Long-term Hydrometeorologic trends Across Seward Peninsula, Alaska

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ABSTRACT

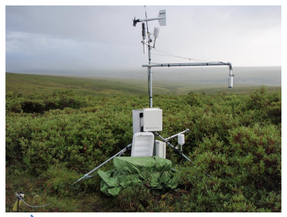
Alaska's Seward Peninsula, in the sub-Arctic of western Alaska, lies on the continental divide and separates the Arctic and Pacific Ocean. The landscape is generally covered by tundra and is underlain by warm and unstable (dis)continuous permafrost, depending on location. Continuous permafrost is mainly located in the northern and interior of the Peninsula where topography is flatter. Discontinuous permafrost is generally located in the south where the University of Alaska Fairbanks' (UAF) Hydrometeorology Network's research sites are located. This discontinuous permafrost generally is covered principally by shrub and tussock tundra and network sites are situated in these vegetation classes.

Observational data used for this analysis comes from the UAF Hydrometeorology Network and National Weather Service stations. Increases in winter air temperature dominate recent climate trends and may lead to degradation of the unstable permafrost. In this research we will look at the decadal trend at the UAF sites on the peninsula and the relationships between subsurface temperatures, snow, sea ice in the Chukchi and Bering seas, and several large-scale climatological parameters. Air and ground temperatures have been recorded continuously to the base of the active layer for over ten years using thermistor strings manufactured by UAF. Snow depth is measured using an ultrasonic type distance sensor. Although two sites were originally instrumented to record snow, all five sites have a several year continuous record of winter snow conditions. The teleconnection data sets are products of the University of Washington and the Climate Prediction Center at the National Oceanic and Atmospheric Administration .

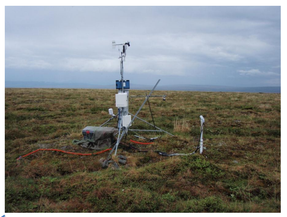
Research Area

The Seward Peninsula is a part of western Alaska and is positioned near the Arctic Circle

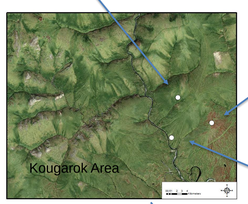
Photos of the main UAF climate stations are shown below. There are three types on the Peninsula: Radio repeater (Skookum Pass), a 3 meter meteorological tower (Council Grid Site, Kougarok Burn Site, and Kougraok Mauze Gulch Site), and sites with more instrumentation and a 10 meter tower (Council Blueberry Hill and Kougarok 10m Met). Each site has at a minimum one air temperature / relative humidity sensor and wind speed / wind direction at the top of the tower. The meteorological sites also have below surface a soil temperature profile, soil moisture profile, summer rainfall, winter snow accumulation, net radiation and air temperature / relative humidity at multiple heights. The K1 burn site sits on an area burned by wild fire. The K2 10m met site was partially burned during a tundra fire in 2002. K2 10m met and C1 Grid are both located along the valley bottom. Consequently, winter temperatures at these two sites are often colder due to thermal stable air masses, which often occur.



K3 Mauze Gulch Station



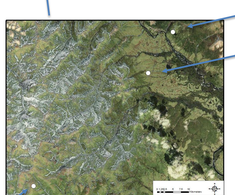
K1 Burn Station



K2 10 meter Met

C2 Blueberry Hill Station

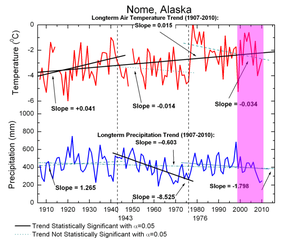
Skookum Pass



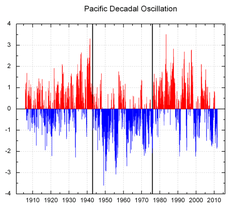
Council and Skookum Pass

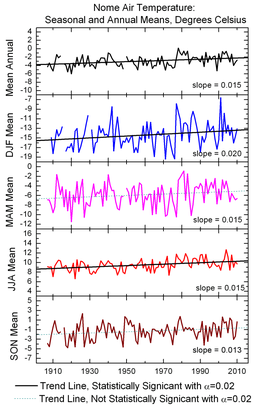
C1 Grid Station

Long-term Trends



The figure to the left shows the long-term temperature and precipitation trends at Nome. Nome has one of the longest continuous records of climate in Alaska. Recent data recovery efforts by our group have pushed the digitized historical record back in Nome back to 1907. The vertical bars at 1943 and 1976 break the time series into three periods roughly coinciding with the generally positive and negative phases of the PDO, shown below. The area highlighted in magenta encompasses the time period these UAF stations have been active on the Seward Peninsula.





The figure to the left displays the seasonal variation over the roughly 100+ year record for Nome. The trends in the shoulder seasons of spring and fall trends aren't statistically significant but the winter has a slightly higher positive rate of change. The colors for summer / fall / winter / spring in this plot are identical to the colors in the scatter plots below.

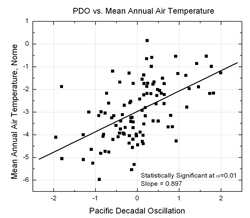
Corelation Coefficient, Nome Air Temperature vs.

	Annual	DJF	MAM	JJA	SON
Pacific Decadal Oscillation	0.538	**0.525**	**0.459**	**0.406**	**0.354**
Arctic Oscillation	--	**-0.394**	-0.236	**-0.331**	-0.281

Corelation Coefficient, Nome Precipitation vs.

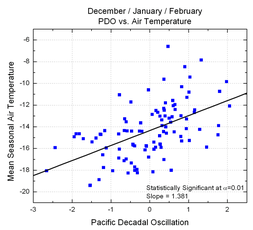
	Annual	DJF	MAM	JJA	SON
Pacific Decadal Oscillation	-0.021	--	--	--	--

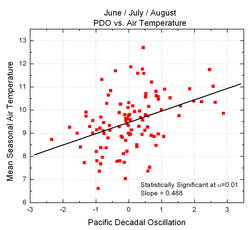
Bolded statistically significant at α=0.01

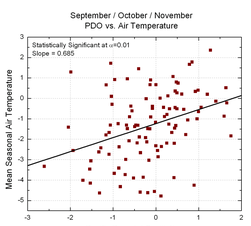


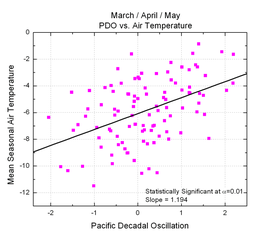
Hartmann and Wendler (2005) investigated the climate shift beginning in 1976 in the coinciding with the changing of PDO from negative to positive [period of study 1951 to 2001]. We repeat some of these analyses using the longer historical record and find a higher correlation, as expected. Results are summarized for the PDO and the Arctic Oscillation in the table above.

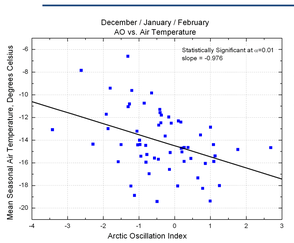
The next series of plots show the relationship between temperature in Nome and the PDO. The figure above illustrates this for the mean annual air temperature in Nome and below we look a bit more closely at the four seasons. Although all four seasons have statistically significant relationships between the two parameters, as can be seen in the table above, the correlation is positive and highest for the winter season.



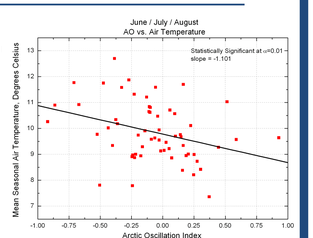






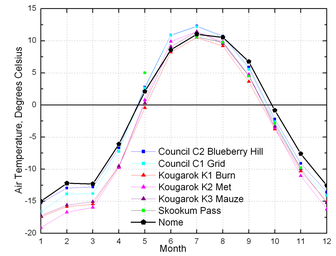


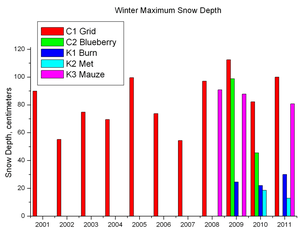
These last two figures show the mean seasonal temperature compared to the Arctic Oscillation. The Arctic Oscillation is generally strongest in winter, as can be seen in the index values on the x axis on these two figures. The influence in summer is basically negligible.



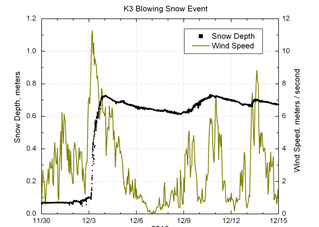
Station Data

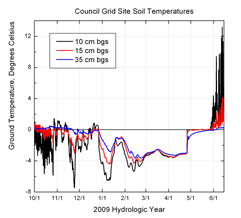
To the right is a plot of the 1999 - 2011 mean monthly air temperature for all sites with at least a 9 year record of data as well as the NOAA station in Nome. Surprisingly, temperatures diverge most on the peninsula in late winter when ice cover on the ocean is greatest. The three Kougarok area sites are furthest inland and noticeably cooler in the winter compared to the Council, Nome, and Skookum Pass stations. Nome has a more maritime climate compared to the Kougarok, Council, and Skookum Pass stations.

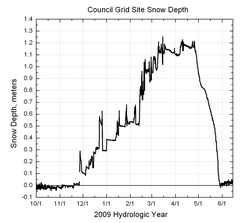




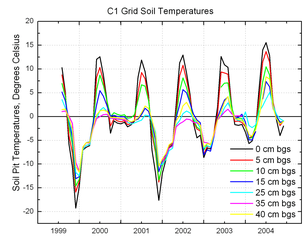
Maximum winter snow depth for the five sites instrumented with ultrasonic transducers is show in the figure to the left. No trend is obvious in the C1 Grid data. Although C1 Grid and K3 Mauze were installed the same year, K3 is terrorized by animals and consistently good data is harder to pass QA. C1 and K2 are both located on a valley bottom but C1 gets a bit more wind which may contribute to the higher snow values at that site. K3 Mauze, as can be seen in the station photo is positioned at the edge of a several hectare shrubland. In the figure below, a blowing snow event causes the shrubs to fill over a several day interval.

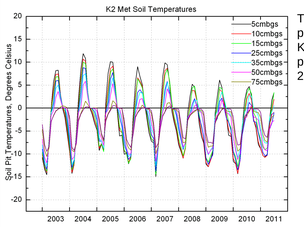




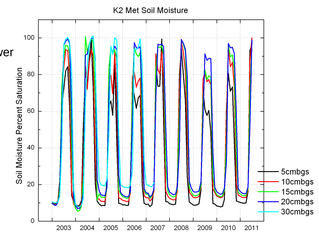


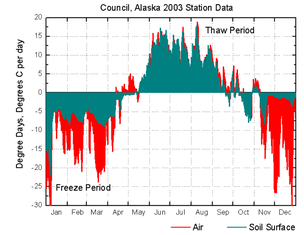
The pair of figures to the left show the impact of snow on ground temperatures over one winter at the C1 Grid site in Council. The diurnal amplitude time series for the ground temperature data at the grid site, like many of the other sites are often fall victim to animal damage. This temperature profile is the second at this site. To the right are mean monthly temperatures for the original temperature profile at the grid site. Deep snow years at C1 correspond to warmer winter temperatures.



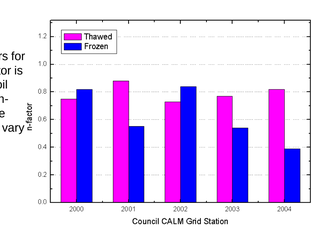


These two figures show ground parameters at the K2 Met tower in Kougarok. The area around the tower partially burned in a tundra fire in 2002.





These two figures show n-factors for the Council Grid site. The n-factor is the ratio of air temperature to soil surface temperature. Summer n-factors are generally close to the same where as winter n-factors vary with snow pack depth.



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