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

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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:

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

Our research objectives are: (1) to document changes in local climatic conditions including solar radiation, air temperature, relative humidity, winds, cloud cover, and the timing and magnitude of winter snowfall, spring snowmelt, and summer rainfall; (2) to measure seasonal active layer thickness and map the extent of permafrost, ground ice, and glaciers; (3) to assess how climate-induced changes affect the movement and quality of water; and (4) how these changes impact vegetation, soil microbiota, and associated greenhouse gas emissions. Linked to these objectives are the continued development and application of non-invasive shallow geophysical techniques and unmanned aerial vehicles (UAVs) as tools to document and monitor changes in permafrost, glaciers, surface and subsurface waters, and vegetation over time.

As the Arctic is currently experiencing unprecedented changes due to a warming climate, the information collected over the duration of this project will significantly improve our understanding of the interconnectedness of climate, permafrost, water, and life, and the potential resiliency of permafrost-dominated landscapes to climate change. This is especially important where ice-rich permafrost is susceptible to thaw, resulting in substantial changes to the hydrology, ecology, and geomorphology of the region. Knowledge generated through this work is also essential for predicting and mitigating detrimental impacts of climate change on infrastructure such as roads, buildings, and airports, and is especially relevant given the increased level of mineral exploration interests in the region. This project has a significant training component involving students at all levels of postsecondary education.

Research will be conducted between May 1 – May 20 and July 1 – August 10, 2023. This work will take place on Axel Heiberg Island at Expedition Fiord (79˚24'N, 90˚44'W). We will be based at the McGill Arctic Research Station on Axel Heiberg Island.

Fieldwork methods will include geophysical surveys to characterize permafrost conditions and aerial surveys to map terrestrial landscapes and vegetation cover. These surveys will be compared with future surveys to monitor and assess changes due to glacial retreat and permafrost degradation. Temporary soil chambers will be deployed in summer to measure

greenhouse gases, and ground sensors installed to monitor soil temperature and moisture. Small samples of water and soils will be collected for laboratory analyses, and small numbers of plant specimens collected for detailed taxonomic identification.

The research will have no impact on the environment, wildlife, or people. Data generated through the duration of this project will be stored on computers at Queen's University and managed by the project leader. Residents of Resolute Bay will be consulted for insight into the landscapes we are documenting, and we invite members of the Resolute Bay community to participate in fieldwork activities. We will publicly share our research results as they are analyzed and interpreted. Result-sharing in Nunavut will include pre-arranged visits with members of the Resolute Bay community, with wider dissemination to other communities through a combination of email correspondence, in-person meetings when possible, or using online platforms such as Zoom.