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CHANGE AND VARIATION IN THE THERMAL STATE OF PERMAFROST IN NUNAVUT

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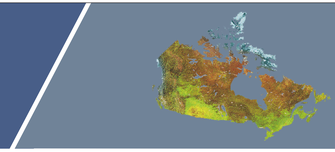
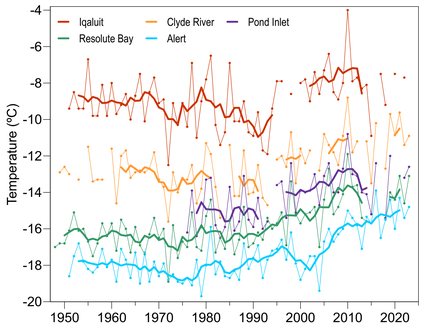


Introduction

The Canadian Arctic is warming faster than the global average and changes in permafrost conditions may affect communities and infrastructure in the North. Most of Nunavut's landmass is within the continuous permafrost zone (Heginbottom et al., 1995). Permafrost monitoring provides essential baseline information to inform land-management activities and northern infrastructure planning. Changes in permafrost conditions can have impacts on landscape stability and ecosystems. Increases in air temperature since the 1950s range from 0.14 to 0.28 °C per decade for Baffin Island and up to 0.39 °C per decade in the high Arctic. Most of this warming has occurred since the late 1980s with a greater rate in the 21st century, especially in the high Arctic.



Annual mean air temperature for the eastern and high Arctic (ECCC, 2024). Five-year running means are shown by thick lines.

Study Sites

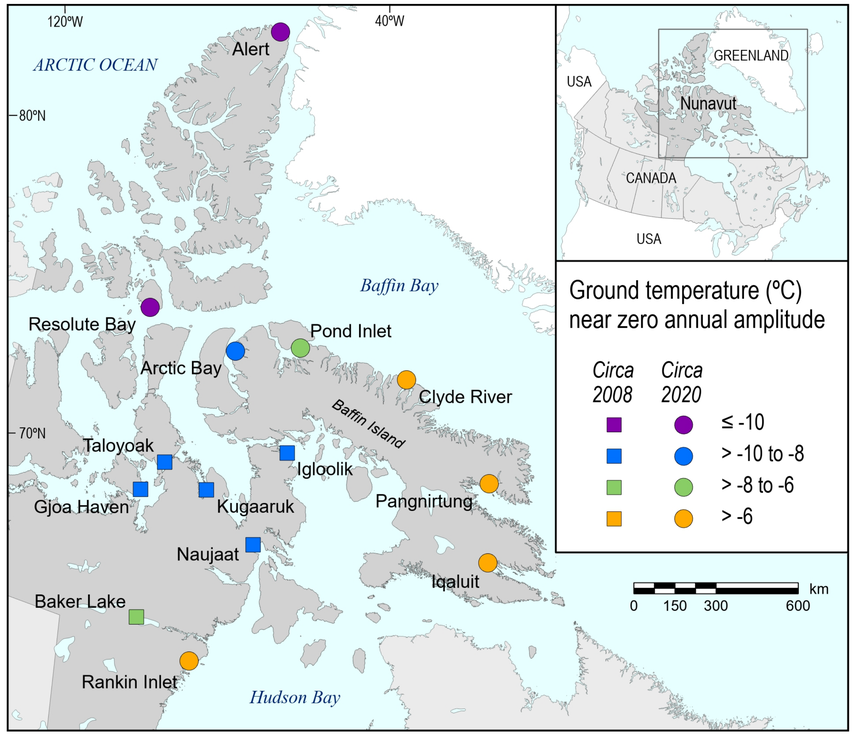
In 2008 and 2009, permafrost monitoring sites were established in ten communities in Nunavut by the Geological Survey of Canada in collaboration with the Nunavut Government and community members. These sites complement the long-term monitoring sites at Canadian Forces Station (CFS) Alert established in 1978 and one site maintained by Environment Canada in Iqaluit. Two sites in the Kivalliq region at Baker Lake and Rankin Inlet also provide information for central Nunavut.

Ground Temperature at Depth

Ground temperature envelopes (maximum and minimum annual temperature) for selected sites for the first and most recent years are shown below. At a depth of 15 m, seasonal fluctuations in air temperature are not completely filtered out. Annual temperature variations at 15 m depth are greater than 0.1 °C for most sites, ranging from 1.3 to 0.1 °C for Resolute Bay and Pangnirtung, respectively.

Annual Mean Ground Temperatures

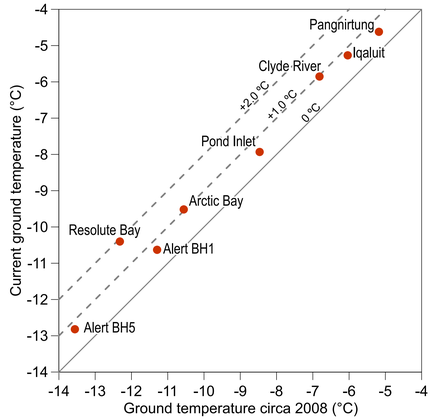
At a depth of 15 m, current annual mean ground temperatures range from > -5 °C in the southern Baffin region at Pangnirtung to < -13 °C at Alert, reflecting the general decrease in air temperature with latitude.

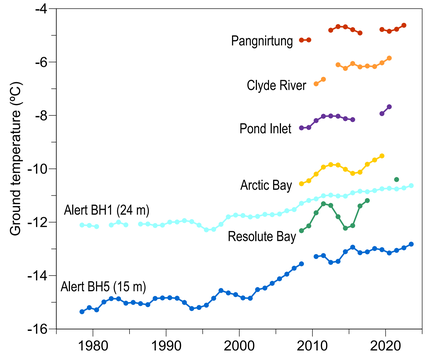


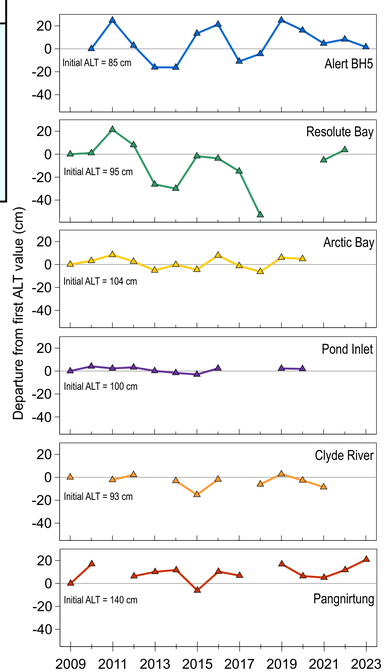
Long-term Trends

Since 2008, annual mean ground temperatures at the community monitoring sites have increased between 0.3 to 0.7 °C per decade on Baffin Island and 1 ºC per decade at Resolute Bay. Although the records for the community sites are only 10 to 15 years long, the rate of warming is similar to that observed at Alert since 2000 (0.6 and 0.8 °C per decade at 24 and 15 m depth respectively).

Ground temperature closely tracks air temperature because of limited surface buffering due to sparse vegetation and thin surficial deposits. Greater permafrost warming after 2000 is also observed in the longer records from Alert. The impact of shorter-term variations in climate are superimposed on the general permafrost warming trend. For example, at Resolute Bay, the 15 m ground temperature record reflects the interannual variability in air temperature, with short periods of warming and cooling.







Active Layer Thickness (ALT)

ALT, based on interpolation of shallow maximum annual ground temperatures, indicate that active layers are generally less than 161 cm thick at the community sites. Average ALT ranges from 87 cm at Resolute Bay to 149 cm at Pangnirtung with a high amount of interannual variation.

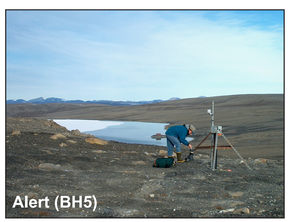
Summary

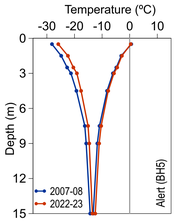
The increase in number of active permafrost monitoring sites in Nunavut since 2008 has enhanced our knowledge of baseline ground thermal conditions. The ongoing operation of these sites and the extension of ground temperature records reduces uncertainty in assessment of changes in permafrost thermal state.

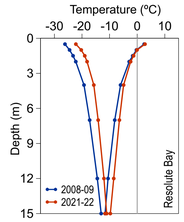
References

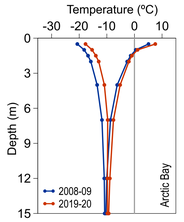
Heginbottom, J. A., Dubreuil, M.-A. & Harker, P., 1995. Canada, permafrost. In The National Atlas of Canada (5 ed.). Natural Resources Canada, Geomatics Canada, MCR Series, 4177, Natural Resources Canada. https://doi.org/10.4095/294672

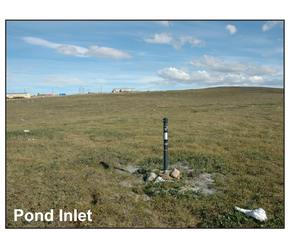
ECCC, 2024. Extracted from the Environment and Climate Change Canada Historical Climate Data web site (https://climate.weather.gc.ca/index_e.html) in October 2024.

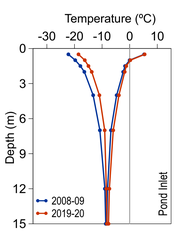


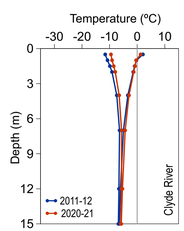


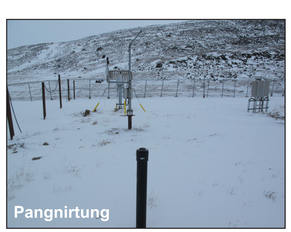


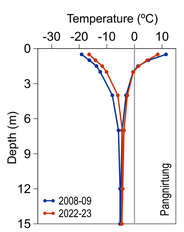












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