



PermafrostNet
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Annual General Meeting Report

2023

NSERC PermafrostNet



Introduction

NSERC PermafrostNet was pleased to invite the permafrost community to our fifth network Annual General Meeting (AGM) in Victoria, BC between Monday 20th and Wednesday 22nd of November 2023. The meeting was an in-person and virtual meeting focused on the progress of the network projects, the synthesis of theme findings, the needs of partners, and future activities, while providing students and post-doctoral fellows opportunities to share their work, interact with other members of the network, and learn about knowledge mobilization and careers.

There were keynote presentations on individual research projects each morning and poster presentations by the graduate students and post-doctoral fellows, as well as updates on theme progress and synthesis products from the theme leaders. The presentations were live-streamed and recorded. The posters, pdfs of presentations and recorded presentations are available on the network website (www.permafrostnet.ca).

The conference was held on the traditional territory of the Lekwungen people, also known as the Songhees and Esquimalt First Nations – past, present, and future – and we acknowledge their land to honour and express gratitude to the Indigenous communities who have historically, and presently, steward and live on this land. The meeting was held at the Inn at Laurel Point in Victoria, BC and a keynote talk was delivered at the Royal BC Museum by John J. Clague - *Loss of the Cryosphere in the Mountains of Western Canada*.

The [Inn at Laurel Point](#) is British Columbia's first carbon neutral hotel. The hotel has been carbon neutral since 2009 and became [Biosphere Sustainable Certified in 2023](#). The hotel is aligned with the United Nations' 17 Sustainable Development Goals (SDGs) through their Project 2030 plan which is centered around zero waste practices, renewable energy generation and making the most of precious water resources, and was the first-ever hotel in North America to join [The Climate Pledge and initiative](#).

The AGM was co-chaired by Professor [Bernhard Rabus](#) (Simon Fraser University) and [Emma Street](#) (University of Victoria), with the poster session coordinated by [Pia Blake](#) (Carleton University) and the career session coordinated by [Jenna Snelgrove](#) (Carleton University).



Title: Annual General Meeting Report, 2023, Victoria, BC, NSERC PermafrostNet.

Report contributors: Tristan MacLean, Andrew Clark, Galina Jonat, Rose Lefebvre, Tabatha Rahman, Danielle Chiasson, Nicole Corbiere, Kaitlyn Diedrichs, Pascale Roy-Leveillee, Melissa Lafreniere and Stephan Gruber.

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Figure 1: Illustrations by Aisu.studio.

Day 1: Theme updates, Community and partner needs, and poster session.

Key notes

Teddi Herring (Theme 1) Key Outcomes of the Canadian Permafrost Electrical Resistivity Survey (CPERS) Database Project.

Zakieh Mohammadi (Theme 1) Permafrost Geotechnical Data: Thaw Consolidation Test Results and Their Application in Settlement Estimation.

Emma Street (Theme 2) Exploring Traditional Knowledge of Permafrost in the Gwich'in Settlement Area and Inuvialuit Settlement Region.

Key Outcomes of the Canadian Permafrost Electrical Resistivity Survey (CPERS) Database Project.

- The project created and populated a database of electrical resistivity tomography (ERT) data to study permafrost.
 - Data collected between 2008-2022.
 - 209 profiles, 280 surveys, 15 profiles with time-lapse data.
 - 16 landform types.
- An interactive web map has built to filter the data.
- Best practices for using ERT to study permafrost were established and published as an open-access article.
- 302 literature sources were compiled in a searchable interactive table.
- Initial large-scale interpretations of the data were made.
- There are aspirations to add more data, improve large-scale interpretations potentially using machine learning, and enhance data sharing and usage in the permafrost research community.

Permafrost Geotechnical Data: Thaw Consolidation Test Results and Their Application in Settlement Estimation.

- Existing thaw consolidation test data on 398 samples (273 fine-grained, 125 coarse-grained) from Nunavik, NWT and Yukon was collected and integrated into a unified database.
- Distinct consolidation behaviors were characterized for fine-grained, coarse-grained, and peat samples.
- There is a range of index properties (water content, void ratio, frozen bulk density) of soil samples and inconsistent reporting of these properties.
- There is a lack of standardized procedures and a need for comparative parameters for consolidation thaw tests.
- Thaw strain insights offer a valuable understanding of ground ice conditions.
- Correlations were identified between thaw settlement parameters for some sample types, and other properties like water content and frozen density, for some sample types.
- Approaches were developed to estimate thaw strain and settlement for peat and coarse-grained sediments.
- Recommended void ratios were proposed to estimate thaw strain for coarse-grained soils.

- The methods showed improved accuracy and reduced bias compared to existing approaches.
- This research contributes to creating a permafrost geotechnical database and frameworks for assessing thaw settlement across soil types, which can optimize engineering designs and inform decision-making.

Exploring Traditional Knowledge of Permafrost in the Gwich'in Settlement Area and Inuvialuit Settlement Region.

- The research places permafrost change in a longer-term context and studies the extent of thawing permafrost and its social, economic, and cultural implications.
- The research is conducted in 8 communities across the Gwich'in Settlement Area and Inuvialuit Settlement Region in the western Canadian Arctic.
- Research is carried out through collaboration with Hunters and Trappers Committees and Renewable Resource Councils.
- Research involves interviews with Gwich'in and Inuvialuit land users. Goal one of these interviews involves documenting Traditional Knowledge of permafrost. This includes conversation revolving around permafrost knowledge transmission, engagement with permafrost, and the significance of permafrost change.
- The second goal is to map permafrost change by documenting permafrost features and areas of permafrost change through the interviews.
- In addition, the project is conducting ethnographic mapping wherein areas of cultural significance, especially those with ties to permafrost, are also marked on the map.
- 110 interviews have been conducted across Fort McPherson, Inuvik, Paulatuk, Sachs Harbour, Tsiigehtchic, Tuktoyaktuk, Aklavik, and Ulukhaktok.
- They are currently in the process of being transcribed and coded to prepare for analysis.
- With the information documented in the first stage of the research, the next step of this project is to move to work with communities on community-identified projects.

Theme updates

Theme 1 (Duane Froese)

- Theme 1 aims to improve the understanding of ground-ice loss and its consequences through better characterization of permafrost in the field and in laboratories so that prediction can better represent processes during thaw and have relevant subsurface input such as ground-ice content.
- Projects are underway related to the PINGO database, ground ice potential database, mapping, regional studies, thermal, hydrologic geochemical and geomechanical properties, and advanced characterization methods.
- Good progress was reported across multiple areas:
 - PINGO database structure developed.
 - Ground ice database compiled with ~50,000 measurements so far.
 - Regional field studies (Mackenzie Valley and Hudson Bay Lowlands).
 - New non-destructive methods are being developed and applied in analyses (CT scanning, dielectric/resistivity techniques).
 - Strong partnerships exist with government surveys and communities (Sahtu, ISR, HBL) to aid fieldwork. Projects include collaborations with the NWT Geological Survey through the Thermokarst Collective Mapping initiative and the Geological Survey of Canada.
 - Students are progressing well; ground ice potential database expected to reach >75,000 measurements soon.
- In summary, Theme 1 efforts to improve permafrost characterization and quantification of ground ice are advancing through database development, field sampling, and lab analysis. This will ultimately support better representation of thaw processes in models.

Theme 2 (Trevor Lantz)

- Theme 2 aims to use monitoring to reveal and quantify permafrost change in Canada and understand its varying rates and expressions at the land surface.
- The theme has two sub-objectives;
 - To measure or infer permafrost change using a variety of new methods.
 - To synthesise new and existing monitoring data and findings.
- Researchers presented several project updates spanning remote sensing, field measurements, simulations, incorporation of traditional knowledge and synthesis concepts.

Examples highlighted include:

- Using Interferometric Synthetic Aperture Radar (InSAR) and field measurements to measure surface displacement (surface heave) and its relation to snow accumulation.
- Mapping and interview-based documentation of permafrost changes noticed by Indigenous communities.
- Modeling to analyze factors affecting formation of polygonal terrain and ice wedge ponds.
- Evaluating thermal metrics using simulations for monitoring capability.
- Leveraging borehole temperature data to quantify permafrost temperature changes.
- Using Airborne SAR and Optical Data to monitor permafrost.
- Developing a conceptual model for permafrost terrain types.
- In summary, Theme 2 comprises a diversity of monitoring-focused research that mirrors the diversity of methods for monitoring. Synthesis activities in Theme 2 are in development.

Theme 3 (Joe Melton)

- Theme 3 aims to improve the accuracy and delivery of transient permafrost simulation so that its results can support stakeholder needs at local and national scales.
- Researchers in the theme are using models like GEOtop, FreezeThaw1DExIce and CLASSIC.
- There are two completed student projects:
 - One was focused on mapping thermokarst dynamics of Yukon lakes with machine learning analysis of synthetic aperture radar (SAR) data.
 - The other was optimizing CLASSIC's soil carbon scheme.
- Ongoing projects are:
 - Quantifying confidence in simulations.
 - Developing simulation-based climate services for permafrost environments.
 - Simulating land cover change and its influence on permafrost with CLASSIC.
- Challenges exist in relation to projects related to incorporating excess ground ice and its impacts into CLASSIC and parameterizing permafrost terrain types for modelling.
- This leaves gaps for contributing to planned synthesis products.
- Next steps involve supporting ongoing student projects and finding ways to fill the gaps through alternative mapping and modeling efforts.
- In summary, Theme 3 has made progress but has also faced some setbacks with efforts to mitigate the losses and contribute to network deliverables underway.

Theme 4 (Pascale Roy-Léveillé)

- Theme 4 studies various hazards including mass movements, flooding, changes in water quality, contaminant release, vegetation and terrain changes.
- Highlighted projects address:
 - Coastal and inland slope stability through modeling, classification and feature extraction.
 - Water quality changes and mercury release with thaw.
 - Evolution of thermokarst landforms and impacts on mercury cycling.
 - Prioritization of thaw-driven hazards and stakeholder perspectives.
- Outcomes contribute knowledge, detection and prediction to support adaptation and to connect with other network themes.
- The theme integrates knowledge from themes 1-3 and produces tools and knowledge to support theme 5.
- A new area of focus involves integrating stakeholder views into hazard assessments, to better link researchers and decision-makers.
- In summary, Theme 4 quantifies risks and impacts related to permafrost degradation across processes and regions. Work also aims to bridge gaps between hazard detection or assessments and on-the-ground adaptation needs.

Theme 5 (Ryley Beddoe and Christopher Burn)

- Theme 5 aims to support northerners in adaptation to permafrost in transition.
- The theme comprises projects initiated to address specific permafrost thaw challenges.
- Highlighted projects span topics like landscape change impacts on mercury release, stability of waste sumps, highway embankment stabilization methods, geotechnical modeling of railway infrastructure, cost analysis of infrastructure maintenance, wind impacts, and railway bridge frost jacking monitoring.
- The network enables education and cross-pollination between students working on adaptation-related studies.

- Over 20 students are currently collaborating on research with Theme 5.
- The ultimate objective is to develop skilled people who can support adaptation needs in the face of ongoing permafrost transitions.
- In summary, Theme 5 promotes student-conducted research targeting practical problems associated with permafrost thaw across infrastructure, contaminant release, landscape evolution, and other themes. Through this experiential learning, the next generation of adaption specialists is being cultivated.

Community and Partner needs

Anne Walker (Environment and Climate Change Canada) on behalf of Federal Director General Working Group on Permafrost – Federal government coordination on “permafrost”.

Key Drivers & Issues

- Permafrost thaw is a critical, immediate and long-term issue.
 - Circumpolar permafrost temperatures are increasing, and have reached record high levels in recent years.
 - Permafrost thaw directly impacts northern landscapes and well-being of communities.
 - Adaptation and mitigation decisions need to be informed by robust and accessible knowledge about anticipated future change.
 - There is expertise in Canada that can be mobilized to address gaps and uncertainties.

Multiple Federal Roles

- A number of players and science initiatives related to permafrost are underway.
- Multiple federal department mandates touch on permafrost issues.

Improving Federal Coordination

- As a first step, ECCC initiated the creation of a DG-level Permafrost Working Group (WG) with key federal departments.

Robert Charlie-Tetlich (GRRB) – Climate Change and the Gwich'in Experience.

The Gwich'in Renewable Resources Board (GRRB) was established under the guidance of the Gwich'in Comprehensive Land Claim Agreement (GCLCA) to be the main instrument of wildlife, fish and forest management in the Gwich'in Settlement Area (GSA).

Observed Changes at a local level

- Traditional travel routes no longer safe to travel due to permafrost landscape changes.
- Unpredictable weather patterns and more frequent severe weather events.
- Early breakup and late freeze-up creating poor ice conditions.
- Changes in species composition and prevalence of diseases, parasites and invasive species.
- Changing distribution and range of wild food sources, resulting in increased food insecurity.

GRRB Research and Management Priorities 2018-2023

- Caribou
- Moose
- Dall's Sheep
- Muskox
- Grizzly Bear
- Muskrat
- Beaver
- Dolly Varden Char
- Species at Risk
- Forest Vegetation & Health
- Climate Change

Wildlife Studies Funded Projects in the GSA:

- Tsee' (Beaver) Population Study – Helen Wheeler, Anglia Ruskin University.
- Divii Project – Sydney Goward, University of Victoria.
- Arctic Salmon Project – Karen Dunmall, DFO/Carleton University.
- Rat River Harvest Monitoring – Colin Gallagher, DFO.
- Moose Population Monitoring – Mike Suitor, YG.
- Nin Nihlinehci'l – Li hah Guk' Andehtr'inahti – (Animals we are watching closely) – Kristi Benson, Department of Culture and Heritage

Partnered Projects

- Impacts of permafrost degradation on łuk dagaii habitat in the Peel River Watershed Project – Trevor Lantz, University of Victoria.



Figure 2: Illustrations by Aisu.studio.

Derek Cronmiller (Yukon Geological Survey) – Permafrost Concerns of Yukon Communities and Highways.

Community concerns:

- Severe erosion affecting rivers, creeks, and drinking water.
 - This can affect travel by river.
- Impacts to aquatic ecosystems and resources
 - What are the impacts on fish?
- Loss of agricultural land from degradation, erosion, and sedimentation.
- Restricted land access and harvesting abilities.
- Construction and development of land on permafrost terrain at risk of thaw.
- Highways face issues including:
 - Road subsidence from thaw.
 - Increased slope failures from permafrost degradation.
 - Construction and loss of ground ice under new roads.
 - Monitoring, maintenance and remediation approaches.
- How does land use need to change in a warming cryosphere? What are the mitigation actions needed?
- Incomplete understanding of ground ice distributions – land development, roads.
- Slope stability – increased frequency of extreme weather events -> activating landslides and rapid failures.
- Maintenance not considering thermal effects of human infrastructure, e.g., gravel piles next to highway.

Opportunities (some in progress)

- Improve maintenance methods, stabilize slopes and prove concepts for increased adoption/funding.
 - Are there better solutions than adding more gravel?
 - Can winter maintenance ideas developed for roads be applied to hunting trails?
- Improve our understanding of the distribution and character of ground ice at many scales.
- Develop predictive tools and early intervention measures.
 - How do we predict spatial and temporal susceptibility of thaw subsidence?
- Can we improve remediation techniques, and what does that really look like?
- Enhance collaboration and data sharing.
- Support Long-term monitoring.
- Create monitoring toolkits for Northerners to understand permafrost and track change in a way that empowers both communities and researchers.

In summary, permafrost thaw creates widespread impacts and hazards across Yukon, but research partnerships can help develop adaptive solutions to mitigate risks.

Q&A

The audience raised topics on how permafrost knowledge is incorporated into government bidding processes and who in regional government is responsible to make sure that needs identified by research are met?

Lolita Hughes (Yukon Parks) – Landscape changes in Tombstone Territorial Park.

Yukon Parks are experiencing issues like flooding, erosion, unstable terrain due to permafrost degradation. The presentation highlighted examples from Qikiqtaruk Herschel Island, Klondike River campground and the record flooding events in 2023.

Yukon Parks provides a range of services:

- Adaptive (trail) management.
- Visitor services: traditional users, recreational hikers.
- Planning – accessing the land.
 - Alpine, steeper slopes, etc.
- Facilities.
- Access.

Scientific monitoring work undertaken by Yukon Parks includes:

- Slope stability.
- Pika surveys.
- Meteorological data from weather stations.
- Snow depth.
- Vegetation changes.
- Visitor impact monitoring on tundra landscapes.

Yukon Parks invites visitors to share their observations after they have been in the park; what did you find? What questions do you have? They also invite users to request support for monitoring of environmental change related to thawing permafrost.

Yukon Parks applies mitigation techniques focused on trails and areas of concentrated use. These include:

- Hardening: geoblock (dispersing weight), rocks, raised platforms.

- Draining.
- Rerouting.

However, regular efforts are often insufficient with increasing closures and costs.

Yukon Parks seek expert guidance on what changes may occur and how best to prepare/manage areas e.g.

- Existing terrain concerns:
 - What signs to watch for?
 - How to assess safety?
- Development of new trails:
 - Where is suitable?
 - What type of slope/terrain?
- Patterns of change:
 - What are the seasonal changes?
 - Soil moisture levels?
 - Thawing?
 - Terrain stability?

In summary, Yukon Parks are struggling with rapidly changing terrain and accessibility due to permafrost thaw. Partnerships with researchers could support adaptation strategies and planning. They can provide research sites, assist with projects, and collaborate.

Jen Humphries (Aurora Research Institute, Aurora College) – Research in the north from the perspective of the ARI: what works and what doesn't.

Aurora Research Institute's (ARI) mandate is *"to improve the quality of life for NWT residents by applying scientific, technological and indigenous knowledge to solve northern problems and advance social and economic goals."*

- Scientific approaches can have fundamentally different motivations and objectives.
- Researchers need to think about how they involve Northerners in the entire research process, not just in collecting data or sharing results, examples:
 - HTC meetings, read up on various organization priorities, community consultation from the outset.
 - Spend time in the North: take formal and informal opportunities to talk about your research.
 - Report: if you work out of Inuvik: ARI speaker series, IRC research letters.
 - Considerations: time, money, relationships.

Angus Alunik (Inuvik) – Changes along the ITH and in the Mackenzie Delta.

Angus presented his observations of the effects of thawing permafrost and related changes. His primary message was that permafrost thaw is real, and it affects people's lives. Monitoring along the ITH and in the Mackenzie Delta has observed changes including issues such as icings, culvert and ice wedge issues, and ponding. This is exacerbated by beavers: clogging up culverts.



Figure 3: Illustrations by Aisu.studio.

Permafrost hydrology side meeting

Convener: Melissa Lafreniere

Participants: Trevor Lantz, Pascale Roy-Léveillé, Duane Froese, Shawn Kenny, Oliver Sonnentag, Robert Charlie-Tetlich; Angus Alunik, Derek Cronmiller, Niek Speetjens, and Cansu Culha.

A summary of the hydrology side meeting is available in the copy of the AGM report available to members.

Day 2: Network synthesis products and network challenges.

Key notes

Omid Asghari (Theme 1) Permafrost Index Properties and development of the Ground Ice Potential database of PermafrostNet.

Hannah Macdonell (Theme 3) Guiding model selection for effective adaptation decision making: A statistical ranking framework.

Galina Jonat (Theme 3) Deriving climate forcing data for simulations of future permafrost thaw.

Permafrost Index Properties and development of the Ground Ice Potential database of PermafrostNet.

- A database was created with physical property measurements (e.g., moisture content, ice, density, grain size, organic content) on over 2000 permafrost samples from 9 different depositional environments.
- This was used to define relationships between gravimetric water content (GWC) and ice content (excess and volumetric) and ultimately estimate ice content in larger databases.
- Threshold GWC values associated with >5% EIC were determined to delineate negligible vs significant excess ice.
- Applying this threshold to a larger database of measurements removed ~70% of samples as having negligible excess ice.
- Zonations in ground ice potential were observed across depositional environments and latitude.
- Biases were noted between the index property database and larger geotechnical databases.
- Next steps are to further test these relations, address biases, move from point samples to vertical ground ice profiles, and include organic/peat samples.
- Overall, the permafrost index property database allows estimation of ground ice potential from GWC. Most samples in geotechnical databases were found to have negligible excess ice based on defined thresholds.
- Further work is aimed at developing integrated ground ice potential databases and methods looking at vertical ground ice profiles and samples with high organic content.

Guiding model selection for effective adaptation decision making: A statistical ranking framework.

- Modelling can make useful predictions of:
 - Ground-ice loss.
 - Active layer thickness.
 - Carbon dynamics.
 - Ground temperatures.
- Challenges exist in evaluating model performance including data availability, statistical interpretation issues, limited spatial observations, incomplete datasets, and the discrepancy between observed variables and variables of interest.
- The study generated ground temperature simulations from multiple models at sites with observations across Canada.
- Site terrain characteristics were incorporated into the simulations e.g., vegetation, snow collection, terrain wetness and ground material.

- Time-series temperature simulations were fed into a ranking framework ("Accomatic") was designed to address the evaluation challenges.
- Methods like bootstrapping time series data and subsetting by terrain type were used to address data limitations.
- Model performance was analyzed across depths to assess if model performance correlated with depth.
- In summary, solutions were developed for key modeling evaluation obstacles, including a ranking framework for model intercomparison and techniques to maximize use of available data. This can guide appropriate model selection for supporting adaptation decisions related to permafrost.

Deriving climate forcing data for simulations of future permafrost thaw.

- Simulations are needed to complement observations in understanding potential future permafrost changes.
- There is a mismatch between the scale of climate models and permafrost models.
- Translating large-scale climate changes down to local impacts introduces uncertainty.
- Key challenges include:
 - Spatial resolution of climate forcing data from Global Climate Models vs local scale data.
 - Temporal resolution trade-offs e.g., daily vs hourly data.
 - Selection of driving data and validation metrics.
- Temporal resolution challenges (daily vs hourly data) are addressed using temporal disaggregation methods.
- Spatial resolution challenges are addressed by applying bias corrections to modeled climate data, (i.e., accounting for errors due to small-scale parameterizations and unresolved topographical properties).
- Questions remain around how to select climate data that will produce the best simulations of permafrost variables when downscaled.
- Next steps involve addressing these questions to reduce uncertainties in deriving localized climate forcing data for permafrost projections.
- In summary, the choice and pre-processing of climate data introduces significant uncertainty in future permafrost thaw simulations. Guidance is needed to select appropriate driving data that captures local climate conditions and leads to accurate permafrost projections.

Network events and outputs

The AGM held three sessions on day two of the meeting for network members to present, work on and discuss project outputs, synthesis products and future network events.

Project summaries and other outputs

The first session provided opportunity for network members to receive support in producing project summaries, for the co-investigators to design the content of a mini-compendium of projects and to enable suggestions for improvements to the knowledge mobilization outputs of the network. Draft project summaries and a mini-compendium were shared with the network, along with supporting templates and guidance documents.

Suggestions of what would make the individual two-pagers, the compendium, and the mini-compendium for dissemination in the interim more useful to participants included:

Compendium

- Draft alternative titles e.g. “Permafrost in Canada: Creating knowledge and envisioning next practice together”.
- Consider an executive summary with two sections: Permafrost in Canada, and Permafrost knowledge in Canada.

Mini-compendium for 2024

- Compile content to fit within 16 pages.
- Edit according to the likely audience of an interim compendium shared at ICOP (permafrost experts) rather than the broader audience of the full compendium.
- Share project summaries as one-pagers.
- Short and combined message from Scientific Director and Board Chair.
- Consider adding theme descriptions to network description and keep everything to one page.
- Include projects and results that are only in progress or submission to provide a preview.
- Have a concluding section that is an outlook and that speaks about the new people educated, the new connections shaping how permafrost work will take place in Canada’s future, and the increased policy interest in permafrost.

Network synthesis products

In the second session theme leaders and early career researchers presented details of the progress towards intra- and inter-Theme synthesis products. Highlights included details on the theme 1 Ground Ice Potential database and Geotechnical Properties of warming permafrost, and the PACS Lab Index Properties database. The theme 2 update included a presentation by Niek Speetjens on a classification framework. A Classification Framework for Permafrost Terrain Types is seen as a key (and difficult) element for connecting scales, modes of observation, and disciplines. Permafrost landscapes and landforms are indicators of conditions, processes and change trajectory. All scales are necessary and have to be linked. Theme 4 provided details of Jackie Ziegler’s project to understand stakeholders’ perceptions of permafrost hazards. This project has three main areas of study; researchers, the hazards and the decision-makers.

Network events

The third session provided an opportunity to discuss knowledge mobilization activities and events until the end of the network and make recommendations to maximize the value of network output and outcomes. There was a brief overview of the existing communications initiatives of the network and the meetings and conferences that the network is involved in, followed by plans for the events to be held before the end of the network e.g., the International Conference on Permafrost (ICOP), in Whitehorse in June 2024, Northern Workshops, the 2024 AGM and a finale event at Carleton University in June 2025, as well as collaborative meetings, conferences the network can contribute to and field training activities.

The participants then formed breakout groups to discuss what new opportunities should the network consider for continuing its momentum, what other events and initiatives to dovetail with and how?

Suggestions for future initiatives and events included:

- A graduate student meeting in the north e.g., a northern workshop could be very valuable for early career researchers.
- A half-day course by members of the network for public works and highways.
- A travelling roadshow.
- Overall synthesis paper to finalize PermafrostNet.
- Hold the finale event in the North.
- Launch of a co-developed synthesis paper at a June 2025 network finale event that, if possible, would be held in the north.
- A synthesis project half day course targeting industries in the north and encouraging government to have a better understanding of the fundamentals of permafrost. Widening network training to bridge the gap between experts and decisions makers.
- Events including permafrost researchers who aren't in the network to learn about the work that's been carried out by the network.
- Focus on partners and partnerships at the next AGM.
 - Hold breakouts for dissemination of specific tools for different groups.
 - Take into consideration how to integrate documented Traditional Knowledge and community expertise into applied practice.
 - Work with the CPA to plan the next steps.
- Events the network can contribute to / leverage.
 - Workshops organized by other organizations in the North.
 - Water stewardship Oct/November 2024.
 - Ecology North Youth workshop 2024.
 - A Northern Climate Change conference (not yet finalized).
 - The next European Conference on Permafrost (EUCOP).
 - The Yukon and NWT Geoscience forums.
 - An event bringing together Indigenous communities across Canada.
 - Events including high school students e.g., have graduate students visit local schools.
- Attendance of graduate students at Northern community planned events e.g., NWT Youth workshops.
 - This will both encourage Northern Youth to engage with science to further their education and will better prepare them for the future changes associated with climate change.
- Develop outreach material/packages for Northern High schools and elementary schools. Maybe hire someone to assemble these materials from network projects.

Network Challenges Panel Discussion

Chair: Brian Moorman

Panelists:

- Duane Froese – Theme 1 (Characterisation of permafrost)
- Trevor Lantz – Theme 2 (Monitoring of permafrost change)
- Joe Melton – Theme 3 (Prediction of permafrost change)
- Pascale Roy-Levéillée – Theme 4 (Hazards and impacts associated with permafrost thaw)
- Christopher Burn – Theme 5 (Adaptation to permafrost thaw)

Summary

In the discussion, key challenges raised were barriers to community and student participation as well as tensions across research scales. Proposed responses focused on structural solutions to engagement limitations, communicating science clearly, portraying research as forward-looking solutions, and capacity building through student recruitment and support.

A more detailed summary of the panel discussion questions and answers is available in the copy of the AGM report available to members.

Keynote Talk - Loss of the Cryosphere in the Mountains of Western Canada

Speaker: John J. Clague, Emeritus Professor, Simon Fraser University.

John Clague, Emeritus Professor at Simon Fraser University, delivered the keynote presentation on the loss of the cryosphere in the mountains of Western Canada in the royal BC Museum on day two of the AGM.

Atmospheric warming on a global scale is inducing physical and biotic changes in Earth's high mountains that are likely unprecedented in the Holocene. In his presentation, John reviewed changes in the presently glacierized mountains of Western Canada, which include a rapid and large reduction in glacier ice and permafrost, a related increase in landslides, river re-routing and other hydrological changes, and changing aquatic ecosystems. Atmospheric greenhouse gas concentrations continue to rise and likely will do so for at least the next decade, if not longer. Mountains will continue to warm, probably reaching temperatures many degrees higher than present by the end of this century. As a result, the rate of physical and biotic changes is very likely to dramatically increase in the common decades, transforming high mountain environments.

Day 3: Careers, Canada's Changing Climate and planning Northern engagement.

Key notes

Allison Plourde (Theme 2) InSAR time series analysis of seasonal active layer dynamics in low-land permafrost terrain.

Andrew Clark (Theme 4) Advancing Arctic coastal erosion measurement and monitoring through UAV-SfM and object-based image analysis.

Rae Landriau (Theme 5) Performance of Drilling Waste Sumps, Western Arctic Canada.

InSAR time series analysis of seasonal active layer dynamics in low-land permafrost terrain.

- This project combines remote sensing with accuracy down to the mm-cm scale surface deformations with *in-situ* field measurements.
- The study includes 6 field research stations with instrumentation measuring subsurface vertical deformation and snow depth over 2018-2023.
- Two InSAR stacks are used - one C-band (RADARSAT) and one X-band (TerraSAR) - to complement the *in-situ* data.
- Field measurements show distinct summer subsidence patterns indicating thaw settlement.
- InSAR phase is sensitive to deformation, atmosphere, topology, snow, and other noise sources.
- A Stefan equation-based model is used to relate temperature and snow data to expected vertical displacement.
- Timeseries analysis shows some agreement but also discrepancies between InSAR and model displacements.
- Possible reasons for discrepancies include overfitting the model, assumptions of stability for reference anchor points, and InSAR limitations.
- Next steps involve addressing these limitations with increased temporal sampling, different radar bands, and redundant field observations.
- In summary, the multi-dataset analysis provides insights into active layer dynamics, but further work is needed to reconcile InSAR and model displacements in permafrost areas.

Advancing Arctic coastal erosion measurement and monitoring through UAV-SfM and object-based image analysis.

- The Arctic coast exhibits some of the highest rates of erosion in the world and climate change applies three accelerating factors; increases in the open water season with a reduction in um summer sea ice cover, leading to a more active wave regime, an increase in the storm severity and thawing of coastal permafrost.
- The research has 3 components focused on erosion quantification, multi-proxy analysis, Object-based image analysis (OBIA) feature extraction, and coastline delineation.
- Strategies were developed for optimized UAV-SfM data collection (drone mapping) for erosion measurements from 3D representations.
- Multi-temporal analysis was conducted comparing different coastline proxies and erosion rates.
- OBIA was implemented for high resolution feature extraction and multiscale classification along Arctic coasts.
- Methods were proposed for broad-scale delineation of multiple coastline proxies.

- In summary, this project develops and evaluates new techniques leveraging UAV and OBIA for improved quantification, mapping, and monitoring of Arctic coastal erosion across scales. The applications stand to benefit coastal modeling, hazard mapping, and adaptation planning in rapidly changing Arctic environments.

Performance of Drilling Waste Sumps, Western Arctic Canada.

- Sumps are drilling waste pits that are built into the permafrost to contain different types of waste, primarily drilling fluids.
- The project plays an important role in capacity building with the Inuvialuit Regional Corporation and the Land Administration, delivering workshops and field training to ensure a legacy of training endures after the network.
- The project's sump assessment addresses which areas are stable or failing, what's contributing to failures and how should it be assessed.
- Over 220 sumps exist containing drilling fluids in permafrost, which raises environmental concerns related to permafrost thaw, solute redistribution, etc.
- Drilling fluids typically include freezing point depressants, particularly potassium chloride.
- Study sites include sumps of different ages (1960s through to 2022) in low lying Delta terrain.
- Analysis methods include assessing percent ponding and ground conductivity distributions.
- Results show:
 - The 1970s sump has completely failed with widespread ponded fluids.
 - An intermediate age sump shows intermediate ponding and conductivity.
 - The most recent sump remains intact with limited evidence of disturbance.
- Conclusions are that sump construction methods and site selection have improved to avoid permafrost thaw and containment failures.
- In summary, this analysis of drilling waste sumps of different ages provides insights into changing practices over time to minimize environmental risks. The most recent sumps are performing well, but legacy sites continue to be of concern in the context of Arctic warming.

Permafrost Monitoring and Canada's Changing Climate Report Discussion

On the morning of day 3 Stephan Gruber chaired a session in the Rogers room on permafrost monitoring and Canada's Changing Climate Report 2025 which featured a presentation by Nathan Gillett (Environment and Climate Change Canada).

Northern Engagement Workshop Planning

In the afternoon of day 3 a Northern Engagement Workshop planning meeting was held in the Spirit room. The session was led by Oliver Sonnentag (NSERC PermafrostNet co-investigator) with support from Jenna Snelgrove (CREATE LEAP Program Coordinator).

Participants included a broad range of attendees at the AGM including Indigenous community members, graduate students, representatives of Yukon Parks and other Northern partners.

A summary of the planning meeting is available in the copy of the AGM report available to members.

Poster presentations

Alexandre Chiasson

Initial Estimation of Excess Ice on a Large Geotechnical Dataset along the Mackenzie Valley Corridor, NWT.

Allison Plourde

InSAR Time Series Analysis of Seasonal Active Layer Dynamics in Low-Land Permafrost Terrain – Northwest Territories, Canada.

Andrew Clark

Advancing Arctic coastal erosion measurement and monitoring through UAV-SfM and object-based image analysis.

Danielle Chiasson

Peat as a portal to the past.

Emma Street

Exploring Traditional Knowledge of Permafrost in the Gwich'in Settlement Area and Inuvialuit Settlement Region.

Erika Hille

Characterizing the response of Arctic streams and rivers to permafrost thaw.

Gabriel Karam

The Effects of Environmental Controls on Epigenetic Ice Wedge Cracking.

Galina Jonat

A proposed framework to generate climate forcing for simulations of future permafrost thaw.

Hannah MacDonell

Guiding model selection for effective adaptation decision making: A statistical ranking framework.

Hosein Fereydooni

Ice Core Detection with Spectral Polarization: A Haines Junction Case Study.

Kaitlyn Diederichs

Predicting Landscape Sensitivity to Permafrost Mass Wasting.

Khatereh Roghangar

A Study of Thermal Modeling Parameters and Their Impact on Modelled Permafrost Responses to Climate Warming.

Léa Cornette

The effects of wildfires on permafrost thaw and soil nutrients in an Arctic tundra ecosystem.

Nick Brown

Preliminary evaluation of temperature-derived metrics for more comprehensive permafrost monitoring.

Nicole Corbiere

Mercury and methyl mercury concentrations in drained basin complexes in Old Crow Flats, Yukon, Canada.

Olivia Meier-Legault

Evaluating Permafrost Thaw and Ground Temperature Change from Borehole Data in Canada.

Pete Castillo

Modelling the Distribution and Sensitivity of Polygonal Terrain in Northwest Territories.

Pia Blake

The effect of snow and soil on the ground thermal regime in steep bedrock slopes.

Rose Lefebvre

Quantifying the contribution of a feather moss cover on the boreal forest ground thermal regime.

Tabatha Rahman

Ice-wedge morphology, distribution, and volume in the Barrens of the Hudson Bay Lowlands, northern Manitoba.

Teddi Herring

Initial outcomes of the Canadian Permafrost Electrical Resistivity Survey (CPERS) database project.

Usman Iqbal Ahmed

Linear Infrastructure & Permafrost Monitoring with SAR & Optical Data.

Zakieh Mohammadi

An approach for qualitative evaluation of permafrost thaw-settlement potential.