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Natural Resource Stewardship and Science

Annual Climate Summary 2018

Arctic Inventory and Monitoring Network

Natural Resource Data Series NPS/ARCN/NRDS—2021/1318

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ON THE COVER
Wildflowers in Kobuk Valley National Park
NPS Photo/Pam Sousanes

Annual Climate Summary 2018

Arctic Inventory and Monitoring Network

Natural Resource Data Series NPS/ARCN/NRDS—2021/1318

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

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.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Contents

Figures

Page

Tables

Page

Abstract

The Arctic Network (ARCN) climate monitoring program has seventeen remote weather stations to monitor climate in Gates of the Arctic National Park and Preserve (GAAR), Noatak National Preserve (NOAT), Kobuk Valley National Park (KOVA), Cape Krusenstern National Monument (CAKR), and Bering Land Bridge National Preserve (BELA). The main goal of the program is to operate these remote sites for the long term in order to help scientists and park managers understand the climate patterns across these large parks. This report summarizes the annual and monthly temperature and precipitation deviations at long-term sites near the parks and at the ARCN weather stations in the parks. The data are downloaded from each park station annually (during summer) and processed in the fall; this report summarizes the last full year of data, which is 2018.

2018 was much warmer than normal statewide and the fifth year in a row where the average temperature was among the top ten warmest years on record since 1925. The mean annual temperatures at the ARCN climate stations were also warm in 2018 even when compared against a relatively short measurement record (2012–2018). Annual temperatures ranged from −6.4 °C at Killik Pass in GAAR to −1.1 °C at the Serpentine site in BELA. The sites near the coast were warmer overall in 2018 than the interior sites, a result of warmer than normal ocean temperatures and record low sea ice extent in the Bering Sea. Across the network, the fall of 2018 was the warmest to date. Fall and early winter brought significant snow to the interior region near GAAR, while the coast experienced heavy snowfall in March. Overall, the snowfall throughout the ARCN region was above normal for the 2017–2018 season. Summer rainfall was greatest at the higher elevation interior sites in the ARCN network; August was the wettest month of summer 2018 across the network.

Between May and September of 2018, the Arctic Network staff performed annual site maintenance at the seventeen ARCN climate stations, four fire remoted automated weather stations (RAWS), and the Snotel site at Kelly Ranger Station in Noatak National Preserve. All of the 2018 ARCN 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/2254699.

Introduction

The Arctic Network Inventory and Monitoring program was established to monitor key ecosystem components of BELA, CAKR, KOVA, GAAR, and NOAT and to provide that information back to park managers for use in the stewardship of park resources. Climate is the most important broad-scale factor influencing ecosystems and therefore the natural resources of parks. Covering more than 19 million acres, the ARCN parks represent a large portion of the mountainous environment of the northern region of the state of Alaska and therefore provide an opportunity to understand climate gradients that have traditionally been a challenge to instrument and monitor. Because global climate models indicate that climate change and variability will be greatest at high latitudes, climate monitoring is critical to understanding the changing conditions of park ecosystems.

The 2018 field season marked the seventh year of operational climate monitoring in ARCN parks. Annual 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 equipment inventory and a maintenance report was completed after the field season to document the details of the site visits—these reports include the field notes, photos, logistics, and sensor metadata (Hill and Sousanes 2020 *in review*).

This annual data report summarizes the annual and monthly weather statistics of the most recent year for the Arctic Network climate monitoring program.

Arctic Network Climate Overview

The climate characteristics of the ARCN are influenced primarily by latitude, elevation, and the proximity to the coast. The high latitude drives the seasonal fluctuation of available solar radiation with limited incoming solar warmth in the winter and an abundance of available light in the summer. Temperature inversions are common through much of the year as a result of low water vapor content, extended periods of snow cover, and low solar radiation. Major topographical influences include the Brooks Range arcing through CAKR, NOAT, KOVA, and GAAR from the Chukchi Sea to the Canadian Border, and the Kigluaik and Bendeleben Mountains traversing the central Seward Peninsula in BELA. The proximity of both the Chukchi and Bering Seas to the parks in northwest Alaska and, more importantly, the presence or absence of sea ice influences land surface temperatures and available moisture for these parks. Davey (2007) provides a more detailed discussion of the climate of the Arctic Network.

Methods

Monthly and annual means and totals were compiled for the climate variables measured at 27 weather and climate stations in and around the ARCN network for 2018.

The ARCN climate monitoring program deployed 17 climate stations between 2011 and 2014 to capture elevational and latitudinal climate gradients within the parks. These sites are referred to as ARCN RAWS (remote automated weather stations). For detailed information on operating procedures see the ARCN weather and climate protocol implementation plan (Sousanes et al. 2017). There are four additional RAWS sites that operate under the Interagency Fire program that are included in this summary. The National Weather Service (NWS) operates three weather stations near the ARCN parks in the communities of Bettles, Kotzebue, and Nome, Alaska that have been in operation for > 50 years; at these sites the 2018 data was compared to the latest climate normal period (1981–2010). And finally, the Natural Resources Conservation Service (NRCS) has three snow telemetry (Snotel) sites near the ARCN parks that were used for year-round precipitation and snow information (Figure 1, Table 1). The Snotel sites were analyzed by water year (October 1–September 30). The ARCN data and metadata for 2018 are archived as discrete deliverables at https://irma.nps.gov/DataStore/Reference/Profile/2254699.

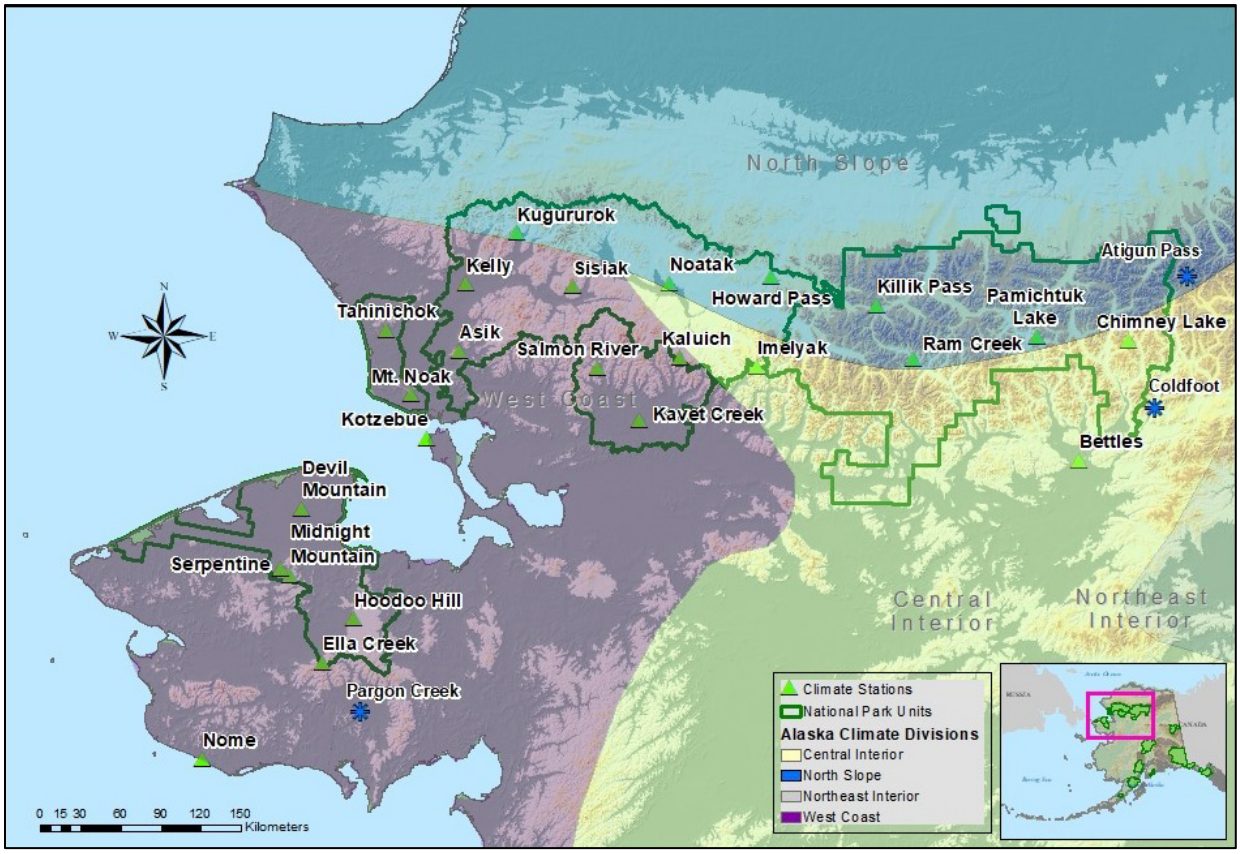

Figure 1. Map of climate stations in ARCN region, including three Snotel sites (blue stars).

Table 1. Climate stations included in this report.

Station Name	Latitude	Longitude	Elevation (m)	Station Type	Start of Record
Asik	67.475	−162.266	410	ARCN	Jul 2012
Atigun Pass	68.130	−149.480	1463	SNOTEL	Jan 1983
Bettles	66.540	−151.310	196	COOP	May 1951
Chimney Lake	67.714	−150.585	1166	ARCN	Aug 2012
Coldfoot	67.250	−150.180	317	SNOTEL	Mar 1995
Devil Mtn.	66.296	−164.520	87	ARCN	Aug 2011
Ella Creek	65.275	−163.820	709	ARCN	Sep 2012
Hoodoo Hill	65.595	−163.411	472	Fire RAWS	Jun 1992
Howard Pass	68.156	−156.896	642	ARCN	Jul 2011
Imelyak	67.545	−157.077	1099	ARCN	Jul 2012
Kaluich	67.573	−158.432	752	ARCN	Jul 2012
Kavet Creek	67.139	−159.044	72	Fire RAWS	Jun 1992
Kelly Station	67.930	−162.280	94	SNOTEL	Jul 2011
Killik Pass	67.984	−155.013	1326	ARCN	Aug 2012
Kotzebue	66.867	−162.633	5	COOP	Sep 1897
Kugururok	68.317	−161.492	335	ARCN	Jul 2014
Midnight Mtn.	65.820	−164.543	691	ARCN	Aug 2011
Mt. Noak	67.141	−162.995	257	ARCN	Jul 2011
Noatak	68.071	−158.704	300	Fire RAWS	Apr 1990
Nome	64.511	−165.440	11	COOP	Aug 1900
Pamichtuk Lake	67.766	−152.164	1019	ARCN	Aug 2012
Pargon Creek	64.990	−163.100	91	SNOTEL	Oct 2000
Ram Creek	67.624	−154.345	1252	ARCN	Aug 2012
Salmon River	67.460	−159.841	381	ARCN	Jul 2011
Serpentine	65.852	−164.708	143	ARCN	Aug 2011
Sisiak	67.995	−160.396	567	ARCN	Jul 2011
Tahinichok	67.550	−163.567	292	ARCN	Jul 2011

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, 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 ARCN climate station and checked for quality. ARCN 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

Temperature

Continuous temperature records date back to 2011 and 2012 for most of the ARCN RAWS. Table 2 lists the monthly and annual temperatures for these sites, with mean annual air temperatures (MAAT) ranging from −6.4°C at Killik Pass in GAAR to −1.1°C at the Serpentine site in BELA (Table 2, Figures 2 & 3). The sites near the coast were warmer overall in 2018 than the interior sites, a result of warmer than normal ocean temperatures and record low sea ice extent in the Bering Sea (Thoman et al. 2020). The 2018 mean annual temperature was the warmest to date for the Serpentine and Devil Mountain sites in BELA. Every other ARCN RAWS site was warmer in 2016.

Table 2. Monthly and annual mean temperatures (°C) from ARCN and Fire RAWS 2018.

Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Asik	−14.3	−8.4	−10.2	−4.2	3.2	10.3	12.3	9.0	7.3	0.2	−7.5	−14.8	−1.4
Chimney Lake	−15.4	−12.3	−12.7	−8.3	0.5	6.4	10.4	4.4	2.4	−3.5	−9.3	−14.2	−4.3
Devil Mtn.	−16.7	−10.1	−11.4	−6.6	0.4	8.7	11.9	9.2	7.4	0.7	−7.1	−15.7	−2.4
Ella Creek	−14.5	−8.0	−10.7	−5.7	−0.3	7.3	10.2	6.3	5.6	−0.7	−7.9	−16.5	−2.9
HooDoo RAWS [a]	−9.2	−9.4	−11.3	−6.8	1.2	9.0	12.4	8.4	7.1	1.3	−7.4	***−16.7*** [c]	−1.8
Howard Pass	−18.3	−10.7	−11.4	−9.8	0.5	6.3	11.6	5.5	4.6	−3.8	−12.8	−20.8	−4.9
Imelyak	−15.0	−9.9	−11.8	−7.1	0.3	5.2	8.9	4.2	3.5	−2.5	−8.4	−15.1	−4.0
Kaluich	−18.3	−10.9	−11.5	−9.4	0.5	6.8	11.3	5.7	4.6	−3.8	−12.3	−20.2	−4.8
Kavet Ck. RAWS [b]	−21.9	−14.2	−10.1	−4.0	6.4	13.5	16.4	11.0	8.2	−0.8	***−8.4*** [c]	***−17.1*** [c]	−1.7
Kelly RAWS	−19.0	−10.2	−10.2	−4.5	4.9	11.7	13.9	10.6	8.2	−0.1	−8.8	−16.9	−1.7
Killik Pass	−17.7	−12.1	−14.0	−10.9	−1.6	3.5	8.3	2.6	1.2	−5.6	−11.9	−18.2	−6.4
Kugururok	−16.5	−9.6	−10.9	−5.3	2.7	10.1	12.3	8.9	7.0	−1.2	−9.2	−16.9	−2.4
Midnight Mt.	−15.8	−8.0	−9.6	−6.6	−0.5	6.6	9.7	6.1	5.3	−1.2	−8.1	−17.2	−3.3
Mt. Noak	−15.2	−9.7	−10.9	−4.9	2.5	10.9	12.3	9.2	7.0	−0.5	−8.6	−15.7	−2.0
Noatak RAWS	−26.9	−17.1	−13.9	−10.7	2.9	9.9	13.6	8.0	6.0	−4.6	−14.5	−22.1	−5.8
Pamichtuk Lake	−17.0	−12.5	−12.7	−8.7	1.3	6.7	11.5	5.1	3.1	−3.5	−10.7	−16.9	−4.5
Ram Creek	−16.8	−12.0	−13.9	−9.1	−0.2	6.4	9.7	4.0	2.2	−4.8	−10.9	−16.9	−5.2
Salmon River	−16.1	−10.0	−10.8	−5.8	3.1	10.3	13.6	8.7	7.1	−1.4	−9.6	−16.7	−2.3
Serpentine	−14.9	−6.8	−9.2	−4.7	1.9	9.5	13.1	9.7	8.4	1.7	−6.3	−15.6	−1.1
Sisiak	−17.6	−11.0	−12.2	−8.1	1.8	8.4	11.6	7.0	5.3	−2.9	−11.0	−18.8	−4.0
Tahinichok	−15.7	−9.4	−11.1	−5.6	2.1	10.0	11.3	9.0	6.9	−0.6	−8.7	−16.3	−2.4

[a] Quartz Creek RAWS was used for HooDoo.

[b] Kiana RAWS for Kavet Creek.

[c] Missing data; nearby station data was used as a proxy, also shown in bold italics.

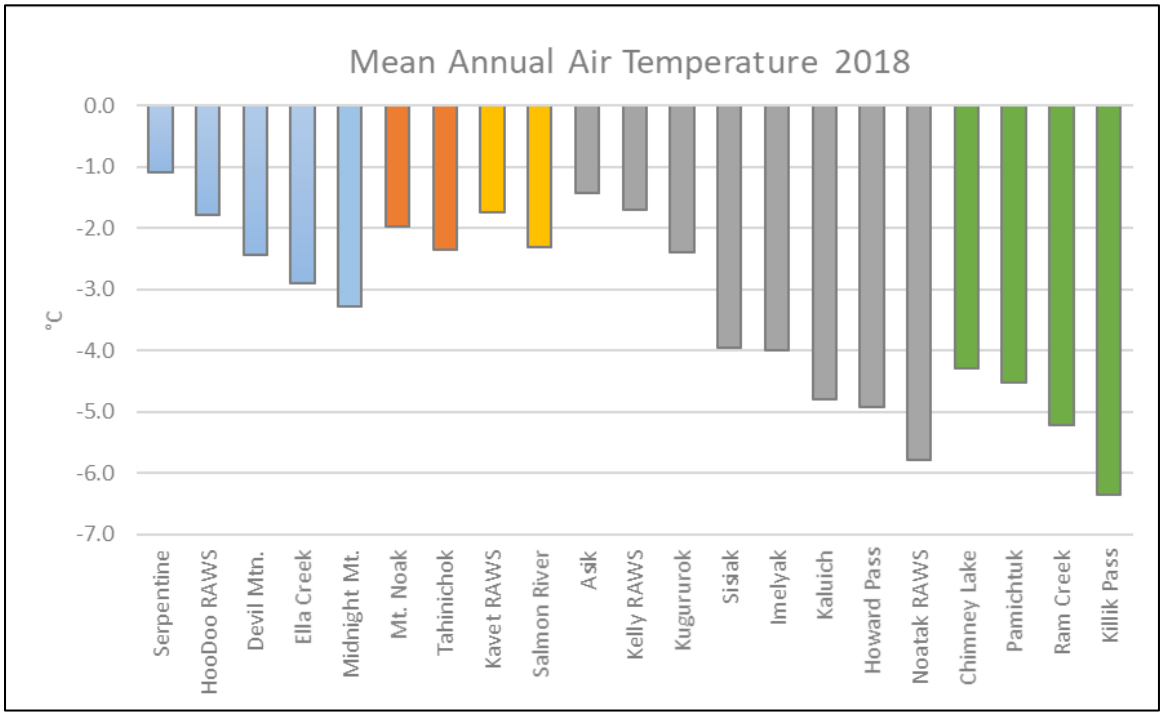

Figure 2. ARCN 2018 mean annual air temperatures, color coded by park. Blue=BELA, orange=CAKR, yellow=KOVA, gray=NOAT, and green=GAAR.

For calendar year 2018, December was the coldest month with a network-wide average temperature of −17.1°C, edging out January by 0.3°C. July was the warmest month with an average temperature of 11.7°C ARCN wide. July was 3.3°C warmer than June and 4.5°C warmer than August (all ARCN RAWS combined average).

The 2017–2018 winter season was the warmest to date for each of the ARCN RAWS sites (the winter season includes December [2017], January, and February). The temperatures were particularly warm in February throughout ARCN, especially in the western regions. Serpentine Hot Springs in BELA was the warmest site with a mean monthly temperature of −6.8°C. On average at ARCN sites, February was 5.9°C warmer than January and 1.4°C warmer than March despite increasing sunlight as spring progressed.

April temperatures were warmest along the western coast while the higher elevation mountain sites in NOAT and GAAR remained cool with monthly means between −8°C and −11°C. The high elevation interior locations remained cool into late spring with temperatures averaging several degrees cooler for May 2018 than the previous few years. The 2018 spring season (March, April, May) was the warmest on record (2012–2018) for Serpentine and Devil Mountain, while spring 2016 was warmer at most of the other sites, except for Kaluich in NOAT and the GAAR stations which were all warmer in the spring of 2015.

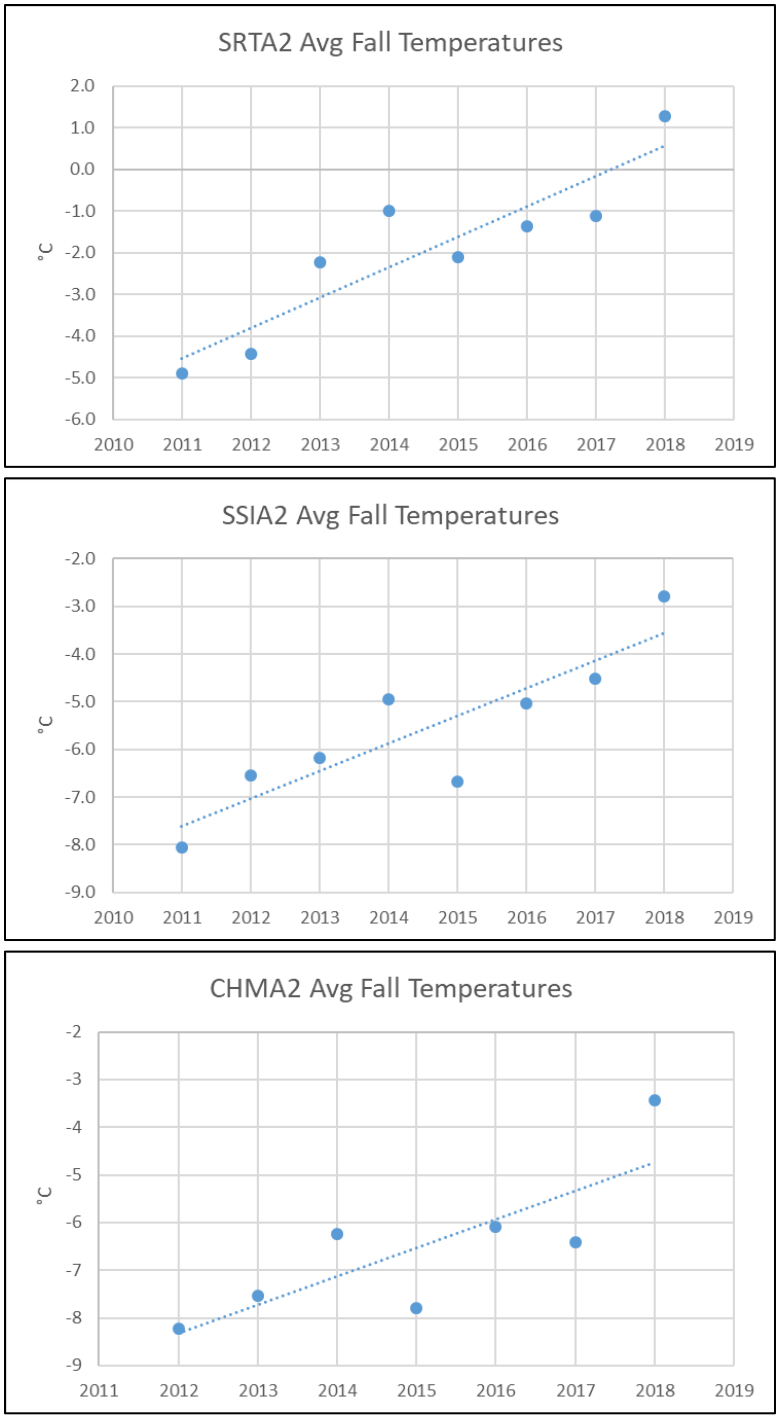

Figure 3. Average fall temperatures at Serpentine (SRTA2) in BELA (top), Sisiak (SSIA2) in NOAT (middle), and Chimney Lake (CHMA2) in GAAR.

Average summer (June, July, August) temperatures ranged from a cool 4.8°C at Killik Pass in the northwest corner of GAAR to a much warmer 10.9°C at Salmon River in KOVA. Summer seasonal temperatures were more variable spatially, with Devil Mountain, Asik, Ram Creek, and Chimney Lake having the warmest summer temperatures to date in 2018, while the summer of 2013 or 2016 were warmer for the other sites.

September and October are generally transition months in the Arctic when temperatures fall below freezing and snow begins to accumulate. However, temperatures in fall of 2018 were much warmer than the period of record average (Figure 3). Across the network, the fall of 2018 was, by far, the warmest to date.

Summer Precipitation

ARCN stations measure summer rainfall with a standard tipping bucket. The ARCN and fire RAWS rain gages are not shielded from wind and therefore measurements may underestimate precipitation at exposed locations. NRCS SNOTEL sites in or near the park boundaries provide a robust precipitation measurement in both summer and winter. Table 3 summarizes summer rainfall measurements at select ARCN RAWS, fire RAWS, and SNOTEL stations.

Table 3. Rainfall (mm) from select ARCN, Fire RAWS, and SNOTEL stations in 2018.

Station Name	Station Type	June	July	August	*Summer (June–August)*
Chimney Lake	ARCN	66	47	79	193
HooDoo RAWS	Fire RAWS	34	52	70	166
Kaluich	ARCN	111	81	74	266
Kavet RAWS	Fire RAWS	39	47	65	179
Killik Pass	ARCN	39	69	105	213
Kugururok	ARCN	39	45	47	132
Noatak RAWS	Fire RAWS	30	44	63	150
Pamichtuk Lake	ARCN	73	62	77	212
Serpentine	ARCN	23	35	72	130
Atigun Pass	SNOTEL	89	132	142	363
Coldfoot	SNOTEL	56	53	94	203
Kelly Station	SNOTEL	20	69	23	112
Pargon Creek	SNOTEL	51	28	53	132

Summer (June–August) rainfall measurements were highly variable in 2018 and ranged from 112 mm at Kelly Station to 363 mm at Atigun Pass (Table 3, Figure 4). The highest monthly total was 142 mm recorded at Atigun Pass in August. Elevation, topography, and storm tracks explain some of the spatial variability as well as localized (convective) summer rain showers that are common in mountainous regions. August was the rainiest month at all stations with >70 mm recorded at most

sites. In summer 2018, Atigun Pass and Kaluich recorded the most rainfall and the lowest-elevation sites (Kelly, Pargon Creek, Kugururok) recorded the least amount of rainfall.

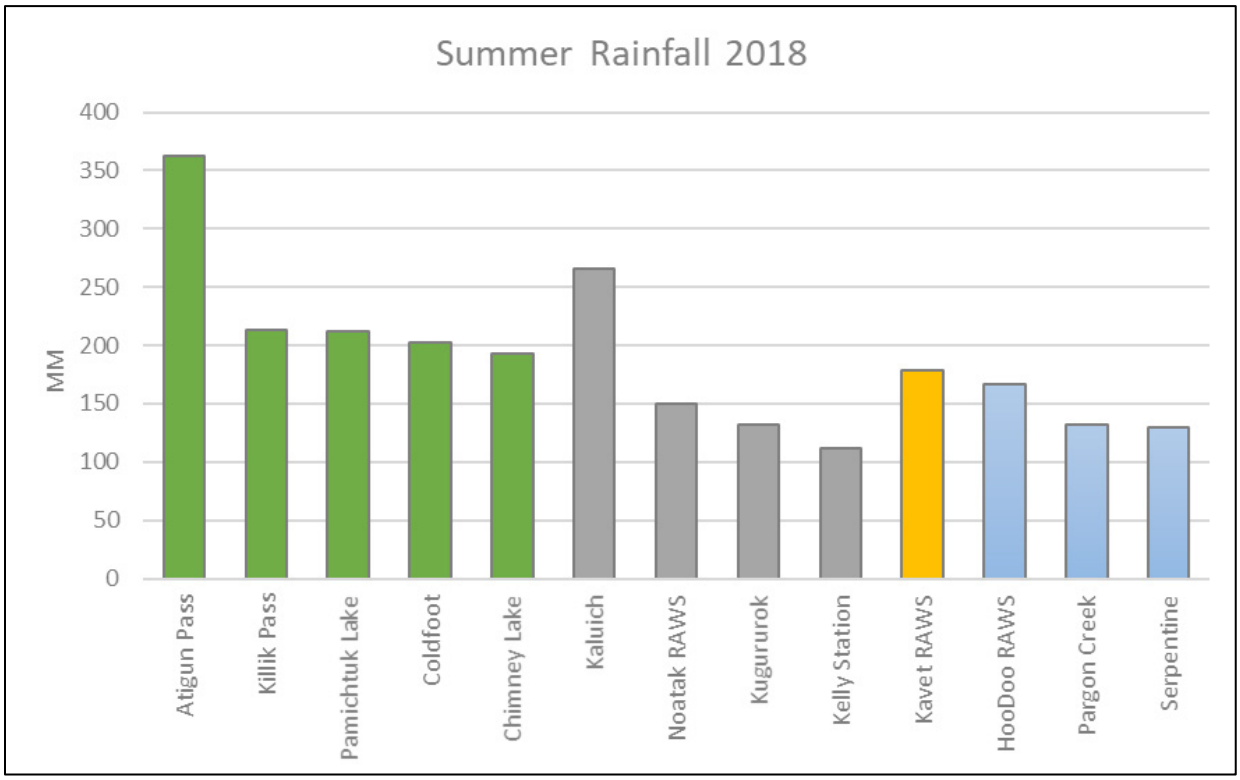

Figure 4. ARCN 2018 summer precipitation. Green sites are in or near GAAR, grey WEAR, and blue BELA.

Snow and Year-round Precipitation (2017–2018 Season)

SNOTEL Sites

Year-round precipitation (rain and melted snow) is recorded at the SNOTEL sites at Coldfoot, Atigun Pass, Kelly Station, and Pargon Creek (Table 4). For water year 2018 (October 1, 2017–September 30, 2018), the Coldfoot SNOTEL site recorded 208 mm of total winter precipitation (snow water equivalent, SWE) from October 1, 2017 through May 1, 2018, which is 112% of the 1981–2010 normal. The total annual precipitation for the site was 465 mm; the cold season precipitation accounted for 45% of the total annual precipitation. The period of continuous snow was from October 5 to May 20. Peak snow depth was 89 cm which occurred on March 9. Peak SWE occurred about a month later with 213 mm on April 2 through 9 and was the highest SWE at the site since 2009 (Figure 5).

Table 4. Precipitation and snow summary statistics for SNOTEL stations in water year 2018.

Site	Winter Precip. mm (% of normal) [a,c]	Annual Precip. mm (% of normal)	Peak Spring Snow Depth cm (Date)	Peak SWE mm (Date) [b]	Snow On	Snow Off
Coldfoot	208 (112%)	465 (100%)	89 (Mar 9)	213 (April 2–9)	10/5/17	5/20/18
Atigun Pass	163 (96%)	645 (110%)	157 (May 20)	–	8/26/17	7/1/18
Kelly Station	262 ( ) [d]	406 ( ) [d]	104 (Mar 24)	254 (April 6–28)	9/27/17	5/20/18
Pargon Creek	236 (138%)	406 (118%)	81 (Mar. 20)	–	10/17/17	5/18/18

[a] The winter season is defined as October 1–May 1.

[b] Snow water equivalent (SWE) is not measured at Atigun Pass or Pargon Creek.

[c] For sites with < 20 years of data, a ratio adjustment method was applied to the normal, based on the normal of a neighboring site with a long period of record (NRCS 2020a).

[d] Kelly Station does not have 1981–2010 normals calculated as of 2020, this site is still being reviewed.

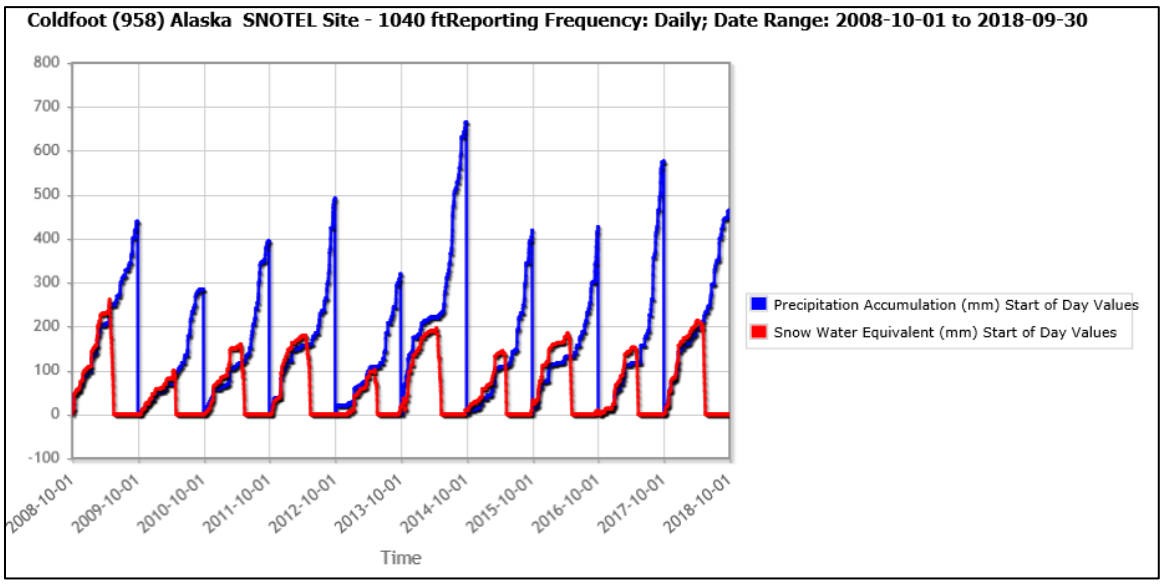

Figure 5. Cumulative precipitation and SWE at Coldfoot over the past decade by water year ending with the 2018 water year. Graph generated from NRCS (NRCS 2020).

The precipitation gage at Atigun Pass recorded 645 mm of precipitation from October 1, 2017 through September 30. The annual precipitation was 110% of normal. The period of continuous snow at Atigun Pass was more than 10 months long, starting on August 26 and persisting through July 1. The peak snow depth at this site is generally in mid-May; in 2018 it occurred on May 20. On May 30 there was still 119 cm on the ground, the most for this date in over a decade of measurements. (Figure 6).

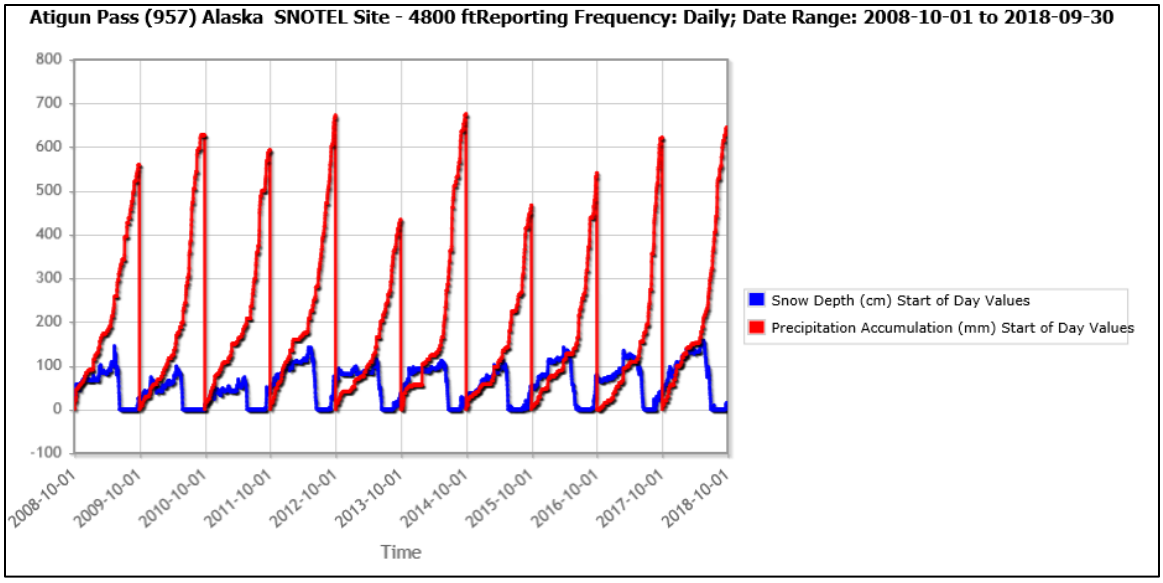

Figure 6. Cumulative precipitation and snow depth at Atigun Pass over the past decade by water year ending with the 2018 water year. Graph generated from NRCS (NRCS 2020).

Kelly Station in NOAT had 262 mm of winter precipitation for the 2018 water year, about 65% of the annual total (406 mm) and about twice as much as the past six years (record dates back to 2012). Snow depth reached its maximum of 104 cm on March 24 with a peak water content of 236 mm (Figure 7). Snow cover persisted at Kelly Station from September 27 through May 20. This was the second latest melt-out date since 2013 when it melted on May 27. The record is relatively short with only six years of data

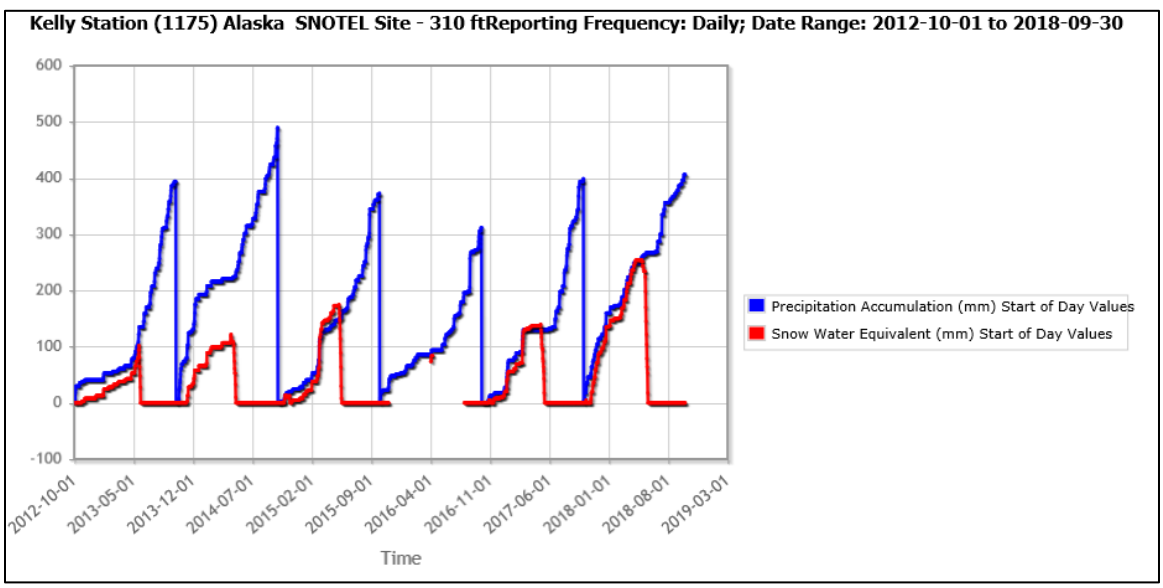

Figure 7. Cumulative precipitation and SWE for the past seven years at Kelly Station in NOAT ending with water year 2018. Graph generated from NRCS (NRCS 2020).

Pargon Creek has been operating since 2000 and this was the fifth wettest year to date at this site. The total precipitation for water year 2018 was 406 mm, with a total of 236 mm for the cold season, which is 58% of the annual total. Peak snow depth was on March 20 with 81 cm, the deepest since 2009 (Figure 8). Continuous snow cover was established on October 17 and melt-out was on May 18.

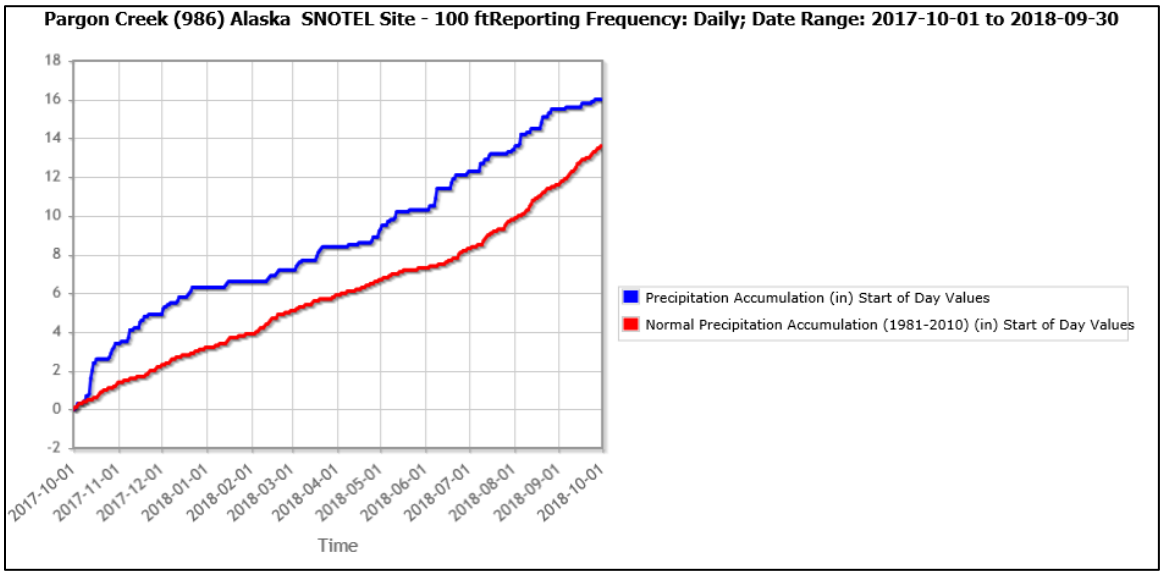

Figure 8. Cumulative precipitation for water year 2018 (October 1, 2017–September 30, 2018) at Pargon Creek. Graph generated from NRCS (NRCS 2020).

2018 Weather at Bettles, Kotzebue, Nome (index sites)

Temperature – Index Sites

Bettles, Kotzebue, and Nome had mean annual air temperatures well above the long-term normal for 2018 (Table 5). It was the second warmest year on record for Kotzebue. 2018 was the fifth consecutive year where the mean annual temperature at Kotzebue was among the five warmest years on record. The warmest years to date in order are: 2016, 2018, 2014, 2017, and 2015. It was the fourth warmest year on record for Nome, the top five warmest years in Nome were: 2016, 2014, 2018, 1978, and 2004. In Bettles, 2018 was the 5th warmest year on record. In Bettles, the warmest years are not all recent. The top five are: 2016, 1981, 1978, 1993 and 2018.

The 2017–18 winter season was warm along the west coast of Alaska as mentioned previously. Numerous warm storms from the south prevented sea ice from establishing off the coast of Alaska. The open water moderated temperatures over land leading to a relatively warm cold season. Winter 2017–2018 was 6.2°C warmer than the 1981–2010 normal in Kotzebue, 4.7°C warmer than normal in Nome, and 3.7°C warmer than normal in Bettles.

Table 5. 2018 monthly mean temperatures and *departures* from 1981–2010 normal for index sites in ARCN (°C).

Station Name	Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Bettles	Average Temperature (°C)	−23.1	−19.1	−12.9	−4.9	7.4	13.6	16.3	10.4	6.1	−1.8	−12.8	−18.3	−3.3
	Departure from Normal (°C)	*+0.3*	*+1.5*	*+2.4*	*−0.1*	*+0.5*	*−1.2*	*+0.9*	*−1.0*	*+1.3*	*+5.4*	*+5.6*	*+2.7*	*+1.5*
Kotzebue	Average Temperature (°C)	−17.1	−10.6	−10.7	−5.9	2.2	11.6	14.7	11.9	9.5	1.3	−7.9	−16.4	−1.4
	Departure from Normal (°C)	*+2.2*	*+7.6*	*+6.5*	*+4.4*	*+2.2*	*+4.0*	*+2.2*	*+1.0*	*+3.8*	*+5.6*	*+4.8*	*+0.1*	*+3.7*
Nome	Average Temperature (°C)	−14.9	−13.7	−12.1	−6.4	2.7	8.8	11.2	10.1	6.0	−1.8	−8.4	−12.5	−2.6
	Departure from Normal	*+1.3*	*+6.1*	*+3.7*	*+3.2*	*−0.3*	*+1.7*	*0.7*	*0.0*	*+2.5*	*+5.4*	*+4.4*	*−2.7*	*+2.2*

Warm temperatures persisted into March and April, with the strongest warm anomalies continuing at the west coast sites of Nome and Kotzebue. It was the second warmest spring on record in Kotzebue. Overall, the average summer season (June–August) temperature was just below normal for Bettles mostly driven by cool temperatures in mid-June and early August. It was just above normal in Nome (+0.8°C), while Kotzebue's warm trend continued with an average summer temperature +2.4°C above the 1981–2010 normal. Statewide, fall 2018 was the second warmest fall on record with records dating back to 1925. The west coast of Alaska was the warmest on record (Figure 9).

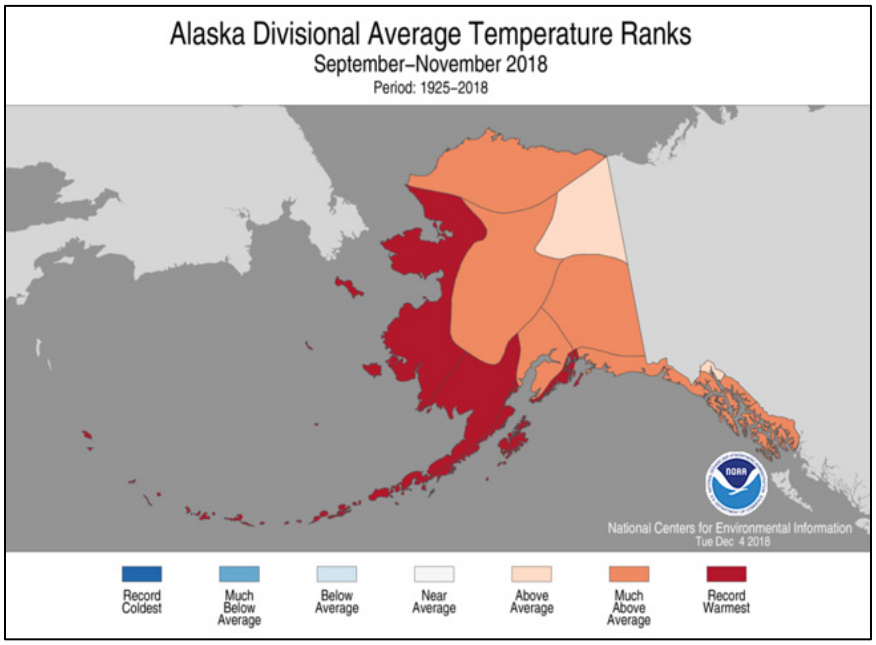

Figure 9. Record warm fall along Alaska's west coast for 2018. Graph courtesy of NCEI (https://www.ncdc.noaa.gov/cag).

Precipitation – Index Sites

Annual precipitation totals at the ARCN index sites varied from 91% of normal in Nome to 130% of normal at Bettles (Table 6). March was a particularly wet (snowy) month at both Kotzebue (482% of normal) and Nome (382% of normal). April precipitation was near normal at Bettles and Nome, but below normal in Kotzebue. May precipitation was well above normal in Bettles, drier than normal in Nome, and about average in Kotzebue. Nome remained drier than normal through the summer, while Bettles was wetter than normal for June and August and Kotzebue was wetter than normal for July. September was a dry month for all of the sites. Bettles ended the calendar year with a very snowy December, with precipitation at 380% of normal.

Table 6. Monthly and annual precipitation (mm) and *departures* from normal (%) for 2018.

Station Name	Precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Bettles	Total Precipitation (mm)	26	14	12	16	62	67	39	77	31	39	19	89	490
	Percent of Normal	*127%*	*65%*	*84%*	*107%*	*277%*	*187%*	*65%*	*114%*	*64%*	*146%*	*80%*	*380%*	*130%*
Kotzebue	Total Precipitation (mm)	7	28	54	5	9	16	48	44	10	20	16	17	274
	Percent of Normal	*42%*	*170%*	*482%*	*35%*	*90%*	*109%*	*130%*	*80%*	*24%*	*76%*	*83%*	*89%*	*98%*
Nome	Total Precipitation (mm)	12	37	63	23	11	7	38	65	33	43	38	21	390
	Percent of Normal	*49%*	*157%*	*382%*	*121%*	*49%*	*29%*	*71%*	*79%*	*53%*	*105%*	*122%*	*76%*	*91%*

Snow – Index Sites

The seasonal snowfall total (July 1–June 30) for Bettles was above normal with 289 cm for the season, about 124% of normal. Most of the snow fell during late fall and early winter. In Kotzebue, the 2017–2018 snowfall total was 273 cm, which is 180% of normal. Total snowfall in Nome was 295 cm for the season, 154% of normal (Table 7). November and March were the snowiest months of the season for both Kotzebue and Nome, however most of the winter months had more snow than normal.

Table 7. Monthly and annual snowfall (cm) and *departures* from normal (cm) July 2017–June 2018.

Station Name	Snowfall	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
Bettles	Total Snowfall (cm)	0	0	0	56	54	82	41	27	25	1	2	0	289
	Departure from Normal (cm)	*0*	*0*	*−6*	*+24*	*+13*	*+43*	*+6*	*−9*	*+2*	*−15*	*−1*	*0*	*+57*
Kotzebue	Total Snowfall (cm)	0	0	0	22	82	50	11	36	62	3	7	0	273
	Departure from Normal (cm)	*0*	*0*	*−2*	*+6*	*+56*	*+21*	*−12*	*+12*	*+47*	*−10*	*+4*	*0*	*+121*
Nome	Total Snowfall (cm)	0	0	0	24	56	47	15	44	86	22	1	0	295
	Departure from Normal (cm)	*0*	*0*	*−2*	*+12*	*+26*	*+11*	*−18*	*+13*	*+64*	*+3*	*−5*	*−1*	*+103*

Discussion

The mean annual temperature at the ARCN index sites averaged +2.5°C warmer than the 1981–2010 normal. The sites near the coast were warmer overall in 2018 than the interior sites, a result of warmer than normal ocean temperatures and record low sea ice extent in the Bering Sea. The 2017–2018 winter season was the warmest winter since the ARCN RAWS sites were established in 2011/12. Summer seasonal temperatures were more variable. Across the network, the fall of 2018 was the warmest to date.

Annual precipitation totals at the ARCN index sites varied from 91% of normal in Nome to 130% of normal at Bettles. There was abundant snowfall in March for the coastal areas and abundant snow in late fall/early winter (2017) for the interior region. Summer precipitation was more variable with drier areas along the southern Seward Peninula and wetter areas in the interior region. Early fall was dry throughout the region. The GAAR region ended the calendar year with a very snowy December.

The climate data for 2018 were compiled and summarized using ARCN data from the NPS sites and from index sites around the region. Seasonal weather summaries are also produced four times a year for WEAR, BELA, and GAAR 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 ARCN 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 ARCN region in 2018 with brief references to the Alaska regional climate for 2018.

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