Results from community-based permafrost monitoring in Nunavut

Mark Ednie and Sharon L. Smith

Geological Survey of Canada, Natural Resources Canada
601 Booth st. Ottawa, ON
K1A 0E8

Natural Resources Canada / Ressources naturelles Canada

Knowledge of permafrost thermal conditions is essential for sound design of infrastructure in the Canadian North and for ensuring its integrity under a warming climate. During the 2008 International Polar Year, the Geological Survey of Canada collaborated with Nunavut communities and the territorial government of Nunavut to establish six new permafrost monitoring sites in the Baffin Region communities of Pangnirtung, Clyde River, Igloolik, Pond Inlet, Arctic Bay, and Resolute Bay. In 2009, four more boreholes were drilled in the Kivalliq (Repulse Bay) and the Kitikmeot (Taloyoak, Gjoa Haven and Kugaaruk) regions of Nunavut (Figure 1).

These monitoring sites were a key enhancement of the existing national permafrost monitoring network. Baseline permafrost information provided to community planners and engineers facilitates design and the development of adaptation strategies to cope with the impacts of climate change on community infrastructure and lifestyles.

The majority of the boreholes were drilled in relatively undisturbed terrain consisting of sparse vegetation over a thin layer of mineral soil underlain by shattered or fractured bedrock. Ground temperatures are measured to depths of 15 m using a multi-thermistor temperature cable deployed in a borehole casing. A datalogger attached to the cable provides continuous data collection.

As of summer 2014, up to five years of ground temperature data have been collected; some records are shorter or have gaps due to datalogger or thermistor cable malfunction.

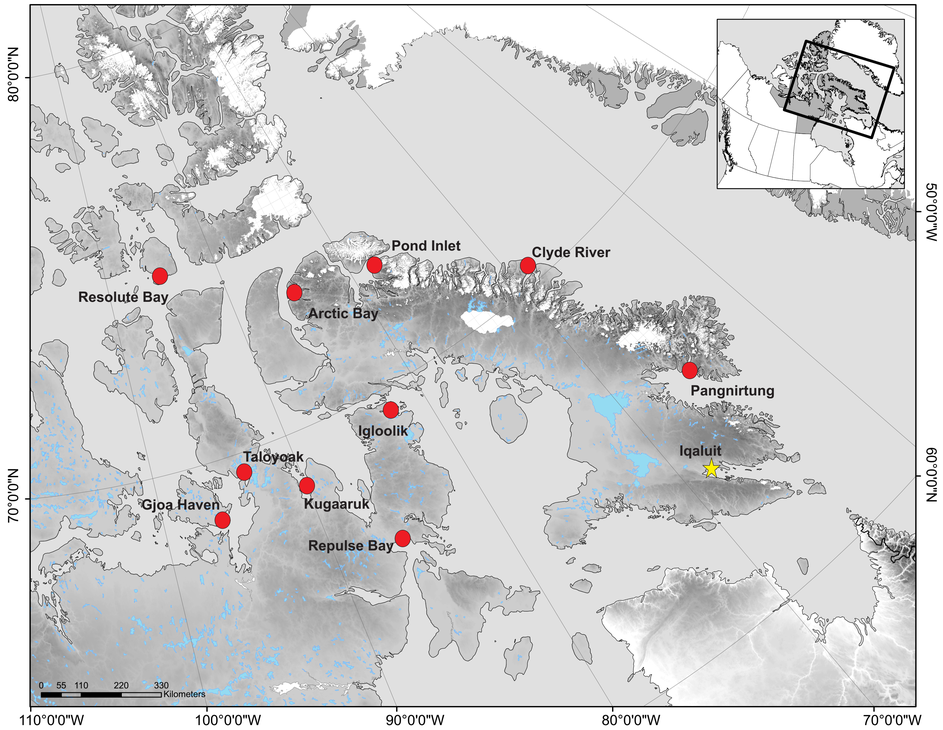

Figure 1. Location of communities in Nunavut with permafrost monitoring installations.

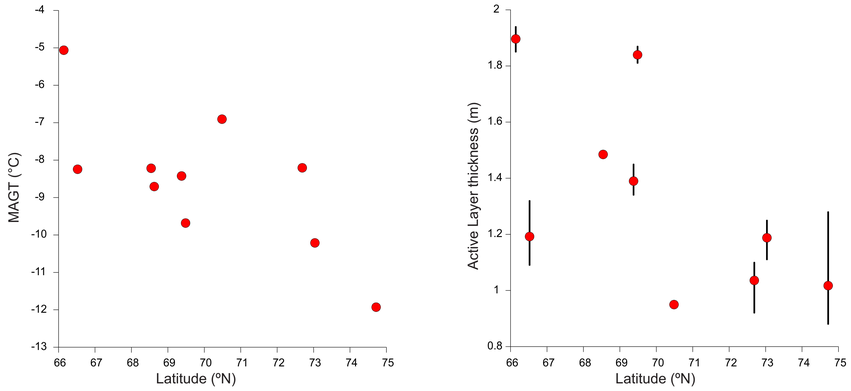

Figure 2. Mean annual ground temperatures (MAGT) at 15 m depth (left) and average active layer thickness and range for the period of record (right).

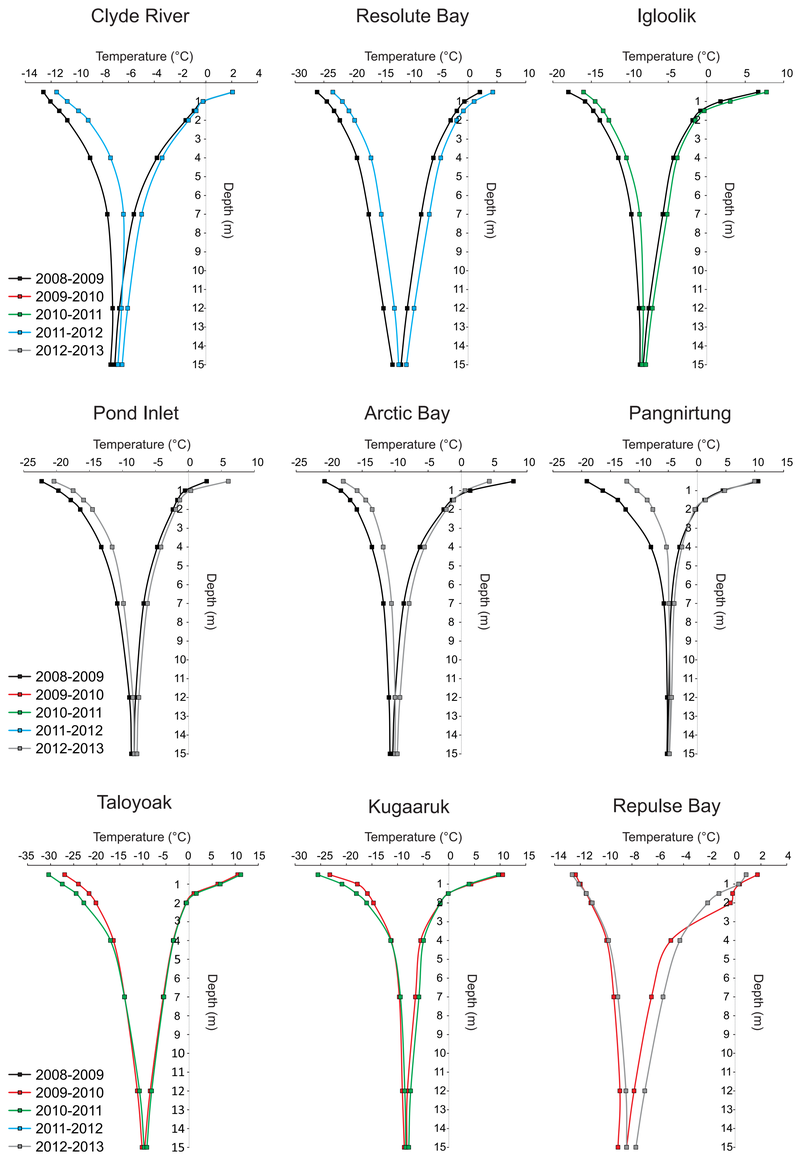

Figure 3. Annual ground temperature envelopes for 9 boreholes in Nunavut. The envelope for the first and last year of available record is shown.

Mean annual permafrost temperatures at 15 m depth range from -5.2°C in Pangnirtung to -12.3°C in Resolute Bay (Figure 2). Active layer thickness, interpolated from ground temperatures, ranges from 0.95 m in Clyde River to 1.90 m in Pangnirtung.

Annual ground temperature envelopes for 9 communities are presented in figure 3. In some communities such as Clyde River and Resolute Bay annual minimum ground temperatures have increased over the past 4 years while annual maximum temperatures have remained the same.

Since 2008, mean annual permafrost temperatures have increased in all the communities (Figure 4 and 5). The warming varies from 0.03°C/year in Igloolik to 0.25°C/year in Resolute Bay with an average warming of about 0.14°C/year.

Air temperatures in the region have increased over the past 25 years (Figure 6). Due to minimal vegetation, snowcover and surface organic layer, ground temperatures are not strongly buffered from air temperature changes. Consequently, annual mean ground temperatures closely follow the warming trend observed in annual mean air temperatures. Permafrost warming observed in these communities is consistent with long term-ground temperature trends in other High Arctic boreholes.

Acknowledgements
Support for this project was provided by Natural Resources Canada, the Canadian Government's International Polar Year Program, and Aboriginal Affairs and Northern Development Canada. Finally we wish to thank the members of the communities and the SAOs for their continued maintenance of the monitoring sites and collection of data. J. Chartrand provided assistance with data compilation.

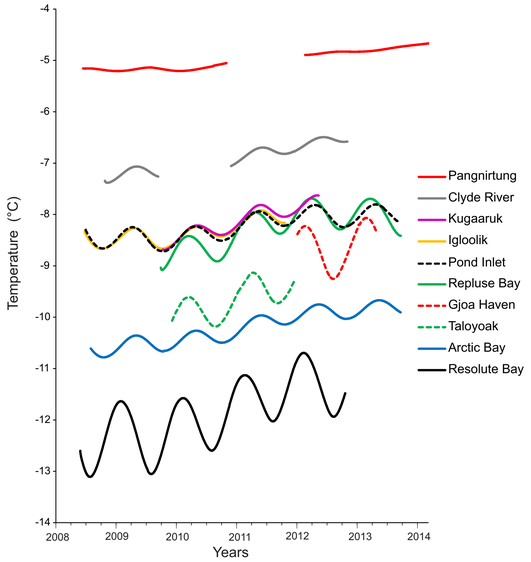

Figure 4. Continuous ground temperatures measured at 15 m depth. The majority of boreholes show seasonal variations in temperature.

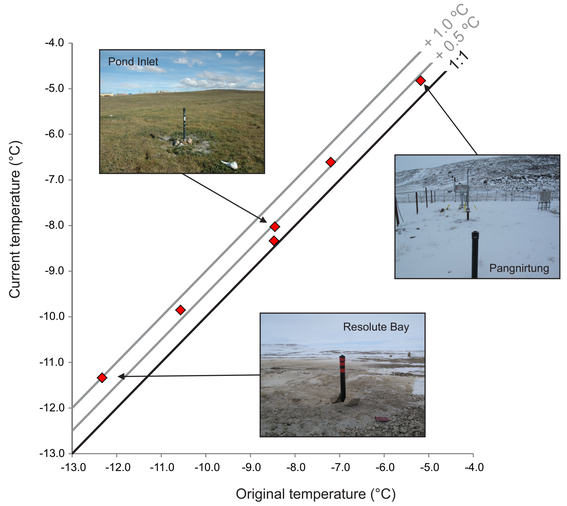

Figure 5. Annual mean ground temperature from the first year of data collection (2008-2009 or 2009-2010) compared to the most recent ground temperature (2011-2012 or 2012-2013) at 15 m depth.

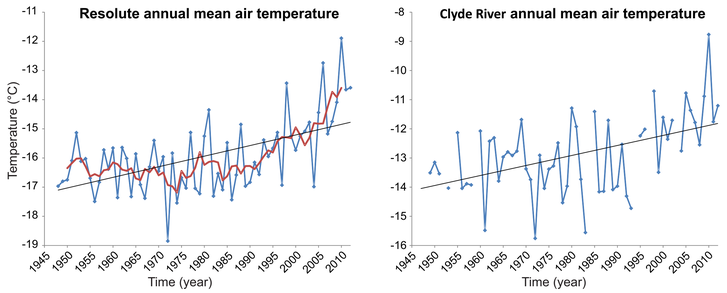

Figure 6. Air temperature trends for Resolute Bay and Clyde River (red line represents a 5 year running mean).