Effect of Snow on Ground Temperatures, Takhini River Valley 1999 Progress Report

Progress report

The effect of snow on ground temperatures, Takhini River valley

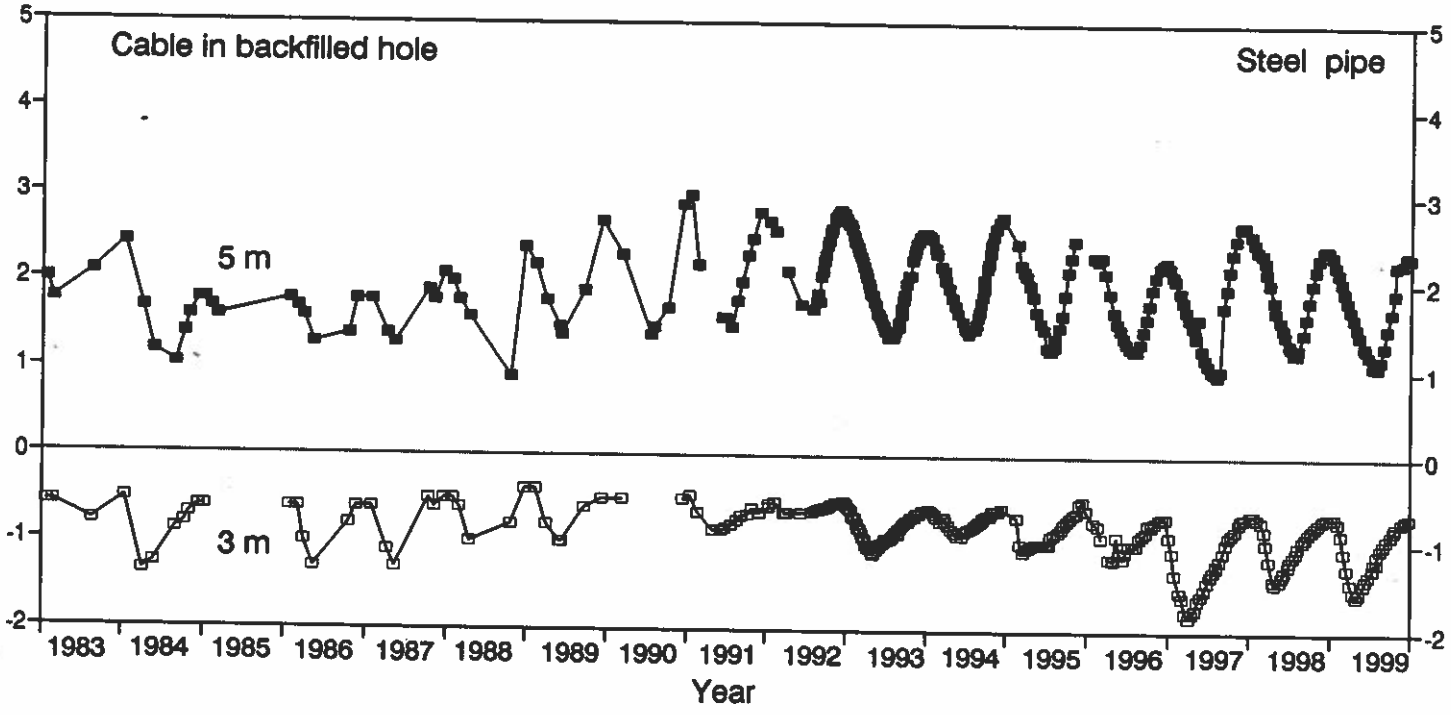
For a third year, the NRI Research Fellowship has been used to support ground temperature data collection at an experimental site in Takhini River valley, 50 km west of Whitehorse. The purpose of the work is to determine the impact of snow cover on ground temperatures. We are specifically interested in determining the extent to which removal of snow cover may cool the ground, because reduced snow cover may be a consequence of global climate warming, if melting exceeds snowfall. Alternatively, as many global climate models predict, there may be greater snowfall and accumulation. So, in July 1999 we also installed equipment adjacent to a snow fence designed to enhance accumulation.

The three adjacent sites have been instrumented with thermistors, and ground temperatures are measured to 5 m depth. The sites are in a meadow, with grass and scattered willows, and the ground is only frozen seasonally. In winter one of the sites is kept cleared of snow; another is "undisturbed"; and the third is next to the snow fence. Diana and Karen White, two school students from Whitehorse, visit the sites every other weekend throughout the year to collect data. In winter they also shovel snow off the cleared site if necessary.

During their visits to the Takhini Research area, Diana and Karen also monitor ground temperatures at a site in spruce forest with permafrost. Measurements have been made at the permafrost site since 1983, so it is becoming an index for environmental change in southern Yukon. The first attached diagram shows ground temperatures at the undisturbed site without permafrost and at the permafrost site for 1983-1999. These data indicate that during the 1990s ground temperatures have cooled slightly as a result of lower snowfall. The data are from differing depths because various sensors failed between 1983 and 1990.

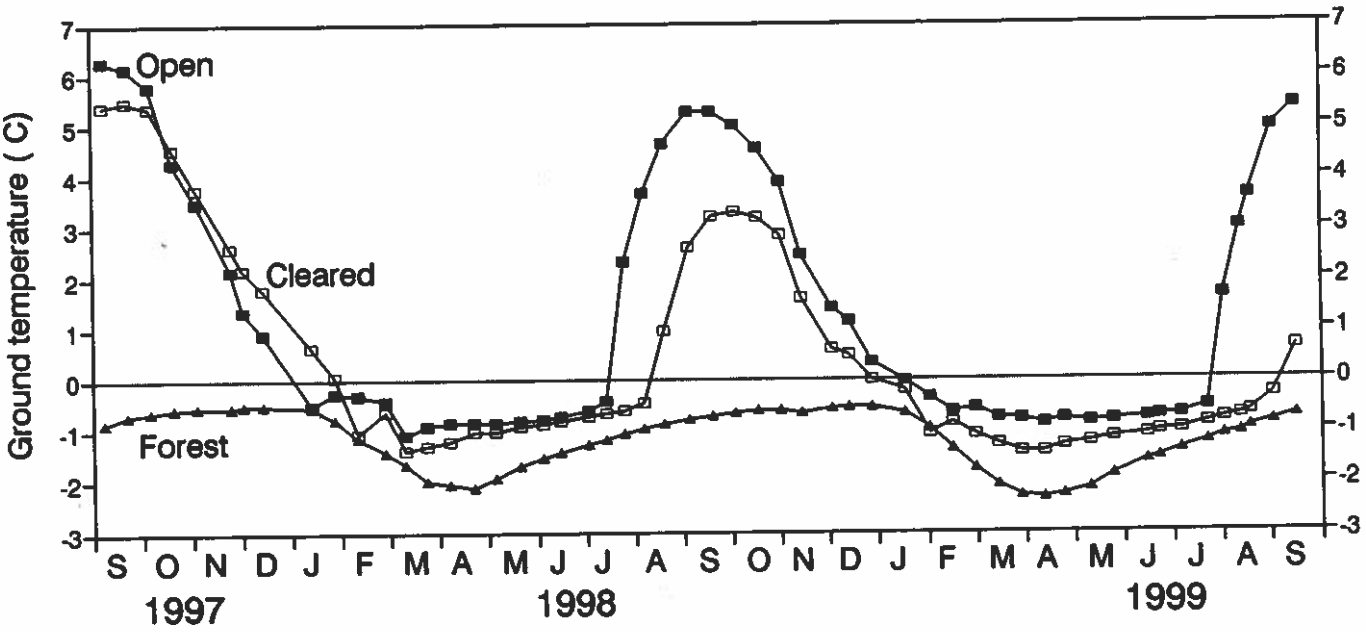
Two other diagrams are also attached, which indicate the effects of snow clearance on ground temperatures between September 1997 and 1999. The first shows that the effects of snow clearance are pronounced during the following summer, when the major difference in ground temperature between the sites occurs. The diagram also shows that ground temperatures have cooled over time as a result of ground clearance, and are moving towards the record from the site with permafrost . The second diagram shows the annual mean ground temperature profile for 1998-99 at the cleared, undisturbed ("open"), and forest (permafrost) sites. The cooling effect due to clearance extends throughout the profile, but the effect decreases with depth. The total cooling of the annual mean ground temperature (~2.0°C at 1.5 m) since the comparative measurements began in 1997 is partly due to snow clearance (~1.5°C), and partly to a cooler year in 1998-99 (0.5°C). We do not know whether snow clearance will lead to permafrost formation, but the cleared site has not reached equilibrium yet, so further cooling is expected. As suggested a year ago, we suspect permafrost may become established in 2001.

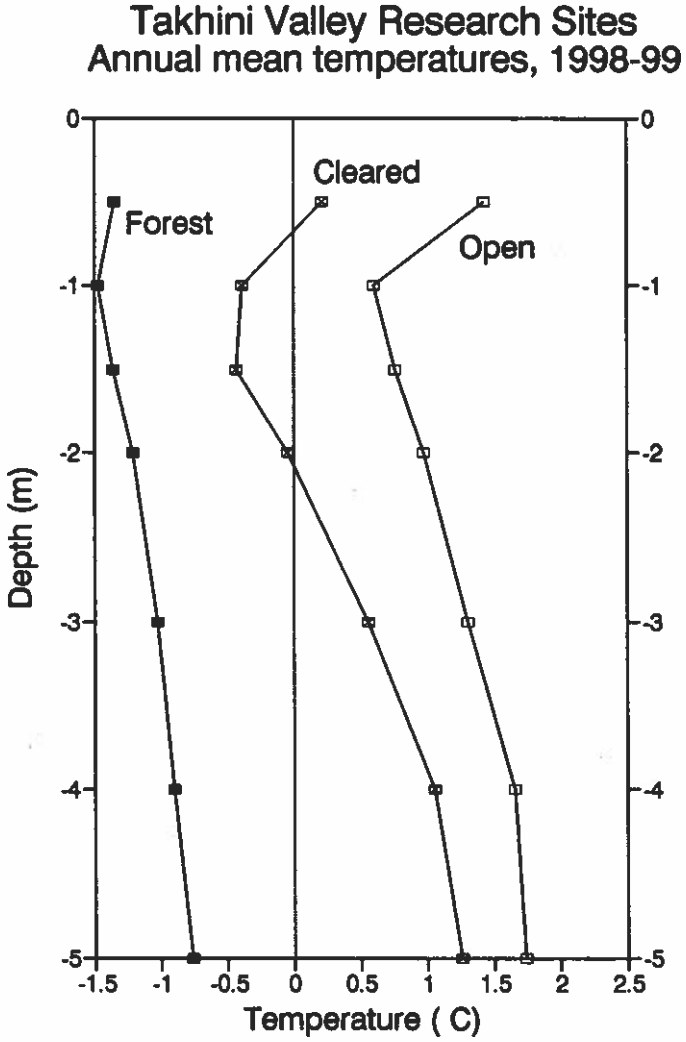
Takhini River valley, SW Yukon
Ground temperatures, 1983 - 1999



Takhini Valley Research Sites
2-m temperatures, 1997-99

(Mean temperatures: Open site, 1.20C; Cleared site, 0.45C; Forest site, -1.16C)




Takhini Valley Research Sites
Annual mean temperatures, 1998-99
Forest
Cleared
Open
Depth (m)
0
-1
-2
-3
-4
-5
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
Temperature (C)

The origin of the "drunken" forest

"Drunken" forest is a term used to describe stands of boreal forest with trees tilted at various angles. The stands are common in Yukon, and are usually associated with permafrost. The stands are common on hummocky ground with substantial ground ice beneath the active layer. The tilting of trees is generally associated with permafrost, but it is not clear whether the tilting occurs episodically in response to specific events, or is a function of normal changes in permafrost terrain due to seasonal freezing and thawing. We have instrumented a site near Mayo to investigate tilting. The field investigations at Mayo are being replicated near Inuvik, in cooperation with the Aurora Research Institute.

At Mayo, we have fitted 25 trees with T-shaped brackets that provide a small platform extending out from the tree. A digital protractor is used to measure the angle of the bracket, and we obtain the tilt of the tree both parallel and perpendicular to the tree. Similar measurements are made near Inuvik, but only 15 trees are monitored there. At Mayo we also collect soil temperatures and snow depths, and we irrigate two trees in summer to investigate whether soil moisture status is associated with titlting. Measurements are made by Ross Cooper and Chad Peck, both of J.V. Clark School.

The accompanying diagram shows tilting for 1996 – 1999 of one tree at Mayo. Almost all the trees show a similar pattern, both near Mayo and at Inuvik. The tilting is associated with ground freezing and thawing, but the movement is not simple. The movement appears to respond to conditions within the ground rather than at the surface, and is associated with the soil movement that maintains ground hummocks. The tilting of most trees appears to induce a cumulative deflection, as in this example, but a few individuals show no temporal trend.

In July 2000 we will have obtained four years' data and it will be time to write up this work. We will describe the annual tilt cycle and account for the movement. We will compare the activity in central Yukon with that near Inuvik. In similar terrain, the trees behave in like fashion at these two sites, but in dry terrain and near ice wedges, they develop a separate dynamic. The tilting of a tree next to an ice wedge at Inuvik, is particularly interesting, because the tree's movement mimics movement of the ice wedge.

Tilting of a tree at Wareham Lake

1996 - 1999