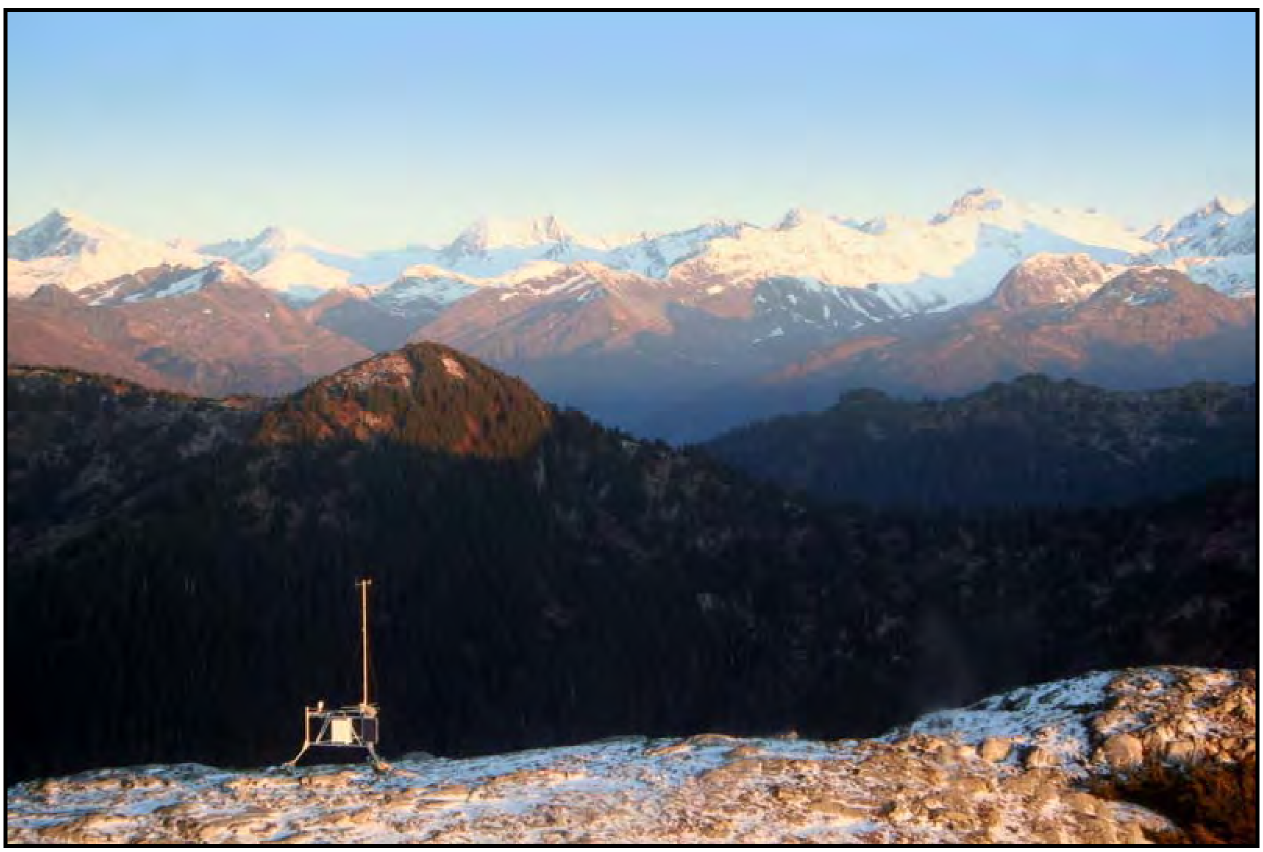
National Park Service
U.S. Department of the Interior

Kenai Fjords National Park
Seward, Alaska

Annual Climate Summary for 2007 – 2008

Kenai Fjords National Park



The Remote Automated Weather Station (RAWS) at McArthur Pass. This station was installed in 2008 through a cooperative effort between the Southwest Alaska Network (Inventory & Monitoring Program) and Kenai Fjords National Park. NPS photograph, 2008.

Annual Climate Summary for 2007 – 2008

Kenai Fjords National Park

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U.S. Department of the Interior
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Seward, Alaska

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SUMMARY

This report briefly discusses the climatic setting of Kenai Fjords National Park and summarizes weather observations for 2007-2008 from four climate monitoring stations that document a range of climatic environments in or near Kenai Fjords National Park (Exit Glacier, Harding Icefield, Nuka Glacier, and Seward Airport). Field activities are reviewed, including the installation of a new station at McArthur Pass, and management recommendations identified. 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, length of day, and the position of the Aleutian Low storm track. Spatial changes in the local climate are primarily driven by elevation and proximity to the coast. 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 2008 were significantly warmer than average. The combined global land and ocean surface temperature ranks 2008 as the eighth warmest year since 1880. The average temperature for the contiguous United States was close to the 20th century average. Most of Alaska experienced colder than average temperatures during 2008. A weak La Niña event that developed in fall of 2007 dissipated and the El Niño/Southern Oscillation was in a neutral phase for much of 2008. 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 2007-2008 water year (October 1, 2007 to September 30, 2008), the climate local to Kenai Fjords National Park was colder than average with weather stations located at the Harding Icefield, Nuka Glacier, and Seward Airport reporting cooler than average temperatures (average temperature at Exit Glacier is not calculated). Annual precipitation at these stations was close to average, with the exception of above average precipitation at Exit Glacier. Colder than average temperatures resulted in more precipitation in the form of snow than rain during winter months, and the above-average snowpack persisted longer than usual at higher elevations.

GLOBAL, REGIONAL, AND LOCAL CLIMATE SYNOPSIS

A recent report published by the National Climatic Data Center (NOAA, 2009) characterizes the global climate for 2008 as significantly warmer than average[1], with the exception of cooler than average conditions across parts of Alaska, central Canada, and the east Pacific Ocean. The warmest above average temperatures occurred throughout the high latitude regions of Europe and Asia (Figure 1). Overall, global land surface temperatures were the 6th warmest on record and the global ocean surface temperature was the 10th warmest since 1880. Collectively, these observations rank 2008 as the 8th warmest year during the period of record. Of note, eight of the ten warmest years on record have occurred since 2001. In contrast, the average temperature for the contiguous United States during 2008 was the coolest in more than ten years. The 2008 average temperature of 53.0 °F was only slightly above the 20th century average of 52.8 °F. Most of Alaska experienced colder than average temperatures during 2008, with the notable exception of the North Slope. Annual temperatures across the state averaged 0.7 °F below normal[2]. Winter temperatures (2007-2008) were near average, spring was warmer (+ 1.0 °F) than average, summer was cooler (- 1.0 °F) than average, and fall was significantly cooler (-2.0 °F) than the 1971-2000 average. Of note, arctic sea ice reached its second lowest melt season extent on record in September. During early September, and for the first time in history, both the Northwest Passage and the Northern Sea Route were navigable. During the 2007-2008 water year (October 1, 2007 to September 30, 2008), the climate for Seward, gateway community to Kenai Fjords National Park, was colder than normal with near normal precipitation.

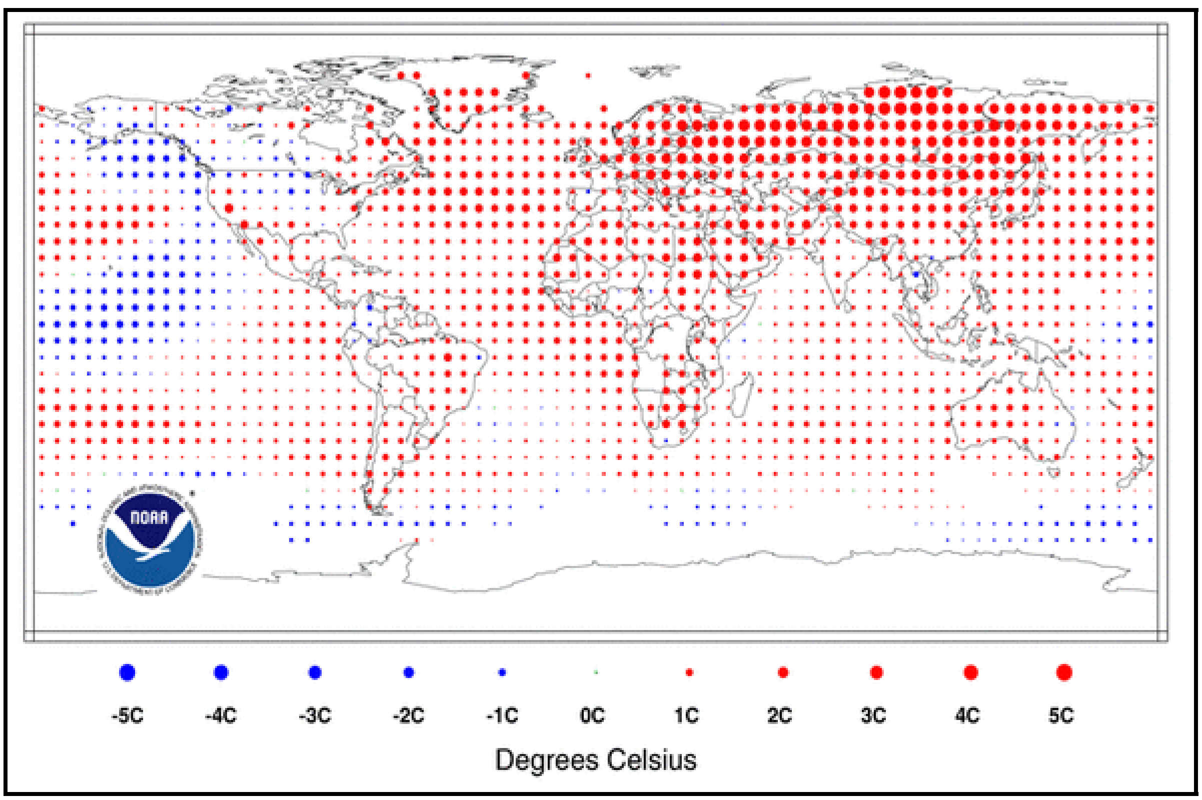

Figure 1. Combined global land and sea surface temperatures anomalies for 2008. Map was generated using data from more than 7,000 stations. Red and blue colors indicate warm and cold temperature anomalies (departure from normal) relative to 1961-1990. (Figure is from the National Climatic Data Center).

Kenai Fjords Climate Characterization

The climate of Kenai Fjords National Park and the Northern Gulf Coast of Alaska is strongly maritime. Relatively mild temperatures and high amounts of precipitation are characteristic of this region. Mean annual temperatures for the region are close to freezing at higher elevations in the Kenai mountain range and warmer in coastal areas (Figure 2). The interaction between the maritime climate and the rugged topography of the Kenai mountain range 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). For example, mean annual precipitation in Seward (windward side) is 72 inches, while the mean annual precipitation in Cooper Landing (leeward side) is only 22 inches.

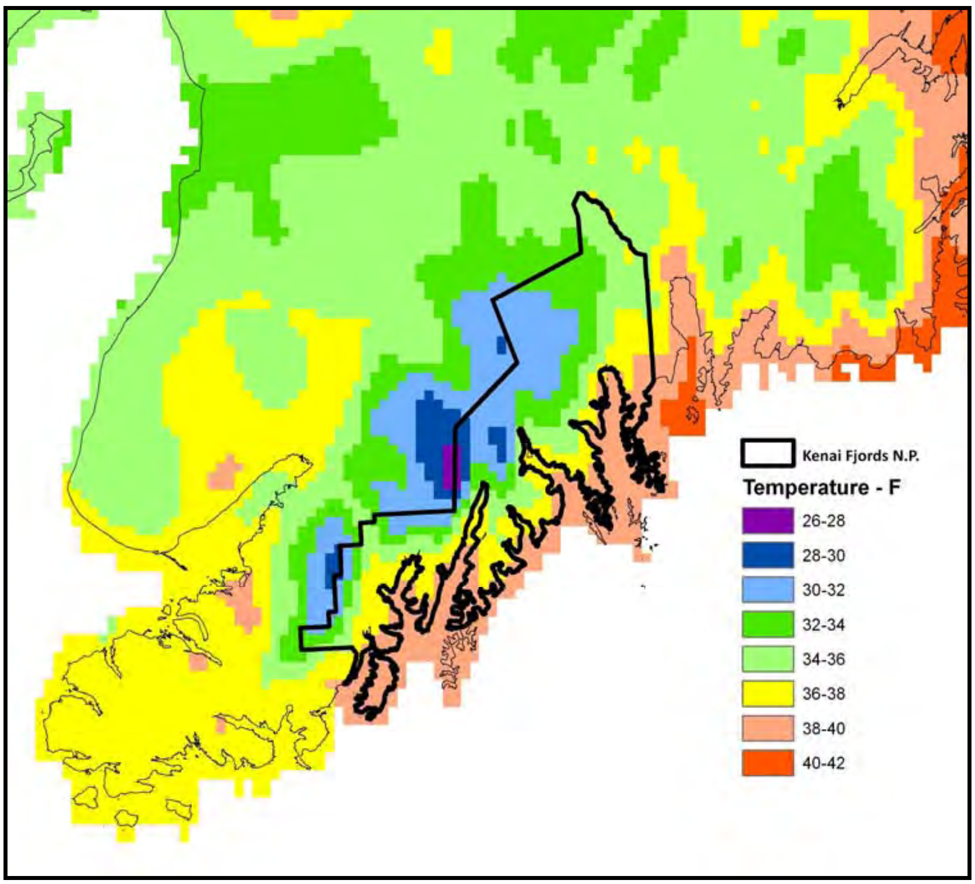

Figure 2. Mean annual temperature (°F) for southern Kenai Peninsula and Kenai Fjords National Park. Figure derived using Parameter Regression on Independent Slopes Model (PRISM) data set based on the 1961-1990 period of record. The PRISM model combines weather station observations and known climate patterns and processes with elevation, slope, and aspect information in order to produce a spatial climate model (PRISM Group, Oregon State University).

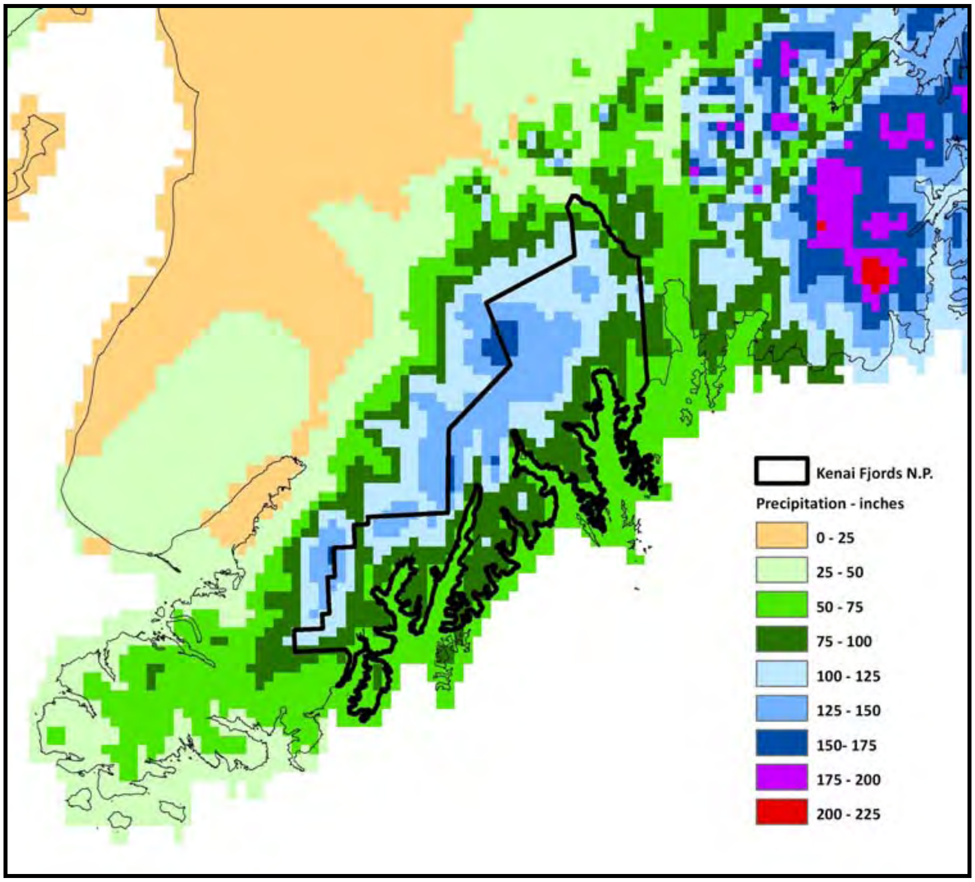

Figure 3. Mean annual precipitation (inches) for southern Kenai Peninsula and Kenai Fjords National Park. Figure derived using PRISM data set based on the 1961-1990 period of record.

Position of the Aleutian Low and Changing Storm Tracks

The Aleutian Low storm track is the predominant climate driver in this region during most of the year (Davey and others, 2007). This semi-permanent low pressure center is located near the Aleutian Islands. Most intense in winter, the Aleutian Low is characterized by many strong cyclones (large-scale circulations of winds around a central region of low atmospheric pressure, rotating counter-clockwise in the Northern Hemisphere). 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).

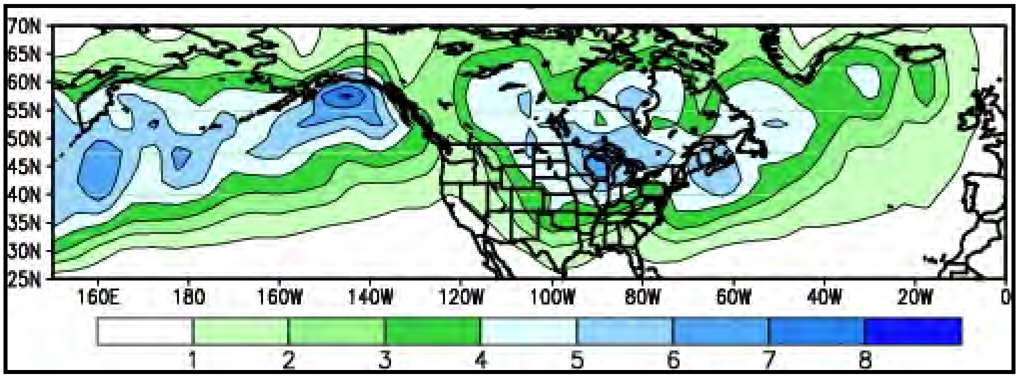

Figure 4. Average storm frequency in the northern hemisphere during fall (October – December). The total number of storms is illustrated using different colors – blue represents the greatest frequency. Storms must last for at least 24 hours to be counted. Note the winter loci of storm intensity that 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)

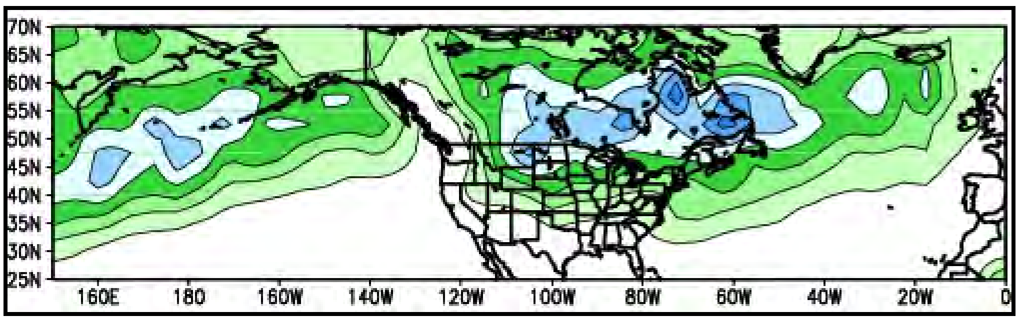

Figure 5. Average storm frequency in the northern hemisphere during summer (July – September). The total number of storms is illustrated using different colors – blue represents the greatest frequency (legend same as Figure 4). Storms must last for at least 24 hours to be counted. The loci of storm intensity 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 (Figure 6). Although the effect of the ENSO on Alaskan weather is not completely understood, the following general observations can be made. El Niño (ENSO-warm) conditions typically result in warmer winter temperatures and increased precipitation across southern Alaska, while La Niña (ENSO-cold) conditions typically result in colder winter temperatures and decreased precipitation (Papineau, 2005; WRCC).

A recent report published by the National Climatic Data Center (NOAA, 2009) summarizes El Niño Southern Oscillation (ENSO) conditions during 2007 and 2008. La Niña (ENSO-cold) conditions developed during September of 2007. This event peaked in February 2008 (Figure 6) and began to dissipate during March. Neutral ENSO conditions were in place by June and persisted through the Northern Hemisphere summer and fall.

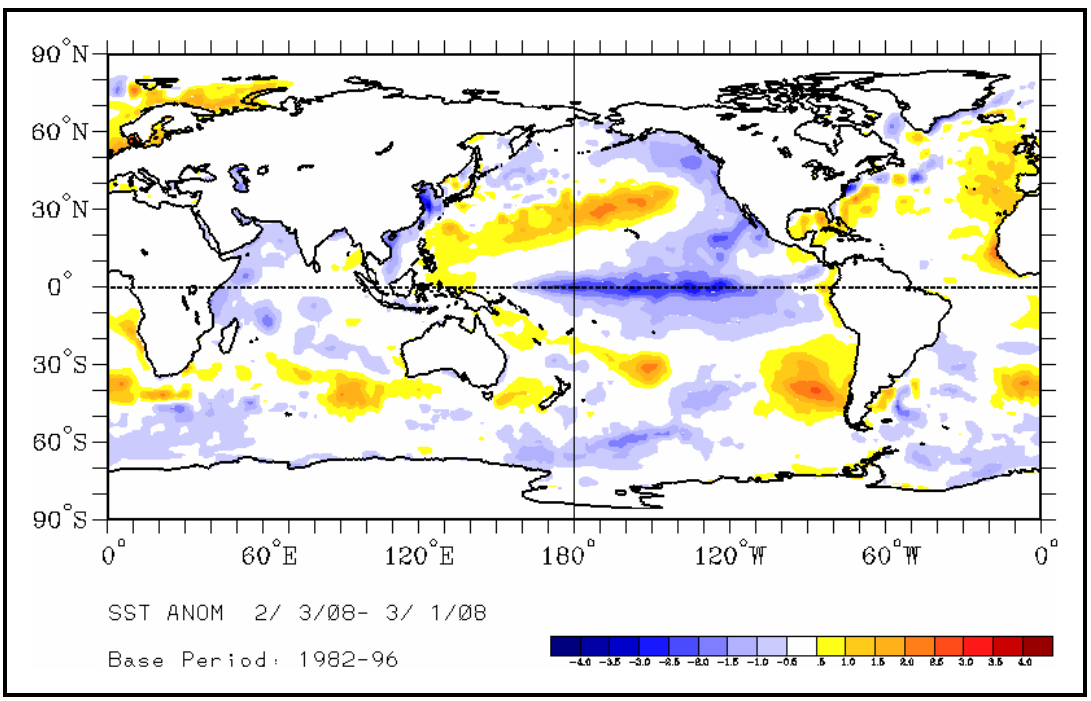

Figure 6. Sea surface temperature (SST) anomalies observed during February 2008 at the peak of the La Niña event. Red and blue colors indicate warm and cold SST anomalies respectively. SST anomalies in the equatorial Pacific region are used to calculate ENSO conditions (Figure is from the National Climatic 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 7). Some climatologists believe that a PDO regime shift to a cool (negative) phase is currently underway.

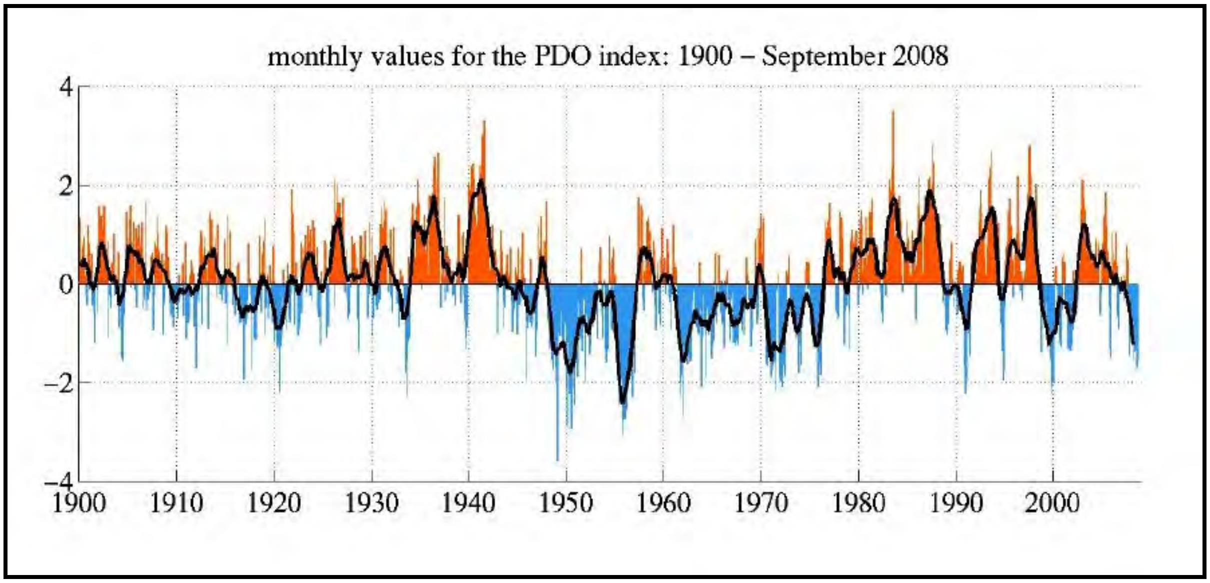

Figure 7. Time series of sea surface temperature-based monthly Pacific Decadal Oscillation index. Cool (negative) PDO regimes are shown in blue, while warm (positive) PDO regimes are shown in red. The vertical axis represents SST departure from normal. (Figure is from the University of Washington Joint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

Beginning in the winter of 1976-1977, Alaska experienced a dramatic shift in climate marked by significant increases in winter and spring temperatures, when compared to the previous 25 years (Figure 8). This shift is now recognized to have coincided with the 1977 shift in phase of the Pacific Decadal Oscillation (Hartman and Wendler, 2005). An explanation for this shift is that warm sea surface temperatures in the northern Pacific direct warm air flow into Alaska during winter, resulting in above average temperatures.

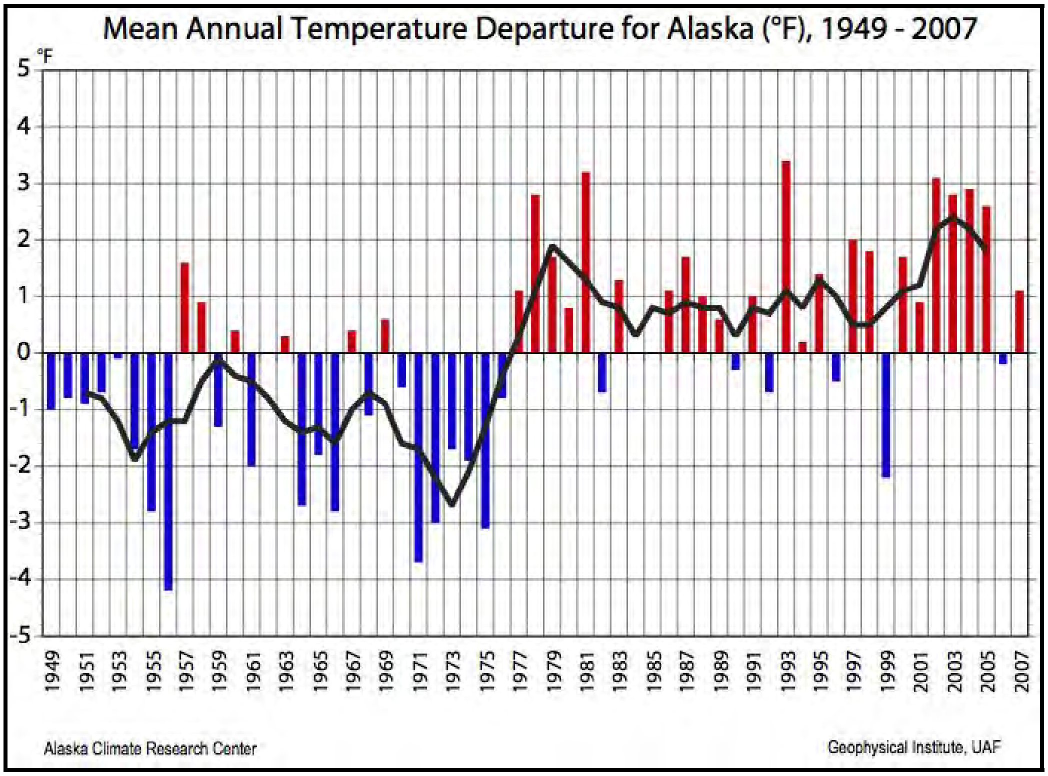

Figure 8. Annual temperature departure from the long-term average (1949-2007) for 19 first-order weather stations in Alaska. Red and blue colors indicate warmer-than-average and colder-than-average annual temperatures. The thick black line represents a five-year moving average. The shift in 1976 corresponds to the transition of the Pacific Decadal Oscillation from a negative (cold) to a positive (warm) phase. (Figure is from the University of Alaska Climate Research Center).

CLIMATE AND WEATHER STATIONS

Location and Station Description

Data from four 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 Exit Glacier, Seward Airport, Harding Icefield, and Nuka Glacier (Figure 9). A new weather station was installed at McArthur Pass in June, 2008; however the short period of data collection combined with damage to the station in early September precludes including data in this report. Although limited in number, other climate and weather monitoring stations (e.g. Pilot Rock) are located nearby; however, they are not included for discussion in this report.

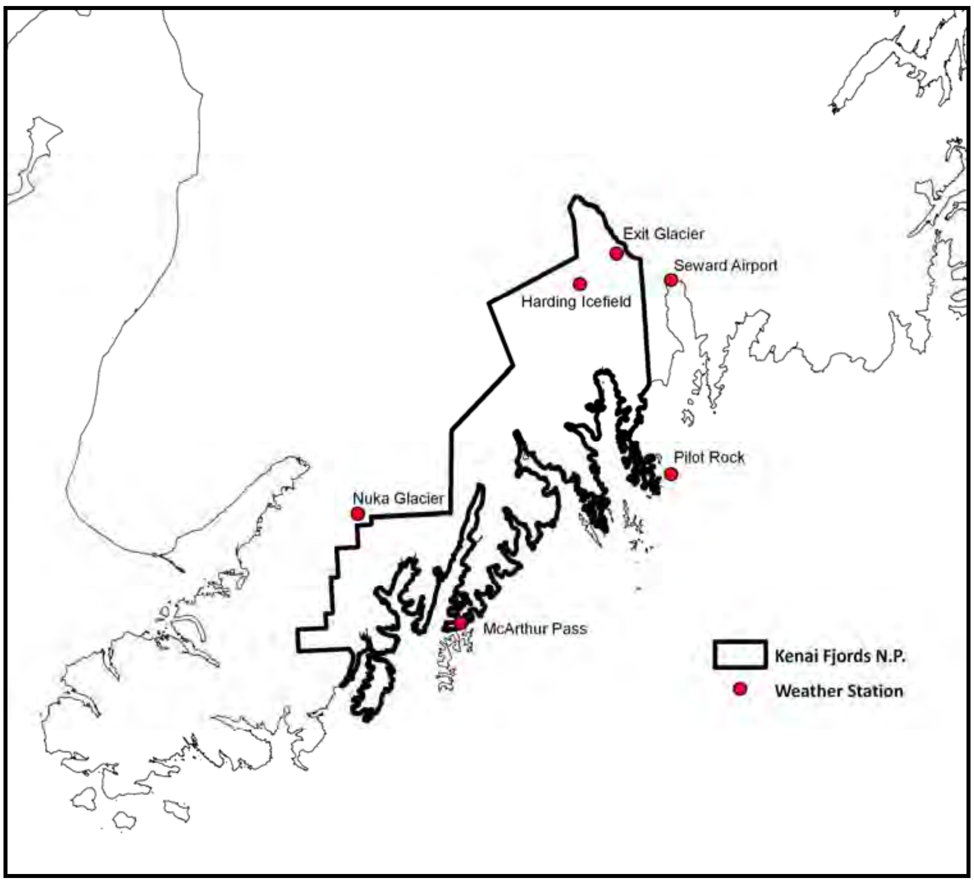

Figure 9. Locations of weather stations discussed in this paper.

Exit Glacier

The Exit Glacier weather station has been in operation since 1983. This Cooperative Observer Program (COOP) station (COOP station 508375) is the longest running weather station within the boundaries of the park and is located adjacent to the Exit Glacier Ranger Station (500 feet elevation). Daily measurements are recorded manually, typically by interpretive staff during summer months, by volunteer caretakers during winter months, with operations coordinated by park Resource Management staff. Temperature (maximum, minimum, and current) and precipitation (liquid and solid), and snow depth are recorded at approximately 5:00pm each day. There is no backup system in place if a day is missed. Each month, data sheets are submitted to the National Weather Service office in Anchorage. Complete data sets are made available by the National Weather Service and the National Climatic Data Center. Summary reports can be viewed at the Western Regional Climate Center's website (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ak8375).

Harding Icefield

The Harding Icefield weather station is now in its fifth 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 (liquid and solid), 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. Data are archived by the Western Regional Climate Center (WRCC) and current weather observations and summary reports can be viewed at the Western Regional Climate Center's website (http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?akAHAR).

McArthur Pass

The McArthur Pass weather station was deployed in June, 2008 by the National Park Service. This remote automated weather station (RAWS) is located on the Kenai Fjords coast approximately 60 miles southwest of Seward on a ridge (1,300 feet elevation) immediately north of McArthur Pass (north of Ragged Island). The McArthur Pass weather station is identical in design to the Harding Icefield station except it does not incorporate an all-season precipitation gauge. Therefore, this station records only liquid precipitation and the data does not accurately reflect frozen precipitation (e.g. snow, hail). Data are archived by the Western Regional Climate Center (WRCC) and current weather observations and summary reports can be viewed at the Western Regional Climate Center's website (http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?akAMCA).

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 on state land. 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).

Seward Airport

Weather observations have been documented at Seward since 1931 (COOP Station 508371, starting 1949). The current automated weather station at the Seward Airport is part of the National Weather Service (NWS) Surface Airways Observation (SAO) network (WBAN Station 26438, starting 1953). 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 (NCDC).

Results and Discussion

Exit Glacier

During the 2008 water year (October 1, 2007 – September 30, 2008), the following weather observations were documented at the Exit Glacier weather station (Tables 1-3, Figures 10-14). A maximum temperature of 74 °F was observed on July 15, 2008 and a minimum temperature of -25 °F was observed on February 4, 2008. Interestingly, this minimum temperature was more than 10 °F colder than the minimum temperature observed at the Harding Icefield weather station (almost 4,000 feet higher in elevation) documented one day later (-13.5 °F on February 5, 2008). This was likely due to a regional temperature inversion, whose effects were moderated by elevation on the Harding Icefield and by the maritime influence in Seward (0 °F on February 4, 2008). Cumulative precipitation (a minimum estimate) at Exit Glacier for the 2008 water year was 88.4 inches, 132% of the annual average precipitation for the 1983-2000 period of record (67.0 inches, 1983-2000, NCDC). Colder temperatures allowed for more snowfall than rain during winter months and the resulting above-average snowpack persisted longer than usual at higher elevations. Snow cover on Exit Glacier also persisted late into the summer season with the firn line (annual snow line) observed at 2,800 (± 30) ft on September 21, 2008. Gaps in data collection (Figure 10) do not permit calculation of an annual average temperature for 2008 because the calculated average would be biased (and warmer) due to missing data during winter and spring. One reason for these gaps was the absence of observations during April and May. After the departure of the winter caretaker, recommencement of daily weather observations was delayed until May 30, 2008 because of access issues due to the persistent snowpack.

*Table 1. Summary of weather observations at the Exit Glacier weather station (Oct. 1, 2007 to Sept. 30, 2008. *Unavailable parameter (see text for more detail). **Published climatological normal (reported by NCDC as 1971-2000, although calculated from an incomplete record [1983-2000]). Data are from the NPS and NCDC.*

Exit Glacier Weather Station	Value	Date
Average Temperature	- - *	Oct 1, 2007 – Sep 30, 2008
Period of Record Average Temperature	35.7** °F	1971-2000 (1983-2000)
Maximum Temperature	74 °F	Jul 15, 2008
Minimum Temperature	-25 °F	Feb 4, 2008
Cumulative Precipitation	88.4 in	Oct 1, 2007 – Sep 30, 2008
Period of Record Average Precipitation	67.0** in	1971-2000 (1983-2000)

*Table 2. Summary of monthly temperatures (°F) at the Exit Glacier weather station (Oct. 1, 2007 to Sept. 30, 2008). *Data from month with five or fewer observations. 30YR Average is NCDC's published climatological normal for period 1971-2000, using station data from 1983-2000. Data are from the NPS and NCDC.*

Exit Glacier Weather Station - Temperature												
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Maximum	54	46	39	38	38	39	49*	66*	71	74	71	60
Minimum	11	7	-11	-18	-25	5	-8*	22*	31	31	31	21
30YR Average	35.3	23.3	18.7	15.7	20.3	27.3	35.8	43.8	51.5	56.0	54.1	46.7

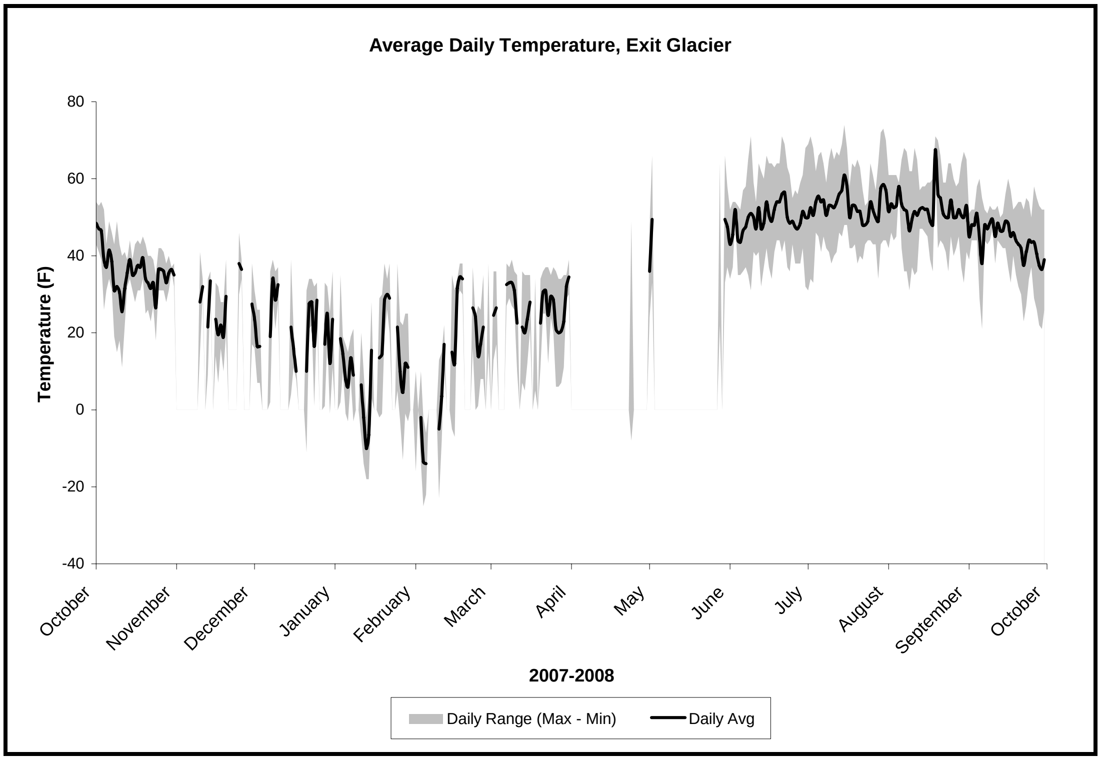

Figure 10. Daily high, low, and average temperatures (°F) for the 2007-2008 WY at the Exit Glacier weather station. Data are from the NPS.

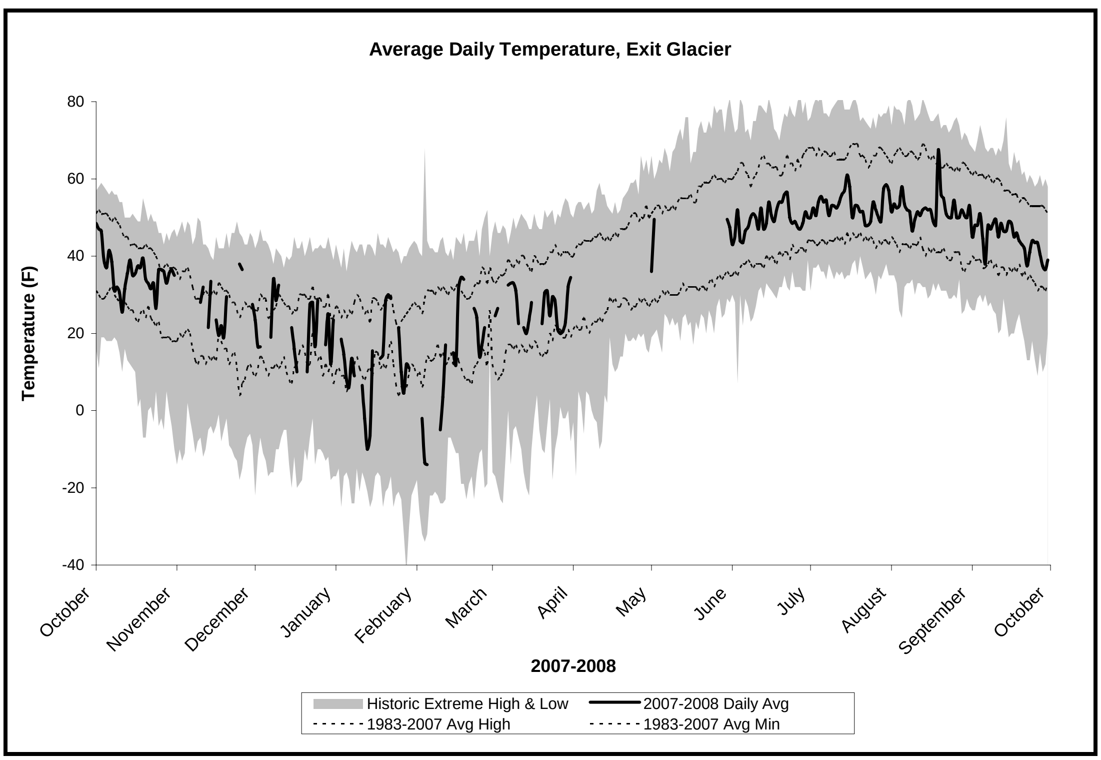

Figure 11. Record high and low temperatures, 25-year average high and low temperatures, and average daily temperatures (°F) for the 2007-2008 WY at the Exit Glacier weather station. Data are from the NPS and WRCC.

*Table 3. Summary of monthly precipitation (in) at the Exit Glacier weather station (Oct. 1, 2007 to Sept. 30, 2008). *Data from month with five or fewer observations. 30YR Average is NCDC's published climatological normal for period 1971-2000, using station data from 1983-2000. Data are from the NPS and NCDC.*

Exit Glacier Weather Station - Precipitation

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Total	7.13	19.77	7.61	5.97	7.45	8.18	3.20*	3.96	2.79	3.95	1.60	16.79
30YR Average	9.64	5.84	7.29	6.27	5.03	4.76	4.43	3.56	2.52	2.58	6.05	9.01
Departure	-2.51	13.93	0.32	-0.3	2.42	3.42	- -	- -	0.27	1.37	-4.45	7.78

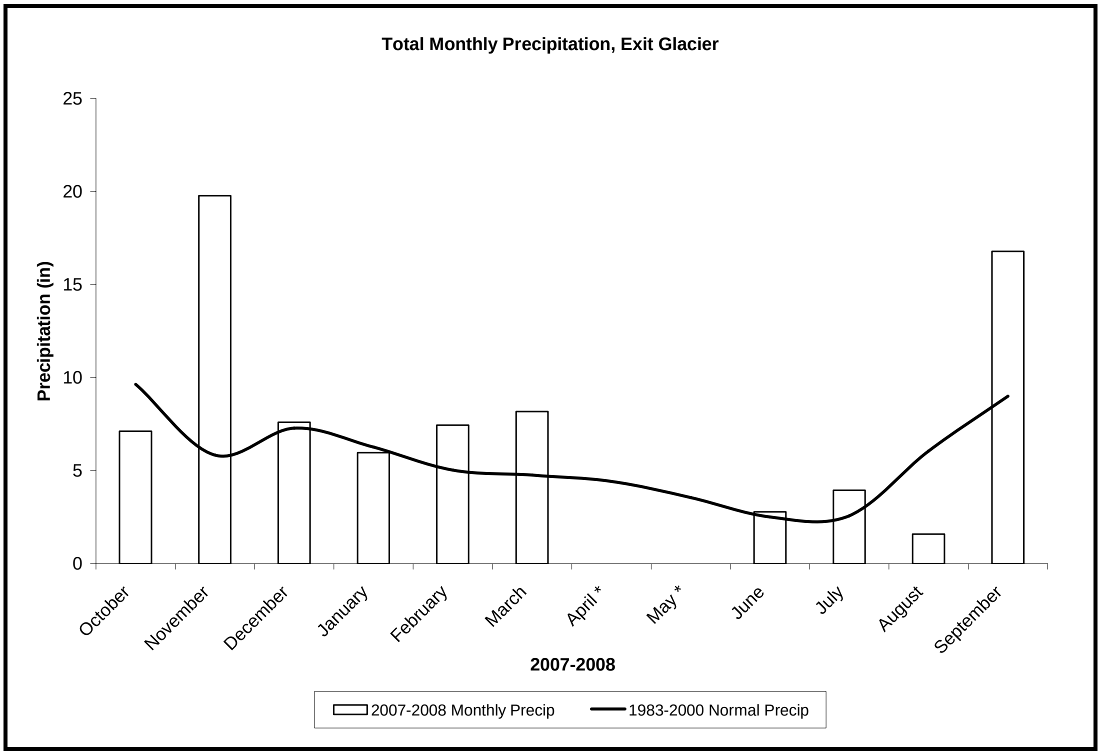

*Figure 12. Total monthly precipitation for the 2007-2008 WY and 1971-2000 normal monthly precipitation at the Exit Glacier weather station. (NCDC's published climatological normal is for the period 1971-2000, using station data from 1983-2000.) *Data are not plotted for months with five or fewer observations (April - May, 2008). Data are from the NPS and NCDC.*

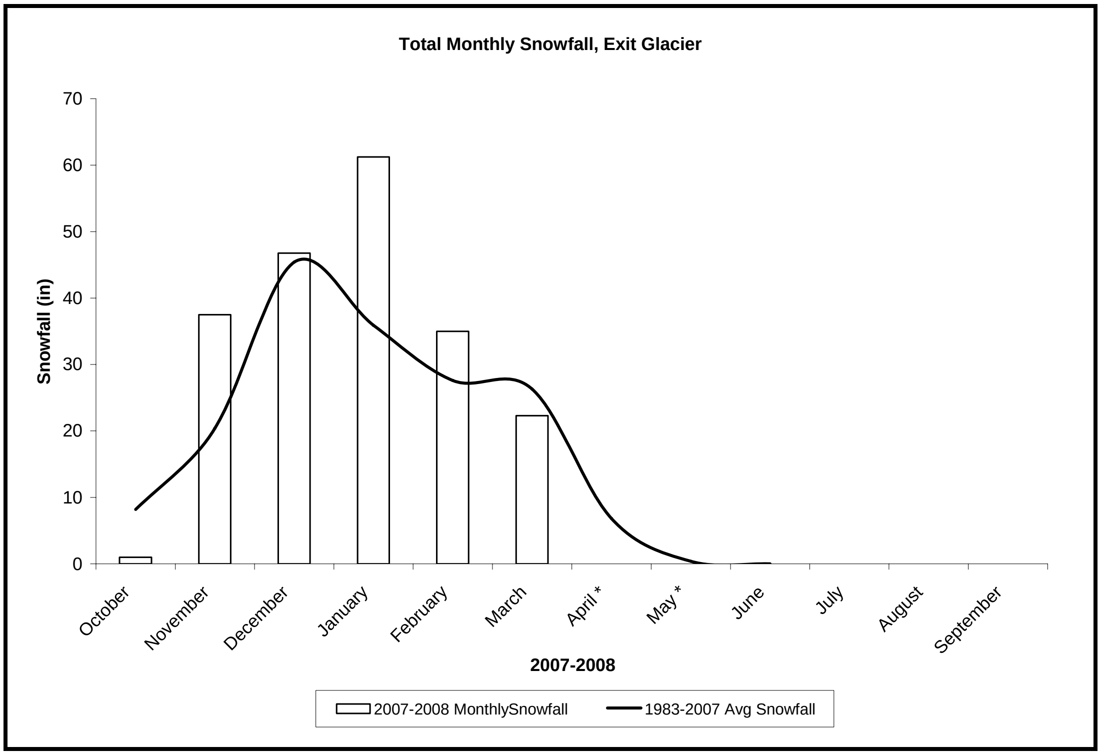

*Figure 13. Total monthly snowfall for the 2007-2008 WY and period of record (1983-2007) average monthly snowfall at the Exit Glacier weather station. *Data are not plotted for months with five or fewer observations (April - May, 2008). Data are from the NPS and WRCC.*

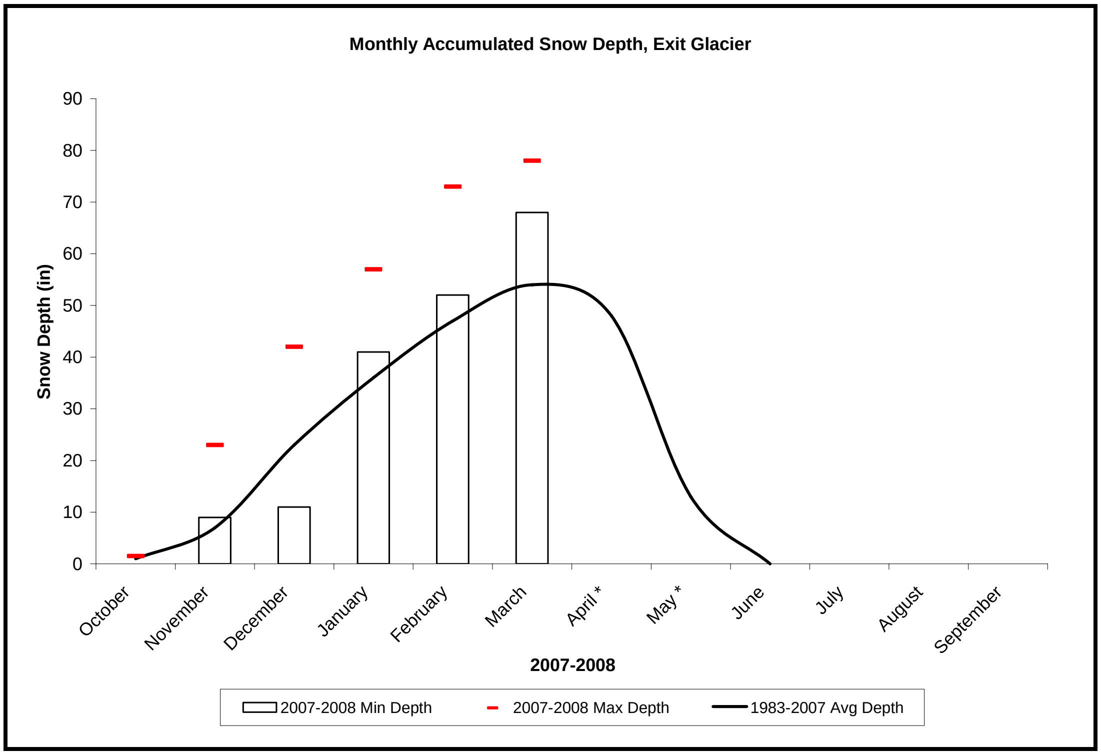

*Figure 14. Total monthly accumulated snow depth for the 2007-2008 WY and period of record (1983-2007) average snow depth at the Exit Glacier weather station. *Data are not plotted for months with five or fewer observations (April - May, 2008). Data are from the NPS and WRCC.*

Harding Icefield

During the 2008 water year (October 1, 2007 – September 30, 2008), the following weather observations were documented at the Harding Icefield weather station (Tables 4-6, Figures 15-19). The average air temperature was 24.8 °F with a maximum temperature of 61.7 °F observed on April 23, 2008 and a minimum temperature of -13.5 °F observed on February 5, 2008. The average air temperature for 2007-2008 was 0.5 °F warmer than the average air temperature for 2006-2007. Cumulative precipitation for the 2008 water year was 35.5 inches, although this measurement is not accurate because of significant undercatch (the weather station was deliberately placed at a windy site so that snow would not accumulate and bury the station). By comparison, a snow pit dug adjacent to the weather station (approximately 300 ft to the southeast) in April 2008 indicated the 224 inch seasonal snowpack (accumulated September 2007 – April 2008) represented 106 inches of precipitation (Klasner, 2008; during this same timeframe the all-season precipitation gauge at the weather station documented 16 inches of precipitation). The average wind speed for this time period was 13.1 mph. A sustained (1-minute) gust of 115.2 mph was observed on November 20, 2007. Overall, winds either blew from the southeast (47% of the time) or the northwest (24% of the time) reflecting the predominant regional trends (southeast winds generated by storm systems in the Gulf of Alaska or northwest gap winds resulting from high-pressure systems in interior Alaska). Wind gusts in excess of 50 mph predominately blew from the southeast (88% of the time). The relatively short (4 year) period of record for this weather station does not allow for comparison to long-term climatological normals.

Table 4. Summary of weather observations at the Harding Icefield weather station (Oct. 1, 2007 to Sept. 30, 2008). Data are from the NPS and WRCC.

Harding Icefield Weather Station	Value	Date
Average Temperature	24.8 °F	Oct 1, 2007 – Sep 30, 2008
Period of Record Average Temperature	26.2 °F	2004 – 2007
Maximum Temperature	61.7 °F	Jul 29, 2008
Minimum Temperature	-13.5 °F	Feb 4, 2008
Cumulative Precipitation*	35.5 in	Oct 1, 2007 – Sep 30, 2008
Normal Precipitation (PRISM**)	125-150 in	1961-1990
Average Wind Speed	13.1 mph	Oct 1, 2007 – Sep 30, 2008
Maximum Wind Gust	115.2 mph	Nov 20, 2007
Winds from NE	17 %	Oct 1, 2007 – Sep 30, 2008
Winds from SE	47 %	Oct 1, 2007 – Sep 30, 2008
Winds from SW	12%	Oct 1, 2007 – Sep 30, 2008
Winds from NW	24 %	Oct 1, 2007 – Sep 30, 2008

*Cumulative precipitation not accurate because of significant undercatch—wind blows precipitation over and away from gauge. **Normal (1961-1990) precipitation value is derived from a climate model (PRISM) and has not been observed at this location. This value is predicted and only serves as a frame of reference.

Table 5. Summary of monthly temperatures (°F) at the Harding Icefield weather station (Oct. 1, 2007 to Sept. 30, 2008). Data are from the NPS and WRCC.

Harding Icefield Weather Station - Temperature												
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Maximum	39.9	40.8	40.3	40.3	28.2	30.4	61.7	58.3	59.7	59.5	58.6	45.7
Minimum	12.2	10.3	-6.7	-11.4	-13.5	6.8	0.3	18.9	26.8	31.8	32.9	21.4
Average	23.7	21.8	14.8	10.7	11.7	17.2	22.3	28.5	35.4	39.7	39.5	32.7

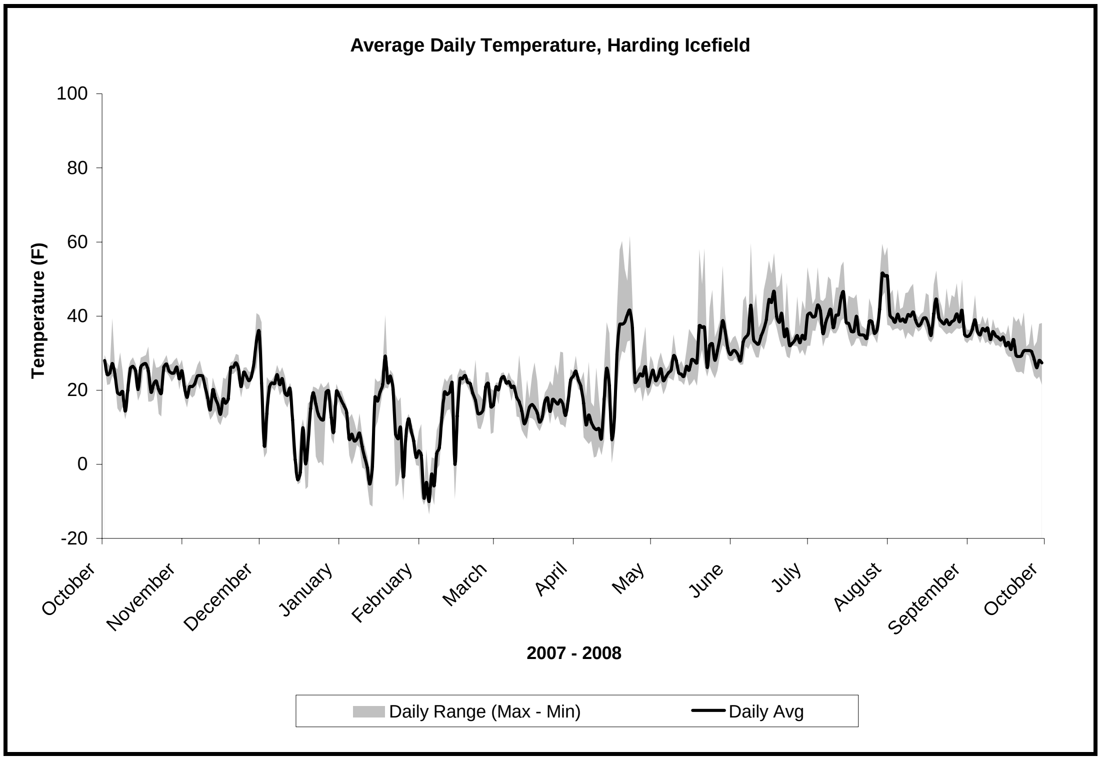

Figure 15. Daily high, low, and average temperatures (°F) for the 2007-2008 WY at the Harding Icefield weather station. Data are from the NPS and WRCC.

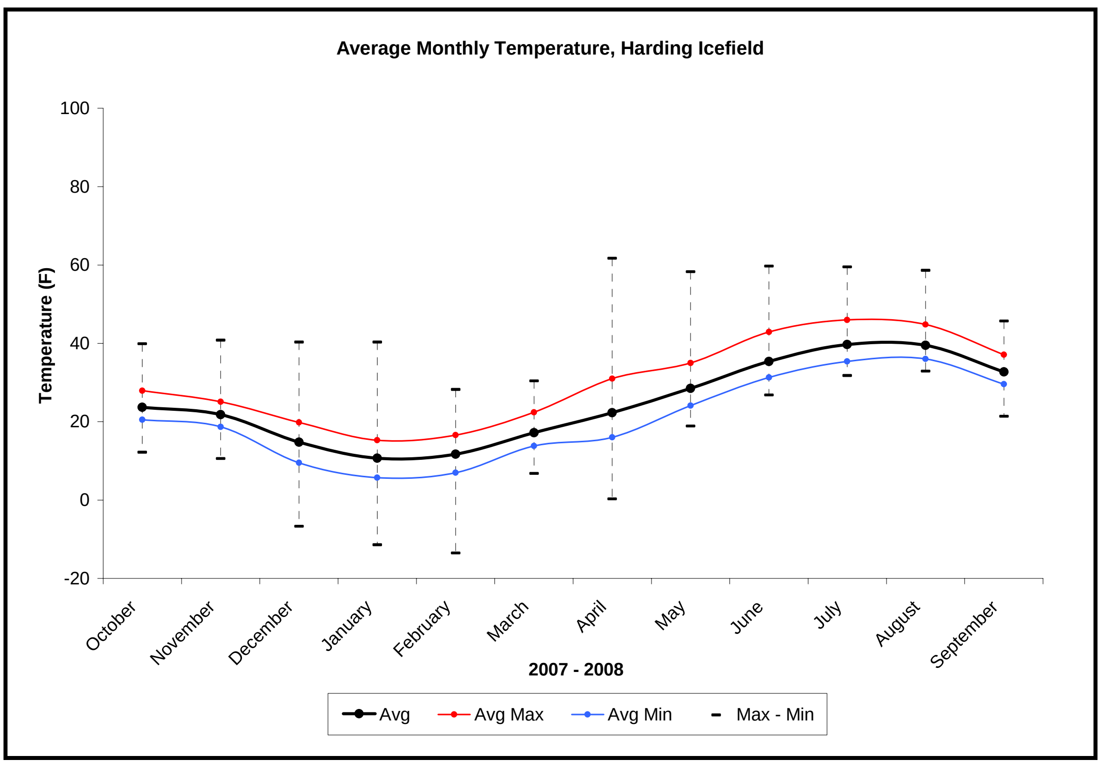

Figure 16. Monthly high, low, average-high, average-low, and average temperatures (°F) at the Harding Icefield weather station for the 2007-2008 WY. Data are from the NPS and WRCC.

Table 6. Summary of monthly precipitation (inches) at the Harding Icefield weather station (Oct. 1, 2007 to Sept. 30, 2008). Data are from the NPS and WRCC.

Harding Icefield Weather Station – Precipitation*												
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Total	2.21	8.08	1.35	0.69	0.02	0.02	3.35	2.91	1.34	2.87	1.28	11.37

*****Cumulative precipitation not accurate because of significant undercatch—wind blows precipitation over and away from gauge.

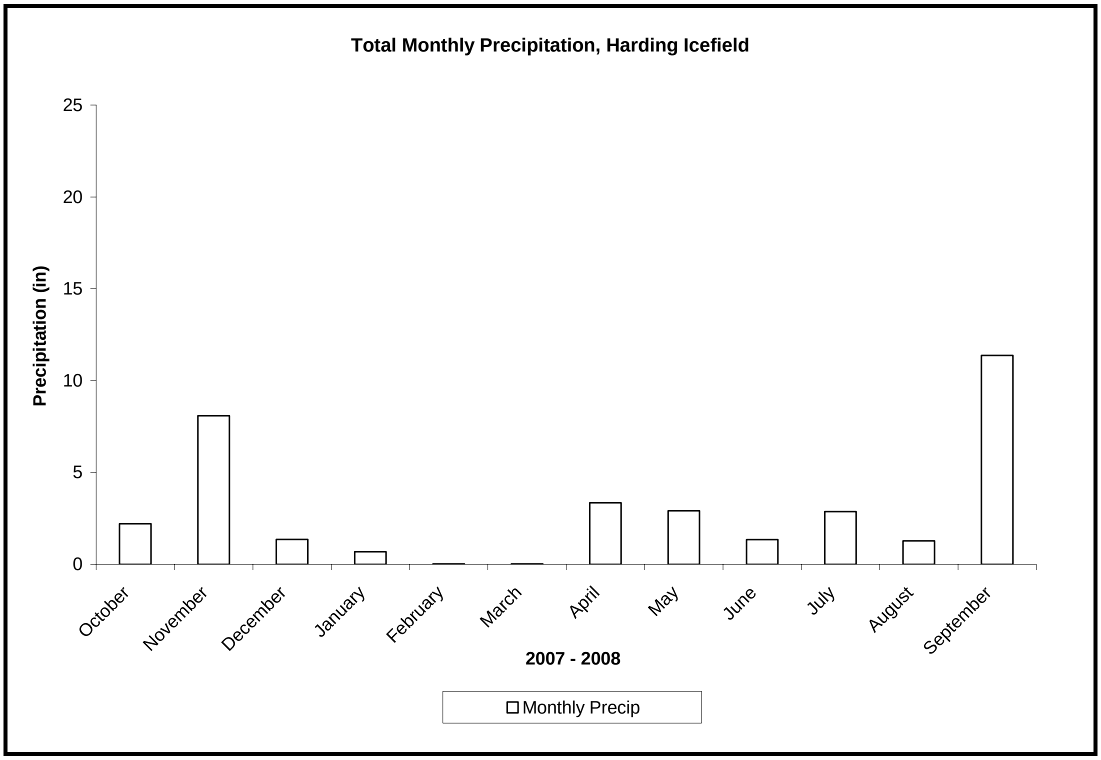

Figure 17. Total monthly precipitation for the 2007-2008 WY at the Harding Icefield weather station. Data are from the NPS and WRCC.

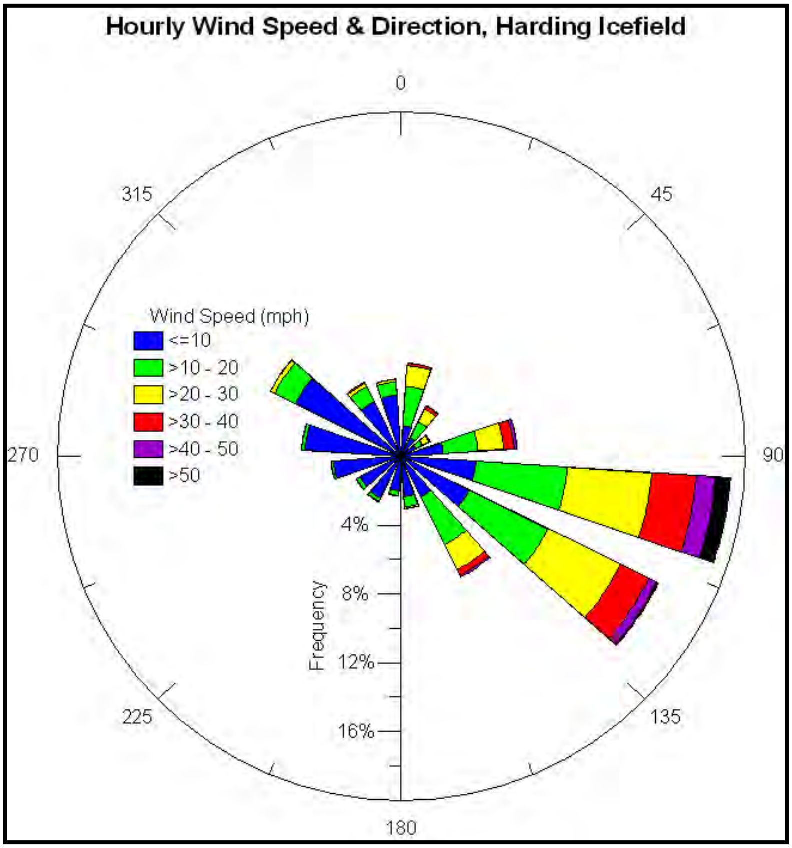

Figure 18. Hourly average wind speed and direction for the 2007-2008 WY at the Harding Icefield weather station. The wind rose is divided into 16 wind directions. Each wind direction is divided into wind speeds using 10 mph breaks. As the percent of time the wind blows from a particular direction increases, the portion of the bar representing that wind speed gets larger. Data are from the NPS and WRCC.

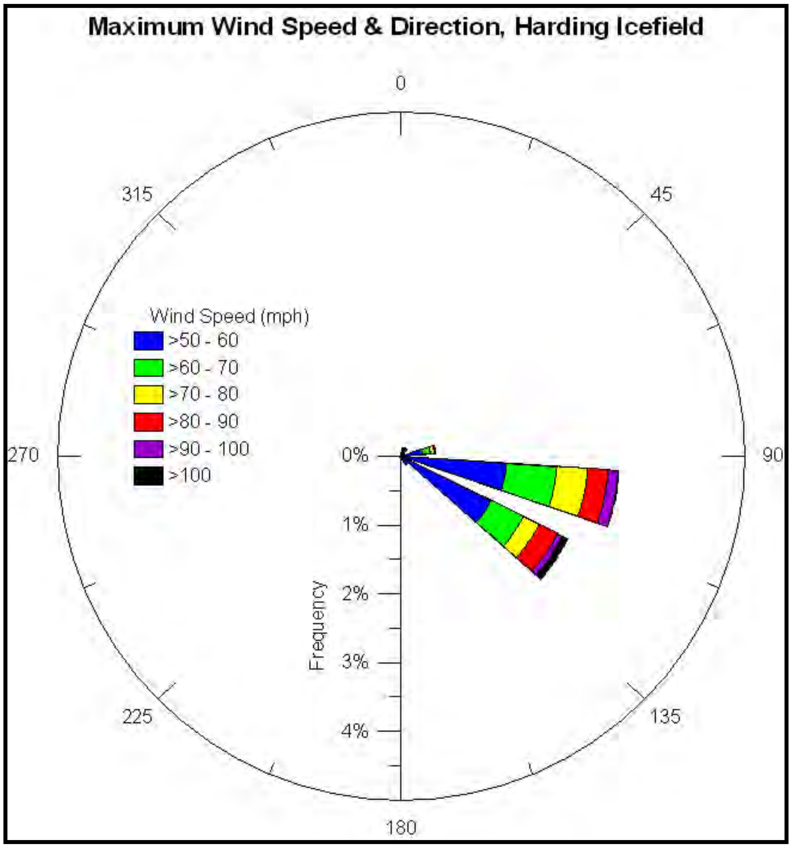

Figure 19. Wind speed and direction for maximum wind gusts (exceeding 50 mph) for the 2007-2008 WY at the Harding Icefield weather station. The wind rose is divided into 16 wind directions. Each wind direction is divided into wind speeds using 10 mph breaks. As the percent of time the wind blows from a particular direction increases, the portion of the bar representing that wind speed gets larger. Data are from the NPS and WRCC.

McArthur Pass

During the 2008 water year (October 1, 2007 – September 30, 2008), the McArthur Pass station was deployed and observations began in June 2008. Due to this extremely limited period of operation during the 2008 water year, results are not presented.

Nuka Glacier

During the 2008 water year (October 1, 2007 – September 30, 2008), the following weather observations were documented at the Nuka Glacier SNOTEL (Tables 7-9, Figures 20-21). The average air temperature was 33.1 °F with a maximum temperature of 66.6 °F observed on July 30, 2008 and a minimum temperature of -22.4 °F observed on February 5, 2008. The average air temperature for 2007-2008 was 0.7 °F colder than the average air temperature for 2006-2007 and 2.2 °F colder than the 13-year period of record (35.3 °F, 1993-2007, no data for 1995 and 1998). Cumulative precipitation for the 2008 water year was 97.2 inches, 116% of the precipitation for 2006-2007 (83.9 in) and 104% of the annual average precipitation for the 16-year period of record (93.1 inches, 1991-2007, no data for 1995). Wind data is not collected at the Nuka Glacier SNOTEL.

Table 7. Summary of weather observations at the Nuka Glacier weather station (Oct. 1, 2007 to Sept. 30, 2008). Data are from the NRCS.

Nuka Glacier Weather Station	Value	Date
Average Temperature	33.1 °F	Oct 1, 2007 – Sep 30, 2008
Period of Record Average Temperature	35.3 °F	1993-2007
Maximum Temperature	66.6 °F	Jul 30, 2008
Minimum Temperature	-22.4 °F	Feb 5, 2008
Cumulative Precipitation	97.2 in	Oct 1, 2007 – Sep 30, 2008
Period of Record Precipitation	93.1 in	1991-2007

Table 8. Summary of monthly temperatures (°F) at the Nuka Glacier weather station (Oct. 1, 2007 to Sept. 30, 2008). Data are from the NRCS.

Nuka Glacier Weather Station - Temperature												
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Maximum	47.5	43.9	37.2	37.0	40.5	39.7	52.3	57.7	54.9	66.6	63.5	54.7
Minimum	17.4	13.3	-3.5	-2.7	-8.3	4.8	-2.0	25.5	32.2	31.1	35.1	28.8
Average	34.6	30.5	23.5	18.5	18.7	25.3	27.9	35.9	42.1	47.7	49.0	44.0
13YR Average	35.5	27.2	24.6	21.3	24.4	24.2	32.0	38.8	45.7	52.4	52.2	45.8
Departure	-0.9	3.3	-1.1	-2.8	-5.7	1.2	-4.1	-2.9	-3.6	-4.7	-3.2	-1.8

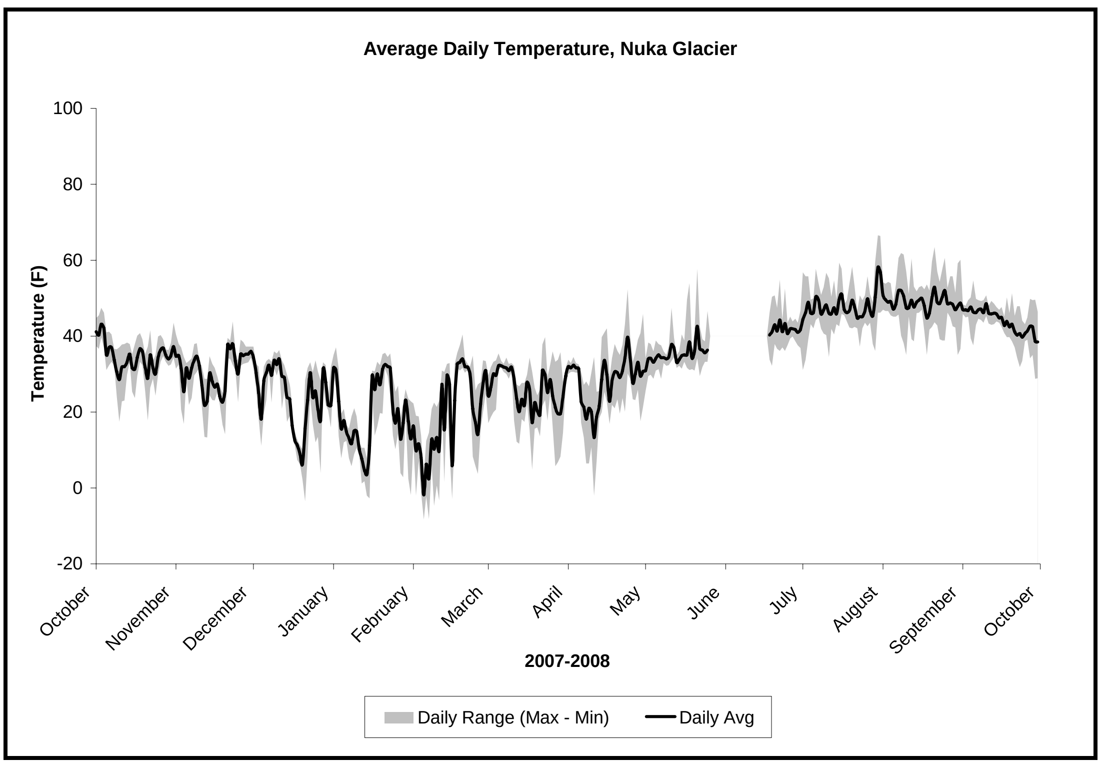

Figure 20. Daily high, low, and average temperatures (°F) for the 2007-2008 WY at the Nuka Glacier weather station. Data are from the NRCS.

Table 9. Summary of monthly precipitation (inches) at the Nuka Glacier weather station (Oct. 1, 2007 to Sept. 30, 2008). Data are from the NRCS.

Nuka Glacier Weather Station - Precipitation

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Total	9.2	23.2	8.9	3.2	7.5	6	3.4	4.9	2	3.9	3.2	21.8
16YR Average	12.4	10.1	11.1	7.2	6.9	6.3	6.8	5.5	4.1	4.3	6.9	11.7
Departure	-3.2	13.1	-2.2	-4.0	0.6	-0.3	-3.4	-0.6	-2.1	-0.4	-3.7	10.1

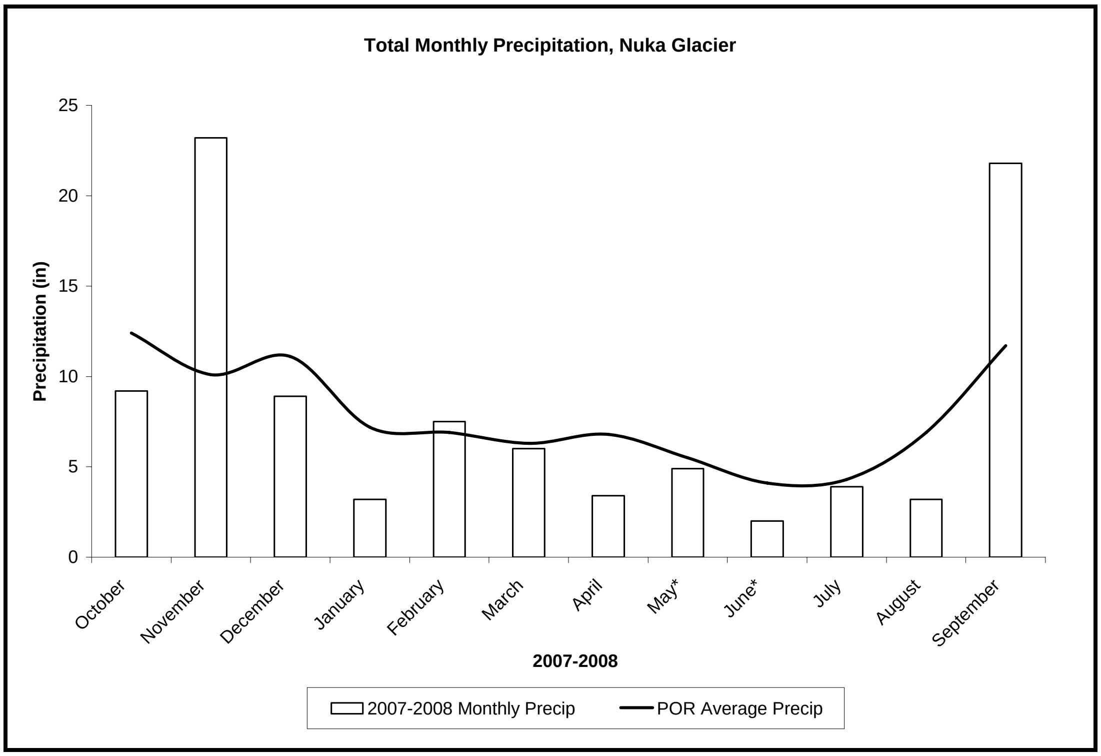

Figure 21. Total monthly precipitation for the 2007-2008 WY and 16-year average monthly precipitation at the Nuka Glacier weather station. Data are from the NCDC.

Seward Airport

During the 2008 water year (October 1, 2007 – September 30, 2008), the following weather observations were documented at the Seward Airport (Tables 10-12, Figures 22-24). The average air temperature was 38.1 °F with a maximum temperature of 74 °F observed on July 29, 2008 and a minimum temperature of 0 °F observed on February 4, 2008. The average air temperature for 2007-2008 was 0.1 °F colder than the average air temperature for 2006-2007 and 2.2 °F colder than the 30-year climatological normal (40.3 °F, 1971-2000, COOP 508371). Cumulative precipitation for the 2008 water year was 69.2 inches, 136% of cumulative precipitation for 2006-2007 (50.8 in) and 96% of annual average precipitation for the 30-year climatological normal (71.8 inches, 1971-2000, COOP 508371). The first (seasonal) snowfall occurred at the Seward Airport on October 20, 2007 (the earliest recorded seasonal snowfall during the last 20 years was September 20, 2003).

Table 10. Summary of weather observations at the Seward Airport weather station (Oct. 1, 2007 to Sept. 30, 2008). Normal values are published climatological normals for 1971-2000 (COOP 508371). Data are from the NCDC.

Seward Airport Weather Station	Value	Date
Average Temperature	38.1 °F	Oct 1, 2007 – Sep 30, 2008
Normal Temperature	40.3 °F	1971-2000
Maximum Temperature	74 °F	Jul 29, 2008
Minimum Temperature	0 °F	Feb 4, 2008
Cumulative Precipitation	69.2 in	Oct 1, 2007 – Sep 30, 2008
Normal Precipitation	71.8 in	1971-2000

Table 11. Summary of monthly temperatures (°F) at the Seward Airport weather station (Oct. 1, 2007 to Sept. 30, 2008). 30YR Average is published climatological normal for 1971-2000 (COOP 508371). Data are from the NCDC.

Seward Airport Weather Station - Temperature												
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Maximum	53	50	42	43	43	42	60	66	64	74	73	59
Minimum	26	18	6	3	0	16	13	29	37	40	40	32
Average	39.2	33.3	27.5	21.4	22.7	31.9	33.9	44.5	48.9	52.8	53.8	47.1
30YR Average	39.8	31.7	28.1	26.2	27.2	32.0	38.6	45.8	52.1	56.4	55.9	49.6
Departure	-0.6	1.6	-0.6	-4.8	-4.5	-0.1	-4.7	-1.3	-3.2	-3.6	-2.1	-2.5

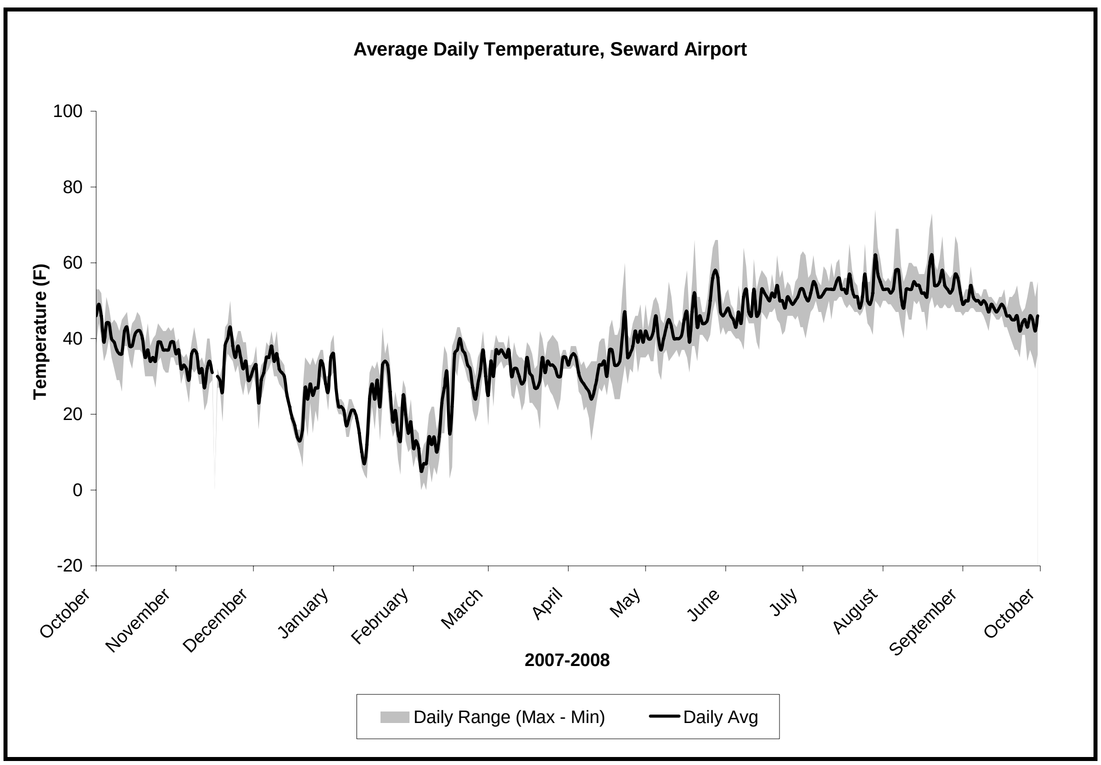

Figure 22. Daily high, low, and average temperatures (°F) for the 2007-2008 WY at the Seward Airport. Data are from the NCDC.

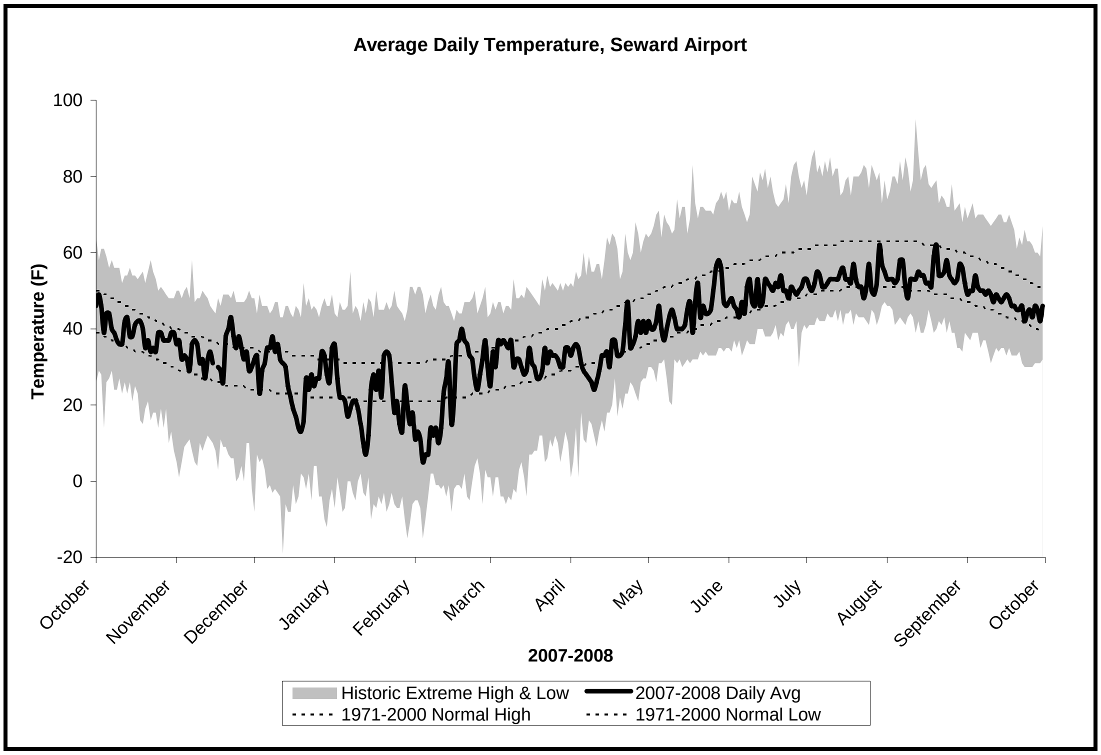

Figure 23. Record high and low temperatures, 30-year average high and low temperatures, and average daily temperatures (°F) for the 2007-2008 WY at the Seward Airport. Data are from the NCDC.

Table 12. Summary of monthly precipitation (inches) at the Seward Airport weather station (Oct. 1, 2007 to Sept. 30, 2008). 30YR Average is published climatological normal for 1971-2000 (COOP 508371). Data are from the NCDC.

Seward Airport Weather Station - Precipitation

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Total	5.82	16.73	5.05	4.36	6.43	5.23	3.37	2.46	1.39	3.75	1.56	13.02
30YR Average	9.81	7.15	7.84	7.19	5.82	4.14	4.71	4.75	2.32	2.24	5.49	10.36
Departure	-3.99	9.58	-2.79	-2.83	0.61	1.09	-1.34	-2.29	-0.93	1.51	-3.93	2.66

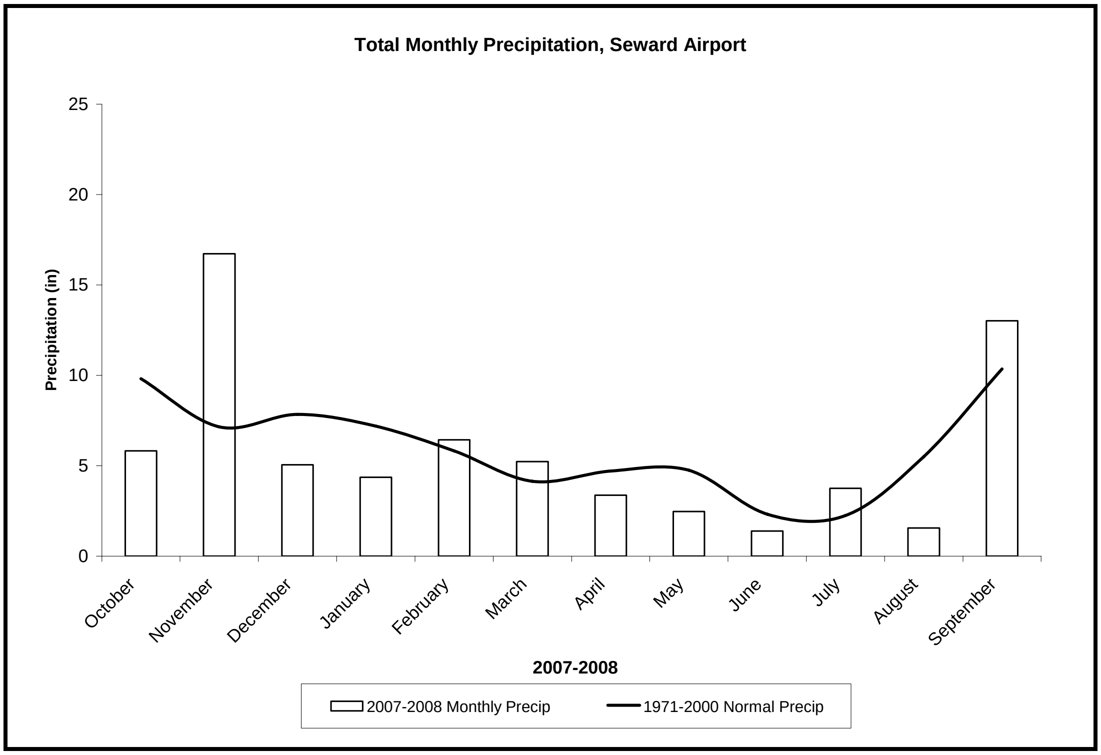

Figure 24. Total monthly precipitation for the 2007-2008 WY and 30-year average monthly precipitation at the Seward Airport. Data are from the NCDC.

CLIMATE AND WEATHER RELATED RECOMMENDATIONS FOR 2009

Monthly summaries for the previous month's weather observations, with links and references for additional information were initiated in 2008. These were shared with all park employees by email. Having refined the concept and receiving positive feedback, we anticipate continuing these monthly summaries.

In the course of preparing this report, it was noted that automated National Weather Service data systems were missing entire months of Exit Glacier COOP station data, even though data was collected and reported for the months in question. Inquiries to determine the cause of these data gaps are ongoing, with potential remedies being original electronic data entry by NPS staff via Internet-transmitted Cooperative Observer Data Encoded Report (WxCoder) or Interactive Voice Remote Observation Collection System (IV-ROCS) interfaces with the COOP program.

To address concerns regarding missing data (days when no one records weather conditions at Exit Glacier), and to better serve visitor, park staff, and scientific interests; a proposal for upgrading to an automated station was prepared in 2008. A Snowpack Telemetry (SNOTEL) site similar to the Nuka Glacier station is the proposed configuration; and recommended elements include temperature, precipitation, snow depth, snow water equivalent, and wind. If successful in obtaining funding to install this station, the COOP program has asked that the existing weather station and the proposed SNOTEL station operation overlap for a period of 3-5 years to allow for climatological comparisons. This would also provide a permanent solution to COOP station data management issues.

With the anticipated 2009 opening of the Kenai Fjords Glacier Lodge along the shores of Pedersen Lagoon in Aialik Bay, the park is investigating options for coordinating the addition of a COOP station. Park rangers stationed at the Aialik Bay Ranger Station currently collect limited weather data during summer months (not reported here due to the limited scope of this data). As the Glacier Lodge will have staff on site full-time during the entire summer, we are communicating with the National Weather Service and Kenai Fjords Glacier Lodge managers regarding merits of (and options for) collecting standardized weather observations at this site. Future annual climate reports will identify outcome of these discussions.

Annual maintenance of the weather stations at McArthur Pass and Harding Icefield will continue in 2009. We are evaluating the installation of a second precipitation gauge (electronic tipping bucket recording only liquid precipitation) in order to compare data with the existing all-season (liquid and solid) precipitation gauge at the Harding Icefield. As noted previously, there are issues with undercatch of precipitation due to windy site conditions and these issues will not be resolved by adding this sensor. Future removal of the all-season gauge will be considered if the liquid-only precipitation gauge correlates well with the all-season gauge. This will greatly simplify seasonal maintenance of the Harding Icefield weather station. High winds at the McArthur Pass RAWS site also are of concern, due to the potential for wind-induced vibration causing the tipping bucket to erroneously record precipitation. Collaboration with the equipment manufacturer is ongoing to evaluate this and mitigate this potential problem.

With continued interest in climate change, and recent perceptions of local climate change after one year of below normal temperatures, the park and Southwest Alaska Network will continue to facilitate integration of climate (change) related information into NPS activities. During 2009 talking points will be prepared, climate change will be a central issue in the Network’s science symposium, interpretive programs will be updated, park management will continue to participate in the Federal Green Challenge (as well as Climate Friendly Parks and other improvements in operational and energy efficiency), and periodic meetings of park staff to discuss pertinent issues will continue.

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ENDNOTES:

[1] "Average" is used loosely (*sensu lato)* when no values are listed. "Average" is used strictly (*sensu stricto)* when values and years are listed.

[2] "Normal" refers to the climatological normal – the prevailing set of weather conditions calculated over a 30-year period, presently 1971-2000. Unless otherwise noted, the use of "normal" refers to the period 1971-2000. Note that values for a climatological normal taken over different periods of time (e.g. 1961-1990) may be different.