NSERC CREATE QCS Summer School 2026 Abstracts

July 20–24, 2026 | University of Waterloo

The second annual summer school of the NSERC CREATE program *"Training for novel directions in quantitative climate science"* (QCS) was hosted at the University of Waterloo during the week of July 20–24, 2026. Herein is the collection of abstracts of talks delivered by invited guest lecturers and QCS co-PIs, and of posters and presentations from the student participants.

We acknowledge the support of the Natural Sciences and Engineering Research Council of Canada (NSERC).

1 INVITED SPEAKERS

1.1 From Navier–Stokes to Neural Networks: Data-Driven Weather Forecasting

Dr. Christopher Subich
Meteorological Research Division, Environment and Climate Change Canada (Dorval, QC)

Numerical weather prediction (NWP) stands as one of the most successful applications of computational fluid dynamics in human history, shaping the development of supercomputing from its infancy. Historically, progress in atmospheric modeling has been driven by a virtuous triplet: advancing computational power, deeper physical understanding of atmospheric processes, and denser global observation networks.

A major byproduct of this classical era is the creation of consistent, high-quality, multi-decadal gridded reanalysis datasets which serve as the "ground truth" for both evaluations and data-driven algorithms. These data-driven algorithms have sparked a profound shift in the meteorological community, as they are increasingly capable of producing highly skillful forecasts with a fraction of the runtime cost required for traditional "physics-based" and PDE-driven prediction systems.

This lecture explores the transition from physics-driven to data-driven weather forecasting. We will examine how generic machine learning architectures such as Graph Neural Networks, Transformers, and Neural Operators view weather as a massive, high-dimensional next-frame prediction problem. We will also address the unique scientific and mathematical challenges at the frontier of AI-NWP: modeling chaotic uncertainty in an ensemble framework, correcting the smoothing behavior imposed by standard loss functions, hybridizing AI with traditional dynamical cores via spectral nudging, and the long-term limits of learning directly from sparse observations.

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1.2 Portfolio options in an overshoot scenario: A systems-view

Prof. Juan Moreno-Cruz
School of Environment, Enterprise and Development (SEED), University of Waterloo

In this talk, Prof. Moreno-Cruz will discuss:

- CDR in the context of climate overshoot.
- Talk about carbon in the climate cycle, and present some options including mitigation, CDR, solar radiation, and adaptation.
- Will look at different policies as portfolios, and explore risks associated with each and unintended outcomes.

1.3 Energy cascades and interactions across scales in atmospheric turbulence

Prof. Mike Waite
Department of Applied Mathematics, University of Waterloo

The turbulent fluid motions of the atmosphere involve interactions of eddies and waves across an incredible range of length scales, from planetary down to millimetre scales. These interactions involve eddies in geostrophic and hydrostatic balance at large scales, where the Coriolis effect and density stratification are strong, and isotropic three-dimensional turbulence at small scales, which is too fast to feel rotation and stratification. The mesoscale, from scales of kilometres to hundreds of kilometres, is between these extremes. Interactions between such a wide range of length scales present a challenge for both theory and numerical simulation. However, under certain conditions, order emerges from this myriad of interactions in the idea of a turbulent inertial range, which underlies classical theories of quasi-geostrophic (QG) turbulence and three-dimensional isotropic turbulence. These theories account for observed characteristics of atmospheric turbulence at very large and very small scales. However, turbulence in the mesoscale remains an open problem. Too small for QG turbulence and too large for isotropic turbulence, the mystery of mesoscale interactions has motivated research on stratified and rotating-stratified turbulence over the last few decades. This talk will give an overview of the history and fluid mechanics of the mesoscale cascade problem and discuss some recent progress in this area.

2 CO-PI & COORDINATOR SPEAKERS

2.1 Short-lived Climate Forcers: A Hazy Climate Physics Problem with Bright Spots

Prof. Paul Kushner
Department of Physics, University of Toronto

Global warming from anthropogenic greenhouse gas emissions presents by far the clearest signal of human influence on climate. But on top of greenhouse warming and its many impacts, anthropogenic and natural short-lived climate forcers (SLCFs) drive their own important and complex climate-change signals. SLCFs include atmospheric aerosol particulates (sulphate haze, dust, sea-salt) and reactive chemical species (methane, ozone, nitrogen oxides, etc.) that have lifetimes and mixing length scales orders of magnitude shorter than carbon-dioxide and other greenhouse gases. Their chemical reactivity, their interactions with solar-terrestrial EM radiation, their role in precipitation and cloud dynamics, and their spatial and temporal heterogeneity present a grand theoretical and modelling challenge. But research on SLCFs has advanced rapidly, which has allowed for key insights to emerge. I'll survey work showing how the recent cleanup in aerosol pollution from East

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Asia has caused some global warming; what we can learn from a clean comparison between simple and complex numerical aerosol schemes; and the unexpected and disturbing short- and long-term climate impacts of fires ignited by a hypothetical nuclear war scenario.

2.2 The making (and modelling) of a thunderstorm

Prof. Dan Kirshbaum
Department of Atmospheric and Oceanic Sciences, McGill University

Thunderstorms represent an essential component of midlatitude and tropical climates, providing rainfall for the survival of plants and animals. However, they also commonly lead to flash-flooding and other hydro-meteorological hazards (lightning, hail, and damaging winds) during the Canadian summer, and their uneven spatial coverage can lead to localized droughts. Moreover, their dynamics are extremely nonlinear and chaotic, making them difficult to understand and predict. These challenges render the study of thunderstorms an important unresolved problem with major implications for science and society. In this presentation, the dynamical behaviour of thunderstorms is covered from different perspectives. The basic thermodynamic and kinematic ingredients for these storms to develop are first reviewed, followed by exposition of the physical processes that complicate this picture and demand further research. The latter include, but are not limited to, cloud entrainment, detrainment, pressure perturbations, and environmental sensitivities. Next, the requirements and challenges for numerically simulating thunderstorms are described, including the importance of model grid spacing, advection, subgrid parameterizations, and ensemble forecasting. Finally, a (relatively) simple 1D model for thunderstorms is described and compared to the results of corresponding large-eddy simulations. Although the 1D model does not perfectly match the simulated results, it highlights the various interacting processes controlling thunderstorms and the areas in which the modern understanding remains incomplete.

2.3 Transmission of Atmospheric Internal Gravity Wave Packets across Retrograde Jets

Dr. Alain Gervais
Department of Applied Mathematics, University of Waterloo

Internal gravity waves (IGWs) propagate horizontally and vertically within stably stratified fluids, in which the background mass density decreases with height. IGWs typically exist as *packets* – spatially localized groups of waves that travel together. If their amplitude is sufficiently large, IGW packets induce an order amplitude-squared mean flow that accelerates the fluid in the vicinity of the waves, leading to amplitude growth which can result in wave overturning, turbulent wave breaking, and an irreversible deposition of momentum to the ambient fluid. IGWs are an important mechanism for transporting energy and momentum in the atmosphere. If upward-propagating waves are incident upon a retrograde background wind jet, linear theory predicts that the waves can partially transmit through the jet. The amplitude of the transmitted waves grows exponentially with height due to anelastic effects, inducing a mean flow that ultimately drives the waves to break turbulently. In this talk, I will describe three-dimensional atmospheric IGW packets and their wave-induced mean flow, and define a transmission coefficient based on pseudomomentum. Using fully nonlinear numerical simulations, I will quantify wave packet transmission across retrograde jets modelling the eastward and westward phases of the Quasi-Biennial Oscillation. I will assess the extent to which the wave-induced mean flow enhances pseudomomentum transmission compared to the predictions of linear theory.

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3 STUDENT POSTERS

3.1 Frontogenesis and frontal arrest in the submesoscale mixed layer

Erin Atkinson, Prof. Nicolas Grisouard
Department of Physics, University of Toronto

Ocean fronts play a key role in the vertical transport of heat, energy and biogeochemical tracers, but their behaviour and life cycle is not well-understood, especially at smaller scales. We present a large-eddy simulation of mixed layer frontogenesis capturing the onset of a submesoscale regime from a larger scale, rotation-dominated front. Frontogenesis shifts the balance between vertical mixing and restratification driven by frontal ageostrophic secondary circulation and the final state is a combination of a small, turbulent arrested region and the restratified remainder of the front, which sits above an unmixed, stable region. The transition to this state is marked by the appearance of down-front symmetric cells, which coalesce to form a circulation that entrains fluid from the mixed layer base. Increased vertical mixing causes arrest at a larger scale due to the shear dispersion originating from the vertically sheared secondary circulation.

3.2 Stratified Shear Instabilities in Cold Water

Khush Bhavsar, Prof. Marek Stastna
Department of Applied Mathematics, University of Waterloo

No abstract was received by publication time. The following abstract was generated by Microsoft Copilot: Under ice-covered winter conditions, small and medium-sized lakes in Canada exhibit inverse thermal stratification, with colder, less dense water overlying warmer, denser water. In the absence of wind forcing and with reduced solar input, stratified shear instabilities become a dominant mechanism governing mixing and transport. This work investigates the development of asymmetric Holmboe instability (AHI) in cold water, a phenomenon arising from the interaction of shear and density stratification under a nonlinear equation of state. Using direct numerical simulations in a laboratory-scale configuration, we examine how the amplitude of the initial velocity perturbation influences instability growth and vortex dynamics. Four perturbation amplitudes are considered, and their effects are quantified through the temporal evolution and spatial distribution of enstrophy. Results show that perturbation amplitude strongly affects the timing, intensity, and structure of the instability. Lower-amplitude perturbations produce more localized regions of intense vorticity and delayed peak enstrophy, whereas larger perturbations result in more distributed vorticity and reduced peak rotational energy. These findings highlight the sensitivity of asymmetric Holmboe instability dynamics to initial conditions and provide insight into mixing processes in ice-covered lakes.

3.3 The Impacts of Ocean-Atmosphere Coupling

Jakob Braga, Prof. Francis Poulin, Prof. Michael Waite
Department of Applied Mathematics, University of Waterloo

Understanding the interaction between the atmosphere and ocean is crucial to modelling or predicting the dynamics of both systems. Observational studies and numerical simulations of atmospheric responses to ocean mesoscale fronts have found strong correlation between the sea surface temperature (SST) and near surface wind speeds, which is interpreted as the SST driving the atmosphere at these scales. Furthermore, studies have shown that SST fronts are capable of modifying

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surface turbulent heat and momentum fluxes which can affect winds, clouds and rainfall, as well as have larger scale effects on storm tracks. These larger scale effects have been observed to feed back onto the ocean and further evolve the SST fronts, thus making the need to understand the fully coupled atmosphere-ocean system more significant. To investigate the specific influence coupling has on the evolution of both the atmosphere and ocean, idealized large eddy simulations are used to model an atmosphere and ocean initialized with an SST warm patch in the presence of weak winds over the course of 24 hours. For simplicity the SST warm patch is initialized to only vary in the zonal direction and winds are initialized to be uniform in space blowing in the zonal direction across the warm patch. Uncoupled systems are first considered followed by a comparison of the simulations coupled together. The coupling is found to have a small impact on the atmosphere over the short time scale, mainly affecting the turbulent kinetic energy, while there is a larger impact in the ocean with coupling causing large scale flow changes as well as greatly altering the turbulent kinetic energy distribution.

3.4 Mechanisms Driving Pit Lake Evolution

Alison Collins, Prof. Marek Stastna
Department of Applied Mathematics, University of Waterloo

The Faro Pit Lake (FPL) is a water reservoir in an abandoned mine complex located in Faro, Yukon. The FPL is surrounded by high embankments, which may impact the wind-induced mixing in the lake. Furthermore, these high embankments may limit the amount of direct solar heating the lake receives. To investigate the influence of these embankments, we use an elevation model for the site of interest, calculate the Sun's position as a function of time, and animate the results. We find that the lake itself does not receive much direct heating, suggesting that indirect heating from the surrounding waste rock will be important. Using this, we build a one-dimensional model for the heating in the surrounding waste rock. Some lake modelling was also done, including estimating the fraction of the lake that is sheltered from the wind. This research provides a foundation to build a more complex model of the FPL to gain additional understanding of its evolution.

3.5 Is there a slow-fast cross-talk in equatorial turbulence?

Akash Dutta, Prof. David Straub
Department of Atmospheric and Oceanic Sciences, McGill University

A linear mid-latitude f-plane Boussinesq problem supports geostrophic (steady) and inertio-gravity (fast) eigenmodes. The separation of timescales between these two kinds of dynamics motivates different higher-order treatments for each: in particular, the variation of f with latitude and the nonlinear interactions between the geostrophic modes are included in a description of a slowly evolving *quasi-geostrophic* (QG) flow, stripped bare of the signal of inertio-gravity waves (IGW). Importantly, the turbulent evolution of the QG flow cascade energy up to large scales, to be dissipated by friction, while the analogous IGW cascade takes energy to small scales where it is dissipated by viscosity. All of this theory is not *a priori* applicable at the equator where f vanishes. In this poster we discuss the equatorial shallow water modal decomposition, into slow Rossby waves, fast IGW and the *intermediate Yanai and Kelvin waves*. We propose a series of numerical experiments to isolate mechanisms of turbulent energy transfer between the slow and fast modes.

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3.6 Diagnosing Ocean Vertical Velocity from Surface Fields with ML

Hanfu Gong, Prof. Nicolas Grisouard
Department of Physics, University of Toronto

Submesoscale vertical velocity w is important for upper-ocean transport but difficult to observe directly. Building on He & Mahadevan (2024), we reimplement an idealized coastal-upwelling setup in Oceananigans and generate a 25-member ensemble spanning wind stress and stratification. Using the simulations, we train various neural models to diagnose subsurface w from surface fields u, v, and ρ, comparing U-Net, plain CNN, and HM-style patch CNN approaches. Current results show moderate slice-prediction skill and stronger patch-CNN performance, with skill highest near the surface and generally decreasing with depth. This framework tests how simulation design, architecture, and data splitting affect ML-based w diagnosis and provides heuristic evidence for promising results with more training.

3.7 Large-Eddy Simulation of Deep Orographic Convection in the Colorado East River Basin During SAIL

Jialin Liu[1], Prof. Daniel J. Kirshbaum[1], Ethan Gutmann[2]
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In the warm season, diurnal moist orographic convection frequently initiates over mountain ranges when sufficient atmospheric moisture, instability, and terrain-induced lifting are present. In some cases, the convective cells can become stationary or develop into severe thunderstorms, creating the potential for hazardous flash floods or landslides. However, due to the fine-scale variability of mountainous terrain and its land-use, and the nonlinear interactions between processes of various scales, the governing mechanism of this type of convection remains inadequately understood, especially over high-altitude complex terrain. In this study, the physical mechanisms of diurnal high-mountain deep convection initiation (DCI) are investigated by synthesizing high-resolution (horizontal grid spacing of around 100 m) real-case WRF simulations with observations from the recent SAIL field campaign (2021-2023), which took place in the East River Basin (ERB) of the Colorado Rockies. The investigation focuses on the case of July 2, 2022, in which diurnally-forced deep convection developed on both sides of the ERB. For this event, the simulation successfully captures the overall timing, location, and intensity of the convection; the diurnal variability of surface variables also agrees with available observations. Simulation results are then explored in detail to understand the triggering mechanisms of four DCI events around the ERB. Two DCI events are triggered by an increase in cloud-base updraft, one is due to valley flow convergence, whereas the other is due to a combination of cold-pool dynamics and thermally-driven orographic circulations. The other DCI events are associated with modifications of atmospheric profiles. In one case, this is achieved through a combination of PBL heating and mid-to-upper-level moistening and cooling, the latter associated with the evaporation of locally initiated clouds. For the fourth case, the same mid-to-upper-level preconditioning is found, but it is associated with the evaporation of deep convection upstream.

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3.8 A Characterization of Point-Scale CTSM Performance in the Canadian Arctic

Matthew Mast, Prof. Christopher Fletcher
Department of Geography and Environmental Management, University of Waterloo

Accelerated warming in the Arctic is actively driving changes in snow cover, permafrost, and terrestrial water storage. This project evaluates how well the Community Terrestrial Systems Model (CTSM) reproduces observed snow depth, soil moisture, and soil temperature at five Arctic sites. CTSM systematically underestimates snow depth relative to ERA5, while soil moisture comparisons are complicated by unreliable sensors in frozen conditions. Soil temperature shows the closest agreement between simulation and observation, though RMSE remains elevated in winter and spring. These results suggest CTSM shows promise for Arctic soil temperature simulation, while soil moisture validation will require more examination. Next steps include incorporating additional variables, testing higher-resolution runs, extending the simulation period, and validating against products such as GRACE terrestrial water storage estimates and bias corrected reanalysis.

3.9 Internal Waves with Rotation: Wall Localisation and Wakes

Fiacra McCluskey, Prof. Marek Stastna
Department of Applied Mathematics, University of Waterloo

Internal waves, here being underwater waves propagated by density differences, are studied most frequently in the open ocean, along coastlines, or on small scales, all of which allow the earth's rotation to be incorporated into a two-dimensional model. In this poster, we investigate internal waves with rotation in full three-dimensional simulations. This poster includes analysis of spanwise structure in the wave trail, shows the effects of increasing rotation strength, and uses three-dimensional graphics to show the stable wave at the end of the simulation.

3.10 Segmentation of SAR Imagery of River Ice in the St. Lawrence River Using Deep Learning

Liubov Poliakova, Prof. Andrea K. Scott
Department of Mechanical and Mechatronics Engineering, University of Waterloo

River ice governs winter flood risk through ice jams and threatens hydro-power intakes, bridges and navigation, while its timing is a sensitive climate indicator. Optical satellites fail precisely when monitoring is needed, since polar winters are dark and persistently cloudy. Synthetic-aperture radar is unaffected by darkness, cloud or snowfall, making Sentinel-1 C-band imagery a natural basis for operational ice mapping. We train a U-Net with an ImageNet-pretrained ResNet-18 encoder to predict per-pixel ice probability from three physically-motivated channels derived from dual-pol Sentinel-1 GRD: co-pol dB, cross-pol dB, and their difference. The dataset comprises 60 image-mask pairs spanning ten winters (2017–2026) over a $\sim$110 km reach of the St. Lawrence upstream of Montréal, hand-labelled from date-matched cloud-free Sentinel-2 imagery. Acquisitions are clustered by date and assigned whole to a single split, enforcing a $\geq$5-day gap so that near-repeat passes cannot leak across split boundaries. The model reaches 0.88 test mIoU (ice IoU 0.87, water IoU 0.90) on a held-out random split, correctly tracing open-water channels through ice from radar texture alone. Performance degrades under leave-one-winter-out evaluation (0.64–0.79 mIoU), and the dominant failure mode is wet ice: meltwater and wet snow make the surface smooth and radar-dark, so frozen basins are read as open water. Adding a static distance-to-shore channel and conditioning the U-Net bottleneck on ERA5 weather (temperature, freezing-degree-days, snow depth and snowfall) via FiLM recovers this case, raising ice recall from 0.48 to 0.95 on a spring 2019 thaw scene. Results indicate the approach is data-limited rather than capacity-limited.

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3.11 A surface mechanism for midlatitude extreme wind intensification

Lucas Prates, Prof. Paul Kushner, Michael Morris
Department of Physics, University of Toronto

Traditional Earth system models struggle to represent midlatitude wind extremes due to an inability to resolve their relevant mesoscale dynamics. With 7 km regional refinement, the variable-resolution version of the National Center for Atmospheric Research Community Earth System Model (VR-CESM) has been shown to skillfully resolve mesoscale turbulence, driving confidence in its projections of future extreme wind events. Previous work has shown that VR-CESM predicts an intensification of wind extremes in the Great Lakes region driven by boundary layer destabilization in a future with stronger land-to-atmosphere sensible heat fluxes. In this study, we use VR-CESM to assess the seasonality of extreme wind event events and their drivers in the Great Lakes region under present day and year-2090 RCP8.5 conditions. The model projects that the climate-change–forced increase to the intensity and frequency of cold-season extreme wind events in this region is dominated by a spring season signal. To first order, this process is caused by enhanced surface absorption of shortwave radiation in a future with greatly reduced spring-season snow cover, resulting in increased fluxes of sensible heat to the atmosphere. This mechanism drives the intensification of both typical and extreme winds via an intensification of the diurnal cycle in near-surface wind speeds.

3.12 Examining the Effects of Borehole Water Extraction on a Synthetic Glacier Model

Janos Rado[1], Prof. Christine F. Dow[2]
[1]*Department of Civial and Environmental Engineering, University of Waterloo,* [2]*Department of Geography and Environmental Management, University of Waterloo*

Accelerated glacier flow and related mass loss to the ocean is an increasing concern as greater volumes of meltwater enter subglacial drainage systems, potentially reducing friction between the ice and the glacier bed. Here, we examine whether borehole water extraction could reduce subglacial water pressure and influence glacier flow in a synthetic Antarctic-style glacier model. A synthetic glacier geometry was developed in the Ice-sheet and Sea-level System Model (ISSM), and the Glacier Drainage System model (GlaDS) was used to simulate distributed and channelized subglacial drainage. The hydrology model was run for 140 years to establish a steady-state baseline before testing different borehole locations, arrangements, extraction rates, and extraction patterns. The experiments showed that water extraction can reduce subglacial water pressure and increase effective pressure beneath the glacier, although limited to small regions of the glacier bed. Higher extraction rates produced stronger changes in effective pressure, distributed sheet thickness, and hydraulic potential, while the response generally weakened over time as the drainage system adjusted toward a new hydrological state. However, meaningful changes were observed only at very high extraction rates, and the cause of this interaction with the basal hydrology system is an ongoing investigation. The next stage of experiments involve coupled hydrology and -ice dynamics modeling to examine how these hydrological changes may affect glacier velocity.

3.13 Simulated Floats in ROMS to Guide BGC-Argo Sampling Strategies

Gaige Stopjik, Arnaud Laurent, Prof. Katja Fennel
Department of Oceanography, Dalhousie University

Dissolved oxygen concentration in the photic zone of the ocean displays diurnal cycles that are phase-locked with the day-night cycle. This signal can be measured by BGC-Argo floats:

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autonomous, sensor-heavy drifters that profile the upper 2,000 m of the ocean in 5- to 10-day intervals. Measurements of the daily cycle of dissolved oxygen have been used to estimate primary productivity in the ocean. However, thus far large numbers of BGC-Argo had to be aggregated. Open questions remain about the uncertainty of such estimates, the number of float profiles required to obtain a reliable estimate, and whether temporal and spatial variations in primary production can be constrained by this method. To address these questions, we evaluate float-estimated primary production within a simulated ocean environment by sampling the output of a biogeochemical model. We use an implementation of the Regional Ocean Modelling System (ROMS) for the northwest North Atlantic Ocean with added Lagrangian particles to mimic float trajectories. By comparing primary productivity estimates from simulated floats to the known primary productivity in the model, we will elucidate how sampling frequency and float density affect primary productivity estimates.

4 STUDENT GROUP PRESENTATIONS

The summer school student participants worked in groups throughout the week to develop a mock research proposal in an area of QCS where a real gap in research currently exists. Each group conducted background research on their chosen area; each member identified a concrete role on their mock research team based on their strengths; the groups proposed actionable research plans, timelines, intended outcomes, and budgets; and described the impact of the proposed research. Each group submitted a written proposal for evaluation by the co-PIs in attendance. The exercise culminated in a group presentation session on July 24, 2026, during which each group pitched their research project and answered audience questions. As part of this exercise, the students composed abstracts for the group presentations, which are included below.

4.1 From Static Maps to Future Risk: An Explainable Deep Learning Framework for Wildfire Susceptibility under Downscaled Climate Projections

Fiacra McCluskey[1], Liubov Poliakova[2], Lucas Prates[3], Tamar Gendler[1]
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Wildfires have potential for immense social, economic, and environment damage. In recent years, anthropogenic climate change has created favourable conditions for record-breaking Canadian wildfire seasons. It is therefore critical to understand the drivers of wildfire susceptibility across regions, and how these drivers may change in the future. Previous research has shown that neural networks are capable of skillfully identifying historical wildfire susceptibility based on topographic, land use, and meteorological indices. This study employed meteorological data from a variety of observational sources. We propose the development of a similar neural network, trained on high-resolution meteorological data derived from a regional climate model. This approach enables us to run our neural network with mid-century projected climate information, leading to a quantitative estimate of how regional wildfire susceptibility may evolve under different socioeconomic pathways. This research will be beneficial to parties interested in the future adaptability and preservation of regions at risk to wildfires.

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4.2 NSERC Discovery Grant application: Interdisciplinary numerical modelling of Jakobshavn deglaciation

Chichi Zhou[1], Janos Rado[2], Jialin Liu[3], Rosalie Cormier[1]
[1] *Department of Applied Mathematics, University of Waterloo,* [2] *Department of Civil and Environmental Engineering, University of Waterloo,* [3] *Department of Atmospheric and Oceanic Sciences, McGill University*

Jakobshavn Glacier, a large outlet glacier located in western Greenland, has been identified as Greenland's fastest-ablating glacier. Over the past several decades, Jakobshavn Glacier has experienced substantial mass loss, contributing to sea-level rise and broader changes in the global climate system. Understanding the mechanisms driving the retreat of Jakobshavn Glacier is therefore of interest in climate research. In particular, the effects of different wind patterns on glacier dynamics and the feedbacks between glacier melt and fjord conditions remain insufficiently understood. Although both atmospheric and oceanic forcing are known to influence its retreat, previous studies have often examined these influences separately, and within idealized configurations that cannot fully represent the glacier's relationships to its environment. This project proposes to numerically investigate the retreat of Jakobshavn Glacier by developing a coupled atmosphere-glacier-ocean modeling framework. The summer season will be the period of focus, when interactions among the three components are strengthened due to enhanced sea-ice mobility and increased surface melting. The research will examine how wind forcing affects the glacier's melting and retreat, how its meltwater modifies fjord conditions, and how these oceanic changes influence the glacier in turn. The results are expected to provide a more comprehensive understanding of the short-term evolution of Jakobshavn Glacier and to offer broader insights into glacier-climate feedbacks in the Arctic region.

4.3 Improving Initial Conditions for Ocean Biogeochemical Models: a Machine Learning Approach to Create a BGC-Argo-Based Reanalysis Field

Leonard Korreshi[1], Gaige Stopjik[2], Elena Prescott[3], Maksym Veremchuk[4]
[1] *Department of Applied Mathematics, University of Waterloo,* [2] *Department of Oceanography, Dalhousie University,* [3] *Department of Atmospheric and Oceanic Sciences, McGill University,* [4] *Department of Mechanical and Mechatronics Engineering, University of Waterloo*

Modeling the 3D distribution of chlorophyll is central to calculating primary productivity in the ocean, with applications in forecasting fish stocks and deepwater carbon deposition. Modern oceanography has both Sentinel-2 satellite remote sensing and BGC-Argo depth casting to create a detailed picture of chlorophyll distribution, on the surface and through vertical profiles. This proposal suggests coupling this data to ROMS, the regional ocean modeling system, and using data assimilation to incorporate the data and nudge model outputs towards observed values, creating a new reanalysis field for chlorophyll that can be used in downstream projects.

4.4 Using neural networks to develop a data-driven parameterization of small-scale turbulence for GCMs

Matthew Mast[1], Jakob Braga[2], Johnny Chen[3], Akash Dutta[4], Téa Fazio[2]
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Since the latter part of the twentieth century, scientists have made use of complex General Circulation Models (GCMs) for weather forecasting, comprehensive climate models, and mechanistic

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models of individual components of the climate system. While advancement in computing power over recent decades has greatly improved the resolution and accuracy of these models, there is still much to be desired in terms of longer term forecasting. A large area of potential improvement for these models can be found within how they calculate parameterizations for effects too small to be explicitly resolved. With the recent interest and development of neural networks for scientific computing we aim to use this technology to improve parameterizations within climate models. Our focus is to develop a suite of neural network parameterizations to improve NCAR's Community Earth System Model (CESM) which includes individual ground, ocean, and atmosphere models with the capability for them to be coupled together. Actionable items include: running long term high resolution simulations to generate accurate training data for a neural network, optimizing architecture and loss functions for the neural network, and finally implementation and integration of the neutral network within CESM.

4.5 Investigating the effects of submesoscale frontal dynamics on Sargassum

Erin Atkinson[1], Khush Bhavsar[2], Lucy Feng Keyes[1], Zarin Tasneem[2]
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The "great Atlantic Sargassum belt" – an annually recurring global-scale patch of macroalgae that first appeared in 2011 as a result of climate change – has been given considerable attention and concern as huge aggregations of Sargassum stranding onto coasts causes significant economic and biological challenges to communities bordering the Caribbean Sea and the Gulf of Mexico, though the resource may have commercial use if promptly harvested. Understanding the transport and accumulation of Sargassum is a vital part of climate adaptation for the affected countries. Sargassum population can be identified from satellite imagery, and this is combined with ocean models to determine likely locations of strandings. These models rely on understanding the interaction between Sargassum rafts and ocean currents. Though images of the ocean surface color can be high resolution, it is only with the advent of recent satellite missions where ocean currents at submesoscales (100 km>) and in near-coastal waters can be well-resolved remotely. We propose a study into the interaction between ocean surface currents at these smaller scales, using data from the NASA Surface Water and Ocean Topography mission and Sargassum populations derived from ocean color. We will evaluate remote sensing methods and compare the results to existing modelling techniques. As part of our data-gathering process, we will develop an online tool to visualize near-real-time data of coincident ocean current and Sargassum observations.

4.6 Improving Wildfire Modelling Through Deep Learning Methods

Alison Collins[1], Hanfu Gong[2], Madison McClernan[1], Callum Neilly[1], Meixin Zhou[3]
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The frequency and severity of extreme wildfires are increasing globally, resulting in concerning socioeconomic and public health consequences. While current models predict average fire behavior adequately, they struggle to forecast rapid, complex changes – such as explosive growth and spotting – due to insufficient resolution in capturing coupled interactions between terrain, turbulent winds, and atmospheric instability. To address this gap, this project proposes a novel, physics-informed machine learning framework that enhances wildfire modeling using Convolutional Neural Networks (CNNs).

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By combining idealized numerical simulations of wind-wildfire-terrain dynamics, satellite observations, and data assimilation, this research will train and benchmark CNN architectures to efficiently learn the spatial patterns governing fire propagation. The resulting models will be validated against comprehensive historical wildfire datasets to assess their accuracy. Ultimately, this project aims to deliver a robust and computationally efficient tool for operational wildfire analysis.

A AWARD WINNERS

Prizes were awarded to students in the following categories: *Best Poster*, as judged by QCS PhD students who participated in the 2025 Summer School (and who did not present a poster at the 2026 Summer School), together with the Program Coordinator; *Poster Award (People's Choice)*, by a majority vote of registered Summer School attendees on the day of the poster presentations; and, *Best Group Project*, by the QCS co-PIs in attendance. The monetary value of each prize was $250 per student, per award.

A.1 Best Poster Award: Lucas Prates

Awarded in recognition of the quality of the scientific content of their poster and their visual and oral presentation of this research during the Student Research Poster Session on July 24, 2026.

A.2 Poster Award (People's Choice): Lucas Prates

Awarded in recognition of the popular appeal of their poster and their visual and oral presentation of this research during the Student Research Poster Session on July 24, 2026.

A.3 Best Group Project: Group 2 and Group 5

Awarded in recognition of their project's feasibility, group skill identification, budget, scientific novelty and strength, as communicated through their written report prepared from July 20–22, and the group's visual and oral presentation of their project during the Student Project Presentation Session on July 24, 2026.

NSERC CRSNG
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