

Theme 4 Hazards and impacts associated with permafrost thaw



Theme 4 Hazards and impacts associated with permafrost thaw



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Theme 4 Hazards and impacts associated with permafrost thaw



2 PhD, 4 MSc, PIs and partners. PDF position is vacant!

Theme 4 Hazards and impacts associated with permafrost thaw

Range of permafrost hazards studied:

- Mass-movements
- Flooding and changes in water quality
- Contaminant mobilisation (mercury)
- Terrain and vegetation changes in traditional territories



P Roy-Leveillee



Erika Hille



Erika Hille



2012/0

Hazard and vulnerability in PNet proposal

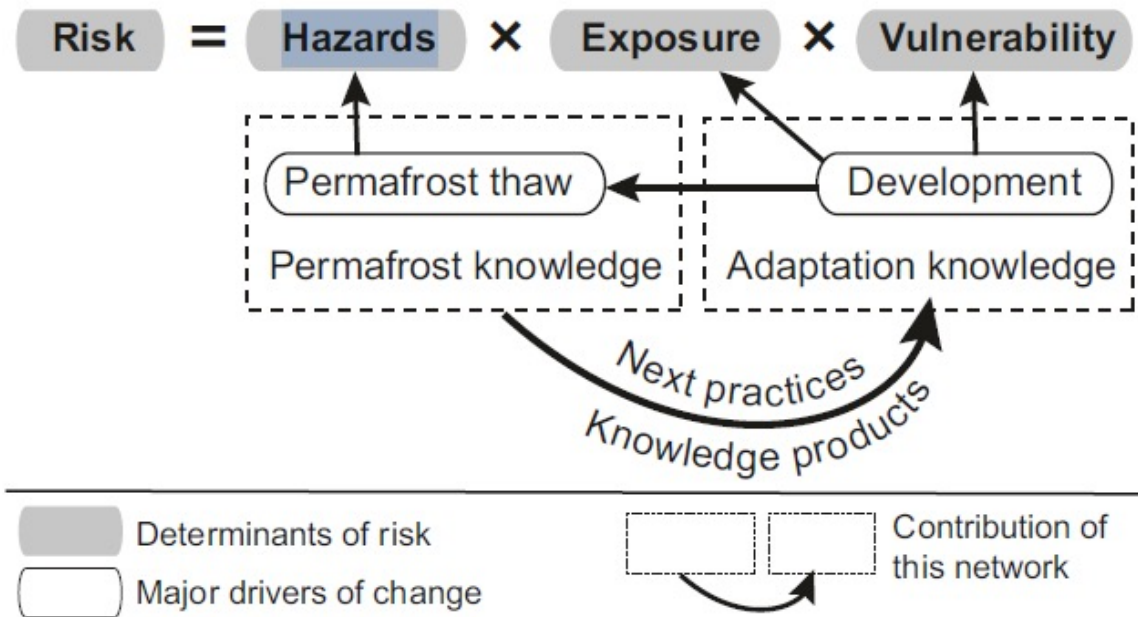


Figure 1. Permafrost thaw affects risk via hazards and exposure. Where driven by climate change, this is beyond our immediate control. Development affects exposure and vulnerability and can additionally change risk via permafrost thaw. Better permafrost and adaptation knowledge can reduce risk by enabling responsible development. Because of climate change, permafrost and adaptation knowledge must include future scenarios.

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What we contribute :

- Improved knowledge, detection, and prediction of hazards in ways that support stakeholders
- Better understanding of stakeholder needs in relation to research (past and future directions)

How we are connected to other themes:

- Integrate knowledge from themes 1-3
- Produce tools and knowledge that support theme 5

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Slope Stability – coastal setting:

- Object-based classification and feature extraction along Arctic coasts completed and **published** (Andrew Clarke).
- Multi-temporal 2D and 3D geomorphic analysis based on Structure-from-Motion competed and **published**. (Andrew Clarke).

Slope stability – inland:

- New student started in 2022 to work on the spatial prediction
- of thaw slumps (Kaithlyn Dietrich)



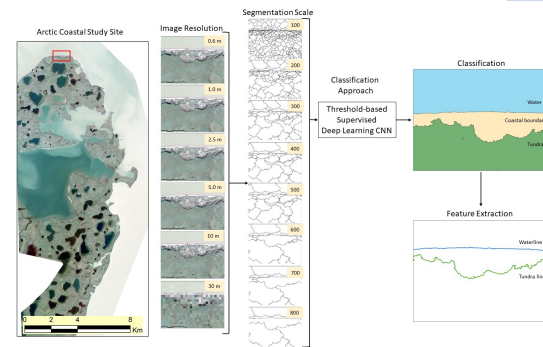
Arctic coastal erosion: UAV-SfM data collection strategies for planimetric and volumetric measurements

Andrew Clark, Brian Moorman, Dustin Whalen, and Paul Fraser

Abstract: Above average warming in the Arctic is leading to increasing permafrost temperatures and a reduction in sea ice cover, which are expected to contribute to increasing rates of Arctic coastal erosion and inland erosion. We studied a 1.5 km stretch of coastline off Richard's Island, Northwest Territories, Canada, consisting of multiple retrogressive thaw slumps (RTS) with varying degrees of activity over a one-year period. Multi-temporal 2D and 3D geomorphic analysis was based on unrectified aerial vehicle-structure from motion (UAV-SfM) data sets collected in 2019 and 2020. Over the observation period, -3.9 m and -1.3 m of planimetric cliff edge and ice retreat occurred, respectively, and corresponded to an average volumetric change of 1.1 m³. The accuracy of UAV-SfM-derived digital elevation models was tested using 2D data collection and processing scenarios, testing the influence of off-nadir camera angle, flight pattern, and georeferencing strategy. We found that oblique imaging and georeferencing strategy had a large influence on vertical accuracy and usability across the study site and has implications for studying volumetric change in RTS. This study advances the geomorphological understanding of RTS processes by highlighting the complex relationship between planimetric and volumetric change along rapidly retreating Arctic coasts, and demonstrates advancements in measurement practices for UAV-SfM data sets.</sup>

Key words: UAV-SfM, Arctic coastal erosion, oblique imagery, coastal retrogressive thaw slump, volumetric coastal erosion.

Résumé: Un réchauffement supérieur à la moyenne dans l'Arctique entraîne une augmentation des températures du pergélif et une réduction de la couverture de glace de mer, ce qui devrait contribuer à augmenter les taux d'érosion côtière et de libération de sédiments dans l'Arctique. Les auteurs ont étudié un tronçon de 1,5 km de côte au large de Richard's Island, Territoires du nord-ouest, Canada, comportant de multiples glissements de dégel régressifs (GDR) avec des degrés d'activité variables sur une période d'un an. L'analyse géomorphologique multi-temporelle en 2D et 3D a été basée sur des ensembles de données UAV-SfM (données aériennes sans pilotage) recueillies à partir d'un instrumenter en 2019 et 2020. Au cours de la période d'observation, des reculs planimétriques de $-3,9$ m



remote sensing

Multiscale Object-Based Classification and Feature Extraction along Arctic Coasts

Andrew Clark^{1,*}, Brian Moorman², Dustin Whalen³ and Gonzalo Vizza⁴

Abstract: Permafrost coasts are experiencing accelerated erosion in response to above average warming in the Arctic, resulting in local, regional and global consequences. However, Arctic coasts are rugged in scale, consisting of 50% of Earth's coastline, and represent a particular challenge for wide-scale, high temporal measurement and monitoring. This study addresses the potential strengths and limitations of an object-based approach to integrate with automated workflows by assessing the accuracy of coastal classification and subsequent feature extraction of coastal indicator metrics. We tested three object-based classification, thresholding, supervised, and a deep learning model using correlated coastal networks, focusing on a 1.5-km stretch of coast in the Western Canadian Arctic. Multiple spatial resolutions (0.5, 1, 2.5, 5, 10, and 30 m) and segmentation scales (100, 200, 300, 400, 500, 700, and 900) were tested to understand the trade-off between accuracy across imaging platforms. We observed classification accuracies greater than 80% for the higher image resolution scenarios using all classification methods. Coastal features, waterline and bankline, or vegetation, lines generated from image classifications were found to be within the image accuracy 80% of the time when compared to reference features. Further, for very high resolution scenarios, segmentation scale did not affect classification accuracy; however, a smaller segmentation scale (i.e., smaller image objects) led to improved feature extraction. Similar results were generated across classification approaches with slight improvements observed when using deep learning CNN, which we suggest has wide applicability. Overall, our study provides a promising contribution towards broad scale monitoring of Arctic coastal erosion.

Keywords: Arctic coastal erosion, coastal feature extraction, coastal classification, object-based image analysis, CNN.

Introduction
Permafrost coasts in the Arctic are sensitive to climate change and are likely indicators and integrators of changes occurring in the global climate system [1]. Permafrost coasts have been shown to exhibit high rates of erosion [2-4] which are influenced and amplified by reductions in sea ice extent, increased duration of the open water season [5], rising sea surface and air temperatures [6], above-normal relative snowfall [6], increasing permafrost temperatures [1, 11], subsidence [12], and increased storm frequency and intensity [13]. These changes to the Arctic system increase the vulnerability of Arctic coasts to increased erosion and altered coastal morphology [14], ecosystems and infrastructure [15], and carbon export to oceans [16], and subsidence [17, 18].

Remote sensing studies of Arctic coastal change are typically conducted through in-situ measurements, or visual interpretation of a coastal indicator [17, 18]. This approach

B. Moorman

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Slope Stability – mountainous terrain and rock faces:

- Simulation of permafrost in heterogenous steep bedrock slopes project near complete (model workflow being applied to all western Canada). (Emily Stewart-Jones)
- New student started in 2022 for the analysis of temperature metrics related to permafrost thaw for past slope instabilities (Pia Blake)



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Water quality and contaminants:

- In NWT: data collection completed to explain spatial variability in the water chemistry of 11 peatland streams and the Miner River (Erika Hille)
- In HBL: Estimates of Hg storage reduced by factor 10 when calibrated with regional field data.
- Over 200 samples analyzed for MeHg, near 200 for microbial, etc (Adam Kirkwood)

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Using river geochemistry to monitor the hydrology of Arctic watersheds

[Erika Hille](#)

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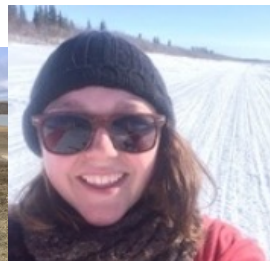
Adam Kirkwood



CRYUL



CRYUL



Erika Hille

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Evolution of lowland thermokarst:

- Collection of peat samples and permafrost cores completed in continuous permafrost lowland for the paleo-reconstruction of post-drainage basin evolution (Danielle Chiasson)
- **1 MSc position open/unfilled**

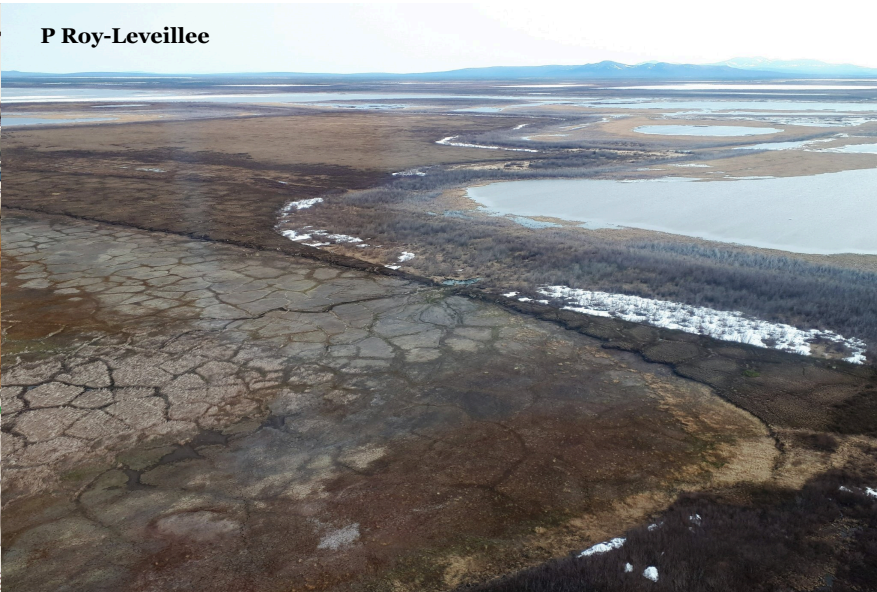
Nicole Corbière



Caleb Charlie



P Roy-Leveillee



Nicole Corbière



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Prioritization of thaw-driven hazards:

PDF position is now vacant.

Key milestones:

- (1) stakeholder surveys and interviews to identify and prioritize thaw related hazards from a stakeholder perspective, and to assess the information produced by the permafrost research community against stakeholder needs and priorities;
- (2) draft recommendation for next research practice in predicting and adapting to permafrost hazards

Key outcomes will focus on two elements: surveying the permafrost priorities of northern stakeholders and identifying how well these priorities are being met by the permafrost research communities. The PDF will also facilitate Theme 4-hosted panels/discussions on thaw related hazards, to co-produce an academic paper on the state of permafrost hazard assessment in Canada and a white paper on next practices in predicting and adapting to permafrost hazards.

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1. How can we increase capacity for effective permafrost hazard assessment in Canada? Including collaboration, knowledge-sharing, and communication across disciplines and sectors.
2. What cross-theme integrations would be beneficial with Theme 4 to strengthen our contributions and mobilize our knowledge?

A reminder our contributions are: a) Improved knowledge, detection, and prediction of hazards in ways that support stakeholders and b) Better understanding of stakeholder needs in relation to research (past and future directions).