Permafrost conditions at Collinson Head

Herschel Island (Qikiqtaruq), Yukon Territory

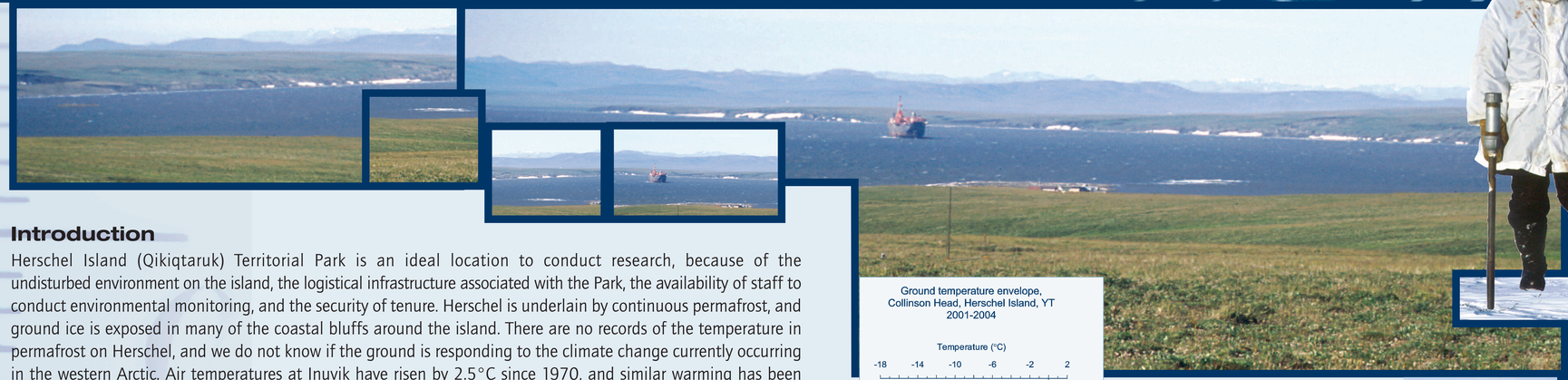

Figure 1. A ground temperature installation like the one on Collinson Head, Herschel Island. The pipe cap provides access to a cable with 9 sensors at depths to 14.5 m below the ground surface.

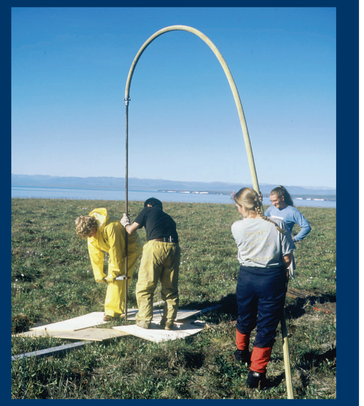

Figure 2. Drilling of a hole on Collinson Head for installation of a ground temperature cable. The hole is drilled by water jet, with water pumped from a nearby pond. At Collinson Head, the upper 15 m of the ground are icy, and were drilled in less than an hour.

Introduction

Herschel Island (Qikiqtaruk) Territorial Park is an ideal location to conduct research, because of the undisturbed environment on the island, the logistical infrastructure associated with the Park, the availability of staff to conduct environmental monitoring, and the security of tenure. Herschel is underlain by continuous permafrost, and ground ice is exposed in many of the coastal bluffs around the island. There are no records of the temperature in permafrost on Herschel, and we do not know if the ground is responding to the climate change currently occurring in the western Arctic. Air temperatures at Inuvik have risen by 2.5°C since 1970, and similar warming has been recorded at Komakuk Beach and Shingle Point, the stations on the mainland nearest Herschel Island. Our research takes place on Collinson Head, near the settlement and airstrip at Pauline Cove.

The purposes of the research are:

(1) to determine the temperature in permafrost at Collinson Head;
(2) to find out how this temperature varies with winter snow cover and vegetation type;
(3) to estimate the change, if any, in ground temperature since 1970; and
(4) to monitor changes in ground temperature associated with future climate change.

The work is focussed on ground temperatures and surface conditions, and complements research led by Dr Wayne Pollard of McGill University on ground ice at Qikiqtaruk.

Mean annual ground temperature at Collinson Head

The ground temperature at Collinson Head has been measured between April and August each year since 2001. The site is in tussocky tundra of the Herschel Terrain type. Temperatures are measured to depths of up to 14.5 m using thermistors on a temperature cable in a one-inch steel pipe casing (*Figure 1*). The pipe was installed in a hole drilled by water jet (*Figure 2*). The jet drill uses water from a nearby pond forced by a Wajax fire pump. The hole was drilled in less than an hour. *Figure 3* shows the maximum and minimum temperatures measured at the site between April 2001 and August 2004. The average temperature of the permafrost is −8°C. This is now a benchmark against which we may measure the impact of climate change at this site. Ground temperatures have not changed significantly between August 2001 and 2004.

Near-surface ground temperatures at Collinson Head

In August 2003 we installed 10 sites with data loggers to measure ground temperature along a 720-m transect leading down from Collinson Head towards Pauline Cove (*Figure 4*). At each site we installed a steel benchmark that could be located in winter in order to measure the snow depth (*Figure 5*). The benchmarks are anchored in permafrost below the active layer, the surface layer of the ground that thaws in summer. The transect crosses a valley, where the snow drifts, so the late-winter snow depths along the transect in 2004 varied from 8 cm to 135 cm (*Figure 6*). At each site, the ground temperature is measured daily at 1-m depth by a miniature logger, sealed in a small box (*Figure 7*). For 2003-04, the annual mean ground temperature at the sites varied from −9°C to −5°C, depending on the depth of snow. In the valley, the early and deep snow prevented freeze-back of the active layer until nearly Christmas, while at the other sites, with less snow, the active layer had frozen by mid-November. In summer, the ground temperatures at the sites along the transect are similar, so it is the winter conditions that separate them out (*Figure 8*).

These data demonstrate the importance of the snow cover to ground temperatures, and, therefore, suggest the significance of changes in snow cover as part of climate change. The observations are of regional significance because there are no other data indicating the range of near-surface ground temperatures that may be observed due to natural variation at present, and they enable a comparison with the only other data set of this kind collected by Dr J. Ross Mackay at Garry Island in 1969-71.

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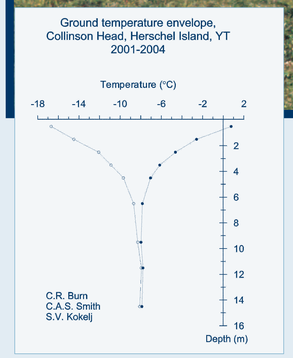

Figure 3. Ground temperature envelope for Collinson Head, with data collected in 2001-04. The measurements are taken during the Park season, between April and August each year.

Figure 4. Downslope view of the hillslope transect, looking down from Collinson Head towards Pauline Cove, the SDC, and the mainland.

Figure 5. Steel benchmarks, extended to protrude above the snow surface, indicate the location of each datalogger along the hillslope transect. These sites are locations for monitoring snow depth, ground temperature, active-layer depth, and heave or subsidence of the active layer.

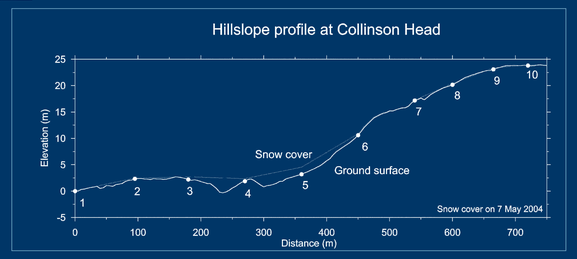

Figure 6. Hillslope profile from Collinson Head, showing the slope and variation in snow depth along the transect.

Figure 7. Photograph of an electrical box that contains a miniature data logger. The box is placed close to the tundra surface. The timing of the freezing season and the date of snow melt in spring may be estimated from temperatures measured in the box.

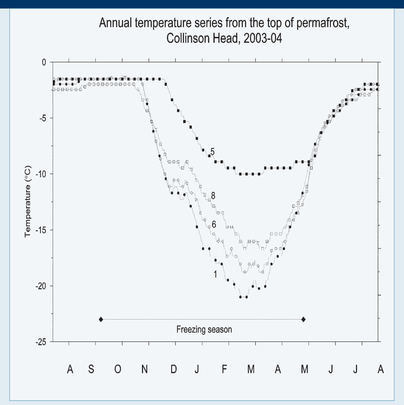

Figure 8. Temperatures at four sites along the hillslope transect above Pauline Cove, indicating the impact of variations in snow cover on ground temperatures over the winter. Note that in summer, temperatures at the sites are similar. But they may be substantially different in winter due to the insulating effect of the snow cover.

Permafrost and recent climate change

In August 2004 we installed a deep ground temperature cable at Collinson Head, to examine the ground temperature profile to 42.5-m depth. This is well below the depth at which the annual variation in temperature is recorded (*Figure 3*). The shape of the profile may indicate the amount of ground warming that has occurred recently, if any. The temperature disturbance we created during drilling had not completely dissipated before the end of the Park season, but the data we do have suggest that the ground at Collinson Head has warmed recently by 1.5 to 2°C. However at this point, this is only a tentative result.

Conclusions

We have two firm conclusions and one tentative result:

(1) The mean annual ground temperature at Collinson Head in tussocky tundra of Herschel Terrain is −8°C.
(2) The range in mean annual ground temperatures for 2003-04 due to natural variation in snow cover was −5 to −9°C.
(3) Ground temperatures at depth suggest the permafrost on Herschel has recently warmed by 1.5 to 2°C.

Other research

We have surveyed the plant compositions at the 10 sites on the hillslope transect, with a view to examining the variation in species composition with snow depth.

We have installed an empty access pipe in permafrost to 6-m depth, with a view to monitoring ground temperatures at various depths by data logger and obtaining information on the ground thermal properties.

Acknowledgements

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