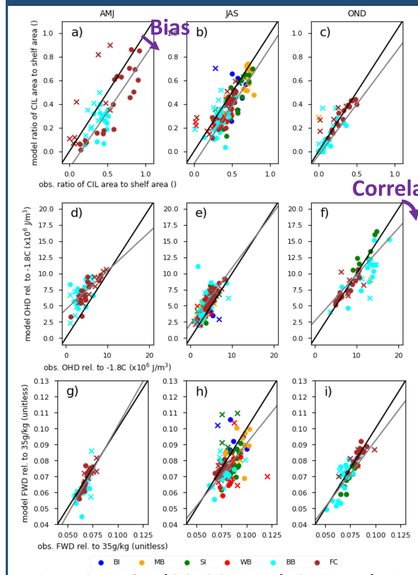


Figure 3: CIL area as a function of week of year for NL transects. CIL area = Area of grid cells on transects with conservative T < 0°C. GLORYS12 data in lines (shading spans the 25th to 75th percentiles) and AZMP data in markers. Dots indicate all AZMP profiles on the transect have data, while x's indicate some profiles are entirely missing.

- CIL area calculated by summing areas of grid cells with T<0°C
- Seasonal **A)** maxima in late winter/early spring and **B)** minima in late fall/early winter
  - Maxima earlier and minima later for more southern transects
- Surface warming leads to spring reduction in CIL area (see below)
  - CIL area loss to summer surface warming limited by stratification
  - Stratification erosion in fall leads to rapid loss/disappearance of CIL area at some transects
- Multiple CIL area maxima at White Bay (WB) and Flemish Cap (FC) transects
  - Advection leads to sub-surface cooling throughout the summer and growth of CIL area
  - Bonavista Bay (BB) is unusual due to its orientation relative to the dominant summer flow



GLORYS12 Evaluation



- GLORYS12 captures interannual CIL area fraction variations effectively (see slope and R^2 below)
- When slope near 1, bias can be interpreted from intercept
  - negative but weakening from spring to fall ➔ under-estimated seasonal cycle
- GLORYS12 reproduces inter-annual variations in sub-surface ocean heat density and surface freshwater density less well than for CIL area

Figure 5: Scatter plots of GLORYS12 vs AZMP for CIL area as a fraction of total shelf area (top row), sub-surface ocean heat density (middle row) and surface freshwater density (bottom row) by season (in columns). Black lines are 1:1 values. Grey lines are ordinary, least-square, best-fit lines whose parameters are provided in the table below for CIL area fraction.

Variable	Season	Correlation	Slope	Intercept	R^2
CIL area fraction	Spring (AMJ)	0.9 ± 0.3	0.95 ± 0.09	-0.15 ± 0.05	0.77
CIL area fraction	Summer (JAS)	0.8 ± 0.2	0.97 ± 0.07	-0.09 ± 0.04	0.68
CIL area fraction	Fall (JAS)	1.0 ± 0.3	0.93 ± 0.04	-0.005 ± 0.009	0.94

Implications and Future Work

- CIL areas are changing seasonally over range of dates when AZMP occupations occur from year to year ➔ seasonal changes may be affecting interpretation of inter-annual variations
  - **Can we determine a seasonal correction for AZMP observations?**
- Advection plays important role in water masses on NL Shelf
  - **Can we predict summer conditions based on observed conditions in spring?** Requires identifying advective timescales and source locations for sites along NL Shelf
- Summer intermediate-depth conditions at downstream stations reflect previous winter's upstream conditions
  - **How will climate change-driven sea ice loss affect summer conditions?**

References: 1. Lazier and Wright (J. of Phys. Ocnog., 1993) 2. Loder (1988) 3. Banks (JGR, 1966) 4. Chubarenko and Stepanova (Prog. In Ocnog., 2018) 5. Miladinova et al., (Prog. In Ocnog., 2018) 6. Therriault et al. (Can. Tech. Rep. Hydrogr. Ocean Sci., 1998) 7. Coyne et al. (doi: 10.20383/102.0739, 2023) 8. Lellouche et al. (Frontiers in Earth Sci., 2021) 9. Dai et al. (J. Clim., 2009)

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On the impact of the latent heat release on the accumulated freezing rain at the surface

Sujan Basnet, Julie M. Thériault

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, Montreal, Quebec, Canada

Background & objectives

- 5-6 April 2023 storm produced freezing rain and ice pellets in Quebec and Ontario. Led to more than one million customers in Quebec without electricity.
- Freezing rain is described as a self-limiting process (Fig 1):

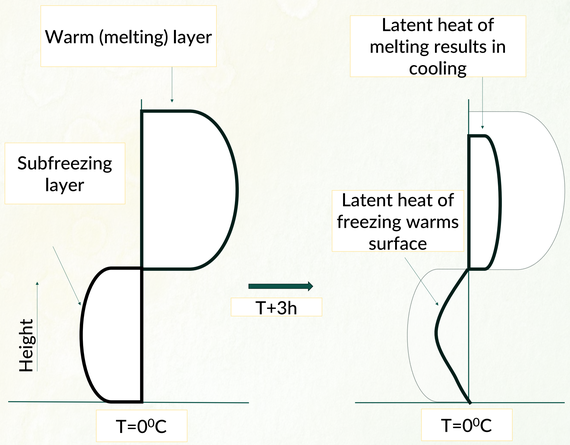


Fig 1: Idealized vertical temperature profile accompanying an evolution of freezing rain, with account of latent heat latent heat absorption and release

Objective: The aim of this study is to quantify the contribution of the freezing of supercooled drops at the surface on the near surface air temperature.

Methodology

- Global Environmental Multiscale (GEM) 5.1.1 was used to simulate the storm.
- Predicted Particle Properties (P3) bulk microphysics scheme for cloud and precipitation processes and Canadian Land Surface Scheme (CLASS) used for land surface scheme.
- Modified the P3 scheme and the CLASS to represent 70% of the latent heat accompanying freezing rain to go to the atmosphere and 30% to the surface.
- Comparison between original (CTRL) and modified (EXP).

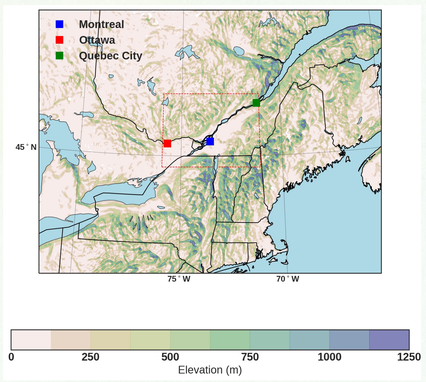


Fig 2: Model domain of the study area. The red dotted line (inner rectangle) is the analysis domain.

Results

Fig 3. shows

- CTRL run was assessed by comparison against meteorological stations-39 for total precipitation and 8 for freezing rain.
- Area north of Montreal received solid precipitation; Area south of Montreal received rain and Montreal mainly received freezing rain. Kemptville, Ontario recorded the largest precipitation at 64.1 mm among the stations.
- For the CTRL run, bias in the total precipitation is 1.9 mm and bias in the freezing precipitation is 10.5 mm.

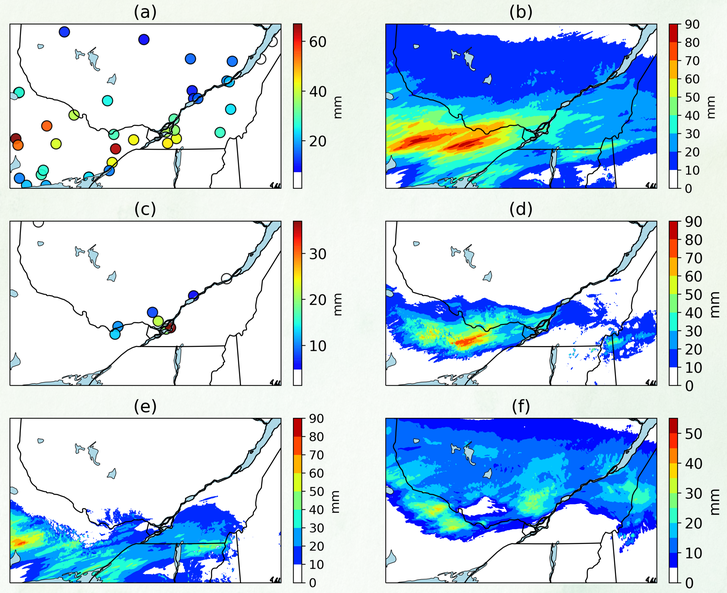


Fig 3: a) Observed total precipitation b) CTRL total precipitation c) Observed freezing rain d) CTRL freezing rain e) CTRL rain f) CTRL total solid precipitation (mm)

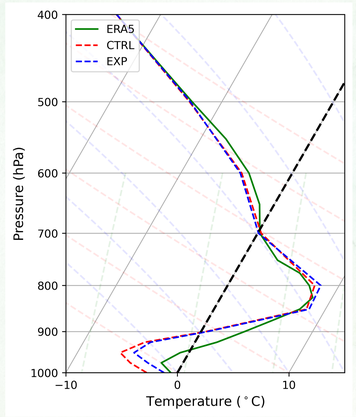


Fig 4. shows:

- Upper air temperature at various pressure levels.
- A refreezing layer at the surface and a melting air aloft, which is typical of freezing rain/ ice pellets.
- The difference in CTRL and EXP is more evident closer to the surface.
- The modification captures the dynamics of the upper air temperature with good measure.

Fig 4: Vertical temperature profile, EXP (dashed blue), CTRL (dashed red) and ERA5 (green) at Ottawa Gatineau Airport (°C) at 1700 UTC 5 April 5 2023

Fig 5. (X) shows:

- The magnitude of the latent heat is higher compared to thermal advection initially.
- In the EXP run, the 2-m temperature reaches > 0°C faster.
- Freezing rain is reduced from 75.1 mm (CTRL) to 21.4 mm (EXP).

Fig 5. (Y) shows:

- The magnitude of the latent heat is comparable to thermal advection initially.
- The time for the 2-m temperature to reach > 0°C is similar in EXP and CTRL.
- Freezing rain in CTRL and EXP runs is 35.1 mm and 32.8 mm, respectively.

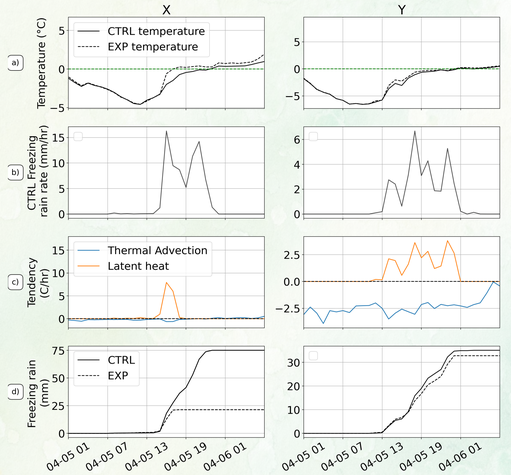


Fig 5: (a) 2-m temperature (°C) b) CTRL precipitation rate c) latent heat and thermal advection in the lowest model level d) cumulative freezing rain between EXP and CTRL at two grid points (X) and (Y)

Summary

- CTRL simulation was well reproduced by the model, but the freezing rain was overestimated.
- The warming from the latent heat from the freezing of supercooled drops contributed to increasing 2-m temperature as well as the upper air temperature.
- The modifications to the model resulted in a reduction of freezing rain accumulation and an increase in rainfall accumulation.
- The order of the magnitude of the latent heat in comparison to the thermal advection played a role in the transition from freezing rain to rain.

Acknowledgements

- Katja Winger and François Roberge
- Compute Canada, GWF, NSERC and CRC

Severe weather from the “Ring of Fire” storms on Aug 23-24/2023

Haizhen Sun (Ontario Storm Prediction Center)

Abstract: A stagnant warm-core mid-level anticyclone dominated the central United States from Aug. 20th to Aug. 25th of 2023, which is known as the ‘’Ring-of-Fire” weather pattern associated with the hot dome developed off east of the Rockies. A few stable waves tracked along a wavy frontal boundary to the northern periphery of the anticyclone, providing continuous forcing mechanisms to the development of repetitive severe thunderstorms over southwestern Ontario on Aug. 23 to 24th. A record-high moist and hot airmass further fueled these storms into well-organized nocturnal mesoscale convective system (MCS) and tornadic squall lines, resulting in damaging wind gusts and microbursts, significant flooding, and tornado over the Windsor-Essex county during the two-day period. This case study mainly focused on the prediction of different thunderstorm types, their propagation, and associated threats, as well as how numerical weather models performed under this extreme convective weather event.

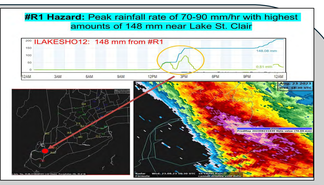
Event Summary

- A prolonged period of convection over extreme SW Ontario on Aug 23-24 produced torrential rainfall, tornado, microbursts and damaging winds
- There were mainly 4 rounds of severe TS within the two days period, each round has their unique features and hazards associated with them, summarized in the following table:

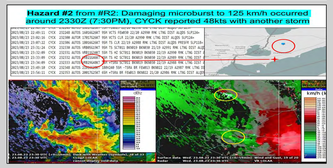
Isolated showers	Heavy rain / Multi-cells	Microburst Heavy rain / Supercells	Flooding rain Intense rainfall rate / MCS	Isolated TS shower	Tornado Microburst Heavy rain / Squalline
	Round 1	Round 2	Round 3		Round 4
August 23	06Z	18Z	00Z	August 24	06Z

- Numerous rainfall totals in the 100-320 mm range were reported within two days, but mostly fell within the 12hr period from the evening of Aug 23 to early morning of Aug 24th.
- Essex, Kent, western Middlesex and western Lambton counties experienced the most severe flooding
- Damaging wind gusts, microbursts and 3 tornado reported over Windsor-Essex area, and 6 Tornadoes reported in the lower MI in the evening of Aug 24th

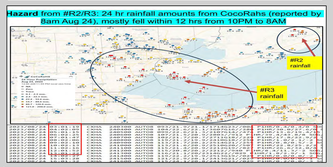
#R1 Hazard: Peak rainfall rate of 70-90 mm/hr with highest amounts of 148 mm near Lake St. Clair



Hazard #2 from #R2: Damaging microburst to 125 km/h occurred around 2330Z (7:30PM). CYCK reported 48kts with another storm



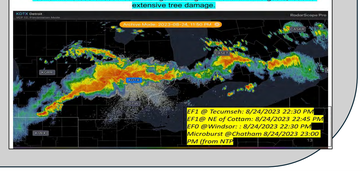
Hazard from #R2/R3: 24 hr rainfall amounts from CocoRahs (reported by 8am Aug 24), mostly fell within 12 hrs from 10PM to 8AM



Impacts: severe flooding over SW Ontario

- Widespread residential flooding, road closures (**at least 10 roads were closed**) in the morning of Aug 24th.
- Highway 402 was closed for 12 hours after being submerged in a river of brown water.
- Many **stranded vehicles** over flooded streets. Numerous crashes were reported in Middlesex and Lambton.
- **A fatality** occurred when a truck fell into a 3 m sinkhole on the main road through Glencoe
- Sewers in lakeshore backed up into basements after the drainage system was overwhelmed over Windsor

#R4 of severe TS rapidly developing over Central and Lower MI with the exceptional moisture and instability in place, these storms quickly grew upscale and became a west-east line of severe QLCS moving towards SWon ON during the evening hours of Aug 24 (8PM to 12PM) Damaging winds and Tornado are the primary hazards for this found with areas of southeast Michigan seeing 90-130 km/h wind gusts, lead to extensive tree damage.

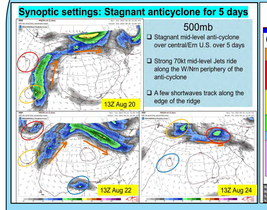


“Ring of Fire” Weather Pattern

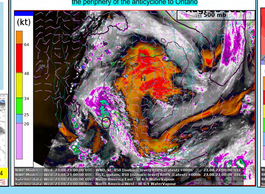
Synoptic settings: Stagnant anticyclone for 5 days

500mb

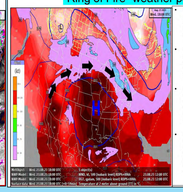
- Stagnant mid-level anti-cyclone over central/Em U.S. over 5 days
- Strong 70kt mid-level Jets ride along the W/Nm periphery of the anti-cyclone
- A few shortwaves track along the edge of the ridge



Dry air under the anticyclone, moistures from Gulf of Mexico transport along the periphery of the anticyclone to Ontario

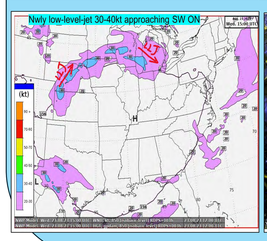


“Ring of Fire” weather pattern

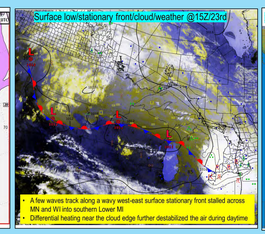


- Sinking air associated with a strong middle-level anticyclonic system east of the Rockies results in hot dome over central USA.
- Underneath the main core of the ridge weather is dry and hot, and remains rather prominent and stationary
- Multiple disturbances rotating around the northern periphery of the ridge provide lifting to the initiation of multiple rounds of severe thunderstorms
- Heat energy is transfemed into these storms, leading to very severe thunderstorms along the ring of the ridge, where barcclinicity and thermal winds are the greatest

Nwly low-level-jet 30-40kt approaching SW ON

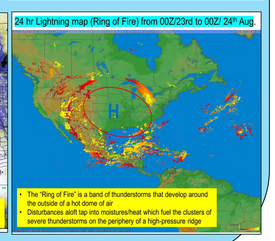


Surface low/stationary front/cloud/weather @15Z/23rd



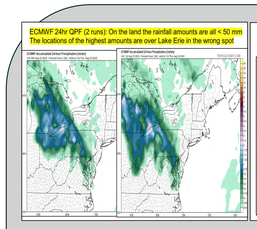
- A few waves track along a wavy west-east surface stationary front stalled across MN and WI into southern Lower MI
- Differential heating near the cloud edge further destabilized the air during daytime

24 hr Lightning map (Ring of Fire) from 00Z/23rd to 00Z/ 24th Aug.

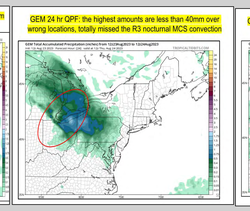


- The ‘Ring of Fire’ is a band of thunderstorms that develop around the outside of a hot dome of air
- Disturbances aloft tap into moistures/heat which fuel the clusters of severe thunderstorms on the periphery of a high-pressure ridge

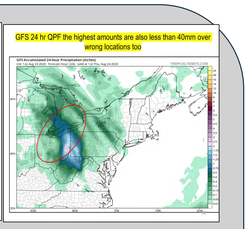
ECMWF 24hr QPF (2 runs): On the land the rainfall amounts are all < 50 mm The locations of the highest amounts are over Lake Erie in the wrong spot



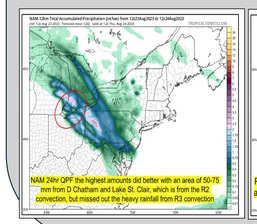
GEM 24 hr QPF: the highest amounts are less than 40mm over wrong locations, totally missed the R3 nocturnal MCS convection



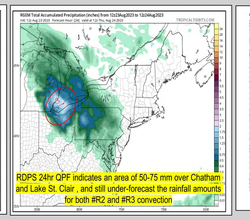
GFS 24 hr QPF the highest amounts are also less than 40mm over wrong locations too



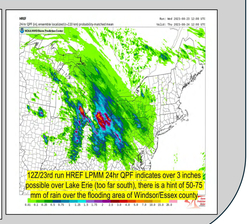
NWP QPF forecast with poor performance



NAM 24hr QPF the highest amounts did better with an area of 50-75 mm from D Chatham and Lake St. Clair, which is from the R2 convection, but missed out the heavy rainfall from R3 convection



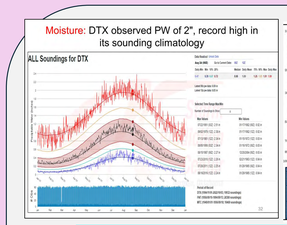
RDPS 24hr QPF indicates an area of 50-75 mm over Chatham and Lake St. Clair , and still under-forecast the rainfall amounts for both #R2 and #R3 convection

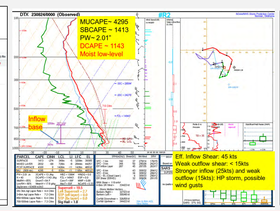


12Z/23rd run HREF LPMM 24hr QPF indicates over 3 inches possible over Lake Erie (too far south), there is a hint of 50-75 mm of rain over the flooding area of Windsor/Essex county

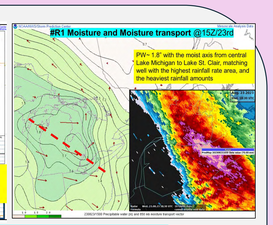
Convective Ingredient comparison for the four rounds of severe storms

Moisture: DTX observed PW of 2", record high in its sounding climatology



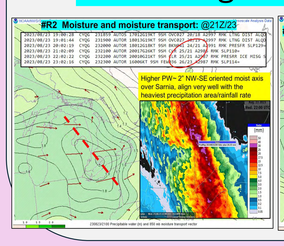


#R1 Moisture and Moisture transport @15Z/23rd

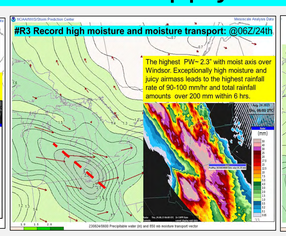


Record high moisture supply and transport

#R2 Moisture and moisture transport: @21Z/23

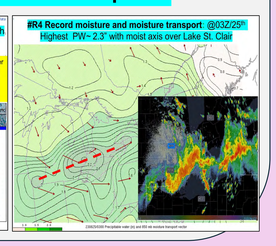


#R3 Record high moisture and moisture transport: @06Z/24th



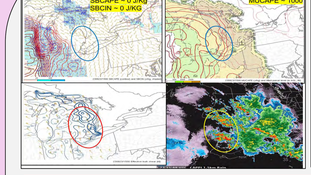
#R4 Record moisture and moisture transport @03Z/25th

Highest PW~ 2.3" with moist axis over Lake St. Clair

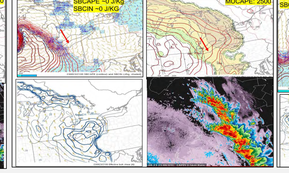


Increased instability from #R1 to #R4 & strong shear

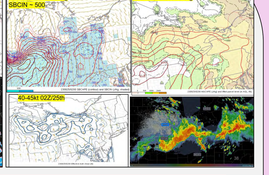
#R1: Instability/shear @15Z/23rd (Elevated convection)



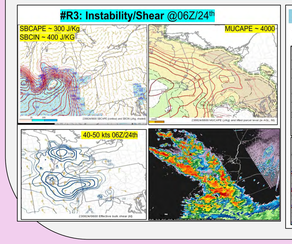
#R2: Instability/shear @21Z/23rd/Aug.



#R4: Instability/shear @02Z/25th

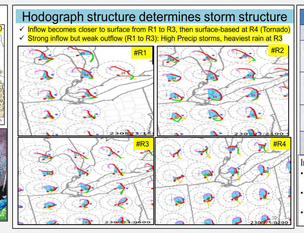


#R3: Instability/Shear @06Z/24th



Hodograph structure determines storm structure

- ✓ Inflow becomes closer to surface from R1 to R3, then surface-based at R4 (Tornado)
- ✓ Strong inflow but weak outflow (R1 to R3); High Precip storms, heaviest rain at R3



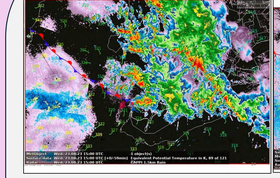
Convection ingredients comparison

#Round of convection		R1	R2	R3	R4
Moisture	PW (mm)	45	50	58	38
	Td_sfc (°C)	18	20	21	21
Instability (J/kg)	MUCAPE	1000	2500	4000	4000
	SBCAPE	0	~50	~300	~2800
Shear (kts)	Effective shear	40-45	40-45	45~50	45-50
Trigger	Low/ front	Stationary front	Stationary front	Low/front	Low/warm front

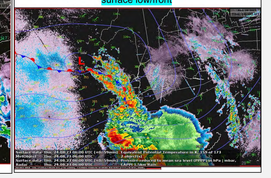
In summary

- Convection triggers are short waves along a wavy frontal boundary to the northern periphery of the anticyclone over central USA
- Shear and instability are exceptional high (especially for #R3/R4) supporting organized supercells, MCS and QLCS
- Record-high moist supply and hot airmass further fueled these storms with potential torrential downpour, damaging wind gusts and tornado

#R1 TS Trigger: Elevated TS initiation along frontal zone

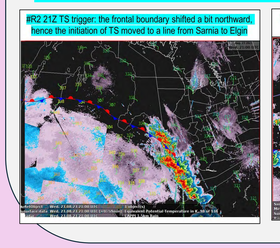


#R3 06Z Aug24 TS trigger: more TS initiation near surface low/front

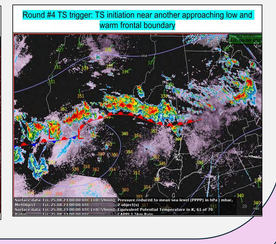


Trigger for convection initiation

#R2 21Z TS trigger: the frontal boundary shifted a bit northward, hence the initiation of TS moved to a line from Sarnia to Elgin



Round #4 TS trigger: TS initiation near another approaching low and warm frontal boundary

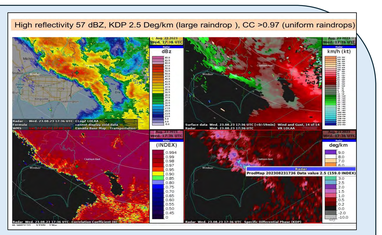


Environment Canada / Environment Canada — Canada

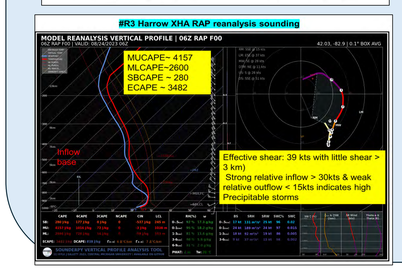
Forecasting convective heavy rainfall

- ✓ Convection assessment for storm types
  - All convection ingredients support supercell TS, multi-cell and QLCS with record-high moisture supply and heavy rain potential
- ✓ Physical precipitation producing process
  - *Warm cloud precipitation*
- ✓ Rainfall is a function of storm motion, storm intensity (rainfall rate) and duration
  - *Quasi-stationary or slow storm movement*
  - *Existence of training or regeneration cells (multi-cells)*
  - *Storms with large precipitation areas such as MCC/squall lines*

High reflectivity 57 dBZ, KDP 2.5 Deg/km (large raindrop), CC >0.97 (uniform raindrops)

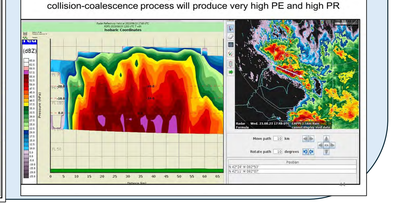


#R3 Harrow XHA RAP reanalysis sounding



Radar cross section indicates very high PE storms

- ✓ Low centroid storm: highest reflectivity in the lower half of cloud
- ✓ Warm cloud process: the majority of high reflectivity is below -10C, so collision-coalescence process will produce very high PE and high PR

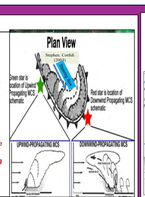


Motions of four rounds of convective storms

MCS movement = Advection + Propagation

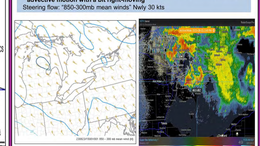
- **Individual cell** is advected by the mean wind in the cloud-bearing layer (**the steering flow**):
  - 850-300mb mean wind or
  - 0-6km mean wind
- **Propagation** refer to the apparent movement of MCS due to new cell develop on one flank. The main types of MCS propagation include:
  - ***Forward*** (propagation and fast movement)
  - ***Quasi-Stationary*** (little propagation and movement)
  - ***Backward*** (MCS appears to move backward due to new cell development on upwind flank even if individual cell movement is slowly forward)
  - ***Regenerative back-building*** (MCS and cells within MCS move forward, but new cells and/or other MCSs develop upwind and move over the same location)
- **Prolonged heavy rain and flash flood are mainly due to quasi-stationary, backward propagation, and/or regenerative cells**

- **Backward (upwind) propagation often occurs:**
  - Quasi-stationary boundaries
  - Steering flow parallel to the convection/stationary boundary
  - frequently associated with **heavy rain**
- **Forward (downwind) propagation often occurs:**
  - More progressive boundaries
  - Steering flow perpendicular to the convection
  - frequently associated with **strong gusty winds**



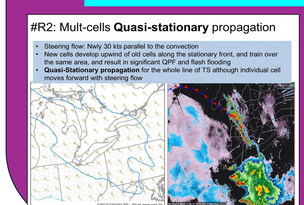
#R1 movement: Advective

- **Discrete individual supercell moves with the main wind (steering flow), pure advective motion with a bit right-moving**
- Steering flow: 850-300mb mean winds: Nwly 30 kts



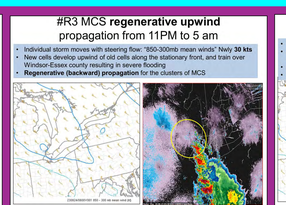
#R2: Mult-cells **Quasi-stationary** propagation

- Steering flow: Nwly 30 kts parallel to the convection
- New cells develop upwind of old cells along the stationary front, and train over the same area, and result in significant QPF and flash flooding
- **Quasi-Stationary propagation** for the whole line of TS although individual cell moves forward with steering flow



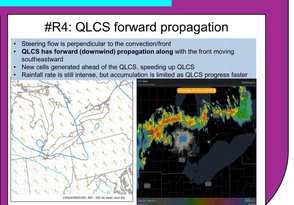
#R3 MCS **regenerative upwind** propagation from 11PM to 5 am

- Individual storm moves with steering flow: 850-300mb mean winds' Nwly **30 kts**
- New cells develop upwind of old cells along the stationary front, and train over Windsor-Essex county resulting in severe flooding
- **Regenerative (backward) propagation** for the clusters of MCS



#R4: QLCS forward propagation

- Steering flow is perpendicular to the convection/front
- **QLCS has forward (downwind) propagation along** with the front moving southeastward
- New cells generated ahead of the QLCS, speeding up QLCS
- Rainfall rate is still intense, but accumulation is limited as QLCS progress faster



Conclusion

- The “Ring of Fire” weather setting provided the continuous lifting to the initiation of multiple-rounds of severe storms from Aug 23 to 24th 2023
- A record-high moist fueled these storms into well-organized nocturnal MCS and tornadic squall lines, resulting in excessive rainfall of 100-320 mm, microbursts, damaging wind gusts and Tornadoes
- Pattern recognition and anticipation of different storm types and their motions are crucial to successfully forecast such extreme event and associated hazards.
- All models did very poorly on the magnitude of convective QPF and the locations of the highest rainfall, and missed the nocturnal MCS, and can only be used as first guess for QPF forecast.

GEMnet : sensitivity to hyperparameters, architecture and ensemble size

Vikram Khade and Alain Beaulne
Meteorological Service of Canada (MSC), ECCC, Dorval, Quebec

CMOS,
9010 poster session affiches,
05 June 2024

The ensemble analysis and 6 hour forecast of 1.5-meter temperature from the 39 km resolution GEM (Global Environmental Multiscale Model) are used in this work. Archived GEPS (Global Ensemble Prediction System) ensemble members 1-10 for JFMAMJ (2017-2022) are used for training (80%) and validation (20%). The total number of training/validation samples are 43440 (71 GB). The year 2023 is used for testing.

Convolutional Neural Network (CNN) is used to train a 6-hour forecast simulator for GEM. Two different architectures of CNN are trained – the first with a maximum of 512 filters (GEMnet1) and second with a maximum of 256 filters (GEMnet2). The optimizer, activation and loss function used are Adam, ReLU and Mean Square Error (MSE) respectively.

The goal of developing GEMnet is not to expressly compete against simulators like GraphCast, Pangu-Weather and FourCastNet, but rather to build inhouse capability and capacity to develop AI based models. Also, this work demonstrates the value of archived data at MSC to develop AI based models.

Fig1

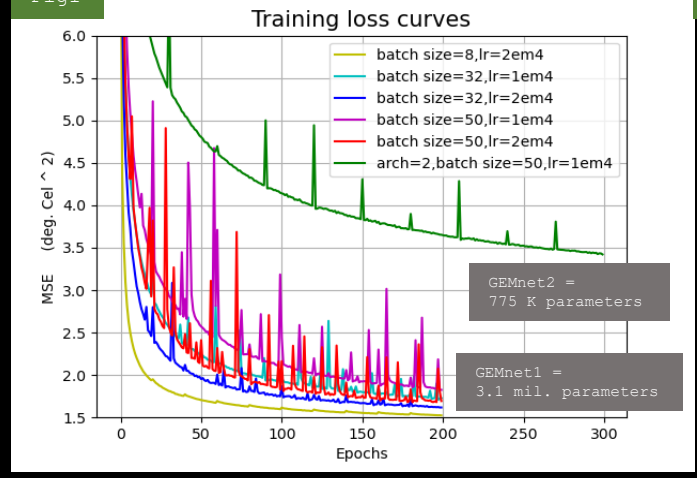
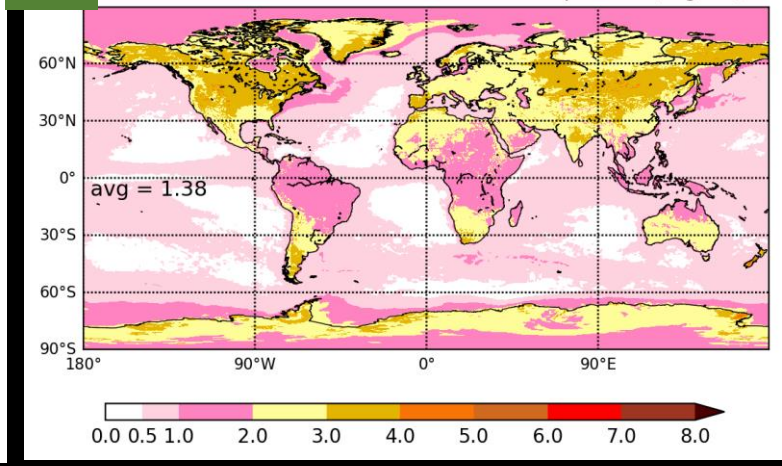


Fig2



Experiments are run on a single NVIDIA A-100 GPU at the MSC to assess sensitivity of the training and testing errors to batch size, learning rate and ensemble size. The training time for GEMnet1 and GEMnet2 is 6.5 and 5.6 minutes per epoch. GEMnet1 executes 1240 forecasts in only 13 seconds on a single GPU.

Conclusions

- The training MSE decreases with decreasing batch size. Smaller batch size tends to overfit.
- The training MSE decreases with higher learning rate. Higher learning rate tends to overfit.
- GEMnet1 has a train and test RMSE of 1.31 and 1.38 deg. Celsius (Fig 2) for a batch size of 32 and learning rate of $1x10^{-4}$.
- GEMnet2 has a train and test RMSE of 1.87 and 1.57 deg. Celsius .
- GEMnet outperforms persistence and climatology for a 6-hour forecast. GEMnet tends to smooth the smaller scales compared to the GEM forecast.
- Experiments using 1 and 5 ensemble members were run and compared against that using 10 ensemble members. The training error decreased with decreasing ensemble size, but the testing error increased. The testing error is 1.38, 1.43 and 1.56 for ensemble size of 10, 5 and 1 respectively with corresponding overfitting of 0.07, 0.1 and 0.34.
- It was found that using tanh activation function gave similar results to using ReLU while using sigmoid resulted in significantly higher training MSE.

Further work

- Use a custom loss function with two terms – one for MSE over land and other for MSE over ocean with more weight to the first term. This could possibly further decrease the error over land (Fig2).
- Apart from 1.5m temperature other variables and few more levels can be included.
- The REQA reforecast database which uses the same GEM model over 1980-2018 can be used for training rather than the GEPS archive. The GEPS archive does not go back to 2018. Also, the GEM model changes over the years.

Fig3a

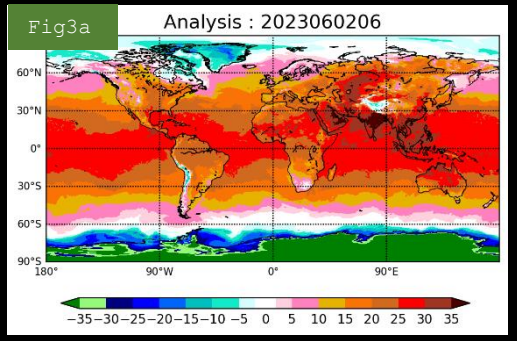


Fig3b

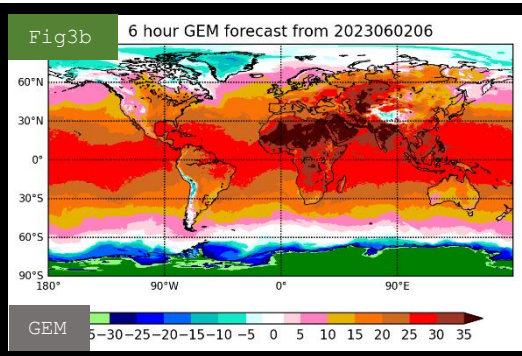
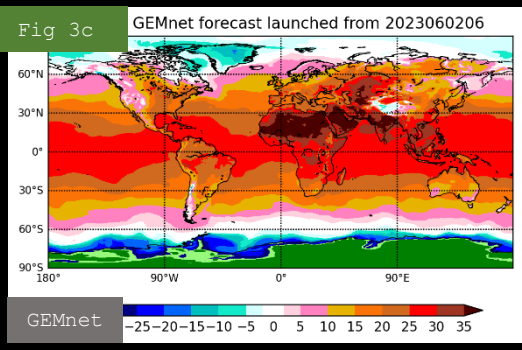


Fig 3 shows a sample from the test data set. (a) shows the initial condition which is fed to both the GEM numerical model and GEMnet1 simulator. (b) shows the 6-hour forecast from GEM and (c) shows the 6-hour forecast from GEMnet. GEMnet captures the broad pattern of the forecast accurately. In general, looking at several samples it is found that GEMnet learns the diurnal cycle though the time information is not used as a predictor.

Fig 3c



Global Lightning Prediction with Ensemble Decision Trees

MING LONG (JERRY) SU (University of Waterloo),
DOMINIQUE BRUNET (ECCC),
MATEUSZ TASZAREK (Adam Mickiewicz University),
JOHN HANESIAK (University of Manitoba),
ROBERT CRAWFORD (ECCC)

Motivations

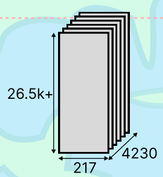
Convective parameters most related to lightning over land in mid-latitudes are fairly well understood. However, less is known about which convective parameters are optimal over the oceans and tropics.

Our research confronts the question, “Can machine learning help to uncover the best convective parameters to predict lightning occurrence at any location?”

Dataset

Computed convective parameters from **ERA5 Reanalysis** using **thundeR** package. Data boasts:

- **4230** unique locations
- Each with **26.5k+** observations
- **217** convective parameters
- All datasets span the **2014-2022** period



Note:

- Data was split into “latitudinal bands” (intervals of 30 degrees as shown in the background), and further dichotomized by land and ocean locations to provide some order to data

Methods

1. Trained gradient-boosting trees with 3 approaches:
   a. BigXGB - trained on data sampled randomly from all over the globe
   b. SpecXGBs - one model for each latitudinal band
   c. iXGB - iteratively learn over different latitudinal bands (achieving global patterns by focusing on local patterns)
2. Evaluated each learning approach by ‘importance’ of learnt convective parameters:
   - Gain - amount of improved performance in model from feature
   - Weight - amount of presence in decision trees

Conclusions

- Current set of convective parameters can be learned to perform very well for lightning detection on land, but not so well over the ocean
- iXGB has potential to learn more robust features due its ability to capture global patterns by iterating over bands to learn the local patterns

Next Steps

- Train random forest or gradient-boosting model on finer selection of convective parameters
- Rerun methods on newly procured dataset comprising of **317+** convective convective parameters
- Further analyze sense of important convective parameters
- Produce a global lightning climatology by running on **ERA5 Reanalysis** with **40+** years’ worth of data

Results

1. BigXGB **(see Figure 2)**
   - Proposition of convective parameters such as most unstable lifted index (MU_LI) is consistent with the observation of the Showalter Index (Burrows, 2005)
   - Relative humidity (RH) is also a feature that is consistent as an important feature over land and the mid-latitudes
   - Other most important convective parameters in terms of gain can be seen in the “visuals” box with graph “BigXGB Gain”
2. SpecXGBs
   - Across the various latitudinal bands, MU_LIs (particularly MU_LI_500_M10) consistently appears as a important lightning prediction parameter
3. iXGB **(see Figure 1)**
   - Has potential for learning more robust convective parameters such as total precipitation (tp) particularly when it comes to oceans since oceans are more humid than land. Moreover, with air movements and collisions between precipitation, such particles can become charged.
4. Gain vs Weight
   - When assessing most important convective parameters by gain, gain tends to represent features that are more impactful when it comes to contributing to detection of lightning
5. Both iXGB and BigXGB shared similar PSS (probability of detection minus probability of false detection), FAR (false alarm rate), and CSI (critical score index) scores when evaluated on the test sets **(see Figure 3)**.
6. Most importantly, XGB’s learning curves demonstrate that the set of convective parameters performs well in detecting lightning over land. Conversely, iXGB’s learning curves also demonstrate that the set of convective parameters perform poorly over ocean due to plateau of learning curve relatively soon compared to that of over the land. **(see Figure 4)**

Figure 1: iXGB Most Important Convective Features by Gain

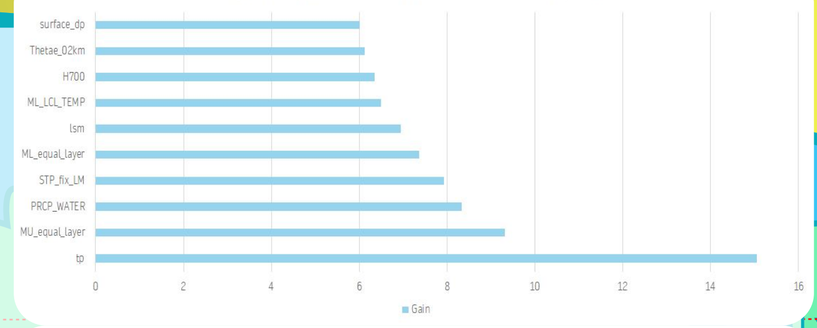


Figure 2: BigXGB Most Important Convective Features by Gain

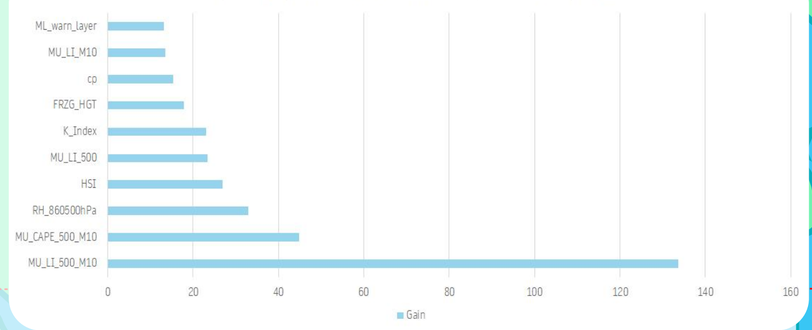


Figure 3: iXGB vs BigXGB

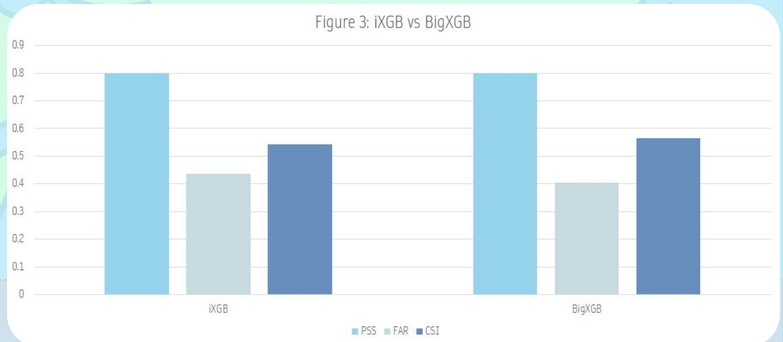
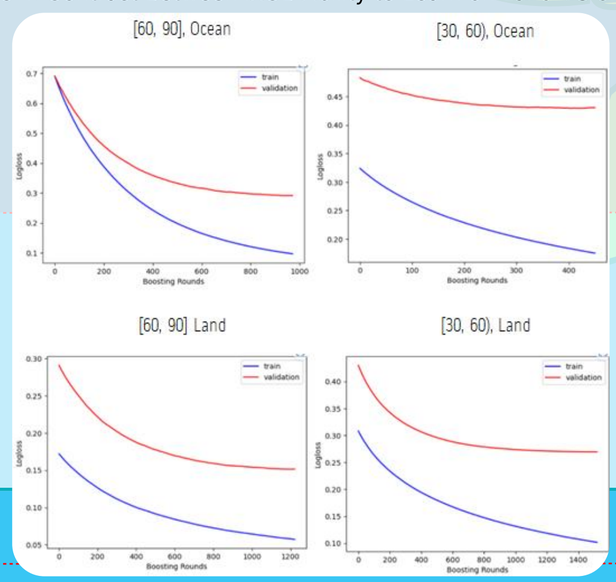


Figure 4: Contrast Between iXGB Ability to Learn on Land VS on Ocean



Hail Forecasting Project

Hokyung (Andy) Lee, Dominique Brunet, Robert Crawford

Motivation

Each year in Canada, hail causes an average $134M in damage (2004-2013). Thus, it is very important to accurately predict hail events to minimize damage

With this project, we aim to achieve:

1. **Improvement in quality of hail report database**
2. **Improve hail prediction accuracy**

Models & Datasets

10K observations of hail vs no hail, previous prepared for CodeML hackathon, were utilized to train the following XGBoost models:

1. **No Hail vs Hail (e.g. Binary)**
2. **Severe Weather vs Non-Severe Weather (e.g. Binary)**
3. **No Hail vs Non-Severe Hail vs Severe Hail vs Seriously Severe Hail (e.g. Categorical)**

Training Results

Model Type	POD	POFD	PSS
Hail vs No Hail	0.989	0	0.989
Severe Weather vs Non-Severe Weather	0.911	0.41	0.502

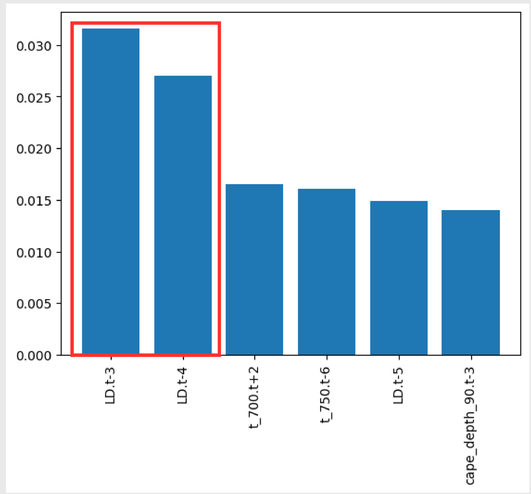
Fig 1. Training Results for Binary Classification Models

Category	POD	POFD	PSS
No Hail	0.951	0.0314	0.92
Non-Severe Hail	0.407	0.133	0.274
Severe Hail	0.624	0.341	0.283
Seriously Severe Hail	0.25	0.0798	0.17

Fig 2. Training Results for Categorical Classification Model

Correlated Features

Lighting density and temperature at 650-700hPa pressure level before hail events correlated with the occurences and severity of the hail the most



Top Correlated Features

1. **LD.t-2**
2. **LD.t-3**
3. **t_650.t-2**
4. **t_700.t-1**
5. **t_650.t-5**
6. **LD.t-1**
7. **t_700.t-5**

Fig 3. Top Correlated Features to Categorical Hail Size Prediction

**LD prefix stands for lighting density*
**t_x prefix stands for temperature at xhPa pressure level*
**t-y postfix represents y hours before hail observation*

Data Extraction via LLM

To accelerate the process of extracting individual features (e.g. reference objects, locations) from the observation notes provided in the dataset, we utilized Large Language Models (LLMs), specifically GPT-4 through Azure API

Similarly, LLM was utilized to filter out confidential information (e.g. name, email, phone number) from observation notes to replace with generic identifiers

Prompt

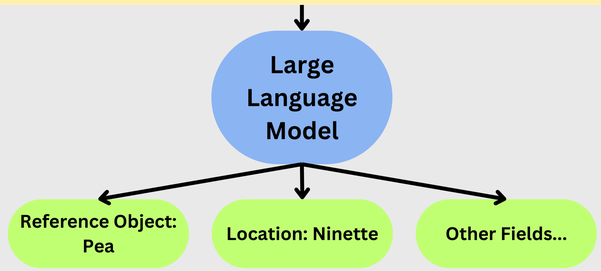
- **Given the provided list of reference objects, extract the value from the provided observation note**
- **...**

Observation Note

- **<person> spotted a tornado on the ground SW of Ninette lasting about 3 minutes on the ground. It was small and rope like in appearance. Lifted just after report. Pea sized hail associated with it.**

Reference Objects

- **pea**
- **marble**
- **...**



The LLM-extracted information was compared with the human-extracted truth values using syntactic match, LLM-assisted eval, and Google Maps API (for locations)

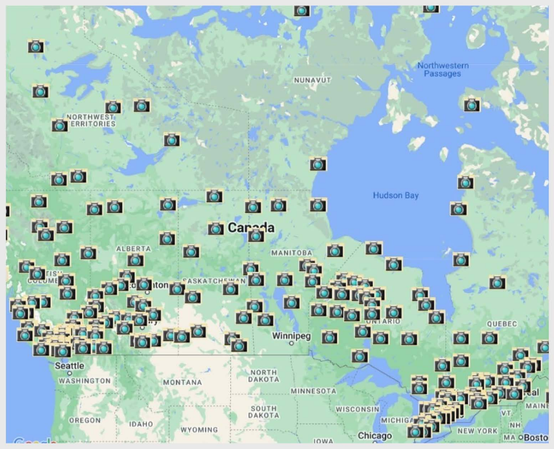
Extracted Data	Accuracy
Reference Object	83.00%
Hail Diameter	91.40%
Location	93.04%

Fig 4. Accuracy of Each Features Extracted from Observation Notes

WebCam Project

Hokyung (Andy) Lee, Dominique Brunet, Robert Crawford

Motivation



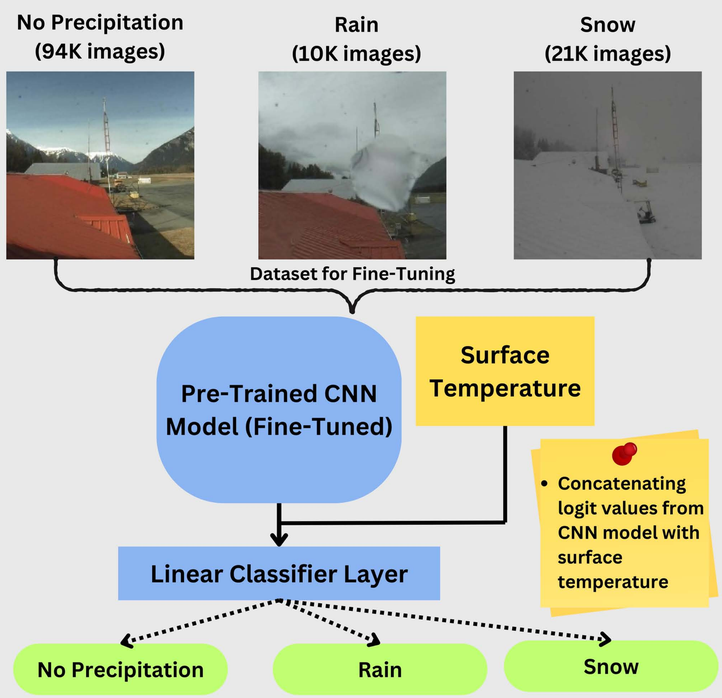
There are 10,000+ webcams around Canada used to monitor weather at airports and traffic on highways

Automating the image classification with machine learning model can have several benefits:

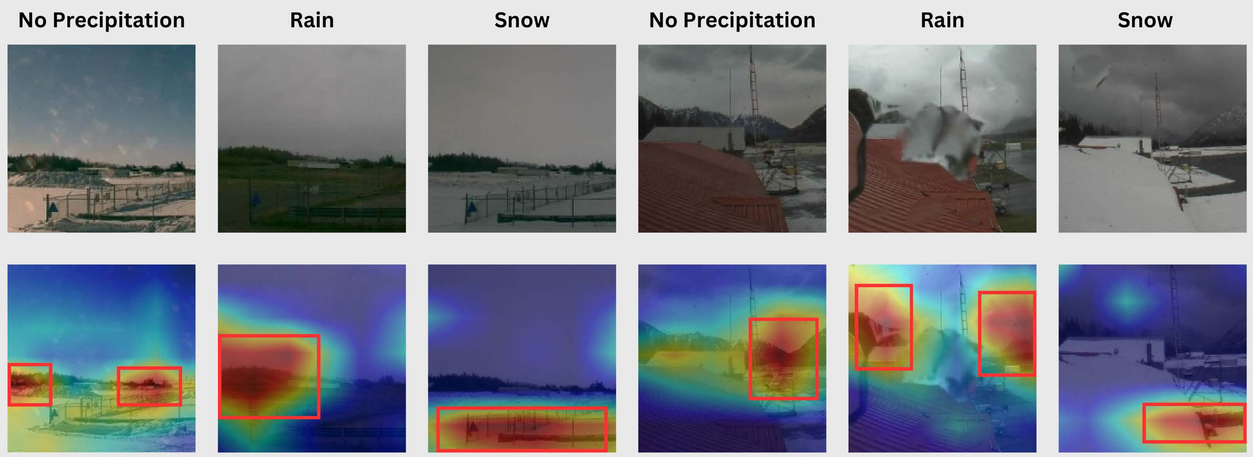
1. Reduced cost compared to automatic present weather sensors or manual observations
2. Ability to flag interesting images to weather forecasters for further analysis

Models & Datasets

125K images collected from 37 different NavCan locations (Dec 16, 2022 to Jan 23, 2024) were used to fine-tune the Convolutional Neural Networks (CNNs), METAR data from each NavCan location was used to match the images to observed surface temperature and precipitation type



Explainable AI



*Grad-CAM method was used to highlight the areas of the image that the model was most focusing on for each precipitation type

No Precipitation
- Light focus on horizon area
- Likely due to brighter sunlight around the horizon during no precipitation

Rain
- Heavier focus above horizon
- Likely due to heavier cloud formation during rain

Snow
- Broad focus on the ground
- Likely due to relatively higher light reflection from the ground during snow event

Training Results

4 different pre-trained CNN models (MobileNetV2, MobileNetV3, DenseNet201, Xception) were used as part of 3 different architectures (image-only, image + surface temperature (hybrid), hybrid w/t learnable weights for each component)

Hybrid architecture with DenseNet201, Xception, or MobileNetV2 models performed the best, achieving 86.4-86.87% overall accuracy. Given that MobileNetV2 runs ~5x times faster than DenseNet201 or Xception models with little performance difference, MobileNetV2 with Hybrid architecture is the most ideal

Model	Param #
MobileNetV2	3.4M
MobileNetv3	5M
DenseNet201	20.2M
Xception	22.8M

Fig 1. Parameter size of each pre-trained CNN models

Model Name	Overall	No Precipitation	Rain	Snow
DenseNet201Hybrid	86.87	83.96	87.26	89.39
XceptionHybrid	86.55	72.73	94.46	92.46
MobileNetV2Hybrid	86.4	83.96	87.03	88.21
DenseNet201HybridWithWeights	86.01	82.78	82.31	92.92
XceptionHybridWithWeights	85.96	82.71	82.71	92.46
MobileNetV2HybridWithWeights	85.93	83.73	84.2	89.86
MobileNetV3Hybrid	84.75	81.13	85.14	87.97
MobileNetV2	84.2	85.5	82	85.1
MobileNetV3HybridWithWeights	74.37	41.98	87.26	93.87

Fig 2. Performance of each model for No Precipitation vs Rain vs Snow classification

Model Name	P(Snow/Precip) @ <= -1C	P(Rain/Precip) @ >= 3C	Avg
Actual	100	99.65	99.825
XceptionHybrid	94.51	95.99	95.25
MobileNetV3HybridWithWeights	100	88.55	94.275
DenseNet201Hybrid	92.7	87.18	89.94
DenseNet201HybridWithWeights	93.78	84.99	89.385
MobileNetV2HybridWithWeights	90	88.04	89.02
MobileNetV2Hybrid	90.54	86.96	88.75
MobileNetV3Hybrid	89.19	85.9	87.545
MobileNetV2	87.84	82.81	85.325
XceptionHybridWithWeights	85.54	66.27	75.905

Fig 3. Each model were also evaluated on conditional temperature range for probability of predicting snow or rain, which served as a preliminary check for models' accuracy on conditions where it is expected to perform well. The poor performance of image-only model served as a motivation to develop the hybrid models

More concentrated precipitation from cold-season storms over expansive lake areas in western Canada

Fei Huo, Yanping Li, Zhenhua Li
Department of Physics and Astronomy, The University of Western Ontario
Contact: fhuo2@uwo.ca

INTRODUCTION

Under climate change, mesoscale convective systems (MCSs) and associated extreme rainfall are expected to undergo several significant changes, driven by alterations in atmospheric dynamics, moisture availability, and temperature patterns.

Fig. 1 A heavy rainstorm in Quebec, Canada. (Image credit: istock)

MOTIVATIONS

Previous research has shown that highest increases are found for MCS precipitation volumes, which is positively related to increasing rain rates and rain areas under the RCP8.5 scenario by the end of 21st century.

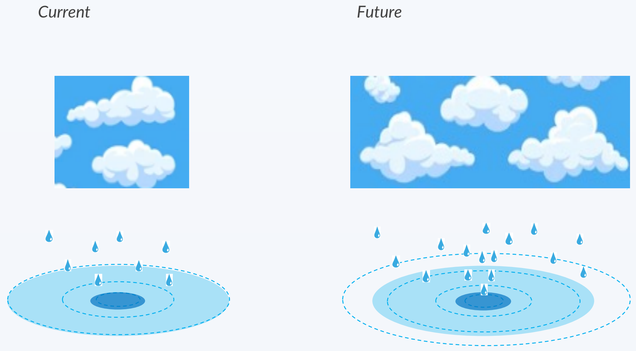


Fig. 2 Response of extreme precipitation events to future climate change

The MODE object identification process can be used to examine if precipitation is concentrated toward storm centres (that is, spatial concentration (SC) decreases) in a warmer climate.

METHODES

Techniques have been refined to delve into the intricacies of MCSs and their evolving spatial patterns in a warming climate:

- ✓ The Method for Object-Based Diagnostic Evaluation (MODE): MODE allows for a comprehensive examination of the characteristics and behavior of MCSs by identifying and analyzing individual convective systems as distinct objects.
- ✓ Convection-permitting modeling over western Canada: Convection-permitting models simulate atmospheric processes at high spatial resolutions, allowing for a more detailed representation of convective phenomena like MCSs.

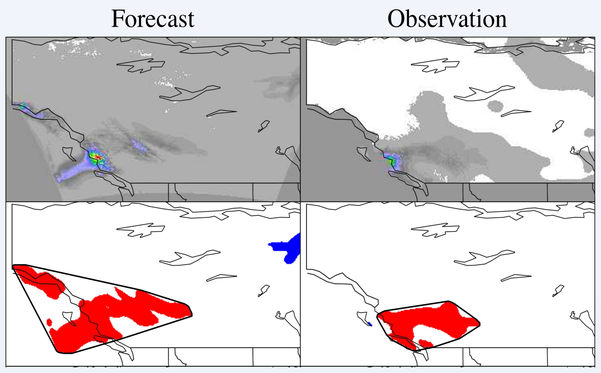


Fig. 3 An example for tracking MCSs with MODE that occurred on Nov 8, 2014.

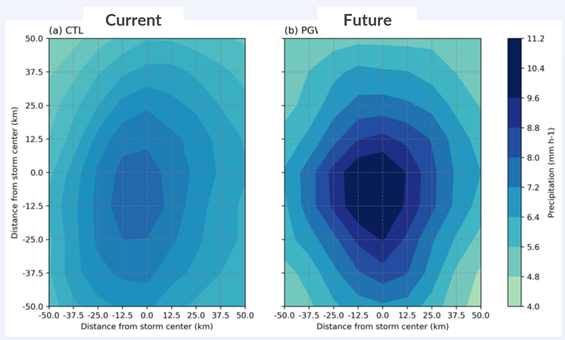
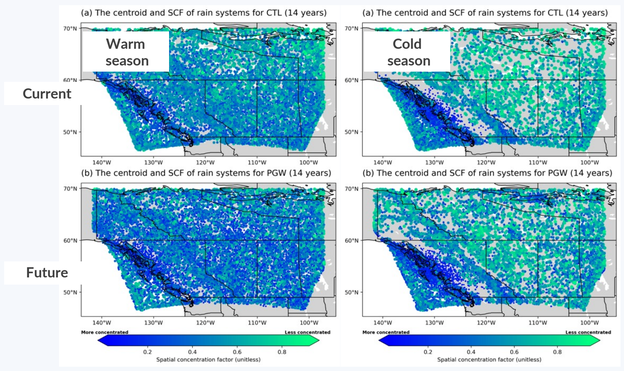


Fig. 4 Daily precipitation averages in current (a) and future (b) climates composited according to the storm center.

RESULTS

Understanding how precipitation patterns may evolve under extreme conditions is crucial for effective climate adaptation and water resource management strategies in the affected areas.



Rain systems become denser and more concentrated

Attributes identified:

- *Area*
- *Axis angle*
- *Aspect ratio*
- *Centroid*

Specifically,

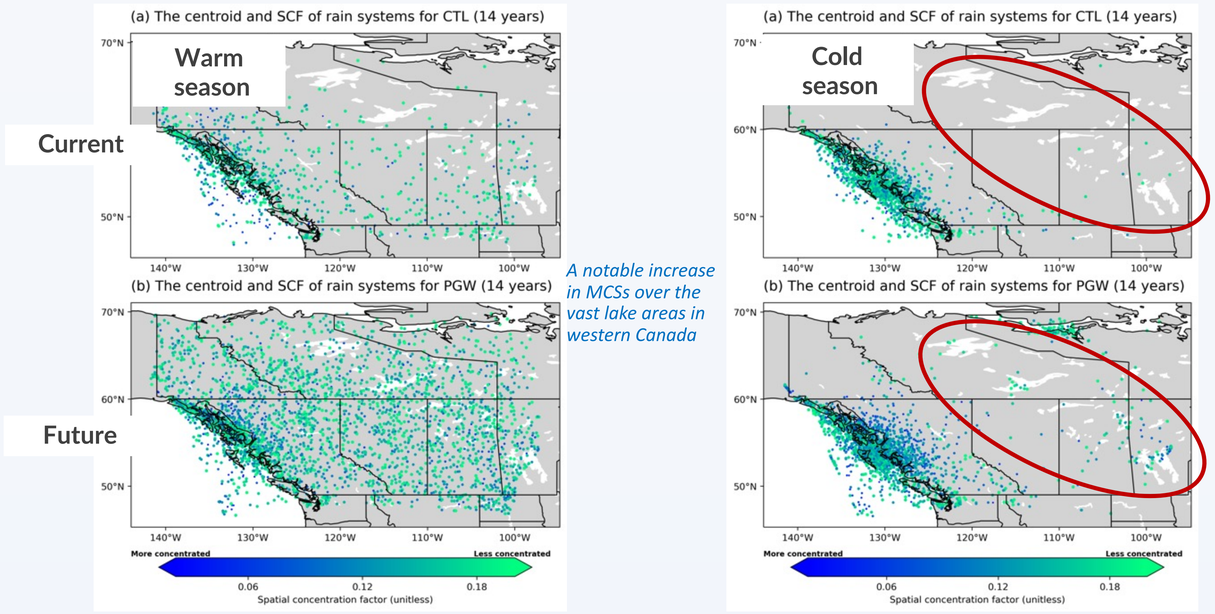
➢ *Spatial Concentration Factor SC calculated by*

SC = Iavg /Ict

Iavg is area-averaged daily precipitation, and Ict is peak daily precipitation

Fig. 5 The centroid and spatial concentration (SC) factor of the warm- and cold-season MCSs in current (CTL) and future (PGW) climates.

By employing a specific threshold (such as a spatial concentration factor < 0.2), we can further investigate changes in precipitation under more extreme conditions.



A notable increase in MCSs over the vast lake areas in western Canada

Fig. 6 The centroid and spatial concentration (SC) factor (<0.2) of the warm- and cold-season MCSs in current (CTL) and future (PGW) climates.

FUTURE WORK

Our upcoming research will focus on two main objectives:

1. Analyzing the probability density functions of Convective Available Potential Energy (CAPE).
2. Investigating Convective Inhibition (CIN) and the associated changes in MCS environments and dynamics.

These investigations aim to deepen our understanding of the atmospheric conditions conducive to convective activity and their implications for the dynamics of mesoscale convective systems.

REFERENCES

1. Davis, C., Brown, B. & Bullock, R. Object-Based Verification of Precipitation Forecasts. Part I: Methodology and Application to Mesoscale Rain Areas. (2006).

2. Prein, A. F. & Heymsfield, A. J. Increased melting level height impacts surface precipitation phase and intensity. Nat Clim Chang 10, 771–776 (2020).

Combining population models and larval dispersal of *Lepeophtheirus salmonis*

John P. Phelan, Michael T. Burrows, Keith Davidson, Alexander G Murray, Philip A Gillibrand, Thomas Adams

The Scottish Association for Marine Science, Scottish Marine Institute, Oban, Scotland, UK.

Aims

- To estimate the dispersal of sea lice larvae and connectivity between sites on the west coast of Scotland using a hydrodynamic model and particle tracking tool
- Use of output from particle tracking tool to estimate number of newly settled chalimus on fish
- Comparison of model output vs. observation to investigate model performance

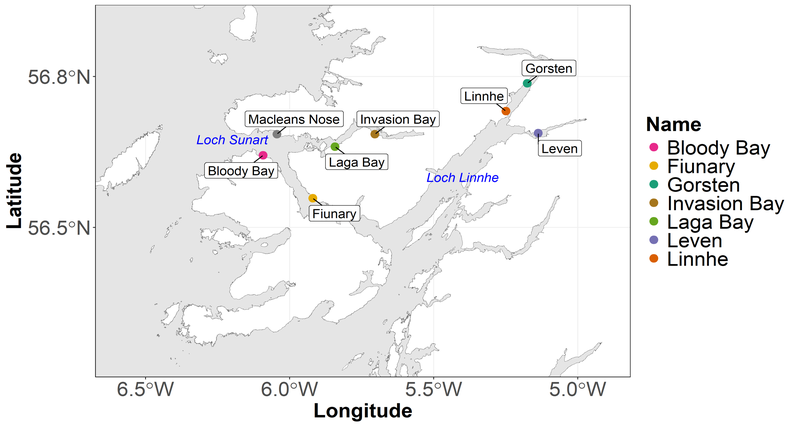


Figure 2. The location of farms being modelled on the west Coast of Scotland

Results

- The dispersal of particles varies with each month (Fig.3)
- Connections between sites also vary depending on location (Fig. 4)
- Using output from particle tracking, population models estimate population structure (Fig. 5)
- Changes in attachment rate affect deviance, which compare model observations and model predictions (Fig. 6)

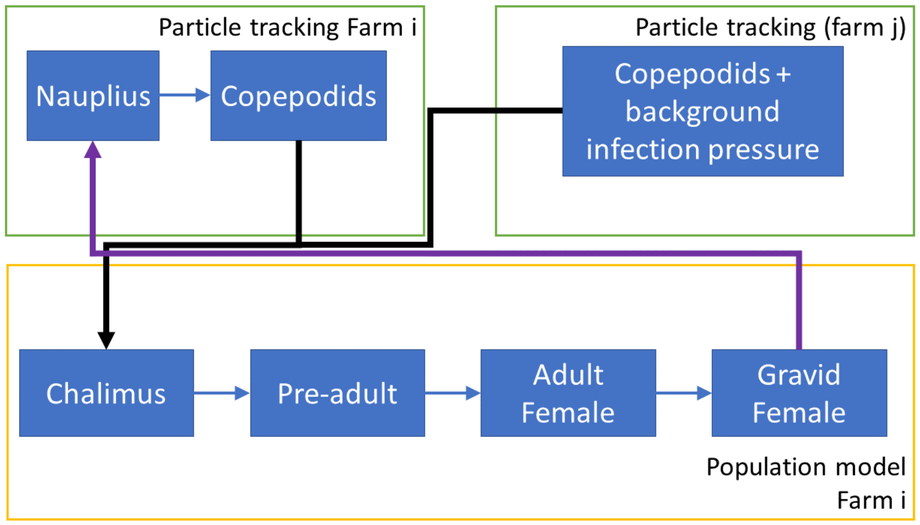


Figure 1. A schematic of the movement of classes between the particle tracking (top two panels) and the population model (bottom panel).

Methods

- Particles are released from farm sites and estimation of number of larvae arriving to sites based on observations
- Population model estimates population structure of attached stages of lice
- Deviance gives estimate of model fit and aids in fitting parameters with decreased deviance indicating closer fit between observations and model predictions

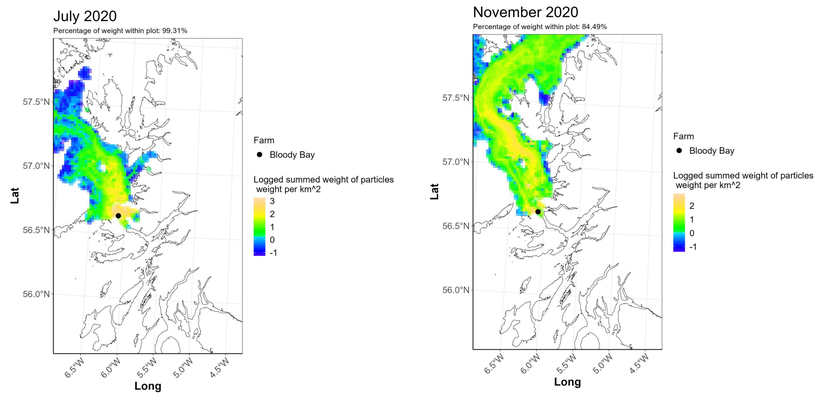


Figure 3. The dispersal of particles from Bloody Bay in July and November 2020. The dispersal distance in July is less than that in November, with more particles remaining closer to the source farm and neighboring farms.

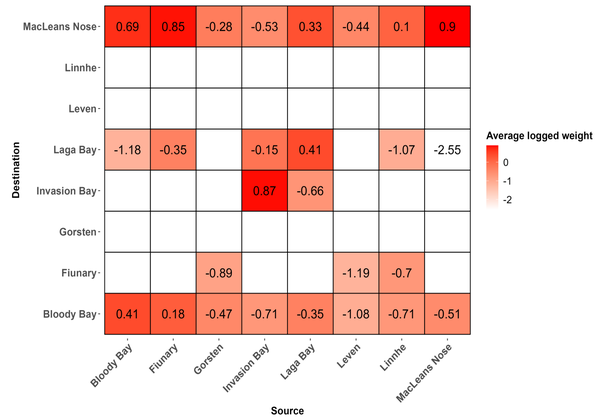


Figure 4. A connectivity matrix of the logged weight of connections of sites in July, August and September 2020. This gives a general overview of connectivity for a season, with stronger connections with deeper shades of red.

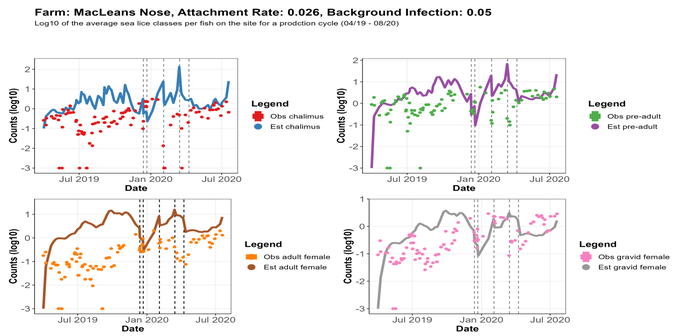


Figure 5. The abundance ($\log_{10}$) of the observed (points) and estimated (lines) classes on MacLeans Nose for one production cycle. Treatments that were applied are represented as vertical dashed grey lines on the plot. -3 on the plot represents 0 sea lice.

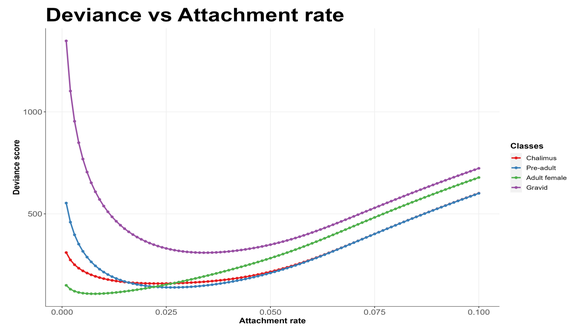


Figure 6. Changes in attachment rate of newly arriving larvae has an effect on the deviance, the estimation of model fit. The deviance is calculated for each stage separately.

SAMS Scottish Association for Marine Science

A partner of UHI

SAIC Sustainable Aquaculture Innovation Centre

Marine Alliance for Science & Technology Scotland

Scottish Government Riaghaltas na h-Alba gov.scot marinescotland

THE DATA LAB value from data

John Phelan
SAMS,
Oban, Argyll, PA37 1QA
https://twitter.com/trjpphelan
E: pjphelan@tcd.ie

Development of MESH-CLASSIC and assessment of the model's carbon cycling capability in a catchment in Ontario

Daniel Mutton[1,2], Dan Princz[3], Bruce Davison[3], and M. Altaf Arain[1,2]

[1] School of Earth, Environment, and Society, McMaster University, Hamilton, Ontario, Canada
[2] McMaster Centre for Climate Change, McMaster University, Hamilton, Ontario, Canada
[3] Environment and Climate Change Canada, Saskatoon, Saskatchewan, Canada

Introduction

The Canadian Land Surface Scheme Including Biogeochemical Cycles (CLASSIC) is a new open source model developed by Environment and Climate Change Canada designed to serve as the successor to the Canadian Land Surface Scheme (CLASS) and the Canadian Terrestrial Ecosystem Model (CTEM). The CLASS-CTEM model previously formed the land-surface component of the Earth System Model.

The Modelisation Environmentale Communautaire Surface and Hydrology system (MESH) is an environmental modelling system developed by Environment and Climate Change Canada to serve as a coupling method between hydrological and atmospheric models in order to improve flow simulations and atmospheric predictions with applications to both climate science and hydrology.

The coupling of the MESH model with the global-scale CLASSIC or CLASS-CTEM model allows for these models to be scaled down to the catchment level. The development and improvement of catchment-scale hydrological and atmospheric models is of vital importance as it will strengthen studies into regional water regimes and how they can be impacted by climate change and extreme climate events.

The coupled ME-CLASSIC model is planned to become the default version of MESH and will see continuous use and development as an open-source hydrologic model for the Canadian hydrologic modeling community.

Study Sites

The model was run on three sites in two different regions. The first two sites are CA-TP39 and CA-TPD part of the Turkey Point Observatory in Ontario Canada, managed by the McMaster Centre for Climate Change, and the other site is US-Wkg, an experimental grassland watershed managed by the United States Department of Agriculture.

Canadian Turkey Point Deciduous (CA-TPD) is a naturally regenerated deciduous forest over abandoned agricultural land, with data collection beginning in 2012 and extending to the present.

Canadian Turkey Point 4 (CA-TP39) is a mature white eastern white pine forest planted in 1939 on cleared oak-savannah land, with data collection starting in 2001 and continuing to the present.

Walnut Gulch Kendall Grasslands (US-Wkg) is a small grassland watershed that was chosen because it has been intensively studied.

In addition to these three sites, the model is also being tested on the Canadian Turkey Point Agricultural site (CA-TPAg) to determine its effectiveness as representing crops.

Results

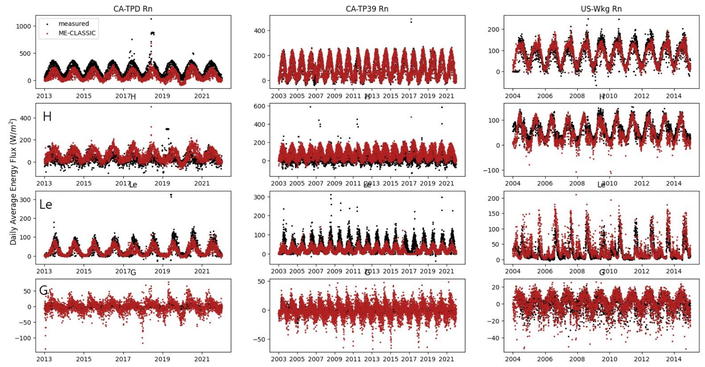


Figure 1: Time series showing measured net radiation compared to the simulated sum of energy fluxes (top row), and comparing the measured and simulated heat fluxes (sensible heat, H, latent heat, Le, and ground heat, G) for each of the three sites.

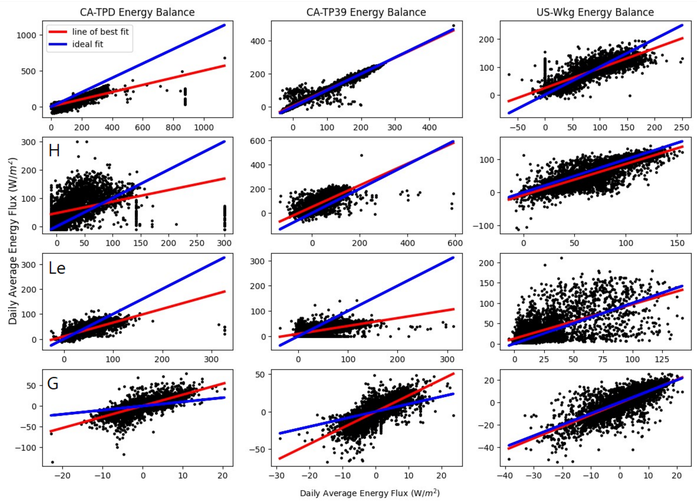


Figure 2: Comparison between measured net radiation and simulated sum of energy fluxes (top row), and comparing the measured and simulated heat fluxes (sensible heat, H, latent heat, Le, and ground heat, G) for each of the three sites.

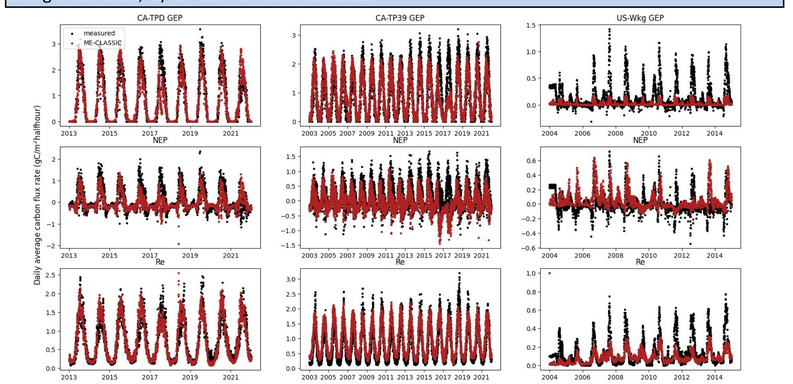


Figure 3: Carbon flux time series showing measured vs simulated GEP (top row), NEP (middle row), and RE (bottom row) for each of the three sites

Early results show that the model does a reasonable job at representing the carbon and energy fluxes at each of the three sites, with some notable areas for improvement.

The first being the underestimation of GEP for the US-Wkg, which is possibly due to improper parameterization, and possible due to improper representation of Vcmax.

The second notable area of improvement is the underestimation of Le at CA-TP. Due to the additional variation between observed net radiation and simulated sum of energy fluxes at CA-TPD, it's possible this issue may stem from radiation not being passed correctly between MESH and CLASSIC and will be investigated further.

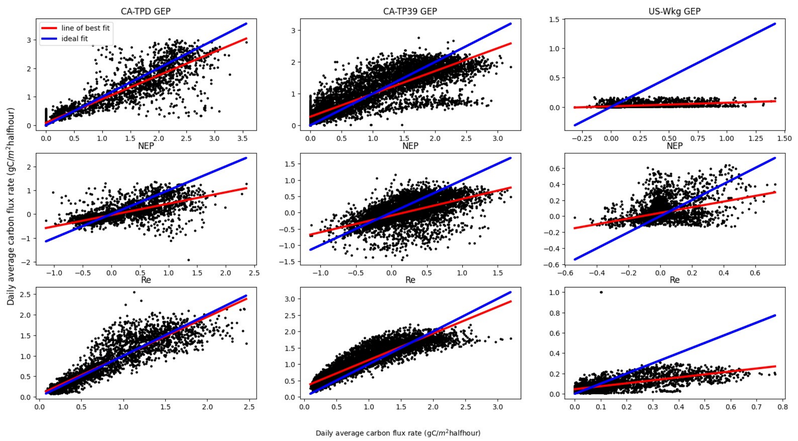


Figure 4: Comparison between measured net radiation and simulated sum of energy fluxes (top row), and comparing the measured and simulated heat fluxes (sensible heat, H, latent heat, Le, and ground heat, G) for each of the three sites.

Future Research Objectives

With the model being successfully coupled, there are a few immediate research objectives. These include:

1. Test model's ability to properly represent each PFT
2. Run model at multiple catchments across Canada
3. Improve model's ability to represent infestation
4. Investigate the impact different forest management schemes have on carbon cycling

Conclusions

Early results from ME-CLASSIC show promising results accurately simulating energy and biogeochemical fluxes at the three different PFT's studied so far. The next steps are to improve the areas of weakness identified, and apply the model at the catchment scale to test its distributed functionality.

Revisiting the Saguenay 1996 flood and analysis of added value from convection-permitting regional climate model

Soumik Ghosh[1,2*], Philippe Lucas-Picher[1,2], Philippe Roy[3], Philippe Gachon[1,2,4], Alejandro Di Luca[1,2]

Email: soumik.ghosh@fulbrightmail.org; ghosh.soumik@uqam.ca

1. Centre for the Study and Simulation of Regional-Scale Climate (ESCER Centre), University of Quebec in Montreal (UQAM), Montreal, QC, Canada
2. Department of Earth and Atmospheric Sciences, University of Quebec in Montreal (UQAM), Montreal, QC, Canada
3. Institut de Recherche d'Hydro-Québec, Montreal,QC, Canada.
4. Department of Geography, University of Quebec in Montreal (UQAM), Montréal, QC, Canada

Motivation :

30 years ago ...	Recent days ...
Coarse resolution weather forecast ...	Kilometer scale simulation at 12 and 2.5km ...
Approx. 30km or coarser ...	Enhanced abilities to simulate extreme rainfall ...
Lack of rainfall stations ...	Relevant for future study on the impact of climate change-induced extreme events on Hydro-Quebec and mining infrastructure.
Low ability in simulating the extreme rainfall ..	

Objectives :

- Identifying a suitable model configuration to simulate extreme rainfall cases using CRCM6/GEM5.
- Assessing the added value of 2.5km resolution in contrast with 12km resolution.
- Assessing model efficiency using spectral nudging.
- Impact of soil moisture conditions on reproducing the extreme rainfall.

Domain :

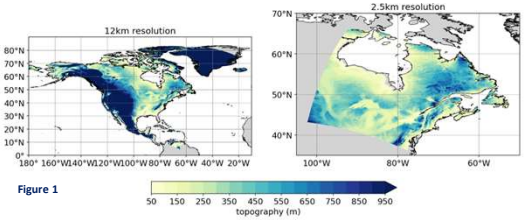


Figure 1

Challenges :

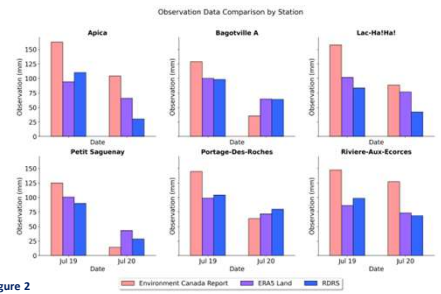


Figure 2

- Lack of Observed and reliable reanalysis datasets.
- Available datasets either in coarse resolution or not available for 1996.

Modeling Framework :

Model :
GEM5-UQAM v5.1.1

Resolutions :
12km & 2.5km

Techniques :
Without spectral nudging & With spectral nudging (U and V)

Parameterization :
With (KFC) & Without

Initial and lateral boundary atmospheric conditions :
ERA5

Surface condition :
ERA5 & CRCM6/GEM5 surface

Experiments setup :

	Resolution	Initiation date	End date	Spectral Nudging	Parameterization (deep convection)	Surface condition
12km	12km	18 Jul	22 Jul	No	Yes	ERA5
	12km	18 Jul	22 Jul	Yes	Yes	ERA5
2.5km	2.5km	18 Jul	22 Jul	No	No	ERA5
	2.5km	18 Jul	22 Jul	Yes	No	ERA5
	2.5km	18 Jul	22 Jul	No	No	UAA
	2.5km	18 Jul	22 Jul	Yes	No	UAA
	2.5km	18 Jul	22 Jul	No	Yes	ERA5
	2.5km	18 Jul	22 Jul	Yes	Yes	ERA5
	2.5km	18 Jul	22 Jul	No	Yes	UAA
	2.5km	18 Jul	22 Jul	Yes	Yes	UAA

References :

Environment Canada Report (1997) Pluies diluviennes du 18 au 21 juillet 1996, au Québec. Ministre des Approvisionnements et Services Canada, 1997. No de catalogue: En56-122/2-1997F. ISBN 0-660-95675-6

Results & Discussion :

Daily accumulated rainfall (mm/day)
[Days count starts from 9 AM to the following day at 8 AM]

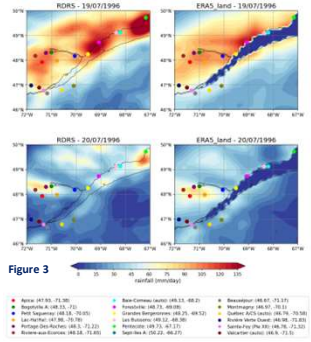


Figure 3

12km Simulations — Deep Conv Parameterization: Yes

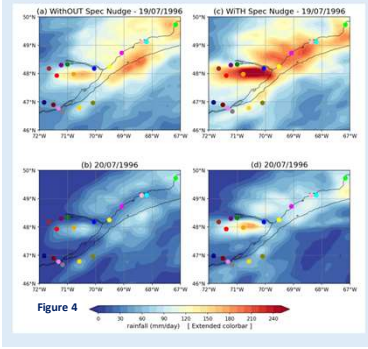


Figure 4

2.5km Simulations (with CRCM6/GEM5 surface) — Deep Conv Parameterization: Yes

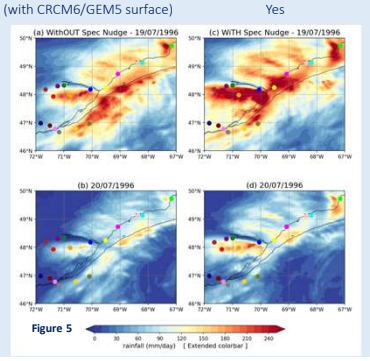


Figure 5

Observed daily spatial pattern during peak extreme days.
The rainfall intensity at the station is nearly half of the total reported by Environment Canada.

Simulations at both 12km and 2.5km resolutions, highlighting the added value in 2.5km resolution.
The 2.5km simulations closely follows the observed rainfall pattern than 12km simulations.
Daily rainfall at the stations aligns with the total reported by Environment Canada (Fig. 2).
Spectral Nudging at the 2.5km resolution effectively captures intense rain band areas in the simulations.

Presents hourly rainfall distribution over different stations of the Saguenay regions.
Rainfall distribution are mostly below 10mm/hr.
Can't verify rainfall over Petit Saguenay; no data from Environment Canada.

Probability Distribution Function (PDF) over two stations.
Light Red is <=25 percentile. Light Green is >=75 percentile. Red dashed curve is Gaussian fit at 95% confidence level.

Closely follows the accumulated rainfall pattern of Environment Canada Report.
ERA5-Land and the RDRS underestimate the rainfall compared with Env. Canada Report.

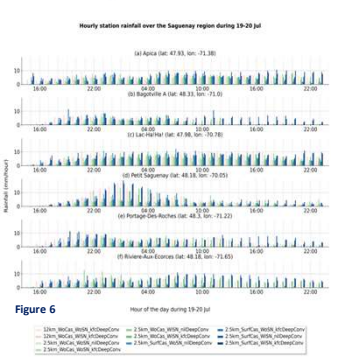


Figure 6

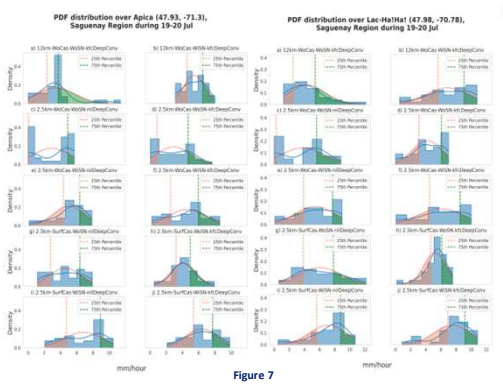


Figure 7

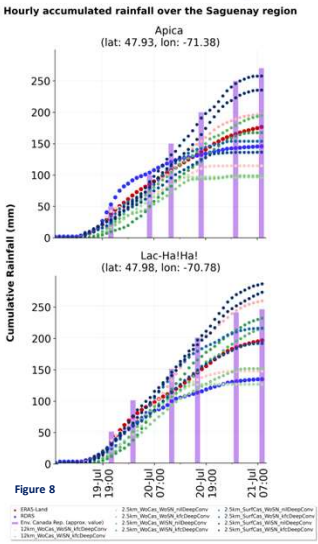


Figure 8

Conclusions:

- Reproducing an extreme event using the model is very challenging.
- Added value on 2.5km resolutions is quite impressive compared to the 12km resolutions.
- Spectral Nudging leads to more accurate simulations.
- Model is very sensitive with the surface modification.
- Challenges in finding a reliable reference is another limit.

Deriving Gridded Ocean Surface Currents from Observed Drifting Buoys to Evaluate GLORYS12 on the Newfoundland and Labrador Shelf

Jennifer Holden (Jennifer.Holden@dfo-mpo.gc.ca), Heather J. Andres, and Nancy Soontiens

2024 CMOS Congress
Session 9010, June 5, 2024
Abstract 12036

Problem Statement

Problem:

- Evaluating ocean model velocities using measurements obtained from drifting buoys is challenging due to differences between Eulerian and Lagrangian perspectives.
- Uncertainty about the most effective method for making this comparison exists (e.g., Coquereau and Foukal[1]).

Objective:

- Introduce a novel method for gridding observed drifter velocities that calculates effective values based on the straight-line distance and time between drifter entry and exit points within model grid cells.
- Bypass sub-grid drifter movements to enhance the validation of ocean models using observed drifter measurements.

Reference: 1. Coquereau, A., & Foukal, P., (2023). Ocean Sci., https://doi.org/10.5194/os-19-1393-2023

Data

To validate the method, we applied it to SVP drifting buoys[2] (right) off the Newfoundland and Labrador Shelf from 2002-2020 (left) and compared the observed velocities to gridded model output from the GLORYS12 ocean model.

SVP Drifters

CMEMS Drifter Trajectories:

- 254 Surface Velocity Program (SVP, 15m drogued) drifters from Copernicus Marine Service (CMEMS) Global ocean in-situ near real-time observations of ocean currents data product.
- Trajectories trimmed to a polygon covering the NL and Lab shelf up to the 1000m bathymetric contour.

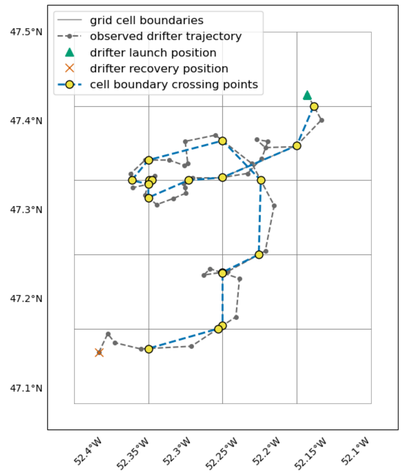
GLORYS12

GLORYS12 Surface currents:

- Copernicus Marine Service daily mean GLORYS12V1 global ocean eddy-resolving reanalysis product.
- Global ocean outputs are displayed on a standard regular grid at 1/12° (approximatively 8 km).

Reference: 2. Global Drifter Program. (n.d.). Surface Velocity Program (SVP). Scripps Institution of Oceanography. Retrieved May 22, 2024, from https://gdp.ucsd.edu/ldl/svp/

Gridding Method

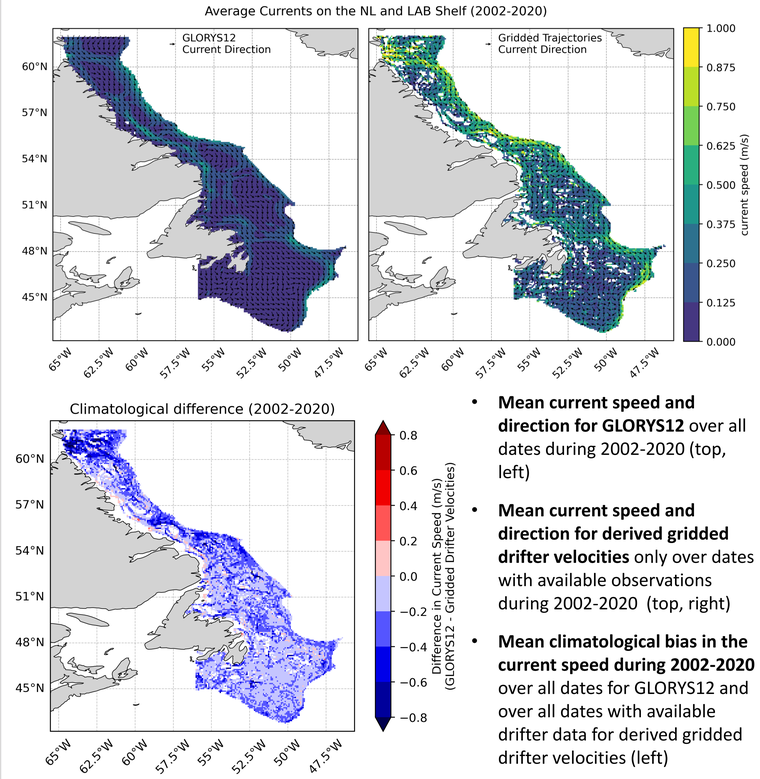


1. **Define a reference grid** covering the entire experiment area. Here, the reference grid resolution was defined to match the GLORYS12 grid.
2. Working on one drifter at a time, **divide the track into segments** where there are time gaps longer than 3h. Select only those reference grid cells that the track passes through for future calculations.
3. **Identify drifter entry and exit points** for all reference grid cells a given track segment passes through. Determine the time at each of these crossing points using the fraction of the distance elapsed between the previous and next track data points.
4. **Identify the straight-line segment connecting each pair of successive crossing points** and determine the midpoint time between crossing points, total time in the cell, total distance travelled in the cell, and the magnitude and direction of the line segment total velocity vector.
5. **Assign each of these calculated values to the midpoint of the reference cell being crossed**. In the case where two successive crossing points occur on the same reference cell edge, the calculated values are assigned to the midpoints of both adjoining reference cells.
6. **Write the gridded values for all segments of a single drifter track to a NetCDF file.** The data is now ready to be compared to GLORYS12 gridded values.

Implications and Future Work

- **Derived effective velocities accurately capture large-scale circulation features**, providing confidence in their use for validating ocean model currents on the Newfoundland and Labrador shelf.
- **GLORYS12 underestimates current magnitudes when compared to the derived effective velocities**. Further study is needed to determine if this discrepancy is due to a selection bias from more drifter positions recorded during summer and fall, compared to GLORYS12 annual averages, which include data from all dates.
- **Further exploration is needed on the effects of spatial and temporal resolution** on both the metrics and the method's ability to capture small-scale features (e.g., eddies).
- Future work will compare the derived effective velocities to those determined using alternate gridding methods as well as extend the methodology to additional drifter types and ocean model configurations

Gridded Comparisons



- **Mean current speed and direction for GLORYS12** over all dates during 2002-2020 (top, left)
- **Mean current speed and direction for derived gridded drifter velocities** only over dates with available observations during 2002-2020 (top, right)
- **Mean climatological bias in the current speed during 2002-2020** over all dates for GLORYS12 and over all dates with available drifter data for derived gridded drifter velocities (left)

Grid Resolution Sensitivity: Preliminary Results

- Repeated analysis process using multiple lower resolution reference grids to explore the sensitivity of metrics to spatial resolution.
- As expected, RMSE of comparisons decrease with decreasing grid resolution due to the increasing ability of GLORYS12 to resolve features on the comparison grid scales.

	Root Mean Squared Error		
Grid Resolution	Magnitude (m/s)	Eastward Velocity (m/s)	Northward Velocity (m/s)
1/12° (original grid)	0.27	0.17	0.17
1/6° (original grid coarsened by factor of 2)	0.23	0.14	0.14
1/3° (original grid coarsened by factor of 4)	0.20	0.11	0.12

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Pêches et Océans Canada
Canada