GLOBAL WATER FUTURES

3rd Annual Open Science Meeting

GWF2020

Compendium of Abstracts

Global Water Futures
GWF 2020

Themes

Climate-driven changes of water environments in cold regions

From anthropogenic pressures to ecosystem services

Innovations in water science and technology

Smart Great Lakes: a vision for future management, policy, and partnership	Kelli Paige	190
Solid state phosphate sensor with enhanced lower limit of detection using modified potentiometry	Vinay Patel	191
A DGT-supported aqueous Hg(II) biosensor for smart water quality monitoring	Kunfu Pi	192
An Auto-reconfigurable Wireless Sensor Network for Internet of Things based Water Quality Monitoring	Gazi Rahman	193
Detection of Lead in drinking water in a microwave sensor integrated microfluidic system	Zhe Ren	194
Long-term and continuous dissolved oxygen monitoring in agricultural soils: A field application of Multi Fiber Optode (MuFO) microsensor system	Fereidoun Rezanezhad	195
Developing next-generation data models for science/community integration	Colin Robertson	196
Lake Ice mapping from RADARSAT and MODIS with Deep Learning	Nastaran Saberi	197
Sensitivity of Hydrological Model Performance on the Selection of Calibration and Validation Periods	Hongren Shen	198
Estrogen composition of final effluent is influenced by the treatment processes used in various secondary municipal wastewater treatment plants in Ontario	Nivetha Srikanthan	199
Upscaling the fill-and-spill hydrological process in wetland dominated landscapes	Mahkameh Taheri	200
Significance of Groundwater Dynamics within Hydrologic Models	Xin Tong	202
The use of high-order time-stepping methods to improve the computational efficiency of hydrological models	Sean Trim	202
Estimating SWE using Unmanned Aerial Systems across an Arctic shrub-tundra watershed	Branden Walker	203
Landscape Controls on Thermokarst Lake Water Balances between Inuvik and Tuktoyaktuk, NWT	Evan J. Wilcox	204
Developments in a pan-Canadian operational ice-jam flood forecasting system	Brandon Williams	205
Positive feedback of biogeochemical models on hydrological models: Implicit hydrological optimization attained by optimizing a biogeochemical model	Befekadu Taddesse WOLDEGIORGIS	206
Zooplankton metabarcoding for assessment of aquatic ecosystem health	YUWEI XIE	207
Development of low-cost sensors with anti-fouling coatings for water monitoring	Nan Zhang	208
Snow Albedo Retrieval based on UAV-borne Hyperspectral data	Dong Zhao	209
An Unprecedented Hyperspectral Airborne Coverage of Western Lake Erie: First Testing of the Watersat Imaging Spectrometer Experiment (WISE) Imager	Kiana Zolfaghari	210

Knowledge co-creation with Indigenous communities

Country Foods and Health Promotion in the Inuvialuit Settlement Region, NT.	Sonja K. Ostertag	231
Bioaccessibility of Mercury in the Muscle of Three Freshwater Fish Species in the Northwest Territories, Canada	Sara Packull-McCormick	232
Using Social Media to Enhance Community Engagement in Environmental Research	Alanna Robbins	233
re:mote – Low-cost Software and Hardware Infrastructure for Water Quality Sensing in Indigenous Communities	Emil Sekerinski	234
Exploring disaster risk reduction using fuzzy cognitive mapping approach: the case of local flooding in Mistawasis Nêhiyawak	Anuja Thapa	235
Building Relationships: Lessons from a Western science facility located in First Nations territory	Dilber Yunus	236

Turning research into policy and management solutions

Title (Click to view abstract)	Main Author	Page
How does water quality affect people's recreation behavior and welfare in Alberta?	Nasim Aminikhezri	237
Spatially Explicit Modeling of Wetland Conservation Costs in Canadian Agricultural Landscapes	Eric Asare	238
Does the community composition of algae and bacteria predict levels of omega-3 fatty acids in subarctic populations of Northern Pike, Esox lucius?	Tara Boag	239
Global flood risk modeling with climate models and machine learning	Mathieu Boudreault	240
Small wetlands as hotspots of nutrient removal	Frederick Cheng	241
Measuring the Role of Place Attachment in a Labelled Discrete Choice Experiment of River Restoration in Beijing, China	Dan Dai	242
Data Management In Action: A Toolkit to Aid Researchers in Building Valuable Datasets	Krysha Dukacz	243
Development of An Integrated Hydro-Economic Modelling Framework for Efficient and Sustainable Water Allocation in the Saskatchewan River Basin	Leila Eamen	244
Importance of Assessing snowpack water equivalent in a subarctic catchment producing hydroelectricity	Michael English	245
The Role of Natural Resources Canada (NRCan) in the Advancement and Innovation of Canada's Water Sciences	Marc-André Faucher	247
Intersectorial research: the role of the Intersectorial Flood Network of Québec in linking natural and health sciences	Philippe Gachon	248
Provincial Scale Flood and Steep Creek Assessments - Successes and Challenges	Kris Holm	249

A monitoring-management framework considerate of cumulative effects for the lower Grand River and nearshore Lake Erie	Elaine Ho	250
Do collaborative water governance approaches accommodate immigrants? A systematic review	Bereket Negasi Isaac	251
Using Fuzzy Cognitive Mapping to Explore Manageable Drivers of Key Lake Erie Eutrophication Indicators	Jessica T. Ives	252
Incentivizing BMP Adoption: Predicting Future Implementation by Examining Past Participation and Experiences	Haiyan Liu	253
Checkered Landscapes: Uncovering the Drivers of Legacy Nitrogen Accumulation in a Mixed-Use Watershed	Joy Liu	254
Right People, Right Resources, and Right Plan: small community's response to forest fires and flooding	Brent McKnight	255
Addressing Climate Risks in the Boreal Forest: Fire and flood understood through the lens of cultural trauma	Jeffrey McLean	256
Addressing Drivers of Eutrophication in the Western Lake Erie Basin: Reflecting on Nutrient Management Efforts in Canada and the United States	Erin Murphy-Mills	258
A Comprehensive Monitoring and Evaluation Framework for Water Resources Management Policy in the face of deep Uncertainty: A Systems Thinking Perspective	Sandile Ngcamphalala	259
Differing soil conditions with landscape position affects soil P form and risk of P loss in agricultural fields of Manitoba Prairies and Lower Great Lakes region	Janina Plach	260
Climate Change at the Field-Scale: Comparing Projections and Observations Across Regions	Will Pluer	261
Economic value of lake water quality improvements in Ontario	Rashadur Rahman	262
Extreme Weather Impacts on the Infrastructure Development Sector	Muhammad Rizwan	263
Water-Associated Disease Index (WADI) expansion: A rapid review and landscape analysis	Eunice A. Salubi	264
Development of an operational simulation tool for Prairie water management	Kevin Shook	265
Creating a Site-Specific Practitioner Tool for Implementing Source Water Protection	Hugh Simpson	266
A transdisciplinary approach to reducing eutrophication and harmful algal blooms	Danielle Spence	267
The Role of Global Water Futures in Advancing Canada's Research Data Management Ecosystem	Michael Steeleworthy	268
Tile Drainage in Vertisolic Soils of near-level Southern Manitoban Landscapes – Implications on Runoff and Water Quality	Kokulan Vivekananthan	269
Assessing impacts of current and novel wildfire management techniques in black spruce dominated peatlands	Sophie Wilkinson	270
Assessing the Impact of Payments for Watershed Services on Xin'an River's Water Quality Using the Synthetic Control Method	Qingmin Zeng	271

Autofluorescence monitoring of cyanobacterial cells for early warning based on microflow cytometry	Yushan Zhang	272

Abstracts with no specified theme

Title (Click to view abstract)	Main Author	Page
The influence of warming and drought in soil CO2 flux in a temperate coniferous and deciduous forest ecosystem	Yueqian (David) Ma	273
How to Use Compute Canada	Stephen O'Hearn	274
Incorporating hillslope-scale subsurface flow in watershed models: an upscaling approach	Mark Ranjram	275

Title: Hydrologic-land surface modelling of sporadic permafrost: A case study of Jean Marie River watershed

Authors:
Mohamed Abdelhamed, University of Saskatchewan
Mohamed Elshamy, University of Saskatchewan
Saman Razavi, University of Saskatchewan
Howard Wheater, University of Saskatchewan

***Correspondence:** mohamed.abdelhamed@usask.ca

Keywords:
Permafrost, land surface modelling, Jean Marie River, MESH, initialization

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
One-quarter of the northern hemisphere land is underlain by permafrost, which plays an important but complex role in the climatic and hydrologic systems of the Earth on local and regional scales. As a result of climate warming, permafrost thaw has been detected in mid to high latitudes (e.g., in the Alps and Tibetan Plateau). Further, permafrost thaw is expected to be exacerbated throughout the 21st century in response to the continued climate warming and other related drivers (e.g., wildfires). Thawing of permafrost has a complex and substantial impact on surface and subsurface hydrologic routing, streamflow seasonality, surface and subsurface storage, geotechnical failures, and carbon dioxide and methane releases. In this study, Environment and Climate Change Canada's Modélisation Environmentale Surface et Hydrologie (MESH) model is utilized to explore future scenarios of change. Its physically-based water and energy balance simulation includes explicit representation of key cold region processes. MESH couples the Canadian Land Surface Scheme (CLASS) and hydrologic routing based on the WATFLOOD model. However, configuring such a complex model (i.e., MESH) is a challenging task. The large number of degrees of freedom, soil layering, initialization of state variables (e.g., liquid and frozen soil moisture) and spin-up strategies are among the challenges that affect the appropriate representation of permafrost state and can introduce simulation bias. The purpose of this study is to examine the impact of model state variable initialization in the sporadic permafrost region (i.e., 10%-50% spatial extent) on the simulation of permafrost characteristics. The Jean Marie River (JMR) watershed was selected as it has a long soil temperature record (1986-2000) down to 10 m. The simulation extends from 1981-2016. The study assesses the ability of a multi-cycle single-year spin-up approach under different initialization conditions (i.e., various ice-content) to replicate the present-climate permafrost characteristics of the JMR. Results show improved estimates of permafrost characteristics when the frozen soil moisture is considered in the model initialization. The study also underscores the significance of state variable initialization (i.e., frozen soil moisture) on producing a realistic representation of permafrost that influences streamflow seasonality and flux partitioning.

Title: Changes in agroclimatic indices over western Canada by the end of the 21st century based on convection permitting modeling

Authors:
Richard Yao Agyeman, University of Saskatchewan
Yanping Li, University of Saskatchewan
Fei Huo, University of Saskatchewan

***Correspondence:** r.agyeman@usask.ca

Keywords:
agroclimatic indices, precipitation, convection-permitting, climate change, growing season

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Understanding the changes and regional differences in growing season conditions by the end of the century will be crucial to agriculture especially over semi-arid regions like western Canada. Future trends and variability in agroclimatic indices and how patterns of growing season precipitation will change under future climate over Western Canada are investigated. Using simulations from convective permitting scale Weather Research and Forecasting model (WRF) with 4km spatial resolution for the end of 21 century under RCP8.5, the effect of changing climate on the growing season is examined together with the constraints and the opportunities to agriculture. High-resolution simulations provides better delineation of future changes in climate, especially those associated with extreme precipitation and temperature events, which in turn result to better representation of agroclimatic information for the agricultural sector of the economy. The results show that the contracting growing season length over a few areas may be counterbalanced by optimum growing degree days as a result of warming.

Title: Regression modeling of land cover change in a lowland ecosystem of the Northwest Territories (NWT)

Authors:
Shaghayegh Akbarpour, University of Waterloo

***Correspondence:** s2akbarp@uwaterloo.ca

Keywords:
land cover modeling, North west, regression prediction, land surface temperature

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The dramatic transformation of land-cover caused by permafrost thaw is modifying the hydrological and ecological characteristics of the lowland discontinuous permafrost regions such as that found at the Scotty Creek Research Station (SCRS). Permafrost thaw is changing the pattern of distribution and extent of the three main landforms types (peat plateaus, bogs, and fens) in the SCRS. To understand the future spatiotemporal evolution of land-cover in the SCRS, it is desirable to be able model the pattern and rate of conversion from each land type to other landforms.
To estimate the probability of transformation in each landform type, we here apply a regression model informed by a set of observable spatial variables affecting the probability of conversion from one type of land cover to others. Selection of independent predictors of land-type changes in SCRS was dependent upon the availability of data, the strength of relationships between probability of change in each land type and the known drivers of lateral permafrost thaw. A multinomial regression model is devised by using the estimated summertime Land surface temperature (LST) and both Euclidean distance and transition cost distance to land cover interfaces to estimate the correlation between the rate of evolution in each land-type and the selected variables. The data for calculating spring/summer LST as an independent variable is derived from Google Earth Engine. The spatial estimate of probability of transition in any location of SCRS is trained using four sets of historical classified land type imagery. Based on the analysis, the rate of transition from peat plateaus to fen and bog is found to be higher than other transitions, as is consistent with permafrost thaw impacts. This transition is complicated by the process of 'bog capture' which is handled via a unique transition cost distance metric. It was also found that rate of transition from peat plateaus to fens and bogs is higher when the LST of each specific location is higher than mean LST of the whole domain. The derived correlation between the map of conversion, and the selected variables for each time step is used to forecast land cover evolution of peat plateaus, fens, and bog in the SCRS.

Title: Empirical approaches to quantifying the freezing characteristic curve

Authors:
Seth Kwaku Amankwah, University of Saskatchewan
Andrew Ireson, University of Saskatchewan

***Correspondence:** ska091@mail.usask.ca

Keywords:
Freezing point depression, Generalized Clapeyron equation

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The soil freezing characteristic curve (SFC) quantifies the amount of unfrozen water co-existing with ice in frozen soils, as a function of temperature. The SFC influences the soil hydraulic properties and is especially crucial in understanding snowmelt infiltration and runoff, frost heave formation and thawing settlement in frozen soils.
The SFC is modelled by combining information from the soil moisture characteristic curve of unfrozen soils (SMC) with the Generalized Clapeyron equation (GCE). While such an approach is straightforward and inexpensive, the effects of solutes are not accounted for explicitly, and the resulting SFC is not always consistent with those observed in the field and laboratory. There is, therefore, a need to validate the GCE relationship against observed relationships, and it may be necessary to develop alternative relationships to facilitate accurate prediction of unfrozen moisture content in hydrological model.
This study sets out to obtain both field and laboratory data that quantifies the SMC and SFC for different soil textures and salinities and to compare the results with those obtained from the GCE. Data were collected from established field sites at St-Denis and the BERMs Old Jack Pine sites in Saskatchewan. A column experiment was set-up in the laboratory to obtain SFCs for silica sand. The SMC for the silica sand was measured in the laboratory using the HYPROP set-up. Here we present results of the field and laboratory experiments. We also compare the GCE relationship with observed values from the laboratory and field experiments using curve fitting analysis.

Title: Wet and Dry Years Have Distinct Changes to DOM Concentration and Composition in Canadian Sub-Arctic Taiga Shield Lakes

Authors:
Pieter J. K. Aukes, Wilfrid Laurier University
Jeremy Leathers, Wilfrid Laurier University
Mackenzie Schultz, Wilfrid Laurier University
Michael C. English, Wilfrid Laurier University
Jason J. Venkiteswaran, Wilfrid Laurier University
Sherry L. Schiff, University of Waterloo

***Correspondence:** paukes@wlu.ca

Keywords:
Dissolved organic matter, Biogeochemistry, Sub-arctic lakes, Metals

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts

Abstract:
Mining activities near Yellowknife, Northwest Territories, released large emissions of metal(loids) since the 1930s, resulting in elevated concentrations of arsenic in the water and sediments of local lakes. These mine-source metal(loids) can enter these aquatic systems either from direct atmospheric deposition or remobilization from the terrestrial landscape, depending on a number of factors, such as precipitation, flow pathways, and redox conditions. Dissolved organic matter (DOM) concentration and composition also play an important role in the mobilization of metal(loids) between the terrestrial-aquatic interface. Predicted climate change in the sub-arctic, including increasing mean annual air and subsurface temperatures and precipitation amounts, will alter flow pathways, DOM sources, and subsurface and lake redox conditions. Further, defining hydrologic flow pathways between the terrestrial and aquatic system near Yellowknife is complicated by the presence of permafrost, low summer precipitation, and lack of visible inflows or outflows. We paired stable water isotopes with DOM characterization techniques to determine the strength of the terrestrial-aquatic linkage across various lakes near Yellowknife. The two-year field campaign serendipitously sampled a wet and a dry year, providing a comparison of lake water chemistry over variable hydrologic conditions. DOM concentrations, compositions (based on UV-absorbance parameters), and stable water isotopes (δ2H and δ18-H2O) varied with hydrologic regime, indicating strong and rapid linkages between terrestrial and aquatic environments. During the 'wet' year, water isotopes indicated that precipitation influence was concurrent with increases to DOM concentration and increases to overall DOM molecular weight. Conversely, the 'dry' year water isotopes indicated significant evaporation with little change to DOM concentration and a shift towards smaller DOM molecules. These results demonstrate that most lakes are quickly responding to differences in hydrology with a quantifiable signature of terrestrial-derived DOM during wet years. These changes have implications for water colour, earlier development of anoxia within surface waters, and mobilization of metal(loids) from terrestrial to aquatic systems.

Title: Looking at Historical Concentrations of Dissolved Organic Matter and Disinfection By-Products in Northwest Territory Public Drinking Water Quality Records

Authors:
Pieter J. K. Aukes, Wilfrid Laurier University
Jason J. Venkiteswaran, Wilfrid Laurier University
Michael C. English, Wilfrid Laurier University
Sherry L. Schiff, University of Waterloo

***Correspondence:** paukes@wlu.ca

Keywords:
Dissolved organic matter, Disinfection by-products, Drinking water quality

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools: Social, economic and health determinants and impacts

Abstract:
Dissolved organic matter (DOM) plays an important role in terms of monitoring and protection of drinking water resources in sub-arctic environments. DOM represents a mixture of thousands of different carbon molecules, and can differ depending on its source or degradation history. During drinking water treatment, DOM can react with chlorine to form carcinogenic disinfection by-products (DBP). However, DOM reactivity depends not only on concentration, but also on the mixture of DOM. Changes to DOM can impact drinking water treatability. In particular, many circumpolar nations have reported an increase DOM having a 'land' signature, which can also contribute to the 'brownification' of many surface waters. Within the Northwest Territories, large stores of carbon are currently frozen within permafrost; however, increases in temperatures and changes to precipitation patterns have the potential to mobilize this carbon into surrounding surface waters. The Government of Northwest Territories Municipal and Community Affairs (MACA) have reported public drinking water quality records since the early 2000s, including data on DOM and DBP concentrations. We compiled these records to better understand the historical prevalence of DOM and DBP across all NWT communities. Additional samples were collected to understand how differences in DOM composition influence DBP formation and chlorine demand, where we find simple UV-based measures can be used to predict DBP formation from a specific water sample. These results help illustrate historical trends in DOM and DBP within drinking water sources, as well as identify DOM compositions that may form higher concentrations of DBP or require additional treatment options.

Title: Carbon cycling in wetland soils: reassessing the enzymatic latch hypothesis

Authors:
Bijendra Man Bajrachara, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** bbajrach@uwaterloo.ca

Keywords:
Carbon sequestration, Enzymatic Latch Hypothesis, hydrolase enzymes activities, Thermodynamic limitation

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Climate change has the potential of turning wetland soils from being a major terrestrial carbon sink to a source. Hence, it is essential to understand the mechanisms through which wetland soils enhance carbon sequestration. Freeman et al. (2001) proposed the so-called "enzymatic latch hypothesis", which states that the absence of dissolved oxygen in peatland soils inhibits phenol oxidase formation resulting in the accumulation of phenolic compounds, which in turn inhibit the production of hydrolase enzymes that are responsible for initiating soil organic matter degradation. In other words, the lack of phenol oxidase leads to the accumulation and preservation of soil organic carbon. We tested this hypothesis by collecting soils from two wetland sites with distinctive features and geochemical properties: the rare Charitable Research Reserve and Luther Marsh, both in Ontario, Canada. The rare soil is from a submerged riparian zone adjacent to a small groundwater-fed stream (pH 7.5, conductivity 450 µs/cm, 21% organic matter), while the Luther Marsh soil is a bog peat (pH 3.9, conductivity 73 µs/cm, 85% organic matter). We subjected the soils to three different treatments: aerobic versus anaerobic conditions, addition of phenolic compounds, and addition of phenol oxidase. We measured hydrolase enzymes activities plus the concentrations of phenolic compounds and phenol oxidase activities. Although the addition of phenol oxidase decreases the concentrations of phenolic compounds, we did not observed the effect on hydrolase enzymes activities reported by Romanowicz et al. (2015). Moreover, short-term aeration of the soils did not increase phenol oxidase or hydrolase enzymes activities. Thus, our results suggest that the enzymatic latch mechanism may not generally apply to all wetland soils. However, our results provide circumstantial evidence that thermodynamic limitations on organic carbon mineralization under the conditions found in wetland soils could be one key reason behind the high carbon preservation efficiency of wetland soils.
Freeman, C., Ostle, N., Kang, H., 2001. An enzymic "latch" on a global carbon store. Nature 409, 149. https://doi.org/10.1038/35051650
Romanowicz, K.J., Kane, E.S., Potvin, L.R., Daniels, A.L., Kolka, R.K., Lilleskov, E.A., 2015. Understanding drivers of peatland extracellular enzyme activity in the PEATcosm experiment: mixed evidence for enzymic latch hypothesis. Plant Soil 397, 371–386. https://doi.org/10.1007/s11104-015-2746-4

Title: Characterizing inter-seasonal bog-fen tributary connectivity in a sub-arctic peatland complex: A 10-year hydrological study

Authors:
Nicole Balliston, University of Waterloo
Jonathan Price, University of Waterloo

***Correspondence:** nballiston@gmail.com

Keywords:
sub-arctic, landscape connectivity, hydrological response, climate, peatland

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; (Big) data science and management

Abstract:
The James Bay Lowland is a subarctic landscape 90% covered by bog and fen peatlands. With the absence of mineral uplands commonly found in other peatland areas, bogs act as water storage features and provide water to downgradient fens during high water table conditions. Fens, in turn, convey water downstream to tributaries via a "fill and spill" mechanism between fen pools. Though previous research has documented the importance of hydrological connection in this landscape, the frequency, duration and inter-annual variation of this process and its effects on streamflow is not well understood. Due to the combined threats of climate change and resource extraction in this area, a greater understanding of peatland complex hydrology is necessary to understand potential feedbacks to water limited conditions. To this end, a bog-fen-tributary complex was selected for study ~100 km west of Attawapiskat. Meteorological (MET) data, snow depth and water table depth were collected directly at the study site from 2011-2015. Linear regressions were performed on these data against MET and water table data collected from the De Beers Victor Mine monitoring program (2007-2017) to extend the analysis beyond the direct monitoring period. Streamflow data were collected from a 3rd order tributary directly downstream of the study site. Results show that prior to spring snowmelt, an over-winter storage deficit is present in both the bog and fen, with an average water table depth (of 46 ± 10 cm and 9 ± 13 cm below ground surface (bgs), respectively. For all years, the fen storage was filled within 48-hours of snowmelt commencement. Additional melt then contributed to streamflow, and relieved the bog water storage deficit, which took an average of 32 ± 19 days to fill. Periods of landscape connection were defined as those in which streamflow was being generated, and corresponded to water table depths of 0 and 10 cm bgs in the fen and bog, respectively. Post snowmelt, the bog and fen were hydrologically connected on average 66±20 and 67±30 % of the time. Years with high total precipitation and close spacing of subsequent precipitation events resulted more frequent periods of landscape connectivity. On average 35% of tributary streamflow was associated with snowmelt 72% occurred within 48 hours of precipitation events. These results provide guidance on the thresholds required to maintain long-term hydrological connectivity in this landscape under future anthropogenic stressors.

Title: High Resolution Albedo Retrievals from Remote Sensing to Assess the Impact of Forest Fire Soot Deposition on High Mountain Snow and Ice Melt

Authors:
Andre Bertoncini, University of Saskatchewan
Caroline Aubry-Wake, University of Saskatchewan
John W. Pomeroy, University of Saskatchewan

***Correspondence:** andre.bertoncini@usask.ca

Keywords:
Forest fires, Soot deposition, Albedo, Remote sensing albedo retrieval, Snow and ice melt

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
Amongst the impacts of forest fires, the deposition of wind-borne soot on snow and ice surfaces can have an important influence on their energy budgets. Soot deposition on snow and ice causes their albedos to decrease and melt rates to increase. Given the intense fire seasons of 2017 and 2018 in Western Canada, and with increasing forest fire coverage and frequency due to climate change, investigating the effect of forest fires on the melt of high mountain snow and ice is important to understanding potential changes in runoff generation in the headwaters of western North America's major rivers. Even though several studies have addressed the presence of soot over snow and ice as light absorbing impurities and their effect in decreasing albedo, there is a lack of studies measuring the spatial distribution of albedo changes at high resolution. This study evaluates the spatial patterns of albedo decrease caused by soot deposition from the 2017 and 2018 fire seasons on the Columbia Icefield, Canadian Rockies. Directional albedo retrievals at 20 m resolution from 14 Sentinel-2 scenes were corrected for anisotropic properties of snow and ice using multi-angular information from the Moderate Resolution Imaging Spectroradiometer (MODIS) to provide high resolution albedo retrievals. These retrievals were evaluated using station-measured albedo at the Athabasca Glacier. Changes in albedo due to soot were analysed using scenes taken during known upwind fire activity. Decreases in snow albedo are observed immediately after fire in the upper elevations of the Columbia Icefield, whilst decreases in ice albedo due to soot deposition appear in the following summer on lower elevation glaciers. Overall albedos decreased by 0.09 (max. decrease: 0.71 and max. increase: 0.53) causing an estimated overall seasonal melt increase of 625 mm w.e. (range: 0 to 3,308 mm) between scenes collected on Aug. 6, 2017 (few fires) and Aug. 8, 2018 (widespread fires). Higher melt values occurred at the ice and snow transition. These findings reveal patterns that would not be possible without the use of spatially distributed high resolution albedo retrievals, shedding light on the importance of using remote sensing to assess the effect of forest fires on snow and ice melt and, consequently, on streamflow generation to communities downstream of the continental divide.

Title: Projected Changes to the Surface Features of Canadian Prairie Droughts

Authors:
Barrie Bonsal, Environment and Climate Change Canada
Zhuo Liu, University of Manitoba
Ronald Stewart, University of Manitoba
Elaine Wheaton, Saskatchewan Research Council

***Correspondence:** Barrie.Bonsal@canada.ca

Keywords:
Drought, Hydro-Climatic Extremes, Canadian Prairies, Climate Change, Impacts

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; Social, economic and health determinants and impacts

Abstract:
Droughts are among the world's most significant hazards, often affecting more people and being more costly than any other form of natural disaster. Although most areas of Canada periodically experience drought, the agricultural region of the Canadian Prairies are most susceptible mainly because of their high natural precipitation variability and their economic dependence on agriculture. A variety of hydro-climatic drought indicators at various temporal scales have identified large area, long duration dry episodes over the Canadian Prairies during the ~100 years. Many studies have also used these indicators to assess projected future changes to Canadian Prairie droughts using a range of climate models. However, these preceding investigations examined droughts on fixed scales with little or no attention to their temporal and spatial evolution. These features are an important aspect since droughts differ dramatically in terms of onset, growth, persistence, spatial extent, termination, peak timing, and overall duration and severity; all which directly effect their impacts and subsequently, potential adaptation measures. This study utilizes the Standardized Precipitation Evapotranspiration Index to assess projected future changes to these drought features using bias corrected temperature and precipitation output from 29 CMIP5 Global Climate Models (GCMs) for the RCP2.6, RCP4.5, and RCP8.5 emission scenarios. Preliminary results show that most GCMs are able to replicate the duration and severity of past severe Canadian Prairie droughts, however, their ability to simulate temporal features such as onset, growth, persistence, termination, and peak timing varies greatly. Future droughts are projected to be more frequent, longer, and more severe, especially near the end of this century under the higher greenhouse gas emission scenario. There is no clear indication of changes to the aforementioned spatial features among the various model projections. Results from this analysis provide a better understanding of potential changes to the temporal and spatial characteristics of Canadian Prairie severe drought episodes that will assist is assessing future impacts.

Title: Sources of uncertainties in the projection of streamflow in a small Great Lakes watershed

Authors:
Olivier Champagne, McMaster University
Martin Leduc, Université du Québec á Montréal
Altaf Arain, McMaster University
Paulin Coulibaly, McMaster University

***Correspondence:** champago@mcmaster.ca

Keywords:
Climate Change, Hydrological modelling, Climex, Analyses of Variance, Great Lakes

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Using an analysis of variance, this study quantifies the different sources of uncertainty in the simulated winter-spring evolution of streamflow and the number of high flows in Big Creek, Ontario (ON), a small watershed of the Great Lakes basin. The Precipitation Runoff modeling system (PRMS) is forced with temperature and precipitation from 50 members of the Canadian Regional Climate Model Large Ensemble (CRCM5-LE) and 11 downscaled CMIP5 Global climate models (GCMs) using two RCP scenarios. Each of these climate
simulations is used with 7 PRMS sets of parameters, given a total of 504 simulations in the 1960-2099 period. The sets of parameters were determined using different combinations of local hydrometeorological data in the objective function used by the Dynamical Dimension Search calibration algorithm (DDS). The results show that the uncertainties in the future evolution of streamflow will be dominated by scenarios in winter and GCMs in spring. The increase in precipitation amount while the snow to rain ratio decreases will attenuate the impact of future climate scenarios on the modulation of streamflow and amplify the impact of GCMs and internal variability. This study highlighted the need for improving the simulation of precipitation by GCMs to reduce the uncertainties in the future evolution of streamflow in the Great Lakes region.

Title: Fire and Ice: The Resiliency of Zooplankton Communities to Wildfire Disturbance

Authors:
Charles-Matthew Chanyi, Wilfrid Laurier University
Thomas Pretty, Wilfrid Laurier University
Dr. Derek Gray, Wilfrid Laurier University

***Correspondence:** chan7050@mylaurier.ca

Keywords:
Ecology, Fire, Zooplankton

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
The Sathú Settlement Area is among the warmest warming regions in all of Canada with an increase in mean annual temperature of >1.5C. This anthropogenic induced change in annual temperature is leading to a higher frequency of wildfires in northern Canada due to higher density of vegetation, and a higher frequency of thunderstorm. With increasing frequency of wildfires occurring in the northern boreal region, it is important to understand how northern boreal ecosystems respond to wildfire disturbance. In the summer of 2014, a fire burned through the SSA, which is an area containing thousands of shallow water bodies. These shallow water bodies could be susceptible to change from wildfire disturbances, with an increase in sedimentation, nutrient loading, and alterations to water chemistry. One group of organisms in these shallow water bodies are zooplankton. Past studies of possible wildfire disturbance on zooplankton communities showed that zooplankton communities are resilience. However, these studies were isolated to southern regions of the boreal forest, where these regions can differ widely from their northern counterpart. A large reason as to why the zooplankton communities have shown resilience is through the ecosystems ability to recover from wildfire disturbance. Vegetative regrowth in the southern region takes approximately four years, with the water chemistry and zooplankton communities showing similar time frames of recovery. In northern boreal regions the ability for vegetative regrowth is more limited, grouped with the presence of discontinuous permafrost within the region, makes the zooplankton communities of their respective regions incomparable. This study aimed to bridge that gap in knowledge, and to better understand if the trend of resiliency in the zooplankton communities to wildfires continues in the north. After identifying zooplankton communities down to the genus of 9 burned lakes, and 11 reference lakes the communities were analyzed on genus richness and diversity, relative abundance of genera, and percent population of functional feeding groups of zooplankton. Post analysis showed there were no discernible differences in zooplankton community composition between burned and reference lakes, meaning the zooplankton of these northern lakes show the same resiliency as their southern counterparts.

Title: Freezing rain events causing power outages in the province of New Brunswick, Canada

Authors:
Julien Chartrand, University du Québec à Montréal
Julie M. Thériault, University du Québec à Montréal

***Correspondence:** chartrand.julien.2@courrier.uqam.ca

Keywords:
Freezing Rain, New Brunswick, Climate Change

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Winter storms associated with severe freezing rain accumulation and strong winds in the province of New Brunswick (NB), Canada, can cause impacts on many sectors of society. For example, the recent January 2017 ice storm in Atlantic Canada resulted in more than 130000 homes without power in NB after up to 50-mm of ice accumulated eastern NB during three days. In collaboration with NB Power, freezing rain events that led to widespread power outages and damages to infrastructure between 2003 and 2013 have been identified. To analyse these events and better understand the links between meteorological conditions and power outages, high-resolution convection-permitting simulations at 4 km grid spacing over the continental US were used. These were produced from 2000-2013 as well as, in pseudo global warming (PGW) mode that assumes a warmer climate (2071-2100 under the RCP8.5 scenario). The local effects influencing the intensity and types of precipitation distribution during the storms were investigated. The results showed that the presence of complex terrain that the presence of the Appalachian Mountains in NB enhances the differential temperature advection associated with veering winds through the process of cold air damming. This favors the development of strong temperature inversion in the lower-levels conductive to high freezing rain amounts in southern NB. In PGW, there is a major decrease in the occurrence of freezing rain events in coastal regions of NB due to warmer sea surface temperatures. In contrast, there is an increase in northwestern NB, especially for long events (>6 hours). Overall, this study contributes to a better understanding of meteorological factors leading extreme freezing rain amounts in NB and to better anticipate the impact of climate change on those storms.

Title: Space-time surveillance of land-cover and climate dynamics

Authors:
Chiranjib Chaudhuri, Wilfrid Laurier University
Majid Hojati, Wilfrid Laurier University
Colin Robertson, Wilfrid Laurier University

***Correspondence:** chiranjibchaudhuri@gmail.com

Keywords:
Space-time surveillance, climate change, Discrete Global Grid System, Cumulative Sum Method, Motifel

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management

Abstract:
Recent earth observation platforms are generating an unprecedented volume of data with potential to transform how we detect and characterize changes in landuse, climate, natural and anthropogenic disturbances, among other phenomena. However, surveillance systems capable of integrating vast amounts of disparate data requires a digital representation of geospatial data which can readily be used for scientific analysis. Discrete Global Grid Systems (DGGS) are a class of spatial reference system which are gaining wide recognition as a data model for heterogeneous geospatial data. A recently developed implementation of a DGGS-based GIS has integrated the advantages of a DGGS data model within a traditional relational database architecture to realize a complete geo-spatial analytics platform. In this study, we have developed and implemented a surveillance cumulative sum method for different environmental variables and detecting landuse-land cover change using a Jansen Shannon Divergence method for all of Canada. Furthermore, we developed a user-interface to perform analysis and visualize large-scale change metrics. In our analysis, the majority of Canada shows warming trends observed over the study period. However, precipitation shows spatially fragmented changes. The LULC analysis found significant anthropogenically-induced lulc changes. However, the interaction between LULC change and changes in climate needs further investigation. Our analysis demonstrates the potential of this architecture for large-scale change detection and shows significant potential for integration with outputs from spatially distributed models.

References:
Colin Robertson, Chiranjib Chaudhuri, Majid Hojati, Steven A. Roberts,An integrated environmental analytics system (IDEAS) based on a DGGS,ISPRS Journal of Photogrammetry and Remote Sensing, Volume 162, 2020, Pages 214-228, ISSN 0924-2716, https://doi.org/10.1016/j.isprsjprs.2020.02.009.

Title: Trends in water and heat related agrometeorological indices across the Canadian Prairies under a changing climate

Authors:
Aston Chipanshi, Agriculture and Agri-Food Canada
Mark Berry, Agriculture and Agri-Food Canada
Yinsuo Zhang, Agriculture and Agri-Food Canada
Garrett Steier, Agriculture and Agri-Food Canada

***Correspondence:** Aston.Chipanshi@canada.ca

Keywords:
Growing season length, Water deficit, humidity temperature index, soil moisture, Canadian Prairies

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
The objective of this presentation is to investigate the characteristics of agroclimatic conditions related to heat and water across the agricultural landscapes of the Prairie Provinces under a changing climate. Heat and water are among the major limiting conditions to agriculture in the semi arid, cold Prairie Region. Therefore multi-variable based indices such as growing season length (GSL) defined in terms of heat and moisture availability, water deficit (the difference between water supply and demand), humidity temperature index (humidex),and root zone soil moisture were calculated for 30-year time slices from the current climate base period (1981-2010) to 2070-2100 to understand their trends. Multi-model ensemble results downscaled to 10km resolution from the CMIP5 data sets were used to calculate the heat and water related indices. We found that GSL, effective growing degree days (EGDDs), water deficit, extreme heat, humidex and soil moisture indices were amplified beyond values of the 20th century climate record. This amplification has implications on where the three broad categories of crops (cool, warm and hot season crops) found on the Canadian Prairies will be grown under a changed climate. The area for warm season and hot season crops will likely expand northwards while that for cool season crops will shrink. In addition, newer crops may be introduced into the region as heat units and the GSL become favourable.

Title: Patterns of tree growth in a boreal peatland experiencing permafrost thaw

Authors:
Katherine D. Dearborn, Wilfrid Laurier University
Jennifer L. Baltzer, Wilfrid Laurier University

***Correspondence:** kdearborn@wlu.ca

Keywords:
boreal forest, permafrost, forest productivity, dendrochronology, peatland

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Satellite-derived vegetation indices indicate that tundra productivity has increased in recent decades, likely in response to climate warming, but that trends in boreal forest productivity have been mixed, possibly due to the confounding influences of permafrost thaw and/or drought stress. In addition to uncertainty surrounding drivers of these trends, it is often unclear which components of boreal vegetation the satellite-derived indices are tracking. In theory, patterns in the indices should match patterns in tree growth, but the two are not always positively correlated, particularly in sparsely treed coniferous forests typical of the northern boreal. In these cases, it is possible indices are reflecting stem demography (mortality and recruitment) rather than growth. To address this uncertainty, we aimed to compare tree growth and demographic patterns to satellite-derived indices of vegetation productivity in a 10ha permanent boreal forest plot that is experiencing rapid permafrost thaw. We previously analyzed stem mortality and recruitment over a five-year period, and obtained measurements of frost table depth, soil moisture, and organic layer thickness throughout the plot. In summer 2019, we collected microcores from over 300 stems representing the three dominant tree species in the plot. We then measured annual ring widths over the past several decades to quantify average growth rates as well as recent trends in growth. We found that the growth rate of black spruce, the dominant species, varied by an order of magnitude across the plot, largely in response to variation in organic layer thickness. However, growth neither increased nor decreased consistently over the past 30 years. In contrast, average growth of eastern larch was relatively uniform throughout the plot, but 30-year growth trends were predominantly positive. This is somewhat in accordance with the demographic data, which revealed a recent decrease and increase in the abundance of spruce and larch, respectively, largely in response to direct and indirect effects of permafrost thaw. Future work will examine trends in Landsat-derived vegetation indices within the plot and quantify the extent to which demographic and ring width data explain these trends. Our results will directly address the current uncertainty surrounding drivers of satellite-derived productivity trends in the boreal forest, thereby improving our ability to predict future forest dynamics.

Title: Fabrication and characterization of activated carbons derived from boreal peats for phenolic compound removal from wastewater

Authors:
Charles-françois de Lannoy, McMaster University
Yichen Wu, McMaster University
Nan Zhang, McMaster University

***Correspondence:** wuy211@mcmaster.ca

Keywords:
feather moss, sphagnum, bioresource, activation, p-nitrophenol

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; Stakeholder engagement and knowledge mobilization

Abstract:
Boreal peatlands occupy vast areas of the world's land and serve important functions for climate regulation, carbon sequestration, and nutrient and water retention. Extreme climates are disrupting this ecosystem, leading to frequent droughts and wildfires, causing changes to peat soil chemistry and structure. Such events are often detrimental to peatland resilience especially because of the associated tendency to cause peat soil hydrophobicity. Hydrophobic boreal peats, such as dried, post-fire peats, frequently cause surface runoff, soil erosion while also impeding plant re-growth. Further, the small organic molecules from pre- and post-fire peat leachates may enter source waters and potable water treatment facilities downstream, leading to increased contamination loading and treatment costs. Boreal peats are cheap, abundant biomass materials, but have long been overlooked for other applications. These pre- and post-burned carbon-rich materials are potentially suitable for making activated carbons. In this study, high surface area porous carbon materials with desirable performance for p-nitrophenol removal were successfully developed from pre- and post-burn boreal peats, by applying a single-step approach through $ZnCl_2$ activation. Porous carbons were characterized by elemental analyses, zeta potential, BET, FTIR, XPS, XRD and SEM. The products contain micro- or mesopore characteristics, and have amorphous carbons, aromatic ethers, esters, alcoholic and phenolic groups at different carbon fractions.
P-nitrophenol adsorption onto the activated carbons follow the Redlich-Peterson isotherm, Freundlich isotherm and pseudo-second-order kinetic model. Adsorption mainly occurs through multi-layer chemisorption, and are impacted by the electron donor-acceptor complexes mechanism, the π-π interactions and steric effects. Adsorption capacity of the biomass sorbents are superior to many other sorbents that were studied. While adsorptive rates are slower than using commercial activated carbon, Norit GSX, they are overal promising because they achieve more than 98 % removal of model contaminants within 4 hrs. This study suggests that considering the precursor abundance, ease of production, and low energy cost, these biomass activated carbons are promising candidates for market use for water and wastewater treatment processes.

Title: Investigation of the linkage between precipitation characteristics and local wind field over complex terrain: case study at Fortress Mountain, Alberta

Authors:
Aurélie Desroches-Lapointe, University of Québec in Montreal
Julie M. Thériault, University of Québec in Montreal
Nicolas R. Leroux, University of Québec in Montreal
Zen Mariani, Environment and Climate Change Canada

***Correspondence:** aurelie.desroches.lapointe@gmail.com

Keywords:
Winter precipitation, Complex terrain, Wind field, Dield campaign, snow cover patterns

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The mountain snowpack is the primary source of fresh water to downstream communities and is a key element in the assessment of natural hazards, such as avalanches and flooding. The major Alberta flood that occurred in June 2013 is a good example of the latter. The deposition of solid precipitation over the winters drives snowpack spatial heterogeneities at the surface. In complex terrain, the fine-scale deposition patterns are controlled by the interaction between falling particles and the surrounding wind field. This interaction depends on the microphysical characteristics of precipitation particles, such as their degree of riming, their size, and their aspect ratio, which directly influence their drag coefficients. Consequently, the likeliness of particles to follow the wind streamlines vary with hydrometeor type. This study aims to better characterize the spatial distribution of solid precipitation for different hydrometeor types and the associated wind-driven processes over complex terrain.
To address this, meteorological conditions were measured using in-situ and remote sensing observations collected at Fortress Mountain, Alberta, during the Storm and Precipitation Across the continental Divide Experiment (SPADE) in May and June 2019. Precipitation particles were characterized using an optical disdrometer (Parsivel OTT) and macrophotography of solid precipitations. In addition, a Micro Rain Radar (MRR) and a Doppler Lidar were deployed at two different elevations of Fortress Mountain (at the valley bottom 1591 m ASL, and at 2076 m ASL) to measure precipitation layers and 3D wind fields above each site. During the 12 storms observed, most of the precipitations at the higher elevation fell as snow while mixed precipitation was observed in the valley. Preliminary analyses suggests a link between observed vertical motions in the wind field and the type of weather system. For example, upward wind motions prior to precipitation events at Fortress top is associated to an upper level trough, leading to upslope flow and orographic precipitation. Moreover, because upslope events produced heavy precipitation, hydrometeor types and deposition conditions of these particular case studies are investigated. Overall, this study improves the understanding of fine-scale precipitation deposition processes in the Canadian Rockies to better prepare for extreme events.

Title: What happens in winter? Efficient modelling of seasonal soil freeze/thaw

Authors:
Élise G. Devoie, University of Waterloo
James R. Craig, University of Waterloo
William L. Quinton, Wilfrid Laurier University

***Correspondence:** egdevoie@uwaterloo.ca

Keywords:
Freeze/Thaw, Modelling, Ground Ice, Hydrology

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Many Canadian catchments have hydrographs dominated by the spring freshet, and this key part of the hydrological cycle is instrumental in replenishing storage. Even catchments which are not nival are still affected by frozen ground. The impacts of ground ice on infiltration, hydraulic conductivity and other properties are often represented through empirical relations, instead of being based on ice content. Models of freeze-thaw capable of estimating ice content are currently available, but are either computationally demanding, based upon the coupled partial differential equations for fluid flow and heat transfer, or they are empirical. Not only are the empirical models generally catchment specific, but they typically represent only one freeze-thaw front which is problematic when representing spring melt. A physically-based interface model of seasonal freeze/thaw is presented. This computationally efficient, semi-analytical, non-equilibrium solution to soil the freeze-thaw problem is proposed as a component of hydrological models to describe seasonal ground ice. The model is developed and validated against the Stefan solution and a benchmarked numerical continuum model. Unlike the Stefan solution, the interface model is capable of representing up to three freeze-thaw fronts, can represent the influence of a partially frozen unsaturated zone, and can be forced with arbitrary surface temperature boundary conditions. The model aims to inform hydrological processes which may otherwise be uncorrected for ice content or assumed to be inactive over the winter. These include ice-dependent infiltration, hydraulic conductivity and thermal properties of soils. The proposed model provides a physical and computationally efficient alternative for representing freeze-thaw in hydrological models and is hoped to improve hydrologic predictions in Canada.

Title: A Multivariate Regression Framework for Predicting Changes in Annual Peak Flows in Western Canadian River Basins

Authors:
Yonas Dibike, Environment and Climate Change Canada
Paulin Coulibaly, McMaster University
Brandi Newton, Alberta Environment and Parks
Rajesh Shrestha, Environment and Climate Change Canada
Barrie Bonsal, Environment and Climate Change Canada
Colin Johnson, Environment and Climate Change Canada

***Correspondence:** yonas.dibike@canada.ca

Keywords:
Peak Flows, Western Canada, Multivariate Regression, SWE

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Flows originating from cold and mountainous watersheds are significantly affected by changes in temperature and precipitation patterns over the region. A warming climate will bring a temperature-induced shift in precipitation from snow towards rain affecting the snowpack volume and snowmelt timing. The magnitude and timing of peak streamflow events will also be affected with implications for infrastructures and ecosystem services. This study applies a multivariate regression framework to investigate the spatial variations and relative importance of different hydro-climatic controls of annual peak flows (APF) and mean spring (MAMJ) flow in several watersheds over western Canada. Basin integrated SWEmax or April 1 SWE and mean spring temperature and precipitation are found to be the most significant predictors of both APF and mean spring flow. The implications of potential changes in those hydro-climatic controls on APF and spring flow are also examined based on Regional Climate Model (RCM) projections. The results show spatial variation in the impacts with the projected increase in spring precipitation mostly compensating the opposite effect of increasing spring temperature and decrease in SWE and resulting in an overall increase in APF and mean spring flow over most of the region.

Title: The relative importance of environmental factors on the interannual variability of carbon fluxes in the boreal forest

Authors:
Mariam El-Amine, Université de Montréal
Alexandre Roy, Université du Québec à Trois-Rivières
Pierre Legendre, Université de Montréal
Oliver Sonnentag, Université de Montréal

***Correspondence:** mariam.el-amine@umontreal.ca

Keywords:
Carbon, Boreal forest, Permafrost, Growing season, Eddy covariance

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
As climate change will cause a more pronounced rise of air temperature in northern high latitudes than in other parts of the world, it is expected that the strength of the boreal forest carbon sink will be altered. To better understand and quantify these changes, we studied the influence of different environmental controls (e.g., air and soil temperatures, soil water content, photosynthetically active radiation, normalized difference vegetation index) on the timing of the start and end of the boreal forest growing season and the net carbon uptake period in Canada. The influence of these factors on the growing season carbon exchanges between the atmosphere and the boreal forest were also evaluated. There is a need to improve the understanding of the role of the length of the growing season and the net carbon uptake period on the strength of the boreal forest carbon sink, as an extension of these periods might not necessarily result in a stronger carbon sink if other environmental factors are not optimal for carbon sequestration or enhance respiration.
Here, we used 55 site-years of observation over six North American boreal black spruce-dominated stands. Redundancy analyses highlight the environmental factors that control the most the start and end of the growing season and the net carbon uptake period. Preliminary results show that the timing at which the air temperature becomes positive correlates the most strongly with the start of the net carbon uptake period (r = 0.49 p < 0.001) and the start of the growing season (r = 0.51, p < 0.01). The end of these periods was most highly correlated with the mean monthly photosynthetically active radiation (r = 0.48, p < 0.001 and r = 0.46, p < 0.001, respectively). Also, the annual net ecosystem productivity is highly correlated with the length of the net carbon uptake period (r = 0.54, p < 0.01). Other environmental controls such as annual precipitations, the mean annual soil temperature or the maximum yearly normalized difference vegetation index have a smaller impact on the annual net ecosystem productivity. We will subsequently highlight the differences in the environmental factors that control the start and the end of the growing season and the net carbon uptake period, as well as the carbon sink strength, between sites that have different permafrost extent.

Title: Using dendrochronology to assess the influence of mine dewatering and climate change on the growth of black spruce in boreal peatlands in the Hudson Bay Lowlands, Canada

Authors:
Matthew Elmes, University of Waterloo
Nicole Balliston,
Emma Davis,
Andrew Trant,
Jonathan Price,

***Correspondence:** elmes.matt@gmail.com

Keywords:
Dendrochronology, Peatland, Climate Change, Drainage, Black Spruce

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools,Predictive modelling and forecasting

Abstract:
Peatlands in the James Bay Lowlands (JBL) are important conveyors of freshwater, sourcing over 50% of the discharge to streams and rivers, which supply fresh water to the brackish James Bay. These peatlands are highly sensitive to disturbance, from reduced water availability attributed to climate change, and through changes in groundwater connectivity attributed to mining and resource extraction. These disturbances can enhance peatland drainage and subsequent water loss, thus influencing the growth of stunted black spruce (Picea mariana), the dominant tree type in the region. However, to date, there is little known about this ecological response in the JBL, despite the ability of such changes to cause a positive feedback with respect to water loss through transpiration. In this study, we reconstruct a chronology of annual tree ring widths of black spruce over approximately 60 years in the JBL. Our primary objectives are to 1) identify whether mine dewatering and subsequent aquifer depressurization at the DeBeer's diamond mine has led to an increase in radial growth of black spruce within the mine-impacted area; and 2) to examine the growth of peatland trees in the region to climatic trends over the past 60 years to aid in predicting the likely ecohydrological response to future climate predictions. Increment cores from trees ranging from 15 to 60 years old were obtained from bog sites located within and outside of the mine-impacted area. Additional field hydrology and climate data were used to interpret dendrochronological results. We found negligible differences in radial growth during the period of pumping (2007-2019) between mine-impacted and unimpacted sites, as climate (precipitation and air temperature) appeared to have an overriding effect on growth patterns. A climate analysis for the JBL is currently ongoing, and will be used to study patterns in radial growth over the past 60 years. We hope these results will help to elucidate the future trajectory of the ecohydrology of peatlands in the JBL and their role as conveyors of water to downstream ecosystems.

Title: Hydrothermal Regime of Riparian Systems in Continuous Permafrost, Western Canadian Arctic

Authors:
Timothy Ensom, Wilfrid Laurier University
Philip Marsh, Wilfrid Laurier University
Steve Kokelj, Northwest Territories Geological Survey

***Correspondence:** enso5730@mylaurier.ca

Keywords:
permafrost, riparian, stream, temperature, icing

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; Stakeholder engagement and knowledge mobilization

Abstract:
In permafrost regions the movement of water during winter has important implications for hydrology, land use, and infrastructure. Knowledge of winter hydrothermal conditions in small, extensive riparian networks over continuous permafrost is limited. Climate warming, changing precipitation regimes and increases in tundra vegetation coverage may be modifying the thermal regime of these systems to delay active layer freeze-back and promote winter water movement. The primary goals of this research are to improve knowledge of the present hydrothermal regime of riparian systems in continuous permafrost, assess the causes of spatial variability among systems, and on this basis project future conditions under a changing climate.
To describe riparian hydrothermal conditions and their spatial variability, water and ground temperature in, beneath, and adjacent to streams of varying catchment size across treeline is being measured continuously. Morphological and ecological properties of contributing watersheds are being compared, and the dynamics of stream icings indicative of the timing and quantity of winter water movement are being monitored at several streams near the 140-km Inuvik to Tuktoyaktuk Highway (ITH). An additional research objective is to describe the causes of the icings occurring at stream crossings along the highway. Concurrent monitoring of streambed temperatures, hydrostatic water level upstream and downstream of highway crossings, snow accumulation and icing size is intended to aid the investigation of causes.
Preliminary results suggest that advective heat transport is important to the winter thermal regime of riparian systems draining small watersheds. Substrate beneath stream channels in small riparian systems may remain unfrozen and convey water depending on material hydraulic conductivity. Highway crossings can alter stream thermal regime to obstruct the drainage of small watersheds, and impeded runoff volume can exceed 1,000 cubic metres in watersheds of 30 square kilometres less.
This research has the potential to provide new insight on winter hydrology in permafrost areas, inform hydrological modeling, advance current understanding of winter flow sources and stream chemistry, and help inform the design, operation and mitigation of hydrological issues associated with linear infrastructure in permafrost.

Title: Characterization of contrasting flow and thermal regimes in two adjacent subarctic alpine headwaters in northwest Canada

Authors:
Luca Fabris, McMaster University
Sean K. Carey, McMaster University

***Correspondence:** fabrisl@mcmaster.ca

Keywords:
flow regime, stream temperature, heat balance, subarctic catchments, alpine headwaters

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Alpine headwaters in subarctic regions are particularly sensitive to climate change, yet there is little information on stream thermal regimes in these areas and how they might respond to global warming. In this paper, we characterize and compare the hydrological and thermal regimes of two subarctic headwater alpine streams within an empirical framework. The streams investigated are located within two adjacent catchments with similar geology, size, elevation and landscape, Granger Creek (GC) and Buckbrush Creek (BB), which are part of the Wolf Creek Research Basin in the Yukon Territory, Canada. Hydrometeorological and high-resolution stream temperature data were collected throughout summer 2016. Both sites exhibited a flow regime typical of cold alpine headwater catchments influenced by frozen ground and permafrost. Comparatively, GC was characterized by a flashier response with more extreme flows, than BB. In both sites, stream temperature was highly variable and very responsive to short-term changes in climatic conditions. On average, stream temperature in BB was slightly higher than in GC (respectively 5.83 °C and 5.70 °C), but less variable (average difference between 75th - 25th quantiles of 1.6 °C and 2.0 °C). Regression analysis between mean daily air and stream temperature suggested that a greater relative (to stream flow) groundwater contribution in BB could more effectively buffer atmospheric fluctuations. Heat fluxes were derived and utilized to assess their relative contribution to the energy balance. Overall, non-advective fluxes followed a daily pattern highly correlated to short-wave radiation. Generally, solar radiation and latent heat were respectively the most important heat source and sink, while air-water interface processes were major factors driving nighttime stream temperature fluctuations.

Title: Canadian Rockies Hydrological Observatory - Field Work Initiatives

Authors:
Greg Galloway, University of Saskatchewan
Robin Heavens, University of Saskatchewan

***Correspondence:** greg.galloway@usask.ca

Keywords:
meteorological, Canadian Rockies

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
The Canadian Rockies Hydrological Observatory operates 35 meteorological and hydrometric monitoring stations. The technical staff, based out of the Coldwater Laboratory in Canmore, AB, are currently involved in the following field based research initiatives: UAV based snowpack assessments and plant-atmosphere process scaling, improving process based research methods in glacier environments, upgrading satellite telemetry for remote glacier stations, ongoing snow surveying and hydrometric monitoring, and the development of an instrument calibration program.

Title: Observing and modelling agriculture-climate-hydrology interactions on the Canadian Prairies

Authors:
Phillip Harder, University of Saskatchewan
Warren Helgason, University of Saskatchewan
John W Pomeroy, University of Saskatchewan

***Correspondence:** phillip.harder@usask.ca

Keywords:
crop growth, agriculture, evapotranspiration, Canadian Prairies, climate change

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
The Canadian Prairie land surface is a mosaic of large-scale annual crops intermixed with perennial pastures and forages. This spatial and temporally dynamic surface heterogeneity confounds the ability to accurately model interactions between cropping practices, hydrology and future climate. In an effort to improve our predictive capabilities in this region, an extensive field campaign has been gathering the necessary observations to validate and improve crop growth models suitable for incorporation into existing cold-regions hydrology models. For the 2018 and 2019 growing seasons, hydrological and biophysical data were collected from forage, pasture, wheat, barley, lentil, and field pea crops at sites near Saskatoon, Saskatchewan. Between crop types, large differences in land-atmosphere interactions and crop water usage of soil moisture were observed. Preliminary modeling efforts to develop locally appropriate parameters and validate the crop representation of AquaCropOS with this novel dataset will be presented. Testing and validation of crop models suitable for incorporation into process based hydrological models improves our ability to understand and predict interactions of changing agricultural practices, hydrology and climate on the Canadian Prairies.

Title: Mapping the future changes of hydrology in the southern boreal forest of Canada using the convection-permitting WRF CONUS simulations

Authors:
Zhihua He, University of Saskatchewan
John W. Pomeroy, University of Saskatchewan
Xiao Ma, University of Saskatchewan

***Correspondence:** zhh624@mail.usask.ca

Keywords:
Southern Canadian boreal forest, Future changes of hydrology, CRHM model, WRF CONUS simulations

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
This study develops a physically based hydrological model using the Cold Region Hydrological Model platform (CRHM) to simulate the major hydrological processes in the boreal forest. The study area focuses on a cross-province transect of around 1.1 million km2 in the southern Canadian boreal forest, which has seasonally frozen soils but little permafrost. The entire study area was divided into 2143 virtual basins with area of around 625 km2 for each basin. In each virtual basin, three hydrological response units (HRU) denoting fen, needle leaf forest and open water (lake and rive channel) are used to represent the most common land cover types in the southern boreal forest. The performance of the hydrological model without parameter calibration was evaluated in comparison to historical observations of streamflow, snow water equivalent (SWE), cumulative evapotranspiration (ET) and liquid soil volume water content in a well-gauged basin, White Gull Creek, Saskatchewan. Near-surface outputs from the convection-permitting Weather Research and Forecast (WRF) model simulations over the contiguous US (CONUS), including air temperature, precipitation, relative humidity and solar incoming radiation, were used to drive the CRHM model in each of the virtual basins. The changes to future hydrology across the entire southern boreal forest are mapped as the difference between the hydrological model simulations driven by WRF outputs in the current (ctrl, 2001-2013) and in a future (pgw, 2087-2099) period. The results show profound changes in southern boreal forest hydrology. Annual precipitation increases by 0.4% to 46% with largest increases in the most western and eastern parts of the southern boreal forest, and the annual mean temperature warms by 4.5-6.9℃ especially in the central part of the forest. Peak SWE (and seasonal snowmelt) increases by up to 58% (52%) in the western, and decreases by up to 87% (75%) in the eastern parts of the forest. Annual ET increases by 14%-70%, while snow sublimation decreases by 9%-66%. Annual runoff change varies widely in the southern boreal forest, increasing in most of the forest (0.1% to 492%) but decreasing (up to 60%) in the south central zones.

Title: The cooling effect of peatlands on near-surface climate in the boreal biome

Authors:
Manuel Helbig, McMaster University
James M Waddington, McMaster University

***Correspondence:** helbigm@mcmaster.ca

Keywords:
climate, peatlands, evapotranspiration

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management

Abstract:
In addition to forests, peatlands are abundant in the boreal biome and store large amounts of organic carbon. They may play an important role for regional climate in the boreal biome through the exchange of heat and water vapour between the land surface and the atmosphere. Understanding how land-atmosphere interactions in peatlands differ from boreal forests may therefore be crucial for modelling boreal climate system dynamics. To assess the influence of peatlands and forests on near-surface climate, we analyse eddy covariance energy flux and albedo data from 33 peatlands and 57 evergreen needleleaf forests - the dominant forest type in the boreal biome. To simulate near-surface air temperature and vapour pressure deficit over homogeneous peatland and forest landscapes, energy flux observations are used to parameterise an evapotranspiration model, and an analytical solution to the surface energy balance is coupled to an atmospheric boundary layer model. We found that peatlands, compared to forests, are characterized by higher albedo, lower aerodynamic conductance, and higher canopy conductance for an equivalent vapor pressure deficit. Compared to forests, this combination of peatland ecosystem properties results in a 400 m to 500 m decrease in maximum boundary layer height, a mid-growing season cooling (1.6C to 2.3C in afternoon air temperatures), and a decrease in afternoon vapor pressure deficit (0.3 to 0.7 kPa) for homogeneous landscapes. The magnitude of these climate impacts decreases with latitude and, thus, with incoming solar radiation. Given that the areal extent of peatlands exerts a strong control on regional climates in the boreal biome, we argue for both the conservation of large pristine boreal peatlands and the large-scale peatland restoration in regions that have experienced extensive peatland drainage and mining.

Title: CoSMoS-MATLAB: A user-friendly toolbox for precise timeseries generation

Authors:
Salma Hobbi, University of Saskatchewan
Chandra Rupa Rajulapati, University of Saskatchewan
Simon Michael Papalexiou, University of Saskatchewan

***Correspondence:** salma.hobbi@usask.ca

Keywords:
Stochastic modelling, Hydroclimatic processes, Generates time series, Parent-Gaussian framework transformations

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
CoSMoS-MATLAB is a user-friendly toolbox that helps scientists and researchers to generate univariate time series mimicking hydro-climatic processes (such as precipitation, wind, temperature, relative humidity, river discharge, etc). The stochastic framework behind CoSMoS unifies, extends, and improves a modeling strategy that generates time series by transforming “parent” Gaussian time series with specific statistical characteristics. The simulation scheme (1) introduces parametric correlation transformation functions, (2) enables straightforward estimation of the parent-Gaussian process yielding the target process after the marginal back transformation, and (3) offers a simple, fast and efficient simulation procedure for every stationary process at any spatiotemporal scale. The user provides the target time series characteristics, that is, the marginal distribution and autocorrelation structure, and the package does the rest. The Graphical User Interface (GUI) makes it easy to select specific distributions and autocorrelation structures, and generate time series of any length. The generated timeseries are visualized in a panel of figures that depict and compare the target distribution and autocorrelation with the corresponding empirical ones.

Title: Thermal-hydraulic-mechanical modelling of groundwater dynamics in a permafrost basin

Authors:
Xiang Huang, University of Waterloo
David L. Rudolph, University of Waterloo

***Correspondence:** xiang.huang@uwaterloo.ca

Keywords:
Thermal-hydraulic-mechanical, Permafrost, Freeze-thaw, Deformation

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Despite a growing interest in predicting the dynamics of thermal regime and groundwater flow systems subjected to freeze-thaw cycles, simulations addressing the evolution and its feedbacks among the thermal, hydraulic, and mechanical fields in a permafrost basin under a changing climate receive comparably little attention. Here we present a fully coupled thermal-hydraulic-mechanical (THM) model, which examines a number of processes, including the heat conduction and convection, water-ice phase change, groundwater flow driven by pressure and thermal gradient (cryosuction), and elastic stress-strain relationships. This THM model framework was first validated by lab experimental measurements from literature and then applied to an idealized aquifer system in which groundwater flow is driven by topography. Simulations show the impact of climate warming scenarios on permafrost distribution, frost heave and thaw settlement, and groundwater discharge to surface water bodies over timescales of decades to centuries. Our results demonstrated that i) there is significant deformation of the land surface as the freeze-thaw process advances in time, ii) disappearance of residual permafrost largely changed the groundwater flow paths and accelerated the base flow into the stream/rivers. These insights into changing patterns of groundwater dynamics, thermal regime and aquifer structure (deformations) help explain observed changes in arctic wetland patterns and landscapes and are crucial for northern water cycles.

Title: Shield Carbon Futures: predicting future change in the face of climate warming and permafrost thaw

Authors:
Ryan Hutchins, University of Waterloo
Sherry Schiff, University of Waterloo
Tonya DelSontro, University of Waterloo
Jason Venkiteswaran, Wilfrid Laurier University
Michael English, Wilfrid Laurier University
David Olefeldt, University of Alberta

***Correspondence:** hutchins.ryan@gmail.com

Keywords:
DOC, carbon, permafrost thaw, lakes

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; (Big) data science and management

Abstract:
Canada contains one-fifth of the Earth's freshwater and ~60% of all lakes globally with the majority of in the northern Precambrian Shield. This area is warming at twice the global average and also stores a significant amount of carbon (C) in peatlands and permafrost soils which is transported to surface waters during periods of hydrologic flow and permafrost thaw as Dissolved Organic Carbon (DOC). In open water bodies, DOC is a critical factor in water quality and aquatic food webs, controlling water temperature, stratification and mixing, metal concentrations, food security (fish production), mercury in fish, light and nutrients, and is an obvious concern for C emissions. DOC can also control drinking water security as DOM controls the amount of disinfection treatment needed to remove pathogens, and chlorination of DOC can result in the formation of cancer-causing disinfection by-products (DBPs). DOC concentrations in Shield lakes are the highest in Canada and are forecast to increase in a warming world, which subsequently could negatively impact aquatic ecosystems and drinking water treatability. Given the amount of C and lakes on the Precambrian Shield, the lack of information on DOC thus represents a key knowledge gap not currently covered by GWF Core projects, despite being identified by the Strategic Management Committee (SMC) as a research need under Pillar 1 (cold regions processes). Here we focus on a key component to water futures of the Canadian boreal, taiga and tundra Precambrian Shield, whereas no other GWF Core projects (Technical Advances, Scientific Advances, and Knowledge Mobilization) currently include the Canadian Shield or a focus on DOC. In addition, the current suite of biogeochemical models for water quality in the GWF portfolio has been developed solely for low DOC environments which do not consider the compositional complexity of DOC. Moreover, the landscape relationships and process rates necessary to include the large Canadian Shield area and most Canadian lakes have not yet been constrained. Here, the overarching objective is to improve the understanding of DOC dynamics in Canadian Northern Shield freshwaters with a focus on predicting future change in the face of climate warming and permafrost thaw. In this presentation we focus on DOC research in an area that covers 46% of Canada. We link on-going research within GWF with long-term research at IISD-ELA and Dorset with large-scale research in Quebec.

Title: The analysis of the climatological features of the eastward-propagating precipitation systems east of Rockies

Authors:
Yunsung Hwang, University of Saskatchewan
Yanping Li, University of Saskatchewan

***Correspondence:** yunsung.hwang@usask.ca

Keywords:
precipitation, observation

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
In this study, the statistical features of MCSs were analyzed using 4-km, hourly Stage IV data from 2002 to 2013 (12 years). Stage IV data are multi-sensor-based mosaicked data (radar+ ground station data) covering the whole Contiguous United States (CONUS) from River Forecast Centers (RFC). Using Method for Object-based Diagnostic Evaluation-Time-Domain (MODE-TD, MTD) tool, the tracks, longevities, propagation speeds, and areal coverage of MCSs were obtained. The lifetime of warm season MCSs were then divided into three stages (developing, mature, and dissipating) based on their longevities (25, 25-75, 75-100 percentiles). The MTD determined feature in Hovmoller diagrams show that, for long-lived events at mature stage, the individual MCSs show eastward-propagating speed slower than that of the climatological statistics derived from precipitation Hovmoller diagrams east of the Rockies, but the speed becomes faster than that of the climatological statistics over the Great Plains. The physical explanation for that will be discussed.

Title: Temperature and Moisture Controls on CO2 Flux Dynamics in Northern Peatland Ecosystems

Authors:
Nidhu Jagoda, University of Waterloo
Kelly Tran, University of Waterloo
Linden Fairbairn, University of Waterloo
Nathan Basiliko, Laurentian University
Pascale Roy-Léveillée, Laurentian University
Fereidoun Rezanezhad, University of Waterloo

***Correspondence:** njagoda@edu.uwaterloo.ca

Keywords:
Soil Respiration, Peatlands, Carbon Cycling, Winter Processes

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; (Big) data science and management

Abstract:
Climate change-driven warming in the northern peatlands is occurring at alarming rates today, with surface air temperatures increasing more than twice as fast as the rest of the planet, and with the greatest warming occurring during the winter. The northern peatlands are immensely valuable ecosystems that store huge amounts of carbon (C) from the atmosphere, however, with the onset of global warming, they have the potential to turn into active C sources. There is also concern over how rapidly rising temperatures will affect soil C effluxes in northern peatlands, largely balanced by C uptake currently, and any resulting perturbation to this balance. The carbon dioxide (CO2) emissions during the non-growing season (NGS; fall, winter, spring) are expected to increase as the climate warms. However, there is large uncertainty in estimates of current NGS CO2 emissions from northern peatlands. The main objective of this study was to evaluate the effects of temperature and moisture variations on CO2 dynamics in sub-arctic peatlands, in both permafrost and non-permafrost peatland ecosystems. Peat samples were collected from different depths of active soil layers and a series of factorial soil respiration batch experiments were conducted using an environmental incubator to simulate realistic conditions similar to natural freeze-thaw cycles during the NGS in sub-arctic regions. Data collection revolved around the response of CO2 fluxes to dynamic soil temperatures (-10°C–35°C) and moisture contents (20%-100% saturation). The data from this study allowed for the visualization of trends involving CO2 flux drivers and processes, which in turn will allow further insight into the effects of future global warming on northern peatland C stocks. The ultimate goal of this project is to enable the development of more accurate models and predictions regarding the vulnerability of Canadian peatland stocks to global warming and provide data to inform more accurate estimates for the Carbon Budget Model.

Title: Response of the Soil Microbial Community under Variable Winter and Fertilizer Conditions

Authors:
Grant Jensen, University of Waterloo
Konrad Krogstad, University of Waterloo
Fereidoun Rezanezhad, University of Waterloo
Laura Hug, University of Waterloo

***Correspondence:** grant.jensen@uwaterloo.ca

Keywords:
Frozen soils, Soil microbiology, Agriculture, Biogeochemistry, Fertilizer

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Microbial activity in soil persists under snow and ice throughout winter, before reaching its apex during thaw events. With winter climate warming, the upper layer of soils will experience colder temperatures as snowpack insulation is lost. Consequently, soils and their microbial communities will undergo a higher frequency of freeze-thaw cycles (FTCs). Impacts to activity and bulk changes to microbial community structure under winter and freeze-thaw conditions have been identified, and our previous work using the soil column experiments indicated a significant increase to observed bacterial diversity following FTCs. However, we still lack a wholistic account of the microbial community response to different winter conditions, including metrics of microbial composition, biomass, and activity changes over the course of the entire non-growing season. The objectives of this study were two-fold. First, examine the impact of FTCs on the efficacy of pre-winter fertilizer amendments with and without nitrification inhibitors. A higher frequency of thaw events may hasten microbial consumption of fertilizer, resulting in decreased efficacy come the spring, and the success of inhibitors has not been tested at higher FTC frequencies. Second, investigate the impact of variable winter and fertilizer conditions on the microbiome. Our approach will decouple microbial activity from cellular abundance, allowing a precise determination of the changes to microbial community composition. In this study, we used agricultural soil to perform a series of factorial batch experiment simulating the upper (0-15 cm depth) soil layer across variable temperature (thawed, frozen, and freeze-thaw cycling) and fertilizer (unfertilized, fertilized, and nitrification-inhibited with fertilizer) conditions. Our microbial analyses included high-throughput community composition profiling, total microbial carbon and nitrogen biomass, and respiratory monitoring of CO_2 and CH_4. These analyses are coupled to metrics of soil geochemistry and nutrient availability to assess the changing environment that acts as a selective pressure on the soil microbial community. This study will determine the specific development of the soil microbiome through the winter, clarify microbial impacts on biogeochemical cycling, and provide end-users with concrete information on the impacts of winter freeze-thaws on agricultural best-practices for fertilization.

Title: Proposed research: Plant Recovery and Wildlife Return to the Boreal Forest after Fire

Authors:
Alexis Jorgensen, Wilfrid Laurier University
Jennifer Baltzer, Wilfrid Laurier University
Andrew Spring, Wilfrid Laurier University

***Correspondence:** jorg0030@mylaurier.ca

Keywords:
Fire, Boreal Forest, Plant Recovery, Wildlife, Succession

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Climate change is expected to cause an increase in both the frequency and severity of wildfire in Canada's Northwest Territories (NWT). There is uncertainty about how this will influence landscape change and, as a result local food security. Animal species show varying responses to fire. Moose often favour burn sites, particularly those 11 – 30 years old, due to the presence of deciduous forage. Caribou, conversely, avoid burnt areas due to increased predation risk and destruction of lichen food resources. The impacts of increased burning in the boreal forest are of concern to both local communities who rely on wild food for subsistence, and NWT wildlife managers. Though several researchers have examined boreal plant recovery from 1-15 years following fire, there is little information available on vegetation recovery and use of burn areas by animals over the long term. My proposed project will address these knowledge gaps through the following objectives: 1. Development of a long-term timeline of plant recovery in the NWT boreal forest following fire 2. Using this timeline to predict when different animals are likely to use a burned area.
Vegetation data collected from 268 burn sites from 5 - 275 years old will be used to characterize trends in plant abundance for different species over time. Plant species of interest will be selected based on their value as forage for wildlife and input from local communities. The developed timeline will then be used to predict when animals are likely to use a burned area based on the availability/abundance of favoured forage. This project will also include significant community engagement. I will spend much of the summer of 2020 in the village of Kakisa in the NWT. I will take community members to local monitoring sites, presenting my research methods and inviting them to share their knowledge of plant and animal use of local burns. In addition, I will train interested community members in vegetation surveys, allowing KTFN to establish their own monitoring program.
This research will contribute to a wider understanding of the influence of fire on the boreal forest and resulting impacts on food security in the face of climate change. Results are intended to be of use to both local communities, who may be required to anticipate and adapt to the implications of an intensified fire regime, and wildlife managers charged with the effective conservation of wildlife habitat.

Title: Exploring the Morphology and Evolution of Supercell Thunderstorms over the Canadian Prairies under Current and Future Climate Conditions

Authors:
Mostofa Kamal, University of Saskatchewan
Dr. Yanping Li, University of Saskatchewan
Dr. Zhenhua Li, University of Saskatchewan

***Correspondence:** mostofa.kamal@usask.ca

Keywords:
Extreme Precipitation, Supercells, Thunderstorm, Convection, WRF Model

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Supercells are considered as the most violent thunderstorm having rotating updraft that persists for a couple of hours. Supercells generate strong wind, golf ball size hail, and occasionally trigger flash-flooding. Supercell storms are infamous for triggering violent tornadoes, which causes widespread damage to property and takes lives. According to Environment and Climate Change Canada, Canada is warming at twice the global average. Warmer temperature affects precipitation characteristics (e.g., rate, frequency) more significantly than total precipitation. Globally, the frequency and intensity of extreme precipitation events have already increased and are expected to rise in the future under enhanced greenhouse gas emissions and climate change scenarios. Thus, this study explores the morphology and evolution of supercell thunderstorms by analyzing simulated supercell case studies over the Canadian Prairies. This study investigates whether the ratio of convective and stratiform precipitation and tornadic to non-tornadic storms change from current levels. How will cloud kinematics and microphysical processes change? The main goal is to explore the impacts of climate change on future supercell thunderstorms. A quantitative analysis of pseudo global warming (PGW) projection against retrospective simulation (CTL) indicates that many severe weather indices, including convective available potential energy, deep layer (0-6km) shear, and boundary layer mixing ratios show higher value under future climate conditions compared to the current climate. These environmental conditions favor supercell development with increased strength, larger size, and lower translation speed. Further, idealized supercell thunderstorms are simulated with the Weather Research and Forecasting (WRF) Model using environmental soundings from PGW and CTL simulations. The idealized simulation illustrates the three-dimensional structure of a supercell and allows us to understand the initiation, organization, and dissipation of various convective cells within a supercell. It is found that the thermodynamic mechanism plays a crucial role in increasing future storm severity. A preliminary comparison of idealized simulations shows that supercell under warmer climate conditions exhibits stronger updraft and faster rotational speed, which results in more precipitation total compared to the current climate. Further analyses will be presented in the meeting.

Title: The Impacts of Winter Soil Processes on Nitrification Inhibitor Effectiveness in Fertilized Agricultural Soils

Authors:
Konrad Krogstad, University of Waterloo
Grant Jensen, University of Waterloo
Laura Hug, University of Waterloo
Mehdi Gharasoo, University of Waterloo
Fereidoun Rezanezhad, University of Waterloo

***Correspondence:** kjkrogstad@uwaterloo.ca

Keywords:
Frozen Soils, Biogeochemistry, Agriculture, Climate Change

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
High-latitude cold regions are warming more than twice as fast as the rest of the planet, with the greatest warming occurring during the winter. Warmer winters are associated with shorter periods of snow cover, resulting in more frequent and extensive soil freezing and thawing. Freeze-thaw cycles influence soil physical, chemical, and biological properties, significantly impacting soil nutrient dynamics. These impacts are critical in agroecosystems, where agricultural activities can severely alter nearby water flows and quality. In a soil column experiment conducted as part of this project, high nitrate concentrations (~150 mg l-1) were observed in fertilized soil column leachates following a transition from a deep freeze to thaw, despite low nitrate concentrations in the applied artificial rainwater and fertilizer. A sacrificial soil jar batch experiment was conducted to better understand the biogeochemical processes of nitrate leaching under winter conditions and determine whether nitrification inhibitors would reduce fertilizer loss under winter conditions. Jars containing agricultural soil were saturated with artificial porewater and divided across three fertilizer conditions (fertilized, unfertilized, and fertilized with nitrification inhibitors) and three temperature conditions (4°C, -10°C, and alternating between 4 and -10°C). CO2 and CH4 effluxes from representative soil jars were measured continuously over the course of the experiment. Porewater samples were also extracted from the soil samples for dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), total nitrogen (TN), major anions, major cations, and pH. In this presentation, we will present the results from the soil column and batch experiments as well as numerical modeling simulating the biogeochemical transformations of nitrogen and carbon in agricultural soils under winter conditions.

Title: Stable water isotopes identify plant-atmosphere interactions and source water in Rocky Mountain subalpine forests

Authors:
Lindsey Langs, University of Saskatchewan
Richard Petrone, University of Waterloo
John Pomeroy, University of Saskatchewan

***Correspondence:** lindsey.langs@usask.ca

Keywords:
subalpine forest, isotopes, source water, mountains

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
Subalpine forests are hydrologically important to the function and health of mountain watersheds. Identifying the specific water sources and the proportions used by subalpine forests is necessary to understand potential impacts to these forests under a changing climate. The recent 'Two Water Worlds' hypothesis suggest that trees can favour tightly bound soil water instead of readily available free-flowing soil water. Little is known about the specific sources of water used by subalpine trees Abies lasiocarpa (Subalpine fir) and Picea engelmannii (Engelmann spruce) in the Canadian Rocky Mountains. In this study, stable water isotope (δ18O and δ2H) samples were obtained from Subalpine fir and Engelmann spruce trees at three points of the growing season in combination with water sources available at time of sampling (snow, bound soil water, saturated soil water, precipitation). Using the Bayesian Mixing Model, MixSIAR, relative source water proportions were calculated. In the drought summer examined, there was a net loss of water via evapotranspiration from the system. Results highlighted the importance of tightly bound soil water to subalpine forests, providing insights of future health under sustained years of drought and net loss in summer growing seasons. This work builds upon concepts from the 'Two Water Worlds' hypothesis, showing that subalpine trees can draw from different water sources depending on season and availability. In our case, water use was largely driven by a tension gradient within the soil allowing trees to utilize tightly bound soil water and saturated soil water at differing points of the growing season.

Title: Late Summer Precipitation and Dissolved Organic Carbon May Facilitate the Export of Metal/Metalloid pollutants From Legacy Mining Pollutant-Affected Peatlands

Authors:
Jeremy G Leathers, Wilfrid Laurier University
Jason J Venkiteswaran, Wilfrid Laurier University
Michael C English, Wilfrid Laurier University
Sherry L Schiff, University of Waterloo
Pieter JK Aukes, Wilfrid Laurier University
Mackenzie DJ Schultz, Wilfrid Laurier University

***Correspondence:** leat4040@mylaurier.ca

Keywords:
Peatlands, Metal Mobility, Hydrology, Water Isotopes, Northwest Territories

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
Giant Mine, located near Yellowknife, Northwest Territories (NWT), released a large amount of arsenic and other metals/metalloids into the atmosphere during the initial phase of its operation. These contaminants were then deposited across the surrounding landscape and many of these pollutants have persisted in the environment. Due to the ubiquity of peatlands in the NWT and their function as an interface between aquatic and terrestrial environments, this research focused on temporal changes in the porewater chemistry of peatlands in the Yellowknife area. We selected three representative lake-associated peatlands and instrumented them with piezometers for collection of porewater samples. As expected, porewater arsenic concentrations were much higher in the peatland nearest to the emission source than those further away. Porewater arsenic concentrations remained low and relatively stable throughout the summer in flatter, more open peatland sites. However, in a black-spruce dominated bedrock ravine site, typical of wetlands that drain uplands down to lowlands, arsenic was higher than in the surrounding sites. However, arsenic concentrations in the bedrock ravine decreased rapidly at the end of August. Overall there is a moderate linear relationship between dissolved organic carbon and arsenic in the porewaters. It appears that late summer precipitation events could provide an important pulse of arsenic in mining pollutant-affected peatlands and facilitate its export into adjacent water bodies. Further, dissolved organic carbon may play an important role in binding and exporting arsenic. It is anticipated that the Yellowknife area will experience increases in late summer precipitation and dissolved organic matter in the coming decades. If so, it is possible that peatlands, such as our bedrock ravine, could act as a source of legacy metal pollutants to downstream water bodies.

Title: Quantifying vegetation change in Wolf Creek, YT through fusion of remotely sensed data

Authors:
Sean C. Leipe, McMaster University
Dr. Sean K. Carey, McMaster University

***Correspondence:** leipes@mcmaster.ca

Keywords:
LiDAR, Vegetation, Change detection, Remote sensing, Data fusion

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
High-latitude ecosystems have experienced substantial warming over the past 40 years, which is expected to continue into the foreseeable future. Consequently, an increase in vegetation growth has occurred throughout the circumpolar North as documented through remote sensing and plot-level studies. A major component of this change is shrub expansion in arctic and subarctic ecotones. Changes in shrubs and other vegetation are critical to document due to their first-order controls on water, energy and carbon balances. Understanding these changes is critical for predicting the future of northern watersheds under a rapidly changing climate. This work uses a combination of LiDAR, optical imagery, and field methods to measure temporal changes in vegetation properties in the well-studied subarctic montane Wolf Creek Research Basin. Terrain indices are used for quantitative comparisons of vegetation change over different landscape positions. LiDAR-derived vegetation models of the study area exhibit high accuracy compared to field metrics and show clear increases in shrub coverage between 2007 and 2018 surveys. Results from this study will help: 1) quantify the rates of vegetation change in an alpine subarctic ecosystem, and 2) link these changes to ecotone and landscape properties such as elevation, aspect, and other topographic indices.

Title: Snowflake particle trajectory in complex terrain using a computational fluid dynamics model

Authors:
Nicolas R. Leroux, Université du Québec à Montréal
Julie M. Thériault, Université du Québec à Montréal
Aurélie Desroches-Lapointe, Université du Québec à Montréal

***Correspondence:** leroux.nicolas_romain@uqam.ca

Keywords:
Snowflat particle trajectory, Preferential deposition, Complex terrain, Computation fluid dynamics modelling

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
The timing and magnitude of snowmelt, as well as the surface-atmosphere energy fluxes, are in part controlled by the snowpack spatial heterogeneities. The spatial variability in snow cover depletion results from spatial heterogeneities in both snow accumulation and melt energy inputs. However, the processes controlling the small-scale heterogeneities during the snow cover accumulation, such as preferential deposition, are either neglected or poorly represented in land surface models. In this study, a computational fluid dynamics model is applied to estimate particle trajectory of solid precipitation over complex terrain. The model solves for the Reynolds-averaged Navier-Stokes equation coupled with a stochastic Lagrangian algorithm for particle trajectory. The model was first evaluated against observed dust deposition over an isolated hill from wind tunnel studies. The model was then applied to estimate snowflake trajectory over an isolated hill and preferential deposition was quantified for different crystal types based on different vertical wind profiles at the inlet and hill characteristics, such as slope angles and height. A simulation of snow particle trajectory over a large mountainous domain (about 1 km x 8 km) is presented and snow deposition was quantified based on terrain topography. Future work will use the results from this physically-based model to develop a simpler parametric model that can be used in land surface models for predicting snow deposition during winter storms on the ground.

Title: High-Resolution Regional Climate Modeling and Projection over Western Canada using a Weather Research Forecasting Model with a Pseudo-Global Warming Approach

Authors:
Yanping Li, University of Saskatchewan
Zhenhua Li, University of Saskatchewan

***Correspondence:** yanping.li@usask.ca

Keywords:
Convection-permiting regional climate simulation, WRF, pseudo-global warming

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Climate change poses great risks to western Canada's ecosystem and socioeconomical development. To assess these hydroclimatic risks under high-end emission scenario RCP8.5, this study used the Weather Research Forecasting (WRF) model at a convection-permitting 4 km resolution to dynamically downscale the mean projection of a 19-member CMIP5 ensemble by the end of the 21st century. The WRF 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. The retrospective WRF-CTL's surface air temperature simulation was evaluated against ANUSPLIN, showing good agreements with cold biases east of the Rockies, especially in spring. WRF-CTL captures the main pattern of observed precipitation distribution from CaPA and ANUSPLIN but shows a wet bias near the BC coast in winter and over the immediate region on the lee of the Rockies. The WRF-PGW shows significant warming relative to CTL, especially over the polar region in the northeast during the cold season. 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 SRB and southern Prairies, the precipitation change is negligible or decreased slightly. With almost no increase in precipitation and much more ET in the future, the water availability during the growing season will be challenging for the 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 Rockies may underestimate the increase in flooding risk and water shortage for agriculture. These simulations provide abundant opportunities both for investigating local-scale atmospheric dynamics and for studying climate impacts on hydrology, agriculture, and ecosystems.

Title: The Impact of Landuse Change on Precipitation in Western Canada Simulated by a Convection-Permitting Regional Climate Model

Authors:
Zhenhua Li, University of Saskatchewan
Yanping Li, University of Saskatchewan
Zhe Zhang, University of Saskatchewan
Alan Barr, Environment and Climate Change Canada

***Correspondence:** zhenhua.li@usask.ca

Keywords:
Landuse change, Precipitation

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Climate change in the Northern Hemisphere high latitudes are more prominent compared to other regions due to polar amplification. Accompanying the significant warming and the increase of the length of growing season is the expansion of agriculture activity to the northern Canadian Prairies and northward shift of the boreal forest biome by the end of century. To understand the projected land use changes' impact on the regional climate over the Canadian Prairies provinces, we conducted a set of simulations including a control simulation with current climate and landuse, a RCP8.5 pseudo-global warming simulation, and a simulation with RCP8.5 climate forcing and projected changes in land-use with high-resolution convection-permitting WRF. The changes due to the global warming and those due to landuse change are investigated through cross comparison with simulations with current landuse distribution and projected landuse distribution in a high-end emission scenario RCP8.5 by the end of 21st century. Landuse change moderately change the surface air temperature, land-surface atmosphere exchange, and precipitation statistics. Landuse change, especially in regions with significant replacement of wooded tundra by forests, can significantly change the precipitation intensity distribution and initiation of convection in summer. The conversion grassland to forest at the fringe of current boreal forest would also change the seasonal cycle of precipiation over the region.

Title: Future projection of extreme wind events for Canada using convection-permitting climate model

Authors:
Xiao Ma, University of Saskatchewan
Yanping Li, University of Saskatchewan

***Correspondence:** xiao.ma@usask.ca

Keywords:
climate change, extreme events, convection-permitting model

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The near-surface winds are expected to be modified due to climate change in the future, thereby the spatial and temporal distributions of extreme wind events on a regional scale will be altered. Canada is a high-latitude country, which will experience warming at a higher rate than the global average. Analyzing accurately the features of Canadian extreme wind events, especially in the future projections, is helpful to offer scientific references to policymakers. The high-resolution regional climate model is a powerful tool to access precise prediction of extreme wind events, as it describes the characteristics in the orographically complex area well and provides information of near-surface winds.
This study uses 4-km convection-permitting Weather Research Forecasting (WRF) model simulation CONUS which include a historical simulation (CTRL) for 13 years (2001-2013), and a future climate simulation of the end of the 21 century under RCP 8.5 scenario using Pseudo Global Warming (PGW) method. The study domain covers the southern part of Canada (south of 56N). The extreme wind events defined using the winds of different heights is analyzed, and compared between these two simulations to show the possible altering of extrme wind events under future climate conditions.

Title: The Runoff Model-Intercomparison Project over Lake Erie and the Great Lakes

Authors:
Juliane Mai, University of Waterloo
Bryan A Tolson, University of Waterloo
GRIP-E/GL Project Team

***Correspondence:** juliane.mai@uwaterloo.ca

Keywords:
Lake Erie, Great Lakes, Model inter-comparison, Model calibration

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
The Great Lakes Runoff Inter-comparison Project (GRIP) includes a wide range of lumped and distributed models that are used operationally and/or for research purposes across Canada and the United States. Participating models are GEM-Hydro, WRF-Hydro, MESH, VIC, WATFLOOD, SWAT, mHM, Noah-MP, HYPE, LBRM, GR4J, HMETS, and purely statistical models. The latter are added to assess the information content of the forcing and geophysical datasets. As part of the Integrated Modelling Program for Canada (IMPC) under the Global Water Futures (GWF) program, the project is aiming to run all these models over several regions in Canada. We started with the Lake Erie watershed and then extended the study to the whole Great Lakes domain.
One of the main contributions of the project is that we identified a standard dataset for model building that all participants in the inter-comparison project can access and then process to generate their model-specific required inputs. The common dataset allows identifying differences in model outputs that are solely due to the models and not the data used to setup the models. This presentation will give an update on the design of the inter-comparison and will report on comparative results for two sets of streamflow gauging stations: A) gauge stations with low-human impact upstream watersheds and B) most down-stream gauge stations directly draining into the lake(s).
The main results are: 1) The best performing semi-distributed model calibrated across all stations at once is HYPE. The mHM is the best distributed model calibrated at each station individually (median NSE = 0.78) while LBRM is the lumped model that is on average the best (median NSE = 0.66). 2) The purely statistical model is highly competitive with and even slightly outperforming all hydrologic models except mHM in the calibration period. 3) The performance of most models decreases in urbanized areas. Only models that are calibrated independently at each station are capable of modelling urbanized areas. 4) No significant change in performance can be observed between low-human impact watersheds and watersheds that are mostly downstream, draining directly into a Great Lake.

Title: What is the Role of Groundwater in a Changing Arctic ?

Authors:
Jeffrey M. McKenzie, McGill University
Barret Kurylyk, Dalhousie University
Laura Lyon, McGill University

***Correspondence:** jeffrey.mckenzie@mcgill.ca

Keywords:
Groundwater, Permafrost, Arctic, Water Resources

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
Our knowledge of changing Arctic hydrologic systems associated water resources due to climate change is based on data collected at or near the land surface from field studies or remote sensing observations. While these studies yield extremely valuable information about transformations in surface water and ground ice distribution, river discharge, and soil moisture, the underpinnings of many of these water-related changes are underpinned by changing hydrogeologic conditions. Thawing of ancient permafrost is opening and creating new subsurface pathways for groundwater flow, thereby altering fluxes and distribution of water, energy, and solutes. We identify different ways that these changes impact Northern society, including the potential for increased contaminant transport, modification to water resources, and enhanced rates of infrastructure (e.g. buildings and roads) damage. Further, as permafrost thaws it allows groundwater to transport carbon and nutrients from terrestrial to aquatic environments via progressively deeper subsurface flowpaths. Groundwater has the potential to catalyze hydrologic change in the Arctic and is a critical component of the narrative of how the Arctic will respond to climate change. This presentation describes the need for cryohydrogeology, the study of groundwater in cold regions, within transdisciplinary Northern research initiatives, including case studies.

Title: Tree rings show strong coherence with eddy covariance fluxes and drought indices in an age sequence of pine forests

Authors:
Shawn M McKenzie, McMaster University
Michael Pisaric, Brock University
Altaf Arain, McMaster University

***Correspondence:** mckenzsm@mcmaster.ca

Keywords:
tree rings, regression models, eddy covariance, drought impacts, forest ecosystems

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
The inherent inter-annual variability in carbon sequestration is important to improve our understanding of the forest carbon cycle. The utilization and integration of different techniques improve our understanding of key controls on forest carbon exchanges to determine uncertainty in their carbon budgets. Eddy covariance (EC) techniques evaluate ecosystem carbon cycle dynamics between forest canopies and the atmosphere by quantifying total carbon gains (gross ecosystem productivity, GEP) and the change in carbon stocks (net ecosystem productivity, NEP). Tree ring methods are a technique to estimate carbon sequestration for individual trees and provide an assessment of forest productivity. Past studies that have attempted to link tree ring growth with EC productivity measures have produced inconsistent results as NEP and GEP time series are often too short. In this study, we construct three relatively long (14-year) tower-based EC time series (GEP and NEP) from an age sequence (15, 42 and 78 year old) of pine forests in the Great Lakes region in eastern North America from 2003 to 2017. These EC fluxes were compared with tree ring chronologies to examine if tree growth records derived from tree rings capture the dynamics of ecosystem-scale productivity. We found that tree ring growth in these different age pine stands were significantly (p < 0.05) correlated with annual value of GEP, while this correlation was not strong with annual values of NEP. Based on the coherence between tree ring growth and EC-based measures of productivity, linear models were developed for all three stands to reconstruct GEP from tree ring measures. While tree ring measures alone were generally sufficient to reconstruct GEP, the magnitude of variance between the two metrics differed during years of moderate drought. During moderate drought, the tree ring metric underestimated the EC metric of GEP. We interpret the difference to a shift in tree priority of carbon assimilates to other areas of the tree to repair drought damage, as well as increases in water use efficiency. The value of this study is the availability of long EC and ring width records from different-aged forests in the same geographic region. This study contributes to the characterization of different modes of productivity in different-age forest in eastern North America using combined techniques and examines how these different age forests may respond to shifts in climate.

Title: Spring Freshet & Channelization Processes in a Sub-Arctic Catchment, NWT.

Authors:
Thomas Misztela, Wilfrid Laurier University
Philip Marsh, Wilfrid Laurier University

***Correspondence:** misz4460@mylaurier.ca

Keywords:
Spring Freshet, Runoff, Peak Flow

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
The spring melt period signifies the start of a dramatic annual change in the continuous permafrost landscapes of Northwestern Canada. The objective of this study was to characterize and observe the hydrological changes occurring in a stretch of stream channel located near the Trail Valley Creek research station, approximately 43 kilometers North of Inuvik in the Northwest Territories. Snow surveys and drone flights were conducted in the stream channel and surrounding watershed prior to snow melt in April and May of 2019. These surveys were carried out in order to characterize the snow conditions within the stream course prior to freshet. Twelve snowpit surveys were also excavated in the stream channel in order to document the variability of snow entrenchment and snowpack densities along the study area. A HOBO pressure transducer was placed at the base of each snowpit so that a documentation of water levels could be observed during the melt period. Flowtracker measurements were also conducted within the main stream channel until deemed too hazardous and daily along three smaller tributaries during peak flow. The findings from this study are meant to help characterize the poorly understood hydrologic and channelization processes occurring in a remote sub-Arctic watershed.

Title: Fire-impacted versus unimpacted ephemeral pools in eastern Georgian Bay: portents of climate change?

Authors:
Danielle Montocchio, McMaster University
Nick Luymes, McMaster University
Prabha Rupasinghe, McMaster University
Patricia Chow-Fraser, McMaster University

***Correspondence:** montocds@mcmaster.ca

Keywords:
forest fire, climate change, water quality, ephemeral pools

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Forest fires are a natural and necessary disturbance in Canada's Boreal forests, in order to recycle nutrients, and increase overall forest biodiversity. Climate change, however, is changing this fire regime, through increased fire frequency, intensity, and duration. In the summer of 2018, central Ontario experienced a severe forest fire, the Parry Sound Fire 33, that was unprecedented both in terms of its extent and severity. This wildfire began in mid-July on the Henvey Inlet First Nation Reserve and expanded north to portions of the Key River and French River drainages, covering an area of 114 km2 by the time it was extinguished in late October. The fire was so intense that it burned the vegetation as well as the organic soils in parts of the landscape, leaving ashes and bare rock. The burn zone consisted of 21.56 km2 of high, 63.25 km2 moderate and 15.79 km2 of low severity burn. During the spring of 2019, we collected water samples from 20 temporary pools that had formed in the scar of the fire. We also collected water samples from comparable vernal pools found in unimpacted forests south of Parry Sound. On average, levels of total phosphorus, total nitrogen and total-nitrate nitrogen were 15, 3 and 75 times higher in impacted compared to unimpacted pools. Mean chlorophyll-α concentrations in fire-impacted pools were 88.39 µg/L and included dense algal blooms. Whereas many of the unimpacted pools had a community of amphibians and benthic invertebrates, the impacted pools lacked amphibian and reptile life, and by July, at least half of the pools had dried up. We observed a rapid transition from bare ground in spring to approximately 70% ground cover, including Northern cranesbill (Geranium bicknellii), fern species and fireweed (Chamaenerion angustifolium), on the surrounding landscape. Tracking the ecological recovery of these pools will help us better understand the magnitude of impact that forest fires can exert on the ecology of vernal pools.

Title: Characterization of open-water flooding using water-level loggers, a poorly recognized lake recharge process in the Athabasca Delta

Authors:
Laura Neary, University of Waterloo
Casey Remmer, University of Waterloo
Jadine Krist, University of Waterloo
Brent B. Wolfe, Wilfrid Laurier University
Roland I. Hall, University of Waterloo

***Correspondence:** lkneary@uwaterloo.ca

Keywords:
Lakes, Flooding, Delta

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Turning research into policy and management solutions

Abstract:
The Peace-Athabasca Delta (PAD; northern Alberta) is a complex northern freshwater landscape recognized as a Ramsar Wetland of International Importance, within Wood Buffalo National Park, a UNESCO World Heritage Site. The PAD contains hundreds of small, shallow lakes that provide important ecosystem services, including habitat for wildlife and navigation for land users. Persisting concerns over declining lake water-levels motivated a petition by the Mikisew Cree First Nation to enlist Wood Buffalo National Park as a UNESCO World Heritage Site 'In Danger'. Response to these concerns prompted inter-jurisdictional participation, a strategic environmental assessment and recommendations by UNESCO which collectively informed a 2019 Federal Action Plan. A key theme of the Action Plan is 'to establish a monitoring regime that tracks the trends of hydrological conditions' to inform adaptive management and maintain hydrological integrity of the PAD. While much attention has been focused on frequency and cause of ice-jam flooding in the Peace-Athabasca Delta, open-water flooding in the Athabasca Delta remains poorly characterized in terms of extent, magnitude and timing. Here, we provide evidence of open-water flooding in the Athabasca Delta using continuous measurements of lake water-levels at ~30 lake sites during 2018 and 2019. Collection of these high-resolution measurements helped pinpoint the timing and duration of flooding, yielding important predictive information for determining future flood susceptibility. Results also provided the means to assess lake water-level responses to spring ice-jam flooding (2018), precipitation and evaporation. Characterizing areas susceptible to open-water flooding and areas prone to drying in the Athabasca Delta is important considering effects of climate change on Athabasca River discharge, potential reduction in frequency of open-water floods, and to inform local communities about change to previously navigable channels.

Title: Characterization of water resource vulnerability to climate change in the Whooping Crane breeding area (Wood Buffalo National Park) using contemporary and paleolimnological approaches

Authors:
Laura Neary, University of Waterloo
Hannah Thibault, University of Waterloo
Brent B. Wolfe, Wilfrid Laurier University
Roland I. Hall, University of Waterloo

***Correspondence:** lkneary@uwaterloo.ca

Keywords:
Lakes, Isotopes, Paleolimnology, Hydrology, Wetlands

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
The Whooping Crane (Grus americana) is a critically endangered species whose small population is threatened by potential climate-driven changes to wetland habitat. The only breeding area in North America lies within northern sectors of Wood Buffalo National Park where wetlands are abundant. While it is known that drought negatively affects their production and increases risk to predation, and water-level rise can decrease reproductive success by flooding of nests along shorelines, insufficient knowledge of the hydrology of this wetland-rich landscape hampers ability to anticipate how climate change will affect Whooping Crane. To address this knowledge gap, we plan to use both contemporary (water isotope tracers, water-level loggers, limnological surveys) and paleolimnological methods to assess current and past hydrological conditions of lakes in the Whooping Crane nesting area. The spectrum of approaches will encompass spatial and temporal dimensions needed to inform potential vulnerability and responses of the wetlands to climate change. Research will contribute directly to addressing a recommendation made by UNESCO to “Continue to closely monitor the entire used and potential nesting area of the Whooping Crane within the Greater WBNP Ecosystem so as to be able to respond to possibly changing management requirements” [WHC/IUCN 2017, p.5] and to implementation of the 2019 Wood Buffalo National Park Action Plan.

Title: Physiological and environmental controls on evaporative partitioning across a gradient of altitudes and vegetation covers in a subarctic, alpine catchment, Yukon, Canada

Authors:
Erin M Nicholls, McMaster University
Gordon B. Drewitt, McMaster University
Sean K. Carey, McMaster University

***Correspondence:** nicholem@mcmaster.ca

Keywords:
Evapotranspiration, Sap Flow, Climate Change

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Widespread changes in vegetation composition, density and distribution are reported across northern, alpine catchments as a result of altitude and latitude amplified impacts of climate change. Quantification of evapotranspiration (ET) across a range of vegetation units spanning thermal gradients is critical to predicting water yield from northern and alpine catchments, yet challenging due to complex environmental and phenological controls on transpiration (T). To date, the partitioning of T from total ET has been limited, specifically over large scales and in heterogeneous, mountain environments. Here, we assess the influence of vegetation structure, meteorological, phenological and soil controls on ET dynamics and partitioning within and among three sites in a subarctic, alpine catchment near Whitehorse, Yukon. These sites span a gradient of thermal and vegetative regimes, providing a reasonable space-for-time comparison as ecosystems shift in the future: 1) a low-elevation boreal white spruce forest (~20 m canopy), 2) a mid-elevation subalpine taiga comprised of willow (Salix) and birch (Betula) shrubs (~1-3 m canopy) and 3) a high-elevation subalpine taiga with shorter willow and birch cover (< 0.75 m) and moss, lichen, and bare rock cover. Eddy covariance and sap flow sensors ran year-round at the forest on white spruce, and during the growing season at the mid-elevation subalpine site on both willow and birch shrubs for a minimum of two years. Surface resistance was measured with a porometer and calculated using a Penman Monteith framework and compared with timing of T. Total seasonal evaporative losses were greatest at the forest, followed by mid- and high-elevation subalpine taiga sites respectively. Stomatal resistance showed distinct seasonal patterns, becoming an increasingly dominant control on total ET gradually in spring at the forest site. T was primarily driven by net radiation and vapour pressure deficit at all sites, with varying species-specific responses to soil moisture. As projections of climate change predict increased air temperature and changing precipitation regimes at high latitudes, the role of vegetation in water and energy partitioning will become increasingly important and needs to be properly incorporated into our prediction frameworks. These results indicate that changes in vegetation will have a potentially large impact on water partitioning across this sparsely observed, heterogeneous, alpine landscape.

Title: Impacts of climate change on the boreal forest's resilience to wildfire

Authors:
Emily Ogden, Wilfrid Laurier University
Jennifer Baltzer, Wilfrid Laurier University
Steven Cumming, Université Laval

***Correspondence:** ogde9440@mylaurier.ca

Keywords:
Boreal forest, Wildfire, Resilience, Climate change, Tree regeneration

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
Northern latitudes are experiencing rates of warming that are four times greater than the global average. This has resulted in changes to the fire regimes, characterized by increased frequency and severity of wildfires. While wildfire is a fundamental component of most northern ecosystems, recent changes in climate are likely to decrease the resilience of forested ecosystems, making them more vulnerable to disturbance induced conversion in vegetation type. Instances of these vegetation shifts are already being observed. However, very little is known about the causes and extent of these vegetation conversions. My research investigates the questions of if and how the frequency of vegetation type conversion has changed, and what are the primary drivers of vegetation type conversion. Using a combination of field data and aerial photographs I will quantify the extent to which forest stands in the Northwest Territories, Canada have undergone changes in vegetation type after wildfire. A sample of 413 plots with burn dates ranging from 1969 to 2014 will be used. Ground surveys have been conducted at each plot, from which I can determine the stand composition of each species at the time of the survey. Historical aerial photographs will be interpreted to quantify the stand composition of each species at each plot before the last known wildfire. Hierarchical partitioning will be used to quantify the independent contributions of potential explanatory variables, ranging from the timing of climatic conditions relative to disturbance events, to characteristics of each plot. A classification tree will be used to explore the interactions between variables. By May 2020, I aim to have quantified the extent of vegetation type conversion after wildfire. My research will lead to a better understanding of the impacts of climate change on the trajectories of Canada's northern boreal forest, and help with adaptation planning by improving forecasts of future conditions.

Title: Functional and structural traits coordination reveals trade-offs in boreal species resource allocation and use

Authors:
Christoforos Pappas, Université de Montréal
Oliver Sonnentag, Université de Montréal
Katherine M. Standen, Wilfrid Laurier University
Nia Perron, Université de Montréal
Matteo Detto, Smithsonian Tropical Research Institute, and Princeton University
Jennifer L. Baltzer, Wilfrid Laurier University

***Correspondence:** christoforos.pappas@umontreal.ca

Keywords:
boreal forest, functional traits, tree structure, plant hydraulics, resource allocation and use

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Black spruce and eastern larch are two widespread boreal tree species with distinct life strategies, crown architecture, and resource use. Black spruce is a slow growing late successional species with evergreen phenology, while eastern larch is a fast growing early successional species with deciduous phenology. The crown architecture of black spruce is relatively narrow while eastern larch has wider canopy and lower degree of foliage clumping compared to black spruce. Moreover, the two species display contrasting stomata regulation, with eastern larch being relatively isohydric while black spruce relatively anisohydric. Here, we used a unique dataset across the distributional range of these two tree species to quantify differences in their functional and structural traits and to investigate trade-offs in their resource allocation and use. We analysed the co-variation and inter-specific differences in functional traits (e.g., specific leaf area, SLA; maximum photosynthetic capacity, Amax; water use efficiency, WUE) and structural traits (e.g., tree height, H; projected crown area, CA) collected across a 2000-km latitudinal climate and permafrost gradient in northwestern Canada, spanning from the southern- to the northern-edge of the boreal forest. Our results reveal significant differences in functional traits with black spruce having lower SLA and Amax in comparison to eastern larch. Moreover, WUE, quantified with instantaneous needle gas exchange measurements and isotopic data, was lower for black spruce in comparison to eastern larch. Structural traits also varied significantly, with black spruce displaying lower H and CA in comparison to eastern larch. However, no significant interspecific differences were found in their Huber values (HV, i.e., the ratio of xylem sapwood area to the total needle area). To further investigate this pattern, we derived an analytical expression relating HV to the examined functional and structural traits. This framework allowed us to explain trade-offs in HV variability as a result of whole-plant functional and structural traits coordination. HV is a critical parameter that describes tree water transport and resource allocation, since it quantifies tree investments in conductive tissues (xylem) relative to evaporative tissues (foliage). These results shed light on whole-plant traits coordination at the boreal forest and provide novel insight into inter-specific differences in boreal tree species resource allocation and use.

Title: Aboveground tree growth is a minor and decoupled fraction of boreal forest carbon input

Authors:
Christoforos Pappas, Université de Montréal
Jason Maillet, University of Saskatchewan
Sharon Rakowski, Université de Montréal, and Karlsruhe Institute of Technology
Jennifer L. Baltzer, Wilfrid Laurier University
Alan G. Barr, Environment and Climate Change Canada, and University of Saskatchewan
T. Andrew Black, University of British Columbia

***Correspondence:** christoforos.pappas@umontreal.ca

Keywords:
carbon use efficiency (CUE), forest inventories, Larix laricina (eastern larch, tamarack), Picea mariana (black spruce), southern old black spruce (SOBS)

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The boreal biome accounts for approximately one third of the terrestrial carbon (C) sink. However, estimates of its individual C pools remain uncertain. Here, focusing on the southern boreal forest, we quantified the magnitude and temporal dynamics of C allocation to aboveground tree growth at a mature black spruce (Picea mariana)-dominated forest stand in Saskatchewan, Canada. We reconstructed aboveground tree biomass increments (AGBi) using a biometric approach, i.e., species-specific allometry combined with forest stand characteristics and tree ring widths collected with a C-oriented sampling design. We explored the links between boreal tree growth and ecosystem C input by comparing AGBi with eddy-covariance-derived ecosystem C fluxes from 1999 to 2015 and we synthesized our findings with a refined meta-analysis of published values of boreal forest C use efficiency (CUE). Mean AGBi at the study site was decoupled from ecosystem C input and equal to 71 +/- 7 g C m–2 (1999–2015), which is only a minor fraction of gross ecosystem production (GEP; i.e., AGBi / GEP ≈ 9 %). Moreover, C allocation to AGBi remained stable over time, with a temporal trend of near zero (–0.0001 yr–1; p-value=0.775), contrary to significant trends in GEP (+5.72 g C m–2 yr–2; p-value=0.02) and CUE (–0.0041 yr–1, p-value=0.007). CUE was estimated as 0.50 +/- 0.03 at the study area and 0.41 +/- 0.12 across the reviewed boreal forests. These findings highlight the importance of belowground tree C investments, together with the substantial contribution of understory, ground cover and soil to the boreal forest C balance. Our quantitative insights into the dynamics of aboveground boreal tree C allocation offer additional observational constraints for terrestrial ecosystem models that are often biased in converting C input to biomass, and can guide forest-management strategies for mitigating carbon dioxide emissions.

Title: Picea mariana transpiration across a boreal subarctic peatland

Authors:
Nia Perron, Université de Montréal
Christoforos Pappas, Université de Montréal
Jennifer Baltzer, Wilfrid Laurier University
Katherine Dearborn, Wilfrid Laurier University
Oliver Sonnentag, Université de Montréal

***Correspondence:** nia.perron@gmail.com

Keywords:
Sap flow, tree hydraulics, boreal forest, Picea mariana

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
Northwestern Canada's boreal forest is a heterogeneous landscape where vegetation plays a role in the water cycle through tree water storage and transpiration. Transpiration is a process in which water is evaporated through the stomata of vegetation and released into the atmosphere. In the boreal region several factors, including vegetation structure, meteorological variables, and local forest stand and soil characteristics can influence the rate and total volume of transpiration over a given period. As a result, estimations of transpiration in high latitude ecosystems are scarce. In this study, we aimed to identify the factors influencing the transpiration of black spruce (Picea mariana), a coniferous tree species that is widespread throughout the northwestern boreal forest. The 21 hectares (20 m2 grid) plot used for this study is dominated by black spruce and located within a subarctic boreal peatland complex underlain with discontinuous permafrost in the Northwest Territories (61°18'N, 121°18'W). We used the heat-ratio method to determine sap velocity (Vs, cm·hr−1), the movement of water through tree stems, as an indicator of plant water-use and transpiration for eighteen black spruce trees during two consecutive growing seasons (2017 and 2018). The structural characteristics of black spruce individuals, namely diameter at breast height and crown area, had a positive linear impact on mean daily Vs. Meteorological variables including vapor pressure deficit (VPD), photosynthetically active radiation (PAR) and air temperature were the strongest meteorological drivers of black spruce Vs, accounting for 66 and 81% of the variance in daytime mean Vs in 2017 and 2018, respectively. Of the local forest stand and soil characteristics considered, soil nutrient supply rate (phosphorus) and soil water content were the only local environmental variables that had a (positive) influence on black spruce Vs, with effects to the amplitude (seasonal daily maximum) of Vs over the 2018 sampling period. Black spruce dominated peatlands are an important component of northwestern Canada's boreal landscape where permafrost thaw and wetland expansion are altering the hydraulic function of black spruce and local water budgets. With the relationship between Vs and the structural, meteorological, and local environmental variables established, we determined the annual transpiration for black spruce across the entire 21-hectare peatland complex.

Title: Understanding Winter Soil Processes: A Predictive Model of Non-Growing Season CO2 Fluxes from Canadian Peatlands using Machine Learning

Authors:
Arash Rafat, University of Waterloo
Fereidoun Rezanezhad, University of Waterloo
William L. Quinton, Wilfrid Laurier University
Philippe Van Cappellen, University of Waterloo

***Correspondence:** arafat@uwaterloo.ca

Keywords:
Peatlands, Machine Learning, Winter Soil Processes, Predictive Modeling

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; (Big) data science and management

Abstract:
Peatlands have been estimated to store appropriately one-third of all carbon stored within soils. With current climate change predictions showing a disproportionate increase in air temperatures in high-latitude cold regions, northern peatlands are becoming increasingly susceptible to the impacts of climate warming. Under the current and future climatic warming predictions, winter estimates of CO2 fluxes are set to increase by 41% percent under a business-as-usual greenhouse gas emissions scenario as rates of soil organic matter decomposition increase with rising air temperatures. Coupled with net reductions in annual snow cover duration and projected seasonal snow accumulations, a better mechanistic understanding of carbon cycling during the non-growing season (October-April) is needed. In this project, we aim to advance the fundamental and mechanistic understanding of soil carbon cycling during the non-growing season in Canadian peatlands. As a first step, we are developing a site-specific machine learning model to predict changes in the production and sequestration of CO2 under varying winter climatic conditions. This approach is first applied to develop a model based on a 13-year continuous record of meteorological data and computed Eddy Covariance CO2 fluxes at the Mer Bleue site in Ottawa, Canada. The model will then be trained using data collected from Canadian peatland sites across the country to obtain a generalized model to be used in future predictions of peatland carbon cycling processes during the non-growing season on a national scale. In this presentation, we present preliminary results and predictions from the site-specific model of CO2 fluxes under further global air temperature increases (different Representative Concentration Pathways), a decrease in snow accumulation, and a reduction in the duration of the non-growing season. Specifically, we attempt to provide a novel understanding into the impact of varying meteorological variables on the net production or accumulation of carbon during the non-growing season.

Title: Multi-year isoscapes of lake water balances across a dynamic northern freshwater delta

Authors:
Casey Remmer, University of Waterloo
Laura Neary, University of Waterloo
Mitchell Kay, University of Waterloo
Brent Wolfe, Wilfred Laurier University
Roland Hall, University of Waterloo

***Correspondence:** crremmer@uwaterloo.ca

Keywords:
Freshwater, Floodplain, Water isotopes

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
High-latitude freshwater landscapes are particularly vulnerable to combined effects of climate change and industrial development. Inadequate knowledge of hydrological and limnological conditions over space and time hampers ability to detect trends and causes of aquatic ecosystem change. The Peace-Athabasca Delta (PAD), Alberta, is recognized as a Ramsar Wetland of International Importance and contributed to the listing of Wood Buffalo National Park as a UNESCO World Heritage Site. Small changes in water levels can alter hydrological connectivity in the delta, which influences habitat availability, biodiversity, ecosystem productivity and access by First Nations to traditional lands. Here we use water isotope tracers collected from ~60-70 lakes in the PAD 3 times during the ice 2015- 2019 ice free season to develop an understanding of hydrological processes controlling lake water balances during a variety of wet and dry years. We integrated isotope-mass balance modelling, used to generate lake evaporation to inflow ratios, with geographic information systems (GIS) to generate 'isoscapes' that allow us to identify areas of the delta that are influenced by river flooding, areas persistently experiencing evaporative water loss and highlight the shifting hydrologic connectivity between wet and dry years. Additionally, we determined river flood extent and magnitude during flood years using lake-specific estimates of input water isotope composition, modelled after accounting for influence of evaporative isotopic enrichment, and the distinct isotopic signature of input water sources, which were used to develop a set of binary mixing models and estimate the proportion of input to flooded lakes attributable to river water and precipitation (snow, rain). Effective visualization of rapidly shifting hydrological conditions across the 6000 km2 PAD landscape provides a sensitive tool for monitoring the response of aquatic ecosystems to multiple potential stressors. Results demonstrate the use of water isotopes for tracking hydrological conditions in complex freshwater landscapes.

Title: Impact of future climate on hydrology and river ice processes in Canada

Authors:
Prabin Rokaya, University of Saskatchewan
Brandon Williams, University of Saskatchewan
Karl-Erich Lindenschmidt, University of Saskatchewan

***Correspondence:** prabin.rokaya@usask.ca

Keywords:
Climate change, hydrology, floods, river ice, cold region

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The river systems in the high-latitude regions of the Northern Hemisphere are particularly sensitive to environmental change. In these cold river systems, annual runoff in a future climate is predicted to increase, owing to projected increases in precipitation and thawing of permafrost regions. Similarly, spring flows are estimated to occur earlier, and ice cover durations are expected to decrease due to the projected delays in river freeze-up and early ice cover breakup. Since the ice regime is an integral component of these northern river systems, the changes in river ice processes, including the timing and severity of ice cover formation and breakup, can result in varying degrees of consequences: from loss of life to damage to infrastructure, from disruption in river transport to hindrance in hydroelectric production, and from disturbance in ecology to water quality deterioration. However, previous studies have shown that climatic effects are spatially asymmetrical, with varying degrees of implications across the regions. Therefore, despite the general consensus on projected impacts of future climate on cold region hydrology and river ice processes, their quantitative assessments across the regions remain largely uncertain. In this study, we investigate the impacts of future climate on hydrology and river ice processes in ten watersheds of different drainage areas and within diverse climate, ecological zones and latitudes in Canada.

Title: The Hydrology of Beaver Dam Dynamics

Authors:
Amanda Ronnquist, University of Saskatchewan
Dr. Cherie Westbrook, University of Saskatchewan

***Correspondence:** a.ronnquist@usask.ca

Keywords:
Beaver dams, Dam flowtype, Pond Water storage, Rain storms

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
The North American Beaver (Castor canadensis) is an ecosystem engineer as the dams they create are well known for their ability to drastically alter the hydrology of river basins. As a result, partnering with beaver is being increasingly considered as a possible nature-based solution to enhance ecosystem resilience to the effects of climate change. Both drought and flood mitigation capabilities have been observed in basins with beaver dams; however, how dams can possess such contrasting mitigation abilities is not fully understood given the incredible variation in the composition and structural integrity of beaver dams. In this study, an extensive cross-site survey was conducted in the Rocky Mountains in Alberta to investigate the way water flows through dams in addition to other dam properties. The dam flow type classification from Woo and Waddington (1990) was evaluated in this new context and expanded to accommodate two new flow types not found in the original study. The survey revealed significant differences in dam structure across the various sites. Overall, differences in dam structure altered the dynamics and variance in pond water storage. Analysis of dam intactness showed older relict dams can still store water and actively impact the hydrology. Despite different capacities to store water, a closer analysis of large rain events surprisingly showed little difference in storage recession limbs between different dam types. These results reveal the incredible variation in dam structure that alters the temporal dynamics of pond storage. The findings also highlight that the response to rain events can be universal. This combination of variability and stability may be the secret to the contrasting mitigation abilities possessed by beaver dams. Study results should help better predict streamflow routing in beaver occupied streams and improve the prediction and modelling of streamflow under a changing climate.

Title: Remote Sensing of Burn Severity, Pre-fire Species Distribution, and Post-fire Health Recovery in Boreal Forests of Alberta, Canada

Authors:
Prabha Rupasinghe, McMaster University
Patricia Chow-Fraser, McMaster University

***Correspondence:** rupasinp@mcmaster.ca

Keywords:
Boreal Forests, Wildfire, Remote Sensing

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Increased global temperature, drought and extreme weather have increased wildfire activity in Canadian Boreal forests. This change in fire regimes will affect ecosystem resilience and make it difficult to predict how forests will respond to future wildfire outbreaks. We use remote sensing and GIS techniques to understand the behavior of fire regimes over large spatial and temporal extents. We use multispectral satellite images of Landsat 4, 5, 7, and 8 images from 1985 to 2018 to evaluate pre- and post-fire canopy species distribution, burn severity, and post-fire health recovery process for four boreal forests in Alberta: Bistcho Lake region, Wood Buffalo National park, Lesser Slave Lake region, and the Richardson backcountry. First, we mapped the burn severity of each fire outbreak using Normalized Burn Ratio. We used Landsat images collected in two phenological states to map the pre- and post-fire canopy species distribution. To assess the post-fire recovery process, we calculated indices for vegetation greenness (Normalized Difference Vegetation Index), vertical leaf layers per unit area (Leaf Area Index), and evapotranspiration estimates using Google EEflux to evaluate changes over time for each burn severity class. We observed higher tendency of severe burns in areas dominated by coniferous species such as jack pine and spruce. Areas dominated by deciduous species such as aspen, birch, and poplar had comparatively fewer severe fire. In addition, areas closer to water features had fewer severe fires and areas within ~10 km of water features had faster recovery than those further away. All indices showed a gradual improvement in vegetation health following fire outbreaks, but the Leaf Area Index also reflected effects of anthropogenic activity in the affected area. We can use these results to anticipate the direction in which new fires would spread, and thus improve on fire management of boreal forests.

Title: Intercomparison of approaches for modelling infiltration in frozen soil

Authors:
Ines Sanchez-Rodriguez, University of Saskatchewan
Andrew Ireson, University of Saskatchewan

***Correspondence:** ics478@mail.usask.ca

Keywords:
Infiltration, Frozen soil, Computer modelling

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Calculating the partitioning of Snow Water Equivalent between runoff and infiltration is crucial for land and water management in cold regions. In the Canadian prairies, snowmelt during spring is the dominant input of water to the soil, streams and groundwater. The objective of this study was to compare different modelling approaches for quantifying infiltration in frozen soils. We compare empirical modelling approaches with physically-based approaches, and compare both models with observations from the St Denis National Wildlife Research area, in Saskatchewan.

Title: Soil organic matter decomposition in cold region peatlands: Application of isothermal calorimetry

Authors:
Saraswati Saraswati, University of Waterloo
Fereidoun Rezanezhad, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** xsaraswa@uwaterloo.ca

Keywords:
Soil Organic Matter Decomposition, Northern Peatlands, Isothermal Calorimetry, Heat Flows, Soil Biogeochemistry

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Global warming increases air and soil temperatures in northern peatlands which impact soil biogeochemical processes and potentially accelerate soil organic matter (SOM) decomposition in this critical cold region's ecosystem. The increase in SOM decomposition is linked to increased carbon emissions to the atmosphere and changes in dissolved inorganic and organic carbon exports, which in turn affect surface water and groundwater quality. Both soil formation and decomposition of SOM represent a flow of energy in the soil system. Therefore, the precise measurement of heat flows provides important quantitative data to better understand SOM degradation under various biological and environmental conditions in northern peatlands. These data can also inform reactive transport and bioenergetics-based microbial reaction network models of soil biogeochemistry. One of the most precise tools to measure heat flows of reactions is isothermal calorimetry (IC), which yields data on both reaction kinetics and thermodynamics. However, very few studies have used IC to characterize SOM degradation in peatland ecosystems. In this presentation, we will introduce the methodological application of IC with different peat soils to monitor the degradation rate of SOM and characterize the associated heat production.

Title: Impacts of changing winter warm spells on snowpack dynamics

Authors:
Lucia Scaff, University of Saskatchewan
Yanping Li, University of Saskatchewan
Sebastian Krogh, University of Nevada
Roy Rasmussen, National Center for Atmospheric Research

***Correspondence:** lucia.scaff@usask.ca

Keywords:
Winter warm spells, Regional climate models, Snow ablation, Convection-permitting scale, Climate change

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
Increasing mean air temperature shifts snowfall to rainfall, reducing snow accumulation and decreases cold content of the snowpack potentially increasing mid-winter snowmelt events. The overall effect is decreasing peak snow water equivalent (SWE) and earlier snowmelt runoff, reducing melt volumes and available water, with impacts on the economy and ecological functions. However, the effect of changes in the magnitude, frequency and variability of extreme temperature events (winter warm spells; WWS) on snow ablation prior to peak SWE has not been investigated, which may potentially lead to further snowpack reductions. An increase in the number and intensity of WWS is anticipated to occur as climate warming continues, particularly in the mountains of western US and Canada. These impacts may vary with topography, atmospheric conditions and the snowpack's pre-existing condition. These mechanisms need to be understood and quantified to better predict the response of snowpack to a warmer climate. Understanding the mechanisms involved in the loss of snowpack over large mountainous areas requires modeling tools that can simulate land and atmospheric processes in complex terrain. This research uses climate simulations from CONUS-I project. The CONUS-I is a 13-year and continental-scale simulation using the Weather Research and Forecasting model in a convection-permitting configuration at a 4-km grid spacing. Observational gridded data and global climate model outputs are used to analyze the model performance in representing historical WWS. The average frequency of WWS shows that climate simulations from CONUS-I can realistically represent the magnitude of longitudinally increasing frequency of WWS in the western U.S. Furthermore, the future scenario shows a persistent positive change of WWS in the western U.S. This work provides a regional characterization of WWS, a quantification of historical ablation volumes and rates during WWS prior to peak SWE, and answers the following questions: What are the controlling physical mechanisms driving mid-winter ablation? How do they vary spatially? How this might change under a warmer climate?

Title: Supporting vector routing and groundwater simulation in the MESH modelling system

Authors:
Leland Scantlebury, University of Waterloo
James R. Craig, University of Waterloo

***Correspondence:** lscantlebury@uwaterloo.ca

Keywords:
hydrological modeling, MESH, integrated modeling, climate change, groundwater

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
The hydrological modelling framework Raven is here modified to support simulation of groundwater and surface water routing using runoff and recharge generated by Environment and Climate Change Canada's MESH (The MEC-Surface & Hydrology System). The vector-based routing approach can support water management, lakes, and reservoirs. The loosely-coupled groundwater simulator, for now, handles two-dimensional unconfined simulation with recharge, exchange with surface water features, and the influence of pumping. The spatially flexible approach takes advantage of Raven groundwater model support for unstructured grids. This first step towards MESH integration with a groundwater model is unidirectional; later support for inundation of the near-surface water column would require full model coupling. The intent is to demonstrate the ease of MESH-Raven coupling and provide a watershed-scale hydrological modeling framework that can help answer important surface and subsurface modeling questions quickly, without unnecessary complexity, and with well-quantified bounds of uncertainty. Models like these are key in helping us understand the impacts of changes in climate, land use, and water demand for our increasingly stressed water resources.

Title: Changing Carbon Cycling In Subarctic Canada

Authors:
Sherry Schiff, University of Waterloo
P. Aukes, Venkiteswaran
M. English,
R. Hutchins,
R.M Couture,
RJ Elgood,

***Correspondence:** sschiff@uwaterloo.ca

Keywords:
carbon cycling, permafrost degradation, dissolved organic carbon, climate change

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Lakes and ponds in the Precambrian Shield geology of northern Canada store large amounts of Carbon (C) in their sediments. This C largely originates in terrestrial catchments where soils, particularly in wetlands, have high organic C content. Decomposition produces high levels of Dissolved Organic Carbon (DOC) within the subsurface that can be transported to surface waters during periods of hydrologic flow. DOC is important in the mobility of trace metals and contaminants and in the provision of safe drinking water to northern communities. In open water bodies, DOC is transformed and can accumulate in lake sediments or be released as Greenhouse Gases (GHG: CO2 and CH4). This part of the subarctic and low arctic shield (taiga and tundra respectively) covers a large portion of Canada and is warming at an accelerated rate resulting in rapidly degrading permafrost and increased drought frequency, both of which affect C pathways. Carbon cycling is also disrupted by human activities including building of infrastructure (dams, communities, roads, mining activities), and forest fire and wildlife management (particularly beaver populations). The subarctic is particularly sensitive to human actions because of shallow active layer depths and low rates of microbial processing. In general, lakes and ponds in the subarctic Boreal Shield have the highest DOC levels in Canada but the fate of DOC under changing conditions is uncertain. We focus on three main sites along a 300 km transect including Yellowknife (forest; sporadic permafrost and where complimentary work is on-going), Snare (treeline; continuous permafrost) and Daring Lake (tundra; continuous permafrost)., we couple hydrology, landscape unit analysis, biogeochemistry and modelling and incorporate new techniques using stable isotopes in addition to natural 14C. In addition, we collaborate in ABoVE2 (Arctic-Boreal Vulnerability Experiment2), a NASA program to quantify North American C emission rates via remote sensing (aircraft missions & satellite) coupled with “ground truthing” (literally) and process-based research. Our overarching objective is to improve the quantitative understanding of carbon dynamics and dissolved organic carbon in Canadian subarctic freshwaters with a focus on processes and rates governing the sources and fate of DOC and the balance between carbon sinks and carbon sources to the atmosphere. Here, we will present new data and results from the intensive 2019 field season.

Title: Catchment: lake area ratio may dictate the concentrations of legacy arsenic pollution in subarctic lakes

Authors:
Mackenzie DJ Schultz, Wilfrid Laurier University
Venkiteswaran JJ, Wilfrid Laurier University
English MC, Wilfrid Laurier University
Schiff SL, University of Waterloo
Aukes PJK, Wilfrid Laurier University
Leathers JG, Wilfrid Laurier University

***Correspondence:** schu9230@mylaurier.ca

Keywords:
Climate Change, Northwest Territories, Metals Mobility, Limnology

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
Giant Mine caused extensive contamination to the local terrestrial and aquatic ecosystems by the aerial deposition of large quantities of arsenic and other metal/metalloids. Long after the mine has closed, concern remains about the long-term mobility of metals/metalloid pollutants in the region. We focussed on a series of previously studied lakes that are equidistant from Giant Mine but varied in catchment to lake area ratio. We quantified the role of catchment variability on metal retention and mobility to compare whether lakes with similar atmospheric input of metals expressed the same metal storage and similar water chemistry throughout the summer. We collected sediment cores from each of the lakes and sampled water chemistry between May and September every other week. Here, dissolved arsenic and dissolved organic carbon (DOC) concentrations differed between study lakes but tended to be positively correlated with a larger catchment to lake area ratio. Further, there was a strong linear relationship between dissolved arsenic and DOC. Dissolved arsenic and DOC concentrations increased since these lakes were last surveyed in 2010. Therefore, it appears that mining pollution-affected catchments will continue to act as sources of metal/metalloids to subarctic lakes, particularly those with large catchment to lake area ratios.

Title: Phosphorus cycling within stormwater management infrastructure in extreme climates: insights from data analysis and reactive transport modeling of stormwater ponds

Authors:
Mahyar Shafii, University of Waterloo
Nandita Basu, University of Waterloo
Chris T Parsons, Environment Canada and Climate Change
Philippe Van Cappellen, University of Waterloo

***Correspondence:** mshafiih@uwaterloo.ca

Keywords:
modeling, stormwater management, phosphorus, climate change, biogeochemistry

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
Stormwater runoff in urban areas serves as an important pathway for exporting nutrients and contaminants to downstream ecosystems. Using a stormwater pond is a traditional approach to stormwater management (SWM) all across the world for flood control and water quality improvement. To improve resiliency against flooding and water quality degradation under climate change, several improved designs such as hybrid extended detention ponds have been proposed, and are currently being implemented in urban landscapes. Despite the abundance of this SWM technology, understanding about their export and internal cycling of nutrients, as well as the interactions between biogeochemical and physical processes is very limited. Our research focuses on the cycling and transformations of phosphorus (P) in stormwater ponds, which is generally neglected in the process of their design and implementation. We develop process-based models of P for stormwater ponds based on existing knowledge and data available in several research studies. The model will be utilized to get quantitative insight into P speciation and transformations at the field scale. Subsequently, the mechanistic P model of ponds will be coupled with an urban hydrology model to characterize the export of P species via stormwater runoff at the watershed scale. Finally, we will conduct scenario analysis using the coupled model and assess the risk of increases in P export in the presence of extreme hydrologic events. This research forms a conceptual risk assessment framework with regard to climate-related changes in urban stormwater nutrient dynamics.

Title: Storms and Precipitation Across the continental Divide Experiment (SPADE): Measurements and Preliminary Results

Authors:
Hilary Smith, Université du Québec à Montréal, and University of Northern British Columbia
Julie M. Thériault, Université du Québec à Montréal
Stephen Déry, University of Northern British Columbia
Hadleigh Thompson, Université du Québec à Montréal
Ronald E. Stewart, University of Manitoba
John W. Pomeroy, University of Saskatchewan

***Correspondence:** hilarysmith11@gmail.com

Keywords:
Hydrometeorology, Atmospheric Sciences, Precipitation

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The continental divide in southwestern Canada is the mountain headwaters source for rivers that flow to three oceans. Most atmospheric flows and storm tracks are westerly and so annual precipitation is typically higher and more persistent on the western side of the divide, but major flooding events can be associated with heavy precipitation that involves less frequent easterly upslope atmospheric flows. Meteorological data over this critical region are nonetheless sparse.
Given the importance of all these types of events, Global Water Future's Storms and Precipitation Across the continental Divide Experiment (SPADE) was initiated to enhance our knowledge of the contribution of different moisture flows on precipitation across the Canadian Rockies. SPADE installed specialized meteorological instrumentation on both sides of the continental divide to gather automated and manual observations during an intensive field campaign from 24 April to 26 June 2019. On the eastern side, there were two field sites at: (i) Fortress Mountain Powerline (2076 m ASL) and (ii) Fortress Junction Service, located in the Kananaskis River Valley (1580 m ASL). On the western side, Nipika Mountain Resort, in the Kootenay River Valley (1087 m ASL), was chosen to compare to Fortress Junction Service. Doppler LiDARs, vertically pointing micro rain radars, optical disdrometers, precipitation gauges and meteorological stations were deployed at these sites. Observers were on site at Fortress Mountain and Nipika Mountain resorts during precipitation events and took manual observations of precipitation type, snow depth and snow water equivalent, as well as microphotographs of snow particles.
The experiment, initial results and the relationships between storm characteristics and origin will be described. Over the course of the field campaign, 13 storms of varying atmospheric conditions, precipitation amounts and precipitation types were documented on both sides of the continental divide. The western side was always warmer and drier than the eastern side, and, regardless of storm type, precipitation on the western side only occurred when precipitation also occurred on the eastern side. Snow mainly fell on the eastern side whereas only rain fell on the western side. Most events were associated with upslope flow on the eastern side. Information from select storms will be shown to highlight such differences in weather conditions and precipitation.

Title: Ecohydrology of the Baker Creek watershed: a multidimensional approach to capturing biophysical change from seasonal to decadal scales

Authors:
Anastasia Sniderhan, Wilfrid Laurier University
Christopher Spence, Environment and Climate Change Canada
Anna Coles, Government of the Northwest Territories
Nia Perron, Universite de Montreal
Oliver Sonnentag, Universite de Montreal
Jennifer Baltzer, Wilfrid Laurier University

***Correspondence:** asniderhan@wlu.ca

Keywords:
Landcover change, Water budget, Plant water use, Taiga shield, Stable isotopes

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
As climate warms, high-latitude regions underlain by permafrost (perennially frozen ground) experience landscape change through processes such as ground subsidence, rerouting of watercourses, and shifts in vegetation and forest cover. Thaw-related processes can indirectly influence hydrology by changing vegetation. In the Baker Creek watershed near Yellowknife, NT we are integrating multiple approaches across different timescales to achieve a holistic understanding of the biophysical system in this typical Taiga Shield basin. This collaborative effort aims to address the following questions: (1) how has landcover within the basin changed over between 1972 and 2017 and what are driving these changes? (2) how has tree productivity changed over the past century and what are the mechanisms? (3) are there species-level differences in plant water use (physiological rates and source water use) over the course of the growing season? (4) how is evapotranspiration partitioned among different landcovers? (5) how do changes in landcover, plant productivity and water use, and evapotranspiration across the landscape affect the water budget of the basin? We aim to answer these questions by employing methods of remote sensing, dendrochronological techniques, tree structure and hydraulic measurements, carbon and water stable isotope analysis, eddy covariance measurement of latent and sensible heat fluxes, and observations of lake water levels and basin discharge. At this meeting, we will be presenting an overview of the approaches we are taking to address the research questions in this project and our results to date.

Title: A classification-based virtual basin modeling approach to understand sensitivity of Prairie hydrology to changes in wetland drainage and climate

Authors:
Christopher Spence, Environment and Climate Change Canada
Balew Mekonnen, University of Saskatchewan
John Pomeroy, University of Saskatchewan
Kevin Shook, University of Saskatchewan
Colin Whitfield, University of Saskatchewan
Jared Wolfe, University of Saskatchewan

***Correspondence:** chris.spence@canada.ca

Keywords:
Prairie, climate change, snow, streamflow, wetlands

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
Canadian Prairie water resources are commonly stressed, testing the resilience of communities. How hydrological fluxes and states across Prairie watersheds respond to climate and land use change is hard to disentangle, creating uncertainty in water management decisions. This paper summarizes the application of a classification-based virtual watershed modeling approach to understand sensitivity of prairie hydrology to changes in climate and agricultural water management. Each ~100 km2 watershed in the Prairie ecozone was classified, and seven watershed classes were identified. A virtual version of a typical watershed in the High Elevation Grasslands class was developed using the Cold Regions Hydrological Model (CRHM). CRHM was parameterized using watershed traits identified during the classification. Once validated, sensitivity to climate was evaluated by forcing the model with expected increases in annual temperature and precipitation. Peak annual snowpack sensitivity to climate increases from east to west while annual runoff sensitivity increases to the south. The response of streamflow to wetland drainage was linear in the High Elevation Grasslands class. However, streamflow in the Prairie Pothole region responds exponentially to wetland loss. These results show the influence of climate and land use on Prairie hydrology is not uniform across the region, and this should be considered in decision making. The presentation will finish with examples of how this research is being used by partners in developing policies and informing land use decisions.

Title: Response of boreal plant communities and forest floor carbon flux to experimental nutrient additions

Authors:
Katherine M. Standen, Department of Biology, Wilfrid Laurier University, Waterloo, ON
Oliver Sonnentag, Département de géographie, Université de Montréal, Montréal, QC
Carolina Voigt, Département de géographie, Université de Montréal, Montréal, QC
Jennifer L. Baltzer, Department of Biology, Wilfrid Laurier University, Waterloo, ON

***Correspondence:** stan0120@mylaurier.ca

Keywords:
boreal, permafrost thaw, plant functional traits, carbon cycling, ecosystem function

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
The climate is warming at an accelerated rate in Canada's North and is leading to widespread permafrost thaw in parts of the boreal biome. At a local scale, permafrost thaw in boreal peatlands leads to changes in soil nutrient availability, mainly increases in nitrogen (N) by two main mechanisms. Firstly, increased microbial mineralization of organic matter due to warmer soil temperatures can increase N availability in surficial soil layers. Secondly, thaw will expose a previously frozen N pool that may be mobilized through increased mineralization rates. These increases in nutrients will influence plants growing in this nutrient poor region. Specifically, plant community composition may change with increasing N because species able to access nutrients at depth will be favoured, thus potentially increasing abundance of these species at the expense of others. In addition, nutrient availability is positively linked to plant functional traits such as foliar N and photosynthetic rate; thus, increases in nutrients will likely increase values of these traits. Since many plant traits are related to carbon and water fluxes, and the land surface energy balance, changes in these traits with increased nutrients could then influence how the boreal biome functions as part of the climate system. Thus, we conducted a nutrient addition experiment to emulate the two main mechanisms of increasing nutrients with permafrost thaw by adding slow-release fertilizer to the soil in 5 treatments: shallow (20 cm, emulating increased microbial mineralization), deep (40 cm, emulating nutrient availability at depth), both shallow and deep, disturbed control (no nutrients added, disturbed as nutrient treatments) and undisturbed control (no nutrients added, not touched). We replicated this set up in two areas differing in their aboveground tree productivity to understand how nutrient increases under different environmental conditions will influence understory plants. We then monitored plant community composition as percent cover, aboveground functional traits, and forest floor carbon fluxes (both carbon dioxide and methane) using a chamber technique in summer 2018 and 2019 to better understand short-term impacts of increasing nutrients on boreal plant composition, structure, and function. This research will greatly contribute to understanding the effects of nutrient increases following permafrost thaw on plant community composition and function in boreal peatlands.

Title: Understanding the role of an upstream watershed on ice-jam flood regimes at the Peace-Athabasca Delta, northern Alberta

Authors:
Mia Stratton, University of Waterloo
Jennifer K. Adams, University of Waterloo
James Telford, University of Waterloo
Johan A. Wiklund, University of Waterloo
Roland I. Hall, University of Waterloo
Brent B. Wolfe, Wilfrid Laurier University

***Correspondence:** msstratt@uwaterloo.ca

Keywords:
ice-jam flood, Smoky River, paleolimnology, snowmelt, spring discharge

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
The Peace-Athabasca Delta (PAD) in northern Alberta has been a focus of concern for decades regarding the declining flood frequency of shallow perched lakes, which support wildlife and are culturally significant for Indigenous Peoples. Regulation at the headwaters of the Peace River by the W.A.C. Bennett Dam began in 1968 and is widely perceived to be the cause of reduced flooding in the PAD. This perception is based on hydrometric records of the Peace River which extend only 8 years prior to regulation. In contrast, paleolimnological records in the PAD indicate a decline in flood frequency since the early 1900s as a result of climate change. Episodic ice-jam floods on the Peace River are critical for flooding vast areas of the PAD and are the main recharge mechanism for perched basins. The Smoky River is an unregulated tributary upstream of the PAD, identified as a large contributor of spring discharge to the Peace River at the time when ice-jams form and flood the PAD. Unsettlingly, climate records from the Smoky River watershed indicate a reduction in snow accumulation beginning in the mid-1970s. However, longer pre-regulation records are needed from the Smoky watershed to determine the role of spring discharge on declining ice-jam flood frequency at the PAD. Sediment cores from six oxbow and upland lakes within the Smoky River catchment were collected and sectioned into 0.5-cm intervals. Oxbow lake cores will be radiometrically dated and undergo a series of paleohydrological analyses including loss-on-ignition, granulometric determination of grain size, and x-ray fluorescence to identify sediment intervals supplied by river floodwaters. Preliminary loss-on-ignition results from two oxbow lakes suggest temporal variation in river discharge, with marked reduction in flooding between core depth intervals 55 to 40 cm in Smoky 4, and a period of high flooding at 45 to 32 cm in Smoky 2. Once cores are dated, this information will be compared to existing records from oxbow lakes in the PAD to determine if high spring discharge events on the Smoky River correlated with ice-jam flooding at the PAD. These findings will further characterize the influence of upstream climate on the hydrology of the PAD and inform a federal Action Plan aimed to improve stewardship of the delta and help anticipate the future of water availability in the face of multiple stressors.

Title: Evaluation of precipitation estimates from high-resolution regional atmospheric reanalysis and their potential utilities in hydrological simulations for the Third Pole river basins

Authors:
He Sun, Institute of Tibetan Plateau Research
Fengge Su, University of Saskatchewan
Zhihua He, University of Saskatchewan
Yanping Li, University of Saskatchewan

***Correspondence:** sunhe@itpcas.ac.cn

Keywords:
Precipitation, Hydrological Simulation, Regional climate model, Tibetan Plateau

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
Precipitation is the key driver of terrestrial hydrological cycle and most important atmospheric input to land surface hydrology models. In many remote parts of the Third Pole (TP, the Tibetan Plateau and its surrounding mountain ranges), direct meteorological observations are either sparse or nonexistent because of the harsh environment, making accurate and reliable hydrological simulation difficult. The estimation of the respective contributions of glacier melt and precipitation to total river runoff of the TP basins still remains uncertain for these reasons. High-resolution regional downscaling and/or reanalysis offer an opportunity to provide necessary forcing for hydrological modelling studies in the TP basins. Over the recent years, some high-resolution regional atmospheric reanalysis from regional climate models (RCMs) over the region have been conducted and some are under planning by several research groups within and outside the Third Pole Environment (TPE) community. In this work, the hydrological utilities of two outputs of the Weather Research and Forecasting (WRF) model are evaluated by driving the VIC land surface hydrological model in four basins in the TP-the upper Yangtze, upper Yellow, upper Mekong, upper Salween, upper Brahmaputra, upper Indus, upper Yarkant, upper Amu Darya and the upper Syr Darya. The model simulations are compared with the observed streamflow at basin outlets. And the results suggest that the precipitation from RCMS exhibit encourage potential in hydrological application in the most of TP basins in terms of reproducing observed flow volume and regimes. However, the RCMs tends to overestimate the precipitation up to 50-100% for the evaluated basins. This work offers some insights for the WRF modeling community in identifying precipitation issues for the TP region.

Title: Effects of Climate Warming on Qinghai-Tibet Plateau: Carbon Sink Function of Plateau Wetland

Authors:
Qingqing Sun, Tianjin University

***Correspondence:** qingqing.sun@uwaterloo.ca

Keywords:
climate warming, wetland, carbon sequestration, Qinghai-Tibet Plateau

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management; Social, economic and health determinants and impacts

Abstract:
The pan-third polar region includes Tibet Plateau, Pamir, Hindu Kush, Iranian Plateau, Caucasus, and Carpathian, covering an area of about 2× 107 km2 and concerning the living environment of 3× 108 people. In Tibet Plateau, as Asia's water tower, the interaction between westerly winds and monsoon affects precipitation directly. Tibetan plateau is warming and wetting, with rates of 0.036℃/yr and 1mm/yr 1961 to 2018. The cause of climate warming is the increasing concentration of long-lived greenhouse gas, mostly caused by fossil fuel burning and Chlorofluorocarbon (CFC-11) emission. Precipitation in south Tibet has been decreasing in recent years, indicating that the southern monsoon is weakening. The source of precipitation in northern Tibet may be evaporation from glacial meltwater, that is, there is an internal water cycle in northern Tibet.
Consistent with the overall change of global glaciers, the glaciers on Qinghai-Tibet plateau show an accelerating trend of melting, especially Heyuan No. 1 Glacier in Mount Tianshan, Urumqi. The mass balance was -712 mm, and the east and west branches retreated by 8.3 m and 5.9 m in 2018, respectively. The permafrost, (1.17-1.66) million km2, has deteriorated significantly since 1981, the temperature at the bottom has risen, and the thickness of the active layer has increased obviously, even reached 245 cm along Qinghai-Tibet Highway in 2018. Only 42,405 km2 permanent glacial snow remained, 43.7% were gone 1980s to 2018. More than 100 lakes (>1 km2), 11,240 km2 (+30%) were increased 1960s to 2018. Remote sensing images show the water level rose, and the lake expanded. Since 1976, Siling Co has expanded, surpassing Nam Co to become the largest lake in Tibet. The trend of lake swamping in Qinghai-Plateau is remarkable. Wetlands increased by 44,795 km2. Mean carbon sequestration rate is 142 g-C/(m2·yr). Net primary productivity, NPP increased by 12% in 2015 than 2000, compared with 0.4% in the pan-third polar region.
The emissions gap for 2°C target in 2030 will be (3.5-4.0) GtCO2 emissions, for 1.5°C, (7.8-8.6) GtCO2 emissions in China, meanwhile, it is high time to protect and recover wetlands, optimize land-use types and energy structure, and increase the carbon sequestration. Hydropower stations alone have reduced 5.23 GtCO2 emissions from 2005 to 2018. Soon, maybe 17 Gt, adjustable water of Three River Sources on Qinghai-Tibet Plateau needs to be allocated more reasonably and efficiently, or even more.

Title: Detecting Shifts in Flow Regimes of Western North American Watersheds using Variational Auto-Encoder

Authors:
Weigang Tang, McMaster University
Sean K. Carey, McMaster University

***Correspondence:** tangw5@mcmaster.ca

Keywords:
Flow Regime Shifting, Deep Learning

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
Changes in streamflow timing and magnitude driven by climate change have considerable implications for aquatic organisms and water security, and is a major hydrological challenge this century. Traditionally, shifts in flow regimes are identified and quantified using the Mann-Kendall test, a widespread non-parametric statistically approach for trend analysis, with a selection of annual- and seasonal-based hydrologic indices derived from long-term hydrographs. Whereas hydrologic indices were designed by hydrologists to characterize streamflow from a variety of aspects, it can be difficult to find a universal combination of indices that fully represent hydrological processes for a range of rivers. Variational Auto-Encoder (VAE), a deep learning algorithm, is considered a powerful tool to self-learn and extract features from raw datasets. In this research, VAE models were developed and trained to extract hydrologic features from Annual Daily Hydrographs (ADHs). Along with classic hydrologic indices, the features derived by VAE were applied to detect the changes in flow regimes of more than 300 natural watersheds at varying scales in western North America over a period of four decades from 1979-2018. VAE features show considerable agreement with classical measures in regional hot spots of changing flow regimes. Pacific North West is one of the hot spots of changes, as a number of indices and features exhibit significant trends at local stream gauges. VAE features provide additional perspectives in the procedure of detecting changes of annual streamflow. They indicate some intricate signals in hydrographs, such as snowmelt-rainfall regime transition, which are difficult to detect using primary hydrologic indices. Further effort should be made to interpret the physical meaning of those machine-extracted features and enhance their connection with specific hydrologic processes.

Title: Occurrences of precipitation events associated with a transient snowline in the Canadian Rockies using simulations of a regional climate model

Authors:
Obert Tchuem, University of Quebec in Montreal
Julie M. Thériault, University of Quebec in Montreal

***Correspondence:** tchuemobert@yahoo.fr

Keywords:
precipitation events, 0°C isotherm, snowline, complex terrain, flooding events

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Identifying the snowline elevation in complex terrain is essential to understanding snowpack variability, and for anticipating available water resources. In addition, spring flooding events are common throughout western Canada, particularly on the eastern slopes of the Canadian Rockies between Banff and Calgary (Alberta). An example is the June 2013 flooding event. These are caused by the variability of atmospheric conditions aloft and at the surface, which influences the location of the 0°C isotherm. This research aims to study the precipitation events occurring in the Canadian Rockies that are associated with a transient snowline, and their future evolution with climate change. Convection-permitting simulations conducted over the Continental United States using the Weather and Research Forecasting (WRF) model at a grid spacing of 4 km from 2000 to 2013 are used. Our preliminary analysis has focused on 2 sites where major flooding occurred simultaneously in 2013. These are Kananaskis, Alberta and Fernie, British Columbia. During 2012-2013, 55% of the events identified at Kananaskis were associated with rain, compared with 35% in Fernie. Longer duration events (> 24 h) were generally associated with mixed precipitation in Fernie. This indicates a variability in the elevation of the snowline which can range from 0.2 km to 1 km during a single event. In addition, rain events may increase by 15% and 13%, then snow events could decrease by 10% and 8% in Fernie and Kananaskis, respectively, if similar weather conditions occur in warmer conditions. Finally, under these same warmer conditions, the duration and amount of rain and mixed precipitation events would increase in the Canadian Rockies. Overall, this study will contribute to a better understanding of the evolution and processes associated with a transient snowline in complex terrain.

Title: Diagnosis of the runoff generation mechanism under changing climate: Bow River basin

Authors:
Zelalem Tesemma, University of Saskatchewan
John Pomeroy, University of Saskatchewan
Alain Pietroniro, University of Saskatchewan
Kevin Shook, University of Saskatchewan
Chandra Rajulapati, University of Saskatchewan
Bruce Davison, University of Saskatchewan

***Correspondence:** zelalem.tesemma@usask.ca

Keywords:
Climate change, Rain-on-snow, Flood, Water management

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Runoff generation mechanisms are important to characterize and quantify for water resource management, flood protection and infrastructure design, particularly in a time of rapid climate change. In cold mountain basins, runoff is mainly generated from snowmelt runoff, rain-on-snow and rainfall-runoff. This study aims to investigate the effects of projected climate change on the runoff mechanisms for the Bow River and Elbow River basins; important mountain headwaters in Alberta, Canada. An enhanced version of MESH (Modélisation Environnementale communautaire - Surface Hydrology) was set up at a spatial resolution of approximately 4km to correspond to the resolution of dynamically downscaled Weather Research Forecast model outputs for current and future climates in the region. Here, incoming solar radiation was calculated as a function of terrain slope and aspect, and precipitation, temperature, pressure, humidity and longwave radiation were corrected for elevation. Model falsification was used to evaluate the necessary cold regions processes (blowing snow, frozen soil infiltration, slope/aspect, glacier melt) and water management processes needed to simulate the natural river and reservoir- managed river hydrographs in the basin. A pseudo global warming (PGW) dynamical downscaling of future warming projection was used to drive the future climate (2086 – 2100). The results show that snowmelt runoff events are projected to increase by up to eight events per year in the Central Ranges of the Canadian Rockies, and to decrease by up to eight events per year in the foothills. Rain-on-snowmelt events become less frequent at low to medium elevations and more frequent at higher elevations. The reduction in the frequency of rain-on-snowmelt events is associated with the substantial shortening of the snow-covered period at low to medium elevations. Rainfall-runoff events are projected to increase by four events per year for both the Bow River as the warmer climate increases the proportion of precipitation falling as rain. Under climate change, rain-on-snowmelt will be less frequent at lower elevations and more frequent at medium and high elevations with a shift from rain-on-snow to rainfall-runoff events at low and middle elevations. These changes are associated with an overall decline in the largest peak flow events and increase in discharges associated with medium and low flows.

Title: Disentangling the effects of soil freezing on carbon and nitrogen cycles in cold region organic soils

Authors:
Heather Townsend, University of Waterloo
Fereidoun Rezanezhad, University of Waterloo
Stephanie Slowinski, University of Waterloo
Christina Smeaton, Memorial University
Merrin Macrae, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** hrtownse@uwaterloo.ca

Keywords:
Winter, Peatlands, Nutrients, Energetics, Carbon

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
In the past, cold region and non-growing season soils have often been considered dormant and ignored from large scale carbon (C) models. Recent revelations in soil microbe diversity as well as accelerated warming experienced by cold regions have brought new relevance to understanding and accounting for soil C mobilization at mid- to high latitudes. In Canada, increases in temperature may lead to the exploitation of peatland dominated northern landscapes due to a northern expansion of agriculture. Field and laboratory observations during spring melts have recorded pulses of more potent greenhouse gases, nitrous oxide (N2O) and methane (CH4), with the largest fluxes occurring in seasonally cold temperate region croplands. Spring CH4 and N2O fluxes link seasonal freezing with periods of oxygen depletion, a phenomenon experienced by 37% of Canada's peatlands. Associated variations in redox conditions may result in shifts to C and N cycles with implications to water quality as microbes adapt to anaerobic metabolisms. In this experiment, we simulated the effects of winter conditions on C and nitrogen (N) cycles using a series of sacrificial batch experiments. Soil samples collected from a swamp in the Turkey Lakes Watershed near Sault Ste. Marie, Ontario, were treated with porewater solutions containing variable concentrations of labile carbon and e- acceptors, sulfate (SO42-) and nitrate (NO3-), and incubated under anaerobic conditions at 5˚C for up to 50 days. Sacrificial sampling over 6 time points measured headspace CO2, N2O, and CH4 as well as porewater pH, major cations and anions, organic and inorganic C, total N, and ammonium (NH4+). Incubated soils were active at low temperatures, oxidizing up to 9 mM of acetate and 1.5 mM of NH4+ over 7 weeks. After 1 week of incubation, porewater pH decreased significantly from 6.7 to 5.3. Peak CH4 concentrations of 100 µM were observed between days 28 and 35; however, CH4 concentrations decreased to zero thereafter. CH4 consumption coincided with an increase in pH from 5.3 to 6.2, despite growing CO2 concentrations and stable values of SO42- and NO3-. Results of bioenergetics-based modelling supports experimental observations of chemolithoautrophic processes, including ammox and anaerobic methane oxidation. The anaerobic oxidation of both CH4 and NH4+ appear to be related and driven by the relative phases of iron and manganese present within the soil and the e- accepting capacity of soil organic matter.

Title: Using the Stefans Equation to model bi-directional thaw between two different boreal plains peatlands with differing peat thermal properties

Authors:
Brandon Van Huizen, University of Waterloo
Owen F. Sutton, University of Waterloo
Dr. Richard M. Petrone, University of Waterloo

***Correspondence:** bvanhuizen@uwaterloo.ca

Keywords:
peatlands, boreal, seasonal ground ice, freeze/thaw

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Peatlands comprise a large proportion of the land area in the western boreal plain (WBP) and act as water stores and sources within the WBP landscape. However, whether these peatlands act as sources of water depends on their storage capacity, which is impacted by the presence or absence of seasonal ground ice (SGI). Thick layers of SGI can significantly reduce peatland storage capacity, which during the spring freshet, lead to large amounts of water leaving the peatland and moving to downstream systems. Understanding the timing of ice-free conditions is important for incorporating peatland storage capacity dynamics into regional hydrological models. Yet, peatlands are largely underrepresented in these models, despite comprising a significant portion of the landscape. Furthermore, many of these peatlands are subject to bi-directional melting during the spring, which has not been adequately incorporated into cold region hydrological models. There is a gap in our knowledge around SGI formation in different peatlands, and how melting can be properly incorporated into watershed scale hydrological models. Therefore, the objectives of this poster presentation are to (1) Quantify the differences, if any, in the timing of SGI melt and thickness between 3 different peatlands (moss dominated poor fen, sedge dominated saline fen, moderate-rich fen) found in the WBP and to (2) Model the annual freeze/thaw in each of these peatlands with bi-directional melt using the Stefan's equation. The findings from this work will help inform knowledge of peatland cold regions processes and provide a baseline for understanding future climate change impacts, which contributes to the GWF meeting theme; Climate-driven changes of water environments in cold regions.

Title: Towards Understanding Terrestrial and Aquatic Greenhouse Gas Dynamics in a Heterogeneous Arctic Tundra Landscape

Authors:
Carolina Voigt, University of Montreal
Gabriel Hould Gosselin, Wilfrid Laurier University
Andrew Black, University of British Columbia
Charles Chevrier-Dion, University of Montreal
Charlotte Marquis, University of Montreal
Zoran Nesic, University of British Columbia
Taija Saarela, University of Eastern Finland
Niels Weiss, Wilfrid Laurier University
Evan Wilcox, Wilfrid Laurier University
Philip Marsh, Wilfrid Laurier University
Oliver Sonnentag, University of Montreal

***Correspondence:** carolina.voigt@umontreal.ca

Keywords:
Arctic, Permafrost, Greenhouse gas, carbon, tundra

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting,(Big) data science and management

Abstract:
The Arctic is currently warming twice as fast as the rest of the world. Warming and associated permafrost thaw in Arctic landscapes may mobilize large pools of carbon and nitrogen and ultimately increase the atmospheric burden of the greenhouse gases (GHGs) carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). Arctic GHG dynamics and their environmental controls are poorly understood. Whether Arctic landscapes act as a net GHG source or sink depends on the complex and spatially varying interactions between topography, hydrology, active layer thickness, temperature, vegetation composition, microbial dynamics, soil type and substrate availability.
Our study site, Trail Valley Creek (68°44' N, 133°29' W), is an upland tundra site characterized by small-scale land cover type heterogeneity consisting of shrub, tussock and lichen patches, polygonal tundra and thermokarst-affected areas, wetlands, lakes, and streams. To understand the large spatial and temporal variability of GHG dynamics across these terrestrial and aquatic landcover types we use a nested observational approach at plot- (<1m2), ecosystem- (~10m2), landscape- (~100m2) and regional (~50km2) scale. Existing ecosystem-scale eddy covariance (EC) measurements of net CO2 and CH4 exchanges are complemented with landscape-scale EC measurements and plot-scale automated and manual chamber measurements within the EC tower footprint and beyond. We complement these multi-scale GHG flux observations with a wide array of auxiliary measurements including soil GHG profile dynamics, lake and soil pore nutrient concentrations, soil temperature and moisture profiles, thaw depth, leaf area index, normalized difference vegetation index, lake catchment characteristics, and quality and microbial degradability of aquatic dissolved organic matter.
Preliminary results from manual chamber measurements show that tussocks are the largest net CO2 sink during the growing season. While the majority of terrestrial landcover types showed small but

consistent and seasonally varying CH4 uptake, lake shore and thermokarst-affected areas displayed high nutrient loads and were hotspots of CH4 emissions. Therefore, capturing the landscape heterogeneity, areal coverage and hydrological connectivity of terrestrial and aquatic landcover types is important, and our study highlights the need to combine belowground, plot-, ecosystem- and landscape-scale measurements to understand biosphere-atmosphere interactions in the Arctic.

Title: Impacts of tall shrub expansion on the hydrology of a low-arctic catchment

Authors:
Cory Wallace, Wilfrid Laurier University
Jennifer Baltzer, Wilfrid Laurier University
Aaron Berg, University of Guelph
Anna Coles, Government of the Northwest Territories
Qianyu Chang, University of Guelph
Philip Marsh, Wilfrid Laurier University

***Correspondence:** wall1643@mylaurier.ca

Keywords:
Ecohydrology, Shrub expansion, Streamflow, Climate change, Arctic

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: From anthropogenic pressures to ecosystem services

Abstract:
Shrub productivity and areal extent are increasing across much of the circumpolar arctic. Substantial focus has been placed on understanding the potential impacts of this shrub expansion at both a global-scale and a point-scale. At the global-scale, work has focussed on surface energy balance feedbacks, including increased transport of water to the atmosphere, decreases in albedo, and changes to the carbon cycle. At the point-scale, work has focussed on impacts of shrub cover on local hydrological conditions such as soil moisture, thaw depth, snow redistribution, and evapotranspiration. However, between these two ends of the spectrum, at the catchment-scale, we still have limited understanding of hydrological responses to shrub expansion and the implications for regional water resource availability in arctic systems.
Here we propose a conceptual model which considers the various hydrologically-relevant ecosystem impacts of shrub (alder and birch) expansion and generates specific hypotheses about how this might influence catchment-scale streamflow responses to summer rainfall events. In particular, we expect increased shrub cover to heighten evapotranspirative fluxes and interception, resulting in reduced total discharge and hydrographs with longer receding limbs. We test these hypotheses using time series of Normalized Difference Vegetation Index (NDVI) (2000-2019), climatic variables (1992- 2019), and isolated streamflow components (1978-2016) collected from Trail Valley Creek, a catchment in the Southern Arctic ecozone of the Northwest Territories. As expected, temperature, rainfall, and NDVI all changed over the period of record. NDVI in particular showed a strong increase, with the majority of 250m pixels beginning to “green” in 2003 or 2015. Surprisingly, no component of discharge, either from monthly aggregates or isolated storm time series showed any trends over time. We propose that the lack of discharge response to changing precipitation is explained by shrub expansion across the basin. Our results suggest shrub expansion might mediate future climate-streamflow relationships, complicating predictions of water resource availability in arctic systems.

Title: Simulating Wintertime Convection Dynamics Using the MITgcm Ice Model

Authors:
Sarah Walsh, University of Waterloo
Kevin Lamb, University of Waterloo
Marek Stastna, University of Waterloo
Andrea Scott, University of Waterloo
Senja Walberg, University of Waterloo

***Correspondence:** sawalsh@uwaterloo.ca

Keywords:
Lake, Ice, Thermodynamics, Modelling, Mixing

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Lake Erie is an important source of drinking water, a location for recreational activities and a haven for unique ecosystems (e.g. Point Pelee). Recent research has suggested that some wintertime processes are significantly increasing amounts of hypoxic water and harmful algal blooms found in the lake during the following summer. Much of the mixing in Lake Erie is caused by wind forcing. Mixing also occurs via an unstable water column that results from incoming solar radiation when water is below the temperature (around 4 degrees) at which the maximum density occurs.
We report on idealized simulations using the MITgcm (Massachusetts Institute of Technology General Circulation Model). The MITgcm is a 3D ocean model with the ability to model sea ice. We will use the model to create high resolution (1m and 10m) toy simulations where we add an ice cover to parts of a small, idealized rectangular lake and observe the mixing and circulation that results for different ice distributions and forcing conditions. We will also compare cases with the model set to be non-hydrostatic, with ones for which it is hydrostatic. Special attention will be paid to mixing that occurs near the ice edge.

Title: The Dynamics of the Beaufort Gyre

Authors:
Elizabeth Webb, University of Waterloo
Francis Poulin, University of Waterloo
Mary-Louise Timmermans, Yale University

***Correspondence:** eawebb@uwaterloo.ca

Keywords:
ocean circulation, sea ice, arctic, differential equation, modelling

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
The Beaufort Gyre is located in the Canadian Arctic and is responsible for the dominant circulation of the Beaufort Sea. This Gyre currently flows in a clockwise direction and collects fresh water from melting sea ice. However, every 5 - 7 years it has been observed to reverse direction and release the collected fresh water into the Northern Atlantic. The last recorded reversal was over 20 years ago. Currently, the Beaufort Gyre holds as much fresh water as all the great lakes combined. When the next reversal happens, it is predicted that the fresh water will be released and then act as a thick, cold blanket over the Northern Atlantic Ocean, preventing heat transferred to the atmosphere, and greatly affecting the European climate and fisheries.
This research focuses on better understanding the dynamics of the Beaufort Gyre in order to gain insight in the transport of heat and melting of the sea ice above. We idealize the Beaufort Gyre in the context of the Quasi-Geostrophic model, where we account for the rotation of earth, wind forcing and bottom drag. Using the finite element library, Firedrake, we compute steady solutions for the Beaufort Gyre and examine how the structure of the gyre depends on the varying strength of the winds. Subsequently, we investigate the stability characteristics of the gyre. The purpose of this work is to investigate the turbulent eddy field that is generated as a result of shear instabilities, how this affects the distribution of heat in the vertical direction and the subsequent impact on the melting of the sea ice above.

Title: Active layer and upper permafrost soil sampling at Trail Valley Creek, NWT

Authors:
Niels Weiss, Wilfrid Laurier University
Philip Marsh, Wilfrid Laurier University

***Correspondence:** nweiss@wlu.ca

Keywords:
Permafrost, Ground ice, Organic matter, Trail Valley Creek

Primary meeting theme: Climate-driven changes of water environments in cold regions

Abstract:
Permafrost conditions are a key factor in understanding and predicting change in arctic ecosystems. Along with topography, ice content largely determines the landscape's response to warming. In mountainous areas mass wasting such as thaw slumps can occur, and in lowlands, permafrost thaw can lead to thermokarst lake formation as well as drainage. Permafrost also stores large amounts of organic matter (OM) and—on a circumarctic scale—plays an important role in global biogeochemical cycles and climate.
Trail Valley Creek (TVC) research station is located in the Western Canadian Arctic, c. 50 km north of Inuvik, Northwest Territories. The area is underlain by continuous permafrost and is one of the most rapidly warming regions on Earth. Research activities at TVC comprise nearly three decades of environmental monitoring with a focus on land surface change, and buffer layer (e.g. vegetation, snow) and atmosphere interactions (e.g. greenhouse gas (GHG) release).
In August 2019 we started systematically collecting samples from soil profiles around TVC, in order to characterize the physical and biochemical properties of the active layer and upper permafrost. These samples will be used to determine ice and OM content, and map their distribution throughout the landscape. Additionally, the data can supplement ongoing research such as permafrost modeling efforts and help interpret processes and heterogeneity of GHG dynamics.
Preliminary results indicate a generally high ice content (57% average for 12 sampling sites) and abundance of OM (28% was recognized as organic-rich or peat-like). In the spring and summer of 2020, we will continue stratified random sampling around the eddy covariance towers, as well as at key landforms and landcover types.

Title: Intensified climate drying and anthropogenic drainage threaten wetlands conservation in Prairie Pothole region

Authors:
Zhe Zhang, University of Saskatchewan
Lauren Bortolotti, Ducks Unlimited Canada
Yanping Li, University of Saskatchewan
Zhenhua Li, University of Saskatchewan

***Correspondence:** zhe.zhang@usask.ca

Keywords:
wetland, climate change, habitat conservation, drainage, waterfowl population

Primary meeting theme: Climate-driven changes of water environments in cold regions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; Stakeholder engagement and knowledge mobilization

Abstract:
Millions of wetlands in Prairie Pothole Region (PPR) are important habitats for more than half of the waterfowls in North America. The existence, abundance, and duration of these wetlands are sensitive to both climate change and anthropogenic activities. Therefore, understanding the impacts of climate change on PPR wetlands is critical to the conserving wetland habitats and protecting waterfowl population in PPR. In this study, a wetland model was constructed with current climate conditions and was applied to predict future wetland distribution under climate change scenario. In this model, the soil water content is the key climatic variable and the importance of shallow groundwater is considered as well, which reflects the surface water balance. The future climate forcing is from a high-resolution regional climate model with the convection-permitting dynamic downscaling approach. The results show that the climate change impacts on wetland distributions are spatially heterogenous and seasonally varied. In western PPR, the wetland abundance increases from spring through summer. However, in eastern PPR, especially in moist mixed grasslands and aspen parklands, wetland fraction increases in spring while decreases in summer due to intensified drying. Furthermore, the future wetland fraction results were overlaid with an anthropogenic drainage map, showing that the areas with strong summer drying in the eastern PPR are in coincidence with the areas with high drainage intensity. These joint effects of climate-drainage pose greater challenges to wetland conservation in eastern than in western PPR, due to the higher land values in eastern PPR and additional cost to restore wetlands from drainage as well. On the other hand, the wetlands in western PPR are projected to be more abundant and prolonged. The outcomes of this study will be useful to direct conservation agencies to prioritize conservation efforts to regions with greater productivities and returns.

Title: Characterization and modelling of hydrological behavior and phosphorus cycling in urban bioretention cell.

Authors:
Bowen Zhou, University of Waterloo
Ariel Lisogorsky, University of Waterloo
Mahyar Shafii, University of Waterloo
Fereidoun Rezanezhad, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** b59zhou@uwaterloo.ca

Keywords:
Bioretention Cell, Modelling, Phosphorus, Urban Stormwater Management, Eutrophication

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
Urbanization increases eutrophication risk to surrounding natural water body by bringing excessive runoff with high concentration of nutrients. Phosphorus (P) loading in runoff discharged from urban stormwater management system is considered as one of the critical controlling factors for eutrophication. Low Impact Design (LID) technologies such as bioretention cells are emerging to reduce P loading to receiving waters in urban areas. A mechanistic understanding of the nutrients reduction achieved by bioretention cells, especially with winter-associated processes, has not yet been developed. In this study, we examine the hydrological and biogeochemical responses under precipitation events, dry/wet conditions as well as seasonal differences in a well-monitored urban bioretention cell maintained by Credit Valley Conservation (CVC) in Mississauga, Ontario. The reduction of P loading by bioretention cell system, under various rainfall and climatic conditions, is assessed by analysis of 7 years field data and a model that simulates both the hydrologic response and biogeochemical processes inside the system. Preliminary results indicate that process of infiltration, adsorption and deep percolation in bioretention cell significantly decreases the amount of runoff and P concentration in discharge, while the reduction efficiency for both runoff and P show strong variation related to seasonal variability of precipitation regimes. In this presentation, we will present the characterization of discharge, water level and outlet P concentration and speciation of bioretention cell under various conditions.

Title: An update on observed and modelled changes in extreme precipitation

Authors:
Francis Zwiers, University of Victoria
Qiaohong Sun, University of Victoria
Chao Li, East China Normal University
Xuebin Zhang, Environment and Climate Change Canada

***Correspondence:** fwzwiers@uvic.ca

Keywords:
Extreme precipitation, Climate change projections

Primary meeting theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; (Big) data science and management

Abstract:
In this talk I will briefly describe results from two studies evaluating (i) observed changes in extreme precipitation from a global network of observing stations, and (ii) undertaking an early evaluation of CMIP-6 based changes in extreme precipitation. Observational data continues to show that extreme daily precipitation accumulations are intensifying globally, although with considerable regional variation, with reductions in intensity evident at many Canadian stations, and in a broad band across China. Observed changes appear to be consistent with changes simulated by an early cohort of CMIP6 models. Biases in the intensity of model simulated extremes are modest over mid-latitude domains, including Canada, when compared to a range of reanalyses, including recent high-resolution products. At broad scales, including over Canada, Intensity scales linearly with warming independent of forcing scenario or the model's equilibrium climate sensitivity, with intensification occurring at a rate that is roughly consistent with Clausius-Clapeyron.

Title: Phosphorus Cycling in the Littoral Zone of Lake Erie

Authors:
Zahra Akbarzadeh, University of Waterloo
Igor Markelov, University of Waterloo
Serghei Bocaniov, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** zahra.akbarzadeh@gmail.com

Keywords:
Lake Erie, Littoral zone, Phosphorus

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Littoral zones of lakes, where land and lake meet, are strongly influenced by on-land anthropogenic activities. Nutrient inputs delivered from watersheds to a large lake must first pass through the littoral zone before reaching the offshore waters. That is, the littoral zone acts as a biogeochemical reactor that modulates the fluxes, timing and speciation of nutrient elements from land to lake. Little is known, however, about the role of the littoral zone on phosphorus (P) cycling in lakes, and how it affects nearshore eutrophication due to excess availability of P. Lake Erie is a large lake, strongly impacted by anthropogenic activities and suffering from eutrophication. While the western basin of the lake is greatly impacted by basin-wide cyanobacterial blooms, the northern shore of the eastern basin experiences nuisance Cladophora blooms. To investigate P dynamics in the littoral zone of Lake Erie, we developed a mass balance model for total phosphorous (TP). The littoral zone was defined as the area between the shoreline and the 15 m water depth contour around the lake. We divided the littoral zone of Lake Erie into 5 segments, roughly within the boundaries of the western, central, and eastern basins. Due to its shallowness, the whole western basin was represented as one big littoral segment. For the central and eastern basins, the northern and southern shores each contained 2 segments extending between 1 and 15 km from the shoreline and roughly corresponding to the depth of the thermocline. Also, offshore reservoirs represented the epilimnion (< 15m of depth) and hypolimnion of both the central and eastern basins. We calculated the TP budget in each littoral segment by including inputs from tributaries, atmospheric deposition, nearshore-offshore exchanges and, for some segments, also water intakes. A segment's water budget was derived from the large-scale circulation patterns reported in the literature. In the model, permanent removal of TP in a given segment occurs through burial in bottom sediments, calculated using literature data on accumulation rates of P in sediments, P resuspension estimations, and internal loading fluxes measured in sediment core incubations with Lake Erie sediments. Our preliminary results indicate that the littoral zones of Lake Erie eliminate around 30% of all the TP input into the Lake.

Title: Valuation of potential and realized ecosystem services in southern Ontario, Canada

Authors:
Tariq Aziz, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** tariq.aziz@uwaterloo.ca

Keywords:
Potential Ecosystem Services, Realized Ecosystem Services, Southern Ontario, Greenbelt, Economic Valuation

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
The full production of services by an ecosystem are called the potential ecosystem services; the portions of the potential ecosystem services that are actually used by society are called the realized ecosystem services. The latter are of particular socio-economic importance due to their direct contribution to human well-being. A key challenge faced by the economic valuation of ecosystem services is how to differentiate between realized and potential ecosystem services. Here, we address this challenge for Southern Ontario—the most densely populated region of Canada. We apply the Co$ting Nature model to generate the combined spatial distribution and use intensity of a bundle of six ecosystem services: water provisioning and supply, water quality, carbon sequestration, carbon storage, flood regulation, and nature-based tourism. The relative distribution of the potential ecosystem services is then combined with regional unit values for the land covers supplying the ecosystem services. Our analysis yields a total potential value of the bundled ecosystem services of $19 billion per year for Southern Ontario. To estimate the value of the realized ecosystem services, the potential values are scaled by the corresponding realized service indices. The resulting value of the realized ecosystem services is $9.7 billion per year, that is, about 50% of the value of the potential ecosystem services. The importance of accounting the realized ecosystem services is illustrated for the Greenbelt, a protected area of about 7600 km2 surrounding the Greater Toronto-Hamilton conurbation, which is home to more than nine million people. Within the Greenbelt, 61% of the value of potential ecosystem services is realized, significantly higher than the regional average. Of particular importance is flood regulation by the Greenbelt, given the growing threat of urban flooding in the Toronto area.

Title: The cost-effectiveness of wetlands as a nature-based solution to reduce phosphorous runoff

Authors:
Angelos Alamanos, University of Waterloo
Roy Brouwer, University of Waterloo

***Correspondence:** aalamano@uwaterloo.ca

Keywords:
Wetlands, Phosphorous reduction, Cost-effectiveness, Nature-based solution, Canada

Primary meeting theme: From anthropogenic pressures to ecosystem services

Abstract:
Wetlands provide valuable ecosystem services. However, many wetlands have been destroyed or are degraded due to land use intensification. Recently, wetlands are increasingly considered a low-cost nature-based solution to solve water challenges like eutrophication. We review almost 4 decades of literature focusing on the role of wetlands to reduce nutrient runoff. Almost 60 studies are identified that assess the cost and effectiveness of different types of wetlands across Canada to reduce phosphorous runoff into surface and groundwater. Regression models are estimated to identify key driving forces behind the observed variation in the cost-effectiveness of wetlands to retain phosphorous and prevent their runoff. Drivers include wetland type, size and geographical location. The results from this meta-analysis provide policymakers with important insights in support of future wetlands conservation and restoration as a cost-effective nature-based solution for sustainable watershed management.

Title: LAKE SEDIMENT CORES AS A WINDOW INTO PAST AND FUTURE LOTIC AND LENTIC TRAJECTORIES

Authors:
Ruchi Bhattacharya, University of Waterloo
Nandita Basu, University of Waterloo

***Correspondence:** r28bhatt@uwaterloo.ca

Keywords:
Legacy Phosphorus, Water quality trajectory, Landuse change, Eutrophication, Paleolimnology

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management

Abstract:
Lake sediments are known integrators of long-term global change across lentic and lotic systems. Inland waters are experiencing elevated productivity and eutrophication despite extensive management efforts. Historic land alterations and agricultural activities have resulted in legacy nutrient accumulations within lakes and reservoirs. Internal loading from legacy accumulations can be a major source of nutrients with water quality implications. The influence of legacy nutrients is often unaccounted in water quality models, which also serves as a challenge for predicting the effect of watershed-lake management efforts. Better quantification of historic changes in lake ecology and sedimentary nutrient stocks with watershed land-use changes and lake morphology are needed for an in-depth understanding of how lake ecosystems evolved and might respond under future environmental stressors. For this purpose, we conducted a meta-analysis of 200 paleolimnological studies across 150 lakes in 20 countries. Preliminary analyses showed that in the last 100 years, lakes have accumulated approximately -20–14000 (median=330) mg/Kg of legacy phosphorus (P) at a rate of -15–230 (median=3.5) mg/Kg/y. We found that most lakes have deviated from their natural historic range of productivity, with the highest legacy accumulations recorded in shallow lakes experiencing long-term alterations. Links between land-use change and nutrient accumulations can provide insights about inland water quality response and help to develop robust predictive models useful for resource managers and decision-makers.

Title: After six years, what have we learned about the hydrological functioning of the constructed Sandhill Fen Watershed in the Athabasca oil sands region?

Authors:
Kelly Biagi, McMaster University
M. Graham Clark, McMaster University
Sean Carey, McMaster University

***Correspondence:** biagikm@mcmaster.ca

Keywords:
constructed wetland, reclamation, oil sands, salinity, hydrologic functioning

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Mine reclamation in the Athabasca oil sands region, Alberta is legally required where companies must reconstruct disturbed landscapes into functioning ecosystems such as forests, wetlands and lakes that pre-existed in the Boreal landscape. Only recently have companies constructed upland-lowland systems to sustain peat-forming wetlands which provide ecosystem services critical to the long-term success of the reconstructed landscape. To date, two upland-wetland systems have been constructed in the AOSR and only recently has enough data been collected to evaluate ecosystem trajectories. The objective is to understand the key hydrological changes post-management of a constructed peatland watershed, and provide insight on the overall system function, the barriers to its long-term sustainability, and its trajectory towards hydrological and hydrochemical stability. Five years of post-management hydrometric data are presented from the Sandhill Fen Watershed, a 52-ha upland-wetland built on soft tailings with a pump system to provide fresh water, support drainage, and limit salinization. SFW was heavily managed in its first few years where pumps dominated the water balance, but since 2014 has remained largely unmanaged with only occasional outflows. As a result, the hydrological exchanges are predominantly vertical, which respond to inter-annual climate variations and vegetation development. Intra-watershed surface and near-surface water movement is primarily towards the wetland from the uplands plus occasional surface runoff from hillslopes during snowmelt and heavy rainfall. Limited outflow has caused persistent ponded water in the wetland which has required occasional drainage when it has caused excessive flooding. Interaction with deeper process water is limited, but transports highly saline waters (>4000 µS/cm) with high Na+ concentrations (~1000 mg/L). This, in addition to evapoconcentration of surface and near-surface waters and limited input of freshwater, has caused a year-over-year increase of salinity and Na+ concentrations which have reached up to 3500 µS/cm and 400 mg/L, respectively in the lowland area. Wetland vegetation has undergone shifts toward salt-tolerant species that can survive in ponded conditions. Considering these changes within the first few years, the ecosystem functions will likely differ between constructed and natural peatlands. Lessons learned from this research will be helpful for future peatland construction in this region.

Title: A Multi-Species Toxicokinetic Modelling Approach in Support of Chemicals Risk Assessment

Authors:
Markus Brinkmann, University of Saskatchewan
Annika Mangold-Döring, Wageningen University, Netherlands
Chelsea Grimard, University of Saskatchewan
Henner Hollert, Goethe University Frankfurt, Germany
Markus Hecker, University of Saskatchewan

***Correspondence:** markus.brinkmann@usask.ca

Keywords:
PBTK model, multi-species model, neutral organic compounds, freshwater fish

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; Social, economic and health determinants and impacts

Abstract:
The production and release of chemicals by our society has been described as one of the greatest threats to the sustainability of human activities on this planet. Legislation of varying rigor has been implemented globally, and which seeks to minimize impacts of chemicals on the environment through ecological risk assessments (ERA). ERA is typically based on toxicity data that are generated by standardized laboratory experiments with select model species. These species, however, might not be representative of native species of concern in an ecosystem. While a wealth of data from non-model species are available in the scientific literature, these data are under-utilized in ERA because of their non-compliance with test guidelines. Therefore, approaches are needed that enable inclusion of these data.
One approach is to use models that facilitate extrapolation between levels of biological organization, exposure conditions, and among species, such as physiologically based toxicokinetic (PBTK) models, which can be used to predict the uptake and biodistribution of chemicals in aquatic organisms, specifically fish. State-of-the-art PBTK models are based on single species approaches and fail to reflect natural variations in physiological parameters across different species. To overcome this limitation, we developed a novel multi-species approach that provides robust estimations of inter- and intra-species variability in model predictions based on a stochastic modelling framework.
In an extensive literature search, 2,777 single values were collected, representing 71.9 % of families of freshwater fishes occurring in Canada. These values were then used to describe the distributions of parameters, which were then used in Monte Carlo-like simulations. Model validation showed that the predicted bioaccumulation potential of most modeled chemicals fell within a 10-fold range of corresponding measured data values. This is in reasonable agreement with previously published single-species models while at the same time significantly improving the level of species diversity. As such, this model will enable more environmentally relevant predictions using already existing data and will ultimately lead to a better understanding of chemical impacts in aquatic ecosystems.

Title: The impacts of atmospheric nitrogen deposition on the nutrient dynamics of a constructed fen-upland in the Athabasca Oil Sands Region, Alberta

Authors:
Rebecca M. Cameron, University of Waterloo
Rich M. Petrone, University of Waterloo
Merrin L. Macrae, University of Waterloo
Felix C. Nwaishi, Mount Royal University

***Correspondence:** rmcamero@uwaterloo.ca

Keywords:
Atmospheric deposition, Nitrogen cycling, Nutrients, Reclaimed fen, Reclaimed upland

Primary meeting theme: From anthropogenic pressures to ecosystem services

Abstract:
Oil sands mining activities have resulted in anthropogenic nitrogen (N) deposition in the Athabasca Oil Sands Region (AOSR). N deposition rates can have important nutrient-cycling implications for surrounding ecosystems and have been linked to changes in plant community composition, soil nutrient cycling and plant productivity. Previous studies have assessed the impacts of N deposition on natural ecosystems in the AOSR, however few have investigated the impacts of N deposition on constructed ecosystems. The Nikanotee Fen Watershed is a reclaimed fen-upland system located within the centre of AOSR activity. Due to its location, the reclaimed system may be vulnerable to N deposition. In comparison with three natural fen sites located between 10-70 km away from the Nikanotee Fen Watershed, results from summer 2018 indicate that the reclaimed system received the highest N deposition rates. The objectives of this research are to: 1) characterize and assess atmospheric N deposition to the fen and upland; 2) assess the relationship between N deposition and nutrient dynamics; and 3) determine an overall N budget for the fen and upland. Ion-exchange resin columns were deployed across the fen and upland to assess bulk N deposition loads in summer 2019. Lysimeter and pore-water samplers were installed in the fen to analyze soil N chemistry and stemflow collectors were installed on the trunks of the four dominant tree species in the upland (poplar, aspen, jack pine and black spruce) to assess how trees intercept and uptake N. Additionally, soil, water and vegetation samples were collected to analyze for total N concentrations in the fen and upland. This research is important to our understanding of how external factors control boreal nutrient dynamics and how they might be impacted by regional industrial activities. This work will also inform future reclamation design and assessment practices.

Title: Using integrated models of economics, hydrology and biogeochemistry to assess changes to ecosystem services on the Canadian Prairies.

Authors:
Emily Cavaliere, University of Saskatchewan
Jared D. Wolfe, University of Saskatchewan
Helen M. Baulch, University of Saskatchewan
Colin J. Whitfield, University of Saskatchewan
Robert G. Clark, Environment and Climate Change Canada
Balew Mekonnen, University of Saskatchewan
Nandita Basu, University of Waterloo
Chris Spence, Environment and Climate Change Canada
Eric Asare, University of Saskatchewan

***Correspondence:** emily.cavaliere@usask.ca

Keywords:
integrated model, Prairies, biogeochemistry, hydrology, ecosystem services

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Over the last century, much of the Prairies has been converted for agricultural use (principally cropland). As a result, Prairie Pothole wetlands have been degraded or lost. These wetlands can provide a diverse set of ecosystem services, such as flood mitigation, nutrient retention, and wildlife habitat. The Prairie region is large and heterogenous, which presents a challenge to informed decision-making that is often based on political rather than geophysical boundaries. A central challenge is how to manage landscapes sustainably to maintain their diverse ecosystem and food production services. To address this need, we are constructing integrated models of economics, hydrology, biogeochemistry and ecology to better understand how climate and land-use interact with prairie wetlands, and to identify solutions that can be used in pragmatic management of these landscapes. We use a virtual watershed approach designed to simulate local scale behaviour that can be more broadly representative of the wider landscape. The virtual approach has been made possible through a classification of over 4000 small watersheds across the prairies according to a wide range of characteristics, including surficial geology, topography, wetland distribution, and land-use practices. This allows us to understand how wetland ecosystem services respond to anthropogenic stressors distinctively across different watershed classes. We explore a range of scenarios to evaluate the effect of different land management and food-production practices, as well as climate change. We expect that predictions from these virtual watershed models can support decision-making in these working agricultural landscapes, and help land managers achieve a balance that supports ecosystem service delivery while mitigating private costs to food producers.

Title: Seismic line disturbance alters soil physical and chemical properties across contrasting boreal soils

Authors:
Scott J. Davidson, University of Waterloo
Ellie M. Goud, Cornell University
Caroline Franklin, University of Alberta
Scott Nielsen, University of Alberta
Maria Strack, University of Waterloo

***Correspondence:** s7davidson@uwaterloo.ca

Keywords:
Disturbance, Peatlands

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Industrial activities for resource extraction have led to a network of seismic line disturbances across Canada's boreal regions. They can have a significant impact on ecosystem function through vegetation removal, simplification of microtopography, alterations of hydrology and changes to biogeochemical processes. Recently, there has been a concerted effort to restore seismic lines using mounding to encourage ecosystem recovery. However, there is very little in the literature on the impacts of these treatments on soil properties. The objective of this study was to identify differences in soil characteristics between areas disturbed by seismic lines, lines restored using mounding and adjacent natural (reference) areas. We collected soil samples at 34 seismic lines and adjacent natural locations in Alberta, Canada. Samples were analyzed for a range of physical and chemical properties. Seismic line disturbances had a significant impact on soil properties by increasing bulk density and moisture on lines. We found ~30% reduction in organic matter on the line compared to adjacent natural sites. This has important implications for carbon cycling, as it indicates increased mineralization rates and loss of carbon dioxide. There was also □13C/□15N enrichment and narrower C:N ratios on the line, indicating increased rates of decomposition. Further, there was increased rates of decomposition on the mounds created for restoration. This implies there is a trade-off between restoration activities that may encourage ecosystem recovery, but also result in carbon losses. More information is needed to understand the impact of current restoration practices on seismic lines for ecosystem function to ensure best management practices during restoration.

Title: Climate change impacts in Six Nations of the Grand River, Ontario under 21st century warming conditions

Authors:
Tariq Deen, McMaster University
M. Altaf Arain, McMaster University
Patricia Chow-Fraser, McMaster University
Olivier Champagne, McMaster University
Dawn Martin-Hill, McMaster University

***Correspondence:** deenta@mcmaster.ca

Keywords:
climate extreme, temperature and precipitation, streamflow, Indigenous, Southern Ontario

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; Social, economic and health determinants and impacts

Abstract:
Hydro-meteorological hazards are the predominant type of natural hazard that affect the Province of Ontario, Canada. They cause billions of dollars in damage and pose a significant threat to life and safety of Ontarians. Their effects range from disruption in transportation networks to crop failures to mental trauma. Therefore the development of disaster risk reduction and emergency response plans are essential for protecting communities from these hazards; locally scaled climate data is crucial for developing robust community plans. This study presents future changes to climatic conditions and extreme events in Six Nations of the Grand River, Ontario - the largest First Nations community by population in Canada. Preliminary results of modelled McKenzie Creek and Grand River streamflow from the Precipitation Runoff Modelling System (PRMS) are also presented. Observed and simulated RCP 4.5 and 8.5 climate data was used to calculate extreme climate indices from the CCl/WCRP/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI). Mann-Kendall statistical tests were used to detect timeseries trends. Temperature and precipitation anomalies indicate that the area will become overall wetter and warmer, with increase trends in both extreme hot temperature and precipitation, and decreasing trend in extreme cold temperature. Results suggest that the community's exposure to winter-spring flooding and summer drought may increase in the future as a result of these changes.

Title: A Random Forest in the Great Lakes: Exploring Nutrient Water Quality Signatures in the Laurentian Great Lakes Watersheds

Authors:
John Dony, University of Waterloo
Qualbe Shadman Chowdhury, University of Waterloo
Kimberly Van Meter, University of Illinois
Nandita B. Basu, University of Waterloo

***Correspondence:** jwldony@uwaterloo.ca

Keywords:
Nutrient water quality, Great Lakes, Nitrogen, Phosphorus, Machine Learning

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting ;(Big) data science and management

Abstract:
Cultural eutrophication and associated excessive nitrogen and phosphorus loading into ground- and surface waters has led to deteriorated water quality and associated ecological and public health concerns. The Laurentian Great Lakes drainage basin is particularly vulnerable to these threats due to its highly populated urban areas and intensive agricultural activities. Despite past successes in reducing nutrient loading, eutrophication persists in the Great Lakes, in part due to continued nutrient loadings from non-point sources.
To move towards more targeted nutrient management, we must acknowledge and better characterize the heterogeneity of responses and behaviours of Great Lakes watersheds to anthropogenic nutrient inputs. In recent years, machine learning tools have grown in popularity for assessing data-driven environmental issues. I apply random forest regression, a widely used machine learning method, combined with stream water quality data, to evaluate the effects of catchment variables, e.g., land use, slope, on nitrogen (N) and phosphorus (P) loading to the Great Lakes. With these techniques, we quantify how land use and other spatial factors affect nutrient fluxes and ratios, e.g. N:P ratios and relative proportions of soluble reactive P and total P. Initial findings suggest the primary importance of agriculture and tile drainage in driving dissolved nitrogen and phosphorus loadings within the Great Lakes watersheds.
Understanding the spatial factors influencing nutrient dynamics is critical for implementing effective management strategies over appropriate scales and managing expectations in observing outcomes. This research will directly benefit water managers and policy makers operating in these watersheds and lead to more effective watershed management for improved water quality and solutions addressing the Great Lake's eutrophication concerns.

Title: Linking soil water content to carbon cycling and soil health: How can we improve process-based models?

Authors:
Linden Fairbairn, University of Waterloo
Fereidoun Rezanezhad, University of Waterloo
Mehdi Gharasoo, University of Waterloo
Chris Parsons, Environment and Climate Change Canada
Merrin Macrae, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** lgfairbairn@uwaterloo.ca

Keywords:
Soil organic matter, Carbon cycle, Climate change, Soil moisture, Agroecosystem

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
Soil organic carbon (C) is a key indicator for soil health and fertility, and thus is a highly important component of agroecosystems. The potential for enhanced C sequestration in soils has received increasing attention, especially for agricultural soils due to the historic depletion of organic C in cultivated lands. The microbial decomposition of soil organic C can result in both the export of dissolved organic C, impacting water quality and aquatic ecosystems, and the emissions of inorganic C as carbon dioxide (CO2) and methane to the atmosphere. The development of mechanistic models that accurately represent these fluxes will require improved process-based understanding of the decomposition mechanisms involved. With a changing climate, it is necessary to quantify how climate-driven changes (e.g., soil moisture and temperature regimes) could affect soil C decomposition and resulting C fluxes. In this research, we studied how soil water content and oxygen availability control soil C cycling. We conducted factorial batch experiments where agricultural soil was incubated at 5 different soil water contents (ranging from 30-100% saturation) and under 2 oxygen conditions (oxic versus anoxic incubation). At the end of the 21-day incubation, gas fluxes (CO2 and methane) and pore water chemistry parameters were measured. The results demonstrated that, under oxic incubation, CO2 fluxes were highest at moderate soil water content (65% saturation). This was expected since fluxes will become moisture-limited at low water contents, and oxygen-limited at high water contents. At high water contents (80% and 100% saturation), CO2 fluxes in anoxic incubations were 75% to >100% of those in oxic incubations. Therefore, contrary to many existing CO2 flux models that only consider aerobic production of CO2, the fluxes of CO2 in both fully saturated and anoxic incubations highlighted that anaerobic production of CO2 should not be ignored. These experimental results led to the development of an updated model for soil CO2 fluxes which considers both aerobic and anaerobic sources of CO2 to more accurately predict fluxes across a range of soil water contents. Increasingly process-rich models for soil organic C decomposition will be required for the accurate predictions of soil C fluxes under future climates, which has wide-ranging applications from greenhouse gas emissions to water and soil quality.

Title: Quantify water use and rainfall partitioning of dominant tree species in a post-mined landscape in the Athabasca Oil Sands Region, Alberta

Authors:
Sarah Fettah, University of Waterloo
Richard Petrone, University of Waterloo

***Correspondence:** S2fettah@uwaterloo.ca

Keywords:
Reclamation, Transpiration, Rainfall Partitioning

Primary meeting theme: From anthropogenic pressures to ecosystem services

Abstract:
Oil Sand processes have caused significant disturbances to forest and wetland ecosystems in Northeastern Alberta. Provincial and federal laws mandate restoration of these systems in attempt to return the landscape to pre-disturbed conditions. Reclaiming these important ecosystems has faced many challenges including re-vegetation of uplands to a state of self-sustainability and productivity. The Nikanotee Fen Watershed in Fort McMurray, Alberta, is a post-mined landscape consisting of a constructed wetland-upland connected through runoff and groundwater. The design of these systems impact many components of the ecosystem, including vegetation growth and productivity. Over time, soil and vegetation cover in the upland will develop, leading to significant changes in the ecosystem. The trajectory of reclaimed sites highly depends on the population of tree species, such as conifers or broadleaf. Development of the tree canopy will lead to increases in precipitation interception and transpiration, ultimately reducing water available for recharge to the adjacent wetland. Characterizing vegetation distribution and composition and their impacts on the water balance may help improve reclamation techniques for future projects. The aims of the study are to i) assess the trends in transpiration of dominant tree species throughout the growing season; ii) quantify throughfall, stemflow and interception of dominant tree species and iii) understand the role they play in intercepting precipitation and its impact on near-surface soil moisture regime and tree water use. The study used a variety of meteorological and hydrological methods to assess the suitability of dominant tree species used in reclamation projects. To examine the variability in tree water use across the upland, vegetation surveys were completed, and several dominant tree species were instrumented with Stem Heat Balance sap flow sensors to determine individual species transpiration rates. Rainfall was partitioned into interception, throughfall and stemflow alongside monitoring soil moisture dynamics and soil water potential to determine the plant available water.

Title: Estimating the Direct and Indirect Costs of Phosphorus Emission Reduction Policies in the Great Lakes Basin using a Multi-Regional Input-Output Model

Authors:
Jorge A. Garcia, University of Waterloo
Roy Brouwer, University of Waterloo
Rute Pinto, University of Waterloo

***Correspondence:** ja4garci@uwaterloo.ca

Keywords:
economic impact analysis, phosphorus emissions, Great Lakes, input-output model

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
The Great Lakes on the Canada-US border, one of the planet's largest freshwater resources, face serious eutrophication problems due to excessive nutrient loading. This study aims to estimate the impacts of different phosphorus (P) emission restriction policies across the various sub-basins on the Great Lakes Basin (GLB) economy and the economy of Canada as a whole. A multi-regional, multi-sectoral Input-Output (IO) model is built for the Great Lakes, the first of its kind, and extended to include P-emission levels for point and non-point source pollution. The direct and indirect impacts of uniform and targeted emission reduction policy scenarios are estimated, employing a mixed exogenous-endogenous IO model, and a new economic optimization procedure is introduced identifying the economic least cost way to reach P-emission standards. New in this study is also that trade flows within and between sub-basins, the GLB and the rest of Canada are modelled explicitly, which allows consistent up and downscaling of economic impacts. The results show that the costs of P-reduction are substantial, a majority of which are indirect, affecting not only the economic activities along the Great Lakes, but the economy of Ontario and Canada as a whole due to their tightly interwoven economic structure.

Title: A New Way of Understanding Agricultural Rebound Phenomenon

Authors:
Mohammad Ghoreishi, University of Saskatchewan
Saman Razavi, University of Saskatchewan
Amin Elshorbagy, University of Saskatchewan
Razi Sheikholeslami, University of Oxford

***Correspondence:** mohammad.ghoreishi@usask.ca

Keywords:
Rebound Phenomenon, Agent-based Modeling, Global Sensitivity Analysis

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
Effective use of water resources has been identified as a means to improve resilience to drought, particularly in the agricultural sector. In recent decades, the idea of shifting to more efficient irrigation systems (e.g., sprinkler irrigation systems) has received increasing attention to reduce the amount of water loss by traditional irrigation systems (e.g., flood irrigation systems), requiring considerable capital investments. However, there are indications that such investments do not lead to a reduction in water use in the long-run, which may even increase paradoxically; a phenomenon known as the rebound phenomenon or Jevon's paradox. One of the fundamental information gaps concerns an explicit evaluation of coevolutionary dynamics and the interactions among socio-economic factors in the rebound phenomenon in agriculture, which calls for the application of systems-based methodologies such as global sensitivity (GSA) analysis methods to look at time-dynamical aspects of the coevolutionary dynamics between various factors influencing rebound phenomenon. In this study, we use a previously calibrated and validated Agent-Based Agricultural Water Demand (ABAD) model applied to the Bow River Basin in Alberta, Canada - home to extensive irrigated farmlands with a history of drought experience. We perform a time dependent variance-based GSA on the ABAD model to examine the direct impact of factors as well as their joint influence due to interactions on rebound phenomenon. The overall findings show that the economic factors are the most important elements, which has an upward trend in the simulation time, in the rebound phenomenon. This finding is supported by the local observation as the net income of irrigated land has an upward trend in this time period. In addition, although the individual effect of the factor representing the social interaction among farmers is less important compared to the irrigation expansion factor, its total-order effect (i.e., the total contribution of a single factor including interactions with all other factors) becomes more important indicating the significant interactions among model factors. This analysis provides a deeper understanding of the coevolutionary dynamics of the rebound phenomenon and paves the way for better management of water resources.

Title: Wild fish grow faster downstream of a municipal wastewater treatment plant (WWTP)

Authors:
Samina Hayat, University of Waterloo
Hadi Dhiyebi, University of Waterloo
Leslie Bragg, University of Waterloo
Mark McMaster, University of Waterloo
Mark Servos, University of Waterloo

***Correspondence:** s3hayat@uwaterloo.ca

Keywords:
ecotoxicology, growth, fish, wastewater, Grand River

Primary meeting theme: From anthropogenic pressures to ecosystem services

Abstract:
Municipal wastewater effluent (MWWE) is a major concern for aquatic organisms due to a variety of contaminants, including pharmaceuticals and personal care products (PPCPs), that have been linked to adverse effects. In the Grand River watershed, rainbow darter (Etheostoma caeruleum) are a small-bodied fish species that have been used extensively to study impacts of MWWE exposure. Fish exposed to wastewater effluent are impacted across various levels of biological organization but the associated nutrient input on fish growth has not been explored. Growth is an important indicator of fish health and is used by the Canadian Environmental Effects Monitoring (EEM) program to understand impacts of metal mining and pulp and paper effluent on fish health. To improve the quality of the final effluent, major infrastructure investments have been made at the Waterloo municipal wastewater treatment plant. This study aims to understand the impact of MWWE on growth of rainbow darter in the Grand River before and after upgrades that came on-line in 2017. Parameters of von Bertalanffy growth curves are compared to assess whether fish downstream of MWWE grow differently from fish upstream. Preliminary results suggest that both male and female fish grow faster downstream of the effluent outfall pre and post upgrades. Understanding and quantifying these differences in growth attributed to wastewater effluent can allow for detection of subtle but important impacts. Use of these small bodied fish can be applied as an endpoint in regional monitoring programs for municipal wastewater to provide a sensitive indicator of fish health.

Title: δ13C-DIC after dark: Evaluating sources of dissolved inorganic carbon to a eutrophic boreal lake on diel and seasonal timescales

Authors:
R.I. Henderson, Wilfrid Laurier University
S.L. Schiff, University of Waterloo
J.J. Venkiteswaran, Wilfrid Laurier University

***Correspondence:** hend3120@mylaurier.ca

Keywords:
algal bloom, eutrophication, stable isotopes, carbon cycle, Experimental Lakes Area

Primary meeting theme: From anthropogenic pressures to ecosystem services

Abstract:
High rates of primary production during the day in low alkalinity systems can cause large diel fluctuations in pH, dissolved inorganic carbon (DIC), and stable isotopes of DIC (δ13C-DIC) in lakes and rivers. We measured these parameters hourly between sunset and sunrise in the epilimnion of Lake 227, an experimentally eutrophic boreal lake, at three times: during an cyanobacterial bloom, a bloom of diverse taxa, and a period of relatively low biomass. We compared measured δ13C values to known end-members to quantify relative contributions of ecosystem respiration (ER), gas exchange, and chemically enhanced diffusion (CED) to the DIC pool. During blooms, δ13C-DIC increased slightly overnight and was -16.6 ‰ on average while, during the lower-biomass period, δ13C-DIC decreased from 0.1 ‰ to -9.2 ‰. [DIC] increased by 57 uM and gas exchange was a greater proportion of DIC return during the lower-biomass sampling event. ER contributed more DIC during the blooms, but [DIC] only increased by 9-37 uM. Contributions by CED were negligible, despite favourable conditions during one of the blooms. δ13C-DIC values of productive lakes can vary substantially on diel and seasonal timescales and are sensitive to changes in pH and ER.

Title: Changing Perspectives: Consider That You Are Nature

Authors:
Stephanie Higgins, University of Waterloo

***Correspondence:** smhiggins@uwaterloo.ca

Keywords:
Knowledge Mobilization, Eutrophication, Nature Civilization False Dichotomy

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
The Aurora Borealis is a natural phenomenon that tourists from around the world travel to see. With hopefully clear skies, chill air, and clean snow on a dark night, green lights up the sky and feelings of smallness and connection to nature come to mind. In the painting, all of nature is represented by the Aurora Borealis, in direct contrast to “civilization,” it is visited, remote, and untouched. When turned 180°, the green sky becomes an algal bloom and the grey snow is a stratus cloud on a warm, humid summer day. A sight viewed near water around the world, algal blooms are a symptom of excess nutrients widely caused by agricultural and urban activities. They range in severity from nuisance to toxic, and cost public tax dollars at water treatment facilities, in losses for the tourism industry, at fisheries and they harm ecosystem species. Ultimately, this oil painting on canvas, sized 16 by 20 inches, is a reminder that we are not far removed from nature, we are part of nature, we change it to serve us and not without consequences.

Title: Investigating the enantioselective behaviour of chiral pharmaceuticals and personal care products in wastewater and surface water

Authors:
Sondus Jamal, University of Waterloo
Leslie Bragg, University of Waterloo
Wayne Parker, University of Waterloo
Mark Servos, University of Waterloo

***Correspondence:** sondus.jamal@uwaterloo.ca

Keywords:
PPCP, aquatic stressors, chiral, fate, effects

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; Social, economic and health determinants and impacts

Abstract:
Pharmaceuticals and personal care products (PPCP) constitute thousands of chemicals and are increasingly being detected in wastewater effluents and in receiving waters at trace levels (i.e. µg/L to ng/L). PPCPs are contaminants of emerging concern as they exhibit pseudo-persistence due to their continuous reintroduction into the aquatic environment via wastewater effluents and can have biological effects even at very low doses. Many PPCPs are chiral with 2n pairs of enantiomers, where n is the number of chirality centers. A chirality center is an atom like carbon, sulfur or phosphorus with different types of atoms or groups of atoms. Enantiomers have the same chemical formula and atom-to-atom linkages but differ in the three-dimensional orientations of their atoms in space such that their mirror images are non-superimposable (like a pair of gloves). Aside from the difference in their optical activity, enantiomers have identical chemical and physical properties in an achiral environment. However, in a chiral environment (e.g. chiral surface or enzyme-linked receptor), one enantiomer may display different behavior compared to the other enantiomer (e.g. difference in drug potency or drug metabolism between the enantiomers). This enantioselectivity may result in changes in the enantiomeric composition of the chiral compound and thereby the fate and effects in the environment. The current research aims to investigate the enantioselective behaviour of select chiral PPCPs such as anti-depressants in wastewater and surface water. It will be achieved by 1) quantifying the occurrence and distribution of chiral PPCP at the enantiomeric level entering WWTPs and examining the results in the context of their use in the population, 2) quantifying at full scale the effect of secondary wastewater treatment and in-stream processes in the Grand River on the enantiomeric composition of the selected chiral PPCP, 3) identifying potential mechanisms contributing to shifts in enantiomeric composition through treatment and in the Grand River through bench scale experiments. The outcomes of this research will support water and wastewater managers to better assess and manage the potential risks of these emerging contaminants of concern.

Title: Spatiotemporal patterns of mining-associated metals in subarctic lake sediments

Authors:
Izabela Jasiak, University of Waterloo
Johan A. Wiklund, University of Waterloo
James V. Telford, University of Waterloo, Wilfrid Laurier University
Roland I. Hall, University of Waterloo
Brent B. Wolfe, Wilfrid Laurier University

***Correspondence:** ijasiak@uwaterloo.ca

Keywords:
paleolimnology, gold mining, arsenic, sediment, Northwest Territories

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Gold found on the shores of Great Slave Lake in 1935 has led to a legacy of pollution in Canada's North. Mining operations at Giant and Con mines released a fine, toxic dust into the atmosphere during the extraction process - arsenic trioxide (As2O3). A lack of emission controls resulted in the release of over 20,000 tonnes of As2O3 into the atmosphere which spread over the surrounding landscape. The majority of emissions were released from Giant Mine in the 1950s and have potentially created repositories in the many lakes, rivers, and soils. Studies of arsenic (As) concentrations in lakewater and surficial sediment have concluded that no potential ecosystem health effects exist beyond a 30-km radius. However, paleolimnological studies at distances well beyond 100-km have identified elevated As concentrations aligning with the timing of peak emissions. Findings suggest that the size of the area that received pollution from the mines remains poorly understood and further research is needed to fully characterize the emissions footprint. To address this need, spatiotemporal patterns of metal deposition are reconstructed from the analyses of lake sediment cores along an 80-km transect following the prevailing wind direction (NW). Results are consistent with previous paleolimnological studies. Impacts of mining emissions are detectable in stratigraphic profiles of As, antimony (Sb), and lead at all lakes. Concentrations of As are well above the CCME Probable Effects Level of 17 mg/g in lake sediment records obtained as much as 80 km from the mines during peak emissions. In line with existing literature, both As and Sb concentrations decrease dramatically with increasing distance from the mines. However, excess inventories of As and Sb identify that pollution has travelled farther than previously believed and is likely evident at distances >80 km. At lakes 10-40 km from the mines (near-field), increasing trends towards the sediment surface are observed for As and Sb, with maximum concentrations occurring at the sediment surface. In contrast, lakes located 50-80 km from the mines (far-field) have well-preserved mine signals, with maximum concentrations occurring at depth and returning to approximately pre-industrial levels at the surface. Differences in metal deposition between near and far field sites are likely the result of sediment focusing, a continued supply of metals from legacy stores in the surrounding catchment, and post-depositional mobility.

Title: Phosphorus mitigation on the Thames River, Ontario: Influence of a dammed reservoir on P loads and speciation

Authors:
Nady Kao, University of Waterloo
Chris Parsons, Environmet and Climate Change Canada
Amanda Niederkorn, University of Waterloo
Mohamed Mohamed, Environmet and Climate Change Canada
Ryan Sorichetti, Ministry of the Environment Conservation and Parks, Etobicoke, Ontario
Philippe Van Cappellen, University of Waterloo

***Correspondence:** nady.kao@uwaterloo.ca

Keywords:
Phosphorus, Reservoir, Dam, Retention, Nutrients

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
Harmful algal blooms in the western basin of Lake Erie (USA-Canada) have been increasing in frequency and severity since the late 1990s. Excess loads of phosphorus (P) from the lake's watershed are one of the primary drivers of this re-eutrophication. The Thames River, in southern Ontario, is the largest Canadian tributary source of P to Lake Erie's western basin. Yet, the role of dammed reservoirs on P loading and speciation in this river corridor remains poorly characterized. We estimated the annual and seasonal retention efficiencies (RE) of the following P pools: dissolved reactive P (DRP), dissolved unreactive P (DUP) and total P (TP) by the largest of these reservoirs (Fanshawe) using a mass balance approach and two years of sampling data (2018-2019). Four load estimation models were used to quantify P loads into and out of the reservoir. Results show that, on an annual basis, the reservoir was a P sink (RE: 29 to 46%) with at most a slight increase of the outflow DRP:TP ratios. However, loads, RE, and DRP:TP showed systematic seasonal variations. For TP, retention was the highest in winter and fall (RE: 49 to 69%), while the reservoir acted as a net source during the summers and one spring season (RE: -25 to -110%). Furthermore, the reservoir's outflow DRP fraction increased during the summers, ostensibly driven by in-reservoir stratification and internal P loading. Our results show that Fanshawe Reservoir exerts a major influence on the flow and speciation of P on the Thames River and, thus, represents a potential point of intervention for P mitigation.

Title: Nutrient Control Is Not Enough To Control Cyanobacteria Blooms

Authors:
Megan L Larsen, Wilfrid Laurier University
Kateri R Salk, University of Waterloo
Helen M Baulch, University of Saskatchewan
Jared Wolfe, University of Saskatchewan
Scott N Higgins, IISD-Experimental Lakes Area
Jason J Venkiteswaran, Wilfrid Laurier University

***Correspondence:** jvenkiteswaran@wlu.ca

Keywords:
cyanobacteria, nutrients, climate change

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Cyanobacterial blooms are a threat to freshwater systems across the globe. Warming, altered stratification, and increased nutrient loads have all contributed to increased bloom risk. However, efforts to mitigate blooms have not kept pace with growing risk. Here, we demonstrate despite a complete reduction in external nitrogen loads to an experimental lake and stable phosphorus loads, the bloom period has grown longer. The long, single, mid-season cyanobacterial bloom gradually transitioned to two, shorter bloom peaks in the early and late season. This is associated with an increase in the number of ice-free days, an increase in the length of the open-water stratification period, and long-term reduction in sulphate. Interestingly, although the total cyanobacterial biomass is dominated by the genus Aphanizomenon in both early and late blooms, the rates of N-fixation are significantly different. Together, these findings suggest that even if nutrient loads are maintained, or decreased, the duration of cyanobacterial bloom risk may grow longer as a result of external drivers. While redoubling efforts at nutrient control may ultimately help mitigate blooms, the opposing effect of climatic changes, combined with lags in ecosystem response suggest that adapting to bloom risk is a necessary intermediate step, to help reduce current risks.

Title: Phosphorus Legacies and Trajectories in Lake Erie Basin

Authors:
Lamisa Malik, University of Waterloo
Kimberly J. Van Meter, University of Illinois at Chicago
Nandita B. Basu, University of Waterloo

***Correspondence:** l6malik@uwaterloo.ca

Keywords:
Nutrient, Water Quality, Anthropocene, Watershed Model

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
In the last five decades, excess phosphorus (P) loadings have caused reoccurring algal blooms in Lake Erie. Efforts in the 1970s to reduce P loadings from P laden detergents were initially successful in ceasing algal blooms, however, surface water P loading became persistent again in the 2000s. It is understood that pollution from non-point sources are mostly responsible for P accumulation across the land-water continuum. However, the forms and relative magnitudes of legacy P accumulation and their respective residence times within the landscape are still not well understood.
To address this knowledge gap, we first develop temporal trajectories of P input and output across multiple watersheds in the Lake Erie Basin. Specifically, we used a mass balance approach to quantify P surplus (the difference between inputs of fertilizer, manure, waste to the watershed and outputs in the form of crop production) across the Lake Erie Watersheds over the 116 years (1900- 2016). These input trajectories were then compared with the total P and soluble P trajectories in the streams draining these watersheds to determine time lags in water quality response. We found response patterns to vary significantly across the Lake Erie basins, with watersheds dominated by point source inputs documenting shorter lag times than those dominated by non-point source. We also observed a significant difference in the P surplus trajectories among Canadian and American watersheds. Afterwards, we developed a process-based model (ELEMENT-P) to quantify P accumulated in the soil, reservoir and sediment pools in major watersheds in the basin. The model also allows us to develop future scenarios to evaluate whether the 40% load reduction proposed in the Great Lakes Water Quality Agreement is achievable by 2025. Our work will provide a way forward for the design of more targeted approaches to water quality management and help guide decision-makers to set realistic targets for reducing P loading.

Title: Agricultural Fertilizer Management Effects on Subsurface Phosphorus Loss Over the Non-Growing Season in Southern Ontario

Authors:
Meredith Marshall, University of Waterloo
Merrin Macrae, University of Waterloo

***Correspondence:** mj3marshall@uwaterloo.ca

Keywords:
Agriculture, Biogeochemistry, Hydrology, Non Growing Season

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Turning research into policy and management solutions

Abstract:
Increased phosphorus (P) loadings from agricultural runoff into the Great Lakes can lead to eutrophication, resulting in harmful algal blooms and hypoxic conditions. Many studies have highlighted the important role of subsurface tile drains in contributing to total P loads from agricultural runoff. However, findings have been mixed as to whether management practices such as fertilizer placement, source, or timing helps to mitigate subsurface tile P losses over the non-growing season (NGS). The goal of this study was to determine if different management practices i.e., conservation till, conventional till, and incorporation, mitigates P loss through tile drains following application of organic fertilizer over the NGS. The objectives of this field-based study were to: 1) quantify annual runoff, and P loss (total P (TP), soluble reactive P (SRP), and total dissolved P (TDP)) from tiles; 2) investigate if tillage depth and frequency influences P loss in tile runoff; and 3) determine if incorporation of organic fertilizer impacts P loss in tile runoff within a silt loam soil. Water samples were collected on an event basis from 3 adjacent tile drains with different management treatments over the span of 8 years (2011-2018) with plots receiving identical fertilizer applications ranging from inorganic spring fertilizer application, fall organic dairy manure application, and no fertilizer. Differences in tile SRP, TDP, and TP concentrations and loadings will be presented in addition to the implications of these results to fertilizer management for farmers and policy makers.

Title: Where's the P in Prairie Potholes? The distribution of phosphorus in Canadian Prairie wetlands

Authors:
Laura McFarlan, University of Saskatchewan
Colin Whitfield, University of Saskatchewan
Angela Bedard-Haughn, University of Saskatchewan

***Correspondence:** laura.mcfarlan@usask.ca

Keywords:
wetland, phosphorus, prairies, water quality

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Prairie wetlands are in the midst of a disappearing act. The number of Canadian Prairie wetlands has been rapidly declining since the early 1900s due largely to agricultural activities and wetland drainage. Impacts of wetland loss include declining water quality and ecosystem health, in addition to reduced water storage. This has spurred an interest in the role that remaining Prairie wetlands play in nutrient cycling and storage. Research to date has focused on comparing intact wetlands to drained wetlands, assessing differences in rates of phosphorus retention. Phosphorus is a commonly applied agricultural fertilizer and an excess or deficit of phosphorus can have ecosystem altering impacts. Limited research has been done to identify how phosphorus concentrations vary in prairie wetlands, and what factors influence these patterns. Specific objectives of this work include determining how wetland surface water phosphorus concentrations vary spatially in the Prairie ecozone and if there are geomorphic patterns, soil and sediment properties or surface water characteristics driving the observed variation. We collected comprehensive data from > 100 pothole wetland sites across the Prairie provinces. This data, along with laboratory-based methods will highlight the ecosystem services provided by wetlands and inform users for better decision-making in wetland removal, restoration, and retention across the Prairies.

Title: Assessing How Exposure influences Disaster Preparedness: A Study of Mining Firms in Canada's Boreal Region

Authors:
Brent McKnight, McMaster University
Emily Lalonde, McMaster University

***Correspondence:** bmcknight@mcmaster.ca

Keywords:
Disaster Preparedness, Wildfire and Flooding, Decision Making

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
Climate change is increasing the frequency and intensity of wildfires and floods facing resource extraction sites in Canada's boreal forest. Managers at these resource extraction sites must decide whether and how to prepare for these events. To better understand this decision making, we undertook a quasi-inductive research design employing qualitative comparative analysis (QCA). QCA is a method that looks to identify configurations of conditions that, when present together, are necessary and/or sufficient for an outcome of interest. In our case, this outcome was firm decisions regarding their disaster preparation efforts. Informed by both the attention-based view (ABV) of the firm and construal level theory (CLT) we gathered mining site data, manager perspectives and corporate level information. Surveys were created and distributed directly to mining site managers operating in Canada's boreal region. The surveys evaluated the respondents' perception of the controllability of extreme weather events on operations, and their psychological distance from climate change, their firm's experience with natural disasters, and their degree of disaster preparedness. We augmented this data by drawing on the firms' website to gain insight into their acceptance of climate change, their association with clean technology, and other important firm-level information. Additionally, we tested the influence of the exposure of the mining sites to wildfires and floods, integrating climate change adaptation research across physical and social sciences.
Despite the scientific consensus, many stakeholders remain confused regarding the causes and consequences of climate change. In this research we explore how different combinations of conditions at the geographic site, manager decision-making and corporate context configure together to result in prepared or unprepared mining firms. This research will shed light on how firms prepare for disasters and that preparation is influenced by perceptions of climate change and exposure. Eventually, this work aims to influence to influence policy-making concerning climate change adaptation in the mining industry.

Title: Linking the Source and Fate of Iron and Dissolved Organic Matter in Boreal Freshwaters

Authors:
Mead, J.L., University of Waterloo
Schiff, S.L, Wilfrid Laurier University
Venkiteswaran, J.J., International Institute for Sustainable Development - Experimental Lakes Area
Higgins, S.N., International Institute for Sustainable Development - Experimental Lakes Area
Elgood, R.J., University of Waterloo

***Correspondence:** jmead@uwaterloo.ca

Keywords:
Dissolved Organic Matter, Iron, Photodegradation

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
Dissolved organic carbon (DOC) is the largest input of carbon to northern shield lakes but the mechanisms influencing the fate of aquatic carbon are poorly understood. Dissolved iron (DFe) influence rates of photodegradation; an important abiotic process for DOC loss. This relationship is especially important to understand as trends of increasing water colour, termed brownification, caused by increasing DOC and Fe are occurring in Northern Europe and North America, likely affecting aquatic carbon and Fe cycles. We analyzed DOC and DFe trends at the Experimental Lakes Area and conducted photodegradation experiments to investigate carbon and Fe fate in lakes. In the photodegradation experiments, we manipulated the DFe concentrations of two boreal stream samples, calculated carbon mass balances, and measured changes in DOM composition. The data will provide insight into the mechanisms controlling the fate of DFe and partitioning of terrestrial carbon between the atmosphere and lake sediments.

Title: Identifying Trends and Knowledge Gaps in Forested Watershed Ecosystem Services Valuation Studies: A Global Meta-Analysis

Authors:
Khusro Mir, University of Waterloo
Roy Brouwer, University of Waterloo

***Correspondence:** kmir@uwaterloo.ca

Keywords:
watershed services, economic valuation, meta-analysis, forest

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; Social, economic and health determinants and impacts

Abstract:
Forest watershed ecosystem services valuation studies have become increasingly popular in the environmental economics literature. However, this research is very heterogeneous in its approach and until now, little work has focused on systematically reviewing and assessing commonalities and differences in the results from these studies. We replicate a previous meta-analysis of the watershed services provided by tropical forests in South and Central America. We significantly increase the scope of our research, studying the valuation literature on a global scale, generating many more data points and defining more (refined) covariates than applied before, in particular with regards to the identification of watershed ecosystem services. The results reveal more and new systematic trends in the valuation literature included in our global database, related to the hydrological forest ecosystem services under valuation and their beneficiaries. Whilst accounting for the different valuation methods, the generated economic values furthermore appear to have become more conservative in time. We identify knowledge gaps for additional research in the future.

Title: Risk Assessment of Mercury in Segmental Hair of Indigenous Communities of the Dehcho Region, Northwest Territories, Canada: Characterizing Chronological Exposure and Seasonal Variability

Authors:
Jean Napenas, University of Waterloo
Sara Packull-McCormick, University of Waterloo
Mylène Ratelle, University of Waterloo
Brian Laird, University of Waterloo

***Correspondence:** jrnapena@uwaterloo.ca

Keywords:
Retrospective Analysis, Mercury, Risk Assessment, Chronological Exposure, Indigenous Health

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Global anthropogenic and natural mercury emissions accumulate within waterbodies of northern Canada via long-distance transport mechanisms. Climate change may also contribute to mercury pollution through multiple mechanisms, such as accelerating the release of mercury from soils. Following its transformation into one of its more hazardous forms (i.e., methylmercury), it can bioaccumulate and biomagnify in aquatic ecosystems. Due to these processes, elevated mercury levels have been detected in some fish species in particular waterbodies of the Dehcho Region, Northwest Territories. Indigenous communities of this region rely on fish (as well as other traditional foods) for nutritional, cultural, and spiritual purposes. A community-based research project was developed with Indigenous communities of the Dehcho Region to assess exposure and risk to mercury. Segmental hair mercury was analyzed from 231 participants from 6 communities of the Dehcho region. The measurement of mercury in hair describes both recent and past exposures. Up to six segments (2 cm per segment) were analyzed to estimate mercury exposure over a 12-month period. Overall, the most recent mercury level measured was low compared to existing health-based guidance values (n=231, GM: 0.38 µg/g, 95th percentile: 2.3 µg/g). These results reinforce previous findings of relatively low mercury exposure among Northern communities. After temporally-aligning segments based on collection period, temporal trends in mercury exposure were examined. It was observed that mercury exposure peaks during summer months (n=126, GM: 0.39 µg/g); while the lowest levels were observed in the late winter months (n=107, GM: 0.29 µg/g). Furthermore, analysis of 99 full length segments revealed that participants with high mercury levels did not maintain high levels throughout the year, resulting in these individuals only briefly exceeding guidance values. To consistently detect these individuals, retrospective analytical methods or repeated sampling is recommended. However, retrospective hair analysis has limited utility because full segmental analysis requires long-haired participants. Therefore short-haired individuals, particularly men, will be underrepresented. Repeated community-based sampling methods would most accurately determine average mercury exposure. This research better informs future policy and health management work by highlighting the dynamic nature of baseline mercury exposure.

Title: Wild fish responses to wastewater treatment plant upgrades in the Grand River, Ontario

Authors:
Kirsten Nikel, University of Waterloo
Patricija Marjan, University of Waterloo
Keegan Hicks, University of Waterloo
Meghan Fuzzen, University of Waterloo
Gerald Tetreault, Environment and Climate Change Canada
Mark Servos, University of Waterloo

***Correspondence:** kenikel@uwaterloo.ca

Keywords:
wastewater, fish, ecotoxicology, Grand River

Primary meeting theme: From anthropogenic pressures to ecosystem services

Abstract:
Municipal wastewater treatment plant (WWTP) effluent is a source of contaminants (nutrients, pharmaceuticals, estrogens, etc.) which can harm aquatic life. Many studies have investigated the effects of WWTP effluent on male rainbow darter (Etheostoma caeruleum) collected downstream of two WWTPs in the Grand River, Ontario. These studies reported disruption at multiple levels of biological organization, including altered vitellogenin gene expression, lower levels of in vitro steroid production, and high rates of intersex. The Region of Waterloo has invested in major upgrades at both WWTPs to improve effluent quality by including additional nitrification and extended solids retention time. The Kitchener WWTP was initially upgraded in 2012 with additional aeration and nitrification. As a result, stable nitrogen isotope signatures in muscle and gonad steroid production of 11-ketotestosterone and testosterone in fish collected downstream of the outfall shifted to resemble upstream reference conditions, and there was a significant reduction in intersex incidence and severity. Upgrades to the Waterloo WWTP in late 2017 created a unique opportunity to investigate whether responses in rainbow darter previously associated with effluent exposure will resemble upstream reference levels following upgrades at a second WWTP. After the Waterloo upgrades, there was a similar recovery of stable isotope signatures, steroid production, and intersex (gene expression analysis is ongoing). These improvements followed the timeline of the plant upgrades. This unique long-term study is also valuable in explaining confounding effects of annual variations in water temperature and flow which can mask or exacerbate the effects of the WWTP effluent. Overall, major capital investments in WWTP upgrades targeted at improving effluent quality have also corresponded with the reduction of adverse responses in fish associated with additional emerging contaminants of concern in the receiving environment.

Title: Phosphorus Pool Dynamics in Riparian Vegetation and Soils

Authors:
Isaac Noyes, University of Waterloo
Merrin Macrae, University of Waterloo
Janina Plach, University of Waterloo
Will Pluer, University of Waterloo
Rob Gordon, University of Windsor

***Correspondence:** iwnoyes@uwaterloo.ca

Keywords:
Phosphorus, Riparian, Biogeochemistry, Nutrients, Cycling

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
The shorelines and banks around surface water resources represent important links between aquatic and terrestrial ecosystems, where they perform important nutrient transformations. In agricultural settings, riparian buffers around stream edges provide important filters for agricultural field runoff that is often highly loaded in sediments, nutrients, and pesticides. Riparian buffers, therefore, are a Beneficial Management Practice that can potentially mitigate the impacts of agriculture on the eutrophication of freshwater resources around the globe. Although this potential exists, numerous studies have shown that riparian buffers can do little to reduce phosphorus (P) loading to waterways, or can increase P loss. Such studies have been linked to both climate (i.e. severe winters) and riparian zone P saturation (which are linked to both age and adjacent land uses). In colder regions, vegetation bound nutrients can be released after freeze thaw cycles, thereby compounding the P issue. Furthermore, the P is released in a highly bio-available form.
This study used a laboratory experiment to evaluate the efficacy of a wetland at retaining P, and, investigated the potential for soil and vegetation P to be released following freezing. Soils and plant material were collected from a wetland both adjacent to and farther away from a P-rich source (dairy farm) and subjected to a range of temperature treatments: +4C, -4C, and -15C. Soils and vegetation were examined both together and separately. Results demonstrated that P loss from soil and plant material increased with proximity to the dairy farm (i.e. where soils had the greatest concentrations). Although all plant material released P following freezing, losses were greatest from plants grown in P-rich soils. However, in most of the wetland, soils were able to retain P lost by plant material. This was not found where soils were saturated with P, as these soils were unable to retain any additional P. The freezing experiments had only observed effects on the release of vegetation P, and no definite trends were observed for the soil. These results help us to understand the biogeochemical mechanisms governing P dynamics in riparian buffers, and highlights the relevance of both cold climates and age in their ability to retain P.

Title: The Impact of Green Infrastructure on Water Treatment Costs and Drinking Water Incidents: A Spatial Instrumental Variable Regression Model

Authors:
Zehua Pan, University of Waterloo
Roy Brouwer, University of Waterloo

***Correspondence:** z64pan@uwaterloo.ca

Keywords:
Green Infrastructure, Watershed Services, Drinking Water Safety, Treatment Costs

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: (Big) data science and management; Social, economic and health determinants and impacts

Abstract:
There is increasing interest in the cost-effectiveness and economic benefits of replacing traditional engineering-based 'grey' with nature-based 'green' infrastructure to address present-day environmental challenges, in particular in the water sector. This study builds on the emerging environmental-economics literature in this field, and sets it self apart in a number of ways. New in this study is the focus on the interrelationship between green infrastructure, water treatment costs and drinking water safety, in particular water supply incidents with public health risk implications resulting in many cases in drinking water advisories. In addition, a new modelling framework is developed, accounting for spatial spill-over effects due to watershed land cover and land use and endogeneity embedded in the relationship between water treatment costs, drinking water billing and the risk of drinking water incidents. Based on data from Ontario, the most densely populated province in Canada, we find a significant impact of forested lands on water treatment costs and drinking water incidents.These results have important implications for future source water protection in increasingly urbanized watersheds.

Title: Potential for application of novel DNA tracers in watershed studies

Authors:
Jacqueline Peters, University of Waterloo
Patricija Marjan, University of Waterloo and University of Calgary
John P. Giesy, University of Saskatchewan
Barb Katzenback, University of Waterloo
Paul M. Craig, University of Waterloo
Dave L. Rudolph, University of Waterloo

***Correspondence:** j29peter@uwaterloo.ca

Keywords:
environmental DNA, tracer, surface water, groundwater, free DNA

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Anthropogenic influence on aquatic ecosystems provides a growing need for affordable and accurate biodiversity monitoring techniques. An emerging and non-invasive technique in the field of aquatic monitoring is detection of environmental DNA (eDNA), which involves detection of species-specific DNA in water. However, knowledge gaps remain regarding how environmental factors such as water quality, temperature, and flow conditions may impact the accuracy and robustness of eDNA detections. eDNA shed from organisms can exist within cells, within organelles, or as free DNA that is extracted on to filters from water samples. Short DNA sequences can be synthesized easily in the laboratory and then used to simulate the free DNA (fDNA) component in the environment. This creates a unique tool to study the environmental processes in streams. Washington Creek is a first order creek in the Grand River watershed of southern Ontario that has been extensively studied for brook trout (Salvelinus fontinalis) eDNA; therefore, this creek was selected for an fDNA tracer experiment. Understanding how fDNA moves in Washington Creek, under various seasonal or weather conditions (e.g. flooding), could improve the effectiveness and accuracy of eDNA sampling and the processes that control its fate. Two fDNA sequences of approximately 100 bp long, T11 and T22, were injected into a stream in fall 2019, 1.5 mL water samples were collected at various distances downstream, and then stored at -80℃. fDNA detection in the water samples was conducted using a SYBR dye-based quantitative polymerase chain reaction (qPCR) with according sequence-specific primers. The amplification efficiencies of the qPCR reactions were 92% and 91.9% for T11 and T22, respectively. Preliminary results for this novel tracer study will be presented. A better understanding of the mechanisms affecting the fate of fDNA in stream systems will improve understanding of eDNA and potentially lead to modifications of the methods to provide the best outcomes. In addition, literally thousands of unique DNA sequences can be synthesized and may find broad application as tracers in watershed studies.

Title: Developing an economic valuation function for the impacts of Nitrogen loads on coastal and marine ecosystem services

Authors:
Rute Pinto, University of Waterloo
Roy Brouwer, University of Waterloo
Hans J.M. van Grinsven, PBL Netherlands Environmental Assessment Agency
Berit Hasler, Aarhus University, Roskilde, Denmark
Jana Compton, U.S. Environmental Protection Agency

***Correspondence:** rute.pinto@uwaterloo.ca

Keywords:
nitrogen loads, marine water quality, ecosystem services, economic valuation

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme:
Cross-cutting challenges and opportunities: None

Abstract:
The ecological and economic importance of coastal and marine systems is widely recognised. Yet, excessive nutrient loads can lead to eutrophication, impair ecosystem services (ES), and cause significant economic costs. The estimation of both the economic costs and benefits of Nitrogen (N) mitigation measures can help support policy and decision-making towards more sustainable and efficient management of the coastal and marine environment. This work reviews three decades of research focusing on the impacts of N loads on ES provision, and associated costs and benefits. Three main research questions are addressed in our meta-analysis: i) which ecosystem services have been identified as impacted by nitrogen loads in coastal and marine ecosystems? ii) which economic methods have been used to assess and value these impacts? and iii) how have causal links been established between changes in N loads and economic values of the affected ES? We combine different sources of data and information to generate a meta-model that explains and predicts how changes in N loads change the economic values of ES in a cost-benefit analysis (CBA). We start in the Baltic Sea since this marine ecosystem has been intensively studied over the past decades, and is hence data rich. Recreation and water quality improvements are the most frequently valued ES impacted by N loads in the Baltic Sea. Although statistically significant relationships are found between costs, benefits and N baseline and reduction levels, location and context-specific N-indicators underpinning unit costs and benefits challenge their combined use in a common CBA framework. We therefore also estimate reduced meta-models to facilitate the scaling up of regional values and allow for a global environmental-economic assessment of the impacts of N reduction policies on coastal and marine ES.

Title: Impacts of a dam on the spawning migration of an eastern Lake Erie walleye population

Authors:
Hillary Quinn-Austin, University of Waterloo
Hadi Dhiyebi, University of Waterloo
Tom MacDougall, Ontario Ministry of Natural Resources and Forestry
Rebecca Rooney, University of Waterloo
Mark Servos, University of Waterloo

***Correspondence:** hm2quinn@uwaterloo.ca

Keywords:
Lake Erie, Walleye fishery, Movement ecology, Reproduction, Acoustic telemetry

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
The Laurentian Great Lakes freshwater fisheries are some of the largest in the world and are valued at over $7 billion annually. Lake Erie's commercial and recreational walleye fishery is the largest of the Great Lakes, requiring effective management to maintain a sustainable and diverse fishery. Lake Erie's walleye fishery is composed of multiple spawning populations, which presents a management challenge. Fisheries managers must consider the movement patterns of distinct walleye populations that make up the harvest to avoid overexploitation of less productive populations and maintain population diversity. While the spatial ecology and composition of Lake Erie's large western basin walleye populations are fairly well studied, less is known about that of smaller eastern basin populations. Studies suggest that Ontario's Grand River walleye population in the eastern basin is genetically distinct but is considered degraded due to blocked access to upstream spawning habitat by the Dunnville Dam. This study used acoustic telemetry methods to determine the movement patterns of walleye with relation to the dam and whether walleye return annually to spawn in the river (spawning site fidelity). Walleye that were tagged with acoustic transmitters and moved over the Dunnville Dam were found to actively migrate upstream to areas with potentially suitable spawning substrate during the early spring, and subsequently return directly to below the dam and the mouth of the river. Tagged walleye also returned to the river in subsequent spawning seasons, indicating a level of site fidelity. These results suggest that the removal of the dam or the construction of a functional fishway could lead to a more productive Grand River walleye population by increasing access to spawning grounds. Furthermore, by describing the migratory movement of this population, fisheries managers can better plan harvest metrics to avoid its overexploitation.

Title: Assessing the impact of stormwater runoff and nutrient export on water quality of a eutrophic lake using StormWater Management Model (SWMM)

Authors:
Jovana Radosavljevic, University of Waterloo
Mahyar Shafii, University of Waterloo
Fereidoun Rezanezhad, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** jradosav@uwaterloo.ca

Keywords:
phosphorus, urban water systems, hydrology

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management; Stakeholder engagement and knowledge mobilization

Abstract:
Urbanization has significant effects on water quantity and quality dynamics within the urban landscape and downstream receiving waters. Solids, nutrients and pollutants that are built up on impervious surfaces during the dry periods are washed off by stormwater runoff towards downstream water bodies. This research aims to evaluate the influence of the urban drainage basin of Lake Wilcox, a eutrophic, shallow lake located in the Greater Toronto Area (GTA), using hydrological and nutrient transport models. Our focus is on phosphorus (P), as a limiting nutrient that causes harmful algal blooms in freshwater ecosystems. First, we use the SWMM model (5.1. version) to simulate flow at the scale of the watershed whose land use varies between 10 and 80% urban density. Modeling results show that urbanization has a very strong impact on the hydrologic characteristics of flow: sub-basins with high urban density show higher amplitude and flashier runoff. Next, we use available total P (TP) concentrations collected in the outflows into Lake Wilcox to predict average monthly TP concentrations in the lake. Ongoing work is comparing the effects of urban drainage on Lake Wilcox TP levels during dry and wet years. The knowledge and information from this study will be useful in selecting proper P reduction strategies within the watershed that will help minimize algal blooms in Lake Wilcox.

Title: Finding the Iron Threshold and Demand by Phytoplankton

Authors:
Purnank Shah, Wilfrid Laurier University
Jason Venkiteswaran, Wilfrid Laurier University
Lewis Molot, York University

***Correspondence:** shah4680@mylaurier.ca

Keywords:
Iron demand, Nutrient management, algal cell culture

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Harmful algal blooms are an ever-increasing problem in many waterways and waterbodies in Canada and around the world. Many policies have focused on lowering phosphorus inputs into waters to curb the growth of algal blooms which cause damages to industries such as fishing and tourism. However, even with decreasing phosphorus inputs into rivers and lakes, the reported occurrences of harmful algal blooms are increasing. Are there other nutrients in play along with phosphorus in the growth and proliferation of algal blooms? Here, we show that iron demand differs for different types of phytoplankton taxa. We also show that cyanobacterial demand of iron is significantly higher when nitrogen is removed and fixation is required. We also show that N-fixing cyanobacteria have a higher iron demand than eukaryotes. This finding shows that while phosphorus is a key nutrient in bloom propagation, iron demand differences can potentially play a role in determining which species is dominant.

Title: Using Quantitative Wood Anatomy to determine the impact of anthropogenic and climatic pressures on peatland tree development, Alberta

Authors:
Karisa Tyler, University of Waterloo
Myroslava Khomik, University of Waterloo
Daniele Castagneri, Swiss Federal Institute WSL
Patrick Fonti, Swiss Federal Institute WSL
Georg von Arx, Swiss Federal Institute WSL
Richard Petrone, University of Waterloo

***Correspondence:** kntyler@uwaterloo.ca

Keywords:
peatland, black spruce, xylem anatomy, boreal, disturbance

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
The natural landscape of the Athabasca Oil Sands Region (AOSR) consists of approximately 50% peatlands. Boreal anthropogenic disturbances from oil and gas activity have amplified habitat fragmentation and shifts in regional peatland regimes. Roughly 80% of boreal anthropogenic disturbances in northeastern Alberta are attributed to linear disturbances, i.e permanent roads. Despite this, the influence of these disturbances on the function and resilience of peatland tree species remains unclear. Past findings based on [annual] tree-ring width/growth analysis suggest permanent roads bear certain implications for peatland ecosystem services. Ongoing studies at an anatomical level might further help to determine intra-seasonal tree growth responses. Quantitative wood anatomy can for example identify which environmental variables affected intra- and inter-ring growth. In the growing season of 2019, tree cores and stem disks were collected from three natural peatlands, as well as water table data, nutrient deposition from road activity, and meteorological data. Transversal sections of wood samples were obtained with a rotary microtome. The sections were stained with safranin and astra blue, and scanned at 100x magnification. Anatomical measurements were performed using the ROXAS software. Information on xylem anatomy were crossed with environmental data. In our contribution, we will show how dendroanatomy demonstrates road-induced changes in growth responses. These quantifications help in understanding climate change and land-use change impacts on peatland ecosystem function.

Title: Agricultural Phosphorus Surplus Trajectories for Ontario, Canada (1961-2016) and Erosional Export Risk

Authors:
Tamara Van Staden, University of Waterloo
Kim Van Meter, University of Illinois at Chicago
Nandita Basu, University of Waterloo
Chris Parsons, Environment and Climate Change Canada
Zahra Akbarzadeh, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** tvanstad@uwaterloo.ca

Keywords:
Phosphorus, Agriculture, Legacy, Nutrient, Spatial

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: (Big) data science and management; Stakeholder engagement and knowledge mobilization

Abstract:
Excess phosphorus (P) loads increase the incidence of nuisance and harmful algal blooms. Since the 1990s, algal blooms are recurring in the lower Laurentian Great Lakes (LGL) despite sustained efforts to mitigate P sources. One possible contributing factor is export of legacy P that accumulated in the LGL watersheds, particularly due to historical fertilizer and manure applications in excess of crop needs. We applied the Net Anthropogenic P Input (NAPI) approach to quantify the anthropogenic P surpluses on the Canadian side of the LGL drainage basin, from 1961 to 2016. As expected, southwestern Ontario, the region with the highest population density and most intensive agriculture, experienced the largest annual and cumulative P surpluses. Between 2003 and 2013, P discharged to Lake Erie by Ontario rivers accounted for only 12.5% of the NAPI to agricultural areas in the Canadian portion of the lake's drainage basin, implying that most agricultural P surplus is retained within the landscape. To identify the source areas with the greatest potential of exporting particulate P to surface waters, the cumulative P surpluses were combined with soil erodibility estimates. The resulting risk map helps locate agricultural areas that should be targeted for nutrient management and soil conservation measures.

Title: Short-Term Pulses in Nutrients Increase Microcystin During Cyanobacteria Blooms

Authors:
Jason J Venkiteswaran, Wilfrid Laurier University
Helen M Baulch, University of Saskatchewan
Nora J Casson, University of Winnipeg
Colin J Whitfield, University of Saskatchewan
Rebecca L North, University of Missouri

***Correspondence:** jvenkiteswaran@wlu.ca

Keywords:
nutrients, toxins, cyanobacteria

Primary meeting theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
Cyanobacteria blooms are a common result of the continued cultural eutrophication of surface waters. In addition to impaired water quality, reduced recreational opportunities by water users, there is increased risk from cyano-toxins. Nutrient-enriched water bodies often receive a combination of press inputs (sustained inputs often leading to a new equilibrium) and pulse inputs of nutrients (short-term inputs often allowing system to return to their previous equilibrium). We tested the role of pulses of different nutrients on microcystin production in seven-bloom affected water bodies in three Canadian provinces and one USA state across the Prairie and Laurentian Great Lakes regions over nine-day incubations. We focused on summer when toxin-producing blooms are typical in these water bodies. Additions of phosphorus (P), urea+P, nitrate+P, and ammonia+P all increased chlorophyll concentrations in all water bodies as well as increasing microcystin concentrations though to varying degrees. Despite significant and meaningful results indicating that pulses of different common dissolved nitrogen species +P increased microcystin concentrations, by far the strongest variable explaining microcystin increases was the individual water body. These results mean that a) pulses of different dissolved nitrogen species +P through rainstorms can be expected to increase microcystin risk but b) common strategies to reduce microcystin risk need to address large between-water body differences, including in phytoplankton species, in the responses to nutrient pulses.

Title: Environmental monitoring of planned forest harvest sites and nearby permafrost terrain in the southern NWT

Authors:
Niels Weiss, Wilfrid Laurier University
Jennifer Baltzer, Wilfrid Laurier University
Jakub Olesinski, Government of the Northwest Territories, Environment and Natural Resources - Forest Management
Merritt Turetsky, University of Colorado
Anastasia Sniderhan, Wilfrid Laurier University
Bridget Rusk, Wilfrid Laurier University

***Correspondence:** nweiss@wlu.ca

Keywords:
Permafrost, Hydrology, Forest harvesting, Landscape stability, Northwest Territories

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
South Slave communities and the NWT government are exploring the viability of commercial forest management to increase local biofuel production and promote economic development. The Government of the Northwest Territories (GNWT) signed Forest Management Agreements (FMA) with Digaa Enterprises (Fort Providence) and Timberworks Inc. (Fort Resolution). The FMAs were planned with the involvement of Aboriginal business corporations to ensure for sustainable timber harvest in designated areas around these communities within the next 25 years. A Forest Resource Assessment was completed to calculate an Annual Sustainable Harvest Limit. Harvesting is currently expected to start in the winter of 2020-2021.
However, there is limited understanding of the environmental impacts and sustainability of forest harvesting in permafrost regions. There are concerns over changes in hydrologic and permafrost conditions, which could potentially compromise landscape stability, and impact downstream water quality. Furthermore, little is known about the rates of boreal forest recovery following harvest in high latitude environments.
In the summer of 2019, we started an interdisciplinary project to better understand linkages and study the potential cumulative effects of harvesting on permafrost, hydrology, and forest regeneration in three target catchments that contain proposed harvest areas. Initial field observations were made in July and thaw depth measurements were carried out in October in order to determine the spatial distribution of permafrost. Ground temperature monitoring was initiated in key landscape components. We plan to expand the current permafrost monitoring network and collect water samples and hydrologic data prior to the proposed harvest and in the years following. Pre-harvest (baseline) and post-harvest observations will be supplemented with data from unaffected control sites. We thereby aim to identify cascading effects from the productive uplands down to permafrost affected wetlands and lakes, as well as the overall ecosystem impacts from forest harvesting.

Title: Modeling Phosphorus Cycling in a Seasonally Stratified Reservoir (Fanshawe Reservoir, Ontario, Canada)

Authors:
Shengde Yu, University of Waterloo
Chris Parsons, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** s228yu@uwaterloo.ca

Keywords:
phosphorus retention, sediment model, water quality

Primary meeting theme: From anthropogenic pressures to ecosystem services
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; (Big) data science and management; Social, economic and health determinants and impacts

Abstract:
Phosphorus (P) is an essential nutrient element controlling primary production in aquatic environments. Here we focus on the fate of P in Fanshawe Reservoir, the largest reservoir on the North Thames River in Ontario. The main function of the Fanshawe Dam and Reservoir is to mitigate flooding along the Thames River, in particular, in the city of London, Ontario. However, Fanshawe Reservoir also represents a potential control point to reduce P loading by the Thames River to receiving Lake St. Clair and, ultimately, Lake Erie. High P inputs to Fanshawe reservoir also explain the recurrent blooms of blue-green algae observed in the reservoir by the Upper Thames River Conservation Authority (UTRCA). To provide a computational framework to analyse existing field data and relate the external P loading to the reservoir to the downstream export of P through the dam, we developed a two-dimensional model for Fanshawe Reservoir using the CE-QUAL-W2 software. The model combines a hydrodynamic, water quality, and sediment diagenesis module. The simulation results imply a major role of internal P loading during the summer when the reservoir stratifies. Retention of P mainly occurs during winter time, while the reservoir is a source of P during summertime. In a scenario where P input to the reservoir is instantaneously reduced by 40%, the annual downstream export of P from the reservoir only decreases by 12%, because of internal P loading from the sediments. Due to the legacy P stored in the sediments, it would take on the order of 20 years for P export from Fanshaw Reservoir to drop to 40% of its current value.

Title: Games to Aid Stakeholders Participation in Water Management

Authors:
Mohammad Khaled Akhtar, Alberta Environment and Parks

***Correspondence:** khaled.akhtar@gov.ab.ca

Keywords:
Serious Game, Bow River Sim, WRMM, Game-based Learning, Water Management

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
Sustainable water management is a complex process and involves a suitable balancing act between different competing sectors and stakeholders. It is well known that without motivation and active participation of stakeholders, it is impossible to balance competing interests. One way to do this is through an effective game-based learning environment where participants can experience the consequences of their decisions but in a risk-free environment. Such meaningful participation can be paramount to sustainable Integrated Water Resources Management (IWRM).
Serious games with real-life examples can be an important tool when it comes to education, learning, conflict resolution and negotiation through communicating science, regulations, etc. 'Serious Gaming' is a broad term used to describe a wide variety of interactive digital products, from flight simulators to city management games. The central philosophy of serious gaming is that it brings together elements of simulations (a real-life situation, event or activity is imitated) and games (players, rules, competition, co-operation). A case study will be presented to show how a serious game, called the Bow River Sim, can be used to facilitate the management of watersheds by promoting social learning, cross-sectoral dialogue, and stakeholder participation.
Bow River Sim is a modern, smart and holistic approach to practice IWRM of the Bow River basin. The single-player game helps the user to understand the Water Resources Management Model (WRMM) and to visualize the implications and impacts around system interactions in the basin. The Bow River Sim simulates water management decision-making by maximizing social, economic and environmental benefits while managing a limited water supply. The overarching goal of this presentation/paper is to explore the potential role of serious games to improve social learning in the Bow River basin. To achieve this end, we aim to (a) provide an overview of Bow River Sim, (b) illustrate how innovations such as serious games can foster dialogue and discussion among stakeholders, and (c) illustrate how Bow River Sim can guide the learning process for the game user about IWRM of the basin. This presentation will offer an overview of the Bow River Sim and demonstrate how innovations such as serious gaming can promote dialog and discussion among stakeholders.

Title: Characterizing the error of manually measuring peat volume with decreasing water content using 3D scanning technology

Authors:
Nicole Balliston, University of Waterloo
Tasha-Leigh Gauthier, University of Waterloo
Jonathan Price, University of Waterloo

***Correspondence:** nballiston@gmail.com

Keywords:
3d Scanning, soil volume, water retention, peat

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Many laboratory-based measurements used to characterize the ecohydrological function of peatlands rely on the accurate measurement of peat volume; however peat is a highly deformable substrate that decreases in volume when water content decreases. This decrease is difficult to measure manually which may result in large errors in the subsequent measurements that rely on volume, and their interpretations. Here we characterize the error associated with manually measuring peat volume by comparing these measurements to a high resolution, 3D scanned rendering of peat samples. Twelve, 30 cm deep peat cores were subdivided into 5 cm segments (n = 72 samples). Volume was measured manually and with a NextEngine 3D scanner (0.1 mm resolution) when the samples had been drained at -2.5, -5, -10, -15 and -25 cm pressure, along with retention for each sample. The volumetric moisture content at each pressure step was then calculated using the volume measured by both methods. Bulk density was also calculated using the volume measurements at -2.5 cm pressure (at the sample mid-point). On average, the manual measurements underestimated peat volume at each pressure step. The manual and 3D scanned volumes were not significantly different from -2.5 to -15 cm pressure, but were at -25 cm pressure (Mann-Whitney; p < 0.05). Bulk density was not significantly different (Mann-Whitney; p > 0.05) as this measurement relied on the volume at -2.5 cm pressure. Unlike the manual measurements, the 3D scanner was able to capture the volume decrease associated with decreasing water content. As a result, the volumetric moisture content was significantly different between methods from -10 cm to -25 cm (Mann-Whitney; p < 0.05). The error associated with manual measurements at higher pressure does not significantly impact volume-based measurements, but it does at lower pressures. As such, we urge caution when interpreting volumetric moisture content values that are based on manually measured volume at pressures below -5 cm as the error may be up to 20%.

Title: ESM-SnowMIP Site-level Results at the BERMS Forests

Authors:
Paul Bartlett, Environment and Climate Change Canada
Libo Wang, Environment and Climate Change Canada
Chris Derksen, Environment and Climate Change Canada
Cécile Menard, University of Edinburgh
Richard Essery, University of Edinburgh

***Correspondence:** paul.bartlett@canada.ca

Keywords:
Snow, SnowMIP, snow model

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The ability to model seasonal snow and its effect on surface energy and water exchange is useful for hydrological and water resource studies, and has become essential in climate and Earth System Models (ESMs). The first Snow Model Intercomparison Project (SnowMIP) evaluated models at four open sites for a combined 19 site-years. Model performance varied but both simple and more complex models with appropriate parameters were found to perform similarly well. SnowMIP2 employed five open and forested site pairs for a combined 9 site-years. There was little consistency in performance for models between years or sites and no subset of better models was identified. The availability of multiannual high quality datasets afforded the opportunity to conduct a more comprehensive multi-site assessment of current models, some of which are employed as land surface components in CMIP6 climate and Earth System Models. ESM-SnowMIP has 28 participating models and ten field sites, seven open sites in various climates and elevations with 97 site-years of data, and three boreal forest sites including 39 site-years of data from the BERMS (Boreal Ecosystem Research and Monitoring Sites) Old Aspen, Old Black Spruce and Old Jack Pine forests. Results focus mainly on the forested sites, with ECCC's Canadian Land Surface Scheme (CLASS) highlighted. Most models overestimated snowpack density which resulted in snow depth being underestimated by an average 0.1 m. Above canopy albedo bias ranged from -0.08 to >0.6 among the models, showing that large positive winter albedo biases persist in some models in the boreal forest. Biases in above-canopy radiative, snow surface and bulk snowpack temperatures are not consistent with respect to size and sign; many models show a combination of positive and negative biases. Some models simulate interception of snow by the canopy, but the amount intercepted and the effect on the surface radiation and energy exchange varies. Almost all of the models, including CLASS, have a cold soil temperature bias in winter but CLASS is among the better models. Differences in performance between models will be presented and attributed to features of model design or model setup where possible.

Title: Response of snow processes to clearcutting and forest regeneration in a small basin in the boreal forest, Quebec

Authors:
Maxime Beaudoin-Galaise, Université Laval
Sylvain Jutras, Université Laval

***Correspondence:** maxime.beaudoin-galaise.1@ulaval.ca

Keywords:
Forest hydrology, Hydrological modelling, Logging, Balsam fir, Snow hydrology

Primary meeting theme: Innovations in water science and technology
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
For the boreal forest in Eastern Canada, previous studies related to the impact of clearcutting on hydrological processes have focused on analyzing short-term changes using empirical relationships with a paired basin approach. While there is generally a rapid increase in streamflows following forest harvesting, few studies in Quebec have evaluated the effects of forest regeneration on a decrease of flows in long-term. Several of these studies have been conducted using data from the "Bassin Expérimental du Ruisseau des Eaux-Volées" (BEREV). This experimental watershed located at the "Forêt Montmorency", Quebec, has a history of hydro-meteorological data over 50 years. The main objective of this study is to estimate the effects of harvesting and vegetation change on boreal forest water balance and runoff. Given the importance of snow processes on the annual water balance in boreal forest, the first specific objective was to measure the effect of harvesting and regeneration on snow accumulation and melt rate. To obtain a detailed analysis on hydrological processes, we have chosen to use the Cold Regions Hydrological Model (CRHM). First, we have quantified the measurement error of the snow water equivalent (SWE) with the federal snow sampler, used in historic snow courses. By comparing the federal snow sampler data with other data obtained with manual and automatic SWE instruments, it was possible to validate the SWE data of the BEREV's snow courses implemented in 1996. With snow courses installed in different stand developments (mature, clearcut, open), we were able to measure the impact of an 86 % clearcut of the basin area on snow hydrological processes. Finally, we used these SWE data to measure the CRHM efficiency to simulate snow accumulation and melt rate in eastern boreal forest. With good confidence in the model's ability to simulate snow processes, the model parameterization will be extended to evaluate the long-term effect of harvesting and vegetation changes on the water balance.

Title: On annual maximum based estimation of very long return period precipitation extremes

Authors:
Mohamed Ali Ben Alaya, Pacific Climate Impacts Consortium
Francis W. Zwiers, Pacific Climate Impacts Consortium
Xuebin Zhang, Environment and Climate Change Canada

***Correspondence:** mohamedalibenalaya@uvic.ca

Keywords:
Precipitation Extremes, Extreme Value Theory, Long Period Return Level, Max-stability, Regional Climate Model

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Statistical extreme value theory (EVT) is a fundamental, heavily used tool for characterizing climate extremes and understanding whether they are changing over time. The recurring impact of devastating extreme events underscores the need for reliable estimates of their intensity and frequency. Most operational frequency and intensity estimates are obtained by using EVT to analyze time series of annual maxima. A key implicit assumption in the application of EVT is “max-stability”, i.e., that the statistical behaviour of annual maxima is predictive of that of maxima calculated over multi-decadal or longer intervals. This assumption cannot be tested using available observational records of length a few decades to perhaps a century at most, and it is rarely discussed in studies of extremes. Here we use a recent large ensemble simulation of the North American climate with the Canadian regional climate model CanRCM4 to assess, for the first time, whether the max-stability holds for annual maxima of extreme precipitation. We find that in the CanRCM4 simulated climate, annual maxima tend not to be max-stable. We explore the implications of the lack of max-stability on the extrapolation to very long period return levels, and discuss how and why the extrapolation problem needs to be carefully reformulated using the extremal type theorem.

Title: Applications of soil moisture products from satellite sensors: from improved retrievals to applications

Authors:
Aaron Berg, University of Guelph
Jaison Thomas Ambadan, University of Guelph

***Correspondence:** aberg@uoguelph.ca

Keywords:
soil moisture, prediction

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management

Abstract:
Over the past decade two satellite missions focused on the retrieval of soil moisture have been launched: the European Space Agency's Soil Moisture and Ocean Salinity mission and NASA's Soil Moisture Active Passive mission. Several researchers in Canada have worked on the validation of soil moisture products and development of improved soil moisture retrievals from these platforms. Validation efforts across many regions in Canada have shown higher retrievals accuracy in agricultural regions and lower accuracy associated within forested and tundra regions. With over 10 years of consistent soil moisture retrievals, typically available every 1-2 days, it is clear that numerous applications of these time series can also be developed. In this presentation recent applications of these soil moisture time series are highlighted for streamflow forecasts, forest fire hotspot identification, seasonal climate prediction and agricultural yield prediction. From our results clear predictive improvements are noted in some regions but these improvements are not always evident, a result that will guide some of our further research for targeting improvements to retrieval approaches to these regions.

Title: Investigation of freshwater fish communities in remote Chilean rivers using environmental DNA detection methods

Authors:
Erika Burton, University of Waterloo, Canada
Patricija Marjan, University of Waterloo, Canada
Gustavo Chiang, MERI Foundation, Chile
John Giesy, University of Saskatchewan, Canada
Mark R Servos, University of Waterloo, Canada
Barbara A Katzenback, University of Waterloo, Canada

***Correspondence:** eaburton@uwaterloo.ca

Keywords:
Fisheries, eDNA, Metabarcoding, Freshwater, Lotic Systems

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Many studies have successful detected macro-organisms in water using environmental DNA (eDNA) techniques under ideal circumstances, however, few bring attention to remote environments and the complications associated with sampling them. The objectives of this study were to a) identify the best practices for eDNA sampling lotic systems in remote areas, and b) identify the distribution of native and invasive freshwater fish species across several cold-water systems. Six rivers in were sampled over two years in Patagonia, Chile. While two of the rivers have been repeatedly sampled, and their populations well characterized, the remaining four are largely inaccessible making traditional sampling techniques difficult or impossible, this makes eDNA detection an ideal method for identifying which fish species are present. Samples were collected, concentrated onto a filter, and preserved in the field. Further processing and analysis were completed at the University of Waterloo. Multiple methods for preserving eDNA on filters were evaluated before sampling for their feasibility during remote sampling and overall efficacy. In the first year of sampling a species-specific assay was validated and successfully used to detect invasive brown trout in Chilean rivers. In year two sampling was completed to build on the data set and generate an assay for metabarcoding of Patagonian freshwater fish species, as well as species-specific assays for the detection of invasive salmonid species. Next steps for building a comprehensive library for Chilean fish species have been identified. With the determination of best sampling practices, eDNA metabarcoding can become a powerful method for analyzing remote and inaccessible aquatic systems.

Title: "Rescuing" USSR historical climate observations to support cold region research: techniques in making climate paper data machine readable

Authors:
Anthony Cavallin, University of Waterloo
Gautam Bathla, University of Waterloo
Bhaleka Persaud, University of Waterloo
Jimmy Lin, University of Waterloo
Kathy Szigeti, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** ac2caval@edu.uwaterloo.ca

Keywords:

Primary meeting theme: Innovations in water science and technology

Abstract:
Recent years have seen an acceleration of climate change related impacts across the world, ranging from amplified melting of Greenland's ice sheet to freezing Arctic temperatures in US cities. The key to unraveling long-term climate change trends is the availability of reliable, high resolution climate data time series. However, prior to electronic data storage and distribution via the internet, historical climate records were often sparsely distributed and of limited access to researchers. In 2017, the Canadian Cryospheric Information Network/Polar Data Catalogue (CCIN/PDC) acquired a collection of records which contained fifty different series and five major series amounting to 2172 booklets compiled by agencies from the former Union of Soviet Socialist Republics (USSR). All data were displayed in the form of maps and tables from 1950 to 1990s. Here, we report on the performance of the optimal character recognition (OCR) techniques that we are currently testing to convert the 20th century paper-based climate records into a machine editable open access format, such as comma separated values, for statistical analysis. We extracted the solar radiation data using a proprietary software (ABBYY FINEREADER OCR Editor) and an open-source software (Tesseract) which is based on neural networks. Results are promising thus far and we have recorded at least 90% replication accuracy of solar radiation data. The advantage of using an open source OCR tool is that our team have full control over the end-to-end extract process, where as, proprietary OCR tool tweaking and/or customization is limited. Despite the challenges faced during the data extraction process successes were booked, and lessons learnt using open source technique that will be useful to many National Meteorological and Hydrological Services globally as these agencies do have millions of climate records that are still stored in paper format but have limited resources. Automation will save time and money. Most importantly, the data are yielding new information from the era when global environmental change is becoming recognized as a major challenge facing science and society.

Title: InundatEd: Implementation, Risk-analytics, and Visualization of a Large-Scale Flood Modelling System on a Big-data – Discrete Global Grid System Framework

Authors:
Chiranjib Chaudhuri, Wilfrid Laurier University
Mary Ann Gray, Wilfrid Laurier University
Colin Robertson, Wilfrid Laurier University

***Correspondence:** gray6970@mylaurier.ca

Keywords:
DGGS, flood, model, R/Shiny

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management

Abstract:
Flood events are the leading global cause of casualties and property loss. In Canada, annual flood-attributed losses range from $1-2 billion (CAD). These losses are exacerbated by rapid urbanization in flood-prone areas and by a dearth of publicly available flood risk information. Flood mitigation practices, including public education, benefit from the development and provision of flood models. The improvement of efficient and accurate hydrodynamic models has been hindered by complexities and expenses regarding input data and computational resources, especially the dichotomy between processing time and model complexity. This research proposes a novel solution to such challenges: the implementation of a flood modelling framework in a Discrete Global Grid Systems (DGGS) data model and the presentation of the models' outputs via an open-source R/Shiny interface robust against algorithm modifications and improvements. The DGGS data model efficiently integrates heterogeneous spatial data into a common framework, rapidly develops models, and can scale for millions of unit processing regions. Use of the catchment-integrated Manning's equation avoids high-uncertainty river cross-sections and produces physically justified flood inundation extents and considers volumetric water conservation. Fast, DGGS-powered analytics allow users to quickly visualize stochastic flood extents and depths for regions of interest. Our stochastic flood-inundation estimation method can address situations where good quality data is scarce and/or there are insufficient resources for a complex model. The model, once set up, can forecast flood-inundation in real-time. Furthermore, several algorithms leveraged the performance of big-data architecture and the R/Shiny interface to visualize flood risk via the stochastic flood inundation maps, building footprints, and HAZUS depth-damage functions. The Jaccard Index was used to validate the modeled flood extents against historical flood extent polygons in the Grand and Ottawa River watersheds. The 100-year flood extent, provided by the Grand River Conservation Authority, was used for the Grand River watershed. Seven historical flood extent polygons provided by Environment Canada from the spring 2019 flood season were used for the Ottawa River watershed.

Title: Automatic extraction of scum from images acquired by field-based cameras at Buffalo Pound Lake, Saskatchewan, using a 3D-convolutional neural network

Authors:
Amir Masoud Chegoonian, University of Waterloo
Kiana Zolfaghari, University of Waterloo
Katy Nugent, University of Saskatchewan
Helen M. Baulch, University of Saskatchewan
Claude R. Duguay, University of Waterloo

***Correspondence:** amchegoo@uwaterloo.ca

Keywords:
Harmful Algae Bloom, Scum detection, Deep learning, Neural Networks

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management

Abstract:
One research objective of the FORMBLOOM project is to retrieve chlorophyll-a concentration from satellite images at Buffalo Pound Lake (BPL), Saskatchewan. For this purpose, we have to extract and exclude the dates when the surface of the waterbody is covered by scum. Thanks to thousands of RGB images taken every 10 minutes by two cameras mounted on the shore and on a buoy at BPL, there is a large collection of images to detect scum; however, analyzing this massive collection of images requires expert knowledge as well as a great deal of time. In addition, some traditional image classification algorithms, such as Maximum Likelihood Classifier (MLC) and Decision Tree (DT) algorithms fail to address this binary classification problem (scum vs. non-scum classes) due to the great range of variation in image parameters, including image view angles, brightness and background objects. The complexity of the problem as well as the large number of available data to train the model suggest that deep learning methods may be more suitable than MLC and DT .
In recent years, convolutional neural networks (CNNs), as a deep learning method, have shown impressive results in the processing of different types of images. CNNs can automatically analyze complex images without prior knowledge and manual settings. In this research, a 3D CNN is used to classify scum and non-scum images. Preliminary results show reasonable performance of the 3D CNN. Scum was detected correctly in the majority of images (~80%) with a few false positives and false negatives produced (~20%). This may be due to the fact that 3D CNNs can extract semantic and abstract information from data, while this feature is not available in more traditional methods.

Title: Using Decision Crash Testing to evaluate ability of 1D hydraulic models to inform flood management decisions

Authors:
Robert Chlumsky, University of Waterloo

***Correspondence:** rchlumsk@uwaterloo.ca

Keywords:
hydraulic, decision, management, backwater, Decision Crash Testing

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management

Abstract:
In the typical water resources flood model application, a 1D backwater or mixed regime flood model is constructed using HEC-RAS or similar tools to estimate water surface elevations for a given set of return period flood flows. Under best practices, the model will undergo examination of input parameters through sensitivity analysis and model calibration/validation based on observed data. However, even these best practices only provide some check on the ability of the model to reproduce observed data, and do not provide direct insight into whether the model can perform well for a particular management decision, such as whether channel works are required to prevent the 100 year event from flooding a private property. In addition, the focus during model calibration tends to be on roughness coefficients, and little attention is given to the modelled cross-sections and other field conditions once the data has been collected and inputted.

In order to determine whether the 1D hydraulic model is fit-for-purpose in informing flood management decisions, the method of Decision Crash Testing (DCT) is applied. DCT was first introduced by Tolson and Craig (2016), and is a framework for validating the model-building process to ensure that the produced model has a high probability of informing a management decision correctly. The method uses synthetic computational experiments to recreate the model-building process and evaluate whether the model was capable of informing the decision correctly in a controlled environment; this provides insight into how the model will perform in real applications. This framework also allows for testing the impact of model-building decisions, measurement error, and other parameters directly in a management decision-making context rather than evaluating general model performance, which may not have correlation to improved decision support.

In this presentation, the DCT framework will be introduced and applied to a case study in which a 1D backwater model is constructed using topographic data, and used to inform a flood management decision. This experiment will both (a) provide a framework for estimating the reliability of the backwater model for informing flood management decisions, and (b) provide commentary on the relative importance of various data inputs and model-building decisions in informing flood management decisions.

Title: Electrical Impedance Spectroscopy: A Noble Approach to Measure Extracted Chlorophyll Concentration

Authors:
Rakibul Islam Chowdhury, University of Saskatchewan
Khan A. Wahid, University of Saskatchewan
Katy Nugent, University of Saskatchewan
Helen Baulch, University of Saskatchewan

***Correspondence:** chowdhury.rakibul@usask.ca

Keywords:
Chlorophyll Sensor, EIS, HAB prediction

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; (Big) data science and management; Social, economic and health determinants and impacts

Abstract:
Chlorophyll-A concentration is one of the most commonly measured water quality parameters. It is an indicator of algal biomass and provides insight into stressors such as eutrophication and bloom risk. It is also a widely used metric in terrestrial ecosystems as an indicator of photosynthetic activity and nutrient limitation. Current laboratory-based methods for measuring chlorophyll-A exploits spectroscopic methods and require expensive instrumentation. In this project, we proposed a noble approach using electric impedance spectroscopy to measure the concentration of chlorophyll-A in an extracted solution using two electrodes and a high precision impedance converter system solution from Analog Device (AD5933). The system was tuned for an optimal electrode orientation, electrode to electrode distance, effective electrode area and excitation voltage by studying different experiments. The proposed sensor was calibrated using the reading of 95%(v/v) ethanol. Extracted chlorophyll solutions of 40 different concentrations were prepared, and at least 10 readings per sample were taken using the proposed sensor system. The ground truth values of the samples were measured in the laboratory using Genesys 20 spectrophotometer by Thermo Scientific. Pearson coefficient and backward elimination were used to determine the significant frequencies that contribute most towards chlorophyll-A measurement. Finally, a simple linear regression model with 11 important features was chosen based on the lowest Root Mean Square and Mean Absolute Error when it was tested on the validation set. The R2 of the fitted model on the training set was 0.93. Our final model resulted in a mean absolute error of ±0.904 µg/L when applied on our test set.

Title: The new FLUXOS-SnoWHAT model: exploring new opportunities for water resources management and evaluation of BMPs through advanced watershed hydrodynamic-transport modelling

Authors:
Diogo Costa, Environment and Climate Change Canada
Kevin Shook and John Pomeroy, University of Saskatchewan
Chris Spence, Environment and Climate Change Canada
Helen Baulch, University of Saskatchewan
Jane Elliott, Environment and Climate Change Canada
Henry Wilson, Agriculture and Agri-Food Canada

***Correspondence:** diogo.pinhodacosta@canada.ca

Keywords:
Snowmelt, Nutrient Pollution, Hydrodynamic modelling, Water Resources Management, BMPs

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
In cold regions such as the Canadian Prairies and Northern US Great Plains, the seasonal snowmelt provides the greatest amount of runoff from agricultural fields, resulting in a large pulse of nutrient transport to wetlands, rivers and lakes. Agricultural runoff is a key source of nutrients, contributing to eutrophication, which is generally considered the most significant stressor affecting water quality worldwide. Seasonally frozen soils limit infiltration and so contribute to large snowmelt runoff volumes, and the post-glacial landscape and poorly defined drainage network create challenges for modelling. In this study, the hydrodynamic FLUXOS model originally developed for 2D river-reach flood and contaminant transport simulations based on the depth-integrated, dynamic wave Saint-Venant Equations, was re-purposed for the study of snowmelt events from field to catchment scales. The new FLUXOS-SnoWHAT (Snowmelt|Watershed Hydrodynamic And Transport model) was tested on the agricultural Steppler basin within the South Tobacco Creek watershed in the Canadian Prairies in Manitoba, for three spring snowmelt events of different intensity. The model was able to capture the spatial-temporal dynamics of snowmelt runoff when compared to observations, and its physically based nature provides insights into the spatiotemporal patterns of valuable hydraulic information such as velocity fields, inundation maps, variable contributing areas, and predominant transport pathways. Some of the findings of this particular model application are that (1) the average flow (both overland runoff and channel flow) velocities were small (0.05 m/s) even during the peak melt rates of large snowmelt events, (2) a large portion of the snowmelt runoff was retained in landscape depressional storage, (3) the contributing area of the basin was very dynamic and depends on the duration, peak discharge rate and total volume of the snowmelt event as well as the initial water storage conditions (power-law predictive models were developed based on the results from FLUXOS), and (4) contaminants tended to be transported via specific pathways that caused large portions of the riparian zone to be bypassed and so unactivated for chemical load attenuation.

Title: Development and potential of heavy metals detection based on microfluidic systems

Authors:
Weijia Cui, University of Waterloo
Zhe Ren, University of Waterloo
Yongxin Song, Dalian Marine University
Carolyn L. Ren, University of Waterloo

***Correspondence:** w27cui@uwaterloo.ca

Keywords:
Heavy Metals Detection, Microfluidics, Review

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Heavy metal pollutions to the water system on earth have evolved to a global issue causing serious risks to human health and other living entities and having an impact on the environment sustainability. Therefore, it is important to regularly monitor the level of heavy metals in the water system such as lakes, basins and rivers. Conventional methods such as atomic absorption spectroscopy (AAS), mass spectroscopy(MS) offer high sensitivity and selectivity in heavy metal detection, but are challenging to realize real time sensing of heavy metals due to the large footprint and capital cost. People have devoted to develop portable devices as point-of-care (POC) testing systems to realize real time detection of heavy metals. Microfluidic-based devices have distinct advantages over their traditional counterparts for POC applications, such as reduced reagent use, shortened analysis time and potential for integration of multiple processes enabled by its continuous flow nature. In addition, their typical small footprint and various manufacturing methods allowing the integration of electrical and chemical sensing techniques make them an excellent alternative for point of care devices to detect heavy metals.

In order to develop impactful microfluidic-based devices serving as POC testing instruments for the detection of metal contamination, a comprehensive review of existing methods and systems for metal contamination in the context of real-time sensing is introduced. In particular, this review starts with introducing the microfluidic-based heavy metal detections using optical and electrochemical sensing techniques and then focuses on presenting the development and potential of integrating microwave sensing with microfluidic devices for heavy metal sensing. Their working principles, sensing performance and microfluidic devices feature are exhibited. In the end, a summary of each method and the comments for future development of microfluidic based device are presented.

Title: Performance comparison of feed-forward neural network and empirical Phycocyanin retrieval algorithms for the Western Basin of Lake Erie

Authors:
Michael Dallosch, University of Waterloo
Dr. Claude Duguay, University of Waterloo

***Correspondence:** mdallosc@uwaterloo.ca

Keywords:
Machine learning, Cyanobacteria, Phycocyanin, Remote sensing, Sentinel-3A

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Over recent decades, there has been an unprecedented return of toxin producing freshwater Harmful Algal Blooms (HABs) in the Laurentian Great Lakes. There is a need for early warning and enhanced observational methods, as in situ observations are expensive and time consuming. Satellite observations have previously been used to predict chlorophyll-a concentrations (a proxy of algae), however distinguishing potentially toxic from non-toxic HABs remains a challenge. This research used Lake Erie as a case study for the application of Sentinel 3A-OLCI imagery in retrieving Phycocyanin (PC), an accessory pigment of toxin producing cyanobacterial HABs. Using in situ observations (2016-2018), a feed-forward neural network is used to construct a predictive PC algorithm, in which the performance was compared to that of traditional empirical models. The OLCI images were corrected for Rayleigh scatter path radiance and converted to top-of-atmospheric reflectance. The neural network was constructed using five bands, DOY, wind speed (m/s) and water temperature (°C), and compared to a multi-linear regression of the same inputs. Empirical models used both two-band and three-band algorithms. Performance was assessed using 10-fold cross-validation and the computed root mean square error (RMSE). A mean RMSE of 8.00 µg/l (ranging from 4.93 – 18.81 µg/l) was achieved with the neural network, while a multi-linear regression of the same inputs provided a mean RMSE of 17.69 µg/l (3.74 – 45.67 µg/l). Linear regression of existing algorithms (2BDA, 3BDA and NDPCI) were found to have weaker predictive capabilities when compared to the neural network (mean RMSE of 628.81 µg/l, 12.65 µg/l and 35.15 µg/l respectively). This is most likely due to the complexity of separating PC from a variety of optically confounding signals using multispectral remote sensing. These methods can be used to predict PC concentrations and make inference on the presence of toxic HABs for all available sentinel-3A OLCI satellite images. Such methods can aid in the construction of forecast modeling and historical trend analysis.

Title: Mobilizing water quality data through open-access tools like DataStream

Authors:
Lindsay Day, The Gordon Foundation
Carolyn DuBois, The Gordon Foundation

***Correspondence:** lindsay@gordonfn.org

Keywords:
data sharing, water quality, open data, knowledge mobilization, data management

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management; Stakeholder engagement and knowledge mobilization

Abstract:
Diverse water monitoring programs led by Indigenous and non-Indigenous governments, academic research groups, communities and watershed organizations are generating valuable information to track the health of freshwater ecosystems in Canada. When brought together, data gathered through these programs can generate powerful new insights into environmental change across distances and timescales that are beyond the scope of any one monitoring initiative alone. But finding ways to connect information gathered by a multitude of monitoring programs and research initiatives across sectoral and jurisdictional silos is a persistent challenge. When it comes to western scientific water quality data — which is one piece of the puzzle — open access tools like DataStream are transforming how this information can be mobilized to inform policy and decision-making around water management and stewardship. Designed with communities, researchers and decision-makers in mind, DataStream is an open data platform that brings water quality monitoring results together in one place, in a consistent format – making it easier to share and access data, and connect results in meaningful ways. First launched in the Mackenzie River Basin in November 2016, DataStream is led nationally by The Gordon Foundation and carried out in collaboration with regional partners and monitoring networks, including the Government of the Northwest Territories, Mackenzie DataStream's founding partner. Today over 80 different water monitoring programs are using DataStream to publish their results including those led by Indigenous organizations, watershed groups, governments and academics including Northern Water Futures researchers and the communities they work with. This presentation will discuss some of our lessons learned in developing this open data platform, and the elements we believe have been key to our success, such as DataStream's data policy, open data schema (based on the USEPA and USGS WQX standard for the exchange of water quality data), and leveraging the latest technologies to advance FAIR (findable, accessible, interoperable, reusable) data principles. We will also share some case studies of how data published on DataStream is being used to inform policy and decision-making.

Title: Review of a sub-alpine solid precipitation intercomparison site in Wolf Creek Basin, Yukon Territory

Authors:
Tyler de Jong, McMaster University
David Barrett, McMaster University
Sean Carey, McMaster University

***Correspondence:** tyler.dejong@mcmaster.ca

Keywords:
Snow, Yukon, Precipitation, Sub-alpine

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
Snow variability, whether it be snowfall or snow distribution on the ground, has been a focus of research for hydrologists attempting to quantify snow water equivalence (SWE) at a basin scale. At a sub-alpine site in the Wolf Creek Research Basin (WCRB), YT, snow precipitation has been recorded by multiple different instruments and techniques to try and assess the mesoscale (~1000 m2) variability of snowfall and snowpack SWE distribution. The various datasets within this intercomparison site are presented here to assess the variability and quality of various instruments and techniques. This work stems from WMO's Solid Precipitation Intercomparison Experiment (SPICE) in which the WCRB contributed to correcting precipitation bias due to wind undercatch (Pan et al., 2016). Here, new additional datasets from different instruments and techniques are used to expand on the work from Pan et al., 2016.

Title: Removal of pharmaceuticals and personal care products from water with β-CD functionalized magnetic nanoparticle in continuous flow process

Authors:
Ezgi Demircan Ozelcaglayan, University of Waterloo
Wayne J. Parker, University of Waterloo

***Correspondence:** edemircan@uwaterloo.ca

Keywords:
β-cyclodextrin, magnetic nanoparticle, adsorption, micropollutants, water

Primary meeting theme: Innovations in water science and technology

Abstract:
The occurrence of pharmaceuticals and personal care products (PPCPs) in water has become a major issue over the last decade as these chemicals have been recognized as emerging organic contaminants. The removal of these organic contaminants from water has been desired due to the uncertainty regarding their potential harm to aquatic life or human health. Although a number of technologies have been studied and applied for this purpose, most of these technologies are not specific to the target micropollutants and have varied performances on their removal. Therefore, there is a motivation for developing novel, simple and cost-effective techniques for removal of PPCPs and adsorption-based processes have the potential to provide efficient treatment of PPCPs in water.
β-cyclodextrin (β-CD) functionalized nanoadsorbents have received attention in this regard as it bears a hydrophobic cavity that can act as an adsorption site that provides opportunities for noncovalent interactions with organic molecules. β-CD is also considered desirable due to its nontoxicity and commercial availability. In the proposed study, a novel β-CD functionalized magnetic nanoparticle (β-CD FMNP) which is currently under investigation in UW will be used. The main objective of this study is to develop a novel adsorption-based treatment technique for removal of PPCPs from water. Specifically, the study aims to:
1. evaluate adsorption/desorption of a list of PPCPs with different physical and chemical properties that are frequently found in wastewater effluents and drinking waters. The assessments will be conducted with concentrations that mimic those in real water systems. Effect of ionic strength, NOM and chirality will also be investigated in terms of competitive adsorption.
2. develop a continuous flow process that achieves recovery/reuse of the β-CD functionalized magnetic nanoparticle by employing magnetic separation. HGMS (High gradient magnetic separator) will be implemented into continuous flow studies with optimized conditions which will provide the recovery and reuse of the particles continuously for removal of PPCPs.
The study consists of batch and continuous flow experiments. Initially, the adsorption process will be assessed in batch experiments. Then a procedure for desorption of contaminants from β-CD functionalized magnetic nanoparticle will be studied in batch experiments. Continuous flow process for removal of PPCPs will be designed to investigate the possible implementation of β-CD FMNP in water treatment systems which will cover adsorption, desorption and recovery/reuse process. Preliminary results suggest that adsorption process is fast and it has a potential to be a novel treatment for PPCPs in water.

Title: Heavy Metal Sensing using Superabsorbent polymers

Authors:
Mohamed Aladdin Fathalla, McMaster University
P. Ravi Selvaganapathy, McMaster University

***Correspondence:** mohamm84@mcmaster.ca

Keywords:
Heavy Metals, Sensing, Water Quality, Hydrogels, Preconcnetration

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts

Abstract:
Heavy metals are toxic to human health and to the ecosystem even in trace quantities. They are released into the environment due to natural processes such as leaching or due to human activities such as mining or industrial production. There is a need for rapid and periodic monitoring of their levels in the ecosystem and watersheds to protect human and animal health. Current methods are laboratory-based and require expensive analytical equipment for their measurement. A simple method to aliquot samples, concentrate the heavy metals in them and measure their concentration using a simple tool such as a cellphone camera can revolutionize the measurement and monitoring of heavy metals in the environment. We have used superabsorbent polymers to perform the various unit operations of precise aliquoting and pre-concentration so that the heavy metal elements in order to detect them calorimetrically using a simple imaging device. We demonstrate that this system is able to aliquot precise volumes of liquid from a sample, concentrate its content by 300 times and is capable of extending the detection range of colorimetric sensing from 1 ppm to 10 ppb for Copper and Iron in the sample. In the case of some elements which are naturally colored, the presence can be visualized even without the addition of a colorimetric dye. This solid-state system represents a significant simplification of the analytical process and is capable of detection of extremely low levels of heavy metals without the use of expensive equipment and therefore is suitable for use in remote settings.

Title: Soil heterotrophic respiration as a function of water content and temperature in a mechanistic pore-scale model

Authors:
Mehdi Gharasoo, University of Waterloo
Linden Fairbairn, University of Waterloo
Fereidoun Rezanezhad, University of Waterloo
Scott Smith, Wilfrid Laurier University
Philippe Van Cappellen, University of Waterloo

***Correspondence:** mehdi.gharasoo@uwaterloo.ca

Keywords:
Soil respiration, Bioavailability, heterotrophic CO2 flux, Dissolved organic carbon, Pore-scale model

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Soil heterotrophic respiration has been considered as a key source of CO2 flux into the atmosphere and thus plays an important role in global climate warming. Although the relationship between soil heterotrophic respiration and soil water content has been frequently studied both theoretically and experimentally, model development has thus far been empirically based. Empirical models are often limited to the specific condition of their case studies and therefore cannot be used as a general modeling platform. It is thus of high priority to develop models that are able to describe the underlying mechanisms with more deterministic terms. To this end, we present here a mechanistic, mathematically-driven model that is based on the common geometry of pores in porous media. Assuming that the aerobic respiration of bacteria requires oxygen as an electron acceptor and dissolved organic carbon (DOC) as a substrate, the CO2 fluxes are directly related to the nutrients (DOC and oxygen) availability to the bacteria. In this approach, the availability of oxygen is controlled by its penetration into the aquatic phase through the interface between air and water. DOC, on the other hand, is only available to a section of the soil that is in contact with water. As the water saturation in the pore changes, it dynamically and kinematically impacts these interfaces through which the mass transfer of nutrients occurs, leading to the direct control of the CO2 fluxes by soil water content. We showcased the model applicability on several case studies and illustrated the model capability in simulating the observed aerobic microbial respiration rates versus the soil water contents. Furthermore, we showed the model potential to accept additional physically-motivated parameters for explaining CO2 rates as a function of both aerobic and anaerobic respiration. The mechanistic nature of the model allows for further expansion of its mechanisms to account for soil respiration at frozen soils or at different temperatures. The frozen water in pores can be considered as ice fractions at the interface between air and water, hindering the exchange of oxygen through it. In this model, the temperature directly affects the catabolic activity of bacteria by controlling the degradation rate constants.

Title: Soil Moisture Content Retrieval Using a Drone Equipped with GNSS Reflectometry Sensors

Authors:
Yusof Ghiasi, University of Waterloo
Claude R. Duguay, University of Waterloo
Armaghan Salehian, University of Waterloo
Gary Chan, University of Waterloo
Justin Murfitt, University of Waterloo
Marie Hoekstra, University of Waterloo

***Correspondence:** syghiasi@uwaterloo.ca

Keywords:
Soil Moisture, GNSS Reflectometry, Drone

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
Studying soil moisture content (SMC) is considered as one of the best ways for farmland management and irrigation assessment. While in situ measurements at different depths are the most accurate way to obtain SMC values, they take an extremely long time even for medium-sized farms. Since some physical properties of surfaces can be retrieved from reflected L-band microwave, and the Global Navigation Satellite System (GNSS) signals are at the same frequency range as L-band, it has been corroborated that SMC can be studied using GNSS multipath. This technique, which is called GNSS-Reflectometry (GNSS-R), has shown the ability to discern surfaces with high dielectric constant, such as water, from other land covers. Therefore, researchers have employed a GNSS receiver with two antennas, such that one is up looking to receive direct GNSS signals, and the other is nadir looking to receive scattered signals to evaluate water content signature on reflected GNSS signals. However, the GNSS-R technique has not yet been tested to obtain SMC values for different land covers. In this study, we produce a relative dielectric constant map for a vegetated area using a GNSS-R sensor amounted to a drone. To this aim, several parallel flight paths are defined over the study area, and the signal-to-noise ratio (SNR) of reflected signals is assessed as a coefficient of the land cover dielectric constant. Next, the results from the GNSS-R experiment are compared with the in situ measurements that are taken simultaneously. The result shows a 90% correlation between in situ SMC measurements and SNRs acquired from the GNSS-R. Moreover, using a leave-three-out validation, we find that the relative mean error to estimate SMC from the GNSS-R experiment results is 10.8%.

Title: Testing and application of RNA-Cleaving DNAzymes for Bioavailable Metal Sensing

Authors:
Gagan Gill, Wilfrid Laurier University
Scott Smith, Wilfrid Laurier University

***Correspondence:** gill4920@mylaurier.ca

Keywords:
Bioavailability, Lead, Sensing, DNAzyme

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The on-site and real-time detection of metal ions is important for environmental monitoring and risk assessment. For appropriate management decisions, it is necessary to specifically sense the bioavailable fraction of metal rather than total metal. DNAzymes are a promising new technology for possible bioavailable metal monitoring that have not yet been fully tested in real waters. In clean, buffered, laboratory waters specific DNAzymes interact with specific metal ions and produce signal (e.g., fluorescence) that can be used to determine total metal concentration. In more complex, natural, solutions it is likely that the free ion concentration is reduced by complexation (e.g., to dissolved organic matter, DOM) and the signal would not be proportional to total metal, but possibly proportional to the bioavailable fraction of total metal; i.e., the fraction of metal available to interact with the DNA. Our research utilizes an existing metal specific RNA-cleaving DNAzyme for Pb2+ (GR5) in test waters representative of natural solutions. In GR5, lead acts as a specific co-factor in DNA catalyzing the cleavage of RNA-containing fluorogenic substrate. In these samples we systematically vary pH, ionic strength and [DOM] and assess changes in DNAzyme generated fluorescence signal compared to calculated lead speciation. In the presence of 5mg/L dissolved organic carbon (DOC), at pH 7.5 and 100 mM sodium acetate, the sum of the free Pb2+, PbOH species and Pb-acetate species were all assumed to be bioavailable. Using the Windermere Humic Aqueous Model (WHAM), different assumptions of what species in the calibration samples that the DNAzyme responded to were tested. The best agreement was when the sum of the three species were all considered bioavailable. The same applied when altering the conditions to pH 6.5. The WHAM model agrees when all three species are considered bioavailable. WHAM indicates that for a total lead concentration of 1 uM, the calculated bioavailable metal is 0.33 uM, compared to measured bioavailable metal of 0.48 uM. To directly compare to bioavailable lead, our new DNAzyme-based approach is applied to exposure solutions from Daphnia magna toxicity tests. Our testable hypothesis is that DNAzyme fluorescence responds to bioavailability if the dose-response curves for survival (y-axisAfter this assessment of DNAzyme responses in natural waters, it will be possible to start to develop tools for real-time, on-site detection of bioavailable metal

Title: Identification and Characterization of Groundwater Discharge in the Bogg Creek Watershed, NWT

Authors:
Brittney Glass, University of Waterloo
Andrew Wicke, University of Waterloo
David Rudolph, University of Waterloo
Claude Duguay, University of Waterloo

***Correspondence:** bglass@uwaterloo.ca

Keywords:
Groundwater, Contamination, Discharge, Permafrost

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management

Abstract:
The Central Mackenzie Valley (CMV) of the Northwest Territories has long since been a region of oil and gas exploration. Of particular interest is a sub-watershed of the CMV, Bogg Creek, which contains a target shale-oil bedrock formation called the Canol Formation. In advance of potential oil extraction, baseline hydrologic monitoring was established such that pre-extraction water quality metrics could be determined. One component of this hydrologic monitoring is the nature of the hydrogeologic system and groundwater surface water interactions. The objective of this component of the hydrologic monitoring program was to identify and characterize groundwater (GW) discharge locations at the land surface within the Bogg Creek Watershed (BCW). GW discharge zones represent potential pathways for subsurface contaminants resulting from hydraulic fracturing, thus, monitoring them for water quality changes is crucial. Further, the CMV is undergoing rapid climatic changes which are expected to impact both water quality and quantity. Given the remoteness of the BCW, traditional in situ methods of locating GW discharge zones are not feasible. Therefore, a remote geophysical method was developed to identify potential GW discharge zones which were later verified in situ. Using a series of image algorithms with remotely sensed imagery for selected years between 2004 and 2017, icings, which are indicative of winter GW discharge, were located within the BCW. Where icings recur on an annual basis, it was hypothesized that permanent GW springs existed. Once these locations were established using the remote method, they were visited in situ during the summer of 2018 and 2019 to verify that they were in fact GW discharge zones, and to collect water samples for further analysis. Predicted icing locations were in strong agreement with in situ verification methods that included thermal imagery and measurements of vertical hydraulic gradients and electroconductivity. GW samples collected from these locations were analyzed for general geochemistry and isotope composition. This data was compiled as baseline GW conditions within the BCW, and will be used in future work which aims to conceptualize the regional GW flow system. This work demonstrated the effectiveness of a remote method for identification of GW discharge, and established critical GW baseline monitoring parameters for a region which is at risk of contamination from potential fracturing activities and climatic changes.

Title: Volumetric heating models and their impact on small scale, non-hydrostatic dynamics

Authors:
Andrew Grace, University of Waterloo
Andrea Scott, University of Waterloo
Marek Stastna, University of Waterloo
Kevin Lamb, University of Waterloo

***Correspondence:** a2grace@uwaterloo.ca

Keywords:
Geophysical fluid dynamics, Penetrative heat flux, Non-hydrostatic dynamics

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Solar radiation is an extremely important factor in geophysical fluid dynamics as it is a major mechanism by which heat is introduced into the flow. The motivation for this research is to understand the role of penetrative radiation in heating shallow bodies of water that experience seasonal ice cover. Focus will be on the impact of radiation on small scale dynamics during the shoulder seasons (spring and fall), with the long-term objective of assessing the shallow western basin of Lake Erie. Penetrative solar radiation, often referred to as "short wave radiation" is parameterized as a body forcing term in the equation for the temperature of the fluid. The magnitude of the forcing decays exponentially with depth following a Beer-Lambert law formulation, but often at different rates to account for different bands of light. In this poster, I will describe the functional form of the short wave radiation and its shortfalls in the MITgcm. Then I will describe how the simple model included with the MITgcm can be improved to account for bottom reflection. In a shallow body of water, the effects of bottom radiation become important because a significant proportion of the incident radiation arrives and is reflected off the bottom. I will then demonstrate the impact that bottom reflection has on the dynamics via a series of simulations of a lock release experiment. The temperatures of the lock release problem will be below the density maximum of freshwater, so a positive heat flux is destabalizing, thus requiring the non-hydrostatic capabilities of the model.

Title: Further technical advancements in the Canadian Hydrological Model (CHM)

Authors:
Kevin R. Green, University of Saskatchewan
Christopher B. Marsh, University of Saskatchewan
Binben Wang, University of Saskatchewan
Raymond J. Spiteri, University of Saskatchewan

***Correspondence:** kevin.green@gmail.com

Keywords:
Simulation, Lookup tables, Snowcast, PBSM

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The Canadian Hydrological Model (CHM) is a next-generation C++ simulation code designed to increase our future capacity for hydrological simulations over a variety of spatial extents. CHM combines multi-scale unstructured spatial meshes with a plug-in architecture of modular process representations for developing models and simulations of hydrological processes.
We present recent technical advancements aimed at improving the efficiency and scalability of CHM. These advancements include: 1) the use of lookup tables (LUTs) for optimizing certain expensive function evaluations, 2) the addition of distributed linear algebra solvers for handling distributed process modules such as the Prairie Blowing Snow Model (PBSM) on large domains, and 3) the experimentation with and tuning of preconditioners for PBSM solvers.
Preliminary results include: 1) a 20% performance speedup from LUT usage on SnowCast simulations (www.snowcast.ca), 2) an over 40% performance speedup total from other core optimizations, and 3) a 60-fold increase to the size of domain on which PBSM can be applied, increasing to the extent of the Canadian Western Cordillera (1.3M km^2).
These results show great promise for the future application of CHM to large domain cold-regions process simulation.

Title: Reservoirs as Hotspots of P Speciation Dynamics: Data Analysis and Modelling

Authors:
Tori Grootjen, University of Waterloo
Nandita Basu, University of Waterloo

***Correspondence:** tegrootj@edu.uwaterloo.ca

Keywords:
hydrology, reservoirs, modeling, phosphorus

Primary meeting theme: Innovations in water science and technology
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management

Abstract:
Overapplication of nutrients to agriculturally dominated watersheds promotes eutrophication in downstream aquatic systems. Phosphorus (P) is a significant contaminant as it is the limiting factor in the production of algae. More specifically, increases in soluble reactive phosphorus (SRP), the bioavailable portion of total phosphorus (TP), have been argued to be responsible for the resurgence of algal blooms in Lake Erie. The transformation of water quality along a river is affected by various chemical and physical processes. Reservoirs act as hotspots for these processes due to sediment and P trapping, and they are also known to alter P speciation dynamics. Here we quantify P loads as they are processed by a reservoir and in particular, the seasonal variability of SRP over a decade within a reservoir in the Grand River Watershed in Southern Ontario, Belwood Lake. Feeding into the Grand River which drains into Lake Erie, the reservoir was found to increase the ratio of SRP:TP by double in summer months (June, July, August). We also found that SRP:TP ratios have increased at the inlet and outlet of the reservoir by 34% and 26% respectively over the past decade. It is believed that this increase in reactivity is fueled by accelerated internal loading in the anoxic hypolimnion. The recycled P stimulates eutrophication and allows for algal growth which can produce toxins and enhance hypoxia. Degraded water quality is just one influence that reservoirs have on downstream ecosystems. Understanding the impact of reservoirs on the reactivity of P is critical in the consideration of dam construction globally.

Title: Implementing the MESH model in a tropical Andean basin

Authors:
Roger Guio, National University of Colombia
Andrew Ireson, University of Saskatchewan
Erasmo Rodriguez, National University of Colombia
Bruce Davison, Environment and Climate Change Canada
David Zamora, National University of Colombia
Pedro Arboleda, National University of Colombia

***Correspondence:** rsguiog@unal.edu.co

Keywords:
MESH, Tropical Andean basin, high topographic complexity, Water balance

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting,(Big) data science and management

Abstract:
An accurate representation of water and energy fluxes between the atmosphere and the surface is required to understand the complex feedbacks between land-cover and climate. Land Surface Schemes (LSSs) provide a useful tool to investigate these responses. From the vast amount of studies that report the use of LSS, the majority correspond to temperate zones, while few cases are considered in tropical regions, like the Andes. Moreover, most of the LSS studies on tropical regions have been carried out on large size basins. The results of these studies have not been satisfactory, mainly because of the poor streamflow simulations when compared to observed data.
The study here reported implemented the H-LSS MESH model in the Coello river basin (1,500 km2) located in the Colombian Andean Mountains. The meteorological forcing used to run the model came from gridded data based on daily observations. Looking for the cause of low performance in streamflow simulations we compared model outputs with observed and reanalysis data. We also conducted a rigorous model´s parameter sensitivity analysis to identify the more influential parameters in the water balance components. Finally, we apply the HBV-sask model in the study area to compare its results with the MESH streamflow simulations, using the Nash–Sutcliffe Efficiency (NSE) metric.
The results indicate that input precipitation, used as forcing in MESH, is underestimated, with flaws in rainfall distribution, associated with limitations in the monitoring network and the high topographic complexity. Parameter sensitivity analysis showed that soil parameters have low influence in the water balance. On the contrary, land and vegetation parameters showed a high influence on the water balance. The NSE metric for the HBV-sask model was slightly better than for the MESH model. To improve the results for the MESH model in the study basin we are now working on a better representation of the water balance, through a mix of changes in albedo and vegetation parameters and increases of precipitation values on the annual scale.

Title: Wildfire effects on water quality at continental and global scales: A meta-analysis

Authors:
Tyler B. Hampton, University of Waterloo
Simon Lin, University of Waterloo
Nandita B. Basu, University of Waterloo

***Correspondence:** tyler.hampton@uwaterloo.ca

Keywords:
wildfire, water quality, meta-analysis, hydrology,

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
Wildfires have been documented to cause drastic deterioration in water quality in streams and rivers. These changes can include increases in suspended sediments, nutrients, organic carbon, metals, and other solutes. There has been some past work on summarizing these effects, but to date there has been no quantitative meta-analysis of the published literature. Furthermore, there is little consensus in the data describing recovery timescales of degraded water quality, and how changes differ with season and within the natural hydrologic regime curve. Our study analyzed data from 105 watersheds across the globe, largely in North America and Australia. We document major shortcomings of these data: often short time coverage (less than 5 years), low sample numbers, and rare co-measurement of water quality and water quantity. We show consistent increases (~75% of sites) in suspended sediments, and nitrogen and phosphorus species (inorganic and organic); along with strong correlation between species, such as total P and sediment. We also improve upon past reporting of water quality changes, which may only summarize the mean response. Concentrations of nitrate, for instance, increase the most at high percentiles (the highest values), suggesting extreme events get more extreme. For many cases where high percentile concentrations increase, low percentile concentrations experience little change, or sometimes decreases. Our study documents strong heterogeneity in responses of water quality to wildfire that have been unreported so far in the literature.

Title: GIS toolboxes for routing network delineation in lake and reservoir dominated watersheds

Authors:
Ming Han, University of Waterloo
Hongren Shen, University of Waterloo
Bryan A. Tolsona, University of Waterloo
James R. Craiga, University of Waterloo
Juliane Maia, University of Waterloo
Frezer S. Awola, University of Waterloo

***Correspondence:** m43han@uwaterloo.ca

Keywords:
Lake, Routing network, GIS tool

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management

Abstract:
Lakes and reservoirs have a critical impact on hydrological, biogeochemical, and ecological processes, and they should be one of the essential components in hydrological and eco-hydrological models. Lakes and reservoirs can be included in hydrological models provided they are carefully integrated into the hydrological routing topology. However, there is no open-source GIS tool that can correctly incorporate numerous lakes into the hydrological routing topology. This poses a fundamental difficulty to considering lakes in hydrological modelling, especially in Canada, and thus most large-scale hydrological modelling efforts tend to either ignore the impacts of all lakes or explicitly simulate the behaviour of only the very largest lakes in a watershed while ignoring the rest. This study develops GIS toolboxes (one in ArcGIS and one open source in QGIS) that supports flexible routing topology delineation with numerous lakes. The routing topology delineated with these GIS tools can appropriately incorporate lakes into the network and can represent both lakes that are connected to the river network and lakes that are unconnected to the river network. The tools require as a minimum a user-provided DEM and lake polygon shapefile. Test results show the toolboxes can process many different types and resolutions of DEMs and produce an array of various resolution vector-based routing topologies. These can form the basis for any subwatershed-based, distributed hydrologic modelling project in lake-dominated regions like most of Canada.

Title: Advances in resolving snow-vegetation interactions with UAV-lidar remote sensing

Authors:
Phillip Harder, University of Saskatchewan
Dong Zhao, University of Saskatchewan
Cob Staines, University of Saskatchewan
John W. Pomeroy, University of Saskatchewan

***Correspondence:** phillip.harder@usask.ca

Keywords:
UAV, snow depth, lidar, snow-vegetation interactions

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management

Abstract:
Unmanned Aerial Vehicle (UAV) remote sensing has been enthusiastically adopted by many hydrologists and snow scientists to provide high resolution spatial observations that bridge scales and quantify small scale processes in new and revealing ways. However, challenges in field operations, and data processing of snow depth to quantify snow redistribution and ablation in areas with vegetation need to be overcome to fully realise its potential. Specifically, quantifying snowpacks beneath needleleaf forest canopies in the Canadian Rockies and deciduous wetland vegetation in the Canadian Prairies at scales that resolve the impact of snow interception and ablation processes on snowpacks under and near trees has been a major hurdle for remote sensing. Improved information on sub-canopy snowpacks is needed to calculate snowcover accumulation, depletion and ablation rates. UAV-lidar provides a tool that resolves sub-canopy snow depth at centimetre accuracy. This is providing unprecedented observations on the spatial variability of forest snowpacks as they accumulate and ablate. A selection of approaches to quantifying snow-vegetation interactions from UAV-lidar data are demonstrated from 2019 and 2020 field campaigns in the Canadian Prairies and Rockies. These advances demonstrate that UAV-lidar remote sensing can provide a critically important component of coupled observation and prediction systems in cold regions.

Title: Comparison of eDNA metabarcoding and electrofishing methods to characterize the upstream-downstream fish community gradient of a Grand River tributary

Authors:
Nathanael Harper, University of Waterloo
Heather A. Ikert, University of Waterloo
Micheal D.J. Lynch, University of Waterloo
Patricija Marjan, University of Waterloo
Andrew C. Doxey, University of Waterloo
Mark R. Servos, University of Waterloo
John P. Giesy, University of Saskatchewan
Paul M. Craig, University of Waterloo
Barbara A. Katzenback, University of Waterloo

***Correspondence:** nbjharper@uwaterloo.ca

Keywords:
eDNA, Metabarcoding, Fish, Electrofishing, Big Data

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
The Grand River is the largest watershed in Southern Ontario, and anthropogenic pressure on this watershed is only expected to increase. The resident human population is projected to grow by over 50% by 2050, adding to the environmental pressures (e.g. habitat loss, pollution, climate change) faced by many local fish species. In the face of such significant growth, novel survey methods are needed to monitor local fish species for conservation and to develop sustainable fish population management strategies. A promising approach to assess watershed biodiversity is the characterization of environmental DNA (eDNA). eDNA is the genetic material contained shed by an organism into the environment. Common sources of eDNA include skin, urine, feces, slime or scales. Metabarcoding is an analysis technique used to simultaneously analyze eDNA of multiple species with the potential to characterize entire fish communities from water samples. The rapid eDNA field sampling procedure enables more reaches to be surveyed during a field day compared to current fish inventory methods such as electrofishing. This research aims to compare species detections using eDNA metabarcoding to species detected during triple-pass electrofishing in reaches along the upstream-downstream gradient of Bauman creek, a first-order cold-water tributary of Ontario's Grand River. Six reaches along an upstream-downstream gradient of Bauman creek were sampled for eDNA, with triplicate 1 litre samples taken along with a sterile field blank. Immediately after eDNA sampling, water chemistry and triple-pass electrofishing surveys were performed. Water samples were vacuum filtered to concentrate eDNA. The concentrated eDNA was extracted from the filtride using Metagenom Bio's SOX Soil kit. To monitor for introduced contamination, an extraction blank was included. The extracted eDNA was assessed for overall integrity and the presence of inhibitory substances. Metabarcoding then characterized the eDNA, allowing amplicon sequence variants to be assigned taxonomic identities via BLASTn. eDNA metabarcoding was able to detect and correctly identify local fish assemblages of different species composition. Additionally, eDNA metabarcoding and triple-pass electrofishing detected similar fish communities across the six studied reaches. This research demonstrates the applicability and utility of

eDNA metabarcoding as a non-invasive technique an end-user could implement to inventory fish communities along a stream.

Title: A distributed approach on spatial data sharing

Authors:
Majid Hojati, Wilfrid Laurier University
Colin Robertson, Wilfrid Laurier University

***Correspondence:** hoja4090@mylaurier.ca

Keywords:
Big Data, distributed systems, IPFS, spatial data sharing

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management

Abstract:
Collaborative environmental science that engages communities, local decision-makers, and scientists requires novel tools for sharing geospatial resources. A sharing strategy for geospatial data can lead to higher levels of collaborations between researchers and maximize use of scientific and modelling data products. Geospatial resources can be categorized into the three levels of sharing: i) sharing the geographical information (GI) collected by different sensors, devices ii) sharing computational resources in order to improve the response time for demanding computing processing requirements and iii) sharing knowledge gained from different domains by modeling the understanding of geographical phenomena. A P2P file storage system is a distributed environment formed by autonomous peers that operate in an independent manner. Each peer stores a part of the available information and maintains links (indexes) to other peers. Compared to the centralized client/server GIS architecture, a distributed GIS architecture has more servers in the system and allows new datasets to be added onto the server experiencing the lowest system load. As a result, the distributed GIS architecture balances the system storage resources much better than does the client server GIS, where a single server is responsible for managing all datasets in the system. InterPlanetary File System (IPFS) is a protocol and a peer-to-peer network for storing and sharing data in a distributed file system. IPFS is built around a decentralized system of user-operators who hold a portion of the overall data. In this paper, we evaluate the potential of IPFS-based data sharing and analysis in support of a collaborative science methodology. In order to have a distributed architecture for sharing spatial data on IPFS and being able to use it for spatial analysis, first a data model to share spatial data on IPFS network is required. For this purpose, a custom-built discrete global grid system was deployed. This data model provides users an ability to perform window-based queries on data stored on IPFS. In order to process the data on such network a Hadoop distributed data was used to analyze spatial data which are stored on the IPFS network. As a case study a raster data layer is stored on the IPFS network and a set of global, zonal and focal map algebra functions are applied to illustrate the possibility of processing big geo data on a distributed network.

Title: Tracking emerging knowledge domains in urban climatology

Authors:
Fei Huo, University of Saskatchewan
Li Xu, University of Saskatchewan
Yanping Li, University of Saskatchewan
Yuya Kajikawa, Tokyo Institute of Technology

***Correspondence:** fei.huo@usask.ca

Keywords:
Urban climatology, Big data analytics, Clustering method, Urban flooding

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management; Social, economic and health determinants and impacts

Abstract:
The number of studies in relation to urban climatology have been rising dramatically since 1990s. Urban climatology is indispensable for the society, economy, and environment. By using the citation network analysis, the aim of this research is to provide a detailed structure of urban climatology research and to track the emerging research domains among a pile of publications efficiently and effectively. These publications were first clustered in the topological manner using the modularity maximization algorithm, illustrated by a large graph layout technique to represent the mainstream of the research in urban climatology. According to the clustered networks, we synthesized common ideas for each research domain and identified the Flood risk (Cluster #U6), the Greenhouse gas emissions (Cluster #U7), and the Urban precipitation (Cluster #H3) as emerging fields in urban climatology. The surge of interest in both urban precipitation and flood under a changing climate is an informative indicator for outlook in urban climatology. Such analysis can improve our understanding the current status and the future outlooks in urban climatology research and can better serve the decision making communities.

Title: Baseline Characterization of a Semi-Alluvial Headwater Creek using a Remote Integrated Automatic Continuous Bedload Monitoring Station

Authors:
Matthew Iannetta, University of Waterloo
Bruce MacVicar, University of Waterloo

***Correspondence:** m2iannetta@uwaterloo.ca

Keywords:
Sediment transport, Bedload monitoring, Open-channel hydraulics, Monitoring station, Predictive modelling

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
Many commonly used bedload monitoring methods often yield limited inter-flood or discontinuous data, which restricts our understanding of bedload transport dynamics. Field efforts involved in collecting these data can be difficult, expensive, and dangerous in some circumstances of significant flow. In this study we present a newly developed remote, integrated, automatic, and continuous bedload monitoring station. The station was deployed in a semi-alluvial headwater creek located in an agricultural watershed in Southern Ontario to characterize baseline conditions for the purpose of developing a field calibrated predictive bedload transport model.
The station integrates two indirect monitoring devices including an in-situ radio frequency identification (RFID) antenna tracker and “Benson-Type” seismic impact plates. 400 synthetic RFID tracer stones divided into 4 half-phi size classes were seeded upstream of the station and will be automatically tracked as they pass over the in-situ RFID antenna. The seismic impact plates convert mechanical energy exerted by bedload particles striking the plate into electrical energy recorded as total counts. A Bunte sediment trap was installed to help calibrate the continuous impact plate data record. The station configuration is unique compared to other existing bedload monitoring stations described in published literature in that it is relatively inexpensive, easy to deploy in the field, and designed for remote applications. Power is delivered through a solar panel and deep cycle marine batteries, and all data collected by the station can be offloaded remotely via secure shell (SSH) internet communication protocol.
Preliminary findings include impact plate counts recorded across multiple flow events and RFID tracer stone movement detected during a significant flood event in the early winter of 2020. The station appears to be a promising method to obtain high resolution bedload transport data over an extended period of time while minimizing field work requirements.

Title: The effect of inclusion of soil capillary fringe on the performance of a new tile drain module developed for the Cold Regions Hydrological Model: Lessons from a farm field in Southern Ontario, Canada

Authors:
Mazda Kompanizare, University of Waterloo
Merrin Macrae, University of Waterloo
Diogo Costa, Environment and Climate Change Canada
John Pomeroy, University of Saskatchewan
Richard Petrone, University of Waterloo

***Correspondence:** mkompani@uwaterloo.ca

Keywords:
Tile drainage, Capillary fringe, CRHM, drainable water

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Systematic tile drainage is used extensively in agricultural lands in Ontario and other parts of North America. Tile networks, which drain excess or ponded water from fields during heavy precipitation or snowmelt events, are necessary for crops to grow efficiently. However, tile drains also transfer significant amounts of water and nutrients to downstream lands and water bodies, and can create both water quality and flooding issues. However, in fields with fine-grained soils with a thick capillary fringe, a significant amount of water and nutrients in soil can be held in the soil rather than drained by the tile network. Consequently, the capillary fringe holding capacity (CFHC) can reduce or delay the transfer of water and nutrients to downstream systems.
A new tile drainage module (TDM) is currently being developed for the Cold Regions Hydrological Modelling platform (CRHM). CRHM is a modular platform that facilitates creation of physically based hydrological process models suitable for cold climates that has recently been extended to include nutrient simulations. However, the lack of a TDM in CHRM has limited its use in areas with tile drainage. The goal of this work is to develop a tile drainage module for CRHM, which operates at an hourly (or sub-hourly) time step, that includes both flow and nutrient transport, and implements the effects of CFHC. This development will make the CRHM model more suitable for application in the temperate climate conditions of Southern Ontario. This presentation outlines recent progress in this effort and highlights model performance. The model was tested by comparing observed and simulated surface and tile flows as well as soil water levels. The sensitivity of modelled tile flow to variables such as capillary fringe thickness and holding capacity will also be discussed.

Title: High resolution simulations of Lake Erie over the summer season

Authors:
Kevin Lamb, University of Waterloo
Senja Walberg, University of Waterloo
Marek Stastna, University of Waterloo

***Correspondence:** kglamb@uwaterloo.ca

Keywords:
lake modelling, MITgcm, exchange, physical processes in lakes

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management

Abstract:
Lake Erie is the shallowest and southernmost of the Laurentian Great Lakes. The lake is divided into three basins with large differences in average depth, and while it has a generally elliptic shape several large features, like the Long Point peninsula, are a challenge to resolve in numerical simulations. In the summer Lake Erie exhibits a sharp pycnocline, and often a large region of hypoxia. Coupled with upwelling episodes this has led to large scale fish kills in the recent past. We report on modeling with the MIT gcm at a variety of horizontal resolutions, with 100m being the finest attempted. We outline features in the 100m grid resolution simulation, such as those evident in the plot of eddy kinetic energy at various depths below, that are not evident in coarser simulations, and discuss the manner in which inter-basin and nearshore off-shore exchange varies with model resolution.

Title: Object-based tracking of precipitation systems in western Canada: The importance of temporal resolution of source data

Authors:
Lintao Li, University of Saskatchewan
Yanping Li, University of Saskatchewan
Zhenhua Li, University of Saskatchewan

***Correspondence:** lintao.li@usask.ca

Keywords:
precipitation feature, MODE-TD, source data, temporal resolution, western Canada

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Object-based algorithm provides additional spatiotemporal information of precipitation, besides traditional aspects such as amount and intensity. Using the Method for Object-based Diagnostic Evaluation with Time Dimension (MODE-TD, or MTD), precipitation features in western Canada have been analyzed comprehensively based on the Canadian Precipitation Analysis (CaPA), North American Regional Reanalysis (NARR), Multi-Source Weighted-Ensemble Precipitation (MSWEP), and a convection-permitting climate model (CPCM). We found light precipitation occurs frequently in the interior valleys of western Canada while moderate to heavy precipitation is rare there. The size of maritime precipitation system near the coast is similar to the continental precipitation system on the Prairies for moderate to heavy precipitation while light precipitation on the Prairies is larger in size than that occurs near the coast. For temporal related features, moderate to heavy precipitation lasts longer than light precipitation over the Pacific coast, and precipitation systems on the Prairies generally move faster than the coastal precipitation. For annual cycle, the west coast has more precipitation events in cold seasons while more precipitation events are identified in warm seasons on the Prairies due to vigorous convection activities.

Using two control experiments, the way how the spatiotemporal resolution of source data influences the MTD results has been examined. Overall, the spatial resolution of source data has little influence on MTD results. However, MTD driven by dataset with coarse temporal resolution tend to identify precipitation systems with relatively large size and slow propagation speed. This kind of precipitation systems normally have short track length and relatively long lifetime. For a typical precipitation system (0.7 ~2 X 10^4 km^2 in size) in western Canada, the maximum propagation speed that can be identified by 6-hourly data is approximately 25 km/h, 33 km/h for 3-hourly, and 100 km/h for hourly dataset. Since the propagation speed of precipitation systems in North America is basically between 0 ~ 80 km/h, we argue that dataset with hourly or higher temporal resolution is required for driving MTD.

Title: Sensing contaminants in water using DNA

Authors:
Juewen Liu, University of Waterloo
Po-Jung Jimmy Huang, University of Waterloo

***Correspondence:** liujw@uwaterloo.ca

Keywords:
biosensors, heavy metals, DNA

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Finding robust, reliable and cost-effective methods for highly sensitive and selective detection of contaminants in water is a long-standing analytical challenging. Here, the use of DNA for this purpose is discussed. Aside from its genetic function, DNA has been used as a sensing molecule in the last few decades due to its high stability, ease of modification and sequence-dependent chemical properties. DNAzymes are DNA-based catalysts, and they are highly attractive for biosensor development. In the last few years, my lab isolated a suite of new RNA-cleaving DNAzymes that are highly specific for various metal ions. Our work started with a series of lanthanide-dependent DNAzymes. A phosphorothioate (PS) modification refers to the substitution of one of the non-bridging phosphate oxygen atoms in nucleic acids by sulfur. We also developed PS-modified DNAzymes for recruiting thiophilic metals such as Cd2+ and Cu2+. Direct selection of a highly active DNAzymes using Ag+ was also achieved. Finally, we obtained Na+- and Ca2+-specific DNAzymes. Most of these DNAzymes were made into fluorescent biosensors for metal ions down to low parts-per-billion concentrations. Using DNA to detect other species such as small molecules and cells will also be introduced.

Title: Use of environmental gradients and eDNA techniques to assess suitability of temporary forested wetlands for amphibians in Georgian Bay, Ontario

Authors:
Nick Luymes, McMaster University
Patricia Chow-Fraser, McMaster University

***Correspondence:** luymesnw@mcmaster.ca

Keywords:
amphibians, eDNA, vernal pools

Primary meeting theme: Innovations in water science and technology
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Amphibians are at risk worldwide due in large part to loss of their diverse habitats. Knowledge of where optimal habitat exists is essential for conservation of amphibians. In Ontario, some of the most important breeding habitat for amphibians occurs in temporary forested wetlands, also referred to as vernal pools. Unfortunately, these pools are critically understudied due to their small size, cryptic positions within the landscape, and difficulties associated with conventional amphibian sampling techniques. Our goal is to develop tools to 1) identify suitable ephemeral wetlands for amphibian breeding habitat based on environmental variables, and 2) assess the presence of target species in these wetlands using novel eDNA techniques. We are particularly interested in the forested region along the eastern shore of Georgian Bay, as this area is under development pressure. During the spring and summer of 2019, we surveyed 35 vernal pools in eastern Georgian Bay for larval amphibians, along with relevant abiotic and biotic variables that may influence their suitability for obligate amphibians. Results thus far suggest that within-wetland primary productivity and hydroperiod are important drivers of community composition, and that the more productive wetlands with longer inundation period have greater species-specific abundances, particularly frogs. This summer, we plan to re-sample the pools to collect more information on pool hydrology, and to evaluate the feasibility of using eDNA to confirm occupancy of blue-spotted salamanders in a subset of pools. Quick and efficient tools for assessing habitat suitability and species presence in wetlands are necessary for informed decisions about the future of land use decisions in undeveloped areas such as Georgian Bay.

Title: Developments in the Canadian Hydrological Model (CHM)

Authors:
Christopher B. Marsh, University of Saskatchewan
Vincent Vionnet, Environment and Climate Change Canada
Kevin R. Green, University of Saskatchewan
Raymond J. Spiteri, University of Saskatchewan
John W. Pomeroy, University of Saskatchewan

***Correspondence:** chris.marsh@usask.ca

Keywords:
hydrology, modelling, cold regions, snow, high performance computing

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
The Canadian Hydrological Model (CHM) is a next-generation Core Modelling deliverable. It uses a novel, multi-scale land surface representation that allows for large reductions in computational elements (70%+) while preserving critical land-surface heterogeneity. Key features of CHM include the ability to effectively and efficiently capture spatial heterogeneity; to include multiple process representations; to change, remove, and decouple hydrological process algorithms; to handle both point and spatially distributed models; to manage multiple spatial extents and scales; and to utilize a variety of forcing fields (boundary and initial conditions). Here, an overview of the Canadian Hydrological Model (CHM) is given, along with technical developments that have enabled expanding the simulation domains from a 8 km2 sub-arctic mountainous basin to the 1.3M km2 Canadian Western Cordillera. These include distributed computing improvements, numerical optimizations, and memory footprint reductions that have resulted in an over 40% speedup. The new tool “Wind Mapper” is presented; this is a new development for CHM in downscaling wind fields over complex topography for million km2 spatial extents, a critical component for estimating blowing snow processes over these large extents. CHM currently includes most snow processes, a discussion on issues related to the inclusion of an SVAT and the entirety of the terrestrial hydrological cycle will be presented.

Title: Near-Real-Time Flood Mapping using HAND model and GIS Derived Synthetic Rating Curves

Authors:
Heather McGrath, Natural Resources Canada
Blair Scriven, University of Calgary
Emmanuel Stefanakis, University of Calgary

***Correspondence:** heather.mcgrath@canada.ca

Keywords:
flood mapping, HAND model, flood prediction, rating curve

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
Traditional methods for flood hazard mapping focus on complex hydrodynamic and hydraulic models to simulate flows and map inundation extents. The extensive data requirements of these models limits their usability within many Canadian communities that are data scarce, while their high computation times are unsuitable for emergency management situations that require rapid results and visualization. Recent research on simplified models, which rely primarily on a high-resolution terrain model and hydrographic network, have shown promising results in accuracy to these complex models and in computation time. One such simplified flood model is the Height Above Nearest Drainage (HAND) model. The HAND model is able to simulate the potential flood extent given a predicted water level. One limitation to their use is that many real-time river prediction services offer data as a measure of flow, not as a reference to water height. Thus, a relationship between height (H) from the HAND model and river discharge (Q) is necessary. Using GIS techniques to solve Mannings' equation a synthetic rating curve (SRC) is developed from solving for Q, given a number of H inputs. Once this SRC has been computed, a predicted inundation extent can be generated on the fly regardless of the prediction - water level or flow - by accessing the HAND raster via Web Map Service and setting the appropriate threshold. The test area, in Ottawa's Rideau River, demonstrates preliminary results using a single friction coefficient (n) within 15% tolerance of published data. However, further testing, including using Land Use/Land Cover to alter the n, is underway to evaluate its impact. In addition, several other study sites are currently being evaluated to determine if similarly positive results are derived.

Title: Online Historical Flood Mapping Tool for Ontario, Canada

Authors:
Hamid Mehmood, United Nations University
Sami Kurani, McMaster University

***Correspondence:** hamid.mehmood@unu.edu

Keywords:
historical floods, Big data, earth observation, remote sensing, cloud computing

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
Flooding is a historically reoccurring issue in Ontario, resulting in significant amounts of damage to personal property and infrastructure. Current flood maps were developed 20-25 years ago, and are outdated. Creating new maps, however, could take up to a decade. In 2019 alone, over $75 million worth of flood-related insured damage was seen throughout eastern Ontario.
Stakeholders have an incentive to understand the flood risks that their communities' face, so that flood mitigating efforts can be taken. A standard tool used to understand flood risk is the flood inundation map, which identifies flood locations in a variety of climate scenarios. While this tool is useful, it requires technical expertise and vast computer resources, which may not feasible for smaller, more focused groups.
The present study investigates the feasibility of constructing an online Historical Flood Mapping Tool (HFMT), specifically optimized for use in Ontario, Canada. This tool would leverage Earth Observation Imagery available as Analysis Ready Data (ARD) and Google Earth Engine as a cloud computing platform. The tool would be used to map historical floods in Ontario from 1974 to the present day, in near real-time. In this study, a data cube is developed from the available Landsat archive to identify temporary and permanent water bodies using the Modified Normalized Difference Water (MNDWI) index, as well as site-specific Height Above Nearest Drainage (HAND) information. HFMT outputs can be used to create historical flood inundation maps, as well as potential risk maps. This information could then be combined with demographic and utility data, for the user-defined time periods. Flood map accuracy could be determined by incorporating a flooding case study and analyzing cell-to-cell agreement. Our aim is not to replace flood inundation maps, but to provide a complimentary tool for rapid analysis.
The paper presents an open-sourced framework and code base for further historical flood mapping tools to be developed in Canada, allowing public and private entities to conduct flood analysis, regardless of limiting resources.

Title: Sensitivity analysis of the biotic ligand model to uncertainty in dissolved organic carbon

Authors:
Mickey Nielsen, Wilfrid Laurier University
Scott D. Smith, Wilfrid Laurier University
James McGeer, Wilfrid Laurier University

***Correspondence:** niel6991@mylaurier.ca

Keywords:
Dissolved Organic Carbon, Remote Sensing, Biotic Ligand Model

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
The biotic ligand model (BLM) is a tool used to quantitatively evaluate how receiving water chemistry affects the bioavailability of metals. Sensitivity testing can be used to understand how the model outputs vary in response to systematic changes in water chemistry inputs. This will allow users of such models to understand how accurate their input parameters must be for a specified level of confidence in the output. Our focus is on dissolved organic carbon (DOC), which is often the most limiting data for application of BLM approaches to metals risk management. When using remote sensing as a tool to measure DOC, the question stands of how well does DOC need to be estimated in order to produce accurate water quality criteria outputs? This study inputs average water chemistries for both cold and warm water regions with 1%, 10%, 25% and 50% variations in the mean values for all parameters, ignoring correlations between dependent parameters. The variation in the model output criterion continuous concentration for copper as a function of DOC, and other model inputs, will allow estimation of how well DOC needs to be estimated in the context of remote sensing, to be useful for water quality and risk assessments. This study will be Phase I, as correlations will be taken into account in future research.

Title: Smart Great Lakes: a vision for future management, policy, and partnership

Authors:
Kelli Paige, Great Lakes Observing System
Becky Pearson, Great Lakes Observing System
Tim Kearns, Great Lakes Observing System

***Correspondence:** kelli@glos.org

Keywords:
Data, Technology

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: (Big) data science and management; Stakeholder engagement and knowledge mobilization

Abstract:
For the past decade, “smart” technologies have transformed the way society and the world interacts, as smartphones and inexpensive sensors have become ubiquitous, allowing us to collect far more data than we can currently use and influencing how we choose to search for, consume, and share information. Ongoing technology advancements include distributed sensing, artificial & augmented intelligence, edge computing, mesh networks, machine learning, integration of diverse data, adaptive and predictive analysis, and automated control and interoperability. This gives us the ability to transform diverse, high-volume, high-velocity data into value in the form of actionable information and sometimes, even direct action.
This notion of using technology to make our environment “smarter” is what inspires the Great Lakes Observing System (GLOS) vision and strategic plan. Furthermore, in partnership with the Council of the Great Lakes Region and the Cleveland Water Alliance, GLOS is issuing a call to action for the development of a Smart Great Lakes Initiative, to organize the region’s technology ecosystem and network of partners around common policy goals to improve monitoring, advance data management and analysis, and spur technology innovation.
This presentation will provide a brief overview and introduction to the Smart Great Lakes concept and review ways for partners to be involved in the Smart Great Lakes Initiative. It will showcase work in Lake Erie as a pilot demonstration that includes engaging stakeholders, securing core observations, and designing then building a sustainable early warning system for harmful algal blooms. As an integral tool for this effort, the GLOS information technology (IT) platform is designed to serve data contributors, service providers, stakeholders and consumers of the data and information. Lessons learned from early Lake Erie implementation will be applicable to the overall Great Lakes region, other regional associations within the U.S. and Canadian Integrated Ocean Observing System (U.S. IOOS and CIOOS), and the Global Ocean Observing System (GOOS).

Title: Solid state phosphate sensor with enhanced lower limit of detection using modified potentiometry

Authors:
Vinay Patel, McMaster University
Ravi Selvaganapathy, McMaster University

***Correspondence:** patelv77@mcmaster.ca

Keywords:
Phosphate sensor, Electrochemical sensor, Potentiometry, Nutrient sensing, Cobalt electrode

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
Phosphate is a major pollutant responsible for the global algal bloom in various water bodies like lakes and ponds. Currently, there are a few laboratory systems for phosphate measurements, but these systems are not portable which limits their application for real-time phosphate measurements in water bodies. Further, these methods need sophisticated instruments, skilled manpower and use toxic chemicals. So, there is an urgent need for a real time phosphate monitoring system which does not require any chemicals, less interference from water turbidity and require minimal human intervention. Electrochemical sensors have many advantages over the widely used conventional colorimetric sensors. These sensors have minimal or no chemical requirements, show less interference from turbidity, are easy to fabricate and are cost effective. However, current electrochemical phosphate sensors are either not selective or not sensitive at concentrations below 10-6M [1], [2].
Here we demonstrate a solid state electrochemical system that is based on Cobalt electrode to provide selective yet sensitive detection of phosphate at lower limits. This sensor uses a modified electrochemical measurement scheme to detect phosphate concentration over a wide range from (10-1M to 10-7M) which is critical for measuring phosphate in the environment where regulatory limits of 0.1mgL-1(1.05 *10-6M) are to be measured in streams that don't empty into reservoirs while it is lower at 0.05 mgL-1 (5.2*10-7M) for streams that do [3].
This sensing methodology can be used to control phosphate levels downstream of the wastewater treatment plant and control phosphate loading in the water bodies by modifying the treatment process at the plant depending on the nutrient load.
References
[1] L. Zhu, X. Zhou, and H. Shi, "A potentiometric cobalt-based phosphate sensor based on screen-printing technology," Front. Environ. Sci. Eng., vol. 8, no. 6, pp. 945–951, 2014.
[2] D. Xiao, H. Y. Yuan, J. Li, and R. Q. Yu, "Surface-Modified Cobalt-Based Sensor as a Phosphate-Sensitive Electrode," Anal. Chem., vol. 67, no. 2, pp. 288–291, 1995.
[3] USEP, A. Quality criteria for water 1986. EPA 440/5-86-001, US Environmental Protection Agency, Washington, DC, 1986.

Title: A DGT-supported aqueous Hg(II) biosensor for smart water quality monitoring

Authors:
Kunfu Pi, University of Waterloo
Juewen Liu, University of Waterloo
Fereidoun Rezanezhad, University of Waterloo
Philippe Van Cappellen, University of Waterloo

***Correspondence:** kpi@uwaterloo.ca

Keywords:
Mercury, Water quality, Monitoring, Smart technology, Environmental biosensor

Primary meeting theme: Innovations in water science and technology
Secondary theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts

Abstract:
Geogenic and anthropogenic contamination of groundwater and surface water resources by toxic metals, such as mercury (Hg), has been a long-standing severe threat to the drinking water quality of many, often economically challenged, communities in Canada and abroad. This contamination also adds ample stress to the already vulnerable aquatic ecosystem health in arid and cold regions. A major challenge for detecting aqueous Hg pollution and monitoring the water quality is the development of reliable and smart detection technologies that are sensitive, field-deployable and user-friendly. The creation of water quality monitoring platforms that are transferable, durable and cost-effective is also a key component of the Global Water Futures' goals and many water management programs in the world. To meet this challenge, we have developed a new biosensing tool for aqueous Hg(II) monitoring by integrating a novel deoxyribonucleic acid (DNA)-based sensing material with the diffusive gradients in thin films (DGT) technique. Compared with the conventional passive sampling device, this new hybrid DGT-supported biosensor uses the DNA-functionalized hydrogel as the Hg(II) binding layer to realize almost simultaneous sampling and measurement. Results of the laboratory test with aqueous solutions of variable complexity demonstrate high selectivity and binding capacity toward aqueous Hg(II). The factors potentially impacting the sensor performance include the variations in pH, temperature and concentrations of chloride (Cl-) and dissolved organic matter (DOM), which are able to alter the effective diffusion coefficients of Hg(II) species through the DGT unit and affect Hg2+ binding to the DNA within the binding layer. However, such environmental interferences can be well accounted for by reactive transport modeling with temperature and diffusion coefficient calibrations. In the support of model corrections, this hybrid DGT-biosensor shows the capacity to accurately detect Hg(II) concentrations across a wide range of hydrochemically distinct freshwaters, including the Great Lakes and some water bodies within the indigenous communities in Canada.

Title: An Auto-reconfigurable Wireless Sensor Network for Internet of Things based Water Quality Monitoring

Authors:
Gazi Rahman, Department of Electrical and Computer Engineering, University of Saskatchewan

***Correspondence:** ehsan.rahman@usask.ca

Keywords:
Internet of Things, Wireless Sensor Network, LoRa, Dynamic sensor node

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions

Abstract:
An application like Water Quality Monitoring (WQM) requires wireless connectivity for its widely sprayed water resources. Cellular network lacks coverage all over these sprayed resources mostly in the rural area. Low Power Wide Area Network (LPWAN) cannot provide long-range comparing to the cellular network. Other than this; power, cost, and technical limitations do not permit us to use any one of the above wireless technologies for the wireless sensor network (WSN) solution for water quality monitoring. Therefore we need to use both the technologies in parallel and the sensor nodes need to form different network topologies dynamically. This research proposed a sensor node that can reconfigure itself to form any network topology dynamically using a device to device (D2D) communication. This WQM system was implemented using LoRa for wider and low power WSN and D2D communication. This WSN was tested using both static and mobile nodes to support different types of WSN topology. We evaluated the nodes' performance by measuring data loss with respect to RSSI and SNR at different distances among the nodes.

Title: Detection of Lead in drinking water in a microwave sensor integrated microfluidic system

Authors:
Zhe Ren, University of Waterloo
Weijia Cui, University of Waterloo
Yongxin Song, University of Waterloo
Carolyn L. Ren, University of Waterloo

***Correspondence:** z56ren@uwaterloo.ca

Keywords:
Microfluidic, Microwave, Lead

Primary meeting theme: Innovations in water science and technology
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
According to the previous standard from WHO, lead could cause a decrease of 3 intelligence quotients in children and an increase in systolic blood pressure of 3mmHg (0.4Kpa) in adults even at a very low level in our drinking water such as 25µg/kg body weight (PTWI, Provisional Tolerable weekly Intake). In general, lead in drinking water mainly comes from aging pipes, which is non-degradable. Early warning is necessary and impactful to prevent or minimize the damage to the health of humans and other living entities. The currently used public health detection system has not been designed to monitor household tap water. In addition, most of the traditional methods of detecting lead require a long (i.e. 3days) and complicated detection process, which limits the wide use of these methods as an early warning system. This work introduces a heavy metal detection method using microwave technique that is integrated with a microfluidic device. Microwave can differentiate materials based on their electric properties such as dielectric constant and/or conductivity in real time with a response of a shift in the resonance frequency and a magnitude change in the reflection coefficient. Integration with a microfluidic device enables the sample to be confined and manipulated for quick detection of trace and label-free liquid (i.e. 1 microliter). The microwave sensor is designed with a double-T structure and the gap of the double-T is aligned with a microchannel where the sample is flowing through. The sensor is fabricated on a glass slide using electroplating and the enclosed microchannel is fabricated on top the sensor. This design is validated to be able to detect a concentration of lead as low as 10 ppb, which is the latest WHO standard for regulating the drinking water. In order to enhance the sensitivity, gold nanoparticles (Au-NPs) are also explored and used to modify the surface of the resonator. The improved sensitivity, reflected by an augmented shift in the resonance frequency is observed.

Title: Long-term and continuous dissolved oxygen monitoring in agricultural soils: A field application of Multi Fiber Optode (MuFO) microsensor system

Authors:
Fereidoun Rezanezhad, University of Waterloo
Tatjana Milojevic, University of Waterloo
Alison Mao, University of Waterloo
Sean Jordan, University of Guelph
Claudia Wagner-Riddle, University of Guelph
Philippe Van Cappellen, University of Waterloo

***Correspondence:** frezanez@uwaterloo.ca

Keywords:
Oxygen Sensor, Water Quality, Agricultural soils, Soil biogeochemical processes

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Dissolved molecular oxygen (O2) is a key parameter for water quality and soil health and the biogeochemical functioning of natural environments is closely linked to spatial and temporal variations in O2 concentrations. We developed a luminescence-based Multi Fiber Optode (MuFO) microsensor system to measure O2 concentrations in real-time with a high degree of spatial and temporal flexibility in saturated and unsaturated soil profiles. In the MuFO system, images of the emitted light are recorded by a high-resolution digital camera, and the digital images are analysed using signal processing techniques to convert light intensity to O2 concentration. We have first successfully implemented the MuFO system in bench-scale experiments under varying hydrological and temperature regimes, and then the field tests have been proven successfully under real-world conditions. In a novel field application, we incorporated the MuFO microsensors into an autonomous field-deployable system with “photo-logging” capability to continuously and remotely measure O2 concentrations. We deployed the MuFO in two agricultural field-controlled lysimeter systems located at University of Guelph’s Elora Research Station over one year and monitored the subsurface O2 dynamics together with soil temperature, moisture content and pore water geochemistry. In this presentation, we present how the optical sensing in soils can be combined with more established methods for porewater sampling and analysis, along with weather data to better understand climatic influences on soil biogeochemical processes. Specifically, we show how the integration of soil O2 measurements with seasonal variations in precipitation and temperature will provide a new dimension in the understanding of carbon and nutrient cycling in the soil system.

Title: Developing next-generation data models for science/community integration

Authors:
Colin Robertson, Wilfrid Laurier University
Chiranjib Chaudhuri, Wilfrid Laurier University
Majid Hojati, Wilfrid Laurier University
Steven Roberts, Wilfrid Laurier University

***Correspondence:** crobertson@wlu.ca

Keywords:
geospatial, big data, data model, dggs

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
Discrete global grid systems are a multiresolution data structure capable of integrating heterogeneous types of geospatial data. Due to their discrete treatment of space, they also support the development of fast and scalable algorithms for large-area spatial analysis and modelling. In northern communities experiencing rapid environmental change, a mix of locally-produced and globally-managed data are often required; produced across a hierarchy of scales. While models and satellites produce spatially explicit representations of environmental processes, communities are also increasingly being engaged in monitoring through citizen science, community-based monitoring, and their own research initiatives. We outline a new data model based on a discrete global grid system for integration of these two forms of spatial data. A relational hybrid data model is presented and a sample application for integrating data is presented. Preliminary results indicate significant performance gains over traditional spatial data architectures. Given the pace of environmental change, scientific research and monitoring, and existing and anticipated impacts on communities, our results hold potential for developing new data-driven applications that integrate sources of information across the science/community interface.

Title: Lake Ice mapping from RADARSAT and MODIS with Deep Learning

Authors:
Nastaran Saberi, University of Waterloo
Andrea Scott, University of Waterloo
Claude Duguay, University of Waterloo

***Correspondence:** nsaberi@uwaterloo.ca

Keywords:
Lake Ice, deep Learning, RADARSAT, MODIS

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
There has been a huge interest in Deep Learning (DL) applications in the recent decade. Hardware capacities' improvement to GPU computing, allowed for significant acceleration in deep models' training. The abundance of datasets led to the use of artificial intelligence in many applications to decrease operational workload and increase accuracy. The abundance of airborne and spaceborne observations and recent advancements in deep learning (DL) is leading to novel environmental monitoring applications to decrease operational workload and increase accuracy. Among different DL applications in remote sensing, image classification is a popular challenge. Numerous studies have focused on image classification using optical imagery to classify land use/land cover and urban features using unsupervised and semi-supervised algorithms. High spatial resolution (~ 1km), frequent observations and ease of human interpretation to label the classes are the main reasons for this popularity. However, cloud coverage is a major bottleneck for using optical imagery.
Synthetic aperture radar (SAR) observations, which are not affected by cloud cover and have relatively high spatial resolution (approximately 50m) is suited for spatial scales required for mapping and modeling many environmental applications. Among published research, one of the useful applications is mapping lake ice phenology and lake ice cover using SAR. Using SAR data for near real-time operational applications is rapidly becoming more achievable as existing SAR platforms, such as Sentinel-1, provide observations in higher temporal resolutions (6-12 days). SAR data has been used in tandem with DL for retrieval of ice concentration for sea ice, and ice/water classification. However, ice/water classification using DL is not yet accurate enough to be used to provide confident classifications for each pixel, in particular on large lakes that may be partially ice-covered. In this research we investigate the performance of data fusion to gain a more accurate retrieval of ice/water using RADARSAT2 and MODIS (Moderate Resolution Imaging Spectroradiometer) lake ice products. A convolutional neural network (CNN) is used to map lake ice/water using RADARSART2 images acquired during ice season of 2014 in the Lake Erie, one of the Laurentian Great Lakes. Lake ice maps using MOD09 (a recently released product of Climate Change initiative (CCI)) are employed in this research as additional data sources to increase the accuracy

Title: Sensitivity of Hydrological Model Performance on the Selection of Calibration and Validation Periods

Authors:
Hongren Shen, University of Waterloo
Bryan A Tolson, University of Waterloo
Juliane Mai, University of Waterloo
Ming Han, University of Waterloo

***Correspondence:** hongren.shen@uwaterloo.ca

Keywords:
Hydrological modeling, Model calibration, Sensitivity analysis

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Hydrological models have been extensively used in both operations and research for many purposes, such as water resources management and planning, floods and droughts monitoring and climate change assessment. In building a hydrological model, it is necessary to select representative observational data sets for model calibration and validation. However, the problem of how to objectively split up calibration and validation periods is largely ignored in research literature and thus, such choice remains a subjective decision for modelers. This study discusses the sensitivity of model performance on the selection of calibration and validation periods. First, representative catchments are selected from the GRIP-GL project with respect to long enough observations and least-disturbed by human activities. To minimize the effect of different model structures, only one conceptual model, i.e. the GR4J model, is employed in the modeling. Afterwards, data records are split into multiple subsets with different lengths. Finally, the GR4J model is calibrated and validated on these subsets. The results could show how model performance is impacted by using different calibration and validation periods, thereby highlighting the importance of considering data splitting when developing hydrological models. This study also gives insight into determining calibration and validation periods in different catchments.

Title: Estrogen composition of final effluent is influenced by the treatment processes used in various secondary municipal wastewater treatment plants in Ontario

Authors:
Nivetha Srikanthan, University of Waterloo
Leslie M. Bragg, University of Waterloo
Hadi Dhiyebi, University of Waterloo
Shirley Anne Smyth, Environment and Climate Change Canada
Mark R. Servos, University of Waterloo

***Correspondence:** nivetha.srikanthan@gmail.com

Keywords:
Wastewater treatment plant, Hormones, EDCs, Analytical chemistry

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Emerging contaminants, including pharmaceuticals and personal care products (PPCPs) and endocrine disrupting compounds (EDCs) continue to raise concern for water management. Household consumption and use of the compounds results in them entering waterways primarily through wastewater treatment plants (WWTPs), which are not designed to treat them. As these compounds range from easily degradable to highly persistent to treatment, a complex mixture of compounds is present in the final effluent and represent a potential risk to aquatic life downstream of discharge sites. Compounds such as natural and synthetic estrogens, have been linked to intersex in fish downstream of many wastewater outfalls. The Wastewater Systems Effluent Regulations (WSER) in Canada require all plants to be operating at secondary treatment or equivalent by 2040, depending on risk factor. This has resulted in various infrastructure upgrades across the country to improve final effluent quality. However, these regulations are targeted towards conventional parameters which do not include PPCPs and EDCs. This study compares the concentrations and composition of estrogens in influent and effluents from nine WWTPs in southern Ontario with varying levels of secondary treatment. Samples were collected using cooled 24-h composite samplers, extracted using solid phase extraction, and tested for specific contaminants (LC-MS/MS) as well as for total estrogenicity (yeast estrogen screen). Concentrations of hormones in the raw influent were consistent across the treatment plants and predominantly composed of the natural estrogen, estrone. Following secondary treatment, there is a change in the composition and concentration of specific estrogens as well as total estrogenicity, although there is considerable variability among plants. As WWTP process are site specific, studying a variety of plants can provide insights into processes influencing their removal and biotransformation and if additional remedial actions are needed.

Title: Upscaling the fill-and-spill hydrological process in wetland dominated landscapes

Authors:
Mahkameh Taheri, University of Waterloo
Mark Ranjram, University of Waterloo
James Craig, University of Waterloo

***Correspondence:** mahkameh.taheri@uwaterloo.ca

Keywords:
Fill-and-spill, Wetland, Hydrologic connectivity, Runoff/snowmelt

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Local storage capacities of wetlands can highly influence runoff generation in flat terrains such as parts of the Taiga Plains or the North American Prairies. To consider the connectivity-threshold process in those catchments, fill-and-spill conceptual models have been used. In such models, precipitation/snowmelt may fill the available storage in each wetland. Once it has reached a certain threshold, it will drain and may subsequently become connected to a cascading network. Application of the explicit fill-and-spill models, specifically in low-gradient landscapes, are limited due in part to the dependency on high resolution elevation data. This study aims to propose a probabilistic fill-and-spill process in large landscapes with thousands of wetlands. For this purpose, watershed properties, such as initial wetland storage deficit, are defined by probability distribution functions. The response of a single wetland cascade sequence is upscaled to the response of thousands of sequences using the derived distribution approach. The proposed methodology has been successfully compared with the results of Monte-Carlo simulations, and demonstrate the accuracy of the approach. Application of this method within current hydrological models will enhance their ability to simulate the emergent response of heterogeneous wetland-dominated basins to a rainfall or snowmelt events.

Title: Significance of Groundwater Dynamics within Hydrologic Models

Authors:
Xin Tong, University of Waterloo
Walter A. Illman, University of Waterloo
Young-Jin Park, University of Waterloo
David L. Rudolph, University of Waterloo
Steven J. Berg, University of Waterloo; Aquanty Inc.

***Correspondence:** x23tong@gmail.com

Keywords:
Groundwater, Hydrologic Model

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Groundwater is the largest component of Earth's available freshwater providing drinking water and food security, sustaining surface water bodies, and maintaining biodiversity. Therefore, diagnosing and predicting hydrologic changes in Cold Regions play a vital role in water resource assessment, groundwater management, and contaminant transport investigations. Hydrologic models are widely used to make predictions of surface water flows, yet how groundwater phenomena is incorporated varies significantly from one model to another.
The main objective of this project is to examine the significance of shallow/deep groundwater flow on surface water flow predictions through high-resolution numerical simulations with HydroGeoSphere (HGS), a 3D physics-based, fully-integrated hydrologic model. The spatial and temporal variations in surface water and groundwater fluxes including its distributions are investigated using data from the well-instrumented Alder Creek Watershed (ACW) (~79 km2) within the Grand River Basin in southern Ontario. In particular, four integrated hydrologic models with an increasing level of complexity to represent the subsurface using HGS have been developed to highlight the significance of groundwater fluxes on surface water flow through: 1) a model incorporating only overland flow data without considering the subsurface; 2) a model with a thin soil layer (1-meter deep); 3) a model with homogeneous subsurface and uniform hydraulic parameters; and 4) a model with detailed hydrostratigraphy with heterogeneous and anisotropic hydraulic parameters. These models all share the same high-resolution topography information, landcover representation, temporal precipitation records, and evapotranspiration data.
Overall, transient simulation results with various conceptualizations of how the subsurface is treated suggest that groundwater flow and subsurface characterization both have large impacts on surface water fluxes. However, this finding is based on our work at the ACW and needs to be investigated further for larger watersheds in different geological terrains under different forcings. Ongoing work will involve the calibration of the models with diverse sets of data and their validation. The final calibrated model developed should serve as a reference to further investigate the impact of anthropogenic activities on both surface water and groundwater flow processes, solute/contaminant transport, as well as winter processes.

Title: The use of high-order time-stepping methods to improve the computational efficiency of hydrological models

Authors:
Sean Trim, University of Saskatchewan
Kevin Green, University of Saskatchewan
Martyn Clark, University of Saskatchewan
Raymond Spiteri, University of Saskatchewan

***Correspondence:** sean.trim@usask.ca

Keywords:
numerical modelling, forcasting, snowpack, time-stepping

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Large-domain computer simulations of hydrological systems are critical for many applications (e.g., flood forecasting and water security assessments). Due to the computational cost of such models, methods that improve computational efficiency are highly desirable. High-order time-stepping methods have the potential to provide high-accuracy solutions with reduced computational costs. In hydrological models, the time evolution of state variables is governed by a system of coupled differential equations. However, the numerical solution process can be simplified by solving the individual equations of state variables in succession rather than simultaneously, a technique known as state operator splitting. We evaluate the relative effectiveness of first- and second-order time-stepping methods in the hydrology software the Structure for Unifying Multiple Modeling Alternatives (SUMMA). To accomplish this, we utilize a test problem involving the movement of water through snow with a known exact solution. We examine the convergence rate to the exact solution for both the first- and second-order methods. A comparison of the accuracy of both methods for a sequence of time step sizes is then presented. Finally, we compare the efficiency of both methods by analyzing run times for a fixed level of accuracy. Comparisons are made both with and without the use of operator splitting. In addition, the use of third-order methods is explored.

Title: Estimating SWE using Unmanned Aerial Systems across an Arctic shrub-tundra watershed

Authors:
Branden Walker, Wilfrid Laurier University
Philip Marsh, Wilfrid Laurier University

***Correspondence:** bwalker@wlu.ca

Keywords:
Snow, Unmanned Aerial System, SWE, Structure-from-motion, hydrology

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions

Abstract:
Spatial variations in snow depth and snowpack density translate to heterogenous snow water equivalent (SWE) in shrub tundra environments, resulting from winter blowing snow processes. Recent advances in Unmanned Aerial Systems (UAS) technology and Structure-from-motion photogrammetry (SfM) have allowed researchers to capture high-resolution spatial and temporal changes in snow depth across snow covered landscapes, marking the advent of a new era of high-resolution remote sensing. However, due to complexities relating to accurately representing or modelling spatial (and temporal) changes to snowpack density there has been little advance towards mapping SWE at comparable scales. In this study we address these shortcomings by combining metre-resolution snow depth maps created using UAS SfM with spatially distributed snowpack bulk density observations to accurately map SWE for a small (1 km2) watershed. Late winter snow depth, density and SWE products were produced across dominant vegetation and topographic land cover types. Spatially distributed snowpack density observations were collected using representative snow surveying within the dominant landcover types. An empirical linear relationship between snow depth and density was produced for each landcover type and incorporated into a model to estimate SWE. Final SWE products were validated using in situ snow depth and SWE observations obtained within the study area demonstrating highly accurate snow depth and SWE results. Furthermore, we were able to provide an in-depth analysis of late winter SWE across the dominant landcover types, revealing significant differences in water storage across the watershed. Analysis is to be continued over the spring melt period (April-May) to assess land cover controls on snowmelt runoff production and the relative importance for controlling the timing and magnitude of the spring freshet.

Title: Landscape Controls on Thermokarst Lake Water Balances between Inuvik and Tuktoyaktuk, NWT

Authors:
Evan J. Wilcox, Wilfrid Laurier University
Branden Walker, Wilfrid Laurier University
Brent B. Wolfe, Wilfrid Laurier University
Gabriel Hould - Gosselin, University of Montreal
Oliver Sonnentag, University of Montreal
Philip Marsh, Wilfrid Laurier University

***Correspondence:** wilc0150@mylaurier.ca

Keywords:
water balance, thermokarst, lake, permafrost, snowmelt

Primary meeting theme: Innovations in water science and technology

Abstract:
The Arctic is warming at twice the rate of the rest of the world, causing precipitation to shift from snowfall to rainfall, permafrost to thaw, longer ice-free lakes, and increased evaporation. How the water balance of lakes formed by thawing permafrost (thermokarst lakes) will respond to the forces noted above is unknown. In some regions, lakes are expanding by thawing adjacent permafrost, while in other regions they are drying up and shrinking, or not changing at all. Previous research has focused on quantifying the water inputs and outputs of individual lakes, but a better understanding of the drivers and processes controlling lake water balances is required to understand how they will respond to a changing climate. Quantifying lake water balance across the Inuvik-Tuktoyaktuk region, where there is a climate and vegetation gradient, allows such an assessment of how drivers and processes affect lake water balance.
The ~5000 km2 area between Inuvik and Tuktoyaktuk, Northwest Territories (69°N, 134°W) contains ~7500 thermokarst lakes, covering ~25% of the area. A main control on the volume of water flowing into a lake is the ratio of lake area to the area of land that drains into the lake – known as the lake area catchment area ratio (LACA). Novel methods seldom used in the Arctic were used to measure lake water level, outflow, catchment snow storage, and evaporation at two adjacent thermokarst lakes with different LACA (6.7 vs 84.1) from 2017 – 2019. To compare lake water balance over a larger region, water isotope samples were collected during March – September 2018 from over 120 lakes across a 2000 km2 area between Inuvik and Tuktoyaktuk.
Paired lake water balance measurements showed that the lake with a larger LACA had a residence time an order of magnitude shorter than the larger lake, and displayed larger fluctuations in water level. The ratio of evaporation to inflow was significantly larger in lakes with smaller LACA, as calculated from 111 isotope samples from 23 lakes. Water isotope compositions also showed that only 10-50% of a lake's water is replaced by snowmelt in spring, while the rest of the snowmelt likely flows over the lake ice. Deeper lakes had significantly less snowmelt mixing, as the volume of water for the snowmelt to mix with was greater than in shallower lakes. These results show that lake water balance can be characterized using lake and catchment properties, allowing future research to more easily characterize lake hydrology.

Title: Developments in a pan-Canadian operational ice-jam flood forecasting system

Authors:
Brandon Williams, University of Saskatchewan
Prabin Rokaya, University of Saskatchewan
Stephen O'Hearn, University of Saskatchewan
Karl-Erich Lindenschmidt, University of Saskatchewan

***Correspondence:** bsw234@mail.usask.ca

Keywords:
forecasting, pan-Canadian, automation

Primary meeting theme: Innovations in water science and technology
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management

Abstract:
This study focuses on the development of an operational ice-jam flood forecasting system on rivers across Canada; pioneering an approach to predictive modeling and forecasting in a pan-Canadian context. Ice jam events and their resultant floods are dependent on site-specific hydrologic, hydraulic and ice conditions and thus, are difficult to forecast due to their complex nature. Without a direct relationship between ice-jam formation and backwater levels, a novel stochastic modelling framework was developed to be easily adapted to different river sites. First, frequency distributions for boundary conditions are established and calibrated for the study site. Framework calibration includes modifying frequency distribution parameters of boundary conditions to recreate backwater level profiles during historic events through the RIVICE model. During forecasting, daily-simulated forecasted flows obtained through MESH models or by a government agency, are used to further constrain frequency distributions of the model boundary conditions. Monte Carlo simulations iterated thousands of times using the RIVICE model extract random inputs with each new run from the frequency distributions to replicate the stochastic nature of ice jamming. The outputs of the simulations give thousands of backwater levels where probabilities of ice jam flooding are established. This process is repeated each day during operational forecasting to establish when and where ice-jam flooding is most likely to occur.
This forecasting approach was adopted to the Churchill River, the Athabasca River, and the Red River. Work is currently being done to adapt this approach to the St. John River of New Brunswick as well. Though this methodology has proved successful, much of the operational forecasting process is tedious and often times takes time away from actual modeling efforts. To promote the framework into a more pan-Canadian context, it would benefit to automate these forecasting operations. An anticipated project necessitates the creation of a fully automated process to calibrate river-ice model frameworks for rivers across Canada and to use these frameworks to provide ongoing ice-jam flood forecasting. The project will most likely first be applied to the St. John River site, and it is hoped that this automation will tackle the crosscutting challenges of predictive modeling, forecasting, and data science and management.

Title: Positive feedback of biogeochemical models on hydrological models: Implicit hydrological optimization attained by optimizing a biogeochemical model

Authors:
Befekadu Taddesse WOLDEGIORGIS, University of Saskatchewan
Helen Baulch, University of Saskatchewan

***Correspondence:** befekadu.woldegiorgis@usask.ca

Keywords:
biogeochemical modelling, hydro-biogeochemical feedback, optimization, equifinality

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
A biogeochemical model should be based on the best hydrological model that represents key processes correctly. However, literature shows that this may not be the case; several uncertainty sources lead to parameter compensation and equifinality, preventing identification of the 'true' hydrological model. Therefore, there is uncertainty associated with hydrological models used to setup biogeochemical models. Additional constraining information reduces the degrees of freedom and uncertainty of hydrological model. Studies show that a biogeochemical model can be improved through simultaneous identification of the hydrological and the biogeochemical model as compared to sequential optimization approach of the hydrological and the biogeochemical models. The simultaneous approach may infer hydrological parameters that differ from those obtained by optimizing the hydrological model alone. In this study, we used a HYPE simulator to setup a biogeochemical model of the Beaver watershed, Lake Simcoe, and systematically evaluated the feedback of the biogeochemical model on the hydrological model. We optimized the biogeochemical model by combining the sensitive hydrological and the biogeochemical parameters without using the hydrological likelihood in the likelihood maximization function. We then evaluated the overall efficiency trend and the uncertainty of the hydrological model. The results showed that the hydrological parameters inferred during the biogeochemical model identification led to a progressive improvement of the hydrological model efficiency that is comparable to the maximum hydrological efficiency achieved by optimizing the hydrological model. Results suggest that a biogeochemical model identification influences the corresponding hydrological model positively, and hence, can constrain a hydrological model to reduce hydrological equifinality. The results also show that it is possible to optimize only the biogeochemical model and achieve a practical hydrological model.

Title: Zooplankton metabarcoding for assessment of aquatic ecosystem health

Authors:
YUWEI XIE, University of Saskatchewan
Tyler Black, University of Manitoba
Phillip Ankley, University of Saskatchewan
Vince Palace, International Institute for Sustainable Development-Experimental Lakes Area
Jose Luis Rodriguez Gil, University of Ottawa
John P. Giesy, University of Saskatchewan

***Correspondence:** yuwei.xie@usask.ca

Keywords:
Ecotoxicology, Aquatic toxicology, Ecogenomics, Next-generation sequencing, mitochondrial COI

Primary meeting theme: Innovations in water science and technology
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management; Stakeholder engagement and knowledge mobilization

Abstract:
Freshwater ecosystems face a variety of stressors in a rapidly changing world. Due to their central position in freshwater food-webs and being influenced by bottom-up and top-down effects, the biodiversity of zooplankton has been used as a bioindicator for lakes. Metabarcoding is a rapid and effective method for identification of zooplankton, particularly for cryptic, rare, and hard-to-identify species. However, methods of metabarcoding of zooplankton still need validation against more traditional methods of identification that are based on visual morphologies of species. Here, eDNA metabarcoding was applied to determine zooplankton responses within a series of controlled boreal lake studies. Specifically, we characterized the alteration of zooplankton biodiversity in mesocosms (limnocorrals) exposed to diluted bitumen, oil-cleaning efforts, and selenium in controlled lake mesocosm experiments at the IISD-Experimental Lakes Area, in Northwestern Ontario. Metabarcoding-based compositional, alpha,- and beta- biodiversity indicators were utilized to determine changes in zooplankton communities for assessment of aquatic ecosystem health. Alterations of metabarcoding-based biodiversity reflected responses of traditional zooplankton measures to the tested chemical stressors. Results of this study will enhance the performance of zooplankton metabarcoding, boost its application for biomonito

Title: Development of low-cost sensors with anti-fouling coatings for water monitoring

Authors:
Nan Zhang, McMaster University
Aly Khalifa, McMaster University
Charles de Lannoy, McMaster University

***Correspondence:** zhangn33@mcmaster.ca

Keywords:
water monitoring, low-cost sensors, surface fouling, anti-fouling coatings

Primary meeting theme: Innovations in water science and technology
Secondary theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Environmental sensors have been extensively deployed to monitor freshwater resources in the field. However, surface fouling reduces the sensor sensitivity, reliability and accuracy. For long-term operation, it is imperative to understand what kind of fouling occurs on sensor surfaces in surface waters, how quickly fouling occurs on different sensor surfaces, and how fouling impacts sensor signals. In collaboration with our First Nations partners, we were able to install a series of sensors in the McKenzie creek, located within the Six Nations of the Grand River reserve. The effects of fouling on dissolved oxygen (DO) and electrical conductivity (EC) probes were field-tested for two weeks and then retrieved to analyze their surface fouling. Additionally, a pH probe was tested in laboratory using simulated conditions. The exposed surfaces of the DO, EC, and pH probes are made of PTFE, graphite, and glass respectively. Testing was done before and after 10% HCl treatment with the goal of removing any surface fouling. The sensitivity of the EC and DO probes showed a 10% and 44% increase in sensitivity after treatment, respectively, suggesting that significant fouling had occurred. Biofouling, specifically, inhibits sensor sensitivity and longevity severely due to strong interactions between bacterial biofouling and the sensor surface. To quantify the contribution of biofouling, the EC and pH probe were tested before and after being submerged for 24 hours in a bacterial culture harvested from tap water. The EC probe showed a 10.6% reduction in sensitivity after the exposure, while the pH probe showed no change, suggesting biofouling was only partially responsible for reduced sensor performance.
Further investigation of antifouling strategies that preserve sensor functionality and accuracy is necessary for effective long-term field deployment. Negatively charged foulants (i.e. organic fouling and bacteria) commonly found in water are susceptible to electrostatic repulsion by negatively charged surfaces. Polymeric surfaces with carbon nanotube (CNT) and gold nanoparticle coatings exhibiting high conductivity have been fabricated to repel surface water foulants in situ when a potential is applied. Further, the development of fouling on these surfaces can be monitored using electrical impedance spectroscopy (EIS) during operation. These conductive coatings will be applied to sensor surfaces by plasma etching or by layer-by-layer assembly.

Title: Snow Albedo Retrieval based on UAV-borne Hyperspectral data

Authors:
Dong Zhao, University of Saskatchewan
Phillip Harder, University of Saskatchewan
John Pomeroy, University of Saskatchewan

***Correspondence:** dong.zhao@usask.ca

Keywords:
Snow Albedo, Hyperspectral Remote Sensing, UAV, BRDF

Primary meeting theme: Innovations in water science and technology
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools

Abstract:
Snow albedo is a fundamental component of the snow surface energy budget and plays a critical role in governing snowmelt processes. So far, observations of snow albedo have largely been restricted to discrete point scales with limited numbers of samples, or much larger scales where sensor fields of view often contain non-snow surfaces, and the small to medium scale spatial variability is unknown. In contrast, Unmanned Aerial Vehicle (UAV) -borne hyperspectral imaging (HSI) remote sensing provides the capability to resolve snow albedo at the high spatial scales needed to observe local scale processes driving the energy balance and snow hydrology of cold regions. This study demonstrates a method to retrieve broadband snow albedo from UAV-HSI data at high resolutions (10 cm). First, a georeferencing, radiometric correction and reflectance retrieval workflow is implemented to translate the raw HSI data into surface reflectance. Second, Bidirectional Reflectance Distribution Function (BRDF) models are established to translate the reflectance data into broadband albedo. This requires: 1) developing auxiliary datasets of pixel-wise viewing and solar geometry, 2) extracting multi-angular observations at common points from overlapping flight areas, 3) fitting existing BRDF models to the multi-angular observations, and 4) applying BRDF corrections to the reflectance data to compute spectral and broadband albedos (400-900nm). This research demonstrates that pixel-wise viewing and solar geometry are necessary to compute BRDF corrections, which are vital for albedo retrievals using hyperspectral data with high spatial resolution. Additionally, a high spatial resolution digital surface model from UAV-borne lidar data improves the retrieval precision over complex topography areas that exhibit high hemispherical directional reflectance. The results show that mapping snow albedo at high spatial resolution can be achieved with UAV-borne hyperspectral data. This new capability provides data that can greatly improve the understanding of the spatial variability of the snow surface energy balance over space and time.

Title: An Unprecedented Hyperspectral Airborne Coverage of Western Lake Erie: First Testing of the Watersat Imaging Spectrometer Experiment (WISE) Imager

Authors:
Kiana Zolfaghari, University of Waterloo
Raymond Soffer, National Research Council of Canada
George Leblanc, National Research Council of Canada
Claude Duguay, University of Waterloo

***Correspondence:** kzolfagh@uwaterloo.ca

Keywords:
Hyperspectral, WISE Imager, Machine Learning, Lake Erie, Algal Bloom

Primary meeting theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management

Abstract:
Anthropogenic eutrophication in Lake Erie, especially in the western basin, has adverse impacts on the ecosystem and economy in that region. As a result, it is crucial to identify and quantify the extent of the algal problem of Lake Erie. Undertaking such an effort on the lake, using a surface water quality sampling approach with sufficient density, would prove to be expensive and exacting. To tackle this challenge, remote sensing and machine learning techniques have advanced rapidly to detect the concentration of optically active water constituents. In traditional remote sensing methods, estimation of these water quality parameters is performed by establishing linear regression with spectral indices or individual spectral bands. However, such empirical regression predictors are not transferrable to water bodies with different optical properties. In addition, these algorithms do not take advantage of the spectral information available in hyperspectral sensors to differentiate between algal types (e.g. cyanobacteria versus others). Application of Deep Learning algorithms making use of hyperspectral data is envisioned in this research. For this purpose, the first ever operational flight of Compact Airborne Spectrographic Imager (CASI) and Watersat Imaging Spectrometer Experiment (WISE) hyperspectral sensors was conducted in August 2019 over the western basin of Lake Erie by National Research Council of Canada. This survey was supported by Global Water Futures program, concurrent with the largest ever one day sampling of Harmful Algal Bloom (#HABGrab19; an international collaboration between 15 Canadian and American organizations). Coordinated flights were organized on the same day, in collaboration with NOAA's Great Lakes Environmental Research Laboratory (GLERL) who flew the Resonon Pika II Hyperspectral imager. The present study describes this survey and introduces the collected CASI and WISE hyperspectral imagery.

Title: An approach to the Two-Row Wampum methodology for the development of an integrated water monitoring framework.

Authors:
Jasmine Baxter, Matawa First Nations Management
Erin Desjardins, Matawa First Nations Management
Sasha Michano, Matawa First Nations Management
Alanna Robbins, Wilfrid Laurier University

***Correspondence:** jbaxter@fourrivers.group

Keywords:
Collaboration, Integrated framework, Water stewardship

Primary meeting theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
Matawa Water Futures (MWF) brings together Indigenous and non-Indigenous forms of knowledge to promote the development of an Indigenous-informed water monitoring framework that will help Matawa member First Nations (MFN) prepare for climate change and future industrial development. This innovative study proposes an integrated framework to advance water science monitoring and increase Indigenous access to critical information needed for informed decision making and water stewardship. This is guided by a Two Row Wampum methodology that aims to bridge Indigenous water values and the research priorities of MFN with Western science approaches of academic co-investigators at Laurier, Lakehead, and Laurentian universities. MWF has been successful in helping to build capacity in MFN by developing three internships for community members and assisting them with entering postsecondary studies. Two interns are undergraduate students in water resource science and geography, while the other is a graduate student in biology, all at Lakehead. This project also involves a non-Indigenous graduate student in environmental studies from Laurier, employed as a research assistant (RA) for MWF. To support this integrated framework with MWF, these students have come together in creating a group to support each other and share experiences within their programs, as well as to discuss their roles and work within the broader project in their internships and RA work. These group meetings were primarily done via telephone and varied according to course schedules. By the end of the academic term, the group will have completed a report documenting the role these meetings have for the students, as well as how they contribute to the MWF project overall. This student-led report will not only support the students involved but will contribute to the larger goals of the MWF project in furthering successful connections and more effective knowledge mobilization based on this. This will overall support the efforts within MWF and by MFN to further support and develop Indigenous-led water stewardship in current and future contexts of change.

Title: Restoring sediment to the Saskatchewan River Delta

Authors:
Gary Carriere, Cumberland House Fishermen's Co-op
Tim Jardine, University of Saskatchewan

***Correspondence:** tim.jardine@usask.ca

Keywords:
knowledge co-creation, sediment trapping, flow regime, toxicity, community planning

Primary meeting theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
As part of a large research partnership between the community of Cumberland House and the University of Saskatchewan that examines long-term changes to water, wildlife and people in the Saskatchewan River Delta, we are determining if sediment trapped in upstream reservoirs can be restored to this critical ecosystem. To do so, we are conducting interviews to understand people's perspectives on the value of sediment. We have learned that water and sediment are intimately connected and should not be studied separately, which will inform modeling efforts going forward. We are testing deposited sediments for harmful chemicals, finding that the type of sediment (clay versus sand) matters more than its source (Lake Diefenbaker versus Codette Lake and Tobin Lake). We are determining where sediment is deposited and where it is generated, finding that sediment supply below EB Campbell Dam is almost non-existent (Total suspended solids < 10 mg/L) whereas sediment is being eroded from a ~20 km stretch in the main channel of the delta (Total suspended solids = 10-75 mg/L). From this eroded sediment, Cumberland Lake experiences deposition through the continued expansion of the Mossy River Delta, but also has days of net erosion caused by wind action on shallow waters. A water and sediment flow model and accompanying visualization tool will be used to explore future possibilities of restoration, and allow the community to determine a path forward for revitalizing the largest inland delta in North America.

Title: Comparison of phosphorus and fecal coliform levels in tributaries of the Six Nations in relation to other stations in the Grand River watershed

Authors:
Patricia Chow-Fraser, McMaster University
Alana Tedeschi, McMaster University
Sawsan Makhdoom, McMaster University
Clynt Kint, Six Nations Band Council

***Correspondence:** chowfras@mcmaster.ca

Keywords:
water quality, Six Nations, McKenzie Creek, Boston Creek, Grand River

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
The Chiefs of Ontario have expressed the need to declare, retain and assert the Indigenous People's relationship with waters to ensure that there is clean water for future generations. Activities associated with agricultural, industrial and urban development can have profound negative impacts on the health of lakes, rivers and wetlands, with subsequent ill consequences for Indigenous communities whose livelihood and diet depend on fish and wildlife that live in these waters. The Six Nations Reserve occupies roughly19,000 ha, and is a large urban reserve, located less than an hour from major metropolitan centres of southern Ontario. Although historically, the community used groundwater as their drinking source, water testing in recent decades have consistently found tap water contaminated with fecal coliform for about a third of the households surveyed. As a first step to help the Six Nations community uncover the sources of these contaminations, we carried out a monthly sampling program in 2019 from April to November to monitor the concentrations of total phosphorus (TP) and the soluble reactive form of phosphorus (SRP) and E. coli at 15 stations of the McKenzie and Boston Creeks that flow through the reserve. For comparative purposes, we also carried out a monthly program at 13 stations along the length of the Grand River. TP and SRP were measured monthly in the Grand River, but E. coli was only measured in September and November. The lowest concentrations for all variables were associated with sites near the headwater of the Grand River, while the highest concentrations occurred at stations within the Reserve. During fall, we measured extremely high concentrations of E. coli that exceeded 400 colony forming units (cfu) at two stations on the McKenzie and Boston Creeks downstream of the sewage lagoon; during the same time period, none of the sites along the Grand River had E. coli levels that exceeded 100 cfu. The geometric mean for E. coli at two stations of Boston Creek and one at McKenzie Creek exceeded the Canadian guideline for recreational contact within the Six Nations Reserve. Whereas seasonal maxima in the Grand River occurred in spring, those for McKenzie and Boston Creeks occurred in the summer, and were almost 2-fold higher. We will relate spatio-temporal variations in phosphorus and fecal coliform to meteorological conditions, land-use alterations in subwatersheds, and point source pollution from the two sewage lagoons.

Title: The Grand Council of Treaty #3's Nibi (Water) Declaration

Authors:
Aimée Craft, University of Ottawa
Lucas King, Grand Council of Treaty #3
Isobel White, Grand Council of Treaty #3
Priscilla Simard, Grand Council of Treaty #3
Maggie Petiquan, Grand Council of Treaty #3
Rhonda Fisher, Grand Council of Treaty #3
Anita Collins, Grand Council of Treaty #3

***Correspondence:** Aimee.Craft@uottawa.ca

Keywords:
nibi (water), declaration, knowledge mobilization, knowledge co-creation with Indigenous communities,

Primary meeting theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
The Social Sciences and Humanities Research Council (SSHRC) Decolonizing Water Partnership grant (Decolonizing Water) and the Grand Council of Treaty #3 (GCT3) propose to deliver an oral presentation on the development of GCT3's Nibi (Water) Declaration at the Global Water Futures' (GWF's) Third Annual Open Science Meeting in May 2020.
The Nibi Declaration relates to GWF's conference theme "knowledge co-creation with Indigenous communities" because the Declaration is a product of the collaborative efforts of the GCT3 Women's Council, Territorial Planning Unit and Decolonizing Water.
The Nibi Declaration is premised upon the fundamental Anishinaabe legal principle that water is life and is sacred. Therefore, all persons have normative obligations to water to ensure its health for present and future generations. The Nibi Declaration identifies this and other Anishinaabe nibi inaakonigewin (water law) principles that will guide citizens of Treaty #3 in watershed management planning and serve as a guide to decision-making in the territory. In this way, GCT3's Nibi Declaration addresses GWF's "social, economic and health determinants and impacts" cross-cutting challenge and opportunity.
Furthermore, GCT3's Nibi Declaration addresses GWF's "stakeholder engagement and knowledge mobilization" cross-cutting challenge and opportunity. The is because the Declaration and its accompanying toolkit are two means through which GCT3 and its research partners have decided to mobilize the knowledge created as a result of the Declaration. These means of knowledge mobilization permit the general public access to the critical Anishinaabe nibi inaakonigewin principles contained within the Declaration. Furthermore, other Indigenous nations seeking to advance their water governance initiatives can draw upon the Nibi Declaration and toolkit as resources in their efforts. The knowledge generated and mobilized as a result of GCT3's Nibi Declaration could also contribute to Indigenous informed solutions to the global water crisis and thereby positively impact every living being on earth that relies on water for survival.
Please follow this link to watch a video about the GCT3 Nibi Declaration: https://vimeo.com/404712174 and here to see a copy of the Declaration: http://gct3.ca/wp-content/uploads/2019/05/Treaty-3-Nibi-Declaration-Final-May-2019.pdf

Title: Water Security, States and the 'Justice' Context -Focus on Indigenous Communities

Authors:
Daniel Cursio, United Nations University; McMaster University
Dr. Nidhi Nagabhatla, United Nations University; McMaster University
Dr. Ramazan Caner Sayan, United Nations University
Dr. Dawn Martin-Hill, McMaster University
Makasa Looking Horse, McMaster University
Dr. Nancy Doubleday, United Nations University; McMaster University

***Correspondence:** cursiod@mcmaster.ca

Keywords:
Environmental Justice, Water Security, Indigenous Communities, Policy, Sustainable Development

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
Issues of water scarcity and quality have become key challenges for sustainable development policy production and delivery for states and communities. In 2013, United Nations agencies, alongside member states, experts, and institutions, proposed the Water Security Conceptual Framework, highlighting a shift for the capacity of populations to safeguard sustainable access to their water needs. Thus, presented is a renewed paradigm for water-secure futures- FILM [Five Means for Looping Integration] aim to interlink water security and environmental justice observations, theories and concepts: 1) the literature- synthesis of themes from existing information, knowledge and policies on water and justice (concepts of justice, water rights, and resource management); 2) the indicator context- how environmental justice scholarship reflects the distribution of environmental burdens/benefits across communities (distributive justice); 3) the case studies- negligence of marginalized groups and indigenous populations (recognitional justice) in water-related processes; 4) the SWOT (strengths, weakness, opportunities, and threats) analysis- examining meaningful participation of marginalized groups and indigenous populations (procedural justice) for water security; 5) the empirical context- sharing 'learning by doing' experiences referenced by Global Water Futures' Co-creating of Indigenous Water Quality 'Tools' project with a focus on youth and water justice. The FILM approach can provide a framework to mainstream the notion of justice in water-related decision-making processes at local, national, and global levels. Operationalizing water justice, the aspects of 'recognition', examine communities and their characteristics (as defined by race, ethnicity, religion, gender, income, and culture) for just policy planning. Currently, environmental justice studies are exploring the dimensions of recognition, noting a lack thereof. This synthesis aims to bridge the concepts of 'justice' and 'water' security by proposing an integrated framework that can be applied for just and sustainable management of water. To address systemic inequalities embedded in resource allocation and usability in the water sector, a systematic reference framework can address the gaps and needs in practice/policy management and governing water systems, including those underlined in Sustainable Development Goal 6 (SDG 6), mainly target 6.b- supporting and strengthening the participation of local communities.

Title: Responding to changes in fish communities in two northern Ontario First Nations.

Authors:
Erin Desjardins, Matawa First Nations Management
Kimberly Jorgenson, Matawa First Nations Management
Sarah Cockerton, Matawa First Nations Management
Dr. Kelly Munkittrick, University of Calgary

***Correspondence:** edesjardins@fourrivers.group

Keywords:
fish, fish habitat, climate change, First Nation, environmental monitoring

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; Social, economic and health determinants and impacts

Abstract:
The Matawa member First Nations (MFN) have a vast homeland and traditional territory covering over 300,000 square kilometres and spanning over nine secondary watersheds within the central portion of northern Ontario. A project was developed with funding from Environment & Climate Change Canada (Indigenous Guardians Program) and the Department of Fisheries and Oceans (Indigenous Habitat Protection Program) to build capacity surrounding fish and fish habitat monitoring within the lands and waters of the MFN. To initiate the project, Four Rivers Environmental Services Group (Four Rivers) of Matawa First Nations Management focused on priority waters in two member First Nations, with benefits expanding to all MFN in future years. A partnership was established with a researcher from Wilfrid Laurier University through the innovative Matawa Water Futures initiative. With support from this partnership, Eabametoong First Nation (EFN) and Constance Lake First Nation (CLFN) sought to address challenges in two specific waterbodies and identified areas for fish and fish habitat monitoring/research priority. Preliminary field programs were carried out the summer and fall of 2019, building off initial winter monitoring work that took place in February of the same year. The purpose of the field programs was to obtain baseline data on water quality and fish populations in lakes of concern near EFN and CLFN in order to guide future research programs to investigate the cause of changes in the lakes of concern. Capacity building was a major component of each of the field programs, where community members were hired as field technicians to learn methods of western science research and field data collection methods, while sharing their knowledge of the lands and waters with the research team. From the baseline data collected, future monitoring efforts are being developed that will allow each community to continue monitoring their lakes of concern to further clarify the issues at hand and to be able to define and track the changes observed.

Title: Water Knowledge Camps: Building Capacity for Cross-Cultural Water Knowledge, Research, and Environmental Monitoring

Authors:
Candice Dimock, University of Waterloo
Kelly Skinner, University of Waterloo
Lex Scully, Sahtu Renewable Resources Board
Deborah Simmons, Sahtu Renewable Resources Board
Leon Andrew, Sahtu Renewable Resources Board
Jennifer Baltzer, Wilfrid Laurier University
Andrew Spring, Wilfrid Laurier University

***Correspondence:** aspring@wlu.ca

Keywords:
Knowledge co-creation, Water monitoring, Indigenous water knowledge

Primary meeting theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Dene and Métis communities across the Sahtú Region, NT., are concerned about the cumulative impacts of development and climate change on the quality and quantity of their waters and consequent risks to human and ecosystem health. Cross-cultural camps are an opportunity facilitate co-creation of knowledge and action plans to address these concerns. The first of three Cross-Cultural Water Knowledge Camps, held at Sahtú Dǝ (Great Bear River) at Tek'áícho Dǝ (Marten River) from August 19-26, 2019, was an opportunity for Dene and Métis people of the Sahtú and academic researchers to come together on the land to share knowledge about water, climate change, and environmental monitoring. The overarching goal of the camp was to create an environment where experiential on-the-land learning facilitated co-production of knowledge grounded in Sahtú Dene and Métis knowledge and experience. The camp involved shared on-the-land experiences with local and southern researchers, Elders, and community members. The design of the camp was patterned on the Cross-Cultural Research Camp model for co-production of knowledge established in the Sahtú, including: 1) interactive experiences in traditional knowledge arising from "way of life" practices on the land; 2) consideration of knowledge and its communication at different scales and from different sources; and 3) science-based research and monitoring questions and methods. In addition to a mix of experiential land- and scientific-based activities, and daily talking circles, focus groups were held on climate change and youth leadership, drinking water, and environmental monitoring. Themes included a need for improved linkages between Guardians/youth and regional community-based water monitoring initiatives. Youth continued developing their leadership and relationship building skills, and increased interest in environmental monitoring. The Camp Resolution defined action items related to youth leadership, climate change, drinking water, and environmental monitoring, supporting the project's goals to facilitate communication between communities and researchers, to respect Dene and Métis knowledge, and to enhance decision-making capacity.

Title: Human Right to Water: Fundamental, Overarching and Critical to Water Justice

Authors:
Nancy Doubleday, McMaster University
Shivani Seth, McMaster University
Nidhi Nagabhatla, United Nations University; McMaster University
Ramazan Caner Sayan, United Nations University
Dawn Martin-Hill, Six Natons and McMaster University
Beverley Jacobs, University of Windsor
Will Stephenson, McMaster University
Makasa Looking Horse, Ohneganos Youth Lead and McMaster University

***Correspondence:** doublen@mcmaster.ca

Keywords:
water justice, gaps, Co-Creation of Indigneous Water Quality Tools, socio-economic and political dimensions, empathy

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
The gap between what is and what ought to be in the world of water justice is broad: in it, we find the aspirations of the UNDRIP (United Nations Declaration on the. Rights of Indigenous Peoples); UN SDGs (Sustainable Development Goals); the UN Charter; and many efforts at implementation of the goals and objectives contained. We also find the “water insecurity” and “ecological grief” of many Indigenous youth (Looking Horse et al.). Our contemporary crises cannot be denied - whether we face immediate water shortages or poor water quality due to contamination, flooding, fire, and drought - or are people and populations migrating due to water and climate crisis. We all face risk. Climate warnings remind us of the urgent nature of the situation - we are all communities without safe water futures - it is just a matter of time and circumstance.
For this reason, we need to learn to address these water issues locally, regionally, and across conventional borders. Innovation in the long-term will depend upon our ability to highlight the socio-economic and political dimensions of crises and risks leading to water (in)justice in addition to climate warnings, water shortage, and water quality. Broader political and economic processes shape the politics of water allocation at local, regional and global levels, and these processes should be taken into consideration when explaining and addressing water (in)justice.
Here we share some multidisciplinary approaches, enabled through Global Water Futures research, illustrating perspectives of adaptation and risk responses that are informed by Indigenous experience in the Co-Creation of Water Quality Tools; and by embodied approaches to adaptive response drawn from ethical frameworks. Diverse drivers of adaptive response are considered, including direct and indirect influences, such as the importance of actors, agency, and empathy.

Title: Testing the Waters: Community-led research on water security and holistic health with Six Nations of the Grand River

Authors:
Sarah Duignan, McMaster University
Denise McQueen, McMaster University
Lori Davis-Hill, Six Nations Health Services
Sawsan Makhdoom, McMaster University
Rod Whitlow, Six Nations of the Grand River Community Member
Clynt King, Six Nations of the Grand River Community Member
Pat Chow-Fraser, McMaster University
Charles-Francoise de Lannoy, McMaster University
Dawn Martin-Hill, McMaster University
Tina Moffat, McMaster University

***Correspondence:** duignase@mcmaster.ca

Keywords:
Knowledge co-creation, Indigenous health impacts, Indigenous water management, Water security, Water quality

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Six Nations of the Grand River (SN) is the largest First Nation reserve in Canada, located within 100 km of several large cities in southern Ontario. Despite recently building a state-of-the-art water treatment plant in the community, only 9% of the 12,892 residents have water lines connected to the plant, leaving the majority of the community to rely on well water or water trucked into their homes. As such, many community members do not have secure and stable access to clean water. This is a long-standing concern for the community because of impacts on health and wellness. Given that Haudenosaunee hold ancient spiritual beliefs and practices tied to water, and the people's livelihoods and diets depend on fish and other aquatic wildlife, household water insecurity has profound impacts on holistic wellness for the SN Peoples. To address this problem, the Co-Creation of Indigenous Water Quality Tools project (PI Dawn Martin-Hill) embedded water and health assessments in local Indigenous knowledge of land, language, community & cultural identity, and empowerment, so that water security assessments may ultimately build autonomy and capacity for SN Peoples.
The project co-designed a targeted program to test for heavy metal and E. coli contamination in drinking water sources that was informed and guided by community members. Of 78 water sources tested, 24 (31%) contained mercury concentrations and 10 (13%) contained aluminum concentrations above the Canadian guidelines for drinking water. In a subset of 72 households, 21 (29%) tested positive for E. coli contamination. A health and water-use survey (co-created with SN Health Services) was conducted on a subset of 66 households to connect water contamination with household water-use, security and self-reported health outcomes. 40 of 66 respondents (60%) experienced household water insecurity during the past month. The major health burdens reported by respondents and linked to household water quality were skin rashes and anxiety/depression. Connecting household water quality test results with

the water use and health survey results offers important insight into the community burdens of water insecurity, highlighting how these daily experiences impact holistic health outcomes for Six Nations Peoples.

Title: Creating a Knowledge Centre in Wekweeti, NWT a small, isolated and traditional Tlicho community

Authors:
Michael English, Wilfrid Laurier University
Jennifer Hickman, Environment and Natural Resources Ministry, GNWT

***Correspondence:** menglish@wlu.ca

Keywords:
community vulnerability, knowledge centre, climate change

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Knowledge sharing in northern communities has become an important part of conducting northern research. Community and traditional knowledge coupled with the knowledge environmental scientists can provide is becoming an acceptable and reasonably well established practice. Banking this coupled knowledge within the community is a growing necessity as currently and in the foreseeable future decisions made by communities will require a well-informed community based up-to-date knowledge of issues directly associated with climate change.
The community of Wekweeti is vulnerable to the impacts of climate change. This community is the most isolated and traditional of all Tlicho communities. Access to the outside world and dependency of all provisions, including fuel, is by plane or for a few weeks of the year, the ice road. As a small community with a population of about 130 residents, the capacity of the community to understand the vulnerabilities, risks, and necessary adaptive actions to reduce impacts of climate change, is limited. In October of 2019 the community prioritized establishing a Knowledge Centre which would serve to: 1. increase understanding of climate change impacts on the community, 2. ensure meaningful engagement with the community and the use of Traditional Knowledge, 3. identify priority areas where more knowledge generation is required, and 4. improve the capacity of the community to be proactive in planning for climate change. All knowledge generated by projects under the Knowledge Centre will be community identified, will blend Traditional and scientific knowledge bases, and involve meaningful community engagement with all community residents.
The Wekweeti Knowledge Centre is in the initial stages of formation; community members identified a number of priority topics related to climate change for the Centre to focus on. These range from concerns about the future of the winter road, access to and safety on the land, food security, and declining mental health as a result of stress and anxiety related to the impacts of climate change. During these meetings, it was decided by community residents that the first project undertaken by the Centre would be a climate change vulnerability assessment of the community of Wekweeti, which includes an assessment of regional climate change projections, the vulnerability of the winter road to climate change, and also the socio-economic impacts to the community as a result of climate change.

Title: Poly- and Perfluoroalkyl Substances (PFAS) in Yukon and Northwest Territories Biomonitoring Studies

Authors:
Joshua Garcia-Barrios, University of Waterloo
Mallory Drysdale, University of Waterloo
Mylène Ratelle, University of Waterloo
Brian Laird, University of Waterloo

***Correspondence:** jgarciab@uwaterloo.ca

Keywords:
Perfluoroalkylated Substances, Human Biomonitoring, Arctic, Persistent Organic Pollutants, Indigenous Health

Primary meeting theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Perfluoroalkyl substances and polyfluoroalkyl substances (PFAS) are a family of anthropogenic chemicals that are used in food packaging, waterproof clothing, and firefighting foams for their water and oil resistant properties. Humans are exposed to these chemicals from ingestion of contaminated drinking water and food, inhalation of indoor and outdoor air, and skin contact with contaminated media. Some PFAS such as perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS), have been added to the Stockholm Convention on Persistent Organic Pollutants (POPs) due to toxicity in humans and animals, persistence in the environment, and accumulation in food chains. Though PFAS levels have been decreasing in human blood in Canada's south since 2007, environmental levels have been increasing in Arctic biota due to long-range transport of direct and indirect sources. However, temporal trends in Arctic residents have yet to be established and no studies have included residents of the Yukon (YT) or Northwest Territories (NWT). To address this data gap, human biomonitoring studies were completed in collaboration with residents from Old Crow, YT, and the Dehcho region, NWT. These projects provide baseline demographic data and blood serum PFAS levels of some First Nations communities in northern Canada. In Old Crow (n=54), six PFAS had a detection rate greater than 50% including PFOS, PFOA, perfluorohexane sulphonic acid (PFHxS), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), and perfluoroundecanoic acid (PFUdA). In the Dehcho (n=109), five PFAS had a detection rate greater than 50% including PFHxS, PFOS, PFOA, PFNA, and PFDA. Generally, males had higher concentrations of PFAS compared to females, and PFAS concentrations tended to increase with age. For most PFAS, Old Crow and Dehcho levels were similar or lower to those measured in the general Canadian population through the Canadian Health Measures Survey (CHMS) and non-Arctic First Nations population through the First Nations Biomonitoring Initiative (FNBI). The key exception to this was for PFNA which was nearly 1.84 times higher in Old Crow and 2.78 times higher in Dehcho compared to the CHMS. Elevated levels of PFNA may result from different factors such as fish consumption or exposure to volatile atmospheric precursors, but sources in this area are not fully known. Future research should work to establish temporal trends in these regions and improve understanding of exposure sources.

Title: Stories and the Participation of Indigenous Women in Natural Resource Governance

Authors:
Dr. Patricia Hania and Dr. Sari Graben, Ryerson University

***Correspondence:** phania@ryerson.ca

Keywords:
Water Governance, Participatory Governance, Indigenous Women, Storying,

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
In this article, the authors explore whether the participation of Indigenous women in resource management can be bolstered by recognizing their governance authority, as expressed through stories. Participatory governance is the dominant organizational arrangement relied upon by provincial and territorial governments to govern water in concert with Indigenous peoples. However, Indigenous feminist scholarship has raised serious questions about the exclusion of Indigenous women from public and private governance, the method of their exclusion, and conditions for rectification. The authors draw on Indigenous feminist scholarship to generate three principles of storying for the purposes of participation: 1) stories facilitate exchange and dialogue; 2) stories revitalize Indigenous women's governance authority; and 3) stories pluralize the norms of resource governance. Relying upon these three principles, the authors forward several policy prescriptions to bolsters public participation by recognizing women's responsibilities and abilities.

Title: Site-to-site variation in water chemistry, nutrient and coliform levels of McKenzie and Boston Creeks, subwatersheds of the Grand River

Authors:
Sawsan Makhdoom, McMaster University
Clynt King, Six Nations Band office staff (retired)
Patricia Chow-Fraser, McMaster University

***Correspondence:** makhdos@mcmaster.ca

Keywords:
water quality, Six Nations, McKenzie Creek, Boston Creek, Grand River

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
The Six Nations Reserve occupies roughly 19,000 ha and is the largest First Nations community in Canada. Although it is located within an hour of several major cities of southern Ontario, tap water of almost 30% of households has consistently tested positive for fecal contamination over the past two decades. To assist the Six Nations community in uncovering sources of fecal contamination in the surface waters, we carried out a monthly sampling program in 2019 from April to November to monitor water chemistry, nutrients and coliform levels at 7 stations of the McKenzie and Boston Creeks, two major tributaries that drain lands of the Six Nations Territory. Compared to McKenzie Creek, Boston Creek was slightly warmer (17.86 vs 16.96□C), with mean specific conductivity that was 60% higher (1200 vs 700 µS/cm). Both creeks were relatively well-oxygenated (percent saturation of 85-90%). By contrast, McKenzie Creek was twice as turbid than Boston (58 vs 21 NTU), had total phosphorus concentrations that were 1.3 times higher than those in Boston Creek (126 vs. 94 µg/L) and total suspended solids concentrations that were 2.3-times higher (59 vs 26 mg/L). Mean concentration of soluble reactive phosphorus, however, was about half for McKenzie compared with Boston Creek (21 vs 45 µg/L). Mean total-ammonia nitrogen concentration for McKenzie was slightly higher than that for Boston Creek (0.138 vs 0.108 mg/L), whereas the mean total-nitrate nitrogen concentration was slightly lower (0.741 vs 0.843 mg/L). Within the Six Nations territory, the geometric mean E. coli concentration exceeded 200 colony forming units (CFU)/100 mL at 2 stations of McKenzie Creek and only 1 station at Boston Creek. The high water turbidity, as well as high levels of nutrients and fecal coliform in McKenzie and Boston Creeks indicate degraded conditions that are much worse than those measured at other locations along the Grand River, and elsewhere in southern Ontario, including highly urbanized regions. Future research should aim to understand how water-quality impairment is related to land uses and/or point-source pollution within these subwatersheds.

Title: Building Community Resilience to Mitigate Impacts of Water Insecurity and Climate Change through Co-Creation of Indigenous Water Quality Tools (CCIWQT)

Authors:
Dawn Martin-Hill, McMaster University
Nidhi Nagabhatla, McMaster University
Altaf Arain, McMaster University

***Correspondence:** dawnm@mcmaster.ca

Keywords:
indigenous peoples, climate change, co-creation, water insecurity

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Indigenous peoples and their interlinkages with nature is key to their cultural and social identity. Such interlinkages remain pertinent towards mapping risks, planning sustainability interventions, and climate change adaptation strategies. However, these interlinkages are not often mainstreamed in public discourses and policy planning on climate change and sustainability matters. Indigenous peoples face direct and indirect impacts of climate change, as of their close dependence and sincere relationship, with nature. Some of the concerns facing the communities include changes in land use and availability of local food sources, uncertainties in weather and climate predictions at the local scale, lack of early warning systems and limited technical capacity - these limitations pose severe challenges to water and food security as well as health and well-being. This synthesis will provide highlights from the GWF project on Indigenous communities that initiated co-creation of data portals, mapping tools, and information systems for adaptation planning with First Nations (Six Nations of the Grand River) responding to the warning by the Intergovernmental Panel on Climate Change (IPCC), wherein lead scientists worldwide reiterated the emergency (i.e. less than 12 years to limit increasing temperatures to 1.5ºC) we face as a humanity.
The key trends projected by global climate reports and national climate projects tend to either overlook or relatively underestimate the trends of climate variations for areas held or managed by Indigenous peoples in Canada and elsewhere in the world. The CCIWQT project makes a 'reference case' for mainstreaming indigenous people in global sustainability planning, demonstrating the need to provide them with the legal and political rights necessary to continue to safeguard the lands they have stewarded since time immemorable. We will showcase critical findings from the ongoing work on climate modeling, community engagement, and knowledge management - an integrated approach adopted by the project to build community resilience and mitigate impacts of water insecurity and climate change through Co-Creation.

Title: Ohneganos: valuing traditional ecological knowledge to decolonize environmental health research

Authors:
Dawn Martin-Hill, McMaster University
Nidhi Nagabhatla, United Nations University
Nancy Doubleday, McMaster University
Tony Vieira, Mohawk College
Charlene Hemlock, McMaster University
Makasa Looking Horse, McMaster University

***Correspondence:** dawnm@mcmaster.ca

Keywords:
co-creation, ohneganos, water security, traditional ecological knowledge, indigenous knowledge

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
From the perspective of the traditional Haudenosaunee, we speak in terms of responsibilities with respect to water, not in terms of water rights. Culturally, we would not abuse this resource (King, 2007). This innovative research project has adopted a 'co-creation' framework –legitimizing Indigenous Knowledge (including Traditional Ecological Knowledge [TEK]) and synthesizing it with Western Science to advance ecological and human health research. IK research includes indigenous methodology, pedagogical practice, ethical protocols, and tools – all which are being created by the community for the community. Legitimizing IK involves recognizing that TEK has a multiplicity of sources - including traditional, spiritual, and empirical, and that it engages a holistic paradigm that acknowledges the emotional, spiritual, physical, and mental well-being nested in the culture and language of a people. This innovative research approach answers the calls for IK to be ethically integrated into water resource/climate change resilience planning to mitigate the water/climate crisis created through colonial policies and environmental racism. For example, the Global Assessment Report on Biodiversity and Ecosystem Services of IPBES (2019) concluded that ecosystems which are controlled and managed by Indigenous people are consistently in better shape than all others. Tools and outcomes that are in development following this innovative research framework include:
(1) learning tools - bilingual science materials, sensors, environmental monitoring capacity
(2) enhancing youth health resilience to climate/water anxieties, oriented to support the United Nations Sustainable Development Goals (e.g. SDG 3, 4, 6, 13, 15, and 17)
(3) training youth/assisting community in water governance, rights, responses inclusive of Indigenous laws [governance] in accordance with UNDRIP and TRC call to action
(4) establishment of the community infrastructure needed to ensure research remains community-led and in alignment with grassroots priorities (i.e. the establishment of a Haudenosaunee Environmental Health Task Force, Grandmothers Council, and Haudenosaunee Confederacy Council Water Committee to advise all aspects of our research)
Dissemination of the project's findings also include contemporary and innovative outcomes such as a virtual reality experience of the Grand River, a living repository with ethnolinguistic mapping, digital stories, water monitoring data, and health survey results.

Title: Harmonizing our water resource management with Indigenous ways of knowing: A Collaboration with the Saskatchewan River Delta

Authors:
Azza Mohammadiazar, University of Saskatchewan, Global Institute for Water Security
Graham Strickert, University of Saskatchewan

***Correspondence:** Azza.moh@usask.ca

Keywords:
Community-engaged scholarship, Saskatchewan River Delta, Cumberland House, Indigenous Communities, Water resource management

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Increases in the global population and accompanying demands for water and food production are having detrimental impacts on the function of watersheds. These impacts include reduced water quality, abnormal flow fluctuations, and changes in sedimentations in water flows, among others. Climate change is a further stressor on watersheds, as it is for all sensitive ecosystems. The Saskatchewan River Delta (SRD) is no exception. Populations in the SRD, such as the Indigenous communities in Cumberland House, have been adversely affected by upstream water withdrawals for irrigation, dam-induced alterations of the seasonal river flows for hydropower, and legacies of industrial pollution. Although research has demonstrated these and other problems, to date the Cumberland House community has seen little in the way of adaptations and solutions.
This research is part of a larger community-based participatory research program examining the human dimensions of water security in the Cumberland House community. In this project, I seek to inform water resource modeling with the values, insights, and perspectives of changes in water resources from the point of view of the people of Cumberland House so that their models may better reflect local contextual factors in execution. To do so, I have used a modification of photovoice with detailed, in depth interviews and field observations to co-gather and analyze narratives of the community members on the issues in their environment. Findings of this research will emerge using a thematic Analysis that captures the community's needs to first enhance social action within the community and then mobilize knowledge within academia.

Title: Collaborative Water Governance fostering participation, relationships, and reconciliation in Mistawasis Nêhiyawak

Authors:
Maria Mora, University of Saskatchewan
Lalita Bharadwaj, University of Saskatchewan
Anthony B.D. Johnston, Mistawasis Nêhiyawak (First Nation)
Michelle Watson, Mistawasis Nêhiyawak (First Nation)

***Correspondence:** mariafer.mora@usask.ca

Keywords:
Collaborative Water Governance, Decolonization, Indigenous ontologies, Interculturality, Community-Based Participatory Research

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
Collaborative water governance has emerged as an approach that promotes the participation of local people, their expertise, and knowledge. Collaborative processes are not easy to be put into practice when they risk to include decolonized approaches that are inclusive of Indigenous water ontologies. From a decolonized perspective, the present research project was proposed and developed based on the principles of Community-Based Participatory Research-CBPR. Working with Mistawasis Nêhiyawak (First Nation in Saskatchewan), the main overall research goal was to understand what water governance means, involves, and implies for Mistawasis Nêhiyawak according to their worldview, traditional knowledge, and socio-cultural connections with water. The meanings that water has for different people in Mistawasis (leaders, elders, women, youth) reflected the Nêhiyawak identity, protocols, and connections (especially for women) with water. From these water meanings, a holistic water governance framework was co-built. The framework shows Mistawasis worldviews and knowledge on the importance of water as a sacred entity to be honoured and respected. Beyond a resource, the framework provided a decolonized perspective for Mistawasis water partners invited to participate in a third stage of this research. Partners interviewed saw the framework as a model that can be incorporated into their work, and as a tool for the application of reconciliation through intercultural relationships among Indigenous and non-Indigenous water responsibility-holders.

Title: Mental Health Mobile Applications available for Canadian Indigenous Communities: A Scoping Review

Authors:
Noella Noronha, McMaster University
Savanah Smith, McMaster University
Christine Wekerle, McMaster University
Cynthia Lokker, McMaster University
Alexander Drossos, McMaster University
Anne Niec, McMaster University

***Correspondence:** noronn@mcmaster.ca

Keywords:
First Nations Health, Mental Health, Mobile Application, Indigenous Health, Water

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
Objective: To create a fundamental understanding of the nature and scope of mental health related applications available for Canadian Indigenous communities. This scoping review is the first of a preliminary community-based-participatory research study which involves focus groups to create the first Canadian Indigenous mental health application.
Methods: A literature search with no timeline restrictions searching databases EMBASE, CINAHL, MEDLINE, psycINFO, grey literature and the two largest application stores Google Play and Apple's App store was collected by the first author. Two raters independently identified the applications that targeted mental health of Canadian Indigenous communities, and all discrepancies were resolved through discussion with a third rater. Application descriptions were exported verbatim and summarized descriptively to thematically analyze each application.
Results: After de-duplication, a total of 100 applications were found through the search strategy. However, only 3 applications underwent scientific review, with 2 available for Apple & Android phones, and 1 available for only Android based phones. None of the applications that met criteria were available through peer-reviewed literature, all were obtained from the grey literature search. Two were tools to connect Indigenous youth to counsellors and networks, and the last was a combination with mental health reporting and connection to networks.
Conclusions: While the need for mental health support in Indigenous communities has been long recognized, there is a limited availability of mental health applications specifically tailored for Indigenous communities although there is an increasing prevalence of those for a general population. These applications lack evidence-based features and have not gone rigorous scientific testing. A user-centered, collaborative, interdisciplinary approach is required to increase the number of evidence-based and culturally applications. A team-based approach, combining research expertise, clinical and traditional practioners from the Indigenous community, community members and application developers can bring together the skillsets and insight required for the creation of a relevant mental health applications to support Indigenous communities. Lessons learned from these applications and

future focus groups will inform practice and policy for future applications and mental health support for the First Nations' communities.

Title: Country Foods and Health Promotion in the Inuvialuit Settlement Region, NT.

Authors:
Sonja K. Ostertag, University of Waterloo
Julia Gyapay, University of Waterloo
Kelly Skinner, University of Waterloo
Richard Gruben, Tuktoyaktuk
Amber Lester, Paulatuk
Brian Laird, University of Waterloo

***Correspondence:** sonja.ostertag@uwaterloo.ca

Keywords:
Diet, Health messages, Inuit, Contaminants, Nutrients

Primary meeting theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
There is increasing recognition that public health strategies related to contaminant exposures in Indigenous communities need to balance the risks and benefits of consuming country foods. This project uses a participatory approach to identify sources of contaminant and nutrient exposure for Inuit and develop appropriate public health messages. This research has three main aims: 1) to generate current, regional data on contaminants in country foods; 2) to revise a Health Messages Survey for the Inuvialuit Settlement Region; and, 3) to estimate the contribution of beluga to overall nutrient and contaminant intake for Inuit in the Inuvialuit Settlement Region and Nunavut. Animal tissue samples were collected in Paulatuk and Tuktoyaktuk from fish, birds, marine mammals and terrestrial mammals through community-based sampling and collaboration with current environmental monitoring programs. Country food samples will be analyzed for legacy contaminants, including persistent organic pollutants and heavy metals (mercury, methylmercury, lead and cadmium). Concentrations of polyunsaturated fatty acids and select vitamins will be determined and animal exposure to infectious diseases will be assessed to respond to questions regarding food quality and safety. Contaminant and nutrient profiles of store-bought foods will be developed using pre-existing data from the Total Diet Study and Canadian Nutrient File. A preliminary Health Messages Survey will be developed using the outcomes from focus group meetings with community members and key informant interviews with public health practitioners in the ISR and Yellowknife, NT. In addition, health messages related to country foods and store-bought foods will be compiled through key informant interviews. The re-assessment of Inuit Health Survey data from 2007-2008 will respond to questions from Nunavut and GNWT Health Authorities about safety of consuming beluga. This research builds on existing environmental monitoring programs and partnerships with communities in the NWT to support future biomonitoring and human health risk-benefit assessments in the ISR.

Title: Bioaccessibility of Mercury in the Muscle of Three Freshwater Fish Species in the Northwest Territories, Canada

Authors:
Sara Packull-McCormick, University of Waterloo
Stephon Duong, University of Waterloo
Brian Laird, University of Waterloo

***Correspondence:** srpackul@uwaterloo.ca

Keywords:
Bioaccessibility, Mercury, Fish

Primary meeting theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
Traditional foods, such as locally caught fish, have important nutritional, social, cultural, and economic benefits for Indigenous communities in Northern Canada. However, elevated levels of mercury in fish in freshwater ecosystems in the Arctic and sub-Arctic are of concern as communities who rely on locally caught fish could be exposed to elevated levels of mercury. In the Mackenzie River Valley of the Northwest Territories, fish sampling has detected elevated levels of mercury in some predatory fish species in some waterbodies resulting in the release of consumption notices. To address the concerns of First Nations communities in the region, a human biomonitoring project was implemented and biological samples and dietary data were collected for use in risk assessments. Access to co-located human biomarker data, human dietary information, fish analyte data, and fish tissue samples from this region provides a unique opportunity for a site-specific exposure assessment for mercury. The inclusion of mercury bioaccessibility data from fish samples from waterbodies in the region may improve the exposure assessment.
Mercury bioaccessiblity was determined in fish muscle samples from three fresh water fish species from a lake in the Mackenzie Valley Region of the Northwest Territories through the use of a gastric-phase in-vitro bioaccessibility model. These samples were from three of the fish species that First Nations communities in the region most commonly reported consuming: Lake Whitefish (n=9), Northern Pike (n=9), and Walleye (n=8). The mean mercury bioaccessibility was similar for Lake Whitefish (42 ± 9.4%), Northern Pike (38 ± 9.1%), and Walleye (42 ± 11%). The mean mercury bioaccessibility was not statistically significantly different between the three fish species (one-way ANOVA, F=0.583, p>0.05, df=2, 23). This mercury bioaccessibility data will be used in a probabilistic mercury exposure assessment model to determine if the inclusion of bioaccessibility data improves the link between the external exposure estimates and bio-marker based measures of internal dose. However, mercury bioaccessibility should be determined for fish samples from additional waterbodies and for additional fish species to create a comprehensive data set for inclusion in the site-specific mercury exposure assessment.

Title: Using Social Media to Enhance Community Engagement in Environmental Research

Authors:
Alanna Robbins, Wilfrid Laurier University

***Correspondence:** robb8943@mylaurier.ca

Keywords:
Indigenous Environmental Knowledge, Methodology, Social Media

Primary meeting theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
Social media offers a unique opportunity to increase community engagement in environmental research. Several scholars have identified this medium as having the potential to serve as a useful tool with relation to Indigenous environmental governance. Matawa First Nations (MFN) is the organization of nine First Nations (in James Bay No. 9 and the Robinson-Huron Treaty areas) to support communities through the development of social and economic opportunities. At this year's MFN Annual General Meeting (AGM) in Constance Lake, a photo contest was created on Facebook to promote the Matawa Water Futures (MWF) project and to initiate data collection of water stories from MFN members. Working with Four Rivers, an organization partnered with MFN to support community-based land and resource management, the contest asked community members to submit water photographs with an answer to the question: "How is water important to you?" to the Four Rivers Facebook page. Throughout the AGM, MWF created a display in a communal space to share the photographs and water stories submitted. Overall, the results of this contest show that social media is a highly accessible method for community engagement. In total, 58 water stories were received from 50 MFN community members. Using social media proved to be a highly approachable method suitable to Indigenous ways of sharing knowledge through photo voice techniques—disseminating research outputs by presenting to an audience a photograph with an accompanying story. Further research on this methodology will support MWF in developing new sites for communicating and sharing information with MFN.

Title: re:mote – Low-cost Software and Hardware Infrastructure for Water Quality Sensing in Indigenous Communities

Authors:
Emil Sekerinski, McMaster University
Waseef Nayeem, McMaster University

***Correspondence:** emil@mcmaster.ca

Keywords:
remote sensing, mesh network, timeseries database, low-cost, open-source

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
The re:mote software and hardware infrastructure comprises low-cost motes with sensors for collecting water quality data, a mesh network connecting motes through a base station to a server, a time-series database and a webserver running on the server hardware, and notebooks for analyzing data programmatically. Only open-source software and low-cost hardware are used, allowing the setup to be used for education and maintained by communities. All the software and the instructions are at https://gitlab.cas.mcmaster.ca/re-mote. The sensor motes, routers, and gateways are based on Arduino and have been tested with commercially available turbidity, ORP, pH, temperature, DO, and electrical conductivity sensors; the motes can be operated by solar panels. The LoRa mesh network allows operations in remote areas by transmitting sensor readings from the motes via routers to a gateway with a 3G connection. The time-series database can support up to 450 sensors when using a low-cost server like a Rasberry Pi. The website has both mobile and desktop versions; it can be adapted to different languages. A formal model for the power consumption of motes and the reliability of the transmission has been developed. Some field tests have been conducted so far.

Title: Exploring disaster risk reduction using fuzzy cognitive mapping approach: the case of local flooding in Mistawasis Nêhiyawak

Authors:
Anuja Thapa, University of Saskatchewan
Graham Strickert, University of Saskatchewan
Lori Bradford, University of Saskatchewan

***Correspondence:** anuja.thapa@usask.ca

Keywords:
Disaster risk reduction (DRR), participatory research, community-engaged research, Fuzzy cognitive mapping (FCM), Indigenous knowledge

Primary meeting theme: Knowledge co-creation with Indigenous communities
Secondary theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
Many Indigenous communities in Canada and around the world face disproportionate exposure to natural hazards caused by historically rooted inequity, geographical isolation, and disregard of Indigenous knowledge. Despite the depth of Indigenous knowledge, the inclusion of it in disaster risk reduction (DRR) remains merely as a theoretical notion. However, in the growing urgency of climate change, DRR can no longer be supported by a single dominant knowledge framework. There is a need to seek and apply methods that facilitate balanced knowledge sharing to provide complementary support to deliver a holistic perspective on disasters.
Fuzzy cognitive mapping (FCM) is a novel participatory method used to represent the individual and collective knowledge of lay experts. We used the FCM-based methodology to explore and elicit flood risk perceptions in Mistawasis Nêhiyawak, a First Nation community in Central Saskatchewan. The individual FCMs were collected from community members in a one-day workshop. They were then condensed qualitatively to derive variables of a similar theme. The condensed FCMs were aggregated to derive a total social group FCM (TSGFCM) that represented collective knowledge of the group and was used to explore different management strategies.
From the nine FCMs, a total of 137 variables were derived that were then condensed to produce 25 upper-level variables. Of the 25 variables, the most central concept in the TSGFCM was emergency planning. Comparison of management options revealed that the increment in variables such as emergency planning, cooperation and coordination, and awareness and understanding reduced the overall flood exposure, risks, and increased the coping abilities of the community. Moreover, the simulations in FCM revealed the need for a balance between short-term coping abilities (e.g., evacuation procedures, recovery actions) and long-term preparedness actions for building the community's resilience to changes in climate patterns.
FCM methodology used in our study allowed not only collecting community knowledge and perceptions of flood risks but also to compare different management strategies based on their perceptions. Through this exercise, emergency planning was found as a necessary action that will be complementary to their existing structural responses. As for our continued work with Mistawasis, future efforts involve supporting their emergency management plan by using scenario-based exercises to test the plan.

Title: Building Relationships: Lessons from a Western science facility located in First Nations territory

Authors:
Dilber Yunus, IISD Experimental Lakes Area

***Correspondence:** dyunusi@iisd-ela.org

Keywords:
Western science, traditional knowledge, collaboration, building relationships, knowledge sharing

Primary meeting theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
Where do we begin to build meaningful relationships in a time when bridging Western science and Traditional Knowledge has become critical in addressing some of the most pressing environmental crises facing our world?
The story of Canada's most unique scientific research facility has plenty to teach us.
IISD Experimental Lakes Area (IISD-ELA) is a freshwater research facility located in the traditional Anishinaabe territory of Treaty #3 in northwestern Ontario. For years, it has been working to expand its portfolio in public communication and prioritizing Indigenous engagement.
Located in Treaty #3 traditional land, IISD-ELA has seized upon a unique opportunity to work more closely with Indigenous communities to look at how the two ways of knowing can work together and benefit each other.
During this session, Dilber Yunus, IISD-ELA's outreach officer, will explain how IISD-ELA has partnered with Indigenous groups through various projects in areas of mercury contamination, community-based monitoring, and Ojibwe interpretation of scientific research to promote knowledge sharing.
She will also explore what IISD-ELA has learned along the way, including the importance of individual connection with respect and honesty; understanding communities' needs; and incorporating the preservation and revitalization of Indigenous culture and language into collaboration efforts.
Finally, she will explain where IISD-ELA needs to go from here, and what the lessons IISD-ELA has learned could mean for other scientific facilities who want to engage with Traditional Knowledge in a meaningful way.

Title: How does water quality affect people's recreation behavior and welfare in Alberta?

Authors:
Nasim Aminikhezri, University of Saskatchewan
Patrick Lloyd-Smith, University of Saskatchewan

***Correspondence:** nasim.amini@usask.ca

Keywords:
water quality, recreation demand, Alberta's provincial campsites, welfare, Non-market valuation

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
A wide variety of freshwater sources in Canada have provided numerous outdoor activities and pleasant sceneries across due to its beautiful nature. Most of these water bodies have good water quality, but some areas suffer the impacts of poor water quality, such as blue-green algal blooms. Furthermore, the areas with poor water quality also tend to be closer to human settlements and associated recreation activities. These lakes are heavily frequented by recreation users, but the impact of poor water quality on recreation is unstudied in Canada.
The goal of this research is to study whether lake water quality affects people's choice of recreation sites and to quantify their behavioral change in response to water quality degrading by using a recreation demand model. A secondary goal is to calculate welfare measures that can be used to understand the economic benefits of water quality improvements and used by decision-makers in a benefit-cost analysis. More broadly, this research aims to improve our understanding of how local environmental quality affects people's decisions.
Data for this paper comes from principal sources for the years between 2014 and 2018.
1. Alberta's provincial campsites recreational data obtained from Reserve Alberta Parks (RAP) system. The data include actual reservations from over 70,000 people per year.
2. The water quality data is comprised of water advisories and different measurements during the open water season.
To achieve the research objectives, We will use a travel code model to assess and predict individuals' behavior, including changing the site or quit recreational travel, in response to environmental changes across lakes in Alberta.
As the first step, we will calculate travel costs. Then, we will use the calculations for estimating a recreational demand function based on a discrete choice model. Since we need to assess individuals' decisions in two levels, participation and site decision, we will use the nested logit model.
Once the models have been estimated, we will use the preferred model and apply it to each water quality indices to assess which aspect of water quality influences an individual's preferences. Lastly, we will create some scenarios to estimate the economic benefits of improving water quality.
Most studies in the United States find that people are willing to incur a cost to obtain a higher level of water quality. We expect the results will conform to the preexisting findings.

Title: Spatially Explicit Modeling of Wetland Conservation Costs in Canadian Agricultural Landscapes

Authors:
Eric Asare, University of Saskatchewan
Patrick Llyold-Smith, University of Saskatchewan
Kenneth Belcher, University of Saskatchewan

***Correspondence:** eric.asare@usask.ca

Keywords:
Wetland, Policy Targeting, Private Economic Value of Drained Wetlands, Wetland Conservation Cost,

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts

Abstract:
Agriculture is a major driver of wetland conversion in the Praire Pothole Region of North America because there is a mismatch between private costs and public benefits of wetland retention and conservation. We applied a spatially explicit wetland conservation cost model to estimate the private economic benefit of wetland drainage in an agricultural landscape in Alberta, Canada, using a canola-wheat crop rotation for 20-years. Moreover, the estimated private economic benefits of wetland drainage were used to assess three wetland conservation policy targeting scenarios based on wetland conservation cost and environmental benefits of wetlands. The results of the study showed a negative correlation between private economic benefits of wetland drainage and the environmental benefits of wetlands; we showed that under this condition, the choice of a wetland conservation policy would be important in achieving a wetland conservation goal, given a conservation budget, in the study area. Our study extends the literature on wetland conservation by showing that, targeted wetland conservation policies could be a more effective policy at conserving wetlands than a uniform conservation policy that is based on the assumption that all wetlands within an agricultural landscape are the same.

Title: Does the community composition of algae and bacteria predict levels of omega-3 fatty acids in subarctic populations of Northern Pike, Esox lucius?

Authors:
Tara Boag, University of Waterloo
Matthew Laird, Ellen Reyes, University of Waterloo
Juan Henao, Ken Stark, University of Waterloo
George Low, Mike Low, Dehcho Aboriginal Aquatic Resources and Ocean Management
Brian Laird, University of Waterloo
Heidi Swanson, University of Waterloo

***Correspondence:** tnboag@uwaterloo.ca

Keywords:
Freshwater Fish, Fatty Acids, Community Composition, Food Security, Mercury

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
In the Canadian subarctic, many remote communities rely on country foods, including fish, to supplement more expensive store-bought options. At the request of community members in the Dehcho region of the Northwest Territories, a research project was initiated in 2012 to look at fish mercury concentrations in important subsistence lakes. Community members and leaders also requested that researchers quantify the level of beneficial fatty acids and micronutrients in subsistence fish species, to better understand both the risks and benefits of consuming fish. Fatty acid concentrations in the food fish Northern Pike (Esox lucius) were analysed from 8 lakes, and total fatty acids, total polyunsaturated fatty acids, and eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were found to be significantly different among lakes.
Many of the health benefits from fish come from omega-3 fatty acids, which are essential for human nutrition, playing a key role in the structure and function of the eyes and brain, and decreasing the risk of cardiovascular disease. However, fatty acids can only be obtained from the diet. In freshwater ecosystems, essential fatty acids are produced by algae and bacteria and transferred up the food chain. However, the type and quality of fatty acids produced varies among primary producer taxa. Generally, algal plankton produce higher quality fatty acids than bacteria, which produce short-chained fatty acids and very few omega-3 fatty acids. As a result, fatty acid profiles in fish may vary among lakes due to variation in algal and bacterial community composition.
This study examines whether among-lake differences in Northern Pike fatty acid profiles can be explained by the community composition of algae and bacteria. We used 16S and 18S rRNA analyses to determine the primary producer composition of the lakes and compared it to fatty acid concentrations collected from fish muscle tissue. We also examined water chemistry, watershed land cover data, and other abiotic factors in each lake to determine whether these factors influence community composition or fish fatty acids. Understanding the factors that lead to variation in fish fatty acids will help us predict the nutritional value of food fish in other lakes, and will allow for better characterization of the risks (e.g., mercury exposure) and benefits of consuming fish.

Title: Global flood risk modeling with climate models and machine learning

Authors:
Mathieu Boudreault, Université du Québec à Montréal
David A. Carozza, Université du Québec à Montréal

***Correspondence:** boudreault.mathieu@uqam.ca

Keywords:
Flood risk, Decision-makers, Financial services industry, Regulators

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; Social, economic and health determinants and impacts

Abstract:
With mounting pressure coming from regulators, the financial services industry (mainly banks, insurers and reinsurers) will soon need to disclose the sensitivity of their profits to various climate scenarios in line with the core principles set out by the international Task Force on Climate-related Financial Disclosures (TCFD). On the other hand, global flood risk modeling is very complex, computationally intensive and certainly not flexible enough for risk analysts to prepare their organizations for TCFD or other regulators' requirements. In this presentation, we introduce a global and climate-consistent flood risk model for socio-economic applications that do not necessarily require high-resolution flood mapping (from hydrological and hydraulic models). With the model, one can analyze the impact of various spatial and temporal patterns of variables such as precipitation and/or temperature, population, wealth, etc. on a risk portfolio. Built upon a general circulation model, the global flood risk model is thus capable of looking into the future, accounting for climate change over various greenhouse gas emission and socio-economic scenarios in accordance with CMIP5 and CMIP6 ensembles.
To illustrate how the global flood model works, we use precipitation and temperature patterns from the National Center for Atmospheric Research's (NCAR) Community Earth System Model (CESM) Large Ensemble (LE) to calculate flood occurrence probabilities and impact distributions per watershed, and each member and year of the ensemble over 1980-2020. The occurrence and impact models are fitted with large databases (past flood history, historical precipitation and temperature patterns and watershed level information such as slope, elevation, land use, etc.) using machine learning methods (regressions, random forest, neural networks). Using the fitted occurrence and impact models, stochastic simulations are used to generate a large and global catalog of flood events along with impacts, expressed as the population displaced and gross domestic product (GDP) affected.

Title: Small wetlands as hotspots of nutrient removal

Authors:
Frederick Cheng, University of Waterloo
Nandita Basu, University of Waterloo

***Correspondence:** fycheng@uwaterloo.ca

Keywords:
wetlands, nutrient cycling, water quality

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
Water bodies such as lakes, reservoirs, and wetlands provide a wide variety of ecosystem services, including retention of nutrients and sediments, and subsequently protect downstream water quality. While the processes controlling nitrogen (N) and phosphorus (P) retention are relatively well-known, there is a lack of quantitative understanding of how the relative nutrient retention in water bodies are affected by size. In this study, we conducted a meta-analysis to quantify the role of small water bodies in landscape scale nutrient processing. We synthesized data from 600 lentic systems across the world to gain insight into the relationship between hydrologic and biogeochemical controls on nutrient retention. Our results indicate that the first-order reaction rate constant, k [T-1], is inversely proportional to the hydraulic residence time, τ [T], across six orders of magnitude in residence time for total N, total P, nitrate, and phosphate. We then used a sediment-water model to show how nutrient removal processes are impacted by system size. Finally, the k-τ relationships were upscaled to the landscape scale using a wetland size-frequency distribution. Our results suggest the disproportionately large role of small wetlands in landscape scale nutrient processing: 50% of nitrogen removal occurs in wetlands smaller than 10^2.5 m2 in our example. Thus, given the same loss in wetland area, the nutrient retention potential lost is greater when smaller wetlands are preferentially lost from the landscape. Such findings are significant to wetland protection and restoration efforts, which have historically focused on maximizing total wetland area rather than on preserving a distribution of different wetlands sizes within a landscape.

Title: Measuring the Role of Place Attachment in a Labelled Discrete Choice Experiment of River Restoration in Beijing, China

Authors:
Dan Dai, Beijing Normal University
Roy Brouwer, University of Waterloo
Kun Lei, Chinese Research Academy of Environmental Sciences

***Correspondence:** daidan0410@126.com

Keywords:
Discrete choice experiment, River restoration, Place attachment, China

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
Water quality and environmental flows in rivers are under enormous threat due to the high rate of urbanization and industrialization in fast growing economies like China. At the same time, large amounts of money are being diverted into river restoration. Contrary to the costs, the benefits of improved water quality and ecosystem health are much harder to quantify and express in monetary terms. The benefits of restoring different parts of the Yongding River in Beijing, China are measured in this study through application of a discrete choice experiment (DCE). Place attachment is measured by sampling residents upstream and downstream of the river and using the river sections as labelled alternatives in the DCE. As expected, the improvement of water quality is valued highly by all river basin residents, but how much of the river is restored, including the alluvial forest, does not play a role. Respondents are mainly interested in the outcome of the restoration efforts (water quality improvement), not how this is achieved. Place attachment plays a significant role, and residents value the restoration of the river in their section of the river higher than in other sections upstream or downstream of their place of residence. Although respondents are willing to pay only a relatively small share of their household income for river restoration, less than 1% as in previous studies, willingness to pay for improved water quality is between a factor 4.0 to 4.6 higher than the average household water bill, depending on the river section. These findings provide policymakers with important guidance for the recovery of the investment costs associated with river restoration projects.

Title: Data Management In Action: A Toolkit to Aid Researchers in Building Valuable Datasets

Authors:
Krysha Dukacz, McMaster University
Alanna Bodo, McMaster University
Natasa Popovic, University of Waterloo
Bhaleka Persaud, University of Waterloo
Gopal Saha, Michael Steeleworthy, Wilfrid Laurier University
Laleh Moradi, Stephen O'Hearn, University of Saskatchewan

***Correspondence:** dukaczka@mcmaster.ca

Keywords:
Data Management, Toolkit, Open Source

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management; Stakeholder engagement and knowledge mobilization

Abstract:
GWF through the GWF Data Policy, along with the broader research community are raising the bar on data by demanding a higher level of transparency and robust documentation. While data management plans and repositories are fairly well developed components of the Research Data Management life cycle, tools to help researchers steward the data between these two states are less defined. This gap has been identified by many in the GWF community and highlighted by Early Career Researchers. This toolkit of templates and best practices is a first attempt to bridge the gap between data planning and preservation.

Title: Development of An Integrated Hydro-Economic Modelling Framework for Efficient and Sustainable Water Allocation in the Saskatchewan River Basin

Authors:
Leila EamenUniversity of Saskatchewan
Saman Razavi, University of Saskatchewan
Roy Brouwer, University of Waterloo

***Correspondence:** leila.eamen@usask.ca

Keywords:
Integrated Hydro-economic Model, Water Allocation, Economic Impacts, Transboundary River Basin

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
Decision-makers in presumably “water-abundant” river basins, such as the Saskatchewan River Basin, face a challenge of reallocating water resources among competing water users if the amount of available water is reduced due to climate change and/or socioeconomic developments. This calls for integrated decision-support tools such as hydro-economic modelling frameworks that inform the efficient and sustainable allocation of limited water resources in the face of highly uncertain futures. Accordingly, the present study develops a spatially integrated hydro-economic modelling framework that couples an inter-regional economic supply-side input-output model and a water resources system model developed in the MODSIM-Decision Support System (DSS) platform. This framework allows us to evaluate the direct and indirect economic impacts of different water re-allocation strategies as well as climate-change-induced water shortages in various sectors at different scales, namely the provincial, sub-basin, and the entire river basin level. This framework is applied to the transboundary Saskatchewan River Basin encompassing the three provinces of Alberta, Saskatchewan, and Manitoba. This basin experiences challenges such as water over-allocation in Alberta, which are exacerbated in the face of uncertainty around future climate and socioeconomic conditions. The present study attempts to inform decision-makers about re-prioritizing water demands and re-allocating water resources based on the economic sensitivity of the basin to a future reduction in water supply. In doing so, we stress-test different sectors and sub-basins to changes in water supply and identify their vulnerability. This information helps policy and decision-makers prepare for and anticipate uncertain water futures.

Title: Importance of Assessing snowpack water equivalent in a subarctic catchment producing hydroelectricity

Authors:
Michael English, Wilfrid Laurier University
Jennifer Hickman, Environment and Natural Resources Ministry, GNWT
Nick Wilson, Wilfrid Laurier University
Pieter Aukes, Wilfrid Laurier University
Roy Judas, Environment and Natural Resources Ministry, GNWT
Shawne Kokelj, Environment and Natural Resources Ministry, GNWT

***Correspondence:** menglish@wlu.ca

Keywords:
Snowpack water equivalent, Globsnow, hydroelectricity generation, drought

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts

Abstract:
Evaluating the accuracy of estimating SWE in the Snare River watershed that generates hydroelectricity for the city of Yellowknife, and other nearby villages is important as snowmelt represents the most important annual recharge event. Getting it 'right' is economically important. The effectiveness of annual spring recharge is associated directly with antecedent conditions the preceding year(s). Terrestrial storage potential in this watershed is low and dry summers often result in the NWT Power Corporation producing electricity using diesel generators. Snowpack water equivalent assessment is done on an annual basis near the end of March/ early April when it is assumed maximum SWE has been reached. The traditional, annual survey is comprised of 9 sites located in a broadly spaced grid with sites more or less equidistant from each other.
There were four objectives to this work: 1. as topography is a controlling factor with respect to snow distribution we determined if the annual snow survey completed in the Snare River basin is reflective of the topography within a 100km2 area around each of the 9 grid points; 2. as it would be useful to utilize satellite data to determine basin SWE in this large basin we conducted an intensive snow survey reflective of the basin topography overlapping two EASE-Grid pixels to determine how well our snow survey estimates compared to Globsnow data, 3. we compared the topography between the intensive site DEM and the grid site DEMs to determine similarities and by doing so established limits of confidence in using Globsnow in estimating basin SWE at least within the same error we found between our survey SWE and Globsnow SWE; 4. lastly, by using the intensive site data we determined the probability of accurately determining SWE if using the same number of sampling data points used in the grid snow survey.
We used the Arctic 5m DEM to spatially organize the intensive study site (located within 2 EASE-Grid pixels) into 9 Terrain Units (accounting for aspect and slope) with SWE sampling sites distributed proportionally to the area each TU covered. Evaluating SWE accurately with this 13,700km2 basin is challenging. To relate our study site to the watershed at large we created a similar DEM (with 9 TUs) surrounding each of the 9 grid sample sites. Overall there is a low probability that the grid site SWE

estimates are reflective of the terrain, and a 6% error between the intensive site field data and Globsnow.

Title: The Role of Natural Resources Canada (NRCan) in the Advancement and Innovation of Canada's Water Sciences

Authors:
Marc-André Faucher, Natural Resources Canada
Alexander Harrison, Natural Resources Canada

***Correspondence:** marc-andre.faucher@canada.ca

Keywords:
Water, Research, Policy

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: (Big) data science and management; Stakeholder engagement and knowledge mobilization

Abstract:
With a changing climate and growing socioeconomic pressures, it is expected that Canada will face more frequent and severe adverse water-related events, such as drought and flood, and that efficient water management will thus become increasingly important. In order to meet these challenges, it is critical that Canada's body of knowledge about water be as complete as possible.
Worldwide, key global organizations have commissioned projects to better align political and scientific objectives to address current and emerging water-related crisis. Most notably, the United Nations have created Sustainable Development Goals aimed at the sustainable use and conservation of fresh and marine water resources, the European Space Agency Thematic Exploitation Platform provides users access to thematic data relevant to geohazards, hydrology and polar issues, and Global Water Futures (GWF) has been undertaking research on various water-related fronts in Canada.
NRCan's Water Program aims to leverage the outcomes of these (and other) ongoing activities, to align itself with national and international initiatives, and to continue delivering high-quality geospatial science and data. This namely includes: entering into partnerships (e.g. MOUs, contracts, support) with GWF and other research institutes in Canada, maintaining efforts to increase our level of understanding of freshwater issues in the context of resource development, and continuing to work with Federal, Provincial and Indigenous partners and stakeholders to help Canadians better understand the level of flood risk in their communities.
NRCan also plays a key role in developing and managing Open Maps, which currently hosts more than 100 NRCan-published datasets pertaining to freshwater and/or flood mapping. The National Hydrographic Network, a foundational data layer for surface water extents is also being revamped and opportunities for new data models, such as the Common Hydrography Features are being explored. Furthermore, ongoing Earth Observation Baseline Data for Cumulative Effects program will address gaps in baseline datasets to better understand how Canada's natural environment is changing.
NRCan's Water Program plays a key role in tying all these initiatives together and establishing linkages across federal, international, academic and industry communities to deliver a comprehensive understanding of Canada's waters that will enable policy and decision-makers to better address emerging challenges.

Title: Intersectorial research: the role of the Intersectorial Flood Network of Québec in linking natural and health sciences

Authors:
Philippe Gachon, Université du Québec à Montréal
Buffin-Bélanger, Thomas, Université du Québec à Rimouski
King, Suzanne, McGill University
Maltais, Danielle, Université du Québec à Chicoutimi
Raphoz, Marie, Université du Québec à Montréal
Maia de Souza, Danielle, Université du Québec à Montréal

***Correspondence:** gachon.philippe@uqam.ca

Keywords:
flash flood, climate change, intersectorial research, mental health, psychosocial impacts

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Flood events have been increasingly affecting the population in Quebec, in particular in the south central areas of the province, where the associated economic and psychosocial costs are considerably high. Indeed, regional climate models predict future changes in the distribution of rainfall patterns, which may lead, on the one hand, to long-term increase in precipitation intensity, and, on the other hand, to accumulated precipitation in a short period, leading to drastic flash flood events. These projections also foresee increased winter flows, with potential floods and ice jams: a rise in winter temperatures leading to reduced snow accumulation but a rapid melting in springtime. Beyond the economic and financial losses during these events, health (e.g. cardiovascular problems) and psychological (e.g. post-traumatic stress disorder) impacts on individuals and communities sometimes end up unaccounted. Indeed, few studies have focused on the development of strategies to reduce the risks of post-disaster issues, and, in particular, to the projection and intensity or duration of flood events and their consequent impacts on health.
Under the umbrella of the Intersectorial Flood Network of Québec (RIISQ), an inter-institutional, multi-organizational and intersectorial network, significant efforts have been devoted to filling in the gaps resulting from the lack of proper intersectorial research, i.e. linking model development in natural sciences and engineering to the health and psychological impacts resulting from flood events. For instance, the improvement of hydro-meteorological simulation models, in particular accounting for intra-seasonal snow and rainfall distribution/variability, represent a medium to long-term strategy to improve the predictability of flood events and their social impacts. A co-construction effort to documenting the interdependence of the features of rising water levels and the physical, mental and social health of individuals, as well as the development of tools to model the relationship between different flood-related effects on the health of the population, are some of the aims of the network. The final goal is to achieve concrete results that could lead to recommendations on effective social and infrastructure interventions and reduced impacts of floods on individuals and communities.

Title: Provincial Scale Flood and Steep Creek Assessments - Successes and Challenges

Authors:
Kris Holm, BGC Engineering
Phil LeSueur, BGC Engineering
Patrick Glover, BGC Engineering
Elisa Scordo, BGC Engineering
Michael Porter, BGC Engineering

***Correspondence:** pgrover@bgcengineering.ca

Keywords:
Geohazards, Flooding, Land Use, Land Use Policy

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management; Social, economic and health determinants and impacts

Abstract:
Flooding impacts communities by damaging property, disrupting transportation corridors, impacting the economy, and sometimes results in loss of life. The mountainous terrain of BC is also prone to geohazards from debris floods and debris flows (steep creek geohazards), which historically have caused the highest proportion of flood-related fatalities. Safeguarding the public against flood and steep creek hazards is a key mandate of governments however there are significant gaps in the completeness and knowledge about geohazard risks. The gaps are largest in rural and First Nations governments which lack the financial means to undertake systematic assessment geohazard risks. Therefore, there is an opportunity to leverage the capabilities of public and private sectors within existing funding structures and responsibilities. Supported by the National Disaster Mitigation Program (NDMP) and the Union of BC Municipalities Emergency Preparedness Fund (UBCM CEPF), BGC has systematically assessed clear-water flood, debris-flow and debris-flood geohazard risk across approximately 200,000 sq.km of southern BC. The work integrates eleven projects spanning six Regional Districts, with participation from local, regional, First Nations and provincial governments. This collaborative approach treats multiple projects as one larger initiative and enables shared objectives for hazard and risk management. It allows local governments to leverage economies of scale to achieve objectives requiring watershed scale assessment beyond their boundaries. Through development of specialized tools and technologies, BGC has prioritized over 10,000 geohazard areas and hazard susceptibility modelling completed across tens of thousands of watersheds and is BC's most extensive flood and steep creek geohazards assessment to date. The integrated approach will help the Province of BC fulfill their long-term objectives for multi-stakeholder collaboration and provincial scale risk assessment, where every study builds on a growing and organized body of knowledge about geohazards and elements at risk. The work will provide information for land-use and policy enforcement and allow governments to prioritize the allocation of resources to reduce geohazard risks in their communities. This presentation will provide an overview of the projects, the tools and techniques developed to perform the assessments as well as the challenges and opportunities to support this approach in other jurisdictions.

Title: A monitoring-management framework considerate of cumulative effects for the lower Grand River and nearshore Lake Erie

Authors:
Elaine Ho, University of Waterloo
Dr. Simon C. Courtenay, University of Waterloo
Dr. Andrew J. Trant, University of Waterloo

***Correspondence:** e23ho@uwaterloo.ca

Keywords:
water monitoring, water management, cumulative effects, co-creation

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization

Abstract:
Water monitoring and management can be viewed as endeavors to understand how our interactions with the water system affect the health of the aquatic ecosystem as well as effects on the economic, cultural and biophysical health of our communities. One of the conclusions of our exploratory research – evaluating monitoring indicators in the Muskoka River Watershed – was that current monitoring does not adequately incorporate diverse stakeholder and rightsholder perspectives. In this research, scientists and water managers were first interviewed to identify opportunities for improving and connecting monitoring and management in Ontario. Second, the Great Art for Great Lakes initiative hosted workshops that engaged with nearly a thousand Canadian and Indigenous community members of all ages to create a permanent art installation while collecting their thoughts on problem areas and potential solutions in their watershed; this study received feedback from 133 individuals. Third, a partnership with Music for the Spirit & Indigenous Arts engaged Indigenous youth from Six Nations of the Grand River to create a traveling exhibit that demonstrates the youths' relationships with water through photography, paintings, drawings and more. These methods, in addition to participant observation and a water manager's workshop, contribute to the creation of a new monitoring-management framework considerate of cumulative effects in the Grand River/Lake Erie estuary. This presentation highlights approaches for including diverse stakeholder and rightsholder perspectives for water monitoring and management. Results from a monitoring review and engagement via the arts are shared.

Title: Do collaborative water governance approaches accommodate immigrants? A systematic review

Authors:
Bereket Negasi Isaac, University of Waterloo
Rob de Loë, University of Waterloo

***Correspondence:** bnegasii@uwaterloo.ca

Keywords:
water governance, collaborative approach, immigrant participation, environmental values, Lake Erie basin

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
The growing trend of immigrants with diverse environmental values and attitudes being integrated into Canadian communities poses unique challenges and opportunities to Canadian water governance structures and processes. On the one hand, there is the challenge of addressing potentially shifting attitudes on the part of water user groups and policy actors. On the other hand, the existing governance system may not be appropriately equipped to engage, incorporate or accommodate new voices and modes of expression by recent immigrants. Some scholars have noted that continuing the existing modes of water governance may be less effective in the face of changing polity, and need to be adaptive and responsive to changing societal needs. In this research, we employ a systematic review of the literature to determine the extent to which participative and collaborative water governance approaches incorporate voices from immigrant communities. A systematic search of the relevant literature on collaborative water governance over the period 2015-2019 (1,560 articles on Scopus and 1,151 articles in Web of Science) was conducted to assess the nature of participation by immigrants in water governance processes. Initial results from the 100 articles that directly focus on collaborative approaches to water governance indicate that the water governance community has been slow to recognize immigrant voices in research. Building on this insight, we have embarked on an empirical investigation of the nature of participation from immigrants on water quality related governance processes in Southern Ontario. By taking the cases of the Iraqi and Indian immigrant communities -- two societies that differ in their environment related worldview from that of Euro-Canadian outlook -in the Cities of London and Windsor, this study offers detailed, systematic and empirical analyses on the interaction between immigration and water governance processes in the Lake Erie basin, and offers governance innovations for addressing potential challenges.

Title: Using Fuzzy Cognitive Mapping to Explore Manageable Drivers of Key Lake Erie Eutrophication Indicators

Authors:
Jessica T. Ives, University of Windsor
Serghei Bocaniov, Paul Weidman
Jan Ciborowski, Steven Wilhelm
Catherine Febria,
Rebecca Rooney,
Michael McKay,

***Correspondence:** jives@uwindsor.ca

Keywords:
expert judgement, interactions, network, drivers, levers

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Lake Erie, and its ability to provide valuable ecosystem services, has long been threatened by eutrophication. Understanding the drivers of eutrophication in Lake Erie requires an understanding of the complex interactions within the ecosystem, including the role of manageable factors. A tool that can be used to synthesize expert knowledge for a complicated issue such as Lake Erie eutrophication is fuzzy cognitive mapping. Fuzzy cognitive mapping allows experts to visually arrange key concepts and the relationships among them, turning a qualitative understanding into a semi-quantitative (or "fuzzy") model. In March 2019, we brought together experts with a range of perspectives on Lake Erie eutrophication to create fuzzy cognitive maps. Specifically, we (1) identified what eutrophication 'is' in Lake Erie and compare this perception with outcomes of past efforts and (2) quantified what proportion of the influence on eutrophication indicators is perceived to be manageable.

Title: Incentivizing BMP Adoption: Predicting Future Implementation by Examining Past Participation and Experiences

Authors:
Haiyan Liu, University of Waterloo
Roy Brouwer, University of Waterloo

***Correspondence:** h445liu@uwaterloo.ca

Keywords:
Best Management Practices, Participation, Probit, Multinomial Logit, Ontario

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
Best Management Practices (BMPs) incentive programs have been introduced to protect agricultural land and reduce nutrient runoff in watersheds. However, their voluntary nature has not led to the expected high participation rates. We examine influencing factors and underlying drivers that are associated with BMP participation and farmer preferences for specific BMPs. Data are collected through an online survey in Ontario in 2019. A binary probit model is estimated to explain past BMP participation and a multinomial logit model to predict future BMP implementation. Results show that a mix of farmer and farm characteristics, motivational drivers and environmental attitudes explain both participation in existing BMP schemes and the likelihood of taking up new BMP's in the future. Preventing soil loss is the most important reason for participation, followed by water protection and increasing financial returns. Higher educated farmers are less likely to decline future participation, while farmers who already implement cover crops, conservation tillage, and buffer strips are more likely to recommend BMPs to others. Farmers are more likely to adopt BMP's in the future if they already apply cover crops, whereas a consistently negative impact on future BMP participation is found if they implemented buffer strips in the past, even though they would recommend this BMP to others. These findings suggest that sharing positive BMP experiences with other farmers, increasing farmers' environmental awareness and raising funding for cover crops and conservation tillage may help expand future BMP adoption.

Title: Checkered Landscapes: Uncovering the Drivers of Legacy Nitrogen Accumulation in a Mixed-Use Watershed

Authors:
Joy Liu, University of Waterloo
Kimberly Van Meter, University of Illinois at Chicago
Nandita Basu, University of Waterloo

***Correspondence:** y536liu@uwaterloo.ca

Keywords:
legacy nutrient, lag times, long-term

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services

Abstract:
In agricultural watersheds across the world, decades of commercial fertilizer application and intensive livestock production have led to elevated stream nutrient levels and problems of eutrophication in both inland and coastal waters. Despite widespread implementation of a range of strategies to reduce nutrient export to receiving water bodies, expected improvements in water quality have often not been observed. We now understand that that long time lags in reductions of stream nutrient concentrations can result from legacy nutrient stores within the landscape. In the present study, we explore how various landscape characteristics drive the accumulation and depletion of legacy N pools in Canada's Grand River Watershed, a predominantly agricultural 6000-km2 mixed-land use watershed that drains to Lake Erie. We synthesized a long-term trajectory of nitrogen surplus at the soil surface for the last 200 years using historical census and stream data. Using the ELEMeNT model, we quantified the magnitude of legacy nutrient pools and identified their locations. Our study provides a way forward for the design of more targeted approaches to water quality management.

Title: Right People, Right Resources, and Right Plan: small community's response to forest fires and flooding

Authors:
Brent McKnight, McMaster University
Sarah Newell, University of Ottawa
Nancy Doubleday, McMaster University

***Correspondence:** bmcknight@mcmaster.ca

Keywords:
Community Resilience, Natural Disasters, Disaster Management

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
Introduction: Climate change is increasing the frequency of wildfires and flooding events making community preparation for natural disasters essential. Smaller communities situated in more remote geographies struggle to build community resilience in the face of these damaging events. Drawing on community resilience research and in-depth interviews, we elaborate theory regarding how communities bolster their responses to natural disasters with the right people, right resources and right plan.
Research Question: What factors allow small communities to effectively respond to wildfires and flooding?
Methods: This is a community-informed case study involving small communities across the boreal forest. Communities with previous wildfires or flooding experiences were consulted. Thirty-one interviews were conducted with community members in a diversity of roles across eight communities. News articles, emergency planning documents, and response reports were used develop the four community case studies while the other four communities were used to inform and triangulate the results.
Results: Participants described the importance of having the right people, the right resources, and the right plan in place. Having the 'right people in the right roles' meant having knowledgeable employees that both possessed a strong understanding of their role and engaged in effective communication across the team. Having the right resources involved having those resources needed to respond to a specific event and the ability to access additional required resources. Finally, participants described the importance of having a well-developed plan laying out the roles and responsibilities of each team member and creating the structure and process that best allows them to respond to an event.
Discussion: In this paper we augment the disaster management cycle by incorporating the importance of right people, resources and plan. In doing so, we contribute to the prior literature in this space by connecting the cycle to important antecedents and outcomes. Communities benefit when key actors understand their roles, know how to access their resources, and sustain an action plan across dormant phases of the disaster cycle. Future research is needed to re-examine the interface between individual communities and administrative and regulatory mandates for emergency preparedness and response.

Title: Addressing Climate Risks in the Boreal Forest: Fire and flood understood through the lens of cultural trauma

Authors:
Jeffrey McLean, Global Health, McMaster University
Kyle Moodley, Global Health, McMaster University
Nancy C. Doubleday, McMaster University & UNU INWEH

***Correspondence:** doublen@mcmaster.ca

Keywords:
climate change, cultural trauma, boreal forest, fire, flood, mitigation, adaptation, health and well-being

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Stakeholder engagement and knowledge mobilization; Social, economic and health determinants and impacts,

Abstract:
Science has clearly demonstrated that climate change can have detrimental impacts on life, human and non-human. Despite active and informed knowledge mobilization, the diffuse and non-linear nature of these negative impacts may serve to limit collective mitigatory and adaptive action. Floods and fires are examples of the water related threats we face in an era of climate change, and they have the potential to seriously disrupt society. When these events disrupt social organization and impact human lives, they can be accurately described as culturally traumatic (Alexander, J. C.; 2012; Brulle, R. J., & Norgaard, K. M.; 2019). Emerging literature linking climate change, identity and resilience, points to a growing need for new approaches: much as fire suppression has been examined critically in relation to the potential for increased fire risk in the future, responses beyond a “recover and rebuild” approach may be needed in seasonally risk-exposed communities. As climate change progresses, the risk of fire and flood may increase in certain areas. The governance and management of these risks may need to change to reflect this. For example, in Belgium, flood risk management has its own government system and is intertwined with water management and planning, and subject to integrated frameworks and policies, as noted by Mees, et al., (2016). Recognizing that cultural traumas occur when groups of people experience events that fundamentally change everyday life, and challenge assumptions ranging from infrastructure needs to the design of governance relations, the need for alternative redevelopment strategies becomes a real consideration (Mees, et al., 2014). As we learn to shift our mutual infrastructure investments from reduction and recovery from flood and fire damage, toward maintenance of resilience to recurrent fire and flood in light of climate change, we will need to advance our collaborative skills to embrace diverse perspectives. One means of achieving this richer repertoire, is to broaden the range of participants and viewpoints contributing to our understanding of landscape functions, and of alternative ways to live within these fire- and flood-scapes under changing climatic conditions. By seeking a deeper understanding of climate change mitigation and adaptation in order to reduce potential impacts and to enhance resilience and responsiveness, we also see more clearly the causal relationship of climate change to cultural trauma. Our ensuing expectation is that applying these insights can contribute to design responses to avoid, or at least mitigate, such climate-driven cultural traumas.
Alexander, J. C. (2012). Cultural Trauma and Collective Identity. The Meanings of Social Life: A Cultural Sociology (1st ed.). University of California Press.
https://doi.org/10.1093/acprof:oso/9780195160840.003.0013

Brulle, R. J., & Norgaard, K. M. (2019). Avoiding cultural trauma: Climate change and social inertia. Environmental Politics, 28(5), 886–908. https://doi.org/10.1080/09644016.2018.1562138
Mees, H., Suykens, C. B. R., Beyers, J. C., Crabbé, A., Delvaux, B., & Deketelaere, K. (2016). Analysing and evaluating flood risk governance in Belgium: dealing with flood risks in an urbanised and institutionally complex country. STAR-FLOOD Consortium.
Mees, H. L., Driessen, P. P., & Runhaar, H. A. (2014). Legitimate adaptive flood risk governance beyond the dikes: the cases of Hamburg, Helsinki and Rotterdam. Regional Environmental Change, 14(2), 671-682.

Title: Addressing Drivers of Eutrophication in the Western Lake Erie Basin: Reflecting on Nutrient Management Efforts in Canada and the United States

Authors:
Erin Murphy-Mills, University of Waterloo
Rob de Loë, University of Waterloo

***Correspondence:** erin.mills@uwaterloo.ca

Keywords:
Water governance, Nutrient management policy, Drivers, Eutrophication, Lake Erie

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
In the 1960s and 1970s, Lake Erie drew widespread concern due to algal blooms caused by both urban and agricultural land uses. Coordinated nutrient management efforts by the United States and Canadian governments led to a significant reduction in nutrient pollution. Unfortunately, the problem of eutrophication has returned since the 2000s as an issue requiring continued binational attention. The significance of the Lake Erie basin both as a population hub and due to its agricultural activities and recreational/commercial fisheries emphasizes the importance of effectively identifying and addressing the drivers of eutrophication. Harmful algal blooms in the western Lake Erie basin, and their implications for ecosystem and economic health, are thus a priority for nutrient management efforts.
Policy and nutrient management solutions to eutrophication in Lake Erie are organized using traditional water governance system framings. These framings lead to problem definitions that result in key drivers of eutrophication being left out of nutrient management efforts. This research takes a critical perspective on how causes of eutrophication are defined to examine the extent to which, and how, water governance for nutrient management in the western Lake Erie basin enables or hinders consideration of external drivers. Understanding drivers of eutrophication, as well as how existing nutrient management solutions affect the consideration of these drivers, contributes to evidence-based policy development.
We analyzed key nutrient management policy documents and conducted policy Delphi surveys with nutrient management and water governance researchers and practitioners in both Canada and the United States. The data reveal shared understandings of the causes of eutrophication and how they are addressed, but also differing views on drivers that require careful consideration, as well as shared concerns about implementation efforts that have implications for nutrient management efforts. Study participants generally agree that most drivers are known, yet current nutrient management efforts are not sufficient to solve eutrophication. Opportunities to reframe the boundaries for nutrient management in the western Lake Erie basin are explored.

Title: A Comprehensive Monitoring and Evaluation Framework for Water Resources Management Policy in the face of deep Uncertainty: A Systems Thinking Perspective

Authors:
Sandile Ngcamphalala, University of Cape Town
Olivier Crespo, University of Cape Town
Johann Lowuw, University of Cape Town

***Correspondence:** sndilen@gmail.com

Keywords:
Monitoring and Evaluation, Deep uncertainty, Water Resources management, Adaptive policy management, Evidence-based decision making

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Knowledge co-creation with Indigenous communities
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts; Stakeholder engagement and knowledge mobilization

Abstract:
In developing a comprehensive monitoring and evaluation framework for water resources management policy, this study attempts to unpack the challenge of deep uncertainty and complexity and how it affects the credibility of the evidence generated to inform evidence-based and adaptive water policy decisions in South Africa. Efforts towards evidence-based adaptive water policy are bedevilled by the challenge of 'uncertainty', broadly defined as the unquantifiable knowledge gap between available knowledge and the knowledge policymakers need to inform specific decisions or value judgements about a policy. This challenge is worsened by the complexity presented by the interdependence and interconnectedness nature of the water resources management system with other social, economic and environmental systems, with a greater risk to dampen or amplify water policy performance. As such, water policy performance is unlikely to follow a linear pattern of change and therefore evaluation approaches designed to track linear logic of policy performance such as theories of change approaches or logical framework analyses, at least in their traditional form, may be limited.
In response, a systems thinking approach was used to help establish a comprehensive view of the variables involved in the complex and deeply uncertain interactions between water resources management and the related social, economic and environmental systems in South Africa. These variables were mapped with multi-disciplinary sector stakeholders to determine potential interactions in the system. Of particular interest was to zoom-in on variables outside the control of water policy managers (water box) and to investigate how these variables could potentially influence water policy performance.
This was important to identify core external variables to the water box that should be targeted in water policy evaluation efforts to improve the understanding of internal water policy performance dynamics. In this regard we recommend that traditional evaluation approaches such as logical frameworks, be induced with systems thinking approaches to strengthen the generation of comprehensive/ systems-wide and credible policy performance evidence, even in the face of deep uncertainty and complexity.

Title: Differing soil conditions with landscape position affects soil P form and risk of P loss in agricultural fields of Manitoba Prairies and Lower Great Lakes region

Authors:
Janina Plach, University of Waterloo
Merrin Macrae, University of Waterloo
Henry Wilson, Agriculture and Agri-Food Canada
Vivekananthan Kokulan, University of Waterloo
Diogo Pinho da Costa, Environment and Climate Change Canada

***Correspondence:** jplach@uwaterloo.ca

Keywords:
Phosphorus, Agriculture, Water Quality, Soil, Landscape

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
Phosphorus (P) storage and release in agricultural soils is controlled by the interaction between hydrology and soil biogeochemistry, reflecting dynamic environmental and soil conditions (e.g., pH, moisture, redox), and abundance and reactivity of soil organic matter and minerals (e.g., clay, metal-oxides, carbonates). Agricultural soils of the Canadian Prairies and the lower Great Lakes region are naturally calcareous, but differ in texture (clay to loams) and topography (flat to hummocky). Establishing soil biogeochemistry and solid-phase P partitioning can help predict critical source areas for P re-release under changing soil conditions (e.g., flooding) and associated P availability to crops and runoff. This is essential to provide insight for farmers into more effective and customized P management strategies based on soil type, landscape position, geographic region and according to risk of soil P loss. The objectives of this field-based study were to determine; 1) legacy soil P concentrations, 2) important reactive solid-phases for soil P sequestration, and 3) potential spatial variation in soil conditions (e.g., moisture, pH, minerals and organic matter) affecting soil P forms across topographic slope within agricultural fields. Surficial and sub-soils were collected across landscape positions (high to low slope) and contrasting soil textures (clay to loam) in Manitoba (5 fields; 0-30 cm) and the lower Great Lakes region (5 fields; 0-90cm). Soil samples were analyzed for soil composition, soil P partitioning and P sorption capacity. Results indicate greater occurrence of ponding at low slope positions affecting the soil composition, soil P partitioning and soil P sorption capacity. In contrast, flat field sites showed no clear difference in soil composition or soil P chemistry. Characterizing soil biogeochemistry linked to soil P availability, and implications for predicting risk of soil P loss impacting water quality will be presented.

Title: Climate Change at the Field-Scale: Comparing Projections and Observations Across Regions

Authors:
Will Pluer, University of Waterloo
Merrin Macrae, University of Waterloo
Jane Elliott, Environment and Climate Change Canada
Henry Wilson, Agriculture and Agri-Food Canada
Kokulan Vivekananthan, University of Waterloo

***Correspondence:** wpluer@uwaterloo.ca

Keywords:
Nutrient transport, Climate change

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; (Big) data science and management; Stakeholder engagement and knowledge mobilization

Abstract:
Water quality is a significant issue globally. Excess loading of phosphorus is leading to the eutrophication of freshwater systems, whereas nitrate has been related to algal blooms in marine ecosystems as well as human health risks in drinking water. Nutrient loading from non-point sources is associated with climate drivers as nutrients are transported hydrologically. An intensification of the hydrologic cycle is predicted in future; however, not all regions within Canada will respond in the same way (e.g. Prairies, Great Lakes Region). Moreover, climate drivers may influence nutrient mobilization in different ways across regions. Climate projections are typically done at large scales, which may be challenging to relate to field-scale processes; however, it is necessary to translate model projections to field scale processes as this engages more directly with communities and stakeholders and provides insight into actionable land use practices. In this study, we explore both climate and landscape drivers of water and nutrient transport at the field scale, in both the Prairies and Great Lakes Region using a rich, multi-year, multi-site set of edge-of-field data. Climate and landscape drivers on hydrology and biogeochemical processes are presented for both regions, and these findings are also compared with climate projections. This work provides an improved understanding of how climate change may impact agricultural water quality in Canada.

Title: Economic value of lake water quality improvements in Ontario

Authors:
Rashadur Rahman, University of Saskatchewan
Patrick Lloyd-Smith, University of Saskatchewan

***Correspondence:** rar727@usask.ca

Keywords:
lake, water quality, economic valuation

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
Ontario has over 250,000 freshwater bodies including four of the Great Lakes. These provide both market and non-market benefits which vary with the quality of water; any change to water quality (WQ) may directly influence the economic benefits of water. As many of the lake WQ benefits are not traded in the market, the monetary value of these benefits is challenging to estimate. But measuring economic benefits can provide information on how much WQ society should improve as improvement costs money. However, the aggregate benefit for WQ improvement in Ontario region has not been explored yet. This study focuses on estimating the value of lake WQ improvement in Ontario with three specific objectives: (1) to estimate the relationship between lake WQ and residential property values; (2) to investigate how the relationship changes across different WQ measures; and (3) to estimate the welfare effects of lake WQ improvements in monetary terms. To estimate the welfare effects, the hedonic approach is followed. This is a revealed preference method that explores the implicit price of non-market goods by using the market values of proxy goods. Different functional forms of hedonic equation e.g. linear, log-linear and log-log models are used where WQ, property and spatial characteristics are used as explanatory variables and housing sale price as a dependent variable. The model will estimate the willingness to pay (WTP) for an additional change in WQ characteristics. I will estimate separate models by using alternative variables to investigate the changes in the relationship across different water quality variables. Finally, I will consider MWTP values resulting from the Hedonic model as a proxy for the welfare benefits to the house buyer. By using the percentage change in the dollar for a unit change in the WQ and aggregating over houses in the region, I will estimate the welfare effects due to WQ improvements. For model estimation, panel data on WQ is collected from the Government of Ontario website. Housing price and attributes are collected from Teranet and Municipal Property Assessment Corporation (MPAC). It is expected that lake WQ improvement may have a significant impact on the nearby housing market. The estimated value of welfare effect may help the relevant authority to analyze the cost and benefits of WQ improvement thus contribute to better lake management process.

Title: Extreme Weather Impacts on the Infrastructure Development Sector

Authors:
Muhammad Rizwan, McMaster University
M. Altaf Arain, McMaster University

***Correspondence:** rizwam5@mcmaster.ca

Keywords:
Construction Companies, Extreme weathers, Technologies, Insurance Products, Financial losses

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services

Abstract:
Infrastructure development is a major economic sector in Canada. This sector is facing disruptions in their operations due to bad and extreme weather conditions. Specifically, extreme weather conditions can cause work delays, damage to machinery, equipment and materials, injuries to workers and disruptions to construction sites. These impacts may substantially increase operational costs and financial loses. Infrastructure development sector is expected to face more damages and disruptions due to future increases in the frequency, duration and intensity of extreme weather events and climate change. The objective of this survey study was to determine the nature and scale of extreme weather event impacts on this important economic sector in Ontario, Canada and explore what strategies may be developed to alleviate these impacts and risks. Study results indicated that construction companies in Ontario are facing more than 50% increase in flooding and high wind events which has significant monetary impacts. Construction companies indicated that operations, planning, construction and human resources are the most important areas of the companies that are impacted by the extreme events. Mostly companies do not have provisions to accommodate their workers during these events. Most companies have not adopted new technologies to deal with or adapt to extreme weather events. Construction companies are facing disruptions in the labor profitability due to these events and there are guide lines available from the Canadian government and insurance products from insurance companies for Infrastructure development sector to deal with impacts related to extreme events. This study will help to better plan, adopt to new technologies and manage the operations and human resources of infrastructure development sector in changing climate.

Title: Water-Associated Disease Index (WADI) expansion: A rapid review and landscape analysis

Authors:
Eunice A. Salubi, University of Waterloo
L. Taing, United Nations University Institute for Water, Environment and Health (UNU-INWEH)
N. Dang, United Nations University Institute for Water, Environment and Health (UNU-INWEH)
H. Mehmood, United Nations University Institute for Water, Environment and Health (UNU-INWEH)

***Correspondence:** easalubi@uwaterloo.ca

Keywords:
risk assessment tool, water-associated disease index, rapid review, landscape analysis, global environmental change

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Predictive modelling and forecasting; (Big) data science and management; Social, economic and health determinants and impacts

Abstract:
The WADI tool was developed to assess and map vulnerability to water-related diseases in light of global environmental change and increased likelihood of extreme weather events such as floods and drought. Originally conceived as a disease-specific tool, it utilizes publicly available data to compositely measure a range of biophysical and socioeconomic indicators that influence vulnerability to the vector-borne diseases of dengue and schistosomiasis. To explore the potential of applying WADI to a range of diseases, a rapid review is being conducted to identify additional indicators that affect human exposure and susceptibility to both vector-borne and infectious fecal-oral diseases. Additionally, a landscape analysis will be conducted to identify alternative data sources – such as crowd-sourced data, geospatial data and remotely sensed data – to improve output resolution (from global to district or city level) and potentially expand the tool's function beyond a risk assessment tool. The improved WADI tool will reflect advances in water and health sciences and data technology in the hopes of supporting real-time evidence-based policy and decision-making.

Title: Development of an operational simulation tool for Prairie water management

Authors:
Kevin Shook, University of Saskatchewan
John Pomeroy, University of Saskatchewan
Chris Spence, Environment and Climate Change Canada
Jared Wolfe, University of Saskatchewan
Colin Whitfield, University of Saskatchewan

***Correspondence:** kevin.shook@usask.ca

Keywords:
Prairie, water management, drainage, modelling

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting; Stakeholder engagement and knowledge mobilization

Abstract:
The hydrography of the Canadian Prairies is complex due to the presence of millions of depressions which trap direct rainfall, blowing snow and surface runoff, and is becoming more complex due to the drainage of these depressions. Currently, there are no operational tools available to assess the effects of proposed drainage, although several research models have been developed. To guide water management decisions, operational tools need to be able to simulate changes in return-period flows and inundated areas at hectare scales and to incorporate detailed hydraulics including water management practices. These tools need to be applicable by practising hydrologists who need hydrological information and have a good understanding of local hydraulics and water management. Here a strategy for building a tool to assess Prairie wetland drainage management using cutting-edge hydrology and hydraulics procedures is presented. Virtual basin hydrological models developed in the first phase of the GWF Prairie Water project using a research model are used to simulate long-term time series of precipitation, upland runoff, streamflow and evaporation for different typologies of Prairie basins, for current and future climates. These hydrology simulations are used to drive simulations of detailed local conditions by hydraulic models. The streamflows and inundated area outputs of the linked hydrology-hydraulic modelling system can be used to determine changes in return-period values with changes in the water management and/or climate. An early prototype of the system is demonstrated.

Title: Creating a Site-Specific Practitioner Tool for Implementing Source Water Protection

Authors:
Hugh Simpson, University of Guelph
John Fitzgibbon, University of Guelph
Jim Myslik, JM Consultants
Charles Lalonde, Ontario Federation of Agriculture
Kevin McKague, Ontario Ministry of Agriculture, Food and Rural Affairs
Don King, Soil Resource Group

***Correspondence:** hugh@uoguelph.ca

Keywords:
Source Water Protection, Risk Management, Stakeholder Engagement, Knowledge Mobilization, Agriculture

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
Source water protection is the first of a five-part multi-barrier approach for protecting municipal drinking water supplies. Source Protection Planning is an approach to source water protection being implemented in Ontario under the authority of the Clean Water Act, 2006. Central to this approach is the development of site-specific Risk Management Plans (RMPs) between regulators and landowners. A critical problem associated with this process is which approach should be used when developing RMP format and content. One option is the traditional expert-driven approach where the regulator determines unilaterally how risks will be managed. An alternative involves a collaborative approach where risk management outcomes are negotiated by regulators with landowners, integrating different types of expert science, local knowledge, and community beliefs and values. This approach can assist regulators who have little or no knowledge of the science associated with a specific land use, and the effectiveness, relative cost and operational considerations associated with risk management alternatives. This paper presents a case study concerning a risk management framework and workbook developed by the Ontario Farm Environmental Coalition. The framework provides a tool to help farmers to identify on-farm risk management measures, and lays a foundation for farmers and regulators to negotiate RMPs.

Title: A transdisciplinary approach to reducing eutrophication and harmful algal blooms

Authors:
Danielle Spence, University of Saskatchewan
Helen Baulch, University of Saskatchewan

***Correspondence:** danielle.spence@usask.ca

Keywords:
eutrophication, harmful algal blooms, transdisciplinary research, choice experiments, ecosystem services

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
Addressing human-induced nutrient pollution of freshwater lakes, known as cultural eutrophication, is becoming increasingly urgent. Globally, there is concern over worsening harmful algal blooms (HABs) associated with eutrophication and predictions that climate change will further intensify current stressors. Eutrophication and HABs have economic, social, and environmental consequences, including the loss of ecosystem services such as recreational utility, clean water for drinking, and habitat for animals. While much is known about cultural eutrophication and HABs, there are fewer examples of successful management of affected lakes than case studies of degraded lakes, potentially due to neglect of the local context. The local context can be accounted for by adopting a transdisciplinary approach, in which academics as well as rights- and responsibility-holders collaborate to share local insights and develop robust, adaptive strategies for managing eutrophication. Therefore, this research proposes to adopt a transdisciplinary approach to contribute to the development of successful management strategies for reducing cultural eutrophication in freshwater lakes. This proposed research will review the literature on in-lake eutrophication reduction techniques to determine the extent to which the effects on ecosystem services have been addressed, specifically focusing on the inactivation of nutrients within lakes. Additionally, choice experiments will be developed in collaboration with local rights- and responsibility-holders. These choice experiments will be used to determine public preferences for the application of nutrient inactivation techniques in specific eutrophic lakes. By determining the socially preferred techniques and investigating the benefits they provide in terms of ecosystem service recovery, this research will contribute to more effective management strategies for cultural eutrophication.

Title: The Role of Global Water Futures in Advancing Canada's Research Data Management Ecosystem

Authors:
Michael Steeleworthy, Wilfrid Laurie University
Bhaleka Persaud, University of Waterloo
Gopal Saha, Wilfrid Laurie University
Krysha Dukacz, McMaster University
Laleh Moradi, University of Saskatchewan
Stephen O'Hearn, University of Saskatchewan

***Correspondence:** msteeleworthy@wlu.ca

Keywords:
Research Data Management, Data Policy, Digital Research Infrastructure, Tri-Agency Policy

Primary meeting theme: Turning research into policy and management solutions
Cross-cutting challenges and opportunities: (Big) data science and management

Abstract:
Data Management (DM) is an integral component of the Global Water Futures (GWF) research enterprise, connecting researchers, indigenous and settler communities, governments and other stakeholders in the collection, access, use and preservation of our research data and publication outputs. With the recent commitment of a funded Digital Research Infrastructure (DRI) organization to better connect the computing, infrastructure, and service capabilities of organizations such as Compute Canada, CANARIE, Research Data Canada (RDC) and others, the data management landscape in Canada stands to experience significant change that will bring benefits to research and scholarship, as well as public access and citizen science. GWF's DM team has deep connections to the Canadian Research Data Management (RDM) policy and organizational landscape and has aligned its work to meet both GWF goals and the national RDM interest. This presentation will introduce you to the critical DM stakeholders and services, explain changes to Tri-Agency policy, and show how the GWF DM team's work is both informed by and is guiding the broader DM ecosystem in Canada.

Title: Tile Drainage in Vertisolic Soils of near-level Southern Manitoban Landscapes – Implications on Runoff and Water Quality

Authors:
Kokulan Vivekananthan, University of Waterloo
Merrin Macrae, University of Waterloo
David Lobb, University of Manitoba
Genevieve Ali, University of Guelph

***Correspondence:** kvivekan@uwaterloo.ca

Keywords:
Phosphorus, Runoff, Tile drainage, Water quality, Agriculture

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: From anthropogenic pressures to ecosystem services
Cross-cutting challenges and opportunities: Stakeholder engagement and knowledge mobilization

Abstract:
The installation of tile drainage systems in Southern Manitoba has been accelerating over the past two decades to improve crop production. Given current environmental and political concerns related to agricultural pollution and the eutrophication of Lake Winnipeg, the role that tiles may play in both runoff and nutrient loading from agricultural fields must be evaluated because tiles can also have environmental consequences due to their capacity to export significant quantities of pollutants such as phosphorus (P) and nitrogen (N) from croplands by acting as subsurface lateral conduit pathways. This study examined surface and subsurface runoff from tiled and non-tiled fields on a farm in Elm Creek, Manitoba from 2015 to 2017 to quantify the edge of field runoff and nutrient losses and to characterize surface-tile connectivity through the vadose zone. The findings from this study suggest that tile drainage will not increase the edge of field runoff and P losses in this region. In fact, tile drains were responsible for 11-28% annual runoff losses, < 5% annual P losses and 40-50% annual nitrate N losses. Significant tile flow predominantly occurred in late spring under wet antecedent conditions when the water table was elevated. During such periods, the chemistry of tile drain effluent was similar to that of groundwater, which was low in P and high in N. In contrast, tile drainage in both early spring (snowmelt) and summer was small. During snowmelt, when most runoff occurs in the Prairies, tile drainage was impeded by the presence of frozen ground and most runoff left fields as overland flow. In addition, the presence of tile drainage did not significantly reduce the occurrence of the overland flow in this landscape. The observations suggest that tile drainage may have agronomic benefits by dewatering the soil profile during late-spring and summer, which may reduce crop losses that typically occur when saturated conditions prevail. However, these potential benefits must be carefully approached considering the inefficiency of the tile drainage to significantly reduce overland flow runoff and its associated nutrient losses in this region. In addition, tiles may also exacerbate the nitrogen problem in this region.

Title: Assessing impacts of current and novel wildfire management techniques in black spruce dominated peatlands

Authors:
Sophie Wilkinson, McMaster University
Patrick Deane, McMaster University
Greg Verkaik, McMaster University
Mike Waddington, McMaster University

***Correspondence:** jmw@mcmaster.ca

Keywords:
wildfire, peatland, management, stakeholder, boreal

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Climate-driven changes of water environments in cold regions
Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management; Stakeholder engagement and knowledge mobilization

Abstract:
Wildfire currently impacts over 1500 km2 of peatlands annually across the Boreal, including areas along the expansive wildland-society interface. As annual area burned increases the area of peatlands disturbed is also likely to increase, whilst pressures on fire management resources intensify. Black spruce dominated peatlands are particularly vulnerable to wildfire disturbance because of their substantial above-ground (i.e. black spruce stands) and vast below-ground fuels (i.e. carbon-dense peat). However, research into best management practices regarding wildfire management techniques in black spruce peatlands is limited. We tested the effects of a traditional, hand-thinning, fuel modification treatment in a black spruce peatland in north-central Alberta using an experimental fire. Although fire-head intensity was reduced, the rate of spread and depth of burn were not significantly different between treated and control stands. Sphagnum moss groundcover effectively limited depth of burn in both stands, supporting research from natural wildfires. Hence, novel fuel modification treatments have been developed specifically aiming to reduce depth of burn by limiting smouldering combustion. We implemented tree removal (thinning and clear-felling) in combination with compression of the ground surface with the aim of short-term increases in fuel moisture and long-term promotion of Sphagnum moss growth. Fuel moisture and bulk density, combined to calculate smouldering combustion potential, were measured across plots in a full factorial design. Evaporation rates were not significantly different between species-compression combinations in the control or thinned treatments, however, in the clear-fell treatment Sphagnum (Sph) evaporation rates were significantly higher than feathermoss (FM). Compression (comp) increased the bulk density of moss/peat, however, this was not always concentrated within the top 5 cm of the peat profile. In general, fuel moisture followed the trend comp-Sph > Sph > comp-FM > FM and smouldering potential was lowest in comp-Sph. Compression reduced the smouldering potential of FM, where some comp-FM samples maintained below threshold conditions, whereas natural FM was always above the threshold to smouldering combustion vulnerability. These initial results directly feedback to the development of adaptive and proactive management of black spruce dominated peatlands that are under increasing pressures from climate-mediated changes to the Boreal

Title: Assessing the Impact of Payments for Watershed Services on Xin'an River's Water Quality Using the Synthetic Control Method

Authors:
Qingmin Zeng & Roy Brouwer, University of Waterloo
Yurong Wang, Nanjing Agricultural University
Ligen Chen, Nanjing Agricultural University

***Correspondence:** qingmin.zeng@uwaterloo.ca

Keywords:
Payments for Watershed Services, Xin'an River, Water pollution, Impact assessment, Synthetic control method

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Turning research into policy and management solutions

Abstract:
This study aims to assess the impact of a newly introduced provincial Payments for Watershed Services (PWS) scheme on water quality in the Xin'an River in Eastern China. This PWS scheme has played a pivotal role in the design and implementation of PWS in China. In order to test the causality between the PWS and water quality improvements in the prefecture city of Huangshan in the province Anhui on the border with Zhejiang province where the river flows into Qiantang River and ultimately drains into the East China Sea, the synthetic control method (SCM) is applied, using panel data from 82 other prefecture cities across six different provinces in China. The results show that industrial water pollution intensity in synthetic Huangshan City decreased sharply from 6.465 tons per ten thousand Yuan in 2011 to 1.934 in 2016, but it is always higher compared to actual Huangshan City. The difference between the synthetic and actually observed pollution levels decreased from 54.1% in 2011 to 36.6% in 2016. Although additional testing confirms causality, the effect of the PWS scheme shows a declining trend in time. The application of the SCM is a promising new avenue in the evaluation of PWS schemes worldwide, but depends crucially on the availability of appropriate data and information.

Title: Autofluorescence monitoring of cyanobacterial cells for early warning based on microflow cytometry

Authors:
Yushan Zhang, McMaster University
Changqing Xu, McMaster University

***Correspondence:** zhang749@mcmaster.ca

Keywords:
cyanobacteria, biosensor, microflow cytometry, fluorescence

Primary meeting theme: Turning research into policy and management solutions
Secondary theme: Innovations in water science and technology
Cross-cutting challenges and opportunities: Social, economic and health determinants and impacts

Abstract:
Autofluorescence monitoring of cyanobacterial cells for early warning based on microflow cytometry
Cyanobacterial blooms have been a growing concern due to its potential risks to environment, public health and economy. Traditional laboratory method needs trained personnel to count cells and determine the cell morphology of various species under a microscope. Various sizes and shapes of cyanobacteria cells makes the traditional counting method very difficult for untrained personnel. More importantly, a quick response time is needed for decision-makers to reduce the impacts of harmful cyanobacterial blooms. The use of photosynthetic pigments for the rapid detection of cyanobacterial cells have been studied in recent years. All cyanobacteria contain phycocyanin (PC) and chlorophyll a (chl-a). However, PC pigment and chl-a have different excitation and emission spectra. Freshwater cyanobacteria PC pigment absorbs orange and red light (maximum at 620 nm) and has a maximum emission at around 650 nm. While chl-a can be excited by blue light (410 to 430 nm) with an emission maximum at 685 nm. Therefore, PC could be a useful tool for classification of cyanobacteria and other microorganisms.
The aim of this study was to prevent the cyanobacterial blooms at the very beginning based on an early warning system to detect cyanobacterial cells in freshwater. In this study, a microfluidic device based microflow cytometer was designed and fabricated for the characterization of cyanobacteria cells. A laser beam of 10 µm was focused in the centre of the microchannel to excite the individual cyanobacterial cell and the in vivo fluorescent signals were collected by a photomultiplier tube (PMT). As the PC content of cyanobacteria is proportional to the cell volume, the microflow cytometer is sensitive enough to distinguish cyanobacterial cells and other microorganisms based on the autofluorescence without extraction.

Title: The influence of warming and drought in soil CO2 flux in a temperate coniferous and deciduous forest ecosystem

Authors:
Yueqian (David) Ma, McMaster University
Myroslava Khomik,
M. Altaf Arain,

***Correspondence:** may118@mcmaster.ca

Keywords:
Soil, Coherence, Temperature, Modeling

Cross-cutting challenges and opportunities: Transferable knowledge and tools; Predictive modelling and forecasting

Abstract:
The majority of forest stands in southern Canada were established through afforestation of previously agricultural plots. These forests may become carbon sources instead of sinks due to advances in extreme climate change or weather events. Forest soil carbon contains two primary types of carbon that are released at different turnover rates: recalcitrant and labile carbon. Recalcitrant carbon compounds release slowly from the soil and contain lignin. Labile carbon compounds are derived from starches and sucrose which decompose faster. In this study we used nine automated soil chambers (LI-8100A, LI-COR inc.) to monitor continuous soil respiration fluxes in two forests in southern Ontario that possess different structural characteristics: 1) a 45-year-old homogenous white pine plantation forest, and 2) a 90-year-old heterogenous mixed hardwood deciduous stand during 2018, a year characterized with extreme droughts and wet periods during the growing season in this region. The purpose of this study was to examine the temporal covariance between soil temperature (Ts) and soil respiration (Rs) at half-hourly resolution and identify differences in Rs between stands. Both Ts and Rs contributed primary to decomposition in soil organic matter. Coherence shows that decomposition was driven by Ts during spring (recalcitrant carbon release) and during fall (senescence; labile carbon release). We also show that prolong periods of dry events in June, July, and August may have generated increased litterfall and promoted Rs. Periods of lag within coherence during October to November was primarily caused by soil moisture increases due to precipitation event and wet periods. We tested the performance of multiple empirical models (Rs Ts, Rs Ts SM, Rs Q10, Null Model, Ratkowsky, Standford and Epstein, Myers, Bunnell, Lloyd and Taylor, Tuomi, and Gaussian – Gamma) built around soil temperature and moisture using the Akaike information criterion (AICc). The Gaussian – Gamma model displayed the lowest AICc and the best fit with a R2 of 0.83 and 0.76 for TP74 and TPD respectively. Rs was in higher coherence with temperature in the coniferous homogenous forest in in the heterogenous deciduous forest. Our findings indicate that the carbon pool of plantation forests may be less resilient to increasing temperatures. Future studies should continue to examine the relationship between Ts and Rs during extreme weather years within plantation forest stands.

Title: How to Use Compute Canada

Authors:
Stephen O'Hearn, Global Institute for Water Security, University of Saskatchewan

***Correspondence:** stephen.ohearn@usask.ca

Keywords:
High Performance Computing, Compute Canada, Graham, Copernicus, Plato

Cross-cutting challenges and opportunities: Transferable knowledge and tools; (Big) data science and management

Abstract:
GWF researchers have at their disposal Compute Canada's massive Graham supercomputer cluster with over forty thousand computing cores and thousands of terabytes of storage. Yet many researchers have been reluctant to harness the power of this resource. Perhaps many prospective users remain daunted by the perception of insurmountable learning curves associated with submitting jobs, working with Linux, and performing parallel computation, and they may not quite know where to begin.
This poster introduces the most common, everyday commands for using Compute Canada's Graham cluster, including logging into the cluster, navigating around its Linux file system, extracting, archiving, and transferring files, loading modules, compiling programs, submitting jobs, and collecting the results. All concepts presented are reinforced through a well-explained, straightforward example program that uses Monte Carlo simulations to approximate the value of pi (3.14). The reader will become familiar with how to compile a program suitable for parallel execution and submit a job to Graham's scheduler to execute 128,000 simulations in parallel using 4 nodes and 32 cores per node. With this understanding, the reader will be able to apply similar sets of commands to accomplish their own high-performance computing work on Graham and other Compute Canada clusters (as well as on Plato and Copernicus) as these clusters have identical software stacks.

Title: Incorporating hillslope-scale subsurface flow in watershed models: an upscaling approach

Authors:
Mark Ranjram, University of Waterloo
James R. Craig, University of Waterloo

***Correspondence:** mranjram@uwaterloo.ca

Keywords:
upscaling, hillslope, modelling, groundwater, subsurface

Cross-cutting challenges and opportunities: Predictive modelling and forecasting

Abstract:
There is an established link in the literature between storage and outflow in a watershed. This relationship is commonly characterized using a power-law function, wherein the subsurface is a reservoir that releases water to the outlet at a specified rate. Previous studies have explored the connection between the parameters of this watershed-scale relationship and the sub-watershed-scale flow response of individual hillslopes. In this work, we extend this analysis by incorporating a more complex understanding of the subsurface as suggested by the literature. Specifically, hillslopes are able to incorporate: the transient influence of watershed-specific recharge data in establishing initial storage conditions; the planar shape of the hillslope as derived from topography; vertical heterogeneity in hydraulic conductivity; and the choice of downslope boundary condition. A major limitation of added complexity in previous studies has been the associated computational cost of numerical solvers required when deviating from a highly-idealized characterization of the subsurface. This work is completed using a novel methodology that allows any user to employ the results of costly, high-quality numerical simulations without the associated computational time. The efficacy of this methodology is demonstrated.