



Annual Climate Summary 2018

Central Alaska Network

Natural Resource Data Series NPS/CAKN/NRDS—2020/1266



ON THE COVER

An Alaska Range glacier in Denali National Park and Preserve.
Photograph by Ken Hill/National Park Service

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

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Executive Summary

The Central Alaska Network's climate monitoring program operates seventeen remote weather stations to monitor climate in Denali National Park and Preserve, Wrangell -St. Elias National Park and Preserve, and Yukon-Charley Rivers National Preserve (Figure 1). The main goal of the program is to maintain these remote sites for the long-term in order to help scientists and park managers understand the climate patterns across these large parks. There are weather stations around the parks that are operated by various state and federal agencies that are used as index sites to compare current climate conditions in the region to the climatological normal - the average weather conditions over a 30-year period. The current climate period used for reference is based on data collected from 1981 through 2010. Unfortunately, a 30-year reference period for Alaska fails to capture the rapidly changing environment we live in. This report presents annual and monthly temperature and precipitation deviations for the index sites and monthly and annual statistics for NPS sites with shorter records. A brief synopsis of regional climate conditions for 2018 is included for climatic context.

2018 was the **second warmest** year on record for Alaska, after 2016. Each of the last five years have been in the top ten warmest years on record for the state with records dating back to 1925. The mean annual temperatures at the CAKN index sites at McKinley Park, Gulkana, and Eagle were, on average, 1.1°C (2.1°F) warmer than the 1981-2010 normal. Annual precipitation totals across the CAKN region varied from 86% of normal in Yakutat to 160% of normal in Eagle.

During the summer of 2018, the Central Alaska Network staff conducted annual site maintenance at the thirteen CAKN climate stations, four snow telemetry sites, and assisted with maintenance of three fire weather stations. All of the 2018 CAKN RAWS weather data and corresponding metadata are available through the Integrated Resource Management Applications (IRMA) Data Store at <https://irma.nps.gov/DataStore/Reference/Profile/2254700>.

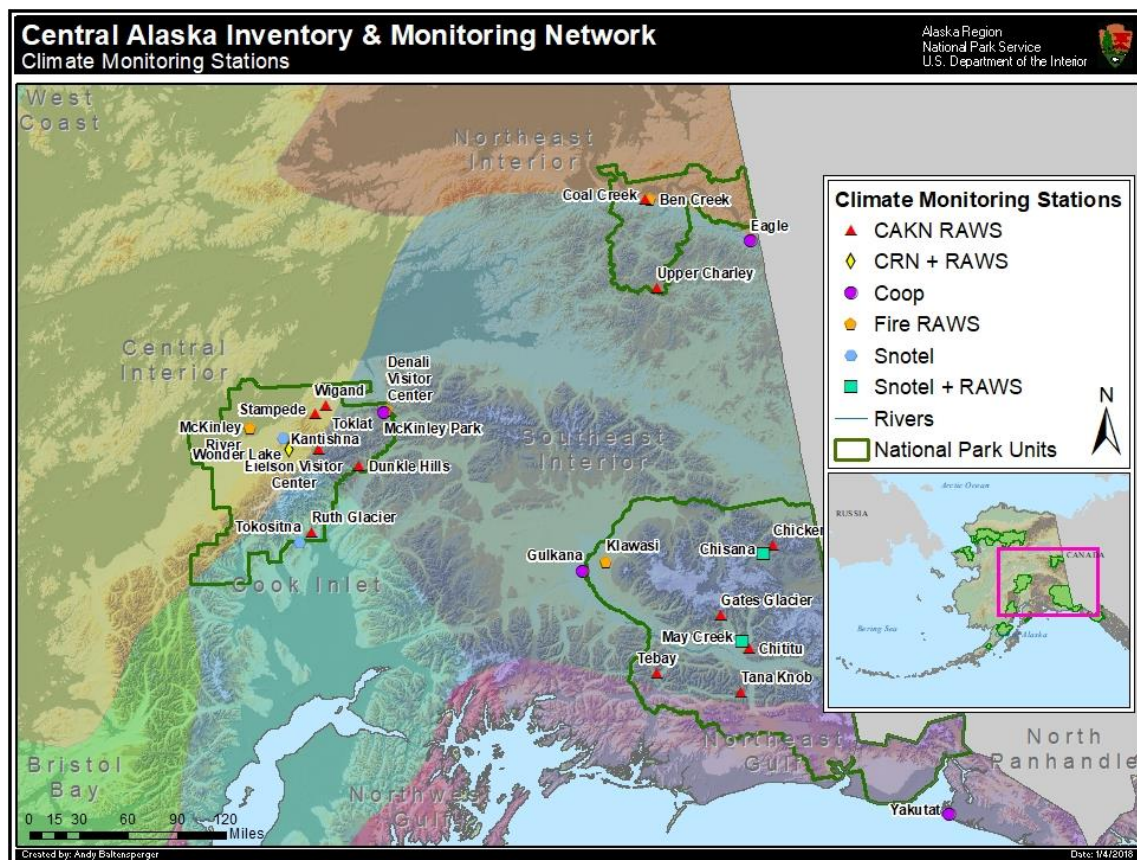


Figure 1. Map of climate and snow stations in the Central Alaska Network parks with the Alaska climate divisions shaded and labeled on the map.

Introduction

Denali National Park and Preserve (DENA), Wrangell–St. Elias National Park and Preserve (WRST), and Yukon-Charley Rivers National Preserve (YUCH) make up the Central Alaska Inventory and Monitoring Network (CAKN), covering over 21 million acres. The network was established to monitor key components of ecosystems of the parks and to provide that information back to park managers for use in stewardship of park resources. Climate is considered to be one of the most important broad-scale factors influencing ecosystems and therefore the natural resources of parks.

The 2018 field season marked the tenth year of operational climate monitoring in CAKN parks. Annual maintenance was performed at all of the climate stations. Maintenance at the climate sites included sensor replacement, troubleshooting, upgrades, data downloads, and sensor calibrations. Station maintenance logs were used to keep track of the climate station inventory for the stations. Equipment performance was tracked and instrumentation was replaced as necessary. A maintenance report is completed after each field season to document the details of the site visits – these reports include the field notes, photos, logistical procedures, and sensor metadata (Hill and Sousanes 2019).

This is the 13th in a series of annual data reports that summarize the annual and monthly weather statistics for the CAKN climate monitoring program.

Central Alaska Network Climate Overview

The Central Alaska Network (CAKN) encompasses strong climate gradients, from the maritime climates in the southern parts of Wrangell – St. Elias National Park and Preserve (WRST) where it borders the North Pacific Ocean, to the strongly continental climates found in northern parts of Denali National Park and Preserve (DENA) and Yukon –Charley Rivers National Preserve (YUCH). The Central Alaska parks constitute parts of the Northeast Interior, Southeast Interior, Central Interior, and Cook Inlet Alaska climate divisions (Bieniek et al. 2012). A transitional climate region lies between the coast and the interior influenced by major mountain ranges which act not only as the environmental controls to drive climate but also contribute to the highly localized micro climates found in complex mountain terrain. Redmond and Simeral (2006) provide a more detailed discussion of the climate of the Central Alaska Network.

Methods

There are five National Weather Service (NWS) stations in the CAKN region that have been in operation for more than 50 years that are used as index sites to place current year regional weather conditions into climatological context. The long-term climate record from McKinley Park (1926-2018) is used as the index sites for DENA. Eagle (1918-2018) is used as an index site for YUCH. Gulkana (1948-2018) and Yakutat (1917-2018) provide context for the long-term climate at WRST. Monthly and annual temperature means and precipitation totals for 2018 are analyzed and compared with the 1981-2010 normal values for each site.

The CAKN climate monitoring program deployed 13 climate stations (CAKN RAWS) between 2004-2013 at mid-elevation sites to capture elevational and latitudinal climate gradients within the parks, and to capture data in areas where there were no baseline references. For detailed information on station locations, station design, and maintenance schedules see the CAKN climate monitoring protocols (Sousanes 2018). Monthly and annual means and totals were compiled for the climate variables measured at the CAKN RAWS, five additional fire RAWS, and five snow telemetry (SNOTEL) sites. The SNOTEL sites were analyzed by water year (October 1- September 30) for year-round precipitation and snowfall amounts. The CAKN data and metadata for 2018 are archived as discrete deliverables at <https://irma.nps.gov/DataStore/Reference/Profile/2254700>.

Data Corrections and Data Quality Grading

Many stations operate under extreme environmental conditions which cause a variety of challenges. The most common problems are caused by wildlife and/or icing. Wildlife (usually bears), can damage sensors, cables, hardware, or the power supply. Icing can obstruct free-air movement on naturally aspirated radiation shields, build up on wind sensors, or block incident solar radiation sensors. Blowing snow or corrosion of snow depth transducers can lead to false snow depth measurements.

During the annual site visits data were downloaded from each CAKN RAWS and checked for quality. CAKN station data, metadata, quality control flags/notes, and sensor history are managed with Aquatic Informatics Aquarius software and stored on the NPS Water Resources Division server in Fort Collins, Colorado. Errors or values outside a standard range were flagged and not used in the summary statistics. Details are logged in Aquarius and are also included in the annual maintenance report. For more information on the QA/QC process see the corresponding standard operating procedure (SOP) at <https://irma.nps.gov/DataStore/Reference/Profile/2253025>.

Results

Weather Summary for 2018

2018 was the second warmest year on record for Alaska. The entire state was warmer than normal with the warmest anomalies along the West Coast and in the Central Interior (Figure 2). Five of the past ten years were among the top ten warmest years on record with records dating back to 1925 (Figure 3) (Thoman 2018).

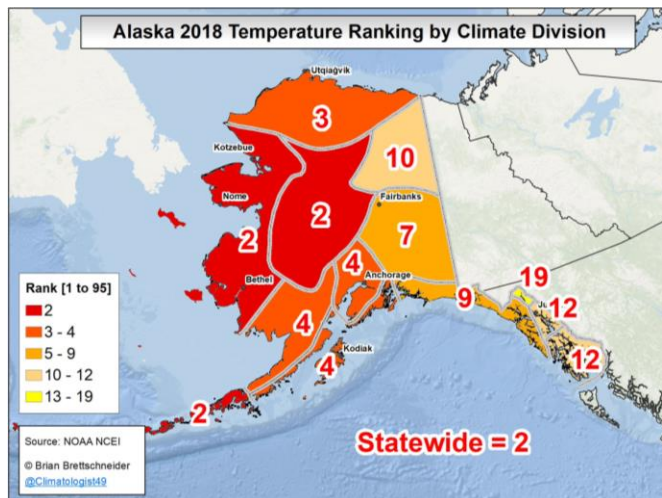


Figure 2. 2018 Temperature ranks for Alaska by climate division. Courtesy of Brain Brettschneider, climatologist for the International Arctic Research Center at the University of Alaska Fairbanks.

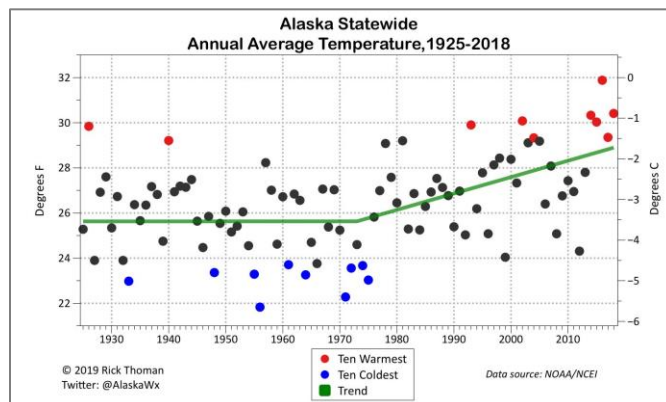


Figure 3. Alaska temperatures since 1925; the last five years are among the warmest. Figure courtesy of Rick Thoman with the Alaska Center for Climate Assessment and Policy (ACCAP).

Coastal communities are feeling the brunt of the weather-driven changes due to the proximity to the ocean, which regulates and moderates the temperature of adjacent landmasses. While the western Alaska national parks including, Bering Land Bridge, Cape Krusenstern, and Noatak are experiencing some of the most dramatic temperature changes due to the lack of sea ice in the northern Bering Sea and Chukchi Sea in the fall and winter, Denali in the Central Interior has been

experiencing much warmer cold season temperatures for the same reason. Without ice, incoming solar radiation is absorbed rather than reflected back to the atmosphere. The ice extent in the Bering Sea was at a record low in 2018 (Figure 4).

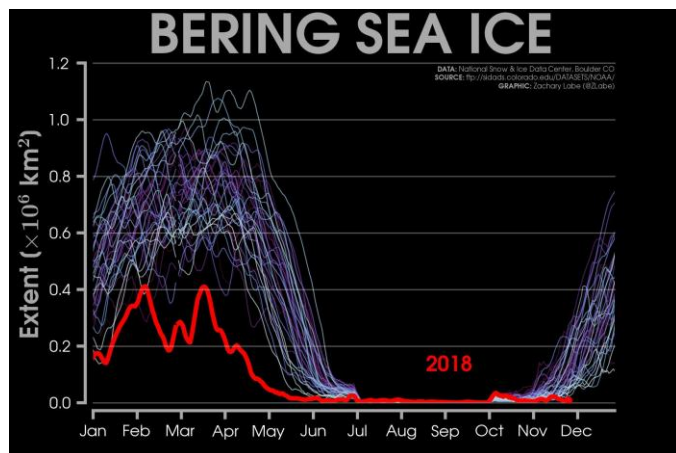


Figure 4. Bering Sea ice remained at record low levels through most of 2018. Graph courtesy of Zach Labe, University of California-Irvine (@ZLabe).

2018 in context: how did it compare to normal?

In 2018, the mean annual temperatures at the five index sites around the CAKN parks averaged 1.1 °C (2.1 °F) warmer than the 1981-2010 normal (Figure 5). 2018 was the third warmest year on record for Yakutat (records date back to 1918, n=84), it was the sixth warmest year on record at Denali (records date back to 1926, n=65), the eighth warmest year on record for Eagle (records date back to 1919, n=69), and the 13th for Gulkana (records date back to 1943, n=72). For the annual rankings only those years with <15 days missing were included. Figure 6 highlights that temperatures were warmest (larger positive deviation from normal) during the fall and early winter of 2018.

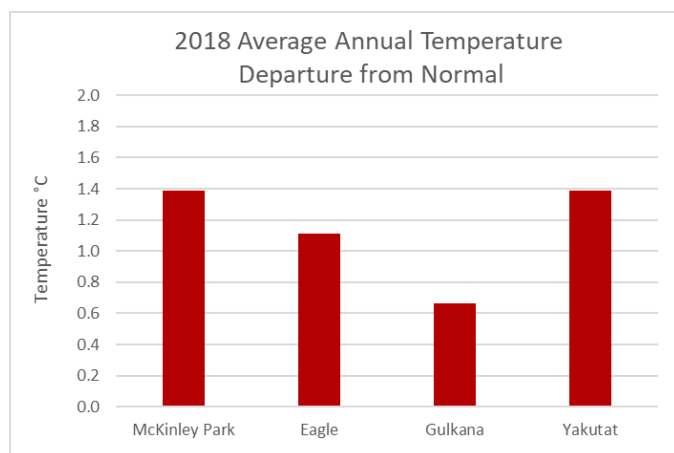


Figure 5. Average annual temperature departures for 2018 for the CAKN index sites.

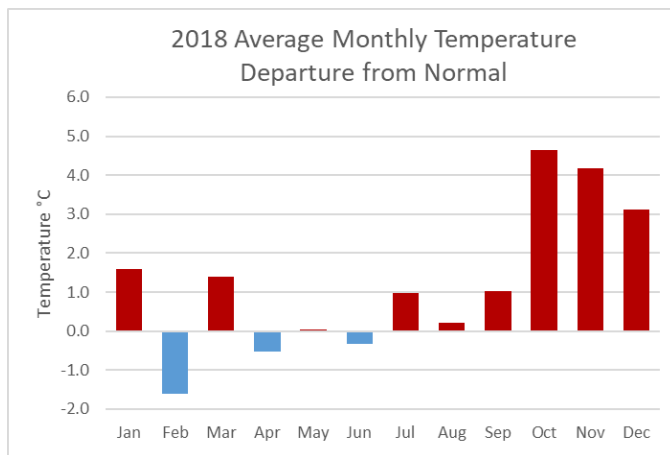


Figure 6. Average monthly temperature departures for 2018 for the CAKN index sites.

Annual precipitation totals across the CAKN region varied from 86% of normal in Yakutat to 160% of normal in Eagle (Figure 7). 2018 was the wettest year on record for the Eagle site, by both calendar year and water year, surpassing the second wettest year (2015) by 94 mm (record starts in 1918, included years with <15 days of missing data, n=71). August definitely stands out as the wettest month of the year relative to normal and September as the driest relative to normal (Figure 8).

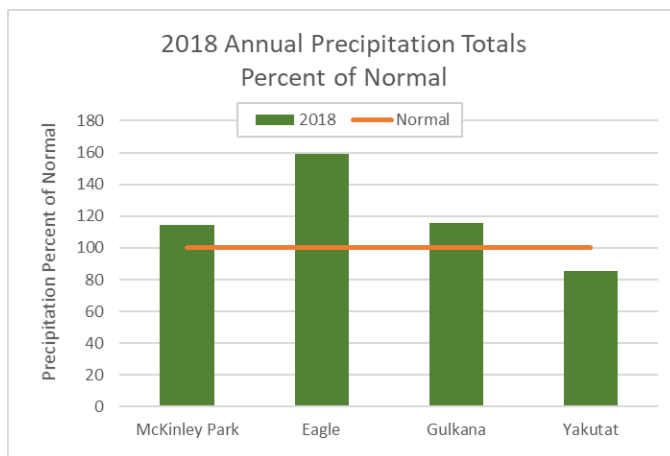


Figure 7. Annual precipitation totals percent of normal for the CAKN index sites.

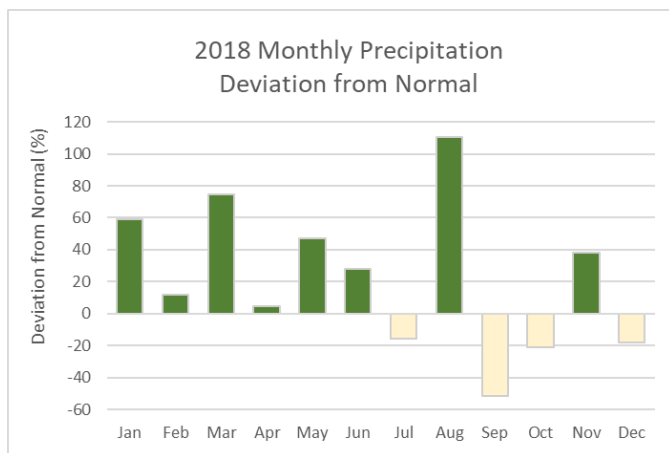


Figure 8. Monthly precipitation deviations from normal for the CAKN index sites

Winter Snow

In communities along the southern coast of Alaska, where winter temperatures are now often above freezing level, more winter precipitation falls as rain rather than snow. Snowfall totals in Yakutat were well below normal for spring 2018; only 3.9 inches of snow was recorded, which is 10% of normal and the 5th lowest spring snowfall total on record. Gulkana, which is north of the Chugach Mountain range, had the wettest winter on record in 2017-2018. The precipitation (water equivalent of the snow) total of 113 mm (4.46 in.) was ~255% of normal.

Higher elevations in the Wrangell Mountains also had a robust snowpack as indicated by the phenology camera and snow depth sensor at the Gates Glacier climate station. In 2018 the snow depth at the Gates Glacier site was nearly double what it was in 2017 (Figure 9). Images from the camera taken on June 1 over the past four years highlight the deeper snowpack and delayed spring melt-out in 2018; the last day of persistent snow for the 2017-2018 season did not occur until June 30 at the Gates Glacier site.



Figure 9. Photos taken on June 1 at the Gates Glacier climate station. Photos from 2015 (top), 2016, and 2017 (bottom) are on the left and the large photo is from 2018.

It was also a big snow year for Denali park headquarters. It was the snowiest season since 2000 and the 12th snowiest on record (since 1926). The snowfall total (July 1 through June 30) was 292 cm (115 inches), the 1981-2010 normal is 196 cm (77 inches). Further west in Denali, the winter of 2017-2018 was the snowiest season to date at the Kantishna Snotel site (record starts in 2006). The peak snow depth was 127 cm (50 inches) in mid-March and the melt-out date did not occur until May 23. At the Tokositna Snotel site, south of the Alaska Range in Denali, the snowpack was below normal overall, similar to recent dry years.

Summer 2018: Warm to the south, cool and wet up north

There was an unusually long stretch of warm weather for Yakutat and the southern areas of Wrangell-St. Elias during summer 2018; Yakutat had its sixth warmest summer on record. Summer rainfall amounts at this location were near normal in 2018. Farther inland in Gulkana, summer temperatures were near normal, but it was the second wettest summer on record with an abundant amount of rain falling in June and August of 2018. Rainfall was also abundant in Eagle, near Yukon-Charley Rivers, with over 279 mm (11 inches) of rain between July 1 and August 31, summer 2018 ranked as the wettest summer on record for Eagle; this followed the wettest May on record.

Overall, the basic climate parameters of average temperature and total precipitation were near-normal for summer 2018 in Denali. June was cooler than normal, July was warm and dry, and August was wet. The summer season ended up 0.1°C (0.2°F) warmer than normal with a seasonal average temperature of 11.8°C (53.2°F). A total of 238 cm (9.35 inches) of rain fell over the three month period, which is 116% of normal

The incredibly warm and dry fall of 2018

It was the warmest October on record for many locations across Alaska, from Nome on the Seward Peninsula, to Yakutat on the Gulf Coast of Alaska. The western coast of Alaska was by far the

warmest, but the warmth was widespread. Statewide it was the second warmest fall on record (Figure 10).

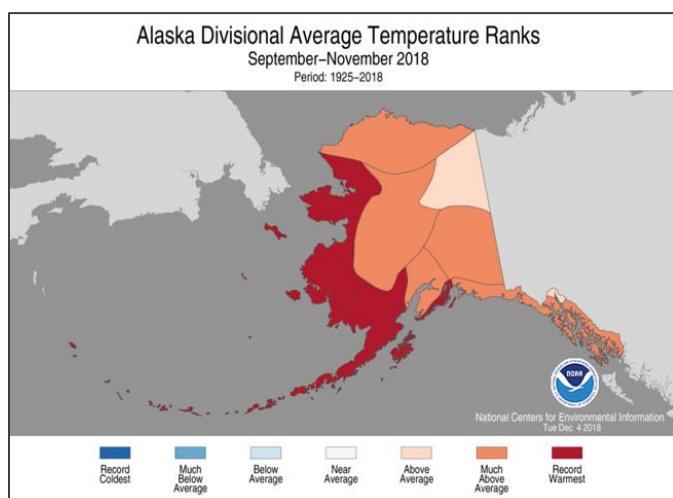


Figure 10. Record warm fall along Alaska’s west coast for 2018. Graph courtesy of NCEI (<https://www.ncdc.noaa.gov/cag>).

Yakutat, on the Gulf of Alaska, is usually a wet place. The adjacent Pacific Ocean acts like a giant flywheel that continually brings rain and snow to this coastal community on the order of 3937 mm (155 in.) a year (Davey et al. 2006). September is usually the second wettest month behind October, but in September 2018 there was an unprecedented dry spell that lasted for 20 consecutive days. According to local climatologists it was likely a ‘once in a lifetime event’, which statistically has less than a 1% chance of occurring during the early fall season (Brettschneider, 2018).

The warmth continued for Yakutat and the fall of 2018 ended up as the warmest on record. There was no snow recorded in Yakutat for the 2018 fall season; which was unprecedented. Other years had trace amounts (1937 and 2002), but 2018 marked the first fall on record where the total snowfall between September 1 and November 30 was zero.

For Gulkana, it was the fifth warmest fall on record and ranked as the eighth driest, with September being the driest of the fall months. In Denali it was the third warmest fall on record. The average temperature for the 2018 fall season was above freezing, which has only happened four other times since 1926. Another extraordinary fall statistic from Denali was the lack of snow; only 13 cm (5.2 in.) of snow was recorded between September 1 and November 30. This is the lowest on record with more than 70 years of good observations from the park headquarters weather station.

CAKN Climate Stations: 2018 Temperature

Temperatures: Overall, it was the third warmest year on record for the CAKN sites with records dating back to 2005. An average of all sites in the network show 2016 as the warmest year and 2015 as the second warmest year to date. If you rank each year from 2005 to 2018, most of the CAKN sites have had the top three warmest years within the last five years (Figure 11). The combined annual departure for 2018 was 1.1°C warmer than the period of record average. Other than the Upper

Charley site in YUCH, the higher elevation sites were warmer than lower elevation sites, driven by warmer cold season (October – March) temperatures due to persistent inversions (Figure 12).

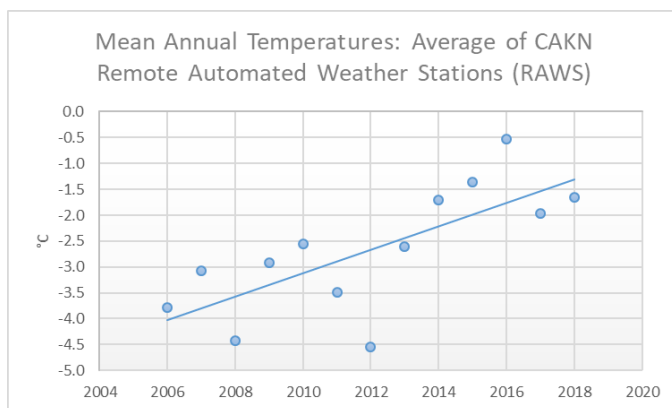


Figure 11. Mean annual temperatures, each dot represents the average of all of CAKN sites with a complete data record for that year.

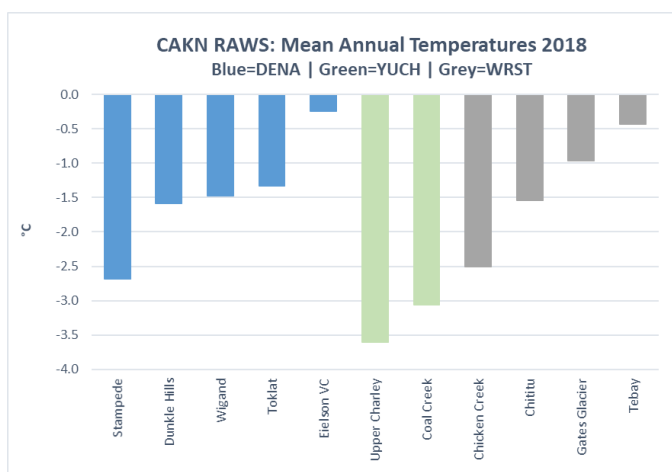


Figure 12. Mean annual temperatures at the CAKN sites in 2018.

Monthly means at the CAKN sites were near the period of record average for January and February, although Coal Creek in YUCH was an outlier and well above normal for January 2018. March was a warm month for the CAKN park sites, but especially for Coal Creek and Stampede, the low elevation valley sites, which were both $\sim 5^{\circ}\text{C}$ warmer than average. Late spring and early summer were cooler than average, with May having the coolest temperature departures. The higher elevation sites were cooler than the low elevation sites relative to average in May. July was a warm month throughout the network; on average, the sites were 1.5°C warmer than the 14 year average. Most of the locations throughout the network were cooler than average in August.

Once the fall season began, temperatures were much warmer than the period of record means for the remainder of the calendar year, similar to the statewide temperature departures. November had the largest positive temperature departures from average. Figure 13 shows seasonal fall temperatures

(September-November) from 2005-2018 at select sites in that range in elevation from 1109 m to 1330 m. The average fall temperature was above freezing for the first time in 14 years at both Eielson Visitor Center (DENA) and Gates Glacier (WRST).

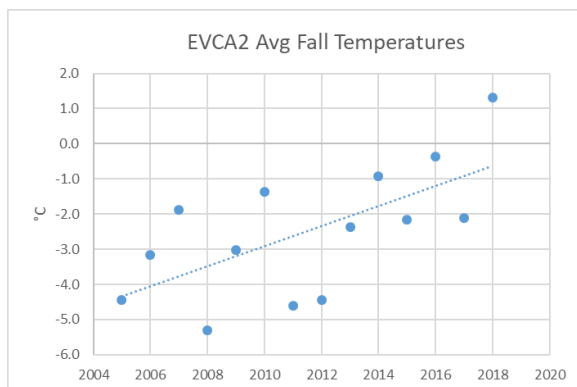
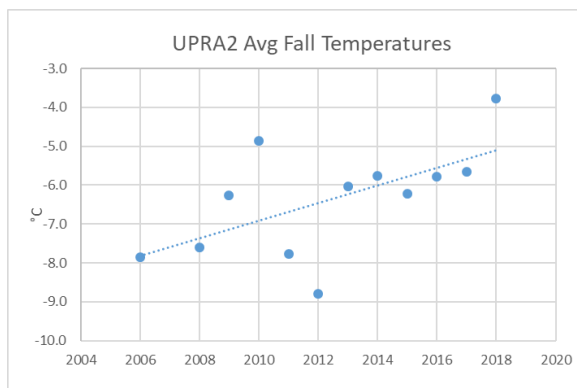
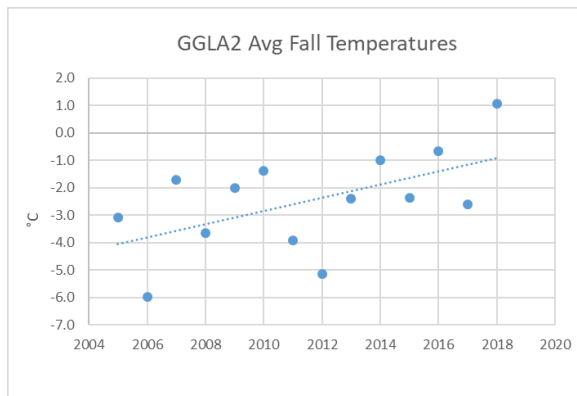


Figure 13. Average fall season temperatures at higher elevation mountain sites in the parks. Gates Glacier (GGLA2) in WRST (top), Upper Charley (UPRA2) in YUCH (middle), and Eielson VC (EVCA2) in DENA (bottom).

Twelve month running mean temperatures for select stations in the three CAKN parks reveal that air temperature patterns are similar among sites; cold years, such as 2008, 2012, and 2017, tend to be

cold region-wide and the same holds true for warm years although the absolute values differ depending on the latitude and elevation of each site (Figure 14).

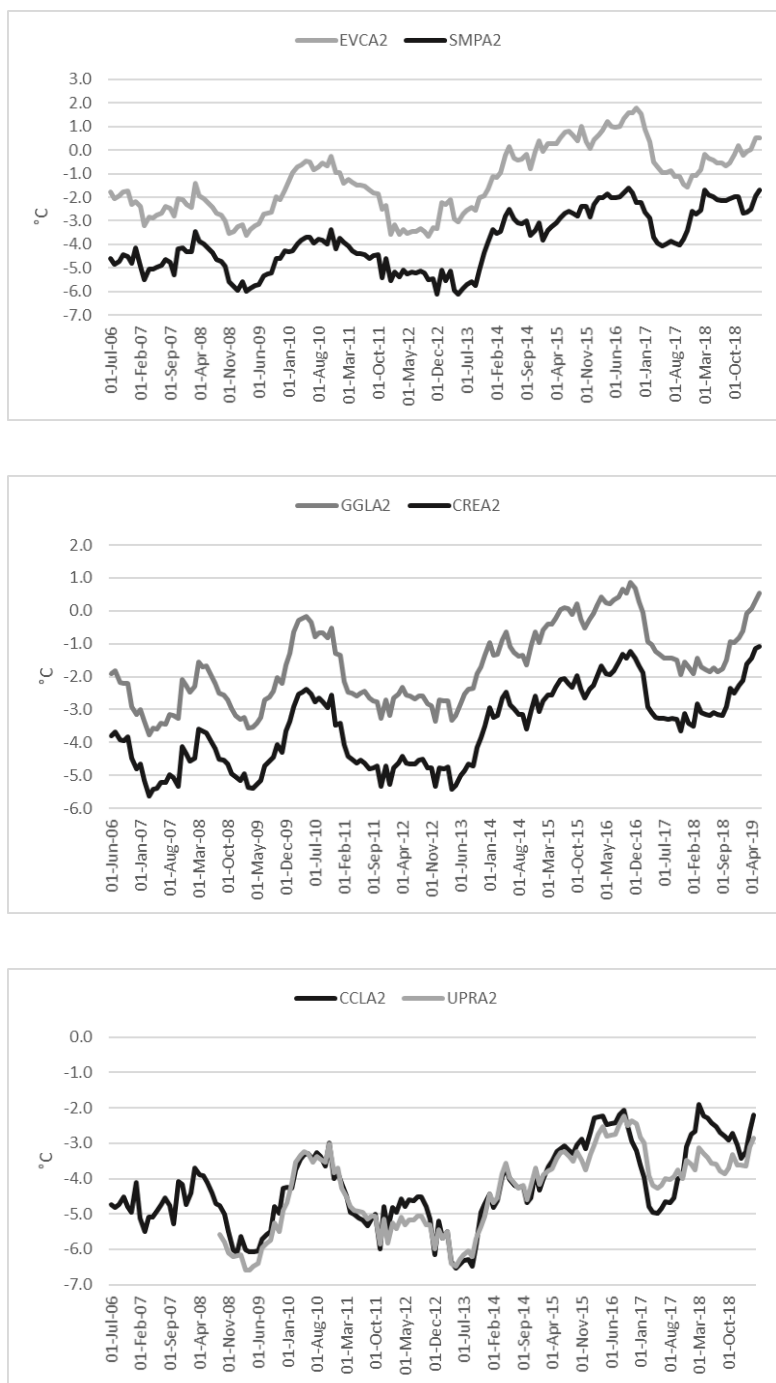


Figure 14. Twelve month running mean temperatures at sites in each CAKN park. Eielson Visitor Center (EVCA2) and Stampede (SMPA2) in DENA (top); Gates Glacier (GGLA2) and Chicken Creek (CREA2) in WRST (middle); and Coal Creek (CLCA2) and Upper Charley (UPRA2) in YUCH (bottom).

CAKN Climate Stations: 2018 Precipitation

CAKN SNOTEL Sites

For water year 2018, the Kantishna SNOTEL site recorded 356 mm of total winter precipitation (snow water equivalent) from October 1, 2017 through May 1, 2018. The total annual precipitation for the site was 886 mm, the highest on record since continuous year round measurements began in 2006 (Figure 15). The winter snow accounted for 40% of the total annual precipitation. Snow-on date was October 6, 2017 and the snow-off date was May 25, 2018. The gauge at Tokositna Valley recorded 648 mm of precipitation from October 1, 2017 through May 1, 2018. This is 45% of the total annual precipitation of 1427 mm for the 2018 water year. The snow on date at this site was October 23, 2017 and the snow off date was May 28, 2018.

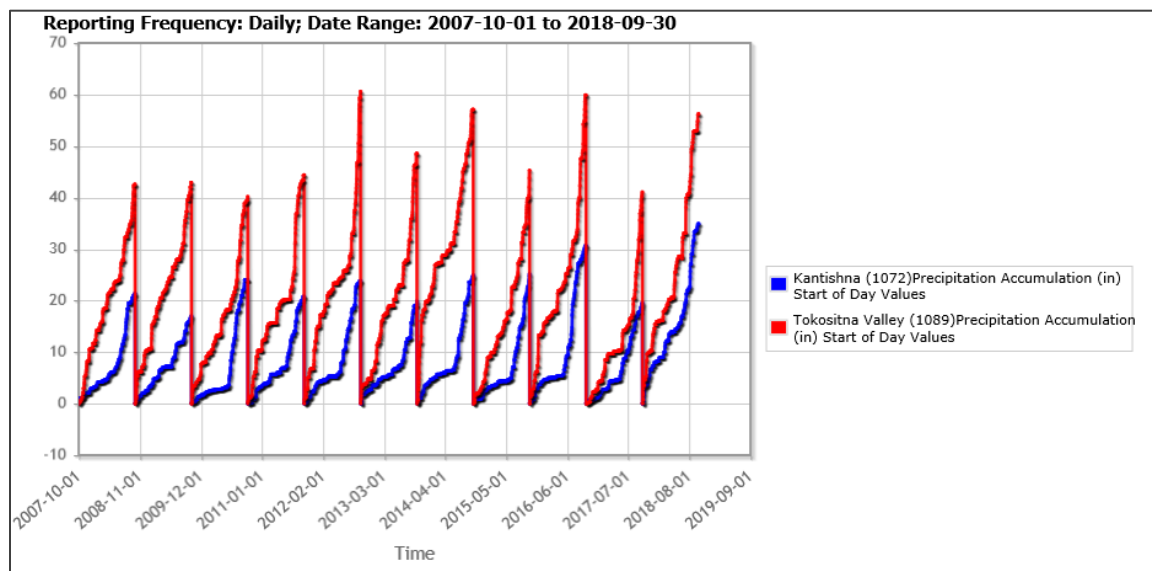


Figure 13. Precipitation accumulation at Tokositna Valley and Kantishna in DENA for water years 2007-2018 (NRCS 2019).

The SNOTEL site at May Creek reported 292 mm inches of accumulated snow water equivalent on May 1, 2018; the annual total precipitation was 556 mm inches, the highest on record at this site (2007-2018) (Figure 16). The winter snowfall accounted for 53% of the total precipitation for the year. The snow-on date was October 13, 2017 and the snow-off date was May 4, 2018. The Chisana SNOTEL site recorded 145 mm of total winter precipitation from Oct 1 through May 1. The total annual precipitation was 320 mm, which is about average for the period of record (2008-2018). The winter snow accounted for 45% of the total annual precipitation for the 2018 water year. The snow on date was October 14 and the snow off date was April 17.

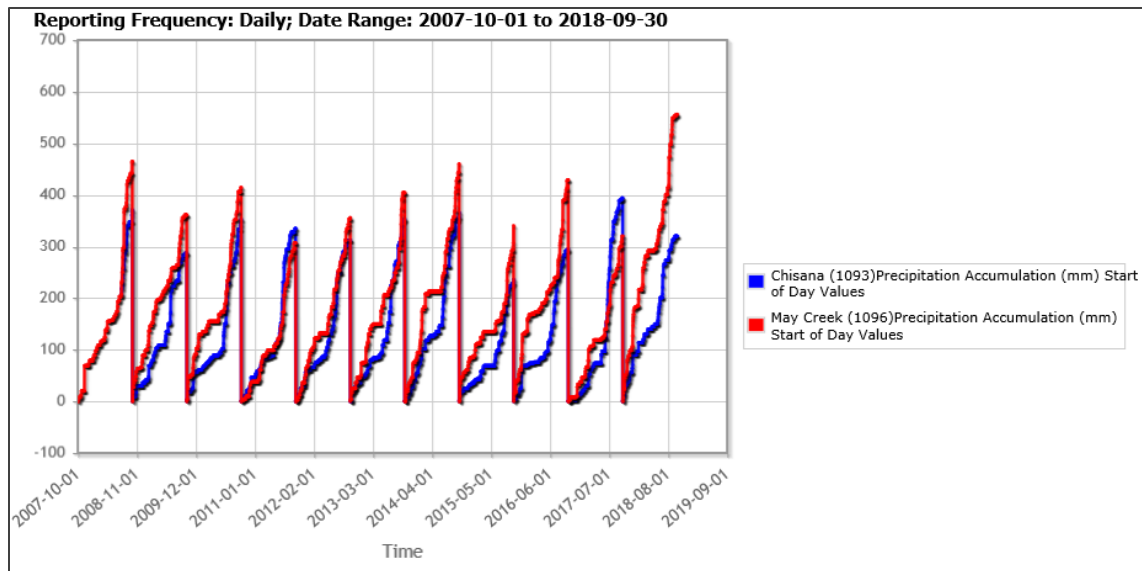


Figure 14. Precipitation accumulation at Chisana and May Creek in WRST for water years 2007-2018 (NRCS 2019).

The American Creek SNOTEL site near Eagle recorded a total of 99 mm of precipitation from October 1, 2017 through May 1, 2018. The total precipitation for the water year was 434 mm, the highest on record for this site (2011-2018) (Figure 17). The winter precipitation accounted for 23% of the annual total. The snow on date was October 20 and the snow off date was May 10, 2018.

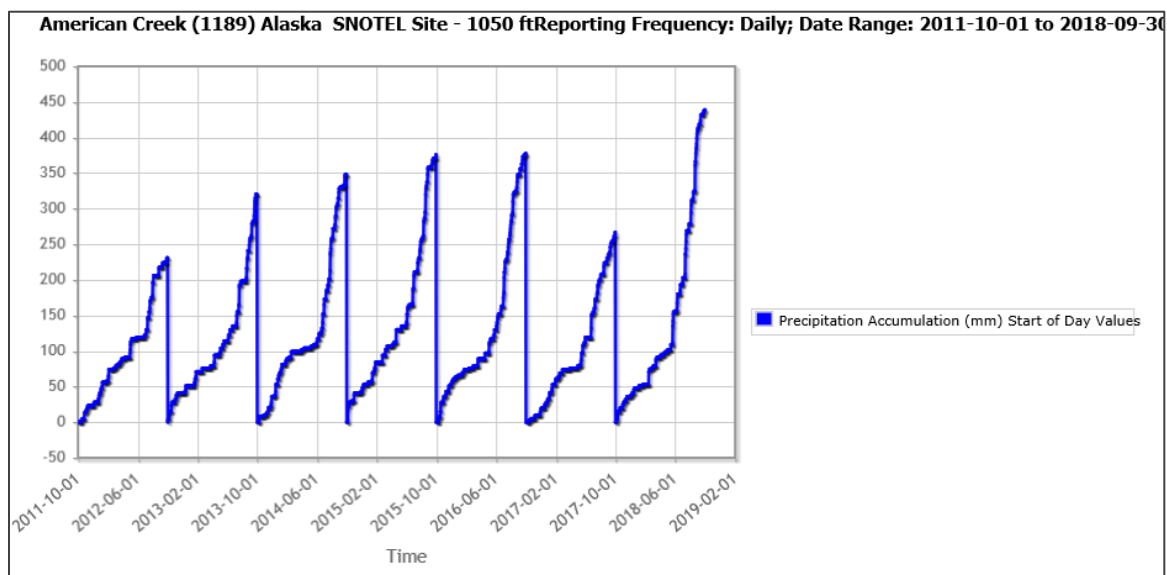


Figure 15. Precipitation accumulation at American Creek in Eagle near YUCH for water years 2011 -2018 (NRCS 2019).

2018 Summer Rainfall

Summer rainfall is measured at the CAKN RAWs sites and this summer was the wettest summer to date (2005-2018) at Gates Glacier in the Wrangell Mountains and Tebay in the Chugach Mountains in WRST with August as the wettest month. In Denali it was the second wettest summer on record at the Ruth Glacier site in the Tokosha Mountains on the south side of the Alaska Range. North of the Alaska Range, June and July were drier than average, but August was a wet month. It was the second wettest summer (since records began in 2005) at Toklat and Kantishna. The Coal Creek and Upper Charley sites in YUCH were relatively dry in June and July, and similar to other interior sites, had a relatively wet August. However, the YUCH sites did not receive as much rain as the Eagle community ~100 km to the east, which had a record wet summer.

Table 1 ranks a select set of the CAKN sites in order from wettest to driest for the climatological summer season that runs from June 1 through August 31. A map of precipitation rates for the summer of 2018 shows the highest rates (precipitation mm/day) centered over the eastern boundary of the state near Eagle and the Chugach Range in southern WRST (Figure 18).

Table 1. Summer 2018 rainfall totals at select sites in the CAKN parks.

Site	June Total mm	July Total mm	August Total mm	Summer Total mm
Ruth Glacier	101	138	407	646
Eielson VC	71	128	314	512
Wonder Lake CRN	86	77	236	399
Toklat	92	52	249	393
Gates Glacier	128	56	409	593
Tebay	94	48	157	299
Chititu	64	32	133	229
Chicken Creek	136	23	32	192
Chisana	86	13	38	137
Coal Creek	25	31	105	161
Upper Charley	58	19	82	160

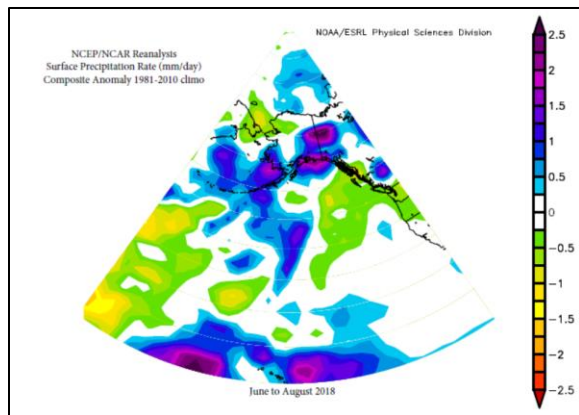


Figure 16. Map showing the surface precipitation rate (mm/day) anomalies for summer 2018 compared to the 1981-2010 normals (NOAA/ESRL, 2019).

Discussion

2018 was the second warmest year on record for Alaska. The mean annual temperature at the CAKN index sites averaged +1.1° C warmer than the 1981-2010 normal. The winter of 2017-2018 was the wettest on record for Gulkana and Denali had the snowiest winter season since 2000. It was the both the wettest summer and the wettest year on record at the interior community of Eagle near YUCH. Yakutat experienced the warmest fall on record and for the first time on record there was no snowfall in the cold season. Denali also had record low snow fall accumulation for fall of 2018. Statewide it was one of the warmest fall seasons on record.

The climate data for 2018 was compiled and summarized using CAKN data from the NPS sites and from index sites around the region. Seasonal weather summaries are also produced four times a year for DENA, WRST, and YUCH and provide relevant information on current weather statistics. These summaries are available from the network website or from [the Integrated Resource Management Application](#) (IRMA) portal.

The data from long-term sites are available from the [National Centers for Environmental Information \(NCEI\)](#). The CAKN climate stations transmit data via satellite and are available on the web from [MesoWest](#) and the [Western Regional Climate Center \(WRCC\)](#). An interagency agreement is in place for the maintenance, data archiving, and data dissemination for the four SNOTEL sites in the network. The data from the stations are transmitted hourly via satellite and are available on-line at [National Water and Climate Center](#).

This annual report provided a climate summary for the CAKN region in 2018 with brief references to the Alaska regional climate for 2018.

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