Report for Nunavut Research Institute for research undertaken in 2025
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Project Title:

Impacts of Climate Change on Permafrost, Ice, and Hydrology in the Canadian High Arctic

Project Leader(s):

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Project Team:

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Abstract:

As part of our ongoing climate monitoring program, weather station data was collected from several automatic weather stations that is being analyzed and compared to previous years to assess how the climate is changing in the area. In addition, images collected from time lapse cameras were retrieved that recorded winter snowfall, spring snow melt, and summer rainfall. Weather conditions are changing from year to year, but no clear pattern has been observed associated with global climate change.

To assess frozen and unfrozen ground, shallow geophysical surveys were conducted at several locations to map thaw depth, permafrost, and ground ice. Ground sensors were also installed to monitor soil temperature and moisture, which will allow us to monitor the timing of ground freeze and thaw during throughout the year. Permafrost is extensive in the area but landscapes do not yet appear to be impacted by climate change, likely due to mountainous terrain, widespread bedrock, and limited ground ice.

Aerial surveys were conducted to generate baseline observations of different landscapes and map vegetation cover. These will be repeated every year to document future changes.

Water samples were collected from local streams to determine their composition throughout the melt season, small samples of soils collected for compositional analyses, and plants were collected for identification to gain a better understanding of the different vegetation communities in the area that absorb different amounts of greenhouse gases. Plant diversity is

high in the area, with different vegetation communities observed based on soil moisture content. Soil analyses are ongoing.

Key messages:

- Weather conditions are changing from year to year, but no clear pattern has been observed associated with climate change.
- Permafrost is extensive but landscapes do not yet appear to be impacted by climate change, likely due to mountainous terrain, widespread bedrock, and limited ground ice.
- Snowmelt is the dominant source of water on land, which evolves over the summer months.
- Plant diversity is high in the area, with different vegetation communities observed based on differences in soil moisture content that absorb different amounts of greenhouse gases.

Objectives:

The primary purpose of this project is to continue scientific research that centres around understanding how current and future climate change is affecting tundra and polar desert landscapes. This project aims to answer the following research questions:

- How is climate change altering local High Arctic weather conditions?
- How is climate change impacting the relative abundance of frozen and unfrozen ground?
- How is climate change modifying the movement and quality of water?
- How is climate change affecting vegetation, microbiota, and greenhouse gases?

Annual activities:

Our group was based out of the McGill Arctic Research Station on Axel Heiberg Island at Expedition Fiord (79˚24'N, 90˚44'W) and conducted research in the local area from June 20 – July 31st. As part of our ongoing climate monitoring program, weather station data was collected from automatic weather stations and repairs made to sensors that were damaged over the past year. Weather station data includes air temperature, relative humidity, solar radiation, wind speed, and wind direction. To assess if or how the climate is changing in the region, weather station data for the past year was appended to our long-term records from each of these stations, analyzed, and compared to previous years. Time lapse cameras were used to assess the timing of precipitation as snow or rain as well as snow melt during the spring season. Images were retrieved and are compared to weather station data to better understand conditions when we are not in the field.

To assess frozen and unfrozen ground, shallow geophysical surveys were conducted at several locations to map thaw depth, permafrost, and ground ice. This included ground-penetrating radar and electrical resistivity tomography, both non-invasive methods that provide information about thawed soil properties, the presence of groundwater, ground ice, and depth to

permafrost. Ground sensors connected to weather stations were also installed to monitor soil temperature and moisture, which will allow us to monitor the timing of ground freeze and thaw throughout the year.

Surveys using unmanned aerial vehicles (UAVs) were conducted to generate baseline observations of landscapes and to map vegetation cover. This year focused on mapping local watersheds. Analyzing the images using software resulted in generation of 3-D models as well as detailed image products from which landscape features were determined.

Sensors were deployed in watershed streams to monitor changes in water depth, temperature, conductivity, and pH, and waters collected to determine their chemical composition from the onset of snowmelt to the end of the field season.

Small samples of soils were collected to assess their composition, and plants were collected for identification to gain a better understanding of different vegetation communities in the area that absorb different amounts of greenhouse gases.

Results and Achievements:

Weather station data collection is an ongoing program and requires 30 years of data before a rigorous climate analysis can be undertaken. Geophysical survey work revealed widespread permafrost, however, we need continue this work in future years to monitor changes. UAV surveys resulted in one watershed being entirely mapped, with plans to do more surveys in the coming years. Stream monitoring showed high water levels with high sediment load during the onset of snowmelt, which transitioned to lower water levels with less sediment later in the summer. All streams are acidic (pH ~6), and late-season waters have high concentrations of calcium, magnesium, and sulfate due to interactions with rocks. Vegetation surveying continued this year, confirming that plant diversity is high in the area with different vegetation communities observed based on soil moisture content. Soil sampling and analyses is a multi-year project with sampling extending into the moraines this year. Soil data collected to date will be incorporated into future graduate and undergraduate student theses to explore weathering processes and relationships to overlying vegetation.

Challenges/Obstacles:

As in the case of 2024, the largest challenge we faced this year pertained to weather. We experienced many days with cold temperatures, rainfall, and snowfall events. Due to this, we were forced to work longer days when weather improved.

Expected Project Completion Date: August 2027.

Project website: We do not yet have a website nor a social media presence for this work.

POLICY RELEVANCE

The research currently does not support policy development or decision-making in Nunavut.

RESEARCH OUTCOMES: BENEFITS

Community engagement:

To explore opportunities for community engagement, emails were sent to Members of the Hunters & Trappers Association of Resolute Bay and Members of the Iviq Hunters & Trappers Organization. These emails described our interest in community members' perspectives on plants and to invite them to participate in a community science project. We unfortunately did not hear back from either group; however, we have contacted them again this year.

Youth engagement:

We always plan for the opportunity to visit Qarmartalik School in Resolute Bay to talk to students, ask them questions, and share our experiences, however, the timing did not work out this past year. We hope students will participate in a community science project we are organizing again for the upcoming field season that focuses on learning from students about Arctic plants. We would also like to ask them to show us plants around Resolute Bay as part of a larger student-led study and answer questions they might have, for example how plants function and how they relate to the landscape. We plan to bring our greenhouse gas analyzers to show how plants absorb greenhouse gases whereas soils emit greenhouse gases.

Training and Employment:

How many Nunavummiut received training from team members? Please describe training and/or compensation provided.

- We did not have the opportunity to meet with Nunavummiut this past year but would like to do so in association with our youth engagement in the years ahead.

How many team members received training from Nunavummiut? Please describe training received and/or what knowledge sharing and/or skills exchange took place.

- Our team members did not receive training from Nunavummiut this past year due to logistical and time constraints. We are exploring opportunities for training from Nunavummiut.

How many Nunavummiut received employment? Please describe employment type and length, role(s) and responsibilities, and compensation provided.

- We did not have the opportunity to employ Nunavummiut this past year but would like to do so as we acquire funding to support them.

How many Nunavummiut received honoraria as research participants? Please describe method of participation (interview, observation, sample, survey, etc.), including compensation provided.

- Nunavummiut did not receive honoraria as research participants, however, as noted above, we would like to involve them in our research around Resolute Bay and Grise Fiord in future years as our program grows. Our proposed community science project includes honoraria based upon experience, scope of work, and time commitment.

Please explain how the project directly benefited Nunavut organizations and/or businesses (e.g., through contract services, local purchases, equipment donations, etc.)

- We purchased food and supplies to support fieldwork at the Tudjaat Co-op in Resolute Bay.

Academic Mobility

If you are affiliated with an academic institution, please answer the following question: For which Level of Project(s) will the data be used? (Check all that may apply)

☒ Research
☐ Post-Doctoral Research
☐ PhD Thesis
☒ Masters (Major Research Paper)
☒ Masters (Thesis)
☐ Graduate Course Project
☐ Staff/Administration Research
☒ Undergraduate Honours Thesis

BUDGET

Category	Planned/Approved Expenditure	Actual Expenditure
Travel and Accommodation	$91,027	$99,677
Equipment, Materials and Supplies	$7,650	$7,320
Salaries/Wages for Nunavut residents	-	-
Salaries/Wages for non-Nunavut resident researchers	$24,000	$24,000
Professional Fees and services in Nunavut	-	-
Professional Fees and Services outside of Nunavut	-	-
TOTAL EXPENDITURES	$122,677	$130,997

Sources of Funding

Natural Sciences and Engineering Program, Discovery Grant Program: $25,000
Natural Sciences and Engineering Program, Northern Research Supplement: $15,000
Polar Continental Shelf Program: $70,113

RESEARCH OUTPUTS / REPORTING TOOLS

In general, research outputs include student presentations, undergraduate and graduate student theses, and manuscripts for publication in peer reviewed journals. Many of these are in progress, but some are at their final stages, detailed below.

- Vegetation data from previous years has been accepted (with revisions) as a scientific manuscript for publication in *Arctic Science.* A full citation will be shared as soon as it is available.
- A graduate student thesis focusing on watershed hydrology and geochemistry will be submitted as two manuscripts for peer review and publication in *Journal of Hydrology* and *Hydrogeology Journal*.
- A graduate student thesis focusing on vegetation diversity and communities will be submitted for peer review and publication in *Biodiversity Data Journal*.
- An undergraduate student thesis focusing on landscape reconstruction of proglacial moraines will be submitted for peer review and publication in *Arctic Science.*

Non-peer reviewed materials produced to communicate results to the public:

Title	Description of Materials
Hydrological Evolution and Geochemical Weathering of High Arctic Watersheds	Oral presentation, Queen's Northern Research Symposium (April 2026)
Surface and Subsurface Runoff Characteristics across Four High Arctic Watersheds	Oral presentation, Canadian Geophysical Union - International Association of Hydrogeologists Conference (May 2026)

Communications plan: Did your project develop a communications plan? Please describe communications/reporting tools used, and list the target audience for each and/or who requested which.

- This project does not currently have a communications plan but will consider developing one if requested.

How were Nunavummiut credited and/or acknowledged in all project outputs, such as co-authorship, participant biographies, article acknowledgements, etc.

- Nunavummiut will certainly be credited and/or acknowledged in all project outputs. We did not work with Nunavummiut this past year but are looking for future opportunities.

DATA AND INTELLECTUAL PROPERTY

Did you enter into a research agreement, data-sharing agreement and/or intellectual property rights agreement with a community and/or designated Inuit organization (DIO)?

- We did not enter into a research agreement, data-sharing agreement and/or intellectual property rights agreement with a community and/or DIO.

Do intellectual property rights apply to your research? If yes, please explain.

- Intellectual property rights do not apply to our research.

Who owns the data? Has the raw data been shared with the appropriate community and/or DIO? If yes, how? How is data security and storage handled by community-based co-owners?

- Data is owned according to university policies, collective agreements and/or employment agreements, which require that data be owned by one or more University, its personnel and its students, in this case Queen's University. Raw data has not been shared with a community and/or DIO but can be upon request.

Where is the data stored and will the data be destroyed within a set timeframe?

- Raw data is stored in Queen's University Scholarship & Digital Collections (QSpace), an online repository of digital content produced and collected by the Queen's community. QSpace will preserve the data indefinitely and is committed to responsible and sustainable management of submitted works as well as associated descriptive and administrative metadata.

Is the data trackable and/or available in a public data repository? If yes, please provide the appropriate information and/or link to ensure the findability and accessibility of the data.

- Yes, data is available through QSpace, an open access repository for scholarship and research produced at Queen's University. https://qspace.library.queensu.ca/home

Please append a copy of your data management plan.

- Our data management plan can be found at the end of this document.

CLIMATE CHANGE

Is your research about climate change (causes, impacts, mitigation, adaptation, etc.)? If yes, explain.

Our research focuses on the impacts of climate change on high Arctic landscapes. Climate warming is contributing to dramatic changes, with permafrost degradation and increasing rates of summer precipitation leading to a rapidly evolving interrelationship between surface waters and groundwaters. This is creating a more interconnected hydrologic system that is expected to accelerate over the next century and will result in shifting biogeochemical conditions in surface and subsurface environments. However, there remains great uncertainty as to how this increased connectivity and associated biogeochemical changes will impact terrestrial environments in terms of nutrient cycling, microbial, plant and insect abundance and diversity, and higher trophic level populations. This project generates interdisciplinary knowledge by building linkages between climate change and permafrost degradation on the timing and magnitude of hydrologic activity and biogeochemical cycling, and how these changes will impact high Arctic ecosystems.

Research includes numerous interrelated activities that focus on the overarching topic of climate change. Questions include: (1) What is the current extent of permafrost in this setting, and how are warming temperatures and associated permafrost degradation impacting interconnectivity between surface waters and groundwaters? (2) How have terrestrial ecosystems changed over time? (3) How are changing hydrologic conditions affecting the timing and magnitude of snowmelt and subsequent geochemical profiles of surface waters and groundwaters? (4) How will future climate change impact the activity and diversity of terrestrial ecosystems and associated biogeochemical processes?

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Data management plan: This project will generate physical, geophysical, geochemical, and visual data from field measurements, sample collection, and UAV activities. This will consist of hand-written observations, tables, graphs, digital photographs, aqueous, gas, and solid chemistry measurements in both raw and curated forms. This data will be collected using commonly accepted data acquisition instruments, software, and methods.

Expected data product #1– Data type: physical samples:
Product Description: Waters, sediments, soils, and plant specimens.
Preservation Plan: All samples will be labeled at the time of collection with the appropriate project number, date, time, and operator initials. These samples will be archived in freezers, refrigerators, or other appropriate storage facilities in the Department of Geography & Planning at Queen's University before processing for their specified analyses. Unused samples will be kept at Queen's University for long-term storage.

Expected data product #2 – Data type: physical data: Physical data (i.e., air temperature, relative humidity, solar radiation, wind speed, wind direction, soil temperature, and soil moisture) and associated readme.txt files containing operator observations and notes will be saved and archived on the project leader's computer that is backed up to two external servers.

Expected data product #3 – Data type: geochemistry data: Both field-based and laboratory measurements of cations, anions, gases, isotopes, and associated readme.txt files containing operator observations and notes will be either recorded digitally (through computers connected to specific instrumentation) or manually in field or laboratory notebooks. This data will be transferred into Microsoft Excel spreadsheets, saved, and archived on the project leader's computer that is backed up to two external servers.

Expected data product #4 – Data type: geophysical data: Data collected using shallow geophysical techniques and associated readme.txt files containing operator observations and notes will be either recorded digitally (through computers connected to specific instrumentation) or manually in field or laboratory notebooks. This data will be transferred to geophysical processing software, saved, and archived on the project leader's computer that is backed up to two external servers.

Expected data product #5 – Data type: aerial imagery: Imagery collected using UAVs and associated readme.txt files containing operator observations and notes will be either recorded digitally (through computers connected to specific instrumentation) or manually in field or

laboratory notebooks. This data will be transferred into image processing software, saved, and archived on the project leader's computer that is backed up to two external servers.

Data and Metadata Standards: The project will leverage existing metadata standards currently employed by commonly used public databases. We will add additional metadata entries for field notes as readme.txt files to accompany the data.

Policies for Access and Sharing: After publication of manuscripts based on the data that we collect, our data and metadata will be publicly available through the publishing journals and Queen's University Scholarship & Digital Collections (QSpace), an online repository of digital content produced and collected by the Queen's community. Additionally, the expertise and knowledge of the data and metadata will be shared openly with colleagues and through public presentations.

Policies for re-use and redistribution: Access to data, metadata, and associated methods generated through this project will be made public in accordance with the policies of QSpace. We will make the data available no later than two years after the completion of each field season. This data is likely to be accessed by researchers and professionals in a variety of disciplines as the project incorporates components of physical geography, geochemistry, hydrology, and botany.

Plans for archiving and preservation of access: Data collected in notebooks from both field and laboratory activities will be retained in a secure location in the PI's laboratory. Additionally, following consultation with Queen's University Libraries staff members, we will deposit all research data in QSpace. All necessary metadata and associated resources will be submitted for accessibility for future users. QSpace will preserve the data indefinitely and is committed to responsible and sustainable management of submitted works as well as associated descriptive and administrative metadata.