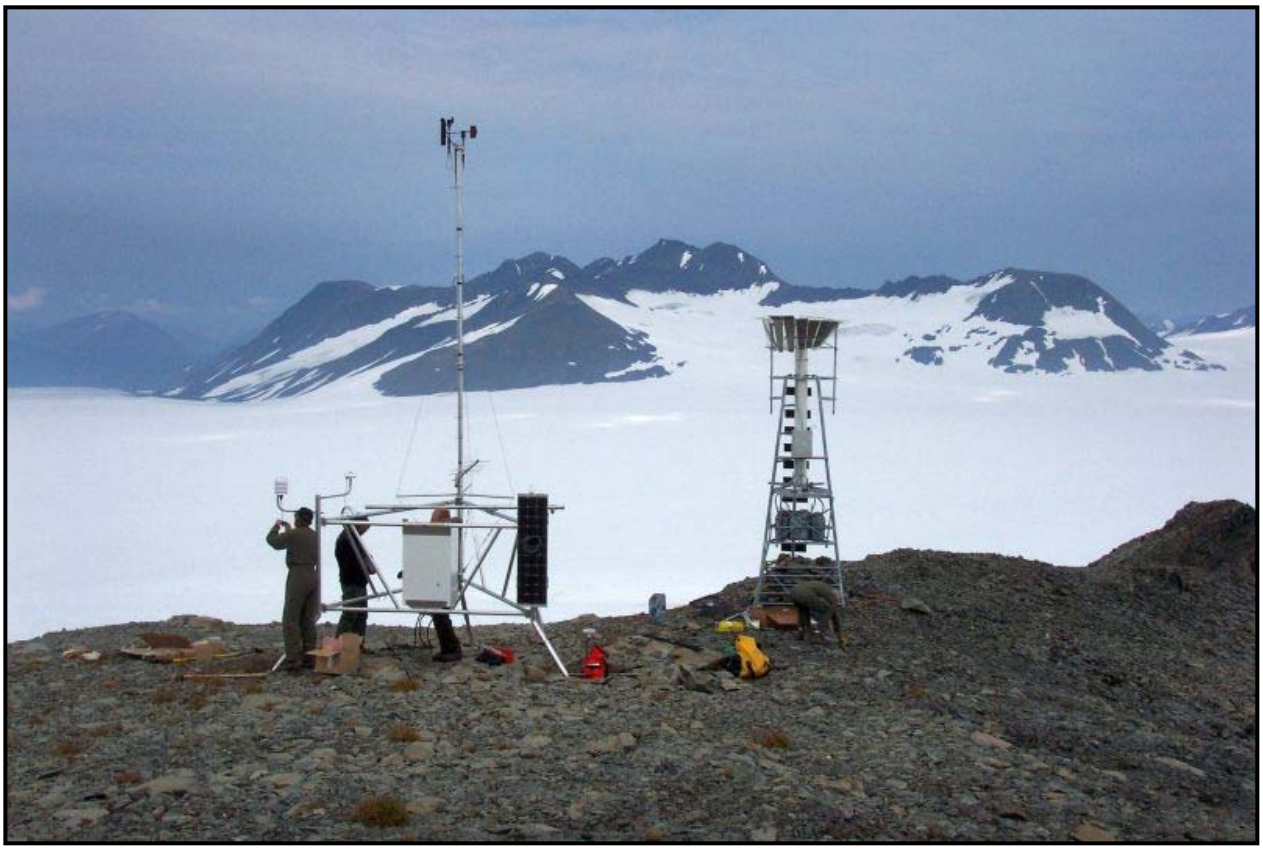
National Park Service
U.S. Department of the Interior

Kenai Fjords National Park
Seward, Alaska

Annual Climate Summary for 2006 – 2007

Kenai Fjords National Park

Chuck Lindsay
National Park Service
Southwest Alaska Network
PO Box 1727
Seward, AK 99664



The Remote Automated Weather Station (RAWS) on the Harding Icefield. This station was installed in 2004 through a cooperative effort between the Southwest Alaska Network (Inventory & Monitoring Program) and Kenai Fjords National Park. NPS photograph, Doug Capra, 2005.

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SUMMARY

This report briefly discusses the climatic setting of Kenai Fjords National Park and summarizes weather observations for 2006-2007 from three weather and climate monitoring stations that document a range of climatic environments in or near Kenai Fjords National Park (Harding Icefield, Nuka Glacier, and Seward Airport). Kenai Fjords National Park is characterized by a strongly maritime climate. Seasonal changes in the local climate are primarily driven by changes in sun angle incidence, length of day, and the position of the Aleutian Low storm track. Large-scale oscillations in the ocean-atmosphere system (e.g. El Niño Southern Oscillation and Pacific Decadal Oscillation) also influence the local climate although their effects are not yet well understood. Global temperatures for 2007 were significantly warmer-than-average (global land surface temperatures were the warmest on record and global ocean temperatures were the 9th warmest on record). Alaska experienced the 15th warmest year on record and witnessed the smallest extent of Arctic sea ice since the late 1970s. A weak El Niño event developed between September, 2006 and January, 2007. La Niña conditions developed in September, 2007. A positive (warm) phase Pacific Decadal Oscillation has been in place for much of the last three decades although there is evidence to suggest that a shift to a negative (cool) phase is underway. During the 2007 water year (October 2006 to September 2007), the following observations were documented at weather and climate monitoring stations located in or near Kenai Fjords National Park. Average annual temperatures ranged from 24.3 °F on the Harding Icefield to 38.2 °F at Seward. Total annual precipitation ranged from 50.8 inches at Seward to 83.9 inches at Nuka Glacier. A maximum sustained wind gust of 105.1 mph was documented on the Harding Icefield. A significant weather event during this timeframe was the "Columbus Day Storm of 2006" when a strong low-pressure system fueled by an intense jet stream affected the greater area encompassing Kenai Fjords National Park with record-breaking rainfall and high winds.

GLOBAL AND REGIONAL CLIMATE SYNOPSIS

A recent report published by the National Climatic Data Center (NOAA, 2008) summarizes both the local and global climate as significantly warmer-than-average. The average temperature for the contiguous United States during 2007 was 54.2°F (the 20th century average is 52.8°F) placing 2007 as the 10th warmest year for the contiguous United States. Global land surface temperatures were the warmest on record and the global ocean temperature was the 9th warmest since records began in 1880. Collectively, these observations place 2007 as the 5th warmest year during the period of record. For Alaska, 2007 was the 15th warmest year since statewide record collection began in 1918. The anomalous warming in the high latitudes of the Northern Hemisphere contributed to the lowest extent of Arctic sea ice since the late 1970s when satellite observations began.

Northern Gulf Coast of Alaska Climate Characterization

The climate of the Northern Gulf of Alaska is strongly maritime. Relatively mild temperatures (Figures 1 and 2) and high amounts of precipitation (Figure 3) are characteristic of this region. The interaction between the maritime climate and the rugged topography of the Kenai-Chugach mountain ranges results in orographic uplift and high precipitation on the windward (south) side of the mountains with significantly less precipitation occurring on the leeward (north) side of the mountains (Figure 3).

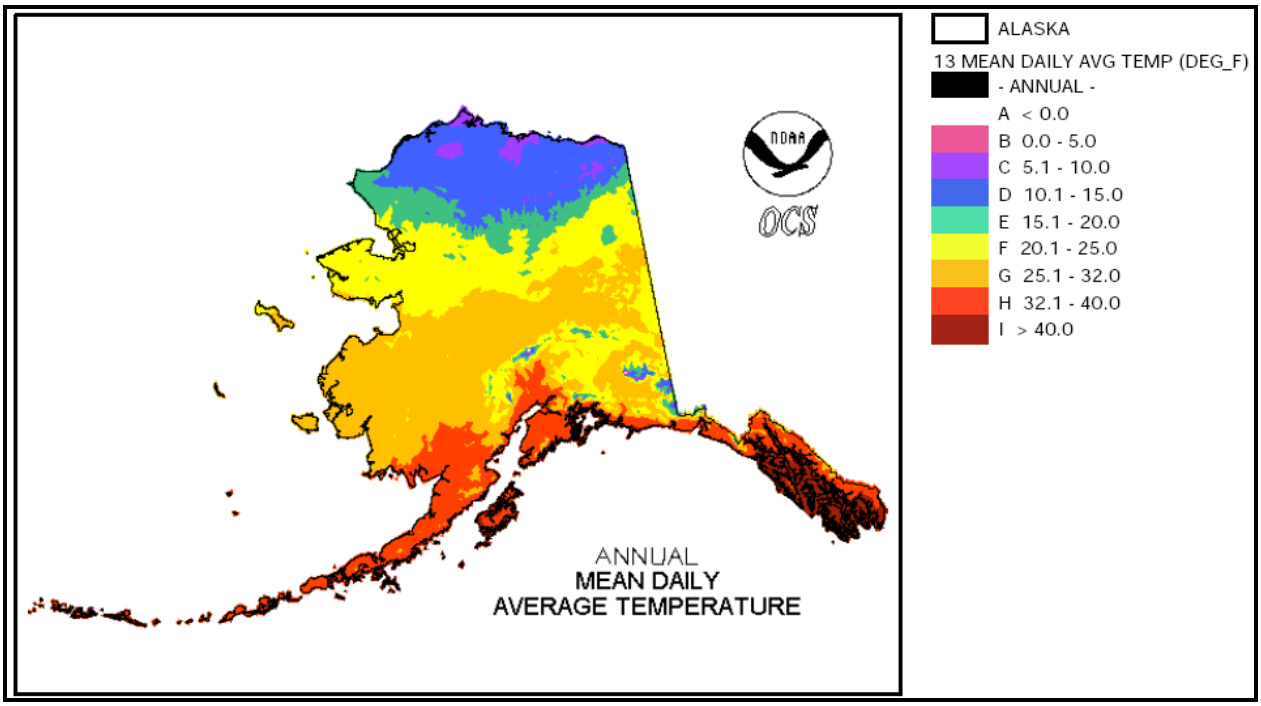

Figure1. Annual mean daily average temperatures for Alaska. (Figure is from the National Climatic Data Center, NOAA)

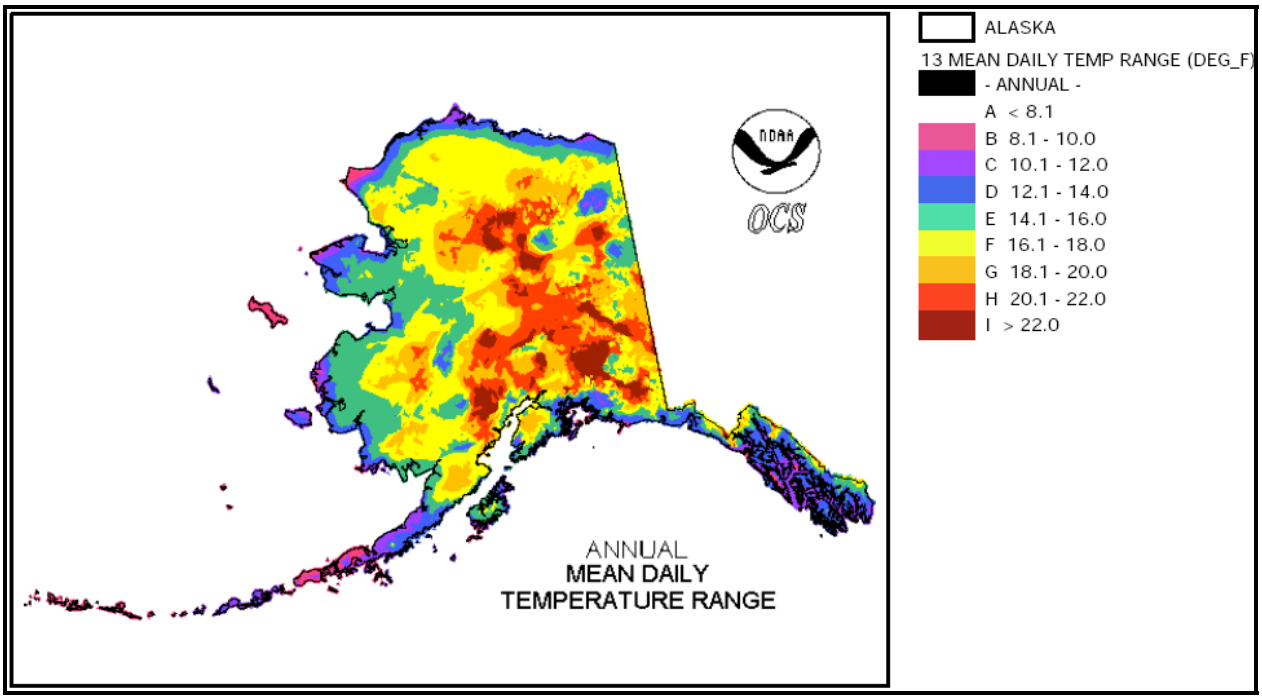

Figure 2. Annual mean daily temperature range for Alaska. (Figure is from the National Climatic Data Center, NOAA)

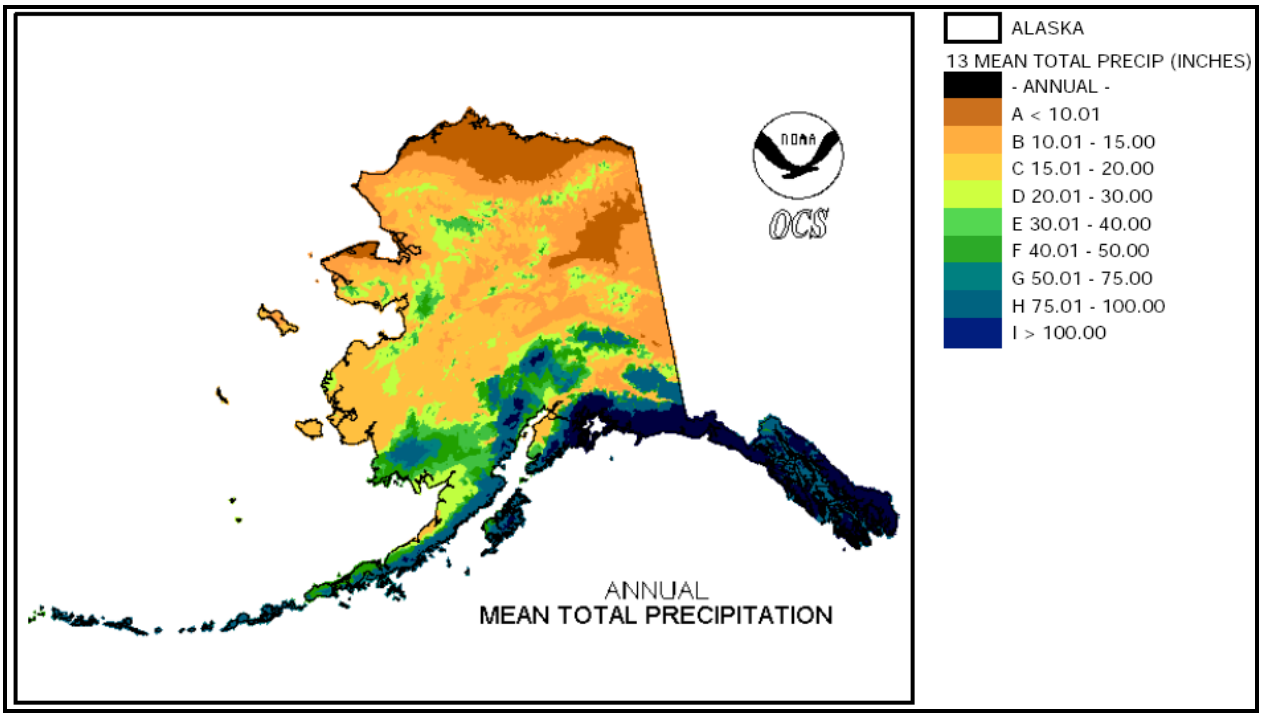

Figure3. Annual mean total precipitation for Alaska. (Figure is from the National Climatic Data Center, NOAA)

Position of the Aleutian Low and Changing Storm Tracks

The Aleutian Low storm track is the predominant climate driver during most of the year (Davey and others, 2007). This semipermanent low pressure center is located near the Aleutian Islands. Most intense in winter, the Aleutian Low is characterized by many strong cyclones. Traveling cyclones formed in the subpolar latitudes in the North Pacific usually slow down and reach maximum intensity in the area of the Aleutian Low. These cyclonic winter storms typically track southeast to northwest before impacting the Northern Gulf of Alaska coast (Figure 4). In summer, the Arctic High retreats, the location of low pressure systems shifts, and the storms track from west to east (Figure 5). This shift in storm pattern partially explains the seasonal decrease in precipitation that occurs in Seward in June and July (Davey and others, 2007).

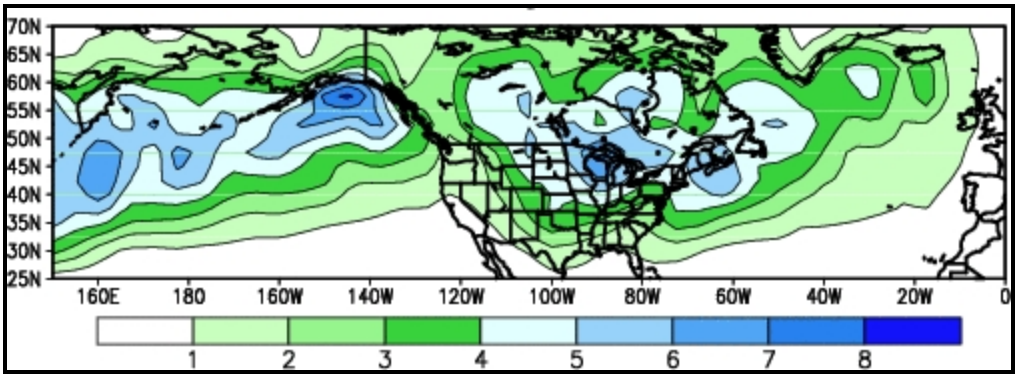

Figure 4. Average storm frequency in the northern hemisphere during fall (October – December). The total number of storms is illustrated using different colors – blue represents the greatest frequency. Storms must last for at least 24 hours to be counted. Note the winter loci of storm intensity that is focused in the Northern Gulf of Alaska. During winter months storms in the Northern Gulf of Alaska track from southeast to northwest. (Figure is from the National Weather Service Climate Prediction Center, NOAA)

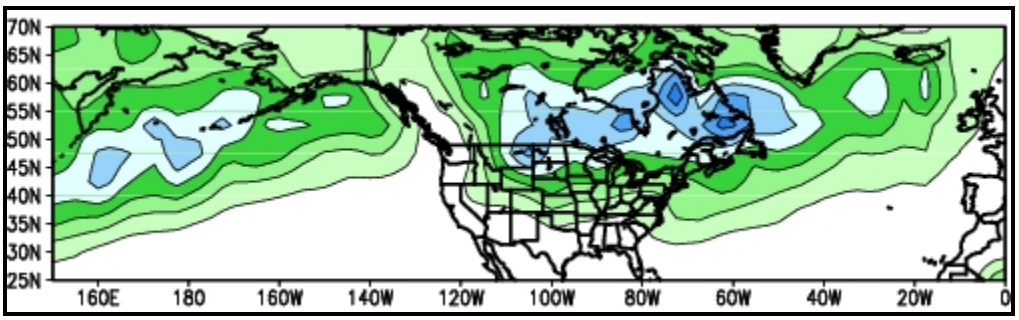

Figure 5. Average storm frequency in the northern hemisphere during summer (July – September). The total number of storms is illustrated using different colors – blue represents the greatest frequency (legend same as Figure 4). Storms must last for at least 24 hours to be counted. The loci of storm intensity that was focused in the Northern Gulf of Alaska in winter months has diminished and shifted to the west. During summer months storms in the Northern Gulf of Alaska typically track from west to east. (Figure is from the National Weather Service Climate Prediction Center, NOAA)

El Niño – Southern Oscillation

The El Niño Southern Oscillation (ENSO) is an oscillation of the ocean-atmosphere system in the tropical Pacific that affects the strength and positioning of the Jet Stream with important consequences to weather conditions. During normal conditions, trade winds blow from the east across the tropical Pacific. These winds force warm surface water west across the Pacific. Resulting sea surface temperatures (SSTs) along the coast of South America are colder, due to upwelling of cold water. During El Niño (ENSO-warm) conditions, the trade winds relax and the upwelling of cold water along the coast of South America is not as strong, resulting in unusually warm ocean temperatures in the Equatorial Pacific. Alternatively, La Niña (ENSO-cold) conditions are characterized by unusually cold ocean temperatures in the Equatorial Pacific. Although the affect of the ENSO on Alaskan weather is not completely understood, the following observations have been made. El Niño (ENSO-warm) conditions typically result in warm temperature anomalies and increased precipitation across Alaska, while La Niña (ENSO-cold) conditions typically result in cold temperature anomalies and decreased precipitation across Alaska (Papineau, 2005).

A recent report published by the National Climatic Data Center (NOAA, 2008) summarizes El Niño Southern Oscillation (ENSO) conditions during 2006 and 2007. A weak El Niño (ENSO-warm) developed during September and October of 2006. This event peaked in December, 2006 and began to dissipate during January, 2007. Neutral ENSO conditions persisted through the Northern Hemisphere summer and then a cooling trend began in July and August, 2007. La Niña (ENSO-cold) conditions were in place during the Fall of 2007 (Figure 6).

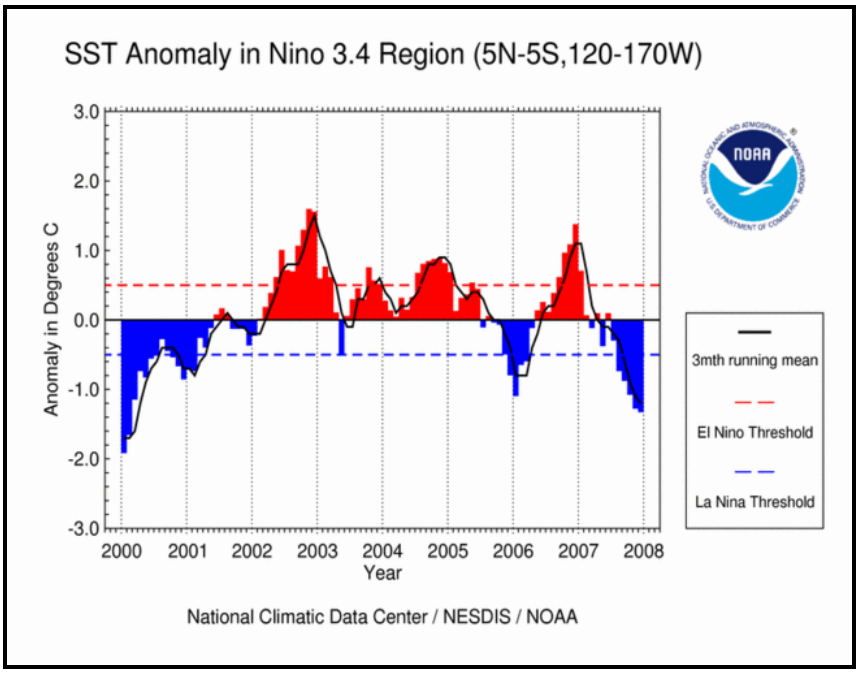

Figure 6. Sea surface temperature (SST) anomalies observed 2000-2007. Red color indicates El Niño (ENSO-warm) conditions and blue color indicates La Niña (ENSO-cold) conditions. (Figure is from the National Climatic Data Center, NOAA).

Pacific Decadal Oscillation (PDO)

The Pacific Decadal Oscillation (PDO) is an oscillation of northern Pacific sea surface temperatures (SSTs) with important consequences to weather conditions and northeast Pacific marine ecosystems. Although the PDO and the El Niño / Southern Oscillation (ENSO) are similar in nature, they exhibit very different long-term behaviors. PDO events persist for 20-30 years, while ENSO events persist for 6-18 months. Causes for the PDO are not currently well understood. Above normal northern Pacific SSTs are referred to as positive phase and below normal northern Pacific SSTs are referred to as negative phase. A warm (positive) phase has been in place from 1977 through at least the mid 1990s (Figure 8). Some climatologists believe that a PDO regime shift to a cool (negative) phase is currently underway.

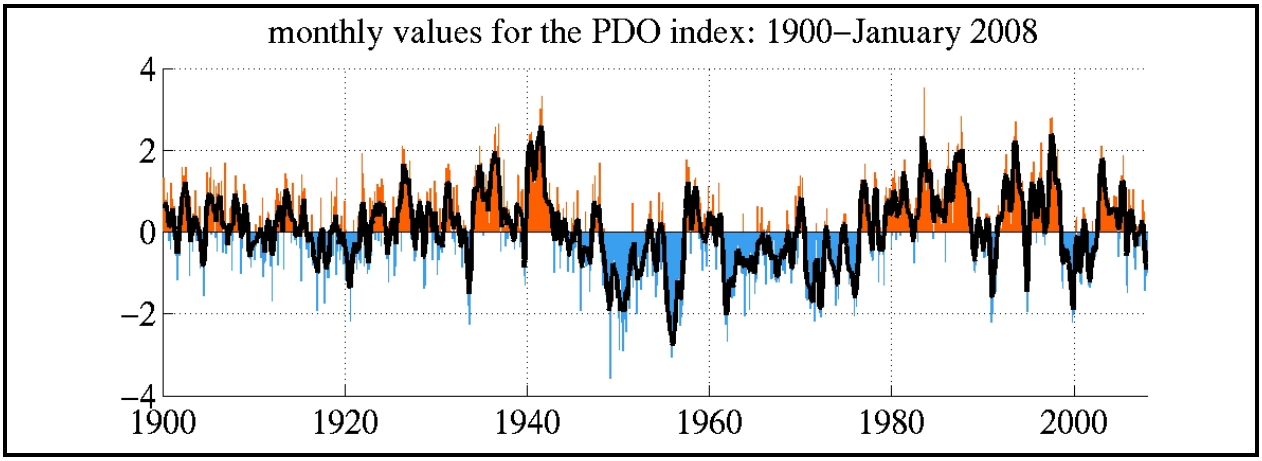

Figure 7. Time series of sea surface temperature-based monthly Pacific Decadal Oscillation index. Cool (negative) PDO regimes are shown in blue, while warm (positive) PDO regimes are shown in red. The vertical axis represents SST departure from normal. (Figure is from the University of Washington Joint Institute for the Study of the Atmosphere and Oceans).

CLIMATE AND WEATHER STATIONS

Location

Data from three climate and weather monitoring stations that characterize a wide range of physiographic environments and micro-climates on the eastern Kenai Peninsula are summarized in this report. These stations are located at the Seward Airport, Harding Icefield, and Nuka Glacier (Figure 8). Although limited, other climate and weather monitoring stations (e.g. Grouse Creek, Pilot Rock, etc.) are located on the eastern Kenai Peninsula; however, they are not included for discussion in this paper.

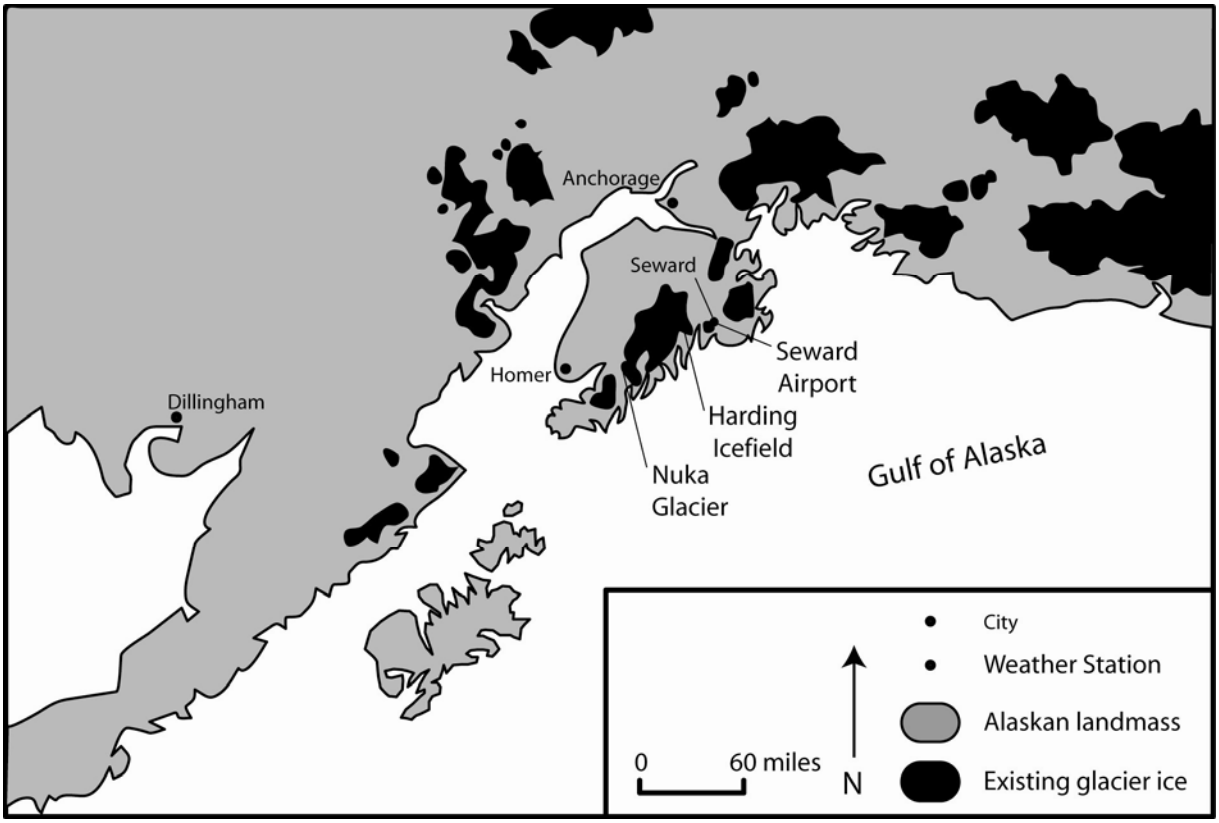

Figure 8. Location of the three weather stations discussed in this paper. (Figure modified from Reger and others, 2007).

Seward Airport

Weather observations have been documented at the Seward Airport since 1953. The current automated weather station is part of the National Weather Service (NWS) Surface Airways Observation (SAO) network. These stations are typically installed at major airports and military bases. Hourly meteorology elements are measured and include temperature, precipitation, humidity, wind, barometric pressure, sky cover, ceiling, visibility, and current weather. Current weather observations can be viewed at the National Weather Service's website (http://weather.noaa.gov/weather/current/PAWD.html). Data are archived by the National Climatic Data Center.

Harding Icefield

The Harding Icefield weather station is now in its fourth year of continuous operation. This remote automated weather station (RAWS) is located 7 miles southwest of the Exit Glacier Nature Center at a nunatak high on the Harding Icefield (4,200 feet elevation). This station was installed in 2004 by the National Park Service. The Harding Icefield weather station is part of the RAWS network that is administered by many land management agencies (the fire community is typically the primary client for RAWS data). Hourly meteorology elements are measured and include temperature, wind speed and direction, precipitation, snow depth, relative humidity, and solar radiation. This data is transmitted by satellite hourly, although many satellite transmissions fail due to antenna icing. Complete data sets are retrieved during annual weather station maintenance (therefore discussion of 2007 weather observations at the Harding Icefield weather station are limited to the time frame preceding September, 2007). Data are archived by the Western Region Climate Center (WRCC) and current weather observations and summary reports can be viewed at the Western Region Climate Center's website (http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?akAHAR).

Nuka Glacier

The Nuka Glacier Snowpack Telemetry (SNOTEL) is part of the Natural Resources Conservation Service (NRCS) Snowpack Telemetry network. This network was originally implemented to measure only daily precipitation and snow water content. Currently, the hourly meteorological elements that are measured include precipitation, temperature, snow depth, and snow water content. The Nuka Glacier SNOTEL site is located approximately 50 miles southwest of Seward - adjacent to the terminus of Nuka Glacier, approximately one mile north of the park boundary. The Nuka Glacier SNOTEL has been in operation since 1990. Data are archived by the NRCS and current weather observations and summary reports can be viewed at their website (http://www.wcc.nrcs.usda.gov/snotel/snotel.pl?sitenum=1037&state=ak).

Results

Seward Airport

During the 2007 water year (October 1, 2006 – September 30, 2007), the following weather observations were documented at the Seward Airport (Table 1). The average daily air temperature was 38.2 °F with a maximum average daily temperature of 78 °F recorded on August 11, 2007 and a minimum average daily temperature of -1 °F recorded on January 9, 2007 (average daily temperatures differ from individual hourly maximum and minimum observations). The average air temperature for 2006-2007 was 2.1 °F colder than the 30-year climatological normal (40.3 °F, 1971-2000; Figure 9). The most precipitation (rain and snow) fell during October and December, 2006 (Figure 10) with almost 5½ inches of rain falling on October 9, 2006 – during the "Columbus Day Storm". Cumulative precipitation for the 2007 water year was 50.8 inches, 29% less than the annual mean for the 30-year climatological normal (71.82 inches, 1971-2000).

Table 1. Summary of temperature and precipitation observations at the Seward Airport weather station (Oct. 1, 2006 to Sept. 30, 2007). High and low temperatures represent daily reported values and are different from individual hourly observations. Data are from the National Climate Data Center.

Seward Airport Weather Station	°F / inches	Date
Temperature		
2006-2007 Daily high	78	8/11/2007
2006-2007 Daily low	-1	1/9/2007
2006-2007 Average	38.2	Daily
Precipitation		
2006-2007 Daily maximum	5.32	10/9/2006
2006-2007 Cumulative	50.78	Yearly

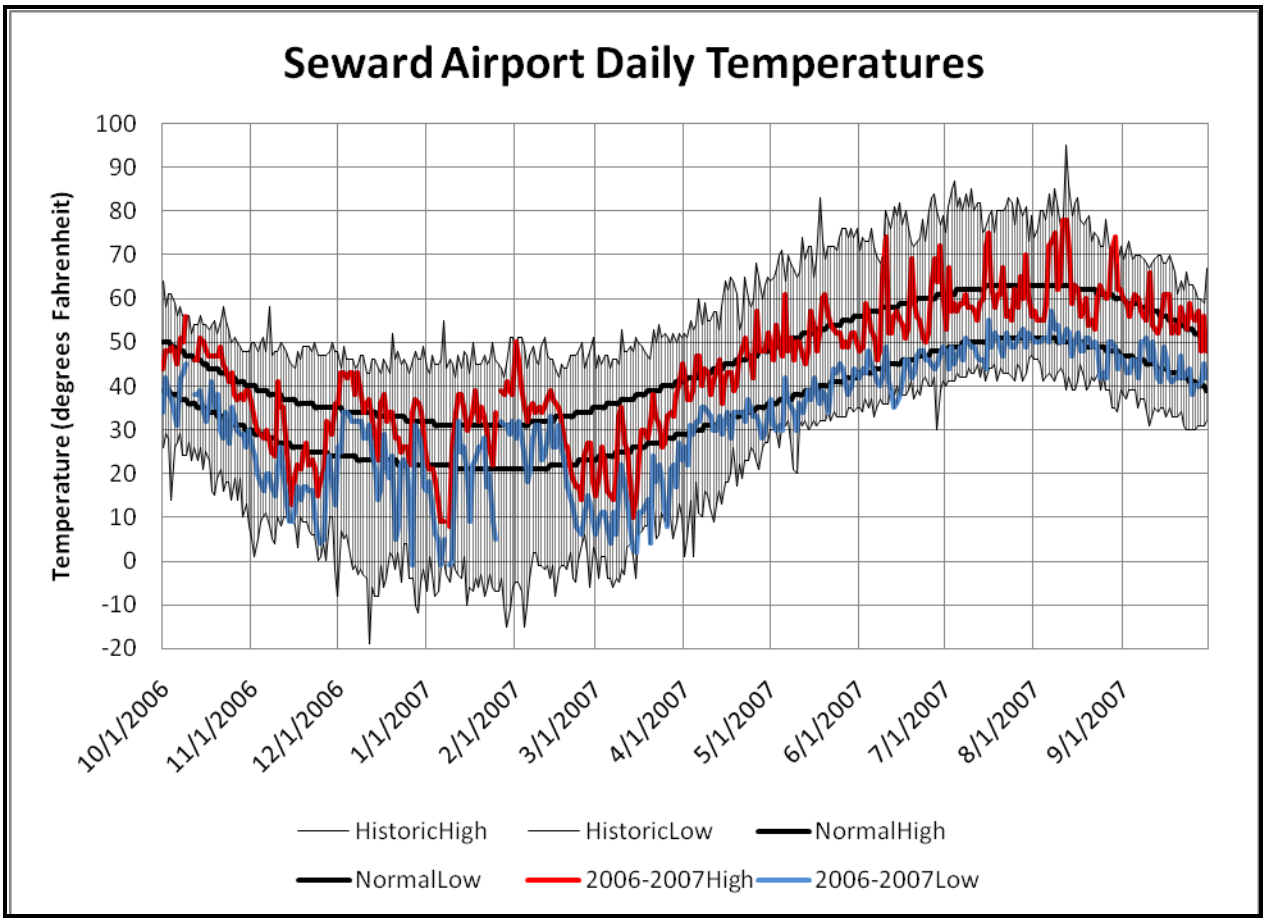

Figure 9. Daily high and low temperatures at the Seward Airport. Observed daily high and low temperatures from 2006-2007 are plotted with red and blue thick lines. The normal high and low temperatures (adjusted average value 1971-2000) are shown with thick black lines. Historic (1949-2007) high and low temperatures are plotted with thin black lines. The shaded area illustrates the historic range of observed temperatures. Data are from the National Climate Data Center.

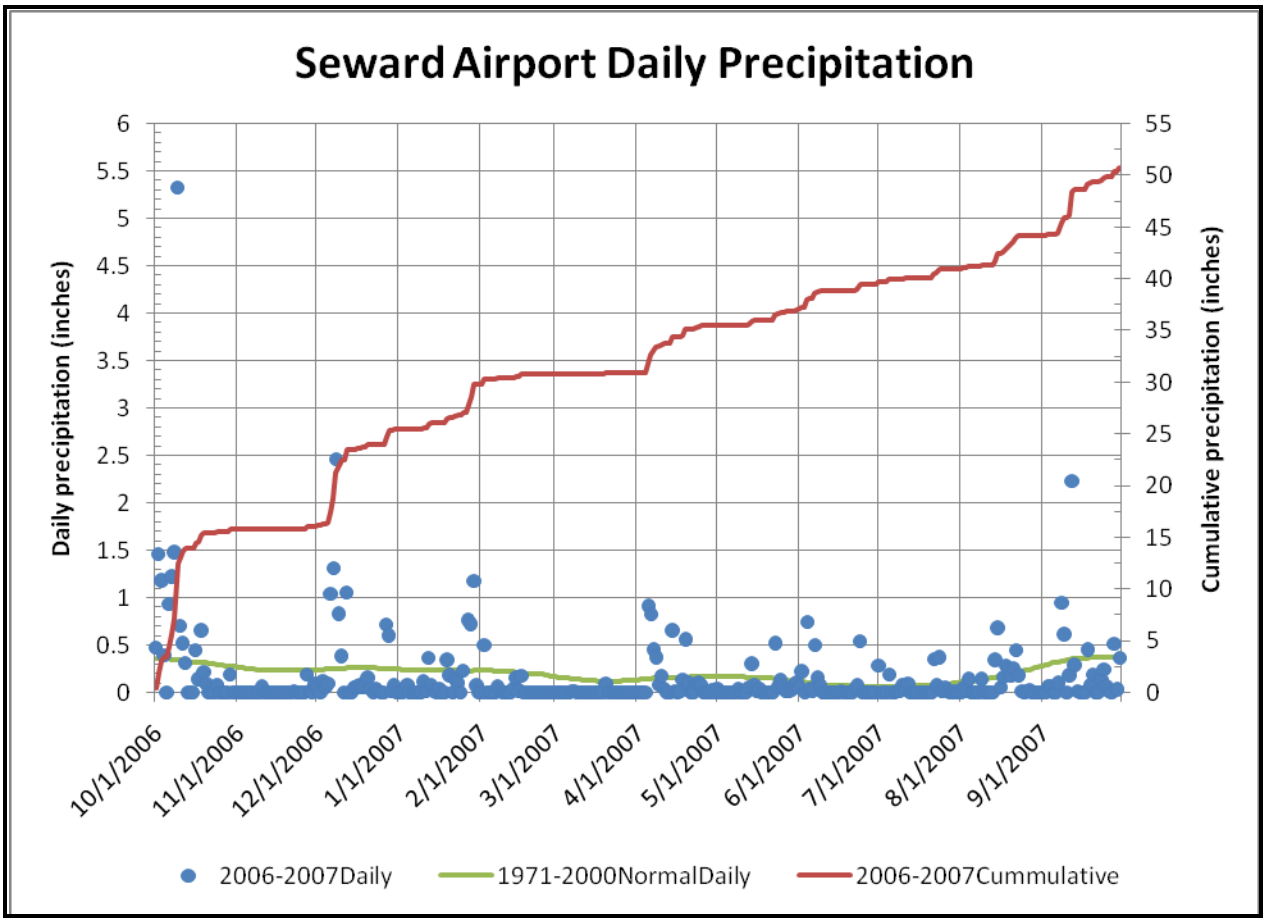

Figure 10. Daily precipitation at the Seward Airport. Measured daily precipitation (2006-2007) is plotted with blue points. Cumulative daily precipitation (2006-2007) is plotted with a red line. Normal daily precipitation (adjusted average value 1971-2000) is plotted with a green line. Data are from the National Climate Data Center.

Harding Icefield

During the 2007 water year (October 1, 2006 – September 30, 2007), the following weather observations were documented at the Harding Icefield weather station (Table 2). The average air temperature was 24.3 °F with a maximum temperature of 68.2 °F recorded on June 21, 2007 and a minimum temperature of -21.4 °F recorded on March 14, 2007 (Figure 11). During this time period, the average wind speed was 10.3 mph. A sustained (1-minute) wind gust of 105.1 mph was measured on October 9, 2006 – during the "Columbus Day Storm" when a strong low-pressure system fueled by an intense jet stream affected the North Gulf Coast of Alaska with record-breaking rainfall and high winds. Overall, winds at the weather station either blew from the southeast (50% of the time) or the northwest (31% of the time) (Figure 12) reflecting the predominant regional trends (winds generated by storm systems in the Gulf of Alaska or gap winds resulting from high-pressure systems in interior Alaska). Although 32.9 inches of precipitation was recorded, accurate measurement of winter-time precipitation on the Harding Icefield is problematic. The weather station was deliberately placed at a windy site so that snow would not accumulate and completely bury the station. The relatively short (3 year) period of record for this weather station does not allow for comparison to a long-term climatological normal.

Table 2. Summary of temperature and wind observations at the Harding Icefield weather station (Oct. 1, 2006 to Sept. 30, 2007). High and low temperatures represent maximum and minimum hourly observations. Wind directions represent normalized hourly observations (NE=0-90°, SE=91-180°, SW=181-270°, NW=271-360°). Maximum gust represents the wind speed for the maximum one-minute sustained gust. Data are from the Western Regional Climate Center.

Harding Icefield Weather Station	**°F / % / mph**	**Date**
Temperature (°F)		
2006-2007 Hourly high	68.2	6/21/2007
2006-2007 Hourly low	-21.4	3/14/2007
2006-2007 Average	24.3	Daily
Wind Direction (%)		
NE	7	Yearly
SE	50	Yearly
SW	12	Yearly
NW	31	Yearly
Wind Speed (mph)		
2006-2007 Average windspeed	10.3	Yearly
2006-2007 Maximum gust	105.1	10/9/2006

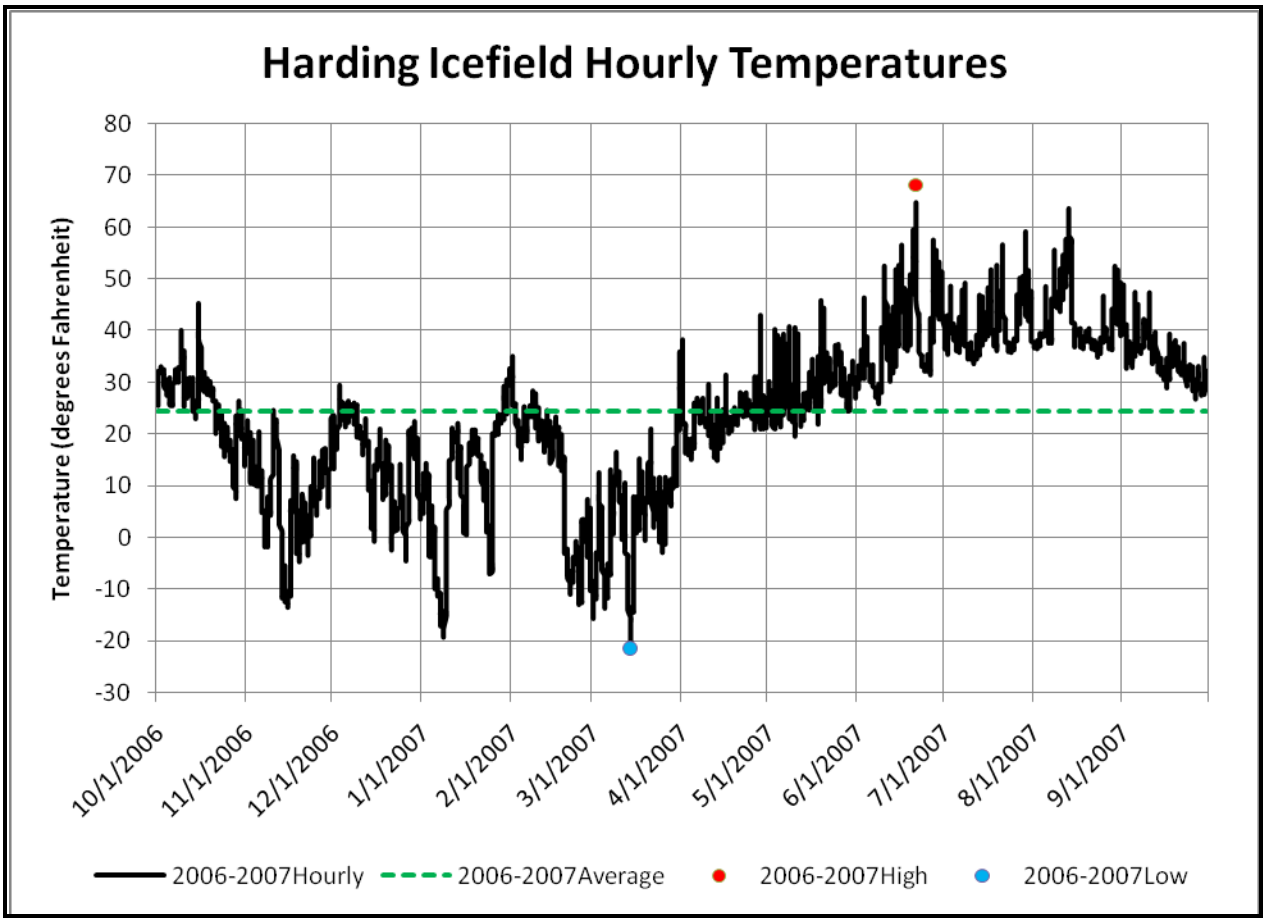

Figure 11. Temperatures at the Harding Icefield weather station for 2006-2007. Average hourly temperatures from 2006-2007 are plotted with a black line. The annual average temperature for 2006-2007 is plotted with a dashed green line. The hourly maximum high and minimum low temperatures for 2006-2007 are plotted with red and blue points. Data are from the Western Regional Climate Center.

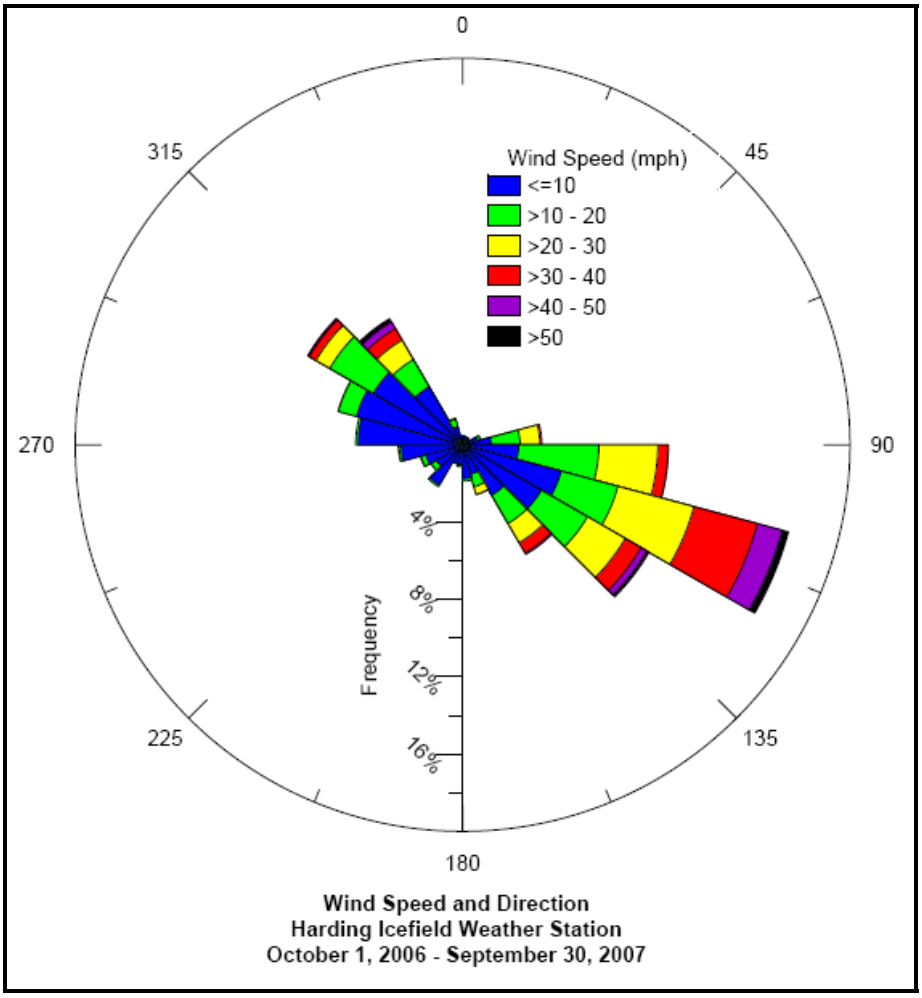

Figure 12. Wind speed and direction at the Harding Icefield weather station for 2006-2007. The wind rose is divided into 16 wind directions. Each wind direction is divided into wind speeds using 10 mph breaks. As the percent of time the wind blows from a particular directions gets larger, the portion of the bar representing that wind speed gets larger both in length and width. Data are from the Western Regional Climate Center.

Nuka Glacier

During the 2007 water year (October 1, 2006 – September 30, 2007), the following weather observations were documented at the Nuka Glacier SNOTEL (Table 3). The average daily air temperature was 33.8 °F with a maximum average daily temperature of 76 °F recorded on June 21, 2007 and a minimum average daily temperature of -21.2 °F recorded on March 16, 2007 (Figure 13). The most precipitation (rain and snow) fell during October and December, 2006 with over 7½ inches of rain falling on October 9, 2006 – during the "Columbus Day Storm" (Figure 14). Cumulative precipitation for the 2007 water year was 83.9 inches, 10% less than the annual mean for the 16-year period of record (93.1 inches, 1991-1997).

Table 3. Summary of temperature and precipitation observations at the Nuka Glacier SNOTEL (Oct. 1, 2006 to Sept. 30, 2007). High and low temperatures represent daily average reported values and are different from individual hourly observations. Data are from the Natural Resources Conservation Service.

Nuka Glacier SNOTEL	°F / inches	Date
Temperature		
2006-2007 Daily high	76	6/21/2007
2006-2007 Daily low	-21.2	3/16/2007
2006-2007 Average	33.8	Daily
Precipitation		
2006-2007 Daily maximum	7.6	10/9/2006
2006-2007 Cumulative	83.9	Yearly

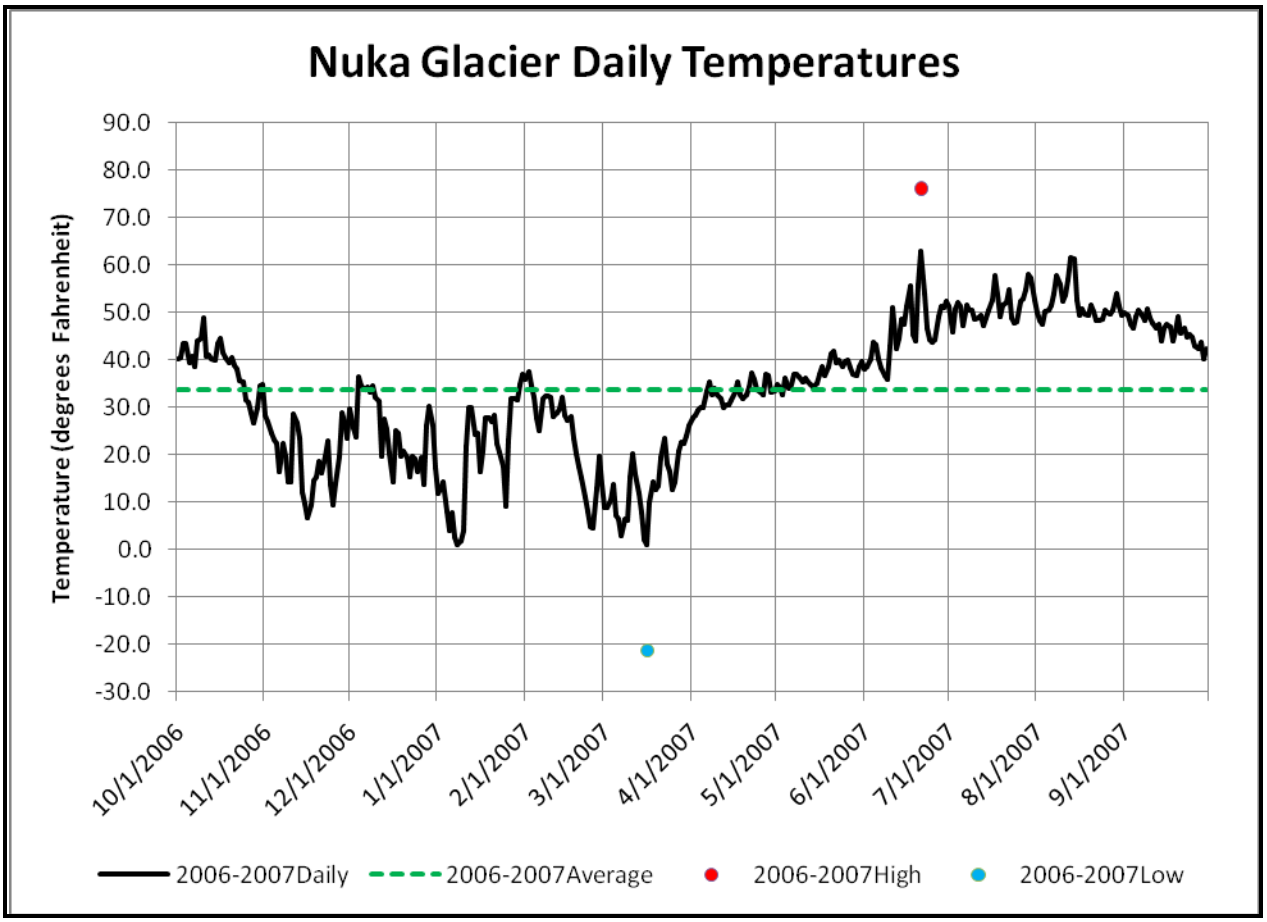

Figure 13. Temperatures at the Nuka Glacier SNOTEL for 2006-2007. Average daily temperatures from 2006-2007 are plotted with a black line. The annual average temperature for 2006-2007 is plotted with a dashed green line. The daily maximum high and minimum low temperatures for 2006-2007 are plotted with red and blue points. Data are from the Natural Resources Conservation Service.

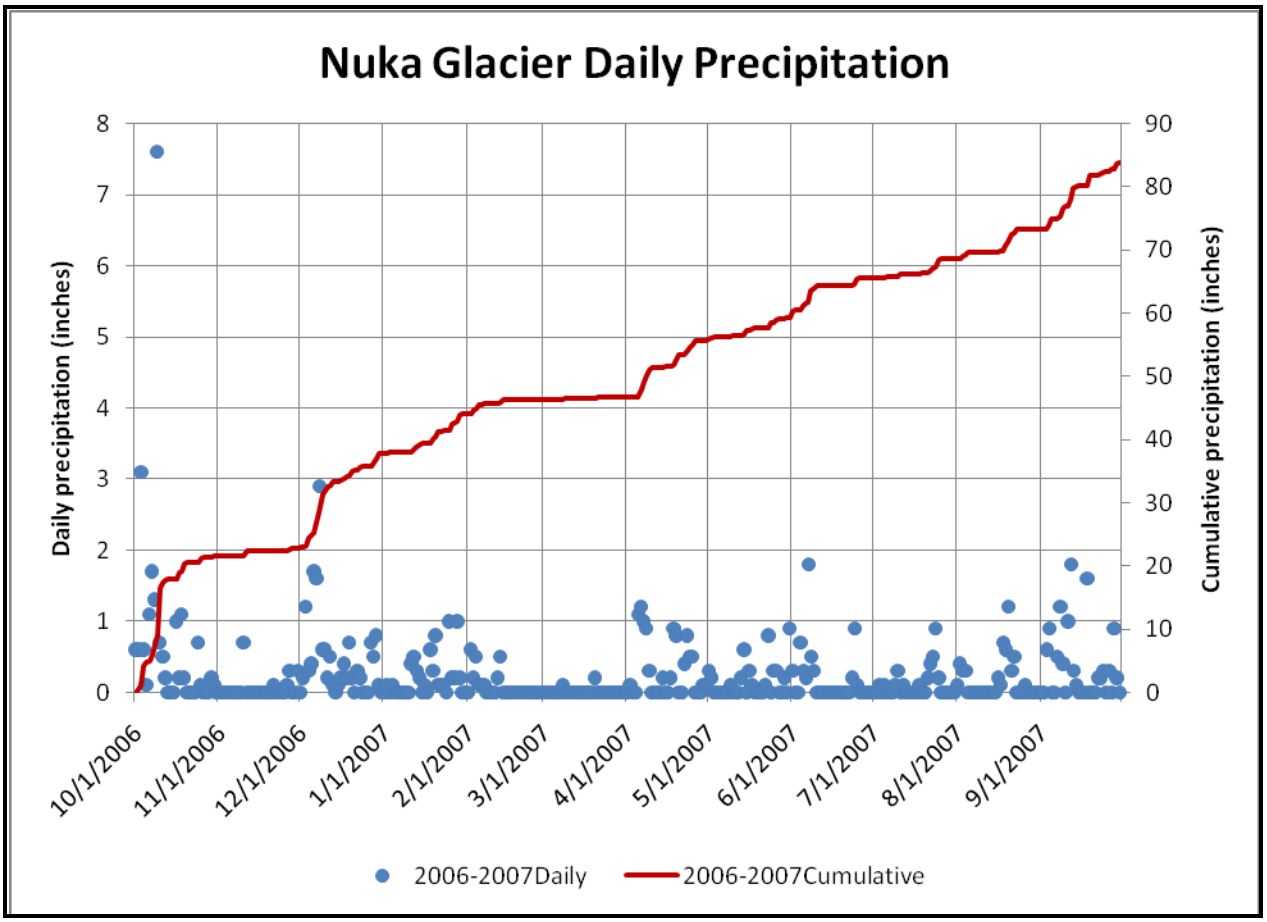

Figure 14. Daily precipitation at the Nuka Glacier SNOTEL. Measured daily precipitation (2006-2007) is plotted with blue points. Cumulative daily precipitation (2006-2007) is plotted with a red line. Data are from the Natural Resources Conservation Service.

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