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Permafrost Temperature Monitoring System

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The World Meteorological Organization's (WMO) Global Terrestrial Observation System (GTOS) had identified active layer and permafrost thermal state in 1997 as two key cryospheric variables for monitoring in permafrost regions (WMO, 1997). In 1999, the Global Terrestrial Network for Permafrost (GTN-P) was established under the GTOS of the WMO. Since 1999, the International Permafrost Association's ad hoc GTN-P committee has made considerable progress in organizing and implementing the GTN-P. An overview of the GTN-P program, its goals and establishment, activities and planned future steps was published in the summer of 2000 (Burgess et al., 2000). The last status report was delivered to the International Permafrost Association in March 2001 (Burgess et al., 2001).

Recent update on the candidate boreholes for Permafrost Thermal Monitoring System can be found at http://sts.gsc.nrcan.gc.ca/gtnp/index.html. This web site currently contains an inventory and location maps of candidate sites, borehole metadata forms for downloading, as well as background material on the GTN-P.
Some 370 boreholes from 16 countries have been identified as candidate sites for inclusion in the GTN-P borehole thermal monitoring system. The majority of the boreholes are between 10 and 125 m deep, and are in the Northern Hemisphere. Figure 1 provides a map showing the location of the candidate borehole sites in the Northern Hemisphere. Most of the boreholes in Russia were measured only once or several times during some short time intervals at some point during the 1970s, 1980s or 1990s. However, many of these sites are still accessible for the recent replication of measurements. At least three groups of sites were monitored for a longer period of time. Permafrost Institute in Yakutsk, Russia performs a long-term thermal monitoring in a group of more than dozen boreholes in Central East Siberia since early 1970s (Dr. V. Balobaev is a leader of this effort). The depth of boreholes varies from 10 m to several hundred meters and frequency of measurements varies from monthly to once in several years. In northern West Siberia (Yamal Peninsula), there is a group of nine 10 m boreholes where temperatures were measured since 1979 (Dr. V. Pavlov is in charge of these measurements). Dr. N. Oberman established a comprehensive system of permafrost temperature monitoring in the European North of Russia. More than 40 boreholes are involved and the measurements continue for the last 20 to 30 years. There are another half of a dozen investigators in Russia who have been measuring permafrost temperatures in a limited number of boreholes during the last two to three decades.

In Alaska at least four groups of boreholes were monitored. First, there are the North Slope deep boreholes where the permafrost temperature was measured by USGS since 1950s (Lachenbruch et al., 1982; Lachenbruch and Marshal, 1986). Second, Max Brower measured temperatures (weekly, bi-weekly or monthly) at many locations in Barrow and within the discontinuous permafrost in 1950s and 1960s. The depths of boreholes vary from 10-15 meters to more than 100 meters. Third and very comprehensive system of permafrost observatories was developed by Prof. T. Osterkamp in late 1970s – early 1980s along the Trans-Alaskan Pipeline and at other locations in Alaska (Osterkamp et al., 1994; Osterkamp and Romanovsky, 1999). Depths of boreholes are typically 60 to 80 meters and the time interval between measurements is usually one year. As a result of this effort, uninterrupted 20-years series of permafrost temperature records were obtained along the IGBP Alaskan transect, which spans the entire permafrost zone in Alaska. Finally, a group of scientists from the Water and Environmental Research Center, University of Alaska Fairbanks (Drs. D. Kane and L. Hinzman) continue permafrost temperature monitoring at several locations in the Fairbanks area and on the North Slope.

In Canada, several groups of investigators (the leaders are Margo Burgess, Mark Nixon, Michel Allard, Stuart Harris, Chris Burn, Joe Eley and others) continue measurements of permafrost temperatures, which were started at different times during the last 35 years. More details about these monitoring programs can by found at http://sts.gsc.nrcan.gc.ca/gtnp/english/bhinventory/canadaNS.htm.

It is necessary to test a very common but lately often scrutinized postulation that the permafrost temperatures are a reasonably good indicator of climate change. Comparison between mean annual air and permafrost temperatures at the Churapcha station, East Siberia (Figures 2) shows that on an interannual time scale, these two parameters vary differently. The correlation coefficient between these two variables is 0.49 for the 1957-1992 time period. This coefficient will be even smaller for any shorter time interval. At the same time, the 10-year running means (Figure 2) show much better correlation (correlation coefficient is 0.87). Using longer averaging intervals increase this correlation even more (Figure 3). Hence, these data suggest that the permafrost temperatures replicate the longer time scale (decadal and longer) changes in climate (air temperatures) much better than the interannual variations (Romanovsky et al., 2000 and 2001). The primer cause of this is a significant interannual variability (but usually not a long-term trend) in the snow cover depths and durations.

Other important variables to measure at the permafrost temperature monitoring observatories are:

- Air and ground surface temperatures (hourly to daily)
- Soil temperatures and moisture down to 1-1.5 meters (hourly to daily)
- Snow cover thickness (daily)
- Active layer depth (summer maximum)

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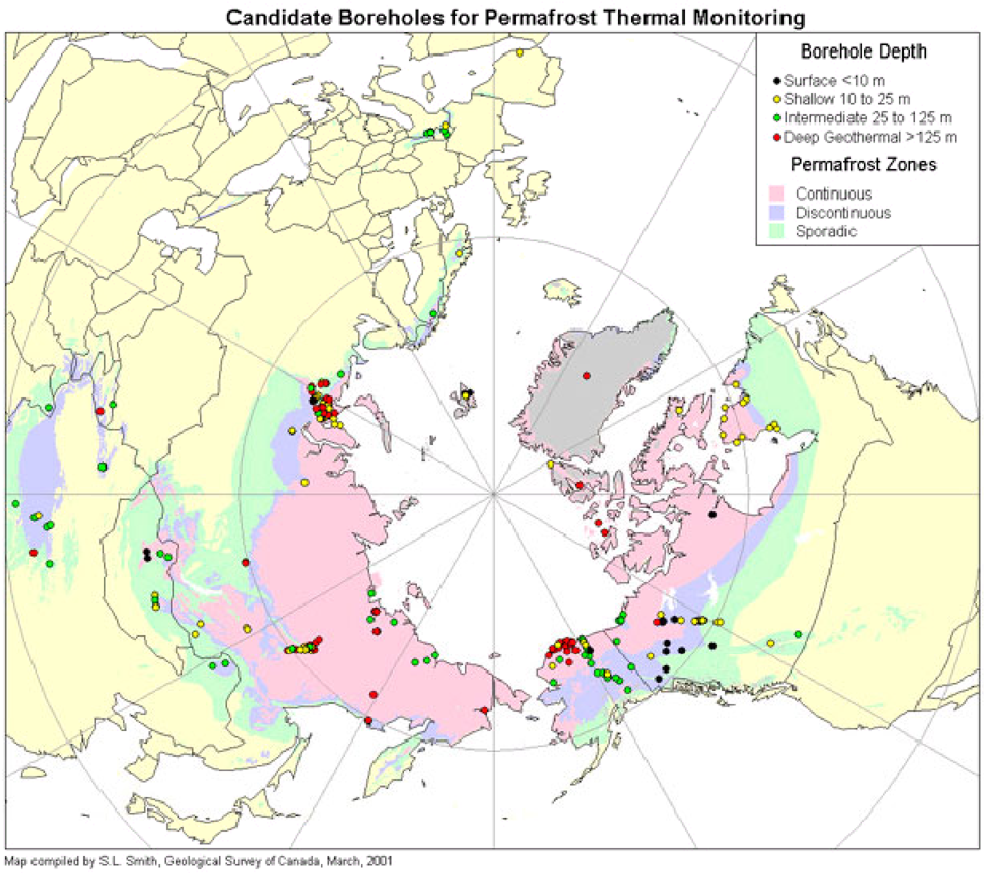

Figure 1. Candidate Boreholes for Permafrost Thermal Monitoring

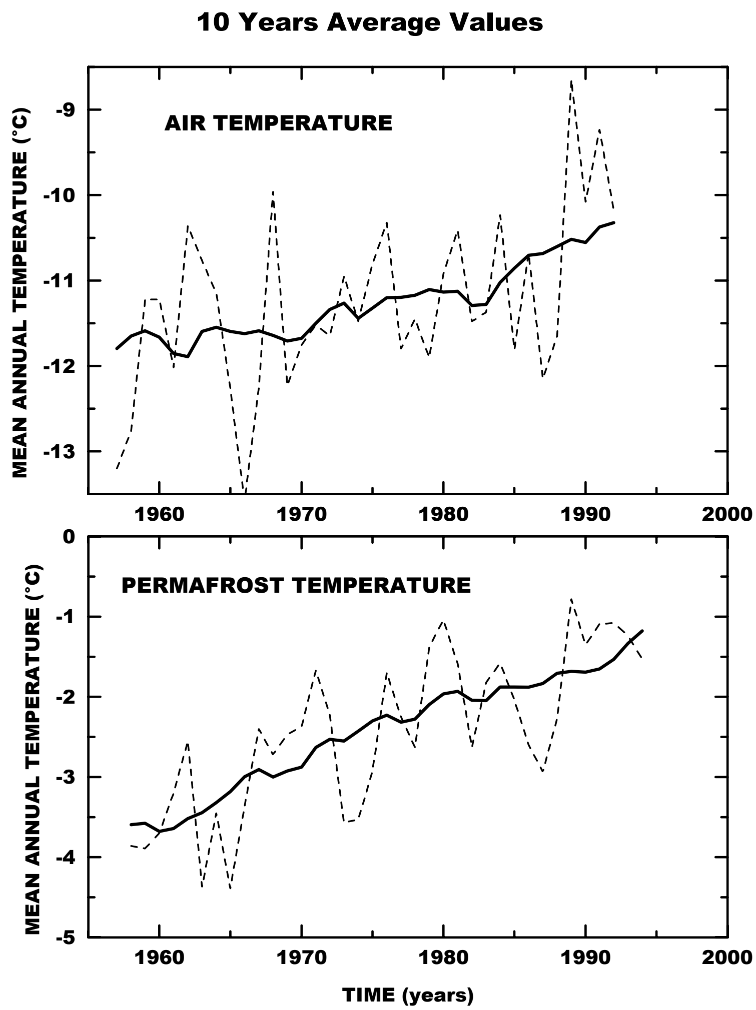

Figure 2. Measured mean annual air and permafrost (1.6 meters depth) temperatures (dashed line) and their 10-years running average values (solid line) at the Churapcha meteorological station, East Siberia.

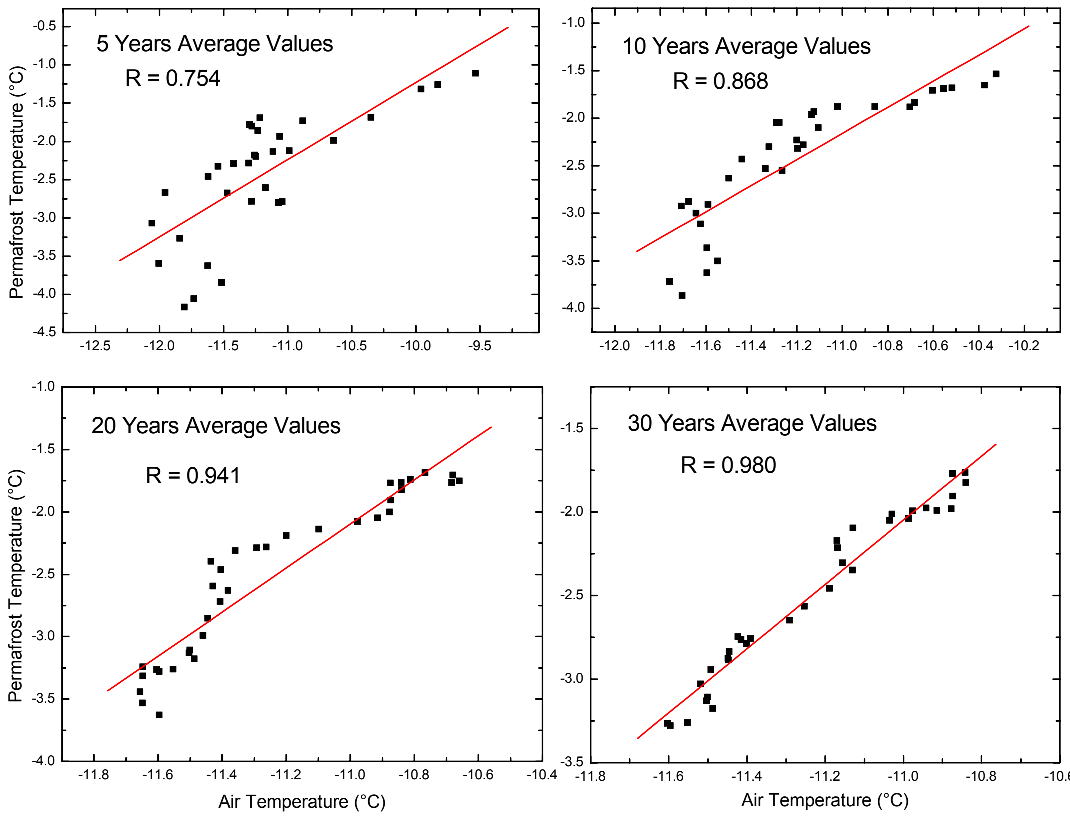
5 Years Average Values
R = 0.754
10 Years Average Values
R = 0.868
20 Years Average Values
R = 0.941
30 Years Average Values
R = 0.980
Permafrost Temperature (°C)
Air Temperature (°C)

Figure 3.