# Third Northern Research Day

**Wednesday, January 23th, 2019**
**McGill Faculty Club, 3450 McTavish Street, Montréal, Québec**
**8:30 a.m. – 5:00 p.m.**

## POSTERS ABSTRACTS

### 1. Highlighting the potential of peer-led workshops in training early career researchers for conducting research with Indigenous communities

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For decades, Indigenous voices have been calling for changes to research approaches and researchers are also increasingly aware of the importance of community-collaborative research. However, in Canada, most researchers get little-to-no formal training on conducting research with Indigenous communities. This is particularly problematic for early-career researchers (ECRs) whose fieldwork often involves interactions with Indigenous communities. To address this lack of training, two peer-led workshops targeted to Canadian ECRs were organized with the following objectives: (a) to cultivate awareness about Indigenous cultures, histories and languages; (b) to promote sharing of Indigenous and non-Indigenous ways of knowing; and (c) to foster approaches and explore tools for conducting collaborative research with Indigenous communities. Workshop success was evaluated based on five themes: scope and interdisciplinarity, Indigenous representation, context matters, skillful moderation and workshop outcomes. Here we present the Indigenous Intercultural Workshops, describe the methodology used to evaluate them and discuss the workshops' success in reaching its objectives. Our findings show that peer-led workshops are an efficient way for ECRs to cultivate awareness of Indigenous realities and to learn about diverse ways of knowing, essential skills that are necessary for the type of collaborative research being requested by Indigenous Peoples.

### 2. Lateral Kindness, Supportive Social Environments in Eeyou Istchee

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Chisaawaatisiiwin is the Cree word referring to kindness, mercy, and grace. What is lateral kindness? It is a concept that draws on Cree values which promote and celebrate positive things that are taking place within the community. In the James Bay Cree culture, kindness was a trait that developed out of the will to survive. There exists an unwritten law that those out on the land must always be ready and willing to lend a helping hand. Today, lateral kindness is seen in platforms such as 'Share the Love'. The purpose of promoting lateral kindness in Eeyou Istchee is to foster personal and communal well-being in a way that encourages Sikischaaymuuwin (peace) and Spaaymunn (hope).

### 3. Updated palaeoclimatic reconstruction for a Cenomanian-aged angiosperm flora near Schefferville, Labrador

Alexandre Demers-Potvin[1]
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The terrestrial ecosystem revolution in the middle of the Cretaceous witnessed the evolution of many modern insect and angiosperm taxa. A better knowledge of local and regional climate trends in deep time can improve our understanding of these ecological and evolutionary trends. Here I present results from the first multivariate palaeoclimate analysis for the environment of a fossil flora dominated by leaves found in the Redmond no.1 mine, near Schefferville. The isolated location of this flora in a region otherwise devoid of Mesozoic sites, as well as its estimated Cenomanian age (93.9-100.5 Ma) make it an essential site for studying the palaeoecology of Cretaceous Eastern Canada. Our analysis reveals that the Redmond flora would have evolved under a mean annual temperature (MAT) of around 15.2°C. These results confer the region a warm temperate and fully humid climate, which agrees with previous palaeoclimate hypotheses. The flora is also well integrated to palaeolatitudinal MAT gradients that use other North American sites of similar age. Our study introduces 14 leaf morphotypes discovered during recent explorations of the Redmond mine alongside insect impression fossils, including freshwater nymphs and beetles that support the hypothesis of a lacustrine depositional environment. Their eventual description will improve our knowledge of the history of biodiversity on the Quebec-Labrador peninsula and can renew palaeontological interest in this region of Northern Canada.

### 4. Improved sea ice drift estimates in Lagrangian methods for sea ice forecasting

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We have recently developed a Lagrangian Ice Tracking System (LITS) for the Arctic Ocean. The LITS tracks motion of sea ice in a Lagrangian framework using sea ice drifts. It has been used to develop a seasonal forecasting model of the minimum sea ice extent (Williams et al. 2016) based on observational drifts. In continuity, we are working on the seasonal predictability of the sea ice system on a regional scale (Brunette et al. 2018). The current version of the LITS uses the Polar Pathfinder sea ice motion vectors (V3, Tschudi et al. 2016). However, the raw drift vectors used to construct Polar Pathfinder contain biases. The satellite-derived velocities (from SMMR, SSM/I, AMSRE, AVHRR) and free drift estimates present a low bias when compared to the buoy drift observations, taken to be essentially true. Biases are larger in the summer, when fewer satellite-derived drifts are available and the composite sea ice drift relies more heavily on the free drift estimates. While being useful for climatic studies and model validation (Sumata et al., 2015), the issues found in Polar Pathfinder become more apparent when building a regional forecasting model. We propose to recompile a new optimally interpolated sea ice drift dataset, using new free drift estimates derived from wind reanalyses, bias-corrected and error-weighted raw drift vectors from Polar Pathfinder, buoy data, and other available satellite-derived drifts. Preliminary work on the derivation of free drift estimates from wind reanalyses will be presented.

## 5. The Canadian Integrated Northern Greenhouse: Results and future development

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Last year, at the 2nd McGill Northern Research Day, I presented the Canadian Integrated Northern Greenhouse (CING), a hybrid between a northern greenhouse and growth chamber housed in a shipping container, developed by McGill's Biomass Production Laboratory. Following this presentation, the CING completed two harvests, one in spring, one in summer and the third run has started this November. Lettuce was grown in the CING in hydroponic conditions, and the yield was compared to an equal amount of lettuce grown in a research greenhouse in the same hydroponic conditions, in simultaneous. Moreover, two nutrient solutions were compared with this experiment in both growing environments, one based off chemical nutrients according to the Hoagland recipe and one based off vermicomposting leachate, an attempt to provide nutrients for biomass production out of food waste, increasing the independency of these systems designed for remote location operation. The first sets of cold climate data from the CING being collected, the CING is still a prototype. However, the concept of shipping container-based biomass production unit is getting more attention for its potential in Northern climate. The building of another prototype in Northern conditions is the second obvious but imposing step this project must take. Hence, this presentation aims at sharing ideas and meeting potential partners for such a project to occur, in the optic to increase the local food production in Northern Canada.

## 6. Design and implementation of a bioreactor and nutrient sensing device for northern food production

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Northern food production is limited by a short growing period and cold temperatures. PoultryPonics is a two-level food-production facility designed for northern regions with a hydroponic plant growth system built on the second floor and the chicken production on the first floor. Using the heat produced by the chickens and the electrical lighting, enough heat is produced to maintain a warm growing environment to grow vegetables even during the cold northern winter. To minimize waste output, a bioreactor producing manure extracts, a watery extract made from chicken manure, was built. Manure needs to be composted and aerated prior being added to the hydroponic system. This solution is an alternative to inorganic fertilizers used for cultivating crops in hydroponic systems. In addition, use of animal manure requires more monitoring of the nutrient solution, specifically ammonium, nitrate, and sodium. Therefore, manure extracts need to be sampled and analyzed regularly to determine the nutrient levels in the solution to prevent nutrient toxicity or deficiency that would impact crop growth and yield. The objective of this study was to design and build a bioreactor to compost and aerate chicken manure. A separate nutrient monitoring system was designed with ion selective electrodes to measure potassium, nitrate, ammonium, sodium and calcium levels in the manure extract solution. Once the ammonium levels were below toxic levels, the solution was balanced and added to the hydroponic system, where kale and lettuce were going.

## 7. Ancient carbon export to lakes

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Canadian Northern environments store in permafrost 1700 Pg of organic carbon (OC) dating to the Holocene epoch. Degradation of permafrost results in the export of OC to lakes, where microbial and archaeal decomposition to methane (CH4) and carbon dioxide (CO2) is enhanced. If transported to the atmosphere, these gases would represent a positive feedback to climate change. An approach to quantify the extent of permafrost OC being utilized by microorganisms to produce CO2 and CH4 after reaching aquatic systems is the 14C analysis of carbon species, based on the fact that permafrost-derived carbon tends to be 14C depleted. In this poster, I present preliminary results consisting of radiocarbon ages of different carbon species in three lakes within a visibly degraded peatland in Northern Quebec covered with sporadic permafrost.

## 8. Heat transfer triggered by mobile subsurface water and thermal insulation caused by seasonal snow cover degrade permafrost and impact overlying highways

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In northern regions, transportation infrastructure is experiencing severe structural damage due to the degradation of permafrost. Using an experimental section of the Alaskan Highway, Yukon, Canada, we are able to assess the impact of snow insulation and subsurface groundwater flow on the destabilization of a road embankment that is underlain by permafrost. Also, a fully-coupled heat transfer and water flow is presented. Results show that in winter snow cover prevents heat released from embankment slope to atmosphere and warms ground by an average of 1.5 °C. In spring, snowmelt water infiltration caused a step temperature increase of 5.0 °C on average over several days, down to a depth 2.9 m. Infiltrated summer rainfall water warmed embankment fill materials at depth of up to 3.6 m, while lowered the near-surface temperatures. Heat advection (as opposed to purely conduction) is caused by the flow of subsurface water and produces warming rates at depth in the embankment subgrade up to two orders of magnitude faster than by atmospheric warming. In fall water trapped under the road significantly delays freeze back of the active layer and contributes to higher permafrost temperature. We conclude that the thermal stability of roadways in snowy permafrost regions is not maintainable in situations where water is flowing under the infrastructure unless mitigation techniques are used. Severe structural damage to the highway embankment are expected to occur in the near future

## 9. Multi-century impacts of ice sheet retreat on sea level and tides in Hudson Bay

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In Hudson Bay, sea level changes associated with ice loss from the Greenland and Antarctic ice sheets will differ in both sign and magnitude due to gravitational effects. Changing water depths give rise to

changes in ocean tides, for which tidal energy dissipation and tidal amplitudes are directly linked to ocean bathymetry (Green, 2010). In the present study, we investigate the impact of sea level changes on tides in Hudson Bay, Canada - a region where tidal energy dissipation is strongly sensitive to bathymetry (e.g. Egbert and Ray, 2000), and the bathymetry is in turn highly uncertain in some parts of the bay. Recent work by Wilmes et al. (2017) indicates that regional variability in future sea level changes as a consequence of ice sheet collapse will impact tides globally, in particular in Hudson Bay. As the magnitude of globally averaged sea level change due to Greenland and Antarctic ice loss remains highly uncertain (e.g. Church et al., 2013; DeConto and Pollard, 2016; Golledge et al., 2015), we present simulations of multi-century sea level changes associated with a suite of Greenland and Antarctic ice loss scenarios using a gravitationally self-consistent sea level model (Gomez et al., 2010). To fully quantify the sea level changes in Hudson Bay, we incorporate the contributions of glacial isostatic adjustment associated with the last deglaciation in our projections. We then consider the impact of these sea level changes on tides in Hudson Bay using the OTIS tidal model. Our results aid in constraining the response of Hudson Bay tidal dynamics to projected sea level changes, elucidating the feedbacks between energy dissipation and shoreline migration, and assessing the impact of climate change on coastal regions in the Hudson Bay.

### 10. How will permafrost thaw affect the groundwater contribution to streams and lakes?

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Storage and movement of groundwater in cold regions is strongly influenced by permafrost which confines groundwater flow to the active zone located above permafrost, to the sub-permafrost aquifer located below permafrost or through perennially unfrozen areas known as taliks. Permafrost thaw due to climate warming modifies hydrological processes by increasing hydraulic conductivity by several orders of magnitude and thereby enhances groundwater storage and hydrological connectivity between aquifers and surface water bodies. While data from previous studies reveal increases in Arctic river baseflow, the hydrogeological processes leading to these changes remain poorly understood. Herein, we use a heat and groundwater flow numerical model that includes dynamic freezing and thawing processes with an improved setup to simulate the impacts of climate warming on permafrost distribution and the spatial and seasonal patterns of groundwater discharge. Under a range of conditions simulated, we show a spatial shift in groundwater discharge from upslope to downslope and temporal shift towards the winter season due to the formation of a lateral supra-permafrost talik underlying the active layer. These insights help explain observed changes in Arctic baseflow and wetland patterns and are important for water resources and ecosystem management.

### 11. Groundwater Flow and Permafrost Distribution in a Subarctic Watershed

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Groundwater processes across subarctic Canada have exhibited sensitivity to climate warming through changes in the thickness and distribution of perennially frozen ground also known as permafrost. New hydrogeologic pathways previously blocked by impermeable permafrost may create positive feedbacks that accelerate thawing. The objective of this study is to develop a conceptual understanding of groundwater processes in northern mountain environments, and to assess the long-term impacts of climate change using a combination of field data and numerical modelling.

The study site, Granger Basin in the Wolf Creek Research Basin, Yukon Territory, is representative of the interior subarctic cordilleran landscape. Our study transect covers both north and south facing slopes. In northern environments, slope aspect controls the amount of radiation that reaches the surface which affects permafrost distribution. A capacitive-coupled resistivity survey was used to map permafrost and bedrock distribution across our transect in March 2018. Using historic stream discharge data, water level measurements, and geophysical surveys, we are creating two dimensional models to simulate groundwater flow and heat transport to identify the potential effects of climate change on subarctic environments.

## 12. Microbial Activity MicroAsssay for extant microbial detection in cryoenvironments

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The search for extant life on other solar system bodies will be a major focus of astrobiology missions in the coming years, especially on Mars, Europa and Enceladus. Axel Heiberg Island's (AHI) extreme environments are model astrobiology analog sites as they are cryophilic, halophilic and low biomass habitats. To increase our knowledge of the microbial communities living in extreme cold environments and the potential for such life beyond Earth, we need to develop new life-detection technologies. Thus, our objective is to develop a robust and sensitive Microbial Activity MicroAssay (MAMA) for cold-adapted and halophilic microorganisms based on the BIOLOG chemistry. To develop this instrument, carbon and inorganic substrates utilized specially by cryophilic and halophilic microorganisms will be identified and the best life-detection colorimetric assay under various conditions (temperature, pH, salinity) will be determine using model extremophiles such as P. Halocryophilus. Up to date, we establish a minimum of 4000 bacteria to detect metabolic activity, but we are working on decreasing the detection limit. Through a collaboration with the NASA Ames Research Center, we are developing a stand-alone concept of the MAMA for remote terrestrial and astrobiology missions. The autonomous MAMA will be tested with various samples surrounding the McGill Arctic Research Station on AHI to provide insights into cryophilic and halophilic life, and on extreme limits of microbial life.

## 13. Meta-analyses of S-oxidizing biofilms from anoxic hypersaline springs in the Canadian high Arctic

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The Gypsum Hill springs on Axel Heiberg Island, Nunavut, are cold, saline springs that flow perennially from sub-permafrost aquifers. In winter, microbial streamers up to 30 cm in length form in runoff channels below snow cover in areas of higher dissolved oxygen content (1 ppm). They consist of microbial cells within a matrix of elemental sulfur and sulfur-containing minerals. Previous molecular analyses identified the streamer microbes to be composed primarily of *Thiomicrospira spp*., an obligate sulfur-oxidizing bacterium, sustained by chemolithoautotrophic sulfide and thiosulfate oxidation and $CO_2$ fixation. In this work, -omic analyses identified *Thiomicrospira spp*. as the dominant community member contributing to sulfur oxidation. However, the lower abundance community also showed genetic potential for sulfur oxidation, indicating a more diverse metabolic community than hypothesized. In addition, carbohydrate metabolism, exopolymeric substance production, and oxidative stress related gene products were identified in abundance. In situ analyses of sulfur isotope fractionation identified sulfur oxidation in the streamers paired with reoxidative cycling by sulfur disproportionators in the spring source sediments. These results identified the streamers as a sulfur oxidizing community adapted to cold hypersaline spring conditions, functioning as part of biotic sulfur cycling in the spring environment.

## 14. In situ DNA-SIP enrichment in concert with genome binning of a high Arctic methanotrophic and methanotroph-associated community

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Greenhous gas (GHG) emissions from Arctic permafrost soils are poised to create a positive feedback loop of climatic warming and further GHG emissions. Active methane uptake in soils can reduce the impact of GHG emissions on future Arctic warming potential. Aerobic methane oxidizers are thought to be responsible for this apparent methane sink, though these organisms have resisted all culturing efforts. In this study, we labelled organisms in situ using Stable Isotope Probing (SIP) with 13CH4 (at 100 ppm and 1000 ppm) to identify organisms involved with CH4 metabolism at an ice-wedge polygon (IWP), Arctic cryosol site. The labeled microbial community was enriched for Proteobacteria and Verrucomicrobia phyla. Sequencing of 13C-labelled pmoA genes demonstrated that Type II methanotroph are the dominant active methanotrophs at this terrain, with Type I methanotrophs being only labeled in the 100 ppm SIP treatment. Genome binning of the labeled metagenomic DNA resulted in 28 total bins. From these we identified nine high to intermediate quality metagenome assembled genomes (MAGs), belonging to α,β-Proteobacteria and Gemmatimonadetes, with three of these MAGs containing genes associated with methanotrophy based on HMMR scans. Furthermore, we identified an Alphaproteobacterial MAG, that contained both an mmoX methanotrophy gene and serine cycle genes associated with Type II methanotrophs.

### 15. Using stable isotopes to track pollutants in Hudson Bay

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Top predators are used as indicator species for pollution levels in the environment. However, trends may be influenced by diet as they are at the top of complex food webs. To date, bulk nitrogen isotope ratios have often been used as a measure of food chain length. Here, we test the idea that a larger suite of isotopes will provide a more nuanced description of the food chain, and better predict pollutant levels. We measured levels of mercury and legacy contaminants in fish and invertebrate prey of thick-billed murres (N = 60). Isotope ratios that accounted for variation at the base of the food web explained pollutants better than bulk nitrogen. Such analyses resolved trends across space, over time and among species that were otherwise obscured. In short, pollutant levels are the product of complex food webs.

### 16. Daring crossing or cautious detour? Contrasting transatlantic migration strategies in a small migratory bird breeding in the Canadian Arctic and wintering in Africa

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Ecological barriers such as oceans, mountain ranges or glaciers can have a substantial influence on the evolution of animal migration. Along the migration flyway connecting breeding sites in the North American Arctic and wintering grounds in Europe or Africa, Nearctic bird species are confronted with significant barriers such as the Atlantic Ocean and the Greenland icecap. Using geolocation devices, we identified wintering areas used by Ringed Plovers (*Charadrius hiaticula*) nesting in the Canadian High-Arctic and investigated migration strategies used by these small Nearctic migrants (60g) along the transatlantic migration route. The main wintering area of the Ringed Plovers was located in Western Africa. We found contrasting seasonal migration strategies, with Ringed Plovers minimizing continuous flight distances over the ocean in spring by making a detour to stop in Iceland. In autumn, however, most individuals crossed the ocean in one direct flight from Southern Greenland to Western Europe, as far as Southern Spain. Moreover, the plovers we tracked largely circumvented the Greenland icecap in autumn, but in spring, some plovers apparently crossed the icecap where it reaches over 2 500 km in height. We explored factors behind such contrasting seasonal strategies along this peculiar migration route. Our study highlighted the importance of Iceland as a stepping-stone during the spring migration and showed that small Nearctic migrants can perform non-stop flights over the ocean from Greenland to Southern Europe, a distance of > 3 500 km.

### 17. Using Foraging Behaviour and Energetics to Identify Marine Habitat for an Arctic Seabird

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Density dependence is considered a key factor limiting colony size and reproductive success in colonial seabirds. Intraspecific competition at large colonies should force birds to travel farther to find food, which is thought to limit colony size by reducing reproductive success. We used measurements of maximum foraging distance from 17 colonies to examine the relationship between colony size and foraging range in thick-billed murres (*Uria lomvia*). Foraging range is expected to increase with the square root of colony size; this prediction was supported by our tracking data, which showed that foraging range scaled to the 0.44 power of colony size. We developed a bioenergetics model to examine how colony size effects chick provisioning, fledging mass, and reproductive success. The model identified thresholds where reproductive success declines sharply with colony size and prey quality. Reproductive success at smaller colonies should be resilient to changes prey quality and prey availability, while large colonies depend on access to high quality prey in order to fledge chicks. Colony size plays an important role in determining foraging behaviour and reproductive success of colonial breeding species. Our approach demonstrates how behavioural theory can be used to inform conservation and management of wildlife; in this case, to identify marine foraging habitat around colonies and estimate prey requirements for large colonies of a priority Arctic species.

### 18. Weather Indices and Migration of the American Golden-Plover

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The American Golden-Plover is a shorebird which undertakes an annual migration across the Americas, often travelling from nesting sites in the high Arctic to wintering ground in South America. While its overall migration timing and habitat use has been established, other aspects of its migratory behaviour remain poorly understood. In particular, the timing of migratory events (departure from nesting grounds, time spent at stopover sites and arrival at wintering grounds) have not been established with precision. We use geolocator data deployed between the years 2011 and 2016 on Bylot Island, Nunavut to visualize the migratory route of each individual. This project provides unique insight into the migratory behaviour of the American Golden-Plover.

### 19. Foraging plasticity in thick-billed murres (*Uria lomvia*)

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The Arctic might be the largest wild place in the world, it doesn't free it from pollution, climate change and human activities. One human activity incarnates all these pressures altogether: shipping, which increasingly affects Arctic marine ecosystems. Unfortunately, climate constraints forces shipping activity to be concentrated in the summer which coincides with seabird's breading season, impacting them when they are the most vulnerable. Properly protecting seabird breeding colonies requires first to know about their foraging behavior to propose biologically relevant conservation actions (i.e. delineating protected areas/adapting shipping lanes). This project aims at gathering data about foraging behavior of

one of the largest seabird breeding colony in the Arctic: Digges islands, Nunavut. There, approximately one million thick-billed murres gather each year from June to August to breed. From 2014 to 2016, we deployed 243 bio-loggers recording location and pressure to learn where these bird forage and how deep they dive. Our results suggest that foraging range in thick-billed murres varies each year, possibly related to ice coverage. In the coldest year (2015), foraging range extended 300 km away from the colony. We also show that breeding stage affects foraging range: when birds are incubating eggs they are freer to forage far away while feeding their chick forces them to stay closer to the colony, which means they are potentially more affected by shipping activities during incubation.

## 20. Monitoring freshwater ice phenology in Canada's North in the era of abundant open-access satellite sensors

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The ice phenology of freshwater lakes throughout the Northern Hemisphere has undergone important climate-induced shifts over the past century. It has estimated that the length of the ice-free season has been increasing an average of 12.3 days/century. In Canada's North, where freshwater lakes and wetlands cover 15 to 40% of the landscape, monitoring ice phenology is vital given its important impacts on climate, socio-economic, ecological and hydrological systems. Remote sensing techniques are particularly well suited to tracking phenological events (*e.g.* spring break-up and autumn freeze-up) over vast and remote regions. The rapid and dynamic nature of ice phenology events has restricted any large-scale monitoring efforts to satellite sensors with frequent revisit times (*e.g.* MODIS, AVHRR), but their low spatial resolution (e.g. > 500 m) limit observations to larger water bodies which make up only a small fraction of northern landscapes. However, the increased abundance of open-access satellite imagery from different sensors has provided opportunities to reduce the trade-off between spatial and temporal resolution. In this study, we present an algorithm developed in Google Earth Engine (GEE) that combines imagery from multiple sensors into a single coherent time series of freshwater ice phenology observations over all of Canada at a 30-metre resolution for the spring seasons of 2014 to 2017. Using Sentinel 2 and Landsat 8 imagery, we build reference datasets from a variety of lakes across Canada to optimize classification trees using machine learning to discriminate ice/snow, water, and clouds. Given the low performance of cloud-masking algorithms in optical imagery captured in winter, we combine the classified images into a single time series, then apply a temporal filter based on a pixel-wise logistic regression to remove misclassifications. Finally, we run a change detection algorithm to estimate the date a pixel transitioned from ice to water. We test the accuracy of our results against the Canadian Ice Service's database of weekly ice cover estimates for over 100 lakes in Canada. Capitalizing on GEE's powerful cloud computing platform and the abundance of free open-access satellite imagery, our analysis provides: (*i*) an accurate estimate of spring break-up events at a high spatial resolution (30 meters), (*ii*) a scalable method readily applied to other subarctic and arctic regions, (*iii*) an updatable workflow capable of ingesting new images added to the GEE repository, and (*iv*) a coherent time series easily improved by adding classified imagery derived from other sensors.