Recent Results From The U.S. Geological Survey Permafrost and Climate Monitoring Network – North Slope Alaska

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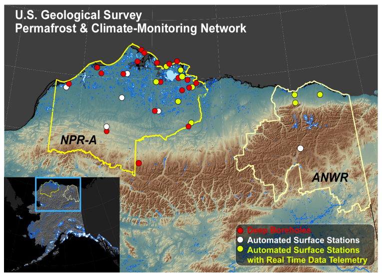
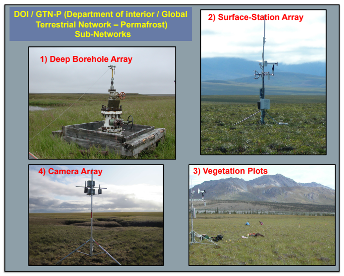
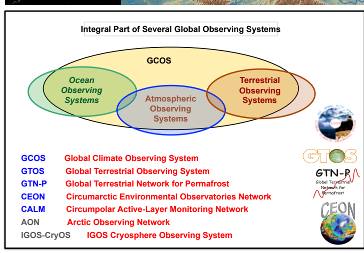
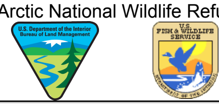
Introduction - We have implemented the DOI/GTN-P (Department of Interior/Global Terrestrial Network – Permafrost) permafrost- and climate-monitoring network, spanning federal lands in arctic Alaska. The monitoring system serves both scientific and societal needs and currently consists of: a) a network of 17 automated ground-based stations which continuously monitor several GCOS (Global Climate Observing System) essential climate variables within permafrost and in the atmospheric boundary layer; b) a network of automated cameras which document rapid permafrost degradation, thermokarst development, coastal and lakeshore erosion, and bird habitats; and c) a 21-element deep borehole array which is used to monitor the thermal state of permafrost; this is the largest array of deep boreholes in the world currently used for this type of monitoring. Nine of the ground-based climate stations are co-located with deep boreholes, forming "permafrost observatories". Deployment of ground-based stations began in 1998 and monitoring of the borehole array has been ongoing since 1979, thus providing more than a decade of surface measurements and three decades of measurements of deep permafrost thermal state. To satisfy some of the needs of the global climate-change community, land managers, and the public, much of the data is now available via real-time telemetry. We have also begun using the community-based next-generation Weather Research & Forecasting Model (WRF) to better understand the spatial patterns of climate variables (e.g., temperature, rain, snow, wind, cloudiness) and extreme events (e.g., rain-on-snow, high winds) at much higher resolutions (1-km) than can be obtained from the surface-station network.

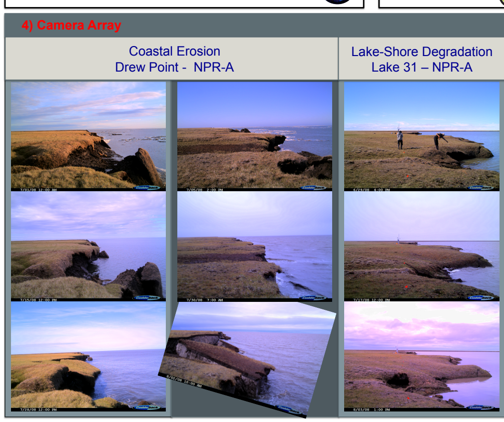




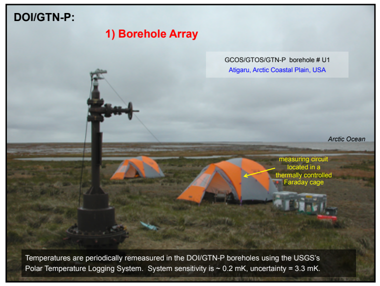


The U.S. Geological Survey is the lead Department of Interior agency. Significant logistical support and collaboration are provided by The Bureau of Land Management Arctic Field Office and the U.S. Fish & Wildlife Service Arctic National Wildlife Refuge.





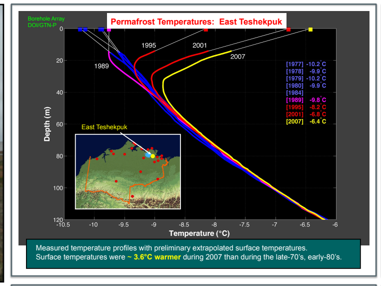
Data from the camera systems (Automated, telemetered, and time-lapse) are documenting rapid permafrost degradation (~ 20 meters of coastal erosion per year) and providing new insights into lake-shore degradation/evolution and wildlife (avian) habitat.



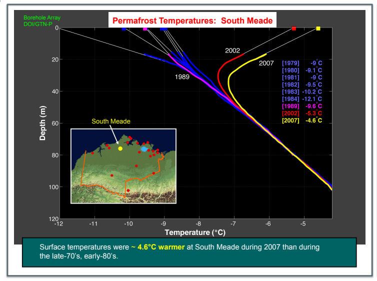
Temperatures are periodically remeasured in the DOI/GTN-P boreholes using the USGS's Polar Temperature Logging System. System sensitivity is ~ 0.2 mK, uncertainty = 3.3 mK.

Data from the borehole array show that mean surface temperatures have warmed 3-4 K in northern Alaska since 1989. This is a significant fraction of the change projected to occur in this region by 2090 by AOGCMs, suggesting the observations are running well ahead of the models.

Northern Alaska experienced a mild cooling during 1983-84. Just a hint of that cooling is visible in the 1984 East Teshekpuk log (it is much more apparent at other sites). Temperature logs acquired during 1989 began to show a recovery from the mid-1980's cooling. The 1989, 1995, and 2001 logs show that temperatures generally warmed throughout the 1990's. The climate record during the 1990's was clearly different from that during the 80's and late 70's. The warming in Arctic Alaska has continued since 2001. Temperatures recorded above 16-m depth are dominated by seasonal effects. The warming at East Teshekpuk is close to the average for the entire borehole array. All the wells in the DOI/GTN-P borehole array on the Arctic Coastal Plain show a similar sequence of events, although the magnitude of the warming varies considerably between sites.

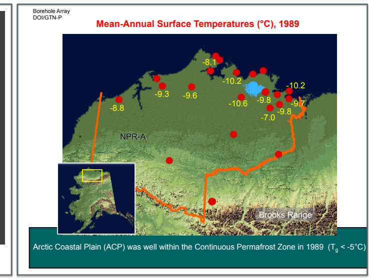


Measured temperature profiles with preliminary extrapolated surface temperatures. Surface temperatures were ~ 3.6°C warmer during 2007 than during the late-70's, early-80's.

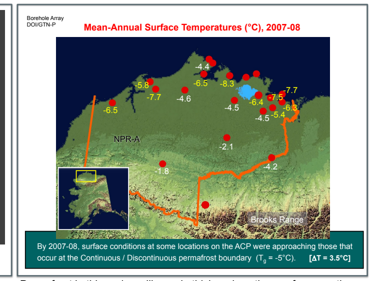


Surface temperatures were ~ 4.6°C warmer at South Meade during 2007 than during the late-70's, early-80's.

Surface temperatures are extrapolated from about 16 m depth where seasonal effects are small. Extrapolated values represent the mean annual temperature just below the maximum depth of the active layer (at the shallowest depth where latent heat effects due to summer melt are absent).

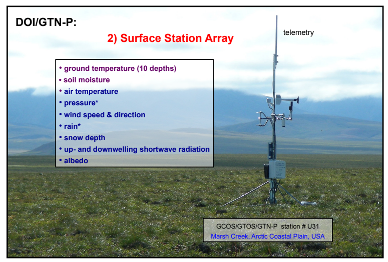


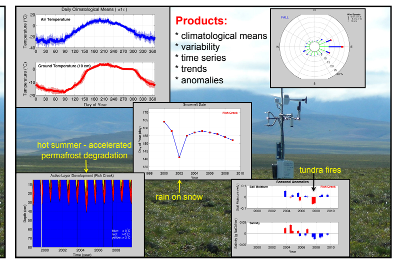
Arctic Coastal Plain (ACP) was well within the Continuous Permafrost Zone in 1989 ($T_g < -5°C$)

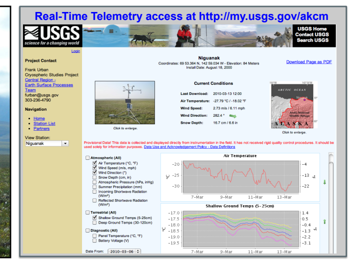


By 2007-08, surface conditions at some locations on the ACP were approaching those that occur at the Continuous / Discontinuous permafrost boundary ($T_g = -5°C$). [$\Delta T = 3.5°C$]

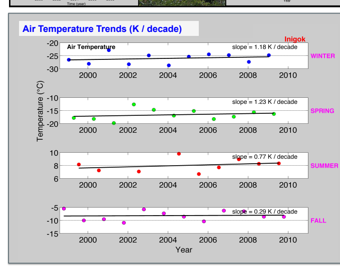
Permafrost in this region will remain thick and continuous for some time. But, if the climate were to remain fixed at its current state, some of the areas on the north side of the Brooks Range would eventually convert to discontinuous permafrost.

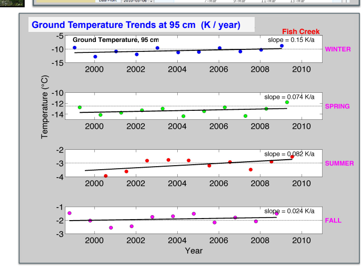




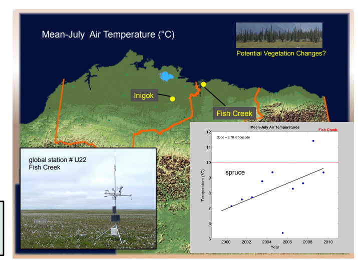


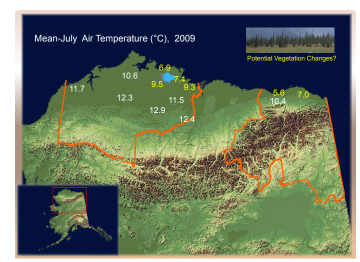
Data from the ground-based climate stations document a significant warming trend over the last decade, during ALL seasons. Trends of (0.1-0.2 K/yr) are observed in both the ground and in the lower atmosphere. Representative plots from the Fish Creek and Inigok sites presented here are typical within the surface station network. Similar to the borehole temperatures, the magnitude of the trend varies from site to site. There is considerable interannual variability at all sites, yet the increasing temperature trends are clear.





There is much interest in the potential for vegetation changes in a warming Arctic Climate. Ignoring other factors such as soil moisture, active layer depth, soil type etc… On the basis of temperature alone, spruce trees can exist when mean-July air temperatures reach about 10°C and ground temperatures reach 7°C. Here we display mean-July air temperatures at a site 10 km from the Arctic Ocean to highlight how how close this site is to that threshold. Mean-July 2009 air temperatures at all surface stations show that the 10°C threshold has been crossed at many warmer, inland stations.





***Acknowledgements** - This work was supported by the Earth Surface Dynamics Program of the U.S. Geological Survey.*

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