Climate and Hydrology – Part 1 (Room: Salon C) **May 15** **Chairs: Dave Rudolph and Sean Carey**		
Time	**Presenting Author**	**Presentation Title (Click to see abstract)**
10:30 – 10:45	Jesse He	Relating groundwater processes and properties of surficial deposits in the Rockies
10:45 – 11:00	Benjamin Roesky	Variability in groundwater temperature discharging to a first order alpine stream as a function of flow path
11:00 – 11:15	Laura Beamish	Hydrogeologic controls on groundwater discharge to fall and winter streamflow in the Canadian Rocky Mountains
11:15 – 11:30	Zhe Zhang	Modeling Groundwater Response to Climate Change in North America Prairie Pothole Region
11:30 – 11:45	Julie Thériault	Storms and Precipitation Across the Continental Divide Experiment (SPADE): Overview of the current field project
11:45 – 12:00	Brock Tropea	Assessing Past and Future Freezing Rain and Wet Snow Events in Manitoba Using a Pseudo Global Warming Approach
12:00 – 12:15	Mohamed Ali Ben Alaya	An approach for projecting future probable maximum precipitation from regional climate models
12:15 – 12:30	Francis Zwiers	Larger increases in more extreme local precipitation events as climate warms
Climate and Hydrology – Part 2 (Room: Salon C) **May 16** **Chairs: Julie Thériault and Mike Waddington**		
Time	**Presenting Author**	**Presentation Title (Click to see abstract)**
13:50 – 14:05	Aaron Berg	Retrieval of soil moisture information in boreal forests
14:05 – 14:20	Manuel Helbig	Increased contribution of peatlands to boreal evapotranspiration in a warming climate
14:20 – 14:35	Brandon Van Huizen	Using Geospatial methods to identify spatial and temporal patterns of Ice-Free Conditions in a Boreal Peatland
14:35 – 14:50	Nicole Balliston	Determining the role of confining layer thickness on peatland drainage in a mine impacted radius
14:50 – 15:05	Matt Morison	Peaty Scorch: Boreal Peatlands Show Reduced Evapotranspiration and Productivity 2-3 Years Post-Burn
15:05 – 15:20	Sylvain Jutras	Forest hydrology research at the Forêt Montmorency, Québec
15:20 – 15:35	Alanna Bodo	Understanding the effects of different forest management regimes on water fluxes in a temperate pine plantation
15:35 – 15:50	Stéfan Sauer	Development and testing of an integrated ecohydrological modelling system (MESH-CTEM)
Climate and Hydrology – Part 3 (Room: Salon C) **May 17** **Chairs: Saman Razavi and Phil Marsh**		
Time	**Presenting Author**	**Presentation Title (Click to see abstract)**
08:30 – 08:45	Kriti Mukherjee	Reanalysis of long-term mass balance records of Peyto and Place Glacier
08:45 – 09:00	Branden Walker	Seasonal development of tundra snow depth and water equivalent using UAS remote sensing and in-situ observations

09:00 – 09:15	Evan Wilcox	Controls on Hydrological Variability of Tundra Lakes in the Mackenzie Delta Uplands
09:15 – 09:30	Michael English	Water security and hydroelectric power generation in the Northwest Territories
09:30 – 09:45	Lindsey Langs	A mixed methods approach to quantifying and understanding subalpine forest water use during two hydrologically differing growing seasons in the Canadian Rocky Mountains
09:45 – 10:00	Mohanad Zaghloul	Toward identifying a seasonal streamflow marginal distribution for Canada
10:00 – 10:15	Kevin De Haan	Investigating Effects of Environmental Properties on Water Use Efficiency and Growth of Maize and Alfalfa crops in Southern Ontario
10:15 – 10:30	Bruce MacVicar	Local and Network Scale Changes to Sediment Transport in Urban River Channels
Human Dimensions and Hydro-Economics – Part 1 (Room: Blair Nelson) **May 15** **Chairs: Roy Brouwer and Sarah Dickson**		
Time	**Presenting Author**	**Presentation Title (Click to see abstract)**
10:30 – 10:45	Eric Asare	A Sub-Basin Scale Analysis of the Private Costs and Benefits of Wetland Drainage Scenarios
10:45 – 11:00	Oscar Zapata	Equally unequal in income level and water consumption? The analysis of inequality in water consumption in the residential sector
11:00 – 11:15	Syed Mustakim Ali Shah	Integrated Water Resources Planning and Management of the Complex, Transboundary Saskatchewan River Basin in Canada
11:15 – 11:30	Patrick Lloyd-Smith	The Economic Value of Water-based Recreation in Canada
11:30 – 11:45	Leila Eamen	The Economic Response to Water Availability due to Climate and Policy Change in the Saskatchewan River Basin
11:45 – 12:00	Ana Frank	Science for decision making: are we set to provide it?
12:00 – 12:15	Nancy Doubleday	Keys to Adaptive Water Futures: Governance, Engagement and Equity
12:15 – 12:30	Bereket Isaac	Linking Water Governance in Canada to Global Socio-economic Drivers: the Case of Demographic Changes
Human Dimensions and Hydro-Economics – Part 2 (Room: Salon B) **May 16** **Chairs: Corinne Schuster-Wallace and Patrick Lloyd-Smith**		
Time	**Presenting Author**	**Presentation Title (Click to see abstract)**
13:50 – 14:05	Philip Loring	Unpacking wicked water problems: conflict and agricultural water management in the prairies
14:05 – 14:20	Mohammad Ghoreishi	An Agent-Based Agricultural Water Demand modeling for Human Adaptive behaviors
14:20 – 14:35	Sarah Newell	Small community response to forest fires and flooding in the Boreal.
14:35 – 14:50	Terry Mitchell	First Nations on Indigenous water Stewardship and Community-based Monitoring
14:50 – 15:05	Meghan Brockington	On-the-Land with Communities in the Northwest Territories: Engaging, Educating, and Empowering Indigenous Youth

15:05 – 15:20	Dawn Martin-Hill	Water as medicine: Digital storytelling as a tool in documenting water anxiety in Indigenous youth in Six Nations
15:20 – 15:35	Christine Wekerle	Indigenous youths' relationships with water: Trauma, advocacy, and resilience
15:35 – 15:50	Robert Patrick	Kikawinaw Askiy: Climate Change Adaptation Planning at Okanese First Nation, Treaty 4 territory, Saskatchewan
Human Dimensions and Hydro-Economics – Part 3 (Room: Salon B) **May 17** **Chairs: Graham Strickert and Anthony Johnston**		
Time	**Presenting Author**	**Presentation Title (Click to see abstract)**
08:30 – 08:45	Bill Marion	Impacts of Flooding: Lived Experiences in Two Saskatchewan First Nation Communities
08:45 – 09:00	Lori Bradford	A Social Psychology of Flooding on Reserves in Saskatchewan
09:00 – 09:15	Anuja Thapa	A Participatory Approach to Enhance and Measure Social Learning for Flood Preparedness in Mistawasis Nêhiyawak
09:15 – 09:30	Miguel Sioui	Learning to be Part of the Land: Directives for Research with Indigenous Peoples
09:30 – 09:45	Nidhi Nagabhatla	Leaving No One Behind'- Guiding vision for Global Water Security
09:45 – 10:00	Kasra Keshavarz	Assessing the viability of transboundary waters agreements under future climate change scenarios – A case study of the Saskatchewan River Basin
10:00 – 10:15	Hayley Carlson	Scenario development from policy discourse in the Nelson-Churchill basin
10:15 – 10:30	Sheri Andrews-Key	Climate Change Adaptation within the Boreal Forest: Linkages between science, management, and policy in sustainable forest management in a Canadian context.
Ecosystems and Water Quality – Part 1 (Room: Salon D) **May 15** **Chairs: Helen Baulch and Emily Cavaliere**		
Time	**Presenting Author**	**Presentation Title (Click to see abstract)**
10:30 – 10:45	Jessica Turecek	Unifying Ecology, Hydrology and Geomorphology: The Relevance of Eco-hydromorphology as a Potential Supra-discipline in River Research
10:45 – 11:00	David Livingstone	Implementation of an environmental monitoring program in the UNESCO Tsá Tué Biosphere Reserve
11:00 – 11:15	Charles-François de Lannoy	Six Nations Water Quality Assessment
11:15 – 11:30	Patricia Chow-Fraser	Health assessment of water resources in two contrasting indigenous communities in Canada: Six Nations of the Grand River, Ontario and the Lubicon Lake Band, Little Buffalo, Alberta
11:30 – 11:45	Pieter Aukes	Examining the Relationship between Dissolved Organic Matter and Disinfection By-Products in the Northwest Territories
11:45 – 12:00	Izabela Jasiak	Defining a legacy pollution footprint: assessing spatiotemporal patterns of arsenic and other metals in sub-arctic lakes using paleolimnology

12:00 – 12:15	Annie Gray	Addressing Barriers to Community-Based Monitoring through Collaborative Development: A Global Water Citizenship Project
12:15 – 12:30	Ben Bondaruk	An Assessment of Water Quality Using Structural Language of Q-analysis
Ecosystems and Water Quality – Part 2 (Room: Salon D) **May 16** **Chairs: Colin Robertson and Nandita Basu**		
Time	**Presenting Author**	**Presentation Title (Click to see abstract)**
13:50 – 14:05	Amir Chegoonian	Remote sensing of lakes to detect and map harmful algal blooms: First steps toward an early warning system for small inland waterbodies
14:05 – 14:20	Melani-Ivy Samson	The Urban Metabolism of the Greater Toronto Area: A Study of Nitrogen and Phosphorus across an Urban, Suburban, and Rural Continuum
14:20 – 14:35	Will Pluer	Agricultural edge of field phosphorus losses in Ontario, Canada: Importance of the non-growing season in cold regions
14:35 – 14:50	Jian Liu	Agricultural Water Quality in Cold Climates: Processes and Management Options
14:50 – 15:05	Serghei Bocaniov	On the role of a large shallow lake in modulating phosphorus loads to Lake Erie
15:05 – 15:20	Homa Kheyrollah Pour	Effects of Winter Conditions on Chlorophyll and Temperature in Lake Erie and Lake Ontario
15:20 – 15:35	Erin Murphy-Mills	Exploring Drivers of Eutrophication in the Western Lake Erie Basin
15:35 – 15:50	Diogo Costa	The Nutrient App: Promoting beneficial management practices acceptance through on-farm instantaneous community-based nutrient sampling
Ecosystems and Water Quality – Part 3 (Room: Salon D) **May 17** **Chairs: Philippe Van Cappellen and Mark Servos**		
Time	**Presenting Author**	**Presentation Title (Click to see abstract)**
08:30 – 08:45	Yuwei Xie	Environmental (DNA) metabarcoding for ecotoxicological assessment of anthropogenic activities
08:45 – 09:00	Peter Kruse	Chemiresistive Sensing Platform for Water Quality Monitoring
09:00 – 09:15	Paul Jones	Next Generation Aquatic Chemistry
09:15 – 09:30	Vinay Patel	Non enzymatic real time phosphate detection using potentiometry
09:30 – 09:45	M. Altaf Arain	Southern Forests Water Future - Ecohydrological responses of different-age conifer and deciduous forests to climate variability and extreme weather events
09:45 – 10:00	Calvin Lei	Effects of elevation on vegetation diversity in Rocky Mountain peatlands.
10:00 – 10:15	Nicola Day	Drivers of land cover change after large fire disturbance in boreal forests
10:15 – 10:30	Katherine Dearborn	Drivers of tree mortality and recruitment in a boreal peatland experiencing permafrost thaw
Modelling (Room: Salon B)		

May 15 **Chairs: Al Pietroniro and Martyn Clark**		
Time	**Presenting Author**	**Presentation Title (Click to see abstract)**
10:30 – 10:45	Alain Pietroniro	Accomplishment of Core Modelling Team
10:45 – 11:00	Martyn Clark	Core Modeling plans
11:00 – 11:15	Yanping Li	High-resolution Regional climate simulation for western Canada
11:15 – 11:30	Vincent Vionnet	Multi-scale snowdrift-resolving modelling of mountain snowpack evolution
11:30 – 11:45	Youssef Loukili	Forensic glacial hydrology of the Slims River piracy and the fate of Yukon's Kluane Lake levels
11:45 – 12:00	Juliane Mai	Status report on the Great Lakes Runoff Inter-comparison Project for Lake Erie (GRIP-E)
12:00 – 12:15	Nandita Basu	Beyond the Mass Balance: A Process Based Approach to Modelling Legacy Phosphorus Dynamics
12:15 – 12:30	Maryam Mohammadiazar	Harmonizing Water Resource Modeling with Indigenous ways of knowing: A Collaboration in Water Stewardship of Saskatchewan River Delta

Determining the role of confining layer thickness on peatland drainage in a mine impacted radius

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Session: Climate and Hydrology

Abstract:
Large volume groundwater extraction has been occurring for 12 years at a diamond mining operation in the James Bay Lowlands. This depressurizes the underlying aquifer, creating the potential for increased downwards seepage from the bog and fen peatlands at the surface. Previous research has identified "high risk zones" near the mine where the underlying confining layer which protects the peatlands from drainage is thinner. However, the longterm impact of deep depressurization in these high risk zones compared to surrounding peatlands is unknown. To determine changes in peat and confining layer elevation, subsidence rods and piezometer nests were installed in 2007 prior to mine operations along a 1.5 km transect ~3.5 km from the mine pit. Subsidence rod, pipe, ground, and water level elevations were measured and hydraulic conductivity (Ksat) tests were completed on each pipe a minimum of twice annually between 2007 and 2018 to determine rates of subsidence and the impact on peat profile hydrology. Peat depth surveys were completed at 40 locations along the transect in 2007 and 2018 to measure change in peat thickness. Results of this analysis show subsidence is occurring both in the confining layer and in the overlying peat, and being further from the mine, waterlevels in the high risk zone declined by more than 100 cm in deeper peat (compared to ~25 cm in the low risk zone). Trends in piezometer Ksat were highly variable, however decreases of Ksat of up to an order of magnitude were observed at the 0.9 and 1.5 cm depths within the high risk zone, while trends in the low risk zone were muted compared to seasonal variation. This results of this research overall demonstrate the high susceptibility of peatlands to drainage and subsidence where the protective confining layer is thinner, in spite of relative proximity to dewatering. This has implications on best management practices for mining operations in the future, which may be required to supplement high risk zones with water in order to preserve peatland functionality and peat structure, particularly in ombrotrophic bogs.

Understanding the effects of different forest management regimes on water fluxes in a temperate pine plantation

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Session: Climate and Hydrology

Abstract:
Future climate change scenarios suggest that forest managers will have to employ climate tailored management regimes to help these ecosystems adapt to the uncertain impacts of climate change and extreme events. Forest management practices may involve partial harvesting or thinning that changes the proportion of live and dead carbon stocks. In this study exchanges of energy, water and carbon, and their response to climatic stress (e.g. drought, extreme heat) is evaluated in variable retention harvesting (VRH) plots in a 79-year-old managed pine plantation in southern Ontario, Canada. This experimental setup is part of Global Water Futures (GWF) Southern Forests Water Futures project and the Turkey Point Observatory. It is comprised of 20 VRH plots (1 ha each), including four different sets of harvesting densities and arrangements (plus one, non-treated control), each replicated four times. These harvesting treatments include either 55% or 33% canopy retention with two different spatial patterns, either uniformly dispersed or aggregated in four circular patches of differing radius. Sapflow sensors (Granier-style) have been installed in two sets of each VRH treatment and two control plots to measure transpiration. Additionally, a roving open-path eddy covariance (OPEC) system has been developed and is being rotated every few weeks between the various VRH plots to measure below-canopy (4.5m above the ground) energy, water and carbon fluxes. For reference, a closed-path eddy covariance system is installed nearby at 34m above the canopy and continuously measures ecosystem level energy, water and carbon exchanges. Through the aforementioned methods, forest evaporation will be partitioned into canopy transpiration and fluxes contributed from the understory (soil evaporation and secondary vegetation). Initial results show significant differences in canopy transpiration and understory evaporation between the different treatment plots. This work will help to gain a more thorough understanding of energy, water and carbon exchanges, and extreme weather impacts on various VRH treatments and to identify which treatment is best suited to enhance water use efficiency and growth of southern managed forest ecosystem in the face of climate change. Such knowledge is crucial for sustainable management of forest ecosystems and development of water resources in the region.

Variability in groundwater temperature discharging to a first order alpine stream as a function of flow path

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Session: Climate and Hydrology

Abstract:
There is growing concern about the effects of anthropogenic climate change on stream thermal regimes. Changes in streamflow, rising air temperatures and decreased shading from wildfires are all expected to contribute to stream warming. The temperature of water plays a fundamental role in the stability of various habitats, including trout that need cold water to migrate and reproduce successfully. In mountain regions, reduced flows in summer months from earlier snowmelt, and rising groundwater temperatures must also be considered. Unfortunately, there have been few field studies on groundwater contribution to streams in alpine environments making it difficult to assess how thermal regimes will be impacted in these settings.

To address this need, research was conducted along a first order alpine stream in the Fortress Ski Area in Spray Valley Provincial Park located in the eastern slopes of the Canadian Rockies. Water temperature was monitored along a 246 m long reach starting at the spring outlet. Meteorological variables were measured at the spring by an on-site weather station.

Downstream cooling, with respect to the spring, was observed in summer months at times when meteorological data predicted warming. Stream gauging indicated an increase in discharge not attributable to surface water inflows. This not only suggests the contribution of groundwater along the reach, but also that this groundwater has a lower temperature than the groundwater discharging at the spring. We found the temperature of this cold and warm groundwater to differ by up to 5.5°C. We attribute this difference to distinct groundwater flow paths. The cold groundwater is a function of average air temperature and snowmelt. The warmer groundwater is modulated in part by an intermittent lake that contributes to discharge at the spring during the summer months. The lake warms from solar radiation, recharges groundwater, which then flows to the spring. Heating of the lake therefore results in higher groundwater temperatures at the spring.

Under a warming climate, a reduced snowpack would likely shorten the duration of the surface expression of the lake. This in turn would reduce the time of warm groundwater contribution to the stream, resulting in stream cooling. This illustrates the complex nature of climate change and the need to further study the effects of both intermittent and non-intermittent alpine lakes on stream thermal regimes.

Seasonal development of tundra snow depth and water equivalent using UAS remote sensing and in-situ observations

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Session: Climate and Hydrology

Abstract:
Arctic tundra environments are characterized by a spatially heterogenous end-of-winter snow distribution resulting from wind transport and deposition. Large spatial variations in snow depth, density and snowpack microstructure result in localized concentrations of water storage across the landscape influenced by topography and vegetation cover. Understanding the distribution of snow across tundra environments is important as the snow accumulation typically accounts for over half of the annual precipitation and is the dominant driver of the hydrological system. Currently, our ability to accurately measure snow has proven difficult and traditional methods often fail to accurately represent small-scale variations in snow cover at catchment scales. Furthermore, the accumulation patterns at landscape scales are poorly documented resulting from technical and environmental limitations. In this study we document spatial variations in snow depth accumulation and ablation across a shrub-tundra catchment as part of the TVCSnow campaign from Trail Valley Creek, NWT. We applied Structure-from-Motion photogrammetry using a fixed-wing Unmanned Aerial System (UAS) resulting in high-resolution snow depth mapping (1 meter) at five key periods of snow accumulation and throughout the snowmelt period. In combination with aerial surveys, snow depth and water equivalent measurements were recorded across the winter accumulation period resulting in a detailed documentation of snow accumulation and ablation for various key landcover types. The ability to capture high-resolution spatio-temporal changes to tundra snow cover furthers our understanding of the relative importance of various land cover types on winter snow accumulation and ablation which has strong implications on the hydrological system during the spring freshet.

Using Geospatial methods to identify spatial and temporal patterns of Ice-Free Conditions in a Boreal Peatland

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Session: Climate and Hydrology

Abstract:
Spring thaw is an important hydrologic period for peatlands in the Western Boreal Plains (WBP) ecoregion where the melting of seasonal ground ice represents an important water input. Seasonal Ground Ice has been shown to represent a potential large source of water near the peatland surface, which may aid in offsetting water losses by reducing available energy for evapotranspiration (ET). This is important because potential evapotranspiration (PET) often exceeds precipitation (P) annually, suggesting that these peatlands persist in a delicate water balance. Projected climate warming for the WBP means better understanding seasonal ground ice melt patterns is warranted, too better predict how they might change in the future. However, the patterns in the high spatial and temporal variability of ice-free conditions and the degree to which there is random or significant patterning is poorly understood. Objective one of this research was to quantify whether there was any spatial variability in depth to seasonal ground ice, elevation of seasonal ground ice, thickness of seasonal ground ice and the melt rate of seasonal ground ice, and to identify exactly where significant clustering was occurring. Objective two was to determine how these spatial patterns may vary at different scales. Initial results show both large and small scale spatial autocorrelation and clustering for each variable. All four variables exhibited some degree of spatial autocorrelation at scales larger than 15 meters. Seasonal ground ice melt rate showed a moderate degree of clustering although it was restricted to one particular area , suggesting that melt rates did not vary significantly across the site. Ice Thickness showed weak clustering, where thicker ice was found along the margins of the peatland compared to the interior, and the initial elevation of seasonal ground ice was found to have clustering that mimicked the elevation gradient at the site. However, superimposed on these larger scale spatial patterns, seasonal ground ice was also found to be clustered at scales less then 5 meters for ice thickness. The degree of clustering appears to be related to the presence of trees. These results suggest that the controls on the timing of seasonal ground ice melt and ice-free conditions varies depending on the scale of the study. This has important implications when conducting energy balance studies that include the spring season. Future work will look to investigate the controls on these patterns.

Assessing Past and Future Freezing Rain and Wet Snow Events in Manitoba Using a Pseudo Global Warming Approach

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Session: Climate and Hydrology

Abstract:
Freezing precipitation events are a major hazard across much of Canada, usually occurring in the form of freezing rain and wet snow and causing significant damage to transportation networks, infrastructure, and vegetation. Under future warming climatic conditions, the spatio-temporal characteristics of precipitation may change, including those of freezing rain and wet snow, but there is considerable uncertainty regarding exactly how these changes will manifest. The focus of this study is characterizing damaging freezing precipitation events within the province of Manitoba and examining their future occurrence within a warmer climate.
To examine these issues, 10 events with freezing rain, wet snow, or a mix of both were identified that impacted Manitoba. These were characterized using data from the Japanese 55-year Reanalysis (JRA-55), several Environment and Climate Change Canada (ECCC) datasets, as well as high resolution Weather Research and Forecasting (WRF) control (CTRL) simulations. To ascertain changes, an accompanying WRF pseudo global warming (PGW) simulation was analysed. Of the 10 events, 8 are within the WRF dataset period (2000-2013).
Large scale and local factors were associated with these events. Most (9 of 10) showed a consistent large scale forcing: a midlatitude cyclone with 500 hPa trough and jet exit enhancing lift, low surface pressure centre nearby, and an atmospheric river. Local factors, such as the elevated terrain of Riding Mountain National Park, influenced 3 or 4 of the events. This arose because the terrain acted as a focal point for precipitation by altering low level temperature and/or wind fields. Terrain is also somewhat co-located with areas of severe ice loading, as calculated by the Canadian Standards Association.
Pseudo global warming simulations reveal an increase in duration and/or extent in 3 of 5 events with freezing rain and 5 of 8 events with wet snow, whereas they decreased or ceased to exist in the other 2 and 3 events, respectively. These changes mainly arose from large scale temperature and moisture increases although local terrain influenced some events. Future analyses of these simulations will include changes in near-surface wind, precipitation accumulation and rate, and possibly ice loading on structures.

Local and Network Scale Changes to Sediment Transport in Urban River Channels

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Session: Climate and Hydrology

Abstract:
The growth of cities is associated with a suite of symptoms of physical and ecological degradation in rivers that together is known as the urban stream syndrome. Despite years of evidence and a range of practices to manage the hydrology and rehabilitate the physical environment, our ability to mitigate or reverse the most damaging symptoms is relatively limited. To better understand how hydrologic change can lead to degradation, we focus on the relatively poorly understood process of sediment transport in urban channels. The objective of the presented work is to quantify this process at two scales, namely the local or 'reach' scale and the broader or 'network' scale. At both scales the work is focused on small catchments (~10 km2) in Southern Ontario with some degree of current or future urbanization.
At a local scale we use field measurements of flood hydrology, channel cross-section changes, and the movement of sediment particle tracers to understand the differences between urban and rural streams. Results show that urbanization without stormwater management results in a tremendous increase in the frequency of disturbance of the bed and degradation due to channel enlargement. In contrast, urbanization with stormwater management can fundamentally change the distribution of particle sizes and the disturbance regime of the bed. We use the 'virtual velocity' of sediment tracer particles, i.e. the rate at which they move per year, to offer a process level understanding of the physical evacuation of alluvial material from urban channels and a direction for future restoration of these channels based on the replenishment of depleted sediment stores.
At a network scale we use an analysis of digital elevation models combined with hydraulic (HEC-RAS) models to assess the magnitude and changes to the magnitude of stream power since urbanization. Stream power allows us to somewhat predict the morphology of these channels where conditioning from the last ice age remains an important control on slope and bed material. The change in stream power since urbanization allows us to identify likely hotspots of erosion within a network and link the model to the economics of channel maintenance and damage to infrastructure. Future work will focus on quantifying the value of preserving natural drainage patterns and investing in low impact development strategies. Work within our GWF project on linking river process models to robust data management systems will allow the results from both scales of analysis to be integrated into user focussed tools. These tools will support decision making on land-use change, stormwater management, and river network restoration.

Controls on Hydrological Variability of Tundra Lakes in the Mackenzie Delta Uplands

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Session: Climate and Hydrology

Abstract:
The Arctic's changing climate is influencing hydrological inputs into thermokarst lakes, which cover large areas of permafrost-underlain regions. Warmer air temperatures are leading to longer ice-free periods and greater evaporation, precipitation is more often falling as rain rather than snow, and deeper frost tables are reducing runoff into lakes. While past research has detailed the general behaviour of lake water balances, the range of hydrological variability in lakes has not been quantified in the Mackenzie Delta Uplands before. The hydrological behaviour thermokarst lakes in similar regions is affected by multiple landscape elements, such as lake area – catchment area ratio (LACA), catchment vegetation cover, and snow storage. To assess hydrological variability in the Mackenzie Delta Uplands, we combined direct and indirect measurements of lake water balance components at multiple spatial and temporal scales across a variety of influential landscape elements.
Lake water balances were calculated for two adjacent lake basins with different LACA's using direct measurements of water level, lake outflow, evaporation, precipitation, and end of winter basin snow storage. Differences in residence time and lake level between the two lakes directly corresponded to their LACA; the lake with a larger catchment relative to its size had a shorter residence time and more variable water levels. Delineation and analysis of 7500 lake catchments in the Mackenzie Delta Uplands showed a large variation in LACA, regardless of lake size. Based on this, we expect a large range of hydrological variability in this region. To assess this, over 120 lakes were sampled for stable water isotopes across a 2000 km2 gradient of boreal forest to shrub tundra. A subset of 62 lakes were resampled after snowmelt, and multiple times through the summer using strategic timing so that the effect of snowmelt recharge, hot and dry periods, and rainfall recharge may be quantified.
Isotope samples will be used to calculate multiple hydrological indicators including evaporation inflow ratio, the amount of snowmelt recharge, the mixture of water input sources, and residence time in each lake. These hydrological indicators will then be compared to multiple landscape and lake elements, such as LACA, vegetation cover, latitude, and lake depth, among others, using multivariate analysis techniques, from which the main controls on lake hydrologic behaviour can be interpreted.

Larger increases in more extreme local precipitation events as climate warms

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Co-Authors:

Session: Climate and Hydrology

Abstract:
Climate models project that extreme precipitation events will intensify in proportion to their intensity during the 21st century at large spatial scales. The identification of the causes of this phenomenon nevertheless remains tenuous. Using a large ensemble of North American regional climate simulations, we show that the more rapid intensification of more extreme events also appears as a robust feature at finer regional scales. The larger increases in more extreme events are found to be primarily due to atmospheric circulation changes. Thermodynamically induced changes have relatively uniform effects across extreme events and regions. In contrast, circulation changes weaken moderate events over western interior regions of North America, and enhance them elsewhere. The weakening effect decreases and even reverses for more extreme events, whereas there is further intensification over other parts of North America, creating an “intense gets intenser” pattern over most of the continent.

Relating groundwater processes and properties of surficial deposits in the Rockies

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Session: Climate and Hydrology

Abstract:
Streamflow from mountain watersheds is regulated by surface deposits such as moraine and talus. These deposits are important conduits and reservoirs of water and can, at times, contribute a majority of flow from a watershed. Groundwater processes within these deposits are affected by spatially varying properties such as porosity and permeability. Characterization of these properties and their variability is therefore a necessary prerequisite towards understanding the discharge behavior of mountain regions. The objective of study is to investigate relationships between groundwater processes and the physical properties of surficial deposits in the Canadian Rockies. To this end, a broad data set spanning several years was collected from the Fortress field site (Kananaskis, Alberta). This data set includes: precipitation and snowmelt (water input); streamflow within and from the site (water output); groundwater levels; and measurements of aquifer properties. Preliminary analysis of these data suggests a relationship between depth and permeability, which may have an important role in controlling discharge from the site. Data was also used to support the creation of a numerical model of groundwater flow. Through model calibration and use, relationships between groundwater processes, governing properties, and watershed discharge will be further investigated.

Storms and Precipitation Across the Continental Divide Experiment (SPADE): Overview of the current field project

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Session: Climate and Hydrology

Abstract:
SPADE investigates the small-scale processes leading to orographic precipitation passing over the continental divide in the Canadian Rockies. A key issue is quantifying the moisture flux that crosses the divide from either the Pacific in eastward moving storms or from the Prairies and Gulf of Mexico in leeside (upslope) storms. To do so, both sides of the divide will be instrumented during May and June 2019. The field campaign makes use of sophisticated equipment such as Doppler scanning lidars, vertically pointing radars, optical disdrometers and hydrometeorological stations. In addition, measurements will be collected at various locations along the continental divide using a portable vertically pointing radar, a microphotography setup as well as hand-held weather instruments. These instruments characterize the precipitation at the surface, the precipitation layer and atmospheric conditions aloft, including the rain-snow transition zone when present. This presentation will give an overview of SPADE and data collected during the first two weeks of the campaign. An attempt will be made to remotely connect with the field participants at one of the SPADE field sites to obtain and visualize data collection in real time. Overall, SPADE will lead to a better understanding of the precipitation processes producing snow and rain across the continental divide in the Canadian Rockies.

Investigating Effects of Environmental Properties on Water Use Efficiency and Growth of Maize and Alfalfa crops in Southern Ontario

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Session: Climate and Hydrology

Abstract:
Uncertainties in future climate and precipitation patterns could pose water availability challenges and changes in moisture stress for crops in Southern, Ontario, Canada. Moisture stress can affect growth and therefore crop yields, which has implications for the water-energy-food nexus. In agriculture, water use efficiency (WUE) is used to provide insight into how water availability affects crop growth. This project investigates the relationships between precipitation and other environmental factors pertaining to WUE for maize and alfalfa forage crops in Southern Ontario. This presentation will provide insights into climate, soil and vegetation impacts on the changes in WUE of these crops at the field scale. Energy and carbon budgets were determined for both sites and used to determine WUE. Correlation analysis links variables to WUE, while a multi-variable analysis is used to determine interdependence of these variables. The results of this study will assist in the discernment of future directions for agriculture in Southern Ontario as we observe changes in water and energy patterns in this region.

Reanalysis of long-term mass balance records of Peyto and Place Glacier

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Session: Climate and Hydrology

Abstract:
Glacier mass balance links meteorological conditions and glacier mass change over a given year. Long-term (>30 year) time series of glacier mass balance at benchmark sites are thus valuable indicators of climate change. These records can also be used to improve hydrologic models that simulate glacier runoff. Glaciological mass balance series may contain errors due to biased or incomplete sampling, logistical constraints, or changes in sampling methodologies, however. Even after accounting for the systematic and random errors of such observations, errors due to climate conditions, surface topography, glacier size and inaccessibility due to avalanches or crevasses may lead to long-term drift in the observational mass balance record. In western Canada, mass balance records that exceed 50 years in length exist for two glaciers (Peyto Glacier in Canadian Rocky Mountains and Place Glacier in the Southern Coast Mountains). Here we reanalyse geodetic and glaciological mass balance observations for Peyto and Place glaciers with the aim to produce homogenized time series of mass change for both glaciers. We use available geodetic mass balance data to calibrate SnowModel which includes a routine to calculate surface mass balance. The North American Lands Data Assimilation System (NLDAS) hourly data of 0.125 x 0.125 degree resolution is used to force SnowModel to produce homogenized annual mass balance (Ba) for Peyto Glacier (1982 – 2015) and Place Glacier (1981-2015). Our modeling also includes an ice dynamics routine to update the surface elevation of the glaciers each year. We compare annual observations and modelled estimates of Ba and provide reanalysed estimates of glacier mass balance and corresponding errors at each site.

Hydrogeologic controls on groundwater discharge to fall and winter streamflow in the Canadian Rocky Mountains

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Session: Climate and Hydrology

Abstract:
Mountain headwaters supply essential water resources to downstream communities and ecosystems. Sustainable management of these resources requires an understanding of hydrologic processes in alpine watersheds. Fall and winter streamflows in the Canadian Rocky Mountains are largely sustained by groundwater discharge, but mountain groundwater processes are poorly understood due to the scarcity of studies in these environments. This study investigated regional variability in mountain groundwater processes using two approaches. First, fall and winter streamflow recessions in 19 watersheds in the Canadian Rockies were analyzed. Then, watershed-scale recession behavior was related to conceptual models of groundwater flow using saturated-unsaturated models of hillslope aquifers. In the first phase of the study, most watersheds were observed to have a two-stage recession characterized by fast exponential decay followed by a period of slower exponential decay. Recessions from all watersheds were fit with piecewise functions to determine recession coefficients and the timing of the transitions between the segments. Variability in recession coefficients was found to explain most variability in mean winter baseflow. Results showed that recession coefficients are geologically controlled: slower recessions and higher winter baseflow were associated with younger, more porous bedrock. Rainier, lower elevation watersheds transitioned to the slow recession phase later in the fall, suggesting that the timing of the transition is climatically controlled. Records from the Bow River at Banff showed that the transition point has been shifting to earlier in the fall, potentially as a result of climatic change. The second, modelling-based phase of the study was in progress at the time of abstract submission and aims to determine if the two-stage recessions can be explained by layering or bedrock topography in dominant hillslope aquifers. Results from this work indicate that both geology and climate control the groundwater processes that sustain fall and winter streamflows in mountain environments.

Increased contribution of peatlands to boreal evapotranspiration in a warming climate

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Session: Climate and Hydrology

Abstract:
The boreal biome covers about 13% of global land area and is dominated by different forest and peatland ecosystems. Evapotranspiration (ET) exerts a major control on boreal freshwater resources, on moisture availability, and on land surface temperatures through evaporative cooling. In a warming climate, increasing vapour pressure deficit (VPD) enhances atmospheric water demand and is expected to lead to increases in ET. However, boreal ET responses to VPD may vary across forests and peatlands and depend on stomatal and soil moisture controls on ET. Here, we analyse how forest and peatland ET responds to VPD using a pan-boreal ET dataset derived from 84 eddy covariance flux tower sites (28 peatlands, 56 forests). Annual and half-hourly ET at the moss-dominated peatlands increases more with VPD than at the vascular plant-dominated forests. However, the ET-VPD relationship is not significant for peatlands and forests in regions where annual potential evapotranspiration exceeds annual precipitation. Earth system models so far have not specifically represented peatlands in their land surface schemes and assume continuous boreal forest cover throughout the boreal zone. Using projected VPD changes at the end of the 21st century (RCP8.5) and observation-driven VPD sensitivity estimates of peatland and forest ET, we estimate the difference of boreal VPD-induced ET changes between a forest-only and a peatland-forest scenario. Differences in ET in peatland-rich ecoregions account for up to 70% of projected precipitation increases, thus, highlighting an increasing contribution of peatland ET in a warming climate. Larger ET in peatland-dominated boreal regions than previously projected may therefore lead to reduced regional freshwater availability and drying, while enhancing the evaporative cooling effect on near-surface air temperatures.

Peaty Scorch: Boreal Peatlands Show Reduced Evapotranspiration and Productivity 2-3 Years Post-Burn

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Session: Climate and Hydrology

Abstract:
Boreal peatlands represent a significant global store of carbon, which are subject to increasing natural and anthropogenic disturbance. Wildfire is the largest disturbance of boreal forest and wetlands annually recovery. Critical to the long-term carbon storage function in peatlands is the (re-)establishment of a near-surface water table. This has been recently shown to in part be facilitated by post-fire reductions in water losses via evapotranspiration (ET), a phenomenon documented previously at the plot-scale. However, reduced ET may also have cascade impacts on other hydroecological processes in recovering peatlands, such as a reduction in carbon sequestration. To investigate the linked cycles of evaporative loss and carbon exchange in burned peatlands, both a burned and unburned ombrotrophic peatland in northern Alberta, Canada, were instrumented with eddy covariance systems to monitor continuous fluxes of energy, carbon dioxide, and water vapour, over two summer seasons (2013 and 2014; 2-3 years post-burn). The burned site showed significant reductions in ET, respiration, and productivity, including a shift in the partitioning of available energy (decreases in Bowen ratio). The decrease in respiration did not fully offset the decrease in primary productivity, and the burned site was significantly less productive than the reference site on a net production basis. This work builds on previous investigations of evaporative reductions in burned boreal ecosystems, providing direct observations of evapotranspiration and CO2 fluxes at a novel ecosystem scale to show the impacts of fire on short-term (2-3 years) post-burn ecosystem hydroecological function.

An approach for projecting future probable maximum precipitation from regional climate models

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Session: Climate and Hydrology

Abstract:
In the context of climate change and projected increase in global temperature, the atmosphere's water holding capacity is expected to increase at the Clausius-Clapeyron (C-C) rate by about 7% per 1°C warming. Such an increase may lead to more intense extreme precipitation events and thus directly affect the probable maximum precipitation (PMP), a parameter that is often used for dam safety and civil engineering purposes. The usual operational approach for projecting PMP changes using regional climate models involves separate PMP calculations for historical and future periods. Two drawbacks of this approach are that these methods are not constructed to quantify the uncertainty of the projected change, and they also implicitly assume climate stationarity within the periods that are compared. We therefore use a statistically motivated approach that quantifies uncertainty and accounts for nonstationarity, which allows us to determine the rate of change of PMP per 1°C warming. The approach is demonstrated by evaluating and comparing projected changes to 6-hourly PMP from two Canadian regional climate models (RCMs), CanRCM4 and CRCM5, over North America. The main results suggest that, on the continent scale, PMP increases in these models at a rate of approximately 4% per 1°C warming, which is somewhat lower than the C-C rate.

Development and testing of an integrated ecohydrological modelling system (MESH-CTEM)

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Session: Climate and Hydrology

Abstract:
An integrated ecohydrological modelling system (MESH-CTEM) was developed by incorporating the coupled Canadian Land Surface Scheme and Canadian Terrestrial Ecosystem model (CLASS-CTEM) in the Modélisation Environmentale Communautaire (MEC) Surface and Hydrology system (MESH). This integrated model is able simulate carbon, water, energy and nutrient cycles from plot to watershed scales and their feedbacks. Model processes are simulated from half-hourly to daily time scales at a spatial grid resolution of 0.02 degree square. Performance of the model was tested by performing simulating from 2005 to 2011 in the Big Creek watershed in Southern Ontario. The Big Creek watershed (573 km2) is an agriculture dominated landscape with significant cover area (~20%) of deciduous and conifer forests. Streamflow data from Environment and Climate Change Canada was used to calibrate MESH-CTEM. Energy, water and carbon flux data from eddy covariance flux towers in conifer and deciduous forest sites from Global Water Futures (GWF) – Southern Forests Water Future (SFWF)'s Turkey Point Observatory was used to validate the forested simulations, while validation of crop simulations conducted from historical energy flux measurements at the Elora station. Compared to the default MESH model, MESH-CTEM showed a significant increase in the simulated streamflow as well as an increase in overall accuracy with a Nash-Sutcliffe value of 0.42. Mean annual evaporation for the needleleaf evergreen forests was calculated as 536 mm yr-1 as compared to observed value of 477 mm yr−1, while simulated mean annual gross ecosystem productivity (GEP), ecosystem respiration (Re) and net ecosystem productivity (NEP) were 1187, 1028 and 159 g C m−2 yr−1 as compared to observed values of 1348, 1184 and 198 g C m−2 yr−1. The simulated catchment-scale averaged annual evaporation was 391 mm yr−1, while GEP, Re and NEP values were 503, 408 and 94 g C m−2 yr−1 respectively. This research will help to include vegetation and climatic feedbacks more accurately in watershed-scaled hydrological studies.

Forest hydrology research at the Forêt Montmorency, Québec

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Session: Climate and Hydrology

Abstract:
At present, there is no other place in Quebec where the hydrometeorology of small forested watersheds (<10 km²) has been studied for as long (> 50 years), and with as much precision than at the "Bassin Expérimental du Ruisseau des Eaux-Volées" (BEREV), located at the "Forêt Montmorency" (FM). Hourly, bi-daily, daily and weekly hydrometeorological data have been collected continuously since 1965. This site has been extensively used to validate various hypotheses related to forest management and its impact on water resources, as well as for forestry hydrology teaching in Quebec. The facility was the subject of over 30 undergraduate, masters and doctoral projects, leading to more than 40 scientific publications and reports between 1980 and 2000. Since his involvement in 2010, Professor Sylvain Jutras has taken over the responsibility of coordinating research activities related to hydrometeorology at the FM. Ongoing projects are:
Boreal Water Futures project: The influence of forest management on hydrology.
As the easternmost site of the Boreal Observation Network, the Montmorency River and the BEREV will both be used to monitor the influence of vegetation change caused by timber harvesting at different scales. Hydrological models such as CRHM will be used in collaboration with GWF researchers.
Improvement of solid precipitation monitoring and snowpack evolution in a forest environment.
The NEIGE site, also located at the Forêt Montmorency, is a unique site for snow measurement and modelling studies. Collaborative research is gathering numerous partners such as ECCC, Quebec Ministry of Environment, Campbell Scientific Can., USherbrooke, UQAM, McGill, UQTR, USaskatoon, Hydro-Quebec, Rio Tinto Alcan. Solid precipitation undercatch, manual and automatic snow water equivalent measurement, and many other scientific issues are studied.
High resolution hydrological modelling combined with energy budget.
This project aims to improve the modelling of evapotranspiration in operational hydrological models to assess the impact of climate change on the water regime of rivers. More than 15 HQP are supervised by ULaval researchers (F. Anctil, D. Nadeau and S. Jutras) and collaborators.
Development of automated tools for stream and wet soils delineation using LiDAR data.
This project is directly linked to the objectives of Québec's Ministry of Forests to produce new high-resolution maps of streams. Field validation combined to robust algorithms are enabling the production of powerful forest and water management tool for both industries and governments.

Toward identifying a seasonal streamflow marginal distribution for Canada

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Session: Climate and Hydrology

Abstract:
In 2013, flood damage in Alberta, Canada was estimated at about CA $6 Billion with more than 100,000 people affected and five deaths. Floods in Canada are a complex phenomenon, and typically affected by the interaction of various hydroclimatic variables, such as summer and spring rain, snow pack and snowmelt, and antecedent soil moisture conditions. The spatial and the temporal interactions of these variables, along with their effects as flood triggering factors, are not fully understood. Multivariate analysis (e.g. copulas) might describe the dependency among these variables and their relationships with peak flow. However, multivariate analysis requires, first, a rigorous univariate analysis of each hydroclimatic variable, including streamflow. The aim of this research is to identify a suitable marginal distribution of streamflow, and explore the assumption that one single marginal distribution could be used to describe daily streamflow observations at 1,119 stations in Canada. In order to identify the marginal distribution, we used the method of L-moments and estimated the sample statistics at a daily scale on a monthly basis. The analysis shows seasonal and regional variation in sample statistics that might invalidate most of the typically used distributions in frequency analysis. To explore the assumption, we formed the theoretical L-spaces of 3-parameter distributions and assessed their potential to describe the observed L-moment statistics in all months and at all regions across Canada. We also built an R package to extend the analysis to eight other climatic variables, aiming to identify their single marginal probability distributions. The identification of a single distribution model that describes each variable will facilitate the construction of multivariate distributions, which will enhance the understanding of flood triggering mechanisms in various regions in Canada.

Water security and hydroelectric power generation in the Northwest Territories

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Session: Climate and Hydrology

Abstract:
Water security in the Northwest Territories is not just about water quality and quantity,
How aquatic and terrestrial ecosystems are responding to accelerated warming in the Northwest Territories has and will continue to be a major concern. The speed with which these changes are occurring has raised questions about water security, which can take many forms in high latitudes regions. Water security concerns cover a wide range of issues, including water quality and the various important forms that water takes, which includes snow and ice. Incursions of warmer air into high latitudes during the winter months impact snowpack structure and snow cover duration. Though perhaps not directly associated with issues of water security, occasional incursions of warm, southern air during negative phases of the Arctic Oscillation are causing a number of impacts, including changes to northern transportation routes (eg. ice roads), changes in snowpack water equivalent (SWE) and snowpack structure, and adding to the myriad of factors negatively impacting barren ground caribou including forest fire occurrence. Of significant concern to 62% of the population of the NWT is the continued operational feasibility of hydroelectric generation in the Snare River basin.
The Snare River system supplies hydroelectric power to about 62% of the NWT population, including the city of Yellowknife. The Northwest Territories Power Corporation (NTPC) operates four hydroelectric facilities along the lower portion of the river, but low water levels and drought conditions in the territory during the last two decades have intermittently and/or completely reduced the possibility of generating hydroelectric power. The International Governmental Panel on Climate Change (IPCC) predicts future amplified warming in the NWT, but is less certain on the future hydrological cycle, particularly how total SWE may be influenced. Accurately assessing SWE before the spring freshet in watersheds providing hydroelectricity to northern communities is imperative as annual snowfall represents about 40% of annual precipitation and more than 80% of annual runoff (Environment and Natural Resources Canada). The importance is amplified by the fact that storage in these northern boreal shield systems is limited due to shallow overburden and presence of widespread discontinuous permafrost. As such the dependency on annual snowpack recharge is significant and thus reasonably accurate estimations of annual SWE in this 14,000 km2 basin are important for management purposes. Over recorded time basin efficiencies (Q/P) are variable with decreasing efficiencies for years leading into severe forest fire summers. As the basin antecedent hydrological conditions become drier it becomes more important to reduce the error in estimates of the annual snowpack for hydroelectric purposes. This paper examines the complexities of determining accurate SWE measurements in a large subarctic basin.

Retrieval of soil moisture information in boreal forests

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Session: Climate and Hydrology

Abstract:
Wildfires are of increasing concen due to their impact on infrastructure, human lives and environment. Therefore, methods for identifying wildfire risk potential are important for wildfire management. The objective of this research was to evaluate the sensitivity of soil moisture products derived from passive microwave observations at L-band within the Canadian boreal forest and identify if these measurements have value for identifying potential wildfire risk. We installed a soil moisture-monitoring network in Central Saskatchewan for evaluation of the retrieval accuracy of the Soil Moisture and Ocean Salinity Mission and Soil Moisture Active Passive mission baseline products. Next we use the National Fire Database (NFDB) points and polygons to classify each of the wildfires for 14 eco-regions within the Canadian boreal forest between 2010-2018. A time series of daily, 3-day, and 7-day soil moisture anomalies prior to the onset of each wildfire occurrence was examined over each of the ecozones. Our results indicate strong negative soil moisture anomalies prior to fire onset. This negative “shift” is statistically significant up to 7-days prior to the onset of the wildfire and may potentially be integrated into risk indicator tools for wildfire preparedness and management.

Modeling Groundwater Response to Climate Change in North America Prairie Pothole Region

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Session: Climate and Hydrology

Abstract:
The groundwater regime in the Prairie Pothole Region (PPR) in North America is strongly impacted by the semi-arid climate and seasonally freeze-thaw soil processes. This complex two-way water exchange between sub-surface soil and groundwater aquifer is underrepresented in previous coupled earth system models. Furthermore, the impacts of climate change on groundwater regime are uncertain. In this paper, we investigate the hydrologic cycle of shallow groundwater in the PPR using a coupled land-groundwater model (NoahMP-MMF) and study its response to climate change at the end of the 21st century. The meteorological forcing for current climate and future climate are from a high-resolution convection-permitting model outputs. The results show that the model reasonably simulates the water table depth (WTD) and the timing of recharge processes, but underestimates its seasonal variation, due to mismatches of the soil types between observations and the model. The most significant change under future climate occurs in the cold season, when warmer temperature changes the rain/snow partitioning and results in later time for snow accumulation/soil freezing and early melting/thawing. Such changes lead to an earlier and longer recharge season, but with lower recharge rates.Different signals are shown in the eastern and western PPR in the future summer, with reduced precipitation and drier soil in the east and little change in the west. As a result, the annual recharge increased by 25% and 50% in the eastern and western PPR,respectively. Additionally, the presence of shallow groundwater in PPR helps buffer the strong evapotranspiration in the summer, which has been neglected in previous projection of future summer climate. This study provides valuable information about the hydrologic cycle under climate change in cold regions and is important for improving the coupling processes between atmosphere and hydrology cycle in earth system models.

A mixed methods approach to quantifying and understanding subalpine forest water use during two hydrologically differing growing seasons in the Canadian Rocky Mountains

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Session: Climate and Hydrology

Abstract:
Fresh water supplies in mountainous regions are at risk as snow and ice stores continue to decline under rising global temperatures, earlier winter snowmelt and changing climate regimes. Alpine forests are of particular importance due to their hydrological connectivity within watersheds such as controlling groundwater base flow, influencing evapotranspiration and snow storage dynamics. A change in the water availability to alpine vegetation could have a drastic effect on the health of these forests, making it imperative to understand the hydrological connectivity of high alpine forests. Study sites located at Fortress Mountain in Kananaskis, Alberta are composed of coniferous tree stands of Abies lasiocarpa and Picea engelmannii. Little is known about water use dynamics of these species at high elevations, specifically the quantity and when they intake their water during the shoulder and growing seasons. In addition, climate model and process based projections show decreases in snowpack depth within subalpine forests. This study used a combination of hydrological and meteorological tools to address coniferous tree water use behaviour before, during and after the subalpine growing season (June-September). Methodologies focussed on determining seasonal transpiration (T) patterns using the non-invasive stem-heat balance method to determine sap flow and eddy covariance to capture stand evapotranspiration (ET) in addition to determining tree source water. Groundwater monitoring wells, soil tensiometers, precipitation gauges, and meteorological stations were used to determine environmental conditions. Stable water isotopes δ18O and δ2H were additionally collected from all source waters (precipitation, snowcover, soilwater, groundwater) in addition to xylem water samples from the coniferous trees within the study area. Understanding tree response to precipitation and drying events was the main objective addressed, yielding stark differences between the growing seasons of 2016 and 2017. Stand T was higher in 2017 (165mm) than 2016 (118mm) despite a much drier and warmer season (213mm of rain compared to 283mm). A deeper, sustained snowpack in 2017 coupled with higher net radiation allowed for higher T rates, helping to address the second objective: which hydrological sources are most important to tree productivity. Well draining soils and shallow depth to bedrock determine a lack of groundwater accessibility for studied trees, thus soil moisture appeared to supply a majority of water to the tree population during mid growing season. Dry conditions in 2017 showed a clear trend between soil moisture levels and tree water use, with 2016 having almost double the soil moisture and tree productivity in the tail end of the growing season. For 2017, 7% of the season's total T occurred with average volumetric water content (VWC) of 0.15 compared to 2016's 14.5% and VWC of .30. Stable water isotope results in 2017 helped conclude which water sources the trees were using throughout the growing season, and which were most valuable for growth. By closely examining the patterns of alpine tree water use, we can begin to clarify how these important ecosystems services will be impacted under a changing climate in addition to helping us better manage our forestry and freshwater resources.

Remote sensing of lakes to detect and map harmful algal blooms: First steps toward an early warning system for small inland waterbodies

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Session: Ecosystems and Water Quality

Abstract:
Small inland waterbodies play a critical role in human and animals' lives; however, studies show increasing degradation in their water quality in recent decades, particularly due to harmful algal blooms. There is a great interest in establishing early warning systems for small inland waterbodies, which can help to detect, identify, map, and even forecast harmful algal blooms. Remote sensing, as a technology, has proven its capability to detect and map harmful algal blooms in coastal waters as well as big lakes. However, there is still no remote-sensing-based early warning system for small inland waters. Using Sentinel-2/-3, Landsat-8, and UAV imaging, complemented by extensive in-situ water quality measurements, we present the framework of an early warning system for Buffalo Pound Lake, Saskatchewan. We develop site-specific criteria and thresholds of a 'bloom' and of 'harmfulness', and define a two-step (nowcasting and forecasting) conceptual model for the system, specifically designed for harmful algal blooms. Then, focusing on the first step (nowcasting component), we propose the design and implementation elements of the system to detect and identify harmful algal blooms using remote sensing technologies. We also describe a semi-automatic process that has been designed and implemented for the estimation of chlorophyll-a concentration using remote sensing observations, providing examples of the capabilities of the system in development.

Drivers of land cover change after large fire disturbance in boreal forests

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Session: Ecosystems and Water Quality

Abstract:
Fire is the dominant disturbance in boreal forests but climate change is causing increased wildfire activity in the North. Evidence shows these altered fire regimes could lead to shifts in forest structure and changes in land cover. For example, there have been sustained shifts from conifer to deciduous dominance after severe fires in Alaska, which has implications for ecosystem functions such as wildlife habitat, nutrient cycling, and ecosystem-protected permafrost. The generalities of these patterns to other regions of the boreal forest after large fire events is unclear. Our overall aim was to investigate forest regeneration after a large fire event in high latitude boreal forests to understand drivers of land cover change across the Taiga Shield and Taiga Plains. The Northwest Territories (NWT) of Canada experienced the largest fire event on record in 2014, with 2.85 Mha burning. We established 221 permanent sites across seven burn scars and assessed regeneration of canopy species by counting seedlings. We assessed regeneration of understory plants and recorded their regeneration modes: from seed or from underground structures that survived the fires (rhizomes). We also undertook DNA sequencing and culturing of the post-fire fungal, including mycorrhizal, communities to relate them to vegetation regeneration. Our results showed that on the Taiga Plains, jack pine increased post-fire across the landscape, even in sites that were previously dominated by black spruce. On the Taiga Shield there was a shift towards paper birch dominance. Further, we found that most of the understory plants survived the fires through underground structures, enabling plants to rapidly regenerate post-fire. This was particularly apparent in areas with thick organic soil layers and poor drainage. The composition of regenerating understory communities were weakly but significantly correlated with mycorrhizas supporting that there are important relationships between above and belowground communities post-fire. Overall, this study suggests that landscape-level hydrology helps to predict the resilience of forest vegetation to wildfire. It further suggests the need to investigate regionally-specific drivers of land cover change to better predict impacts of a changing fire regime on forest structure.

An Assessment of Water Quality Using Structural Language of Q-analysis

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Session: Ecosystems and Water Quality

Abstract:
Water quality monitoring data is often characterized by rich attribute information representing a suite of water quality parameters, discrete spatial sampling and dense temporal samples. While community-based monitoring networks have increased in recent years, drawing insights from this data remains a challenge requiring expert interpretation. New approaches to data visualization and analysis of complex structured datasets may provide ways to help close the gap between data and understanding. Q-analysis is a language of structure used to study global and local dynamics of complex systems. For the spatial analysis problems with the emphasis on water quality and health, it is a challenge to establish a well-defined connectivity patterns among various water components. This study explores the use of Q-analysis for Mackenzie DataStream monitoring program to analyze connectivity patterns between system components over a discrete representation of space in order to recognize the overall behaviour of a system and identify areas of water system vulnerability. In particular, using the notions q-nearness and q-connectivity a series of relations is established between water components and explicit spatial locations to describe severity effect in ecologically vulnerable areas for varying definitions of vulnerability. This approach is an effective tool for acquiring significant understanding of the complex structure of the aquatic ecosystem, which might help to facilitate decision making processes in ecological policy and sustainable environment in the future.

Effects of elevation on vegetation diversity in Rocky Mountain peatlands.

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Session: Ecosystems and Water Quality

Abstract:
Rocky mountain peatlands in the Upper Bow River Basin are poorly understood systems, uncharacterized and unmapped by the government in Alberta, Canada. I characterized vegetation biodiversity of mountain peatlands and identified the changes in vascular plant and bryophyte composition across an elevation gradient. To investigate changes in plant community composition, I selected eleven sites ranging from 1415 – 2102 meters above sea level where I measured the abundance of vascular plant and bryophyte species along transects. Preliminary results suggest that site elevation is significantly related to vegetation species composition (Mantel Test, $r = 0.5223$, $p = 0.001$). Additional sites along the elevation gradient are required to improve resolution of the observed changes in plant community composition with elevation. Basic ecological data collected in this study, such as species lists, contributes to a broader understanding of these peatlands by providing valuable information to hydrologists and landscape ecologists. Biodiversity information can also be used by stakeholders to determine the health of these mountain peatlands and can have conservation implications by potentially identifying rare species.

Six Nations Water Quality Assessment

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Session: Ecosystems and Water Quality

Abstract:
First nations communities in Canada have historically suffered from poor water quality and insufficient water infrastructure. There are currently 59 First Nations communities under drinking water advisories, impacting over 3000 homes and 175 community buildings. Many of these drinking water advisories are a result of water quality in wells and cisterns. In order to address these drinking water advisories and to help build water resilience for First Nations communities, a thorough evaluation of the current state of on-reserve water is necessary. In collaboration with our Frist Nations partners, we collected and evaluated water from 75 households of the Six Nations of the Grand River. Water was collected from all sources of water for each household. Households obtained their water from either private wells, cisterns, and/or distribution lines from the Six Nations water treatment plant. For each household, when possible, water samples were collected from taps as well as from the source of the tap water. In total 132 water samples were collected from Six Nations households. These samples were analyzed for their pH, turbidity, conductivity, total organic carbon (TOC) concentration, inorganic carbon (IC) content, total carbon (TC) content, and for the concentrations of various minerals and metals (Li, Be, B, Ca, Mg, Al, Ti, V, Cr, Mn, Fe, Co, As, Cu, Pb, Na, Zn, Li, Hg, Ni, Se, Mo, Ag, Cd, Sn, Sb, Ba, Pt, Tl, U).
The analytical results indicated that 10 wells and/or cisterns from 75 households contained concerning levels of Mercury (Hg). This represents mercury contamination in 13.3% of all households sampled. In addition, a few wells [#] and cisterns contained higher than regulation limits of Chromium (Cr) [1], Manganese (Mn) [1], and Lithium (Li) [2]. 91 wells also contained higher than acceptable levels of turbidity and 17 contained higher than regulation total organic carbon concentrations. These results were spatially mapped in GIS to the locations on the Six Nations Reserve from which they were collected. Geographic distribution indicated that the majority of the contaminated wells were near to the Grand River and MacKenzie Creek. To identify the source of the contamination, these water samples were analyzed for the presence/absence of artificial sugars. Previous reports have indicated that artificial sugars exist in readily detectable concentrations from surface waters, but are absent from ground water. The presence or absence of artificial sugars in well and cistern water is a good indicator of whether this water contains surface or ground waters, respectively.
Letters detailing water quality were provided to all households that participated in this initial study. A Further 85 households will be tested in the following year to confirm these results as well as to identify changes in household water quality from a previous study conducted in 2003/2004.

The Nutrient App: Promoting beneficial management practices acceptance through on-farm instantaneous community-based nutrient sampling

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Session: Ecosystems and Water Quality

Abstract:
Freshwater ecosystems remain at risk of eutrophication due to increasing anthropogenic inputs of nutrients into the hydrological system and a lack of public awareness on the connection between agricultural practices and the impact of nutrient enrichment on proximal water bodies. Close monitoring of the amount of nutrient buildup is key to locating hotspots of contamination through temporal and spatial comparison of nitrate (NO3) and phosphate (PO4) levels as well as to understanding the hydrological processes involved in the transport of these nutrients. This monitoring is a critical part of the remediation process but can be made difficult due to the reliance on expensive lab technology and lengthy procedures for accurate measurements of NO3 and PO4 levels and is therefore often inaccessible to farmers and the general public.
The importance of community-based monitoring of excess nutrient buildup has been highlighted upon by previous attempts to provide the general public with more easily accessible tools to measure nutrient levels and include them in community-based monitoring programs. However, such attempts have been limited to NO3 and pH, and have shown persistent biases when tested in the Canadian Prairies. In this study, a new mobile application, the Nutrient App, was developed to measure NO3 and PO4 concentrations in water based on on-farm cheap instantaneous colorimetric water quality test kits. Concentrations are obtained through image processing of photos of the test results. The mobile app was tested under controlled laboratory conditions that accounted for different light and temperature scenarios, as well as different mobile software and hardware. It was also evaluated in natural waters sampled in the Canadian Prairies that included wells, rivers, lakes and wetlands. The results show a relative error of approximately 30% for both NO3 and PO4, which was considered useful to support nutrient management and identify hotspots of contamination. This app is available for download on both the iOS and Android app stores and is an important step toward promoting nutrient export reduction and beneficial management practices acceptance through on-farm instantaneous community-based nutrient sampling.

Exploring Drivers of Eutrophication in the Western Lake Erie Basin

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Session: Ecosystems and Water Quality

Abstract:
In the past several decades, the challenges of water quality in Lake Erie have persisted. In the 1960s and 1970s, Lake Erie drew widespread attention as a result of algal blooms caused by both urban and agricultural land uses. Coordinated nutrient management efforts to address point source pollution by the United States and Canadian governments led to a reduction in algal blooms. Unfortunately, the problem of eutrophication has returned since the 2000s as an issue of public concern. The significance of the Lake Erie basin as an agricultural and industrial hub, combined with its large and growing population, highlight the importance of effectively identifying and addressing the drivers of eutrophication.
From a governance perspective, responses to algal blooms on Lake Erie are organized primarily using a water-centric, basin approach. Scoping the problem around basin boundaries may result in some key external drivers being left out when identifying the causes of the problem. This research critically examines to extent to which, and how, water governance for nutrient management in the Lake Erie basin enables or hinders consideration of external drivers in governance. Lake Erie is an example of nutrient management efforts with international relevance, comparable to other large scale, transboundary water quality situations such as eutrophication in the Baltic Sea. Understanding the effects that external drivers may have on water quality in Lake Erie could have immediate relevance beyond the case study, as water quality issues are a significant global challenge.
Through policy analysis and policy Delphi surveys with nutrient management and water governance researchers and practitioners, the research delineates the existing governance system for nutrient management in the western Lake Erie basin and identifies external drivers and the extent to which they are accounted for in the governance system. Ultimately, the research aims to identify ways to critically assess water governance approaches, to improve both the practice and study of water governance as well as contribute to binational efforts to address eutrophication in the Lake Erie Basin.

Implementation of an environmental monitoring program in the UNESCO Tsá Tué Biosphere Reserve

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Session: Ecosystems and Water Quality

Abstract:
Great Bear Lake and its watershed are critically important to the livelihoods, culture and spiritual well-being of the Sahtúot'ine of the community of Délı̨nę, Northwest Territories (NWT). The region, given internationally recognized status by UNESCO as the Tsá Tué Biosphere Reserve, is also globally significant since Great Bear Lake is the largest pristine lake on the planet. Helping to ensure the lake and its watershed remain healthy and properly utilized is the core mandate of the Tsá Tué Biosphere Reserve. As community members have been observing the impacts of both climate change and development on the lake and surrounding ecosystem, the need to enhance the research and monitoring capacity of the community is critical. Support is needed to fulfill the requirements of the biosphere reserve designation and enable Délı̨nę to strengthen its stewardship of the region through the design and implementation of an Indigenous Guardian water quality monitoring program for the Tsá Tué Biosphere Reserve. The Tsá Tué Guardian program represents the next step in Délı̨nę's progress toward regaining sovereignty through stewardship. The water quality and quantity research and monitoring initiative will be a key component of that stewardship, and will serve as an example for other communities and Indigenous governments in the NWT, nationally and internationally about what can be accomplished through vision and determination by Indigenous peoples.

Effects of Winter Conditions on Chlorophyll and Temperature in Lake Erie and Lake Ontario

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Session: Ecosystems and Water Quality

Abstract:
The abundance and productivity of phytoplankton in lakes are subject to a complex set of pressures. Because climatic drivers –ice cover, temperature, wind speed, and precipitation– impact the physical environment in which algae live, climate change imparts long-term changes in phytoplankton dynamics. To assess and unravel the changes that affect lentic ecosystems, long-term data-series are of paramount importance. The need for more effective environmental monitoring has led to notable advances in satellite technology and algorithm development, including enhanced ocean color sensor data acquisition capabilities to detect and blooms with adequate spatial and temporal resolution. The concentration of chlorophyll-a (Chl-a) is one of the most widespread and informative parameters to monitor algal biomass and trophic conditions in lakes. Therefore, much attention has been devoted on relating variations of Chl-a distributions to in-lake physical properties, the lake surface temperature and thermal structure of the water column.
Results show that the timing of lake ice break-up and freeze-up is largely linked to the rate of heat gain from solar radiation and hence increasing of lake water surface temperature. With the current climate change, Lake Erie is experiencing shifts in ice duration by the maximum variation of two months and Lake Ontario is experiencing an increase of water temperature. These shifts will cause biological and chemical processes in annual and seasonal growth and the timing of algal blooms intensity.

Defining a legacy pollution footprint: assessing spatiotemporal patterns of arsenic and other metals in sub-arctic lakes using paleolimnology

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Session: Ecosystems and Water Quality

Abstract:
In the absence of long-term environmental monitoring prior to and during resource development, identifying the extent of pollution is challenging but important for assessing risks to ecosystem health. Legacy pollution from Giant Mine in the Northwest Territories is a concern because while gold smelting operations ceased in the late 1990s, the fine, toxic dust As2O3 dispersed into the atmosphere, potentially creating repositories in the surrounding landscape. Lake water surveys and the sampling of surficial sediment have identified a confined emissions footprint within a 30-km radius of the mine. However, these measurements may not capture the range of aerial deposition of emissions from the mine, particularly peak emissions released during the 1950s. Paleolimnological studies from far-field locations have shown evidence of arsenic enrichment coinciding with the timing of peak mine emissions during the 1950s, suggesting further research is needed to characterize stores of legacy metals derived from Giant Mine pollution. To address this need, as part of the Sub-Arctic Metal Mobility Study, temporal patterns of metal deposition and hydrological conditions are being reconstructed from sediment cores collected from eight lakes along an 80-km transect northwest of Yellowknife, following the prevailing wind direction. Preliminary results have revealed arsenic concentrations well above the CCME Probable Effects Level of 17 mg/g in lake sediment records obtained ~20 and ~40 km from the mine. At 40 km, a strong departure in the arsenic – organic matter (OM) relation suggests enrichment of arsenic between 7 and 3-cm depth is likely due to pollution from Giant Mine. The catchment of this lake was severely burned by a forest fire in 2014, and peak concentrations found just below the sediment-water interface suggest that arsenic in the catchment may have been remobilized. Interestingly, at 20 km, sediment core relationships with OM are weak but substantial increases of arsenic (and antimony) towards the surface may be due to diagenetic processes or increasing supply of Giant Mine – derived legacy metals stored in the catchment. Ongoing analyses of these and other lake sediment cores will provide further characterization of the Giant Mine emission footprint, and the depositional and post-depositional history of arsenic and other metals in sub-arctic lakes and their catchments.

Unifying Ecology, Hydrology and Geomorphology: The Relevance of Eco-hydromorphology as a Potential Supra-discipline in River Research

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Session: Ecosystems and Water Quality

Abstract:
A fundamental shift in approaches to river management has occurred in recent decades. Decisions pertaining to water management in Canada, the European Union, Mexico, South America, Africa and Asia are prioritizing a data-driven management approach, increasing pressure on practitioners and researchers to develop better data-driven models and methods for analysis. Despite decades of research, significant challenges persist in attempting to predict the short and long-term effects of management interventions and climactic changes due to highly variable environmental conditions. A major research priority in response to these challenges is to develop a deeper mechanistic understanding of the links, patterns and interactions between biota, hydrology, river geomorphology, as well as ecological functions and structure; however most studies continue to approach river research using a disciplinary framework, with only rudimentary integration of data across disciplinary boundaries, tempering progress.
Eco-hydromorphology is uniquely situated as a potential supra-discipline to address long-standing challenges in fluvial ecosystem methods including, but not limited to the need to broaden disciplinary scope to better understand variable interactions, the identification of key indicators and drivers of change, as well as model validation, generalizability and integration into evidence-based management and restoration. Interdisciplinary sub-disciplines exist that focus on relationships at the interface of multiple disciplinary factors, including biogeomorphology, ecogeomorphology, ecohydrology/hydroecology, geobiology, and ecohydrolics. However, these sub-disciplines generally only examine the underlying mechanisms connecting two of the parent disciplines; only eco-hydromorphology considers ecology, hydrology and geomorphology, simultaneously. This study explores the degree to which eco-hydromorphology may be relevant to river research, through evaluating how eco-hydromorphology differs from other interdisciplinary sub-disciplines applied in river research, conceptual gaps present in eco-hydromorphological literature, and propose limitations for application.
One of the main challenges which reduce the current applicability in river research is the lack of explicitly defined parameters, framework, and terminology. Eco-hydromorphology offers a novel opportunity to examine science at the interface of three heavily researched disciplines, but the degree to which this approach will be relevant to river research is dependant on the ability of researchers in this supra-discipline to define their focus relative to other disciplinary and interdisciplinary research. Traditional approaches utilize correlation-based methods that are unable to provide robust results in highly variable conditions, because they are forced to extrapolated outside of observed conditions to make predictions. Conversely, eco-hydromorphological modeling offers a unique approach to predicting changes in river systems by focusing on the underlying mechanisms that connect ecological, hydrological

and geomorphological variables. These underlying mechanisms experience significantly less variability than individual river processes, and thus provide the opportunity to build more reliable predictive models.

Optimally, the models produced would provide practitioners with a tool that would allow for exploratory scenario analysis to be conducted, revealing the predicted physical and/or ecological impacts of multiple management strategies. A transdisciplinary approach should be adopted to increase the relevance of eco-hydromorphological modeling through collective involvement of scientists, practitioners/managers, and public stakeholders.

Agricultural Water Quality in Cold Climates: Processes and Management Options

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Session: Ecosystems and Water Quality

Abstract:
Today, humans are facing grand challenges in producing sufficient food for the growing population while minimizing pollution to the environment. Unfortunately, agriculture has been identified as a major source of nutrients, contributing to the eutrophication of many lakes around the world including Canada. This has promoted great efforts to identify beneficial management practices to reduce nutrient transport from land to water in the last several decades. In cold regions, however, a grand challenge in nutrient management remains unaddressed. Because of their unique hydrological and biogeochemical processes, identifying appropriate beneficial management practices has been an impediment to progress. For example, snowmelt-runoff generated on frozen soils does not allow water infiltration and nutrient retention by soils. In addition, freezing and thawing of plant materials that are used as riparian buffers and winter soil covers can result in release of nutrients. Clearly, there is a need to review the processes and management options related to agricultural water quality in cold climates. Here, we summarize key hydrological and biogeochemical processes related to agricultural nutrient transport in cold environments, discuss the efficacy of management options to mitigate nutrient transport, and highlight future research needs.

Drivers of tree mortality and recruitment in a boreal peatland experiencing permafrost thaw

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Session: Ecosystems and Water Quality

Abstract:
Permafrost, or permanently frozen ground, is thawing rapidly throughout the circumpolar north. The majority of the boreal forest is underlain by permafrost, and is undergoing substantial hydrological and ecological change as a result. In boreal peatlands, areas underlain by permafrost are raised 1-2m above the surrounding landscape due to the expansion of water as it freezes. This forms a mosaic of forested, well-drained permafrost plateaus and low-lying, permafrost-free wetlands with little or no tree cover. As permafrost thaws, these plateaus often subside, resulting in waterlogged soils that slow tree growth and reduce forest cover over decadal time scales. However, thaw can also create new drainage pathways that contribute to wetland drying and an increase in forest cover. This spatial variation in forest response to thaw, combined with a lack of data on stand-level forest dynamics in northern regions, make it difficult to predict future boreal forest composition and structure. To improve predictions, we used tree census data and measurements of key abiotic variables from a large (10ha) permanent forest plot to describe and explain recent patterns of mortality and recruitment in a boreal peatland underlain by discontinuous permafrost. We found that mortality of black spruce, the dominant tree species, was more than double that of recruitment between 2013 and 2018. Spruce loss was highest in areas with thick organic soils and was partially driven by waterlogging associated with permafrost thaw (23.5% of all deaths). In contrast, recruitment of larch, a more flood-tolerant species, was over four times greater than mortality, and occurred primarily in low-lying portions of the plot with thin organic soils. However, net gains of larch were considerably smaller in magnitude than net losses of spruce, resulting in a 0.7% per year net loss of forest overall. In summary, forest loss within the plot was partially attributable to permafrost thaw, but organic layer thickness was also an important driver of forest dynamics. Areas with access to mineral soil will likely see reduced rates of forest loss and a shift towards greater larch dominance in the near future. These changes will have important consequences for future boreal habitat suitability and surface energy exchange.

Southern Forests Water Future - Ecohydrological responses of different-age conifer and deciduous forests to climate variability and extreme weather events

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Session: Ecosystems and Water Quality

Abstract:
Southern Canadian temperate forests of Great Lakes region are a critical component of the global carbon cycle and regional water resources. They play a major role in providing healthy environment and sustainable water resources in this highly populated, agricultural and industrialized landscape. A large portion of these forests has traditionally been managed for timber production and are in different stages of development. The response of these southern different-age and different-species forests to extreme weather events such as drought and heat stresses, climate variability and management regimes is not fully understood. In this study, long-term (2003-2018) eddy covariance flux, forest inventory, dendrochronology, stable isotopes data in an age sequence (79-, 44-, and 18-years old as of 2018) of conifer (pine) and a deciduous (>90-yr old Oak) forests located in temperate-boreal transition zone in southern Ontario, Canada are examined to determine the impact climate variability and extreme events on their growth and water use efficiency. These forest sites are part of Global Water Futures (GWF)-Southern Forests Water Futures project's Turkey Point Observatory. Study results show that while in conifer stands, simultaneous occurrence of heat and drought stress in the early growing season was a major factor to cause a large decrease in annual net ecosystem productivity (NEP), in deciduous forest drought stress early in the growing season was a major factor for reduced NEP. Drought stress had the strongest impact on the middle age forest which had the largest carbon sink and water demand. Severity of heat and drought stress impacts was highly dependent on the timing of these extreme events. Long-term intrinsic water use efficiency (iWUE) derived from tree-ring and isotopic records showed 50 µmol mol–1 increase over 1969-2012 period indicating the influence of warming temperatures and increasing atmospheric evaporative demand on forest water use and a shift in homeostatic response of trees in regulating stomatal conductance. Overlapping eddy covariance fluxes also showed a similar response where a greater amount of carbon was fixed to water lost. This research will help to improve our understanding of eco-hydrological and biogeochemical processes and resilience of Southern Canadian forests to negative impacts of climate change and extreme weather events and develop/test eco-hydrologic models (e.g. MESH-CTEM) for sustainable development of water resources in the Great Lakes region and across Canada.

The Urban Metabolism of the Greater Toronto Area: A Study of Nitrogen and Phosphorus across an Urban, Suburban, and Rural Continuum

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Session: Ecosystems and Water Quality

Abstract:
It has been predicted that approximately 65% of the developing world and 85% of the developed world will be living in cities by 2050. Toronto, the largest city in Canada and the fourth largest in North America, is expected to double in population in the next 50 years. Although such rapid urbanization can lead to enormous social, economic, and environmental change, little is understood about how population growth in Toronto and the "Golden Horseshoe" region around Lake Ontario will impact the ecological systems of Southern Ontario. In our study, we are particularly interested in the ways in which increasing population densities in the Greater Toronto Area are impacting nutrient flows across Southern Ontario's urban/rural continuum and how changing nutrient dynamics may lead to increasingly impaired water quality in Lake Ontario and beyond. In this work, we utilize a mass balance approach to quantify the flow of nutrients through urban, suburban, and agricultural areas of the Greater Toronto Area. A wide range of factors are considered, including human behaviour, domestic animals, stormwater management, and wastewater treatment processes. The present results suggest that any study of urban metabolism must take into account not only nutrient flows within urban boundaries, but must also identify externalities of urban development associated with a range of processes, from global trade to regional waste management.

Health assessment of water resources in two contrasting indigenous communities in Canada: Six Nations of the Grand River, Ontario and the Lubicon Lake Band, Little Buffalo, Alberta

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Session: Ecosystems and Water Quality

Abstract:
Of the 600+ indigenous communities in Canada, the Six Nations (SN) of the Grand River in Ontario is one of the largest, with over 25,000 registered members and a reserve of 190 sq. km, whereas the Lubicon Lake Band (LLB) of Little Buffalo in Alberta, is one of the smallest, with approximately 500 members and a land settlement of 246 sq. km. The SN is located in a heavily agricultural watershed, downstream of several large cities in southern Ontario, whereas LLB is located in a very remote region of northern Alberta, surrounded by oil and gas infrastructure. As part of McMaster's Co-creation of Water Quality Tool Project, the Ecosystem Health team co-developed a sampling program with both communities to monitor the quality of drinking and/or surface water on their reserves. During 2018, we found that 29% of the 75 households sampled for tap water on the SN reserve were contaminated with E. coli, and this is higher than the 27% of 312 wells tested in 2003 and 19% of the 104 tested in 2004. The McKenzie Creek, one of the two major streams draining the SN reserve, was also contaminated with E. coli and had levels of nutrients and turbidity that were too high for recreational use and for supporting aquatic life. Of the three lakes assessed for the LLB, Haig Lake had clear water, relatively low nutrient and is the only lake that currently supports a recreational fishery. The two lakes located on the negotiated land claim, Little Buffalo and Lubicon Lakes, were extremely shallow (<1.5 m) and nutrient rich (total phosphorus >100 µg/L), and no longer appear to support fish, although Little Buffalo was once fished by the community 30 years earlier, when it had been at least twice as deep. Currently, it is the shallowest lake of the three sampled, and is more of a marsh than a lake. The Sensor's team will use results of these assessments to develop an appropriate slate of sensors for long-term deployment in both communities.

Next Generation Aquatic Chemistry

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Session: Ecosystems and Water Quality

Abstract:
The recent development of new mass spectrometry technologies and instrumentation has increased the amount and quality of analytical information that can be obtained from samples. In particular, dramatic increases in mass resolution have made possible unequivocal identification of contaminants even in complex mixtures and matrices. The development of Ultra-High Resolution Mass Spectrometry (UHRMS) has made available previously unprecedented levels of mass resolution and mass accuracy in timeframes compatible with typical chromatography systems. In addition to high mass resolution and accuracy Fourier transform based instruments provide 'image current' detection giving full mass spectral data for each scan. When coupled to liquid chromatography systems we have used these capabilities to investigate the occurrence of various halogenated disinfection by-products (DBPs) as well as naturally occurring organohalogen compounds. The recent release of a GC/UHRMS systems brings levels of mass resolution not previously available for the analysis of POPs by GC chromatography. Here we report the use of GC-UHRMS for identification and quantification of PCDD/Fs and PCBs. The methods developed are based on standard US-EPA methods (Methods 1613 and 1668) but are enhanced by use of the new capabilities provided by image current detection and high mass resolution (> 100,000 FWHM). Robustness of the PCDD/F analyses were demonstrated by excellent calibration characteristics and ability to detect all 2,3,7,8-substituted congeners even in an extract of used motor oil. Reanalysis of fish tissues previously analyzed by a magnetic sector instrument demonstrate accuracy of identifications and quantifications and provide validation of the method. Analyses were also conducted to determine the potential for a 'mutiplex' analysis of various POPs where the resolving power (>120,000 FWHM) of the MS system was able to eliminate potential interferences from a variety of 'non-target' organochlorines. In addition, the potential for simultaneous HRAM and MS/MS analyses will be demonstrated.

Chemiresistive Sensing Platform for Water Quality Monitoring

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Session: Ecosystems and Water Quality

Abstract:
Chemiresistive sensors are a well-established technology for gas-phase sensing applications. They are simple and economical to manufacture, and can operate reagent-free and with low or no maintenance. Unlike electrochemical sensors they do not require reference electrodes. While in principle they can be made compatible with aqueous environments, only a few such examples have been demonstrated. Challenges include the need to prevent electrical shorts through the aqueous medium and the need to keep the sensing voltage low enough to avoid electrochemical reactions at the sensor. We have built a chemiresistive sensing platform for aqueous media. The active sensor element consists of a nanocarbon film, such as carbon nanotubes, exfoliated graphene, or pencil traces. The first member of that platform is a free chlorine sensor.[1-3] We are currently working to expand the applicability of our platform to other relevant species, in particular anions and cations that are commonly present as pollutants in surface and drinking water.[4] Our sensors can be incorporated into a variety of systems and will also be suitable for online monitoring in remote and resource-poor locations.
[1] L. H. H. Hsu, E. Hoque, P. Kruse, and P. R. Selvaganapathy, A carbon nanotube based resettable sensor for measuring free chlorine in drinking water. Appl. Phys. Lett. 106 (2015) 063102.
[2] E. Hoque, L. H. H. Hsu, A. Aryasomayajula, P. R. Selvaganapathy, and P. Kruse, Pencil-Drawn Chemiresistive Sensor for Free Chlorine in Water. IEEE Sens. Lett. 1 (2017) 4500504.
[3] A. Mohtasebi, A. D. Broomfield, T. Chowdhury, P. R. Selvaganapathy, and P. Kruse, Reagent-Free Quantification of Aqueous Free Chlorine via Electrical Readout of Colorimetrically Functionalized Pencil Lines. ACS Appl. Mater. Interfaces 9 (2017) 20748-20761.
[4] P. Kruse, Review on Water Quality Sensors. J. Phys. D 51 (2018) 203002.

Examining the Relationship between Dissolved Organic Matter and Disinfection By-Products in the Northwest Territories

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Session: Ecosystems and Water Quality

Abstract:
A warming climate has significantly altered the processing, cycling, and fate of carbon in the arctic. In particular, large stores of carbon immobilized within permafrost have the potential to be released to the surrounding environment in gaseous, particulate, or dissolved phases. Dissolved organic matter (DOM) is comprised mainly of carbon and can influence aquatic health and drinking water quality. During water treatment of water supplies, DOM can react with chlorine, a common disinfectant, to produce carcinogenic disinfection by-products (DBP). However, DOM reactivity depends upon its composition, which is influenced by differences in sources and processing within the environment. We sought to understand the historical prevalence of DOM and DBP across NWT community water sources, and to determine the relationship between northern DOM composition and DBP formation. Public community water records were obtained from Municipal and Community Affairs website to determine the average concentration of DBP and DOM over time. Field samples were collected from surface waters (ponds, lakes, creeks, rivers) and from the deepest extent of the active-layer in July. The amount of DOM was quantified using the concentration of dissolved organic carbon, while DOM composition was assessed using elemental ratios, ultraviolet and visible absorbance, fluorescence, and size-exclusion chromatography parameters. DBPs were characterized by via trihalomethane and haloacetic acid concentrations. We find both DOM and DBP to be prevalent within treated NWT water sources, with DBP generally below the maximum acceptable concentration. However, differences between DOM and DBP concentration within the MACA database suggests other factors play a role in determining the amount of DBP formed. Although the MACA database did not provide information on chlorine consumption, our field samples provide information about how chlorine consumption varies with DOM quantity and composition. Further, we show how DOM concentration and composition can vary widely across a relatively small spatial scale, and that DOM with a strong ‘terrestrial’ signature results in higher DBP concentrations. Permafrost thaw and increases to terrestrial-like DOM have been observed in other circumpolar nations, hence these results highlight the need to monitor both the amount and type of DOM in Canada’s North, as well as how changes to carbon cycling may impact drinking water treatability.

On the role of a large shallow lake in modulating phosphorus loads to Lake Erie

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Session: Ecosystems and Water Quality

Abstract:
The new 2012 Great Lakes Water Quality Agreement (GLWQA) demands more robust estimates of total load of phosphorus (P) to Lake Erie and scientifically-based understanding whether a 40% reduction in total P load can be achieved by corresponding decreases in each of its sub-watersheds. While sub-watersheds that feed directly into the lake constitute a greater portion of Lake Erie's watershed, about 20% feed indirectly. Among the latter are those that discharge indirectly via a large shallow lake, Lake St. Clair, which due to its size has the ability to modify the nutrient fluxes, and therefore creating an uncertainty in the relationship between sub-watershed reductions and the amount ultimately contributing to Lake Erie. Lake St Clair has a large watershed (14,000 km2) with three significant tributaries, Thames, Sydenham and Clinton rivers. To facilitate the improved understanding between reductions in P in these three largest tributaries to Lake St. Clair and load that contributes to Lake Erie, we applied a three-dimensional coupled hydrodynamic and ecological model to Lake St. Clair to construct the P load-response relationships. The latter indicate that the tributary-specific spatial and temporal variations in nutrient loads are important for their within-lake transport and retention. This means that the sub-watersheds may possess different relative efficiencies for the downstream transport of their nutrient loads to Lake Erie. These findings are important for a more accurate quantification of watershed-to-lake nutrient fluxes and development of enhanced and better informed nutrient control measures to appropriately align policy priorities and available resources.

Non enzymatic real time phosphate detection using potentiometry

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Session: Ecosystems and Water Quality

Abstract:
Phosphate is a very common pollutant for both surface and ground water. Phosphate along with nitrate is known to cause eutrophication in coastal waters and lakes, which can severely affect aquatic life. According to WHO, the maximum permissible limit for phosphate is 1mgL-1 while Australia, has the maximum permissible limit as 0.046 mgL-1. For phosphate pollution prevention, many governments have also issued strict regulations to treat phosphate in wastewater before disposal. Therefore, it is crucial to measure the phosphate concertation to maintain optimal water quality of drinking water and natural sources.
At present, phosphate sensing is done by numerous methods including amperometric, potentiometric, fluorescence, and optical methods. There are two major drawbacks in the potentiometric sensors published in literature: Limited working range (>10-5 or 10-6 M) and sensor reusability. The proposed study aims to develop a real time phosphate monitoring system with a sub micromolar working range and can measure phosphate in samples like surface water, wastewater etc. We are using a potentiometric sensor to measure the phosphate concentration. The preliminary design includes a two-electrode system with cobalt wire electrode as working electrode and a silver-silver chloride electrode as a reference electrode, with a glass slides as the supporting material. The sensor measurements were done in dip settings where the sensor was connected to the measurement device and the sensor was dipped vertically into different phosphate solutions. The measurements were done using eDAQ potentiostat and Keitheley 2410. The sensor was redesigned into a microfluidics channel to facilitate easy usage.

Environmental (DNA) metabarcoding for ecotoxicological assessment of anthropogenic activities

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Session: Ecosystems and Water Quality

Abstract:
Anthropogenic activities threaten freshwater ecosystems and can cause systematic community-level effects in an ecosystem and eventually, leads to losses of biodiversity and ecological functions. Traditional ecotoxicological quality assessment approach includes chemistry analyses, ecotoxicological tests, ecological risk assessment, and biological monitoring. However, the ecological effects of multiple anthropogenic contaminants on multiple aquatic communities are mostly unknown. Since morphology-based biomonitoring approach is labor-intensive, time-consuming and difficult to achieve, emerging metabarcoding provides a tool for rapid biomonitoring and measuring fluctuations in aquatic biodiversity can boost development of conservation and management strategies for freshwater ecosystems. Metabarcoding of bulk and environmental DNA samples can be used to survey multiple communities, including bacteria, fungi, animals, and plants. I will present some applications of eDNA metabarcoding for ecotoxicological assessments of anthropogenic stresses in the freshwater environment.

Addressing Barriers to Community-Based Monitoring through Collaborative Development: A Global Water Citizenship Project

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Session: Ecosystems and Water Quality

Abstract:
Community- based monitoring (CBM) data is a vital component of water resource management and environmental stewardship. However, the adoption and application of CBM data, particularly in scientific fields, has been limited by barriers such as the perception of unfavorable CBM data quality and access to context-appropriate analysis tools. To address these barriers and to bridge contextual gaps between stakeholders, open source tools for use with citizen science data can be developed – one of the objectives of Global Water Citizenship. To inform current and future monitoring initiatives, insight into the barriers to the adoption of CBM data and analysis tools in a Canadian context is required. In this sub-project, we propose the development of an open source tool for community-based water quality data analysis. The proposed tool will investigate barriers to tool adoption through its development process and barriers to CBM data actionability through its functions and design. A prototype version of the proposed tool was provided to members of Canada's community-based water quality monitoring community. User feedback on the relevance, robustness, and intuitiveness of the prototype was solicited and examined in the context of participants' experience with community-based monitoring. The prototype was well received overall, with many participants confirming the tool's potential in the CBM field. Recurring suggestions for improvement included informal language and better connections between visualizations (i.e., between maps and graphs). The use of published guidelines in conjunction with simple graphics was cited as a useful output. Participants also expressed a desire for simple explanatory content and for plain-text results. The feedback coincided with participants' varying experiences communicating monitoring results to stakeholders in diverse contexts, reflecting the heterogeneous nature of CBM participation. It is expected that an iterative process of end-user recruitment, participation, and developer-to-participant feedback will address this barrier, creating and reinforcing networks within the broader network of Canadian community-based water monitoring.

Agricultural edge of field phosphorus losses in Ontario, Canada: Importance of the non-growing season in cold regions

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Session: Ecosystems and Water Quality

Abstract:
Agricultural phosphorus (P) losses are a global economic and water quality concern. Much of the current understanding of P dynamics in agricultural systems has been obtained from rainfall-driven runoff and less is known about cold season processes. An improved understanding of the magnitude, form and transport flow-paths of P losses from agricultural croplands year-round, and, the climatic drivers of these processes is needed to prioritize and evaluate appropriate best management practices (BMPs) to protect soil-water quality in cold regions. This study examines multi-year, year-round, high-frequency edge-of-field P losses (soluble reactive P (SRP); total P (TP)) in overland flow and tile drainage from three croplands in southern Ontario, Canada. Annual and seasonal budgets for water, P, and estimates of field P budgets (including fertilizer inputs, crop uptake and runoff), were calculated for each site. Average annual edge-of-field TP loads ranged from 0.18 to 1.93 kg ha-1 yr-1 (average, 0.59 kg ha-1 yr-1) across the region, including years with fertilizer application. Tile drainage dominated runoff across sites, while the contribution of tiles and overland flow to P loss differed regionally, likely related to site-specific topography, soil type and microclimate. The non-growing season was the dominant period for runoff and P loss across sites, where TP loss during this period was often associated with overland flow during snowmelt. These results indicate that emphasis should be placed on BMPs that are effective during both the growing and non-growing season in cold regions, but that the suitability of various BMPs may vary for different sites.

A Participatory Approach to Enhance and Measure Social Learning for Flood Preparedness in Mistawasis Nêhiyawak

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Session: Human Dimensions and Hydro-Economics

Abstract:
In the prairies, flood events are predicted to become more severe and frequent due to land use changes and climate change. Small and rural communities are particularly at higher risk because often these communities do not have the capacity and resources to deal with such extreme events. As such, in the community flood management, there is a shift in paradigm from using a reactive flood defense approach to adopting a proactive one. Social learning is known to enable individuals and communities to anticipate a problem, collect, share and mobilize their knowledge and resources to develop action strategies for preparing better for future extreme events. Participatory methods aim to facilitate social learning, and many studies have described learning as an 'outcome' of participation. However, there is limited empirical evidence when it comes to mapping social learning as a 'process' rather than an outcome. Therefore, in this study, we explore to what extent do people learn in the social learning process in the context of participatory approaches. We use the case of flooding issue in Mistawasis Néhiyawak, a First Nations Cree community in Central Saskatchewan. First, we develop a conceptual framework and key indicators for assessing learning from the existing body of literature. Then, data collected in a one-day participatory workshop held in the community was analyzed using the key indicators. For individual learning indicators such as changes in mental models to indicate the adoption of new information or knowledge was used. Similarly, for group learning, relational outcomes such as expression of trust, opportunities for collaboration and shift in perception of dependence to the feeling of involvement were selected as some of the key indicators. In the workshop, aerial images and model-based flood extent maps were used to stimulate the learning process. Participants drew individual cognitive maps as an external representation of their understanding of flooding issue in the community. Instead of using pre/post evaluation of the cognitive maps, we analyze changes in the maps throughout the workshop as an indicator for the process of learning. We also analyze the discussions emerging from both aerial image and flood extent maps to understand how group interactions influenced changes in individual cognitive maps. The approach and methods used in this research are intended to explicitly measure social learning and fill some of the gaps in empirical research. It is also expected that social learning will help the community both identify flood concerns and mobilize the available resources (knowledge, technical, and infrastructural) in taking a proactive approach to flood preparedness.

Linking Water Governance in Canada to Global Socio-economic Drivers: the Case of Demographic Changes

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Session: Human Dimensions and Hydro-Economics

Abstract:
In Canada and other parts of the world, many water problems originate from drivers outside of the mandate or awareness of those directly charged to manage them. This misalignment creates significant challenges in meeting goals for water sustainability. Global migration patterns and their effects on environmental values among populations in receiving countries is a less studied area. With recent declines in fertility rates in Canada, increases in population growth from immigration has become the primary source of population growth since 1999, accounting for up to two-thirds of such growth. In Ontario, the geographic focus of this study, more than 75% of the projected increase in population in the period 2017-2040 is expected to come from immigration. This immigration pattern has contributed to cultural diversity in the province as never seen before; the majority of recent immigrants do not come from the same source countries as 50 years ago. Some studies have observed that unlike the European settlers who brought with them a worldview in which people and culture were perceived to be separate from nature, some of the more recent immigrants come to Canada having experienced a respectful and reverent relationship to their local waters embedded in their community life, cultural practices, spiritual beliefs, and day-to-day activities. Such changes in demographic characteristics, as well as the accompanying shifts in attitudes may affect the environmental values of the 'water user' groups as well as those involved in water-related decision-making processes. To what extent this growing immigrant population will adopt the 'myth of water abundance' in Canadian psyche, or introduce alternative stewardship values is less understood. This brings a unique challenge to Canadian water governance structures and processes as they continuously deal with potentially shifting attitudes on the part of user groups as well as policy actors. This study aims to offer detailed and systematic analyses of the role of changing demographics and societal values on water governance processes in the Ontario portion of the Great Lakes basin as well as offer potential governance innovations in addressing those challenges.

Impacts of Flooding: Lived Experiences in Two Saskatchewan First Nation Communities

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Session: Human Dimensions and Hydro-Economics

Abstract:
Flooding is an issue for many Indigenous communities in Canada. Many Saskatchewan communities have experienced severe spring flooding and incidents of evacuation have occurred over a series of years. James Smith Cree Nation has experienced 4-5 consecutive years of flooding and on April 4th, 2017 this Nation issued a state of emergency. Yellow Quill First Nation has also experienced similar flooding events with resulting significant impacts to community infrastructure. Flooding is a common threat in these communities.
Impacts to flooding go beyond those visually observed by the presence of flooded roads, houses and measured contamination in water supplies. We would like to share our lived realities and experiences of flooding in our communities. We hope to provide insight into some of the invisible losses to our communities that are not easily seen or measured through economic assessments but are of tremendous value to our communities. We hope to create greater understanding of the impacts to our livelihoods and our traditions and shed light on the realities of flooding threats in our First Nations communities. We also wish to give hope to other communities First Nation and non-First Nation who are experiencing similar challenges in their communities by sharing the lessons we have learned as well as the approaches to flood risk management and health service provision during and after such events.

Kikawinaw Askiy: Climate Change Adaptation Planning at Okanese First Nation, Treaty 4 territory, Saskatchewan

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Session: Human Dimensions and Hydro-Economics

Abstract:
Climate change threatens Kikawinaw Askiy (Mother Earth)—our lands, water, fish, and plants—all that gives life. Okanese First Nation aspires to achieve reconciliation with Kikawinaw Askiy by restoring our sacred ecology of how to live on the land in a respectful and life-sustaining way. In 2018 Chief Marie-Anne Day Walker-Pelletier and Council gave approval for a source water protection plan with the goal to protect source water for future generations. Groundwater is our only source of drinking water. Climate change and past land use practices threaten our sacred and life-giving water. This planning process has partnered with the University of Saskatchewan in knowledge sharing and relationship building.
Okanese First Nation is located in Treaty 4 Territory, Saskatchewan, approximately 110 km northeast of Regina. This presentation describes our source water protection plan and how the planning process engages community members, including youth, women, and Elders to guide future community development, protect public safety, infrastructure, and ensure wise economic investments. Okanese has also installed a network of climate change monitoring stations and has developed a climate change adaptation strategy. Through these initiatives we will protect all living beings that depend on healthy water, our sacred responsibility from the Creator.

Indigenous youths' relationships with water: Trauma, advocacy, and resilience

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Session: Human Dimensions and Hydro-Economics

Abstract:
Climate change continues to increase vulnerability to water insecurity and mental health issues in ways that reflect gender and health inequities (Brubaker, Berner, Chaven, & Warren, 2011). Indigenous communities are disproportionately affected by water insecurity, quality, and accessibility. Studies have found a link between inadequate access to water, to clean tap water, and mental health symptoms or distress, particularly in women (Wutich & Ragsdale, 2008; Stevensoon et al., 2012). There is a stark lack of such work as applied to Indigenous youth. Western science supports the link between stress, especially when resources are uncertain, and poor health among youth. In Indigenous teachings, women are the water carriers and therefore have a unique role in protecting the water; as such water is critical for adolescent expectant parents. Both having inadequate access to water and the experience of having local watersheds being polluted, or drained by large corporations may itself be a chronic trauma event, layered upon other community and colonial traumas. Importantly and uniquely, youth water resilience actions (advocacy, sensor monitoring, water testing skills, clean-up, protests) may buffer the impact of water-related stress. This presentation will overview the relationship of youth to water based on our preliminary work with Six Nations youth and international Indigenous water advocates. It will focus on practical strategies to support resilience in youth, and present a mobile resilience tool, JoyPop, that may be useful for adaptation to this intersectional issue of water, mental health, and advocacy.

Water as medicine: Digital storytelling as a tool in documenting water anxiety in Indigenous youth in Six Nations

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Session: Human Dimensions and Hydro-Economics

Abstract:
Mental health need has been identified in our GWF co-creation health research consultations with Six Nations of the Grand River community. A critically important indicator of their quality of life and wellness requires access to clean water. Co-creation has found significant concerns about barriers to environmental/food and water security are determinants of cultural continuity thus major stressors that affect youth wellness. Climate change creates environmental uncertainty, which in turn may make youth more susceptible to depression and anxiety generally, and specifically to the stressor source (poor water quality/water anxiety; water affected food sources/food insecurity) (Majeed & Lee, 2017). A recent study using data spanning several decades found that suicide rates are increasing with increase in temperature as a result of global warming in both the U.S. and Mexico (Burke et al., 2018). Indigenous youth mental wellness must be centered in land, the language, community, cultural identity, and empowerment (Martin Hill, 2009).
The GWF existing co-creation health team builds on Cocreation team's health consults and heard from community alarming levels of water anxiety FN youth/families are experiencing, health services and Six Nations youth identified a need to further address lack of access to water as detrimental mental health and well-being. Our project's main objective is to sustain strong, healthy First Nations, and our co-creation health team incorporates Onkwe:Honewehneha (Haudenosaunee ways of knowing) through reinvigorating ancient practices, modalities of kinship and mentorship, and incorporating Haudenosaunee-identified metrics of wellness. Traditional medicine and healing are difficult concepts to define, as many Aboriginal peoples describe the medicine and practices within the localized geographical context of their community or nation. However, working definitions are provided by the World Health Organization (WHO) and the Royal Commission on Aboriginal Peoples (RCAP). The term "traditional medicine" as defined by WHO is the sum total of knowledge, skills, and practices based on the theories, beliefs, and experiences Indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement of treatment of physical and mental illness (WHO, 2001). TEK mixed methods explore (1) access to clean water, (2) eco-system sustainable living, (3) cultural knowledge, (4) teachings/stories of gender and sex, (5) land-based healing and learning, connection and expression through arts. Empowering youth with digital storytelling documents traditional stories, and lived experiences of youth expressing water anxiety, perceptions of water quality, and positive water actions. These digital water stories, emphasizing youth positive action, serve a role for further water advocacy and youth agency as an open-access knowledge mobilization tool.

Science for decision making: are we set to provide it?

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Session: Human Dimensions and Hydro-Economics

Abstract:
The expected effects of climate change and environmental degradation are propelling governments to require solid scientific advice prior to committing to specific actions.
In collaboration with Ontario Ministry of Agriculture, Food and Rural Affairs, we are engaging decision makers to identify the feasible best management practices for Ontario farmers that will protect water quality and enhance soil quality and productivity. Using the Thames River Watershed, ON, as a study area we conducted in depth analyses of investments made to ensure implementation of Beneficial Management Practices (BMPs) for the period 1970 - 2000. We correlated these analyses with phosphorus loads, modeled for the period 1970 – 2016. To understand where and which BMPs need to be implemented to improve water quality and achieve goal of 40% reduction in the Thames River Watershed, we are assessing the capacity of several hydrological models to synthesize the effect of BMPs on hydrology and watershed water quality.
Here, we discuss the problems of obtaining data, lack of governmental consistency when advising BMPs implementation and lack of long-term monitoring of provided investments, and finally problem of Pan-Canadian approach when it comes to models application. The aim of this presentation is to initiate constructive discussion and new collaborations that will support on-going research.

Keys to Adaptive Water Futures: Governance, Engagement and Equity

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Session: Human Dimensions and Hydro-Economics

Abstract:
Beyond the distinct articulation of the Sustainable Development Goals (SDGs), in particular SDG 6 that outlines goals and target for ensuring availability and sustainable management of water for all, the cross-scale work of knowledge integration for water futures is understood to be a significant challenge. In that context, we will discuss a set of narratives addressing strategies for crossing scales, boundaries, disciplines, and diverse socio-economic interests. The necessity of creating shared intersections and making common cause is key to creating effective fora in support of adaptive water governance, and for the realization of water rights and justice under conditions of uncertainty and changing socio-economic and socio-political scenarios. First, we will review elements from theory and practice needed for effective governance, with contributions from experiential learning trials, to reflect on alternatives for structuring water relations through ecological, social, cultural, and gendered lenses. Second, we reflect on how various Global Water Future (GWF) projects, including the one focusing on indigenous issues, contribute to mechanisms, experience and tools to achieve- 'target 6.b-- supporting and strengthen the participation of local communities in improving water management; and the Boreal Water Futures attention to "governance gaps" necessary to achieve SDG 'target 6.6' - specifically protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes [by 2020]. Noting that issues of engagement and equity are central to designing governance measures, polices and interventions for Adaptive Water Futures, we expect the focus on strengthening capacity of citizens, HQP, scholars and stakeholders to remain pertinent for long term sustainability of water and/or water security. Thus, aligning with the vision of SDG 'target 6.a' to expand cooperation and capacity-building in support of water - and related activities and programmes is another key element to effectively managing water allocation, distribution, pricing, as well as related technologies and infrastructure, including nature-based solutions.

Taking note of these factors, the third section will illustrate how various water governance concepts, frameworks and approaches, including the Water Security agenda of UN Water (2013); SDG6 goals and targets, and United Nations Resolution 64/292-The human right to water and sanitation, can be operationalized to propagate engagement and equity dimensions in water resources management through effective integration in pedagogical and scholarly activities, based on research and investigation. In addition, the focus on stakeholder involvement as outlined in these concepts also contributes to strategic enhancement of the adaptive capacity and resilience of local communities, water users, and managers.
In conclusion, knowledge exchange and experiential learning tools, strengthen our ability whether applied locally in classroom settings (organisational network) or in a longer term joint international program such as 'Water Without Borders' to scale the information, knowledge and learning generated by core GWF projects for effective dissemination and transformative change.

Climate Change Adaptation within the Boreal Forest: Linkages between science, management, and policy in sustainable forest management in a Canadian context.

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Session: Human Dimensions and Hydro-Economics

Abstract:
As the climate continues to change, forest ecosystems are experiencing stresses that have not been seen in the historical past. These changes are impacting many facets of the boreal forests around the world. In Canada, the Canadian Council of Forest Ministers (CCFM) has recommended that it is essential to consider both climate change and future climatic variability in all aspects of sustainable forest management (SFM). Policy and management practices need to evolve in the face of a changing climate in order to be sustainable.
In Saskatchewan, Canada, the Ministry of Environment has recognized that adaptation in forest policy and management practices is required. In December 2014, stakeholders from Saskatchewan forest industry and government came together to explore potential future climate scenarios, impacts on operations and management, and how to address adaptation for SFM in the future. Using this workshop as a jumping off point, we are now addressing, in more detail, some of these concerns and the gaps between policy and management tools and adaptations. It is apparent to all parties involved that this is important and must be addressed in order to put policy makers and practitioners in a better position to assess and manage SFM vulnerabilities and mainstream adaptation options into planning and management of Saskatchewan's forests for the future.
The Saskatchewan provincial government and Mistik Management Ltd. (a forestry company in Saskatchewan, Canada) partnered to undertake a vulnerability assessment in order to assess climate change and sustainable forest management. Mistik is currently developing a 20-year forest management plan and the vulnerability assessment will be incorporated into their plan. The vulnerability assessment of their management area was completed using a practitioner's guidebook developed by the CCFM. Through this assessment, climate change impacts were identified, and Mistik's adaptive capacity was analyzed. Based on the vulnerability assessment and the analysis of their adaptive capacity, Mistik has now begun mainstreaming the results into their forest management plan and their SFM system. The Forestry Branch of the Saskatchewan government is also utilizing the results of the Mistik vulnerability assessment to help guide forest policy direction to increase flexibility and promote adaptation in an environment of increasing climatic uncertainty in Saskatchewan.

Scenario development from policy discourse in the Nelson-Churchill basin

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Session: Human Dimensions and Hydro-Economics

Abstract:
Scenarios are consistent stories about the future of systems that are too complex and uncertain for standard methods of prediction. Scenario development facilitates robust decision-making, resulting in management options that perform adequately across a wide range of future conditions. The use of scenarios facilitates adaptive management and water system resilience. Scenarios intended for policy discussion incorporate the visions of water stakeholders including farmers, water managers, and representatives from environmental groups and governmental organizations at a range of scales. Scenarios capture both what is plausible and what is desirable (Wiek, 2013).

Scenario development for the Nelson-Churchill Basin focuses on policies that may or may not be implemented to foster system resilience. Current policy discourse includes the potential for green and hard infrastructure; economic policy instruments such as water markets and insurance programs; regulatory policies like laws, regulations, standards, and codes; and changes in governance to streamline, coordinate and add capacity to decision-making. We present the results of an NVivo-assisted scan of policy discourse in the Basin and provide an overview of stakeholder dialogue across stakeholder groups, time periods, and regions. Preliminary results show increasing interest in green infrastructure strategies, emphasis on economic instruments from agricultural groups, watershed stewards, and industry representatives; and preferences for regulatory policy instruments from environmental groups and representatives of provincial governments. Results demonstrate the value of incorporating the views of a wide variety of stakeholders and form the basis for discussion of an early round of working scenarios.

This process generates potential variables that can be incorporated into model development and projections. Ideally, exploratory modeling and stakeholder participation furthers public discussion of alternative futures and the consequences of policy decisions on future states (Keeler et al. 2015). The analysis contributes to an understanding of normative preferences across groups, times and space and scenario elements that will be considered desirable (Wiek, 2009), relevant (White et al. 2015; Riddell et al. 2018), and plausible (Wiek et al., 2013) by stakeholders involved in water governance in the basin.

Assessing the viability of transboundary waters agreements under future climate change scenarios – A case study of the Saskatchewan River Basin

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Session: Human Dimensions and Hydro-Economics

Abstract:
About one half of the Earth's surface is cover by river basins which are shared between two or more jurisdictions, supporting livelihood of about one half of the world's population. Sharing of water between the involved jurisdictions is mainly regulated through apportionment agreements. While a warming climate is expected to change the pattern of water resources availability, many of these transboundary water agreements are remained ignorant to this fact. This may increase vulnerability of transboundary river systems to future climate change, a potential threat to livelihoods and ecosystems. This could be especially true for river systems located in Canada, a country which is already experiencing a rapid warming climate. This study aims at deepening our understanding of how deeply uncertain changes in future climate would affect the robustness of transboundary waters agreements. We illustrate our study on the Saskatchewan River Basin (SaskRB), a large, strategic transboundary river basin located in western Canada. Most of the water in this basin originates from the Rocky Mountains in the west, flows through three Canadian provinces of Alberta, Saskatchewan and Manitoba, and finally drains into the Lake Winnipeg in the east. The sharing of water between jurisdictions is regulated through the Master Agreement on Apportionment signed between the provinces in 1969. Our study examines the robustness of this sharing agreement through a scenario analysis approach. In our "scenario discovery" method, a stochastic weather generator is used to produce several climate scenarios with many perturbed attributes to represent plausible future states of the world. These scenarios are fed into a hydrologic-water resources model of the basin to assist in analyzing the result of each scenario on the catchment's river flow. The robustness of the agreement is evaluated on points where rivers cross political borders by using a number of performance measures. The results of this study include several vulnerability maps that indicate climate conditions under which the agreement succeeds or fails.

The Economic Response to Water Availability due to Climate and Policy Change in the Saskatchewan River Basin

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Session: Human Dimensions and Hydro-Economics

Abstract:
The Saskatchewan River Basin (SaskRB) has been facing water allocation issues, such as the over-allocation of water in Alberta, that intensify competition among different water users due to the impacts of climate change on the amount of available water. Consequently, efficient water allocation among competing users becomes more challenging for decision makers. Under such circumstances, assessing the economic impacts of different water availability scenarios and alternative water allocation policies helps identify the most efficient policy options in the face of climate change induced water shortage. However, in the case of multi-jurisdictional river basins, such as SaskRB, evaluating these impacts in an integrated manner across the entire river basin is essential to identify the most promising water allocation policies.
Despite the importance of adopting an integrated approach in evaluating the economic impacts of different water availability and policy options, none of the previous studies of the SaskRB have considered the entire river basin as an integrated system. Mainly focused on one sub-basin (e.g., the South Saskatchewan River Basin) or a province (e.g., Alberta), these studies failed to evaluate the impacts of climate change or alternative policy options on the economy of the SaskRB as a whole. To fill this gap in the literature, we aim to assess the economic impacts of different water availability options in the SaskRB due to climate and policy change on not only sub-basins and provinces that share this river basin but also the entire river basin as an integrated system.
In this study, we developed an inter-regional Supply-side Input-Output modelling framework for the SaskRB to evaluate the direct and indirect economic impacts of different water availability options under climate and policy change conditions. Unlike previous studies that adhered only to administrative (e.g., provinces) or hydrological (e.g., sub-basins) boundaries, this study combines these boundaries to examine the impacts of water availability under climate and policy change on the economy of both provinces and sub-basins in the SaskRB. We apply this model to investigate the economic response of the SaskRB to two different water availability scenarios. In the first scenario, we assume that reduction in available water due to climate change is uniformly imposed to all industrial sectors, while in the second scenario, we consider a number of policy options to mitigate the economic impacts of this water shortage in the SaskRB.
Findings of this study show that adopting appropriate water allocation policies, such as prioritizing water demand of different sectors, using alternative water sources (e.g., groundwater or saline water), and water re-use helps mitigate the economic impacts of a shortage in water availability. Results reveal that by adopting these policy options, the provincial GDP can be improved by between 40 and 60 percent, and GDP losses in the SaskRB can be reduced by almost 50 percent.

A Social Psychology of Flooding on Reserves in Saskatchewan

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Session: Human Dimensions and Hydro-Economics

Abstract:
This presentation reviews the social psychological processes of coping with flooding on two Indigenous reserves in Saskatchewan. Water asset mapping, photovoice, rich picture, interview and sharing circle evidence exists to suggest that people on reserves respond in diverse ways to floods, and the social psychological processes (i.e., risk perceptions, control beliefs, aggression, gender-related factors) that govern these responses have evolved from decades of inequities in flood mitigation and responses. We translate these findings into rules for agent-based modeling (a separate presentation) and review potential policy gaps and failures that have led to community psychological vulnerability to floods.

An Agent-Based Agricultural Water Demand modeling for Human Adaptive behaviors

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Session: Human Dimensions and Hydro-Economics

Abstract:
As extreme events, such as drought, have become increasingly widespread, human behaviors have evolved, impacting both water supply and water demand. Most importantly, farmers have adapted to drought using several strategies, including water-saving technology and changing crop patterns, reducing agricultural water demand. These evolving behaviors have significantly reduced the system determinism, thus creating uncertainty on long-term water planning and should be included in the future water demand prediction. Although urban water demand modeling has been recently studied through socio-hydrological models, modeling agricultural water demand with a non-stationary structure remains elusive. In this study, we attempt to address this challenge by developing an agent-based agricultural water demand model. Using the concept of collective behavior, emergent farmers' water use behavior, we assess the effects of both water-saving technologies and changing crop patterns for the drought policies on estimates of agricultural water demands. We focus on the Bow River Basin (BRB) in Alberta, Canada, as a case study. The government of Alberta has recently managed to improve water conservation, productivity and efficiency in the agricultural sector, leading to a decrease in water demand. The crop patterns in the BRB have been switched from forage to other crops like cereals, oil seeds and specialty crops, which require 150 to 200 mm less water during growing seasons. In addition, the observations indicate the increase in using more efficient on-farm irrigation systems. We model agricultural water demand to capture the complexity of this socio-hydrological system about how individual farmers decide to adopt a new on-farm irrigation system and change crop patterns to reduce their water demand. The findings are broadly consistent with the observed diverted agricultural water, crop patterns and water-saving technology trend in the BRB. This model can lead to a better understanding of agricultural water demand, thereby enabling policy makers to enhance long-term water planning through applying other new water-saving technologies or crop pattern changes. Additionally, this model can be used as a participatory modeling to simulate the collective behavior of the farmers and policy makers in different scenarios for adaptation to drought.

Leaving No One Behind'- Guiding vision for Global Water Security

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Session: Human Dimensions and Hydro-Economics

Abstract:
Through the 'Water for All' campaign, the World Water Development Report 2019 enabled mainstreaming the vision of 'Leaving No One Behind' as an integrated approach to achieving sustainable water management and long-term water security. The synthesis underlined the relevance of informed policy and inclusive decision-making, while providing a directional agenda to the water community worldwide, users and managers, how to improve availability, accessibility and quality related challenges in the water provisioning services, particularly for individuals and groups living in vulnerable situations by: a) providing an overview of innovative, fit to purpose solutions at local scale ; b) stating the barriers and opportunities in managing access to water supply and sanitation services that are essential to overcoming poverty, social and economic inequities; c) emphasizing that human right to water (UN General Assembly and the Human Rights Council recognised this in 2010) entails people as rights-holders and states are duty-bearers of providing water and sanitation services to its citizens. The talk will further highlight how the global discourse on 'Leaving No One Behind' can address challenges related to 'water rights' through available tools and measure related to water management and development, mainly the Sustainable Development Goal 6 and Resolution 64/292, the human right to water and sanitation. In conclusion, how mega initiatives like the 'Global Water Futures' program can possibly integrate this thinking in its ongoing projects and activities. The overview of Chapter 2 from the report that tackles physical and environmental dimensions that applies to the access to acceptable and affordable drinking water, and how fit-for-purpose solutions and investment in capacity strengthening of local and indigenous populations is required to provide for the safe collection, transport, treatment of water at multiple scales and in multiple geographies will be shared ;linking with the context of UNU INWEH's contribution to GWF projects 'Southern Forests Water Futures' and 'Co-creation of Indigenous Water Quality Tools'.

Unpacking wicked water problems: conflict and agricultural water management in the prairies

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Session: Human Dimensions and Hydro-Economics

Abstract:
Agricultural water management (AWM) is a hotly contested issue in the Canadian Prairies. Prairie provinces provide a significant contribution to Canada's agricultural sector, but AWM, and specifically the practice of draining wetlands or otherwise moving surface water to free land for crop production, can come at the expense of conservation and biodiversity goals. As such, while AWM practices are essential for farmers they have also become a target for environmental activism because of concerns that include increased down-stream flood risk and impacts on recreational water uses. In this talk, we discuss AWM as a "wicked problem" and illustrate how the contested practices and differing perspectives defy easy categorization and policy solutions. Conflict in the prairies surrounding AWM, and in Canada surrounding agriculture in general, are both escalating. We discuss this conflict, and what it means for effective management of water resources during times of change. While the details of this case are specific to a particular governance and management regime in Saskatchewan, the broad themes regarding conflict escalation and management are relevant to water and environmental security conflicts around the world.

Small community response to forest fires and flooding in the Boreal.

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Session: Human Dimensions and Hydro-Economics

Abstract:
Background
Community resilience is a broad field studying how communities resist, respond to, and adapt following a disaster. This field focuses on understanding the resources and capacities required for communities to respond effectively to wildfires and flooding. Researchers have focused in the past on building various frameworks of these resources and capabilities that can be used to create indices to measure levels of resilience for different communities. However, there are important variations in what is required to allow a community to respond and adapt to a fire or flood event based on the size of the event, preparedness level of the community, and other confounding variables that impact their ability to be resilient.
In this research we a shifting the approach to examine the adaptive capacities associated with changing resources within communities over time, both during and between events. We aim to identify patterns or pathways of change in resources and the adaptive capacities of a community to determine if these changes are purposeful or accidental. This understanding of changes will allow us to provide insight for communities about how to maintain preparedness between events and attend to longer term degradation of resources. Additionally, if patterns of change are identified this will inform the existing debate within governments and communities regarding the proportion of funding to allocate for immediate event response versus prevention and mitigation efforts.
Methods
We are using a community-engaged case study research approach. We have engaged 6-9 small communities in designing our study and are now in the process of collecting data through interviews with community members (approx. 50), news articles about past flood or wildfire events affecting the community, and disaster-specific reports. Small communities are the focus of this research as they are often neglected by researchers and experience a unique set of challenges and benefit from assets larger communities may not possess.
Results
This research focuses on how communities shift and adjust adaptive capacities and related resources prior to, during and following wildfires and floods. Patterns related to these short- and long-term changes in resources and ability to respond are important for communities to understand when planning for a future flood or fire. This research identifies the mechanisms through which community adaptive capacity to respond to events change between disasters as well as immediately following an event. Understanding these mechanisms will shed light on potential policies directed at proactive measures communities can take between disasters with government funding at various levels. Next steps of the research involve engaging other communities who have not experienced a significant flood and fire event in the past. This will allow not only knowledge mobilization of the research results, but also sharing between communities of lessons learned and approaches to planning that can strength community response across Canada.

On-the-Land with Communities in the Northwest Territories: Engaging, Educating, and Empowering Indigenous Youth

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Session: Human Dimensions and Hydro-Economics

Abstract:
Northern Canada is one of the most rapidly warming regions on Earth, resulting in dramatic changes to ecosystems (i.e. varying quantity/quality of water and unprecedented rates of permafrost thawing). Northern communities deal directly with the impacts, which affects their livelihoods, food and water security, health and wellbeing, and the future for young Northerners. Hence, it is imperative that the younger generation are empowered to monitor and measure the changes impacting their territorial lands in order to protect the land and water for the future. I am collaborating with Northern Water Futures (NWF) and Dehcho, Tlicho, and Inuit communities to enhance land-based education for Indigenous youth in the Northwest Territories (NWT). With funding from NSERC PromoScience, three youth-focused, 1-week on-the-land camps (Camp #1: Willow Lake, 2018; Camp #2: Daring Lake, 2019; Camp #3: Trail Valley Creek, 2020) are planned with community partners. These camps aim to engage, educate, and empower youth in NWT with scientific and traditional knowledge to protect the land and water. Each camp involves traditional activities led by Elders, and hands-on science-based learning led by NWF. During Camp #1 (August, 2018) at Willow Lake (Edéhzhíe), I helped facilitate and deliver activities to educate Dehcho youth from Fort Providence and Fort Simpson. My experiences and relationships from Camp #1 guide this research and provide insights for Camps #2 and #3. This presentation will focus on Camp #1, specifically the lessons learned, various activities facilitated, knowledge co-production, and the role of land-based education for communities in the North.

Integrated Water Resources Planning and Management of the Complex, Transboundary Saskatchewan River Basin in Canada

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Session: Human Dimensions and Hydro-Economics

Abstract:
The Saskatchewan River Basin (SaskRB) is a large multi-jurisdictional river basin of great ecological, social, and economic importance spanning the Canadian provinces of Alberta, Saskatchewan, and Manitoba and the US State of Montana, and is a key water resource for these Prairie regions. Water management in this basin is complicated by multiple administrations and operating policies, numerous water user groups, and unequal spatial and temporal distribution of supply and demand. In addition, the upstream water of the basin is highly controlled by both provincial and international agreements, while the sharing of water between the provinces is facilitated by the Master Agreement in Apportionment (1969). As a result, the provinces are primarily responsible for water management and utilize their own decision-making models, resulting in fragmented water management according to political rather than catchment boundaries. Increased development, along with increased hydrological variability due to climate change, are likely to further complicate the process of water management in the SaskRB. This increased complexity in water management and possible future shortcomings of the international and interprovincial apportionment agreements, particularly under water stress conditions, highlight the need for basin-wide integrated water resources management (IWRM). The objective of this study is to develop an integrated water management model for the entire SaskRB based on the current water management infrastructures and hydrologic conditions, in line with the aims of the Integrated Modelling Program for Prediction and Management of Change in Canada's Major River Basins (IMPC), with a focus on investigating the anticipated risk of irrigated agriculture and associated water management options under a range of future scenarios. For this purpose, we used the MODSIM-DSS software package, developed for river basin water management and decision support. We emulated the current physical system within this model and validated it by comparing the model results with that of the Water Resources Management Model (WRMM) presently used by the Saskatchewan Water Security Agency (WSA) and Alberta Environment and Parks (AEP). This integrated model will be run under a range of future scenarios of hydro-climate change and irrigation expansion to assess the vulnerability of the water resources system under different conditions. The results of this study will provide insights into vulnerabilities of the system and the viability of the planned irrigation expansions across the basin.

First Nations on Indigenous water Stewardship and Community-based Monitoring

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Session: Human Dimensions and Hydro-Economics

Abstract:
Water is Life: Initial Reflections from Matawa
The goal of Matawa Water Futures is to engage in community led, Indigenous-informed water science that supports Indigenous decision making and water stewardship. Working in partnership with Matawa First Nations and university-based scholars at Laurier, Lakehead, and Laurentian, we are developing research protocols and practices that integrate Indigenous knowledge and Western science to contribute to a more robust and effective water monitoring and governance system.
In this presentation we will discuss findings and reflections on early learnings from our initial community engagement session, the Water is Life: Matawa Environmental Gathering hosted December 11-13 by Matawa Four Rivers Environmental Group in collaboration with Laurier and Laurentian Universities. Using community visioning processes and the science café method we gathered community perspectives and values on water and priorities for water monitoring from over 30 Indigenous participants from the 9 Matawa communities. The discussions provided rich and detailed community perspectives on Indigenous values and water stewardship. The visioning exercise invited First Nations community members to address the questions: Why water is important?; What changes are evident?, What are the current and potential impacts to community wellness of these water changes?, and How do communities protect water? In the world café small groups moved through five stations to provide early methodological insights, traditional water values, and community monitoring priorities with recommendations for engagement and pathways forward.
Shared community views and values and water visioning findings were reflected in the participant quote "Water is Spiritual, Water is Sacred, Water is Life". During the prioritization activities, 8/9 communities chose water quality and changes in water as their top monitoring priority. Most communities identified traditional foods and traditional medicines as their second and third priorities. The Matawa participants' main overall environmental concern across, all communities, however, was contamination from resource development, past, current, and potential with one community identifying monitoring of contaminants as its top monitoring priority.
Key findings of the gathering including the need to develop protocols for the protection of sacred knowledge, and the vision of Matawa First Nations developing a water declaration will be shared. We will discuss guidance received regarding the importance of research protocols and data security with recommendations to engage community members in small groups and through social media such as radio programing and Facebook. We will share rich community insights gathered on environmental stewardship and community-led environmental monitoring discussing community-identified priorities, barriers, and pathways forward. The sharing of insights will create opportunities for collaboration with other First Nation initiatives within GWF.

The Economic Value of Water-based Recreation in Canada

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Session: Human Dimensions and Hydro-Economics

Abstract:
Outdoor recreation is one of the most tangible ways human experience their surrounding natural environment and almost 90 percent of Canadian adults participate in some form of nature-based recreation. Recreation is often touted as an important aspect of physical and mental health, yet there is still much to be learned about quantifying the economic value Canadians receive from participating in outdoor recreation. Canadians spent $40.1 billion on nature-related recreation representing 2.9% of GDP. These expenditures represent what Canadians spend on recreation, not the economic benefits Canadians receive from participation.

The objective of this paper is to quantify the economic value of water-based recreation in Canada. The valuation of ecosystem services such as recreation is challenging because there are rarely market prices attached to the benefits people receive from nature. Even when partial market prices exist they often do not capture the full set of resources that individuals give up to participate in recreation activities. For example, recreationists pay site and license fees and spend money on equipment but also incur monetary and time travel costs associated with accessing the site. Economists have developed a specialized suite of tools for estimating the value of environmental amenities in these contexts, including both revealed and stated preference methods.

To quantify the welfare benefits of recreation in Canada, we draw upon the Value of Nature to Canadians (VNC) survey conducted by Statistics Canada. The VNC survey was administered by mail and the internet to a nationally representative sample yielding over 24,000 responses. The VNC survey collected trip information for 17 different recreation activities including hiking, cycling and mountain-biking, camping in tents, non-motorized water activities, beach activities, alpine skiing and snowboarding, cross-country/backcountry skiing and snowshoeing, golfing, photographing or filming nature in general, gardening or landscaping with plants, birding, hunting waterfowl, hunting gamebirds (other than waterfowl), hunting small game mammals, hunting large game mammals, hunting other wild animals, trapping game animals, and fishing. Having such a rich set of recreation activities provides a unique opportunity to comprehensively assess the total welfare benefits of recreation while accounting for potential substitution effects between recreation activities.

We implement a Kuhn-Tucker (KT) travel cost model which incorporates both the extensive and intensive trip decisions using a single welfare theoretic framework. Preliminary results reveal substantial economic benefits of water-based recreation in Canada. The results also reveal substantial heterogeneity in recreation benefits across individuals and regions. We calculate per activity day values for each province and territory in Canada which provide policy makers with value estimates that can be used in benefit cost analysis.

Learning to be Part of the Land: Directives for Research with Indigenous Peoples

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Session: Human Dimensions and Hydro-Economics

Abstract:
In this presentation, I reflect on my positionality as a 'northern' Indigenous scholar doing PhD research in a Maya community in Yucatan, Mexico, and also describe how I applied Indigenous research methods. I discuss how my Indigenous cultural and family background informed my approach in learning from the Maya people to be "part of' the Maya home- land -- the Yucatan. I believe that my research approach could be useful to other Indigenous (and non-Indigenous) scholars in my position who are thinking about doing water-related research, as part of the Global Water Futures initiative, in a vastly different Indigenous context and may be of benefit from a few directives or guidelines, which I have developed based on my personal experience.

A Sub-Basin Scale Analysis of the Private Costs and Benefits of Wetland Drainage Scenarios

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Session: Human Dimensions and Hydro-Economics

Abstract:
The loss of wetlands and the corresponding loss of wetland ecosystem services (e.g. flood control, water storage, carbon sequestration etc.) is an important problem in the Prairie Pothole Region of North America, including western Canada. Research has shown that the primary driver of wetland loss within the Canadian prairies is agricultural development. The private economic incentive to drain wetlands has increased over time with the increased size of field operations equipment and technological changes that have decreased the cost of drainage such as broader integration of Global Positioning System (GPS) technology in farming operations. The development of acceptable and effective wetland conservation policy requires an improved understanding of these economic incentives including the magnitude of the private or on-site benefits and costs of wetland drainage. Considering a policy approach that targets specific wetlands or lands within an agricultural landscape, the goal of this study is to inform a least cost approach to wetland drainage in Sub-basin 14 watershed in the Vermilion River Basin, Alberta. We conduct a spatially explicit analysis of the net-present value of wetland drainage scenarios, using a GIS database, that focus on the most agriculturally productive lands of the sample sub-basin. This approach mirrors the real decision-making process of agricultural producers, where relatively small wetlands on the most agriculturally productive lands are the most at-risk wetlands and enables us to locate and quantify the range of wetland drainage net benefits.

Equally unequal in income level and water consumption? The analysis of inequality in water consumption in the residential sector

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Session: Human Dimensions and Hydro-Economics

Abstract:
Income inequality has extensively studied in developing and developed countries. Causes and consequences of income inequality have been reported in different studies. However, the analysis of inequality in access to natural resources, in general, and inequality in water consumption, in particular, has been scarcely studied. In the residential sector, the unequal consumption of water may depend on several factors, such as household preferences, water prices, wealth levels and income inequality, weather conditions, water supply at the municipal level, and institutional and technical capacity of water utilities. The understanding of the determinants of inequality in water consumption can inform government authorities about the interventions that can reduce it.
I use data from Ecuador, a country characterized by its level of income inequality, which makes it an ideal case to study the determinants of inequality in water consumption across municipalities that differ in terms of income levels, institutional quality, and weather conditions. The advantage of using information from this country is that we can study the effect of different determinants of inequality in water consumption by comparing water consumption of households across different socioeconomic conditions, population density and institutional quality at the municipal level. I use information for the period 2012-2016 to construct a panel of 150 municipalities in the country. I calculate the Gini coefficient to measure inequality in household water consumption at the municipal level. To identify the determinants of inequality in water consumption I include average socioeconomic characteristics of households, and institutional and demographic characteristics of the municipalities. The former include family income and size, average price of water, and education level of the household head. The latter include availability of water supply, population density, institutional quality and income inequality.
The regression estimates from a fixed-effect models show the magnitude of the effect of individual and municipal variables on the level of inequality in water consumption, and whether this effect is statistically significant or not. I find that the municipal average price of water is associated with a reduction in inequality in water consumption, whereas a higher population density and weaker institutional quality, measured by water supply availability and service coverage, increase it. The results are robust to the use of the Gini coefficient and other measures of inequality in water consumption. Important policy implications result from the identification of variables that have a significant effect on inequality in water consumption in the residential sector and that can be altered by changes in water policies and institutions.

Harmonizing Water Resource Modeling with Indigenous ways of knowing: A Collaboration in Water Stewardship of Saskatchewan River Delta

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Session: Modelling

Abstract:
Increases in the global population and accompanying demands for water and food production is having detrimental impacts on watersheds' function. These impacts include reduced water quality, flow fluctuations, lack of sediment replenishment, etc. The Saskatchewan River Delta (SRD) is no exception. Populations in the SRD, such as Cumberland House, have been adversely affected by upstream water withdrawals for irrigation, dam-induced alterations of the seasonal river flow for hydropower, and legacies of industrial pollution. The Saskatchewan River Delta has received little attention from the federal and provincial governments. To address the gap, my proposed research seeks to understand to what extent local and traditional knowledge can add value to water resources models and in turn how water resource models add value to communities' decision-making. My study will use a community-engaged scholarship approach based on qualitative research techniques such as Photovoice, which by integrating photography and dialogue, reflects on community's needs and enhances their voice. This kind of knowledge may advance efforts to accurately model the water flows from upstream to downstream to illustrate the conditions that lead to adverse impacts on the Delta and its communities.

High-resolution Regional climate simulation for western Canada

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Session: Modelling

Abstract:
To assess the risks posed by climate change to local environment and ecosystem in western Canada, a thorough downscaling of future regional climate scenarios from large-scale climate model projections is indispensable. The cold region in western Canada features the Canadian Rockies, where the small-scale atmospheric processes play important roles. Convection-permitting models generate more realistic regional to local scales climatic information compared to models with coarser resolution and convective parameterization. We present here an evaluation of the set of 4-km convection permitting WRF simulations conducted in western Canada. A retospective simulation (CTL, October 2000-September 2015) over western Canada was conducted with ERA-interim reanalysis as intial and boundary conditions. A pseudo-global-warming (PGW) simulation with reanalysis-derived initial and boundary conditions perturbed with changes in filed variables derived from the CMIP5 ensemble-mean high-end emission (RCP8.5) scenario climate by the end of 21st century. The comparison of surface air temperature between CTL and gridded observation ANUSPLIN shows that WRF simulation of daily mean temperature agrees well with ANUSPLIN temperature in terms of the geographical distribution with cold biases east of Canadian Rockies, especially in spring. The daily minimum/maximum temperature of WRF-CTL and ANUSPLIN shows a similar pattern of geographical distribution compared to that of the daily mean temperature in all seasons with smaller/larger cold bias. The WRF-CTL simulation captures the main pattern of distribution of precipitation in the observed precipitation from ANUSPLIN and CaPA: high precipitation near the BC coast in winter and over the immediate region on lee side of the Canadian Rockies. WRF-CTL is wetter than ANUSPLIN in all seasons especially in the north. WRF-CTL's precipitation shows more agreement with CaPA, which is also wetter than ANUSPLIN. Future warming scenario, WRF-PGW, shows significant warming across western Canada. The warming is stronger in cold season, especially over the northeast polar region in winter and over the Canadian Prairies in spring. While precipitation changes in PGW over CTL vary with seasons, more increase occur in spring and late fall for both basins, and nearly zero or decrease for precipitation in summertime in SRB. This seasonal difference in the change of precipitation means that the Canadian Prairies and the southern Boreal Forest biomes will likely see a slight decline in precipitation minus evapotranspiration during the summer months which might have an impact on soil moisture for farming and forest fires. The change in precipitation is the least in summer where parts of the Prairies get less precipitation in PGW than in CTL. The water availability during growing season would be challenging for the Canadian Prairies with almost no increase in summer precipitation and the much larger evaportranspiration in PGW than in CTL. WRF-PGW shows an increase of high precipitation events and makes the distribution of precipitation events toward more extreme intensive events in all seasons, especially in summer. Due to this shift in precipitation intensity to the higher end in the PGW simulation, the seemingly moderate increase in precipitation total amount in summer for both basins may not reflect the real change in flooding risk and

water availability for agriculture. The 4-km WRF dynamical downscaling of the current and future(RCP8.5) climate provides valuable high-resolution regional climate data for many applications in hydrology and climatic impact studies.

Accomplishment of Core Modelling Team

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Session: Modelling

Abstract:
Climate warming and human actions are altering precipitation patterns, reducing snow levels, accelerating glacier melting, intensifying floods, and increasing risk of droughts, while pollution from population growth and industrialization is degrading water systems. With such unprecedented change, it is clear that the historical patterns of water availability are no longer a reliable guide for the future. Adaptation to these changes requires new modeling tools that precisely capture these interconnected forces and their societal implications. The core modelling team is charged to deliver these "new modeling tools" for Canada and the cold regions of the world.
This presentation will summarize the major accomplishments of the core modeling team, including (1) developing prototype forecasting streamflow forecasting systems for key mountain river basins; (2) production of pan-Canadian WRF simulations for current and future climate; (3) application of process-based models spanning scales from research catchments (e.g., Marmot Creek, Whitegull Creek) to major Canadian basins (e.g., Mackenzie, Great Lakes, Saskatchewan); (4) development of process-based models of water quality; and (5) development of next-generation modeling capabilities. These accomplishments substantially advance computational infrastructure for hydrological research and applications in Canada.

Status report on the Great Lakes Runoff Inter-comparison Project for Lake Erie (GRIP-E)

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Session: Modelling

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 scientific pur- poses across Canada and the United States. The models participating to date are GEM-Hydro, WRF-Hydro, MESH, VIC, HYPE, and LBRM. The project is aiming to run all these models over the entire Great Lakes domain with Lake Erie cho- sen as the initial domain (GRIP-E). Inter-comparison studies were however already conducted for Lake Michigan (GRIP-M) and Lake Ontario (GRIP-O) with various models including a subset of the aforementioned models.
One of the main contributions of the project is to identify a default, consistent dataset for model building that all participants in the inter-comparison project can access and then process to generate their model-specific required input variables. This presentation will give an update of the datasets all collaborators agreed on and the various scripts converting these datasets into model-specific setup files. The presentation will give an update on the current stage of the model intercomparison, will highlight the results achieved so far and discuss the next steps.

Core Modeling plans

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Session: Modelling

Abstract:
The next phase of the core modeling effort will focus on the high-priority tasks that are necessary to accomplish pan-Canadian simulations/predictions of the terrestrial water cycle. The proposed work will: (1) improve estimates of pan-Canadian spatial meteorological fields, obtained through a fusion of WRF and GEM climate model simulations with station observations, and explicitly representing the uncertainty in the spatial meteorological fields; (2) advance information on geospatial intelligence (datasets on topography, vegetation, soils, etc.) to simplify application of hydrologic models across Canada; (3) advance methods for parameter estimation, sensitivity analysis, and benchmarking, to improve model applications over large geographical domains; (4) develop next-generation hydrologic modeling capabilities, to provide the process representation and computational infrastructure that is necessary to support pan-Canadian simulations of the terrestrial water cycle; and (5) develop an advanced comprehensive streamflow forecasting test-bed. This presentation will summarize the current capabilities in each of these areas, the major research challenges, and the expected outcomes from the GWF core modeling team.

Beyond the Mass Balance: A Process Based Approach to Modelling Legacy Phosphorus Dynamics

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Session: Modelling

Abstract:
Phosphorus (P) inputs to human-impacted watersheds have more than doubled over the last century in response to the use of fertilizers, detergents, and P additives in a range of products, from animal feed to motor oil. Although mass balance studies consistently show P inputs exceeding outputs in human-impacted areas, the forms and relative magnitudes of legacy P accumulation are still not well understood. In the present work, we have developed a parsimonious, process-based model, ELEMeNT-P, that pairs soil P dynamics with both erosion processes for simulation of surface P transport and a travel time-based approach for simulation of transport and retention along subsurface pathways. Using a more than 100-year trajectory of watershed P inputs to the Grand River Watershed, we have not only reconstructed total phosphorus yields at the watershed outlet, but also estimate the magnitudes of P accumulation along surface and subsurface pathways. As Lake Erie and other inland lakes continue to be impacted by eutrophication events, even after significant improvements in nutrient management practices, such estimates of legacy P accumulation will be crucial to setting realistic targets for reducing P loading and for better understanding the contribution of P legacies to current and future lake nutrient dynamics.

Multi-scale snowdrift-resolving modelling of mountain snowpack evolution

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Session: Modelling

Abstract:
The evolution of mountain snowpacks over time and space has substantial variability due to processes occurring across a large range of scales: from orographic enhancement of snowfall at large scale to gravitational and wind-induced transport of snow on the ground and snow interception in forest canopies at smaller scales. This complexity represents a challenge for hydrological forecasting in mountainous terrain. In this study, a multi-scale modeling approach is proposed to represent the complex spatial evolution of snowpacks in the Canadian Rockies. It relies on the Canadian Hydrological Model (CHM), a modular, multi-physics, multi-scale, spatially distributed hydrological modeling framework. CHM permits variable spatial resolution by using the efficient terrain representation of unstructured triangular meshes. It includes parameterizations to simulate snowmelt and ablation by the energy budget approach and snow redistribution due to avalanches, blowing snow and snow interception. Short-term forecasts from the GEM (Global Environmental Multi-scale) atmospheric model running at 2.5 km drive CHM, and are downscaled to the unstructured mesh using process-based procedures. In particular, a wind downscaling strategy combines meso-scale GEM output and micro-scale pre-computed wind fields. GEM-CHM was applied to simulate snow conditions during winter 2017/2018 over two areas of the Canadian Rockies: the Kananaskis region (1000 km2) and the upper Bow River Basin (16000 km2). GEM-CHM simulations are evaluated using multi-scale snow observations from the Canadian Rockies Hydrological Observatory: (i) point-scale and transect measurements of snow density and depth, (ii) high-resolution snowcover indices of snow absence and persistence derived from remotely sensed imagery and (iii) maps of snow depth derived from airborne LiDAR. The multi-scale observations allow us to assess the impact of the atmospheric forcing (especially precipitation and wind field) and the resolution of the CHM unstructured mesh on the simulations of snowpack variability. These preliminary results will help guide the development of GEM-CHM as a snowpack forecasting system in the Canadian Rockies.

Forensic glacial hydrology of the Slims River piracy and the fate of Yukon's Kluane Lake levels

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Session: Modelling

Abstract:
Kluane Lake, Lhù'ààn Mān, is Yukon's largest lake extending over 430 km2 with depths down to 78 m. As a great freshwater storage and aquatic habitat, it constitutes a vital traditional resource for the Kluane and White River First Nations, and a focal point of the ecological and economical life in southwestern Yukon Territory. Until the piracy of its headwaters by Kaskawulsh River in 2016, Slims River (Ä'äy Chù) was the main source of inflow to Kluane Lake, part of the Yukon River Basin. Both rivers are fed from the Kaskawulsh Glacier, located in the Icefield Ranges of the St. Elias Mountains. The continued retreat of this glacier caused water to divert from its terminus to flow eastward, redirecting all if not most of the Slims headwaters south to the Pacific Ocean through Kaskawulsh and Alsek Rivers. This research work addresses major questions posed by Kluane First Nation of Burwash Landing, residents of Destruction Bay and surrounding areas and Yukon Government on the history and impending fate of lake levels. For this purpose, an attentive scientific investigation helped in generating full flow and level records of the Kaskawulsh-Glacier/Slims-River/Kluane-Lake glacio-hydrological system. A comprehensive literature review spanned from the research of Bostock (1969) who foresaw the Slims piracy, to the exclusive study by Shugar (2017) who witnessed and documented it. As a modeling tool, MESH land surface hydrology model was parameterized using soil type, land cover and glacier cover, and was run with and without Kaskawulsh Glacier contributions to the Slims River. Forcing inputs from the EU WATCH Project meteorological dataset (1901-2001) were used to reproduce historical conditions. The simulated lake levels and Kluane River flows were compared and calibrated to hydrometric observations available since 1952. Model results over the previous century captured some previously reported years of partial diversions caused by glacier dynamics, and revealed a non-reported one, 1989, as the worse for the Slims. To evaluate the impact of climate change, MESH was also driven by outputs from the WRF atmospheric weather model at 4-km resolution, under both controlled and pseudo global warming RCP8.5 scenarios for this century. Due to the permanent piracy of glacier meltwaters, summer peak lake levels are ultimately reduced by 1.5 m on average as occurring and through the future. The conviction of the pirate Alsek River is corroborated by its clear water gains in observed hydrographs and runoffs when Dezadeash River flows are subtracted from a downstream ECCC Alsek gauging station. These findings will help assess potential flow regimes and inform environmental adaptation and infrastructure investment around Kluane Lake.