Permafrost Monitoring System in Alaska: Structure and Results

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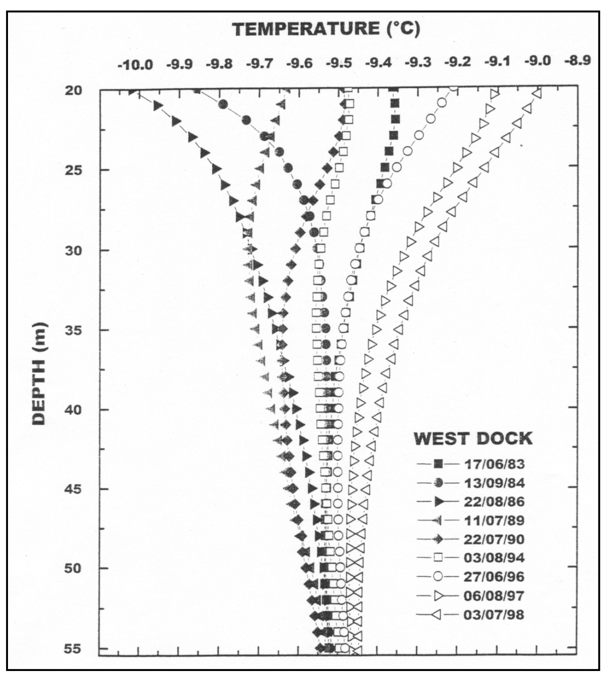
Today I would like to present data collected from the monitoring system established in the late 1970s and early 1980s by Professor Tom Osterkamp of the Geophysical Institute of the University of Alaska at Fairbanks. Although there are several other groups (such as CALM sites and Art Lachenbruch's sites of the USGS) working on this topic in Alaska, I will only be discussing the work of our group.

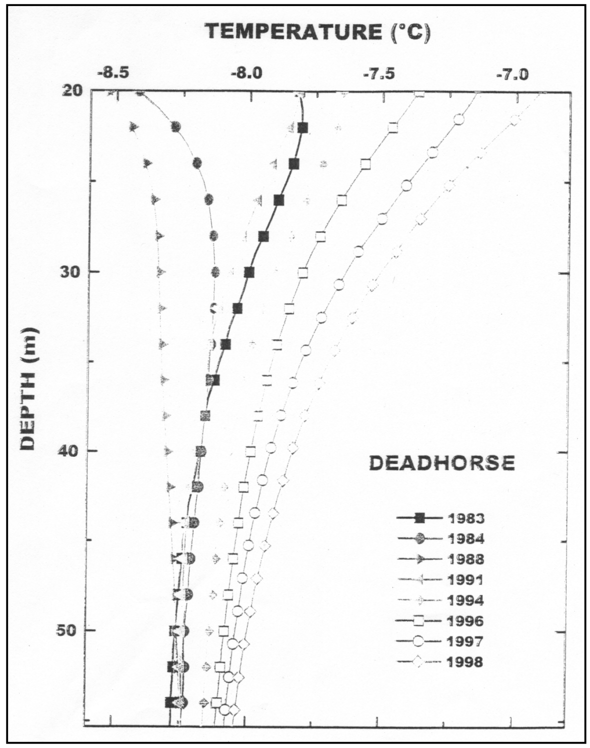
Margo has already mentioned the reasons that we measure ground temperatures. Analysis of these temperature profiles can help in the development of hypotheses about past and contemporary climate change.

Most of our sites are along a trans-Alaskan transect that crosses continuous and discontinuous permafrost, ending in the sporadic permafrost zone. These sites were established to study the interaction of climate and permafrost. Each red dot on the map represents one of our measurement boreholes. Measurements at deep boreholes (60-80 metres) are made once a year. Most of these sites also have automatic data recording (measuring every two hours) of air temperature, ground surface temperature, and temperatures approximately every 10 cm on a 1-metre cable. In 1998 we began to add soil moisture measurements at three or four depths at these sites, starting with the northern sites. Blue dots on this map represent deep borehole sites (40-80 metres) where measurements are made once every few years rather than annually. The yellow dots show the sites where only the 1-metre temperature cables and soil moisture sensors are installed. At these sites, each dot represents 4 cables for each location. Every effort was made to keep the surface intact when these sites were established.



I would like to present some results that highlight the duration and continuity of these measurements. The first data are for the most northern site, and represent ground temperature data for 20 to 55 metres depth. The pattern has the appearance of seasonal variation, but at these depths these variations are inter-annual. Measurements started in the early 1980s, and show the effect of constant cooling to 1987-88, followed by a period of more or less constant warming. A warming trend of about 1 degree is apparent at a depth of 20 metres. This represents a warming at the surface of 4 degrees or so. The significant inter-annual variability demonstrates the need for a long term monitoring record before an overall picture of the permafrost temperature regime emerges.

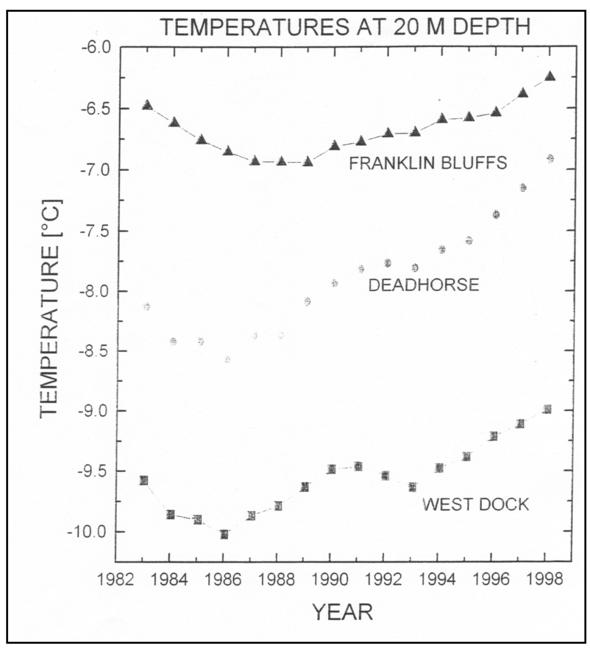
The next site shows a warming trend of 1.5 degrees at 20 metres depth over the same period of time. This data for this site has the same features as for the previous site. Averaging the temperatures at each depth over the 15-year interval gives a profile that curves toward warmer temperatures near the surface, suggesting that there is a warming trend on top of the decadal scale variations. These results are typical for most boreholes over the period of measurement.

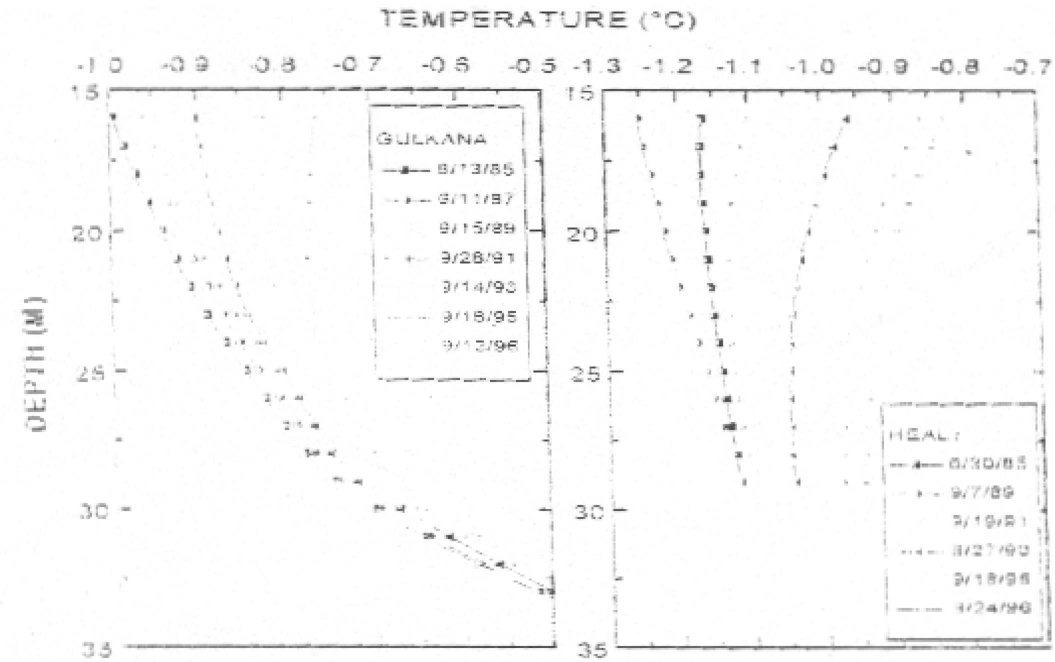


The data in this figure shows the temperature time series at 20 m depth for three sites moving from the coast inland. They all show the warming trend since the mid 1980s, with short-term variations. The cooling around 1992 is typical for North America as well as Siberia.

The consequences of a warming trend of this magnitude are significant for infrastructure in central Alaska.

In the Fairbanks area, the profile shows stable temperatures from 1986 to 1989, after which temperatures have been warming





Data for this site (missing graphic) includes soil moisture measurements taken using the Vitel system. This provides soil moisture during both summer and winter, making it possible to estimate the unfrozen water relationship in conjunction with the temperature data. The data shows that during the summer (at the same temperature) the unfrozen water content of the frozen active layer is much higher compared to the upper part of the permafrost, even though the soil is essentially the same. Unfrozen water relationships determined using this approach could be used in modelling, although we need to do some comparisons with other methods.

In conclusion, my recommendation to this meeting is that monitoring should not be restricted to field measurements and field studies, but should include modelling. I would like to conclude with some results from numerical modelling (graphic missing). For input we used weather station air temperature and snow cover, and used recorded near surface ground temperature data and a permafrost temperature profile to calibrate the soil thermal properties. With the calibrated model, it is then possible to reconstruct the permafrost thermal history for the length of the climatic record.