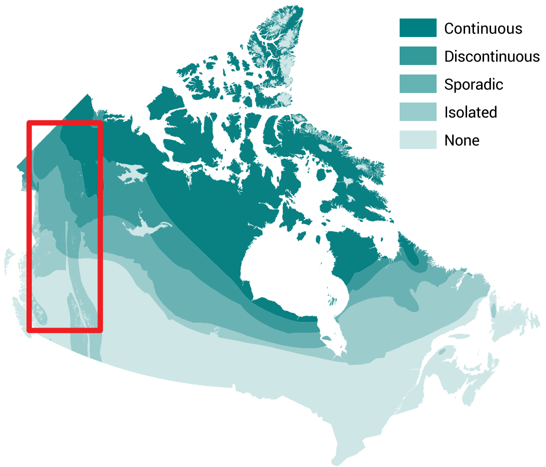
Modelling temperatures in rock walls in permafrost terrain of western Canada



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Keywords: Mountain permafrost, ground temperature, bedrock thermal regime, simulation, rock fall hazards.

Study locations: 4 study sites across BC and Yukon where rock temperatures loggers were installed in steep bedrock.

This research provides new insight into the relationship between rock temperatures, climate and topography. It demonstrates the use of a rock temperature simulation workflow in western Canada to inform permafrost conditions. This is important because understanding the spatial distribution of permafrost in rock walls can help assess and mitigate the risks of rock falls in mountainous regions, which are increasing due to climate change. For example, these simulations can inform geotechnical engineering, hazard assessment, or basic research. Knowledge of permafrost degradation in rock walls can contribute to improving safety and infrastructure planning for linear infrastructure and communities.

Figure 1. Dawson City Yukon with the Sunnydale slide across the Yukon River. Failure of this slope could result in flooding of Dawson City. Methods developed in this project are being utilized to better understand permafrost at this location.

Research summary

Climate change is accelerating the degradation of permafrost in mountainous regions, leading to increased rock fall hazards. In western Canada, where permafrost distribution is poorly understood, this creates risks to infrastructure and communities. This research addresses the specific problem of predicting permafrost presence and characteristics in rock walls, which is important for hazard assessment. The study simulated surface offsets, the difference between mean annual air temperature and mean annual rock surface temperature, using a physics-based model, integrating climate and topography data. The model was tested with temperature measurements in steep rock walls across British Columbia and Yukon. Results demonstrated the model's ability to capture fine-scale variability in rock wall temperatures, revealing key patterns related to latitude, elevation, and aspect. This is a step forward in understanding permafrost distribution and degradation in western Canada, enabling specialists to better assess rock fall hazards, enhancing infrastructure planning and safety in vulnerable regions.

Taking action

To address the issue of rock fall risk related to degrading permafrost in rock faces, the next steps should focus on expanding data collection and refining predictive models and their use. First, more temperature measurements across a broader range of sites help enhance and demonstrate model accuracy. Second, performing a similar study with more complex surface conditions such as vegetation and snow, which significantly impact ground temperatures, will increase the applicability of this modelling workflow. Third, these methods can be applied to high-risk areas, in combination with remote sensing technologies to track and predict changes over time. Finally, collaboration between researchers, engineers, and local governments is important for translating our findings into actionable strategies, such as early warning systems and specific infrastructure design.

Connections to other projects

3 4 This project is part of Theme 4 - *Hazards and impacts associated with permafrost thaw* and has been closely connected through collaboration with projects in Theme 3 — *Prediction of permafrost change*. This project is closely connected to Victor Posgay's project *Modelling subarctic air temperature inversions for better simulations of permafrost* in Theme 3.

Partners, team members and support

Partnerships and collaborations were crucial to the success of this research. Northern research support, particularly Alice McCulley from Tr'ondëk Hwëch'in First Nation, was instrumental in helping select field sites. Shared fieldwork with the Yukon Geological Survey provided essential logistical support, and Tombstone Territorial Park staff provided valuable insight into the research area. NSERC PermafrostNet Data Scientist Nick Brown was invaluable for troubleshooting software issues, and Alex Bevington of the British Columbia Government provided data from BC field sites.

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References

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