Alaska Climate Research Center

The Alaska State Climate Center

ANNUAL REPORT 2021

Denali and the surging Muldrow glacier on September 27, 2021. Phto: Carl Schmitt

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KEY OBSERVATIONS

Temperature

Alaska was colder than average for the second year in a row compared to the 1991-2020 normal. 2021 was the coldest year since 2012. Temperatures were much cooler than normal across most of the state from February through the beginning of April, as well as in November. A cool spring is characteristic of La Niña. Overall, sixteen first-order stations recorded negative departures from normal annual temperatures and three stations recorded positive annual departures.

Precipitation

The North Slope, West Coast, and Interior were wetter than normal, with Fairbanks setting a new record for highest total annual precipitation. The Cook Inlet and Bristol Bay regions were drier than normal. Conditions across the Panhandle were close to average.

Snowfall

Above average snowfall was observed in Fairbanks and Juneau, while Anchorage and Bettles recorded below average snowfall for the year.

Wildfire season

Like 2020, the 2021 wildfire season was not extremely active, with only 389 fires recorded and 254,000 acres of land burnt. The 2021 burnt acreage was significantly lower than the average of 650,000 acres, let alone the 2 million acres burnt during the 2019 wildfire season.

Sea ice extent

2021 began with below average sea ice extent. Late in the season, low pressure across the Arctic Ocean helped slow the decline of sea ice. The seasonal sea ice extent maximum of 14.77 million square kilometers occurred on March 21, tied for the 7th lowest maximum in the satellite record. The minimum was reached on September 16 at 4.72 million square

2021 Temperature in Detail

Annual Temperature at the First-Order Stations

The majority of Alaska's first-order weather stations reported colder than average annual temperatures in 2021 (Figure 1, Table 1). The mean deviation from normal across the 19 selected stations was -1.17°F, with the largest negative departures recorded at Kotzebue and King Salmon and the largest positive departures recorded at St. Paul Island and Cold Bay. The statewide mean deviation per the NCEI nClimDiv data set (Vose et al., 2014) was even lower at -1.6°F. 2021 was the coldest year since 2012 (Figure 2). Individually, all of Alaska's climate regions were colder than average. The North Slope and West Coast had the largest negative departures from normal (Figure 3).

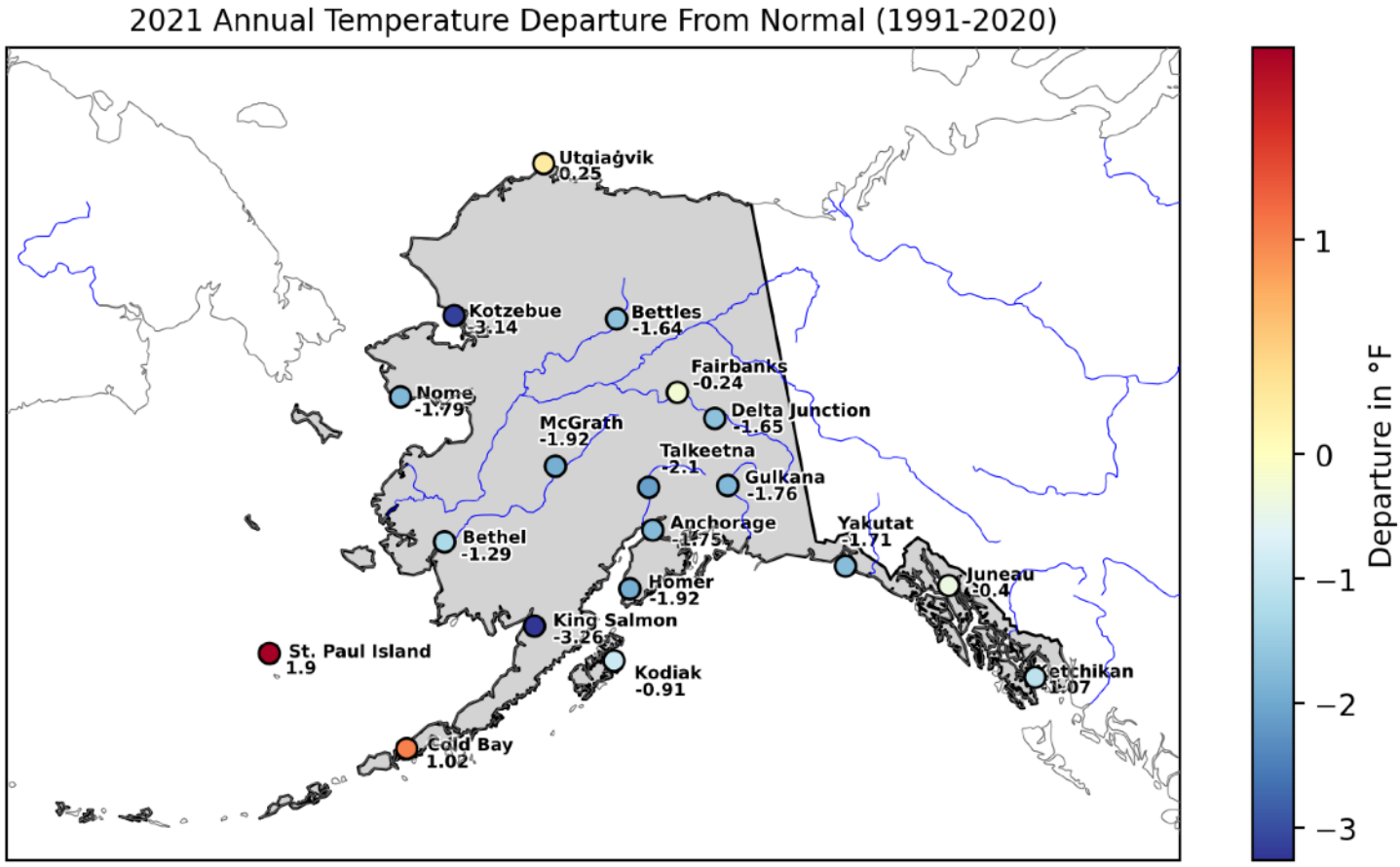

Figure 1. *Mean annual (2021) air temperature deviations (in Fahrenheit) from the normal (1991 - 2020) for selected stations.*

Monthly Mean Temperatures

In absolute terms, July was the warmest month of 2021 (55.9°F) and August was the second warmest (53.0°F). In terms of deviation from the climatological mean, January was the warmest month with a station average deviation of 5.2°F above normal. October was the second warmest month in relative terms with a much lower average deviation of 0.6°F. February was the coldest month (10.4°F) in absolute terms and had the second most negative deviation from normal (-5.4°F). November was the second coldest month (12.6°F) in absolute terms and had the the greatest negative deviation from normal (-8.1°F).

At 16 of 19 stations, monthly temperatures peaked in July, with three stations recorded in their highest monthly means in August. The coldest month of the year for most stations was February (10). Five stations recorded their codes months of the year in November and four in December. The highest (positive) deviations were recorded in January for 15 stations, in February for Cold Bay and St. Paul Island, in May for Nome, and in December for Bethel. The lowest (negative) deviations occurred in November (11 station), February (Bettles, Delta, Fairbanks, Gulkana, Utqiaġvik), and December (Juneau, Ketchikan, Yakutat).

Figures 5 through 9 show climographs for, respectively, Anchorage, Utqiaġvik (Barrow), Fairbanks, Juneau, and St. Paul Island, as examples of 2021 temperature deviations in the five main climate regions of Alaska. Much of the state had warmer than average temperatures during most of January, when below normal sea level pressure and mild air from the mid-latitudes prevailed across Alaska, followed by colder than average temperatures in February. During February and March, Anchorage had 57 consecutive days with daily maximum temperatures below freezing (Figure 5), the second longest streak on record. Many locations also experienced an abrupt shift in temperatures during April. Record breaking minimums during the first two weeks of the month were followed by warmer than normal temperatures during the second half of the month. On April 18, Fairbanks reached 60°F, an almost 100°F degree increase in temperature from the previous week. The Juneau airport recorded its earliest 70°F day on record on April 17. The first 80°F day in Juneau was on June 27, during a period of record high temperatures in southeastern Alaska associated with the high-pressure heat dome over the Pacific Northwest (Figure 8). In Fairbanks, fall was characterized by swings between periods of

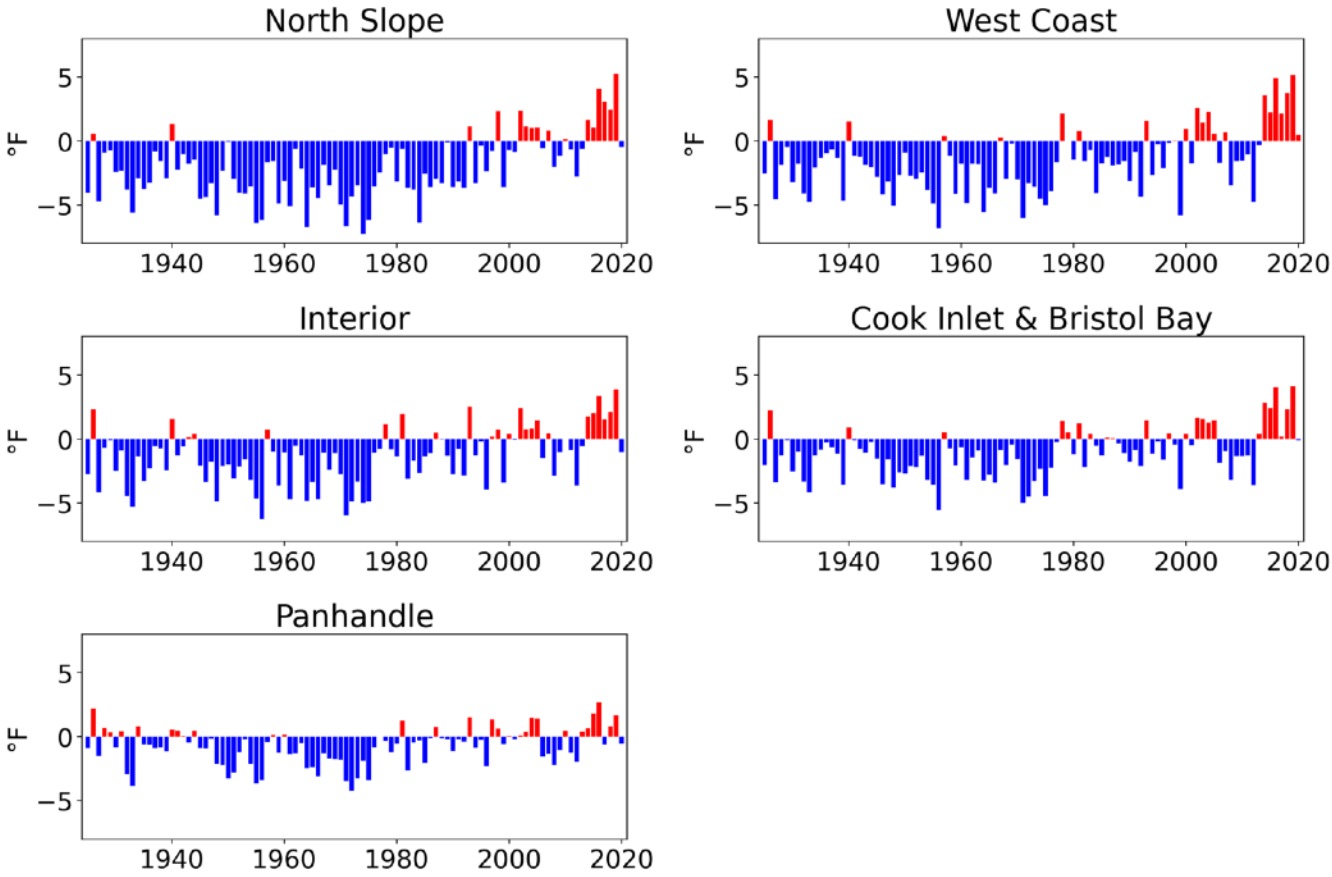

Figure 3. *Time series of annual mean temperature departure from the normal (1991-2020) for the Alaska climate divisions. Data source: NOAA nClimDiv.*

above normal and below normal temperatures (Figure 7). Upper-level troughing and anomalously high pressure over the Bering Sea brought arctic air to the state in November, with colder than normal temperatures persisting over much of the state. The largest departures from normal were recorded over the West Coast (Figure 9). In December, upper-level ridging centered over Alaska. An atmospheric river transported warm and moist air northward, with temperatures often above normal in Anchorage, Utqiaġvik, Fairbanks, and St. Paul Island. Downstream of the ridge, temperatures were below normal in Juneau through the end of the year.

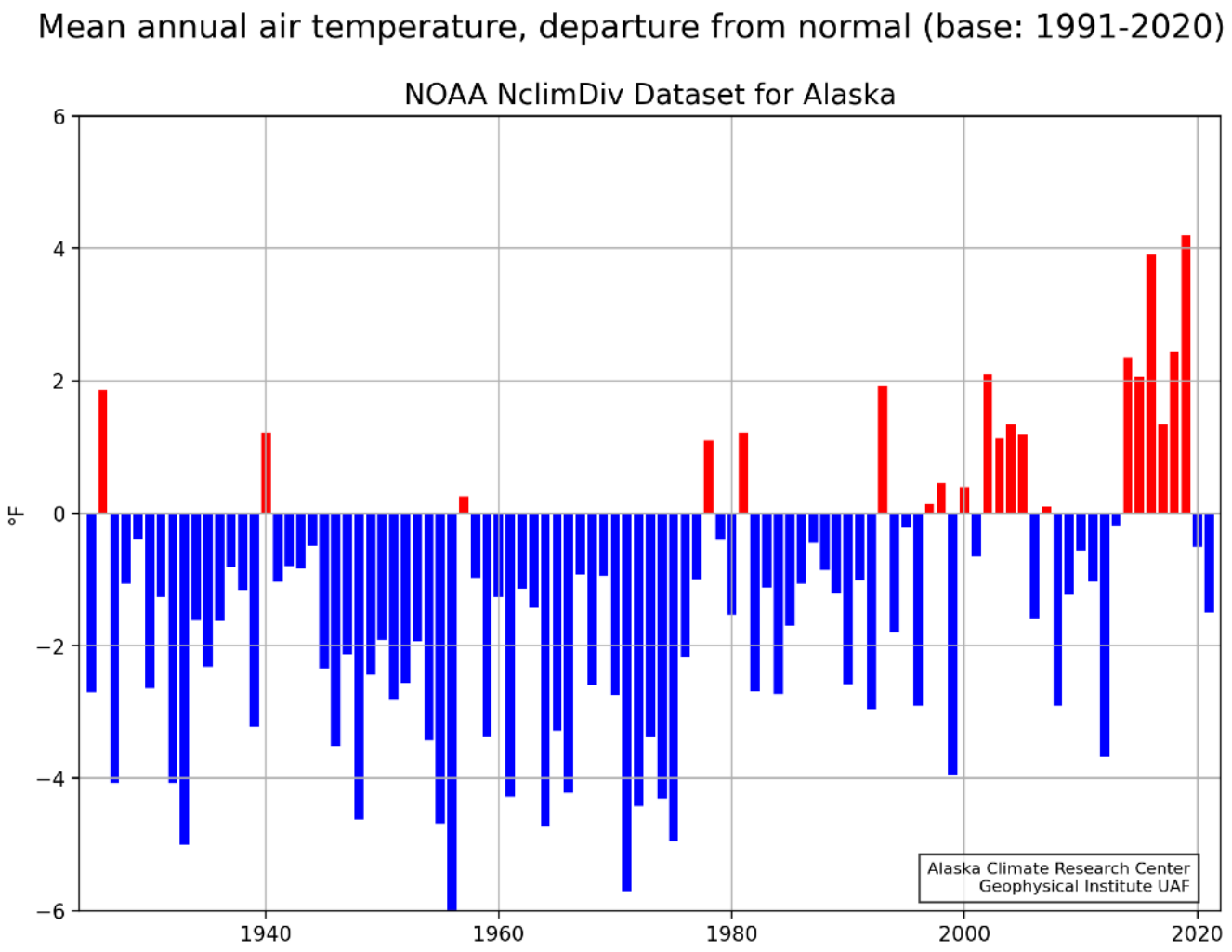

Figure 2. *Mean annual (2021) air temperature deviations (in Fahrenheit) from the normal (1991-2020).*

Temperature connections with Large-Scale Circulations

The large-scale coupling between atmospheric circulation, El Niño-Southern Oscillation (ENSO) and the related Pacific Decadal Oscillation (PDO) also influences the climate of Alaska (Mantua et al. 1997, Hartmann and Wendler 2005). For example, a positive PDO usually leads to above normal temperatures in Alaska. In 2021, the PDO was negative throughout the year, with the lowest values from October to December and less negative values in January and August.

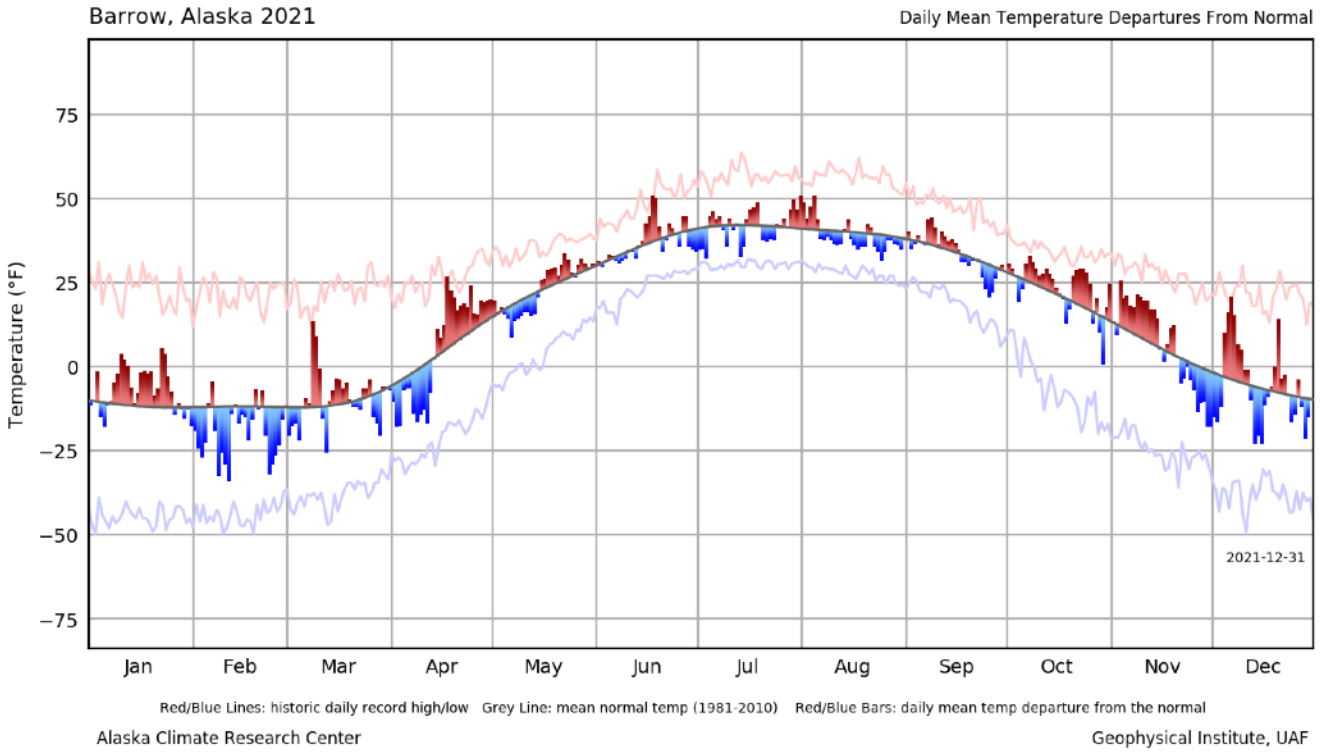

Figure 6. *Mean normal temperature, daily mean departure from normal, and historic daily record minimum and maximum for Utqiaġvik (Barrow), 2021.*

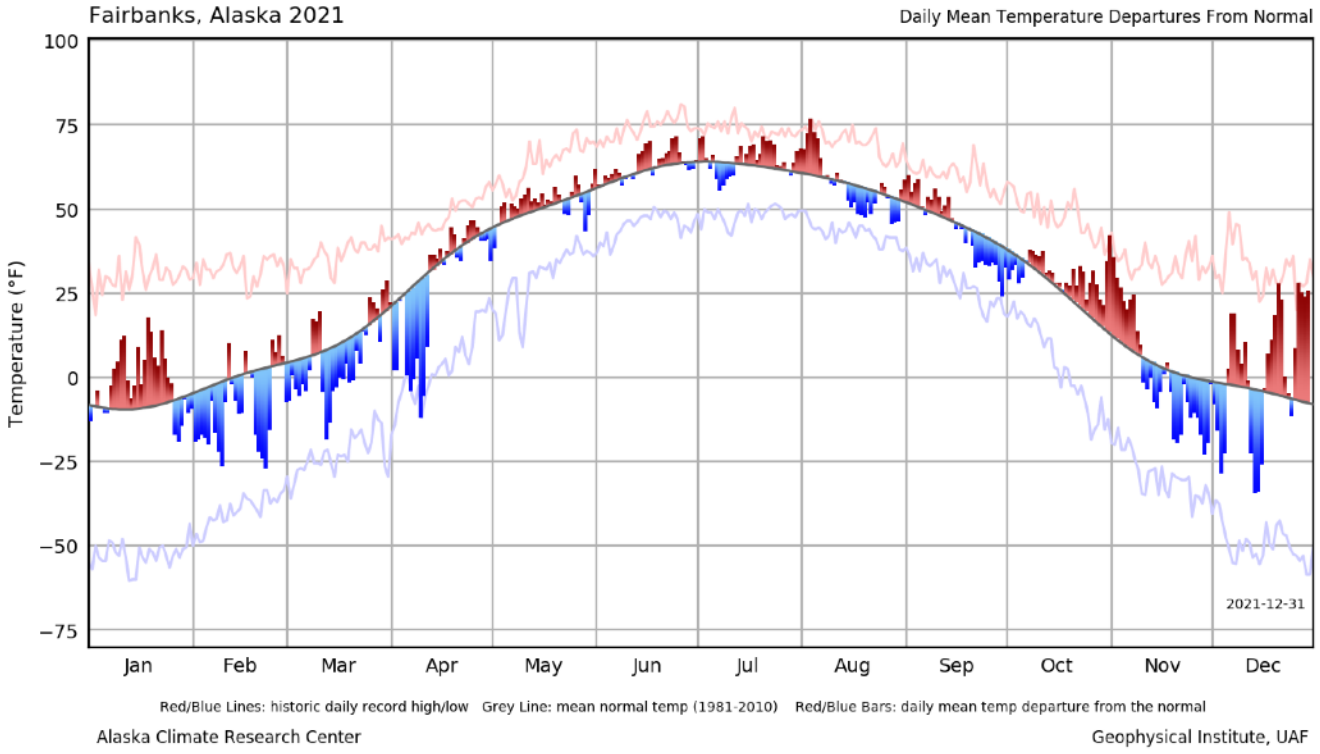

Figure 7. *Mean normal temperature, daily mean departure from normal, and historic daily record minimum and maximum for Fairbanks, 2021.*

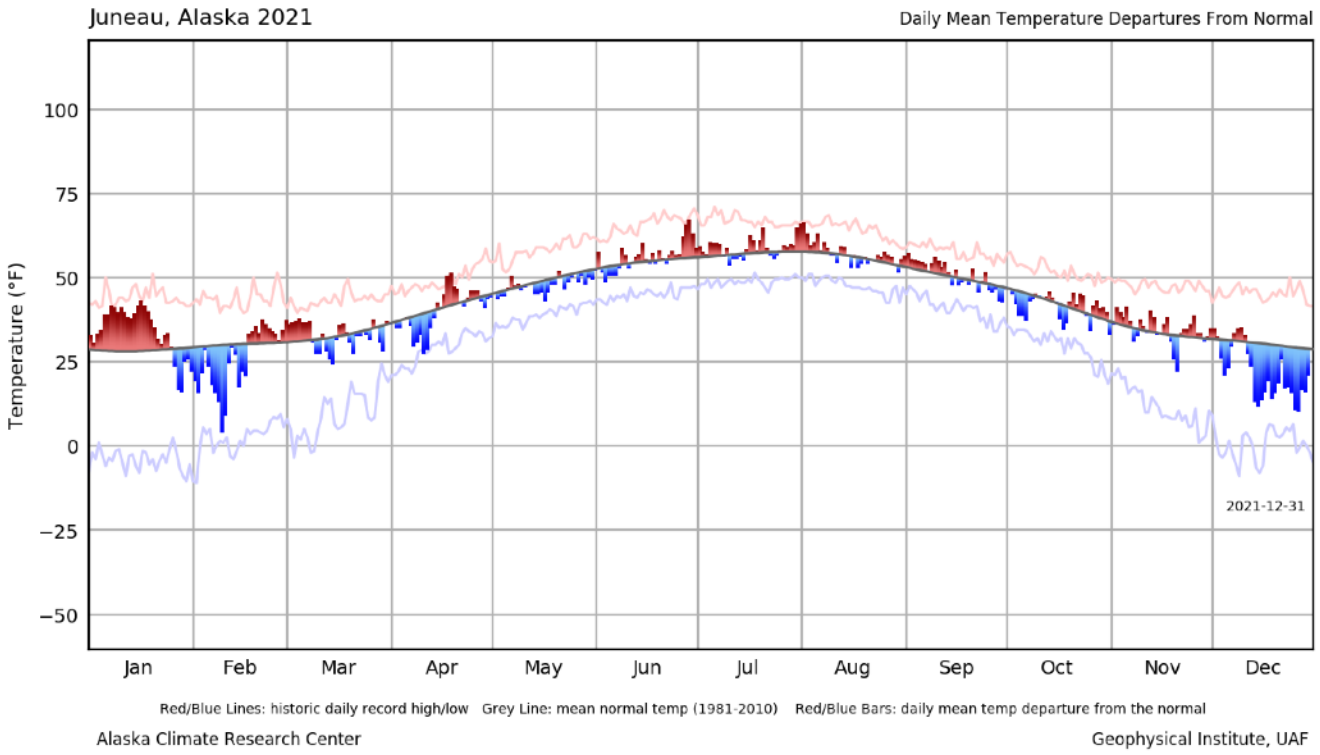

Figure 8. *Mean normal temperature, daily mean departure from normal, and historic daily record minimum and maximum for Juneau, 2021.*

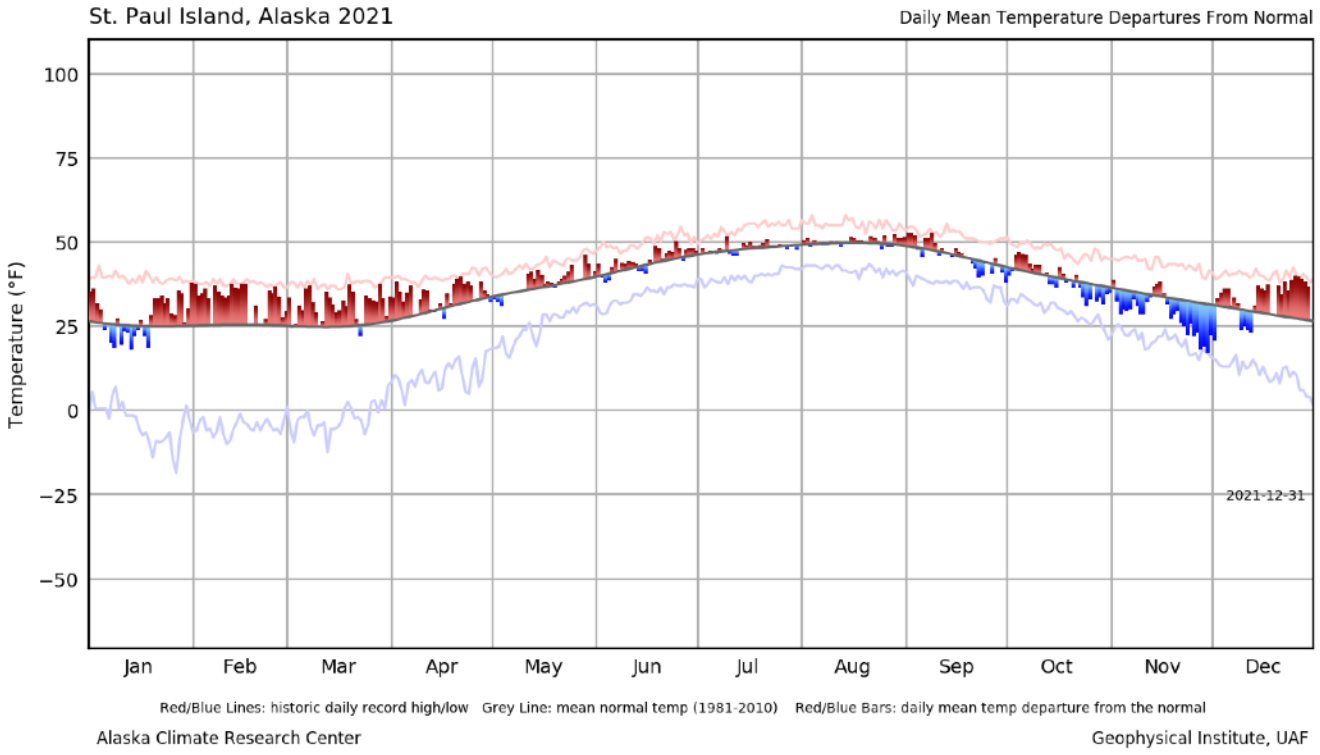

Figure 9. *Mean normal temperature, daily mean departure from normal, and historic daily record minimum and maximum for St. Paul Island, 2021.*

ENSO phases cycle from positive to negative on a much shorter time scale than the roughly decadal time scale of the PDO, with cold/warm phases typically lasting 6-8 months. El Niño winters are characteristically warm and wet over southern Alaska and western Canada, while La Niña winters are characteristically cold and dry over the same areas. 2021 saw two consecutive La Ninas with a transition to ENSO neutral conditions in between. This is sometimes referred to as a "double-dip". Unlike El Niño phases, it is common for La Niña to occur in consecutive winters. The interaction between PDO and ENSO is complex, but the combination of cold (La Niña) conditions and negative PDO led to overall cooler annual temperatures for Alaska.

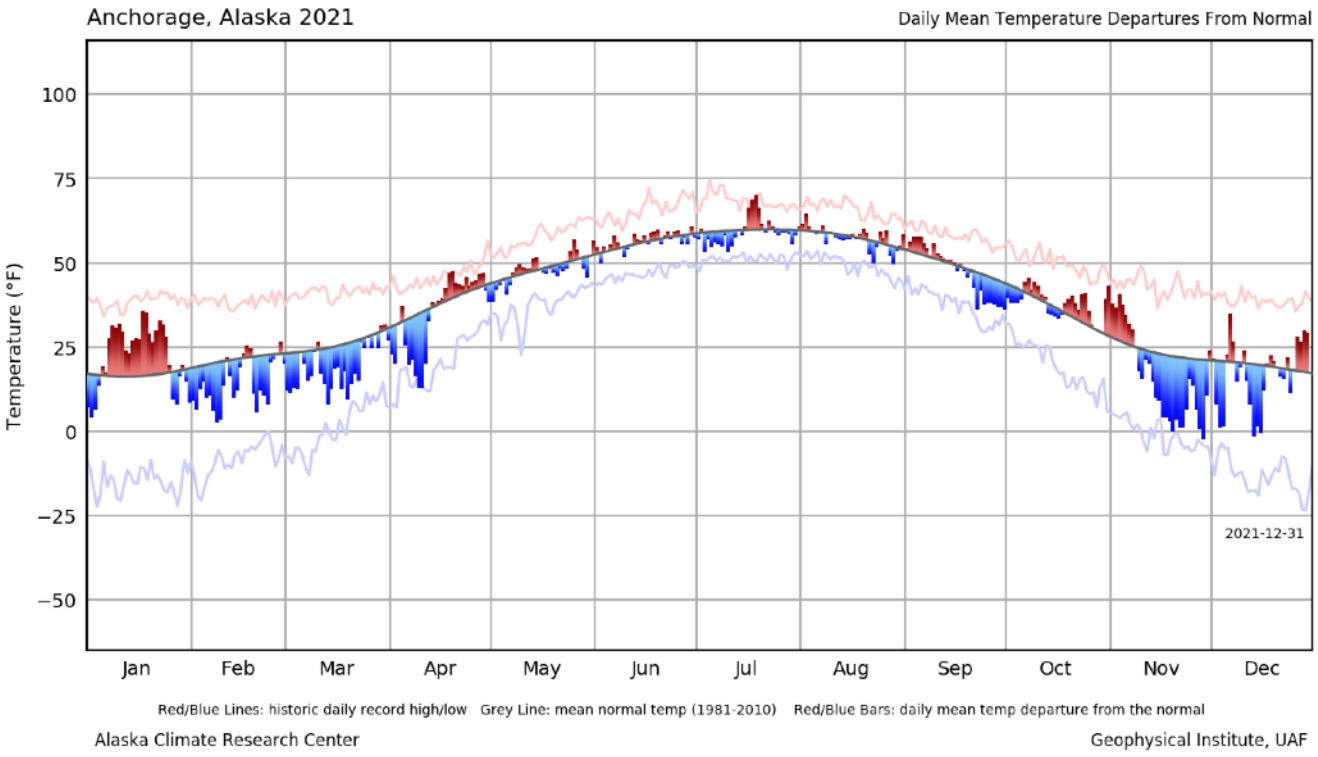

Figure 5. *Mean normal temperature, daily mean departure from normal, and historic daily record minimum and maximum for Anchorage, 2021.*

Station	Observed (ºF)	Normal (ºF)	Departure (ºF)
Anchorage	35.9	37.6	-1.8
Bethel	30.2	31.4	-1.3
Bettles	22.4	23.9	-1.6
Cold Bay	40.4	39.3	1.0
Delta Junction	28.4	30.0	-1.6
Fairbanks	28.2	28.3	-0.2
Gulkana	26.6	28.3	-1.8
Homer	38.2	40.0	-1.9
Juneau	41.8	42.1	-0.4
Ketchikan	45.0	46.0	-1.1
King Salmon	33.4	36.5	-3.3
Kodiak	41.4	42.2	-0.9
Kotzebue	21.0	24.0	-3.1
McGrath*	25.5	28.9	-1.9
Nome	26.3	28.0	-1.8
St. Paul Island*	38.2	35.9	1.9
Talkeetna	33.9	35.9	-2.1
Utqiaġvik	14.1	13.7	0.2
Yakutat	39.6	41.1	-1.7

Table 1. *Mean temperature for 2021, normal temperature (1991-2020) and deviations from the mean for the 19 first-order meteorological stations in Alaska, color-coded to Figure 1. An asterisk (*) marks stations with more than five days of missing data. Missing data are ignored in the computation of the mean.*

2021 Precipitation in Detail

Annual Precipitation at the First-Order Stations

In 2021, the North Slope, West Coast, and Interior saw above average annual precipitation. The Panhandle was close to normal, while the Cook Inlet and Bristol Bay regions were drier than normal (Figure 10). In absolute terms, Ketchikan was the wettest of the First Order stations in 2021 with a total of 143.7 in. For Ketchikan, this value is slightly below the climatological mean (149.5 in, 96% of normal). The station with the largest deviation from normal was Fairbanks, where 2021 was the wettest year on record. Other above average precipitation stations include Utqiaġvik, Kotzebue, Nome, St. Paul Island, Juneau, Gulkana, and Bethel. Close to average precipitation was observed in Bettles, King Salmon, Cold Bay, Anchorage, Homer, and Kodiak, while below normal precipitation was observed in Yakutat and Talkeetna (Figure 11&12, Table 2).

Monthly Precipitation at the First-Order Stations

Starting off 2021, precipitation was below normal over the Interior and North Slope in January, with monthly sums ranging from 7% to 49% of normal. Monthly totals were above normal over the Southwest, where Cold Bay received double the precipitation typical for the month. In February, precipitation was significantly above normal over much of the Interior and Bristol Bay, and below normal over the Seward Peninsula, Kodiak Island, northern Panhandle, and just south of the Brooks Range. Monthly totals were significantly above normal (2-4 times above normal) in McGrath, King Salmon, Fairbanks, Utqiaġvik, and Bethel. In March, precipitation was above normal across almost all of the state, with much higher than normal totals (3-4 times above normal) recorded at Fairbanks and Bethel for the second month in a row. The West Coast, Panhandle, and much of the Interior received near average or above normal precipitation in April, while the Cook Inlet and North Slope received below normal precipitation. For the third month in a row, Fairbanks recorded especially high deviations from normal and recorded almost 4 times the average monthly amount of precipitation. Much drier than normal conditions were present over the West Coast and Interior in May, while the rest of the state recorded at or above normal precipitation. In June, substantially higher than normal precipitation was observed over the Northwest as well as the northern and central Panhandle, while drier than normal conditions prevailed across the Interior, Bristol Bay, and Cook Inlet. The West Coast and North Slope received above normal precipitation during July, with Kotzebue

recording its wettest month on record. Nome recording its second wettest July on record, while the eastern Interior and southern Gulf Coast saw below normal precipitation.

In August, a shift to a cooler and wetter weather patterns brought wetter than normal conditions to the Interior, Cook Inlet, and the Panhandle. The Northwest was also wetter than normal during this month, while the North Slope and parts of the Bristol Bay area were drier than normal. September was a dry month for much of the state, with only the North Slope and parts of the Panhandle receiving near or above normal precipitation. October was a wetter than normal month over Bristol Bay, parts of the Interior and Cook

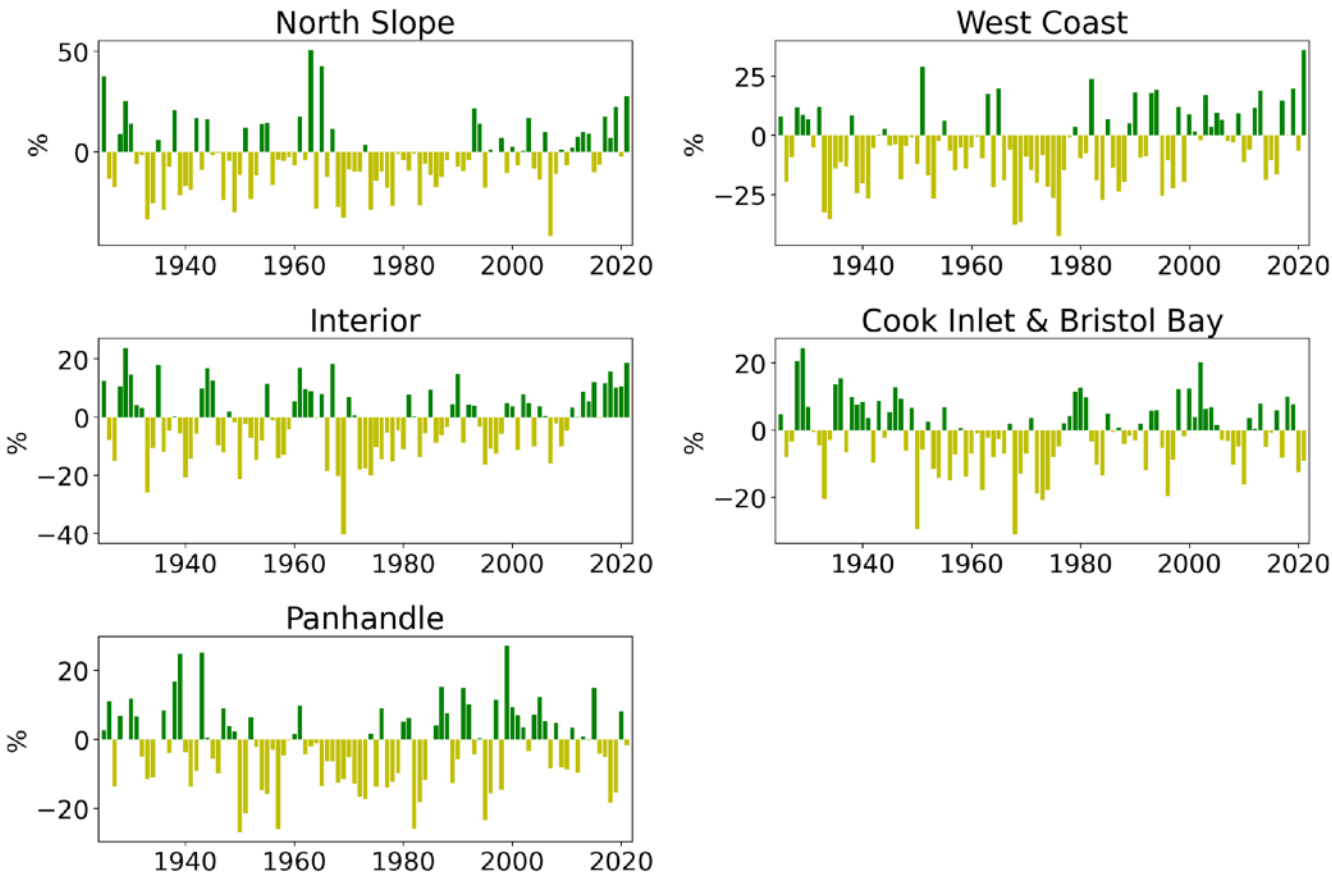

Figure 10. *Time series of annual precipitation sums as percentage departure from the normal (1991-2020) for the Alaska climate divisions. Data source: NOAA nClimDiv.*

Inlet, and drier than normal across the Northwest and Southcentral regions. Precipitation was below normal across most of the state in November, with the exception of the central and southern Panhandle. In December, precipitation was below normal across the

southern Gulf Coast and above normal for the rest of the state. Several stations across the West Coast, North Slope, and Interior recorded much higher than normal precipitation (3-4 times normal) due to multiple strong storms associated with atmospheric rivers. The monthly total in Fairbanks was almost 10 times greater than normal and the wettest December on record. Fairbanks also set a new daily precipitation record of 1.93 inches during an uncharacteristically long and intense rain-on-snow event, the third highest daily total on record for any month at this station. December 2021 was also the wettest December on record for Nome, and the second wettest for Bethel, Kotzebue, and Utqiaġvik.

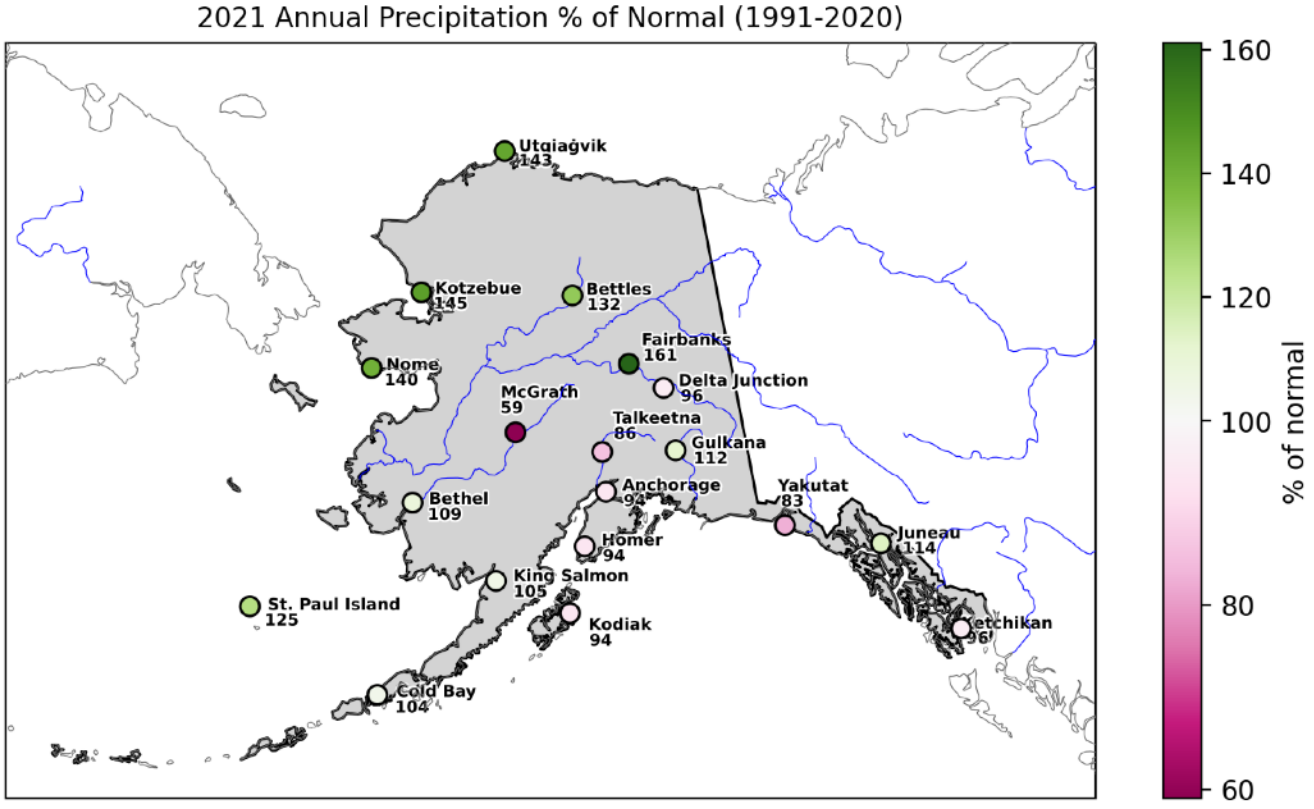

Figure 11. *2021 precipitation deviation (%) from the normal (1991-2020) for the selected stations. Precipitation data for Delta Junction are from the Granite Field SNOTEL station and data for McGrath are from the McGrath SNOTEL station.*

Station	Observed (ºF)	Normal (ºF)	Departure (ºF)
Anchorage	15.4	16.4	94.0
Bethel	21.4	19.7	108.5
Bettles	21.1	16.0	132.0
Cold Bay	44.3	42.7	103.7
Delta Junction	16.3	10.3	158.0
Fairbanks	18.7	11.7	160.6
Gulkana	13.2	11.8	111.8
Homer	22.4	23.9	93.8
Juneau	76.5	67.0	114.2
Ketchikan	143.7	149.5	96.1
King Salmon	22.5	21.4	105.0
Kodiak	73.2	78.3	93.5
Kotzebue	16.5	11.4	145.4
McGrath	27.3	18.1	115.0
Nome	24.1	17.2	140.0
St. Paul Island	30.5	24.3	125.5
Talkeetna	22.9	26.5	86.3
Utqiaġvik	7.7	5.4	143.4
Yakutat	116.5	140.4	83.0

Table 2. *Annual precipitation (inches) for 2021, normal precipitation (inches) (1991-2020), and deviations from normal (%) for the 19 first- order stations. Shades of purple and green correlate with Figure 11. Precipitation data for Delta Junction are from the Granite Field SNOTEL station and data for McGrath are from the McGrath SNOTEL station.*

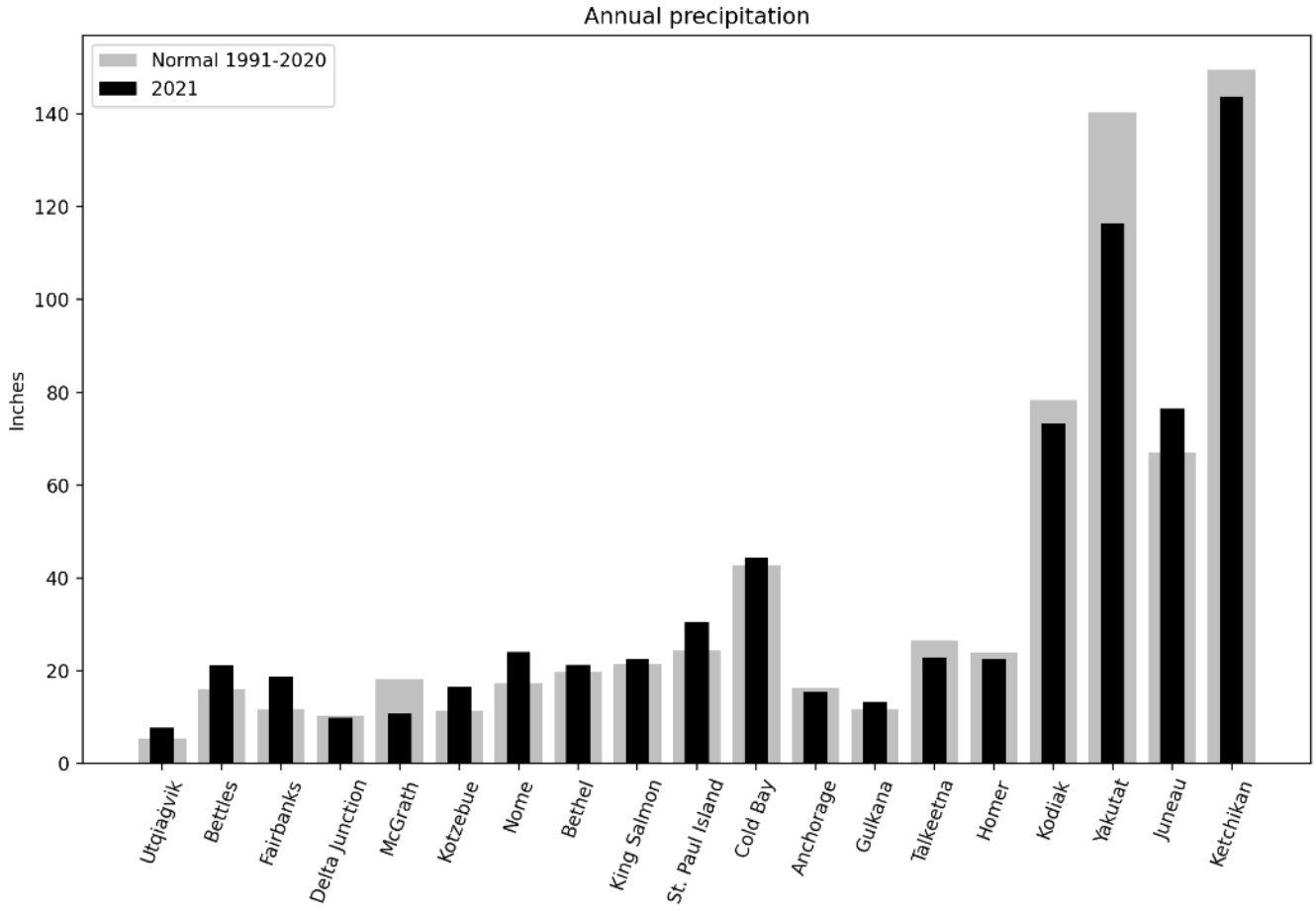

Figure 12. *Precipitation sums (in inches) for 2021 and corresponding normal values at the selected stations (1991-2020) for the selected stations.*

2021 Snowfall

Snowfall for 2020/21 was above average in Fairbanks and Juneau, and below average in Anchorage and Bettles (Figures 13 and 15, Table 3). These are the only four of the selected stations that report snowfall. On a month-by-month basis (Figure 14), January snowfall was substantially below normal at all four sites, with Fairbanks recording a total of only 0.5 inches during the month. In February, snowfall was above average in Anchorage, Juneau, and Fairbanks, while Bettles was much below average for the second month in a row. By the end of the month, the snow depth had doubled in Fairbanks. With temperatures colder than average across the state and several frontal systems bringing above normal precipitation, snowfall was above normal at all four sites by the end of March, with Juneau (290%) and Fairbanks (308%) recording much higher than normal values. Storms during the first ten days of April brought significant snowfall over the Interior and Panhandle, resulting in snowfall totals 9 times higher than normal in Juneau

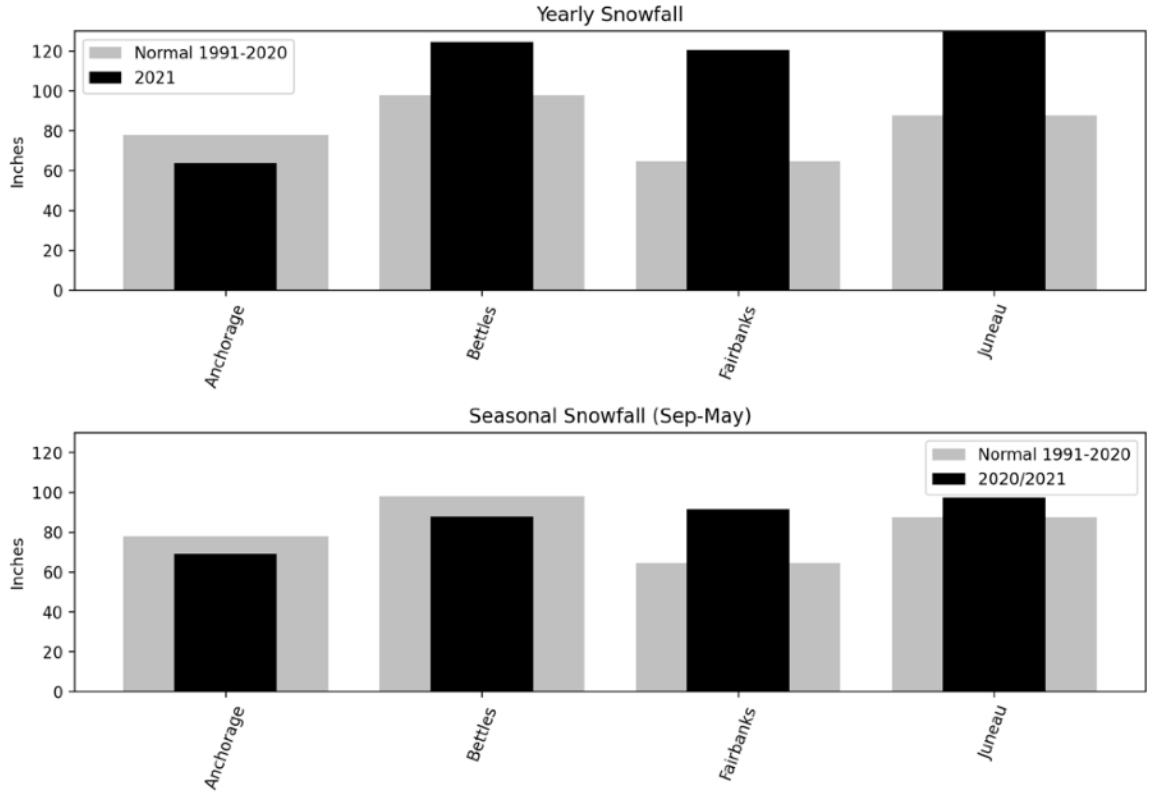

Figure 13. *Annual snowfall averaged over four of the selected stations. 2021 values (black) compared to the normal for 1991-2020 (gray). Top panel shows values for the 2021 calendar year, bottom panel for the 2020/21 winter season.*

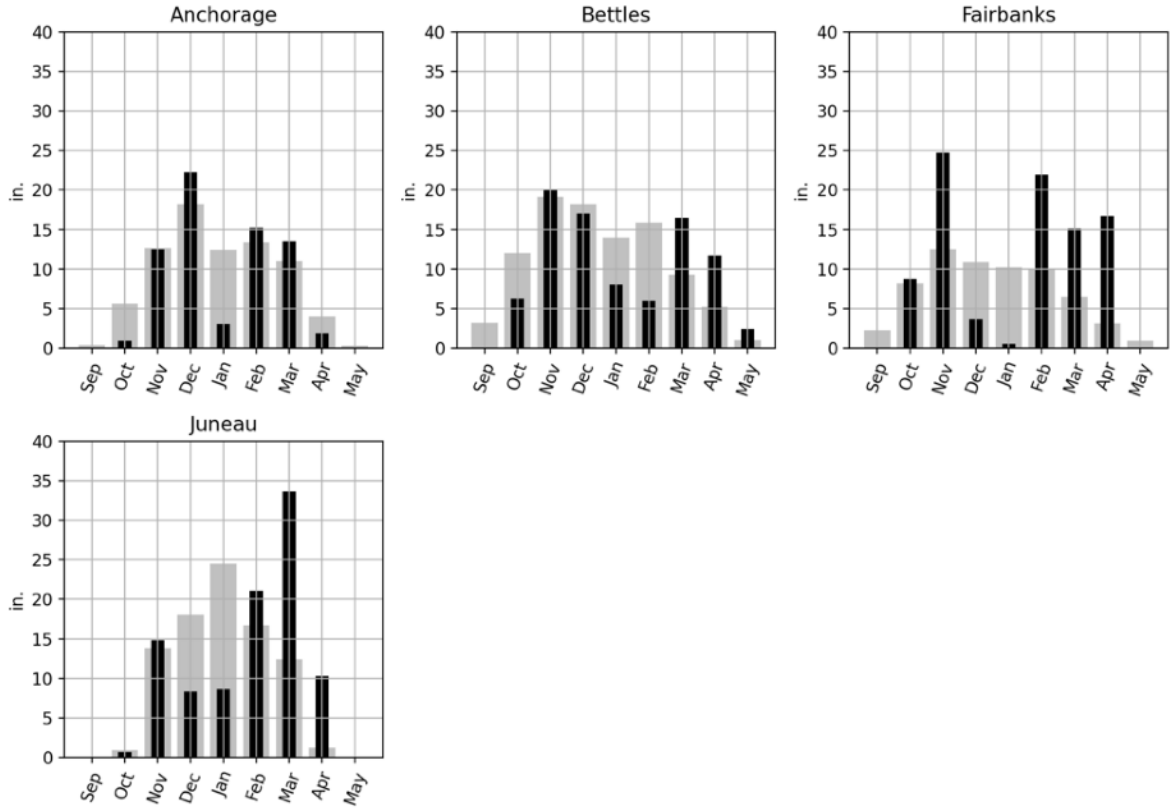

Figure 14. *Monthly snowfall in inches for selected stations in 2020/2021 (black bars), compared to the 1991-2020 normal (gray bars).*

and over 5 times higher than normal in Fairbanks. In Anchorage and Bettles, snowfall was below normal for the month.

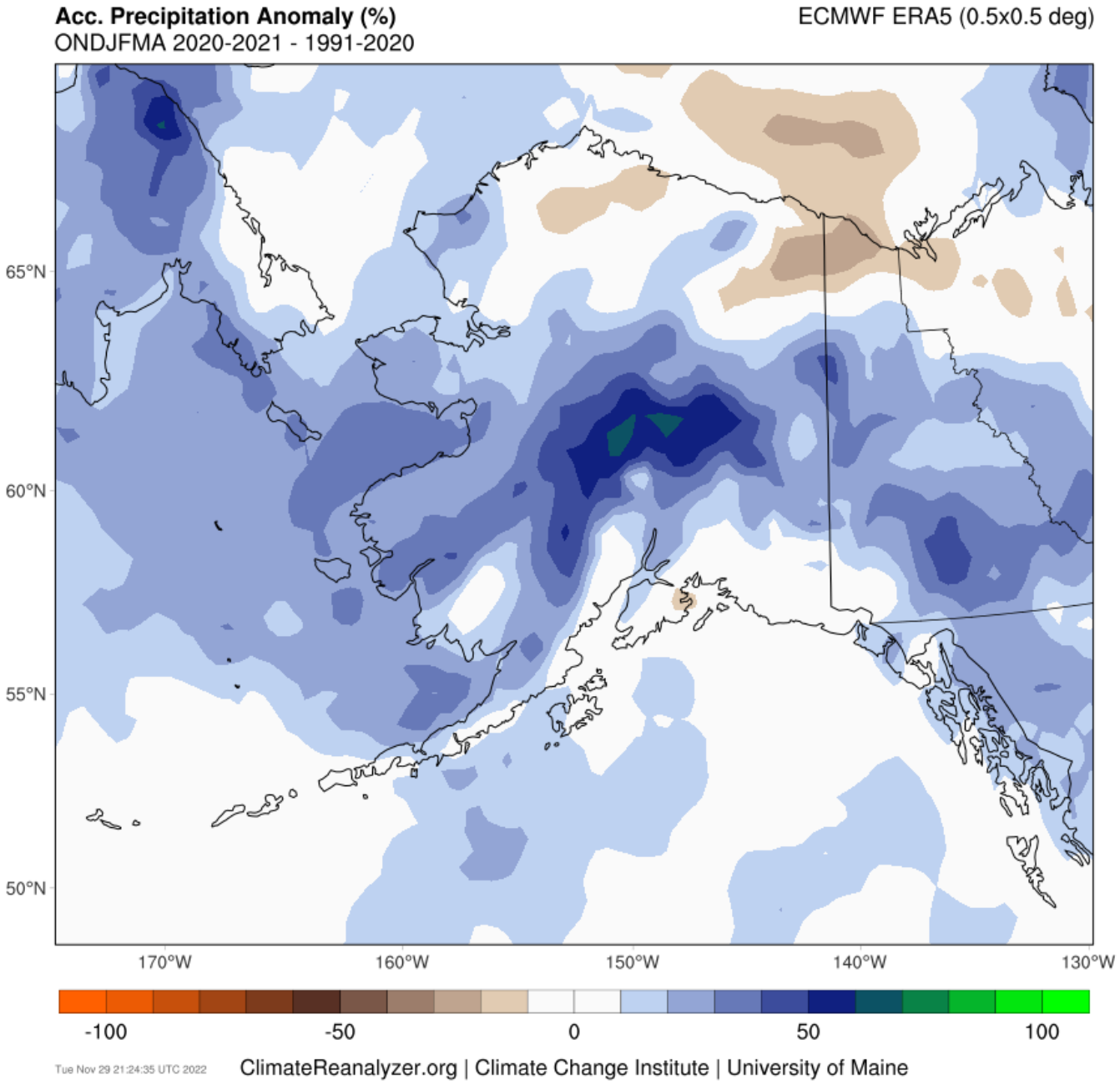

Figure 15. *October 2020 to April 2021 precipitation anomaly over Alaska, based on ERA5 reanalysis data. Far above average precipitation in the Interior, close to or slightly below normal in the north and south-central region. Image from ClimateReanalyzer.org*

September brought the first snowfall of the new season at many locations across the Interior, Bristol Bay, and Cook Inlet regions, with some areas affected by multiple storms at the end of the month. Tok saw its highest September snowfall in its 50-year record history, receiving 16 inches from two separate storms. Anchorage had its first major snowstorm of the season in November, and the first snowfall of the season in Juneau was soon followed by an active train of snowstorms. Monthly snowfall in the fall months was above average in those locations, while snowfall was below average in Bettles and Fairbanks. Extreme weather events in December fuelled by tropical moisture, brought heavy snowfall, as well as freezing rain and rain, to the West Coast and Interior. Almost 3.5 feet of snow were recorded at Wiseman over a two-day period, and Fairbanks received almost two feet of snow during two storms at the end of the month. Snowfall was above normal for the month in Bettles and Fairbanks, and below normal in Anchorage. Colder than normal temperatures over the Panhandle resulted in the majority of precipitation falling as snow, so that above average snowfall was recorded in Juneau despite overall drier than normal conditions.

2021 Snow (calendar year)			
	Snow (in)	**Normal (in)**	**Deviation (%)**
Anchorage	63.9	77.9	82.0
Bettles	124.5	97.9	127.2
Fairbanks	120.4	64.6	186.4
Juneau	137	87.6	156.4
2020/21 Snow (September 2020-May 2021)			
	Snow (in)	**Normal (in)**	**Deviation (%)**
Anchorage	69.2	77.9	88.8
Bettles	87.9	97.9	89.8
Fairbanks	91.3	64.6	141.3
Juneau	97.4	87.6	111.2

Table 3. *Snowfall sums for the 2021 calendar year and the 2020/2021 winter season, normal snowfall (1991-2020), and deviations from normal (%) for the selected stations that report snowfall.*

2021 Arctic Sea Ice

Arctic sea ice, particularly the development of sea ice in the Bering and Chukchi Sea, is a key driver for Alaska's climate. 2021 started with below average Arctic sea ice extent. The ice extent then increased at an average pace. For two weeks at the end of February, sea ice extent decreased, then began increasing again at the beginning of March. The annual sea ice extent maximum was reached on March 21 at 14.77 million square kilometers (5.70 million square miles), tying with 2007 for the 7th lowest maximum extent in the satellite record. Throughout the spring and summer months, the rate of decrease varied, with periods of rapid loss in June and slower rates during April and May. After greater sea ice loss in the first two weeks of July, widespread low pressure over much of the Arctic Ocean helped to slow ice loss later in the month. Persistent low-pressure in the Beaufort Sea also resulted in a slower decline in sea ice extent in August. On September 16, the annual minimum extent of 4.72 million square kilometers (1.82 million square miles) was reached, the 12th lowest value in the satellite record and the highest minimum since 2014. However, with Arctic sea ice at its second lowest extent on record the year before, the extent of multiyear ice in 2021 was one of the lowest on record. Sea ice extent rapidly

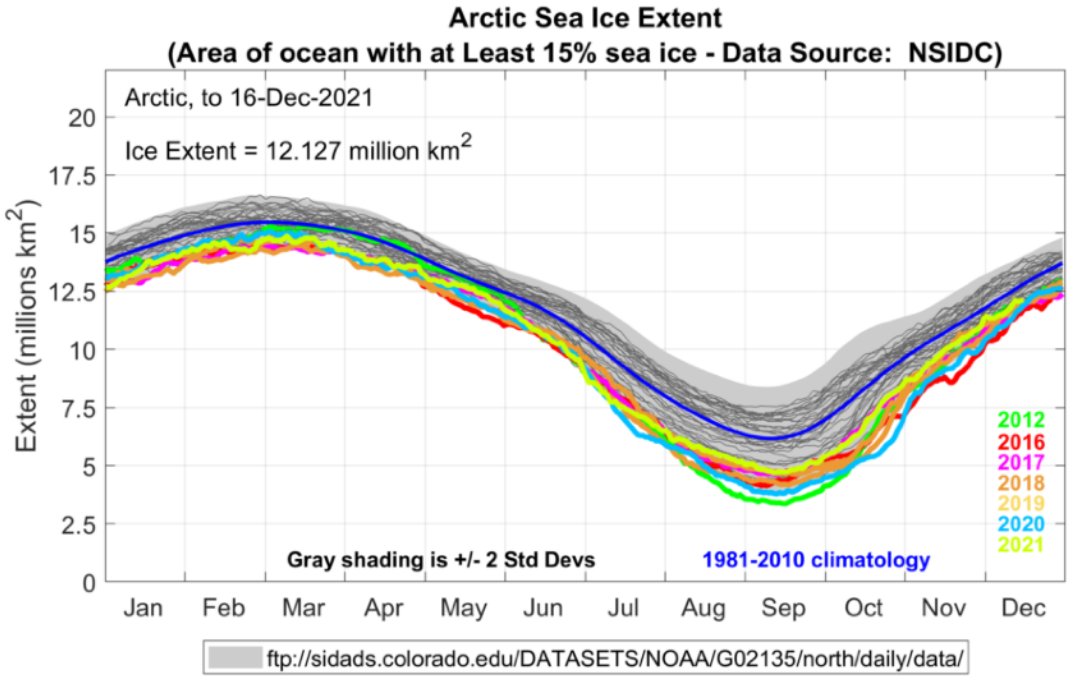

***Figure 16**. Time series of daily Arctic sea ice extent. This year's data (2021), seen in lime green, are updated through January 6, 2022. The median sea ice extent for the 1981-2010 reference period is depicted in dark blue. Plot compiled by: Howard J. Diamond, PhD; Climate Science Program Manager at NOAA's Air Resources Laboratory Data Source: National Snow & Ice Data Center (nsidc.org/).*

increased in the Beaufort and Chuckchi Seas, as the ice retreated late in these areas and ocean temperatures remained low. Sea ice extent grew at a faster rate than average in November, and by the end of the year Arctic sea ice extent was again above average. A time series of daily Arctic sea ice extent can be seen in Figure 15, with the lime green line showing data for 2021.

2021 Wildfire Season

2021 was the second year in a row with a relatively moderate wilde fire season. There were 389 fires reported statewide, with a total area burnt of 254,500 acres (AICC 2021). Twice as many fires (252) were caused by humans than by lightning (126); however, the area burnt by human-caused fires (9,893) was considerably smaller than that burnt by lightning-caused fires (244,593). A substantial end of winter snowpack helped to offset the effects of lower-than-normal precipitation across much of the Interior during the late spring and summer, and a shift to cooler and wetter conditions in August helped to put out wildfires and end the fire season.

2021 Drought Conditions

At the start of the year, abnormally dry conditions were present over the Northwest, the Yukon Flats, and the Tanana Valley. With above normal precipitation across much of the state, there was neither dryness nor drought in the state from February through April. Then abnormally dry conditions developed over the central and eastern North Slope in May and continued through June. Several months of precipitation deficits resulted in abnormally dry and moderate drought conditions across the Interior and the eastern part of the state in July. Much needed rainfall to these areas came in August, improving drought conditions. No drought or significantly dry conditions were present through the rest of the year.

Newsworthy Information

January: On January 2, 2021, the Howard Pass weather station recorded an air temperature of -33°F and wind speeds of 47 mph, resulting in a n exceptional windchill of -78° F. The station, located in the western Brooks Range, has recorded windchills of -70° F or colder each year since its installation.

January 23rd was the 50th anniversary of Alaska's all-time lowest temperature. A low of -80°F was recorded in 1971 at Prospect Creek Camp, located about 160 miles north of Fairbanks. The high temperature that day was -64°F, two degrees higher than the state's record for the lowest high temperature.

Only 0.5 inches of snow were recorded in Fairbanks during January 2021 (0.1 inches as of January 26, when the linked article was published). A persistent storm track to the south of Fairbanks kept precipitation away from Alaska's eastern interior during this time. Overall, seasonal snowfall in Fairbanks has been on the decline, particularly in the fall.

February: According to new research published in the journal Climate Dynamics, thunderstorm frequency could triple in Alaska by the end of the century. Continued loss of sea ice in the Arctic Ocean would provide greater moisture availability, leading to more frequent thunderstorms.

The new climate normal (1991-2020) is anticipated to reveal significant differences for Alaska. In May, NOAA is scheduled to release the nation's updated 30-year Climate Normals, which will span from 1991 to 2020.

New research shows that a forest had established itself in the path of the La Perouse Glacier in SE Alaska by about the year 1206. That was many centuries before the glacier rumbled forward to consume the trees, turning the area into a ghost forest. During the time La Perouse Glacier was advancing, most of the world was experiencing cooler temperatures. Researchers call the period — from about 1250 to about 1900 — the Little Ice Age.

March: A low pressure system centered around the northern Gulf transported significant amounts of humidity into the Gulf coastal regions and the Cook Inlet. The Anchorage area

was blanketed with up to 17 inches of snow from the afternoon of March 10 and into Thursday, March 11.

Glaciers in SE Alaska have been melting since the end of the Little Ice Age. When this melting occurs, the land can rebound (rise). Given the proximity of these glaciers to strike-slip faults, a new study shows that the melting can initiate "unclamping" of the faults, leading to earthquakes.

April: For the first time in 64 years, Denali's longest glacier, the Muldrow, began surging. A glacial surge is a short-lived, cyclical event where ice advances suddenly and substantially, sometimes moving at speeds 10 to 100 times faster than normal. The affected section of Muldrow glacier is normally easily and safely traversed and is the common northern route up Denali, but may be impossible to cross after the surge based on reports from climbers after the previous 1956-57 surge and abundant recent imagery collected from the current surge.

Scientists from the University of Alaska Fairbanks and other institutions used the research vessel Sikuliaq, satellite imagery, and an arsenal of scientific equipment to measure smaller-scale physical processes not represented by regional and global ice and climate forecasts. This new study provides the first high-resolution observations of warm, northbound water sliding beneath the surface of the cold Beaufort Sea.

The Kobuk 440 Sled Dog Race in Northwest Alaska resumed Monday, April 5, 2021, after dangerous weather paused the race on Sunday and organizers rerouted the course. "This feels like the most difficult 440 that we've ever had, weather-wise," said Paul Hansen, president of the race.

May: Ice on the Tanana River in the Alaska community of Nenana melted enough on April 30, 2021, to send a wooden tripod adrift, tripping an alarm and adding another valuable data point to a century-old record of climate change. The ice broke up at 12:50 p.m. Alaska Standard Time, and those who correctly guessed the day and time split a large jackpot.

June: Fire season got underway in Alaska and the UAF geophysical institute helped battle the flames. The Geographic Information Network of Alaska (GINA), with support from the

federal Joint Polar Satellite System program, uses data from two satellites orbiting 512 miles above Earth to provide fire managers with information vital to fighting wildfires in Alaska.

Major flooding occurred after a glacial dam release dumped even more water into the already swollen Taku river. Increased snow melt from recent heavy rains and warm temperatures pushed the river above minor flood stage during the morning of Sunday, June 27th.

July: Meteorologists were stunned when three successive thunderstorms swept across the icy Arctic from Siberia to north of Alaska, unleashing lightning bolts in an unusual phenomenon that scientists say will become less rare with global warming.

Wildfire smoke from Siberia filtered into Southcentral Alaska and created a haze across Anchorage skies. Hundreds of intense fires burned in taiga forests in Siberia and eastern Russia. The haze isn't too unusual for Anchorage: Wildfire smoke from Siberia and eastern Russia spilled into Southcentral Alaska skies last summer, too.

Much of the state will soon reach the average yearly date when the air won't get any warmer. Temperatures peak several weeks after we get the most sunlight because the ground absorbs energy from the sun and releases it to the air. The day the heat emitted by the surface starts decreasing is usually the day we start feeling cooler temperatures.

An 8.2 magnitude earthquake that struck off Alaska's coast on July 28 was the strongest one since 1964, and was felt throughout the Alaska Peninsula and Kodiak. A tsunami was generated by this event but did not pose a threat to communities.

August: Climate change has severely reduced the length of the seal hunting season in a rural Alaska village, potentially threatening a key feature of the community's Indigenous way of life.

The American Meteorological Society released its annual State of the Climate report for 2020 on Wednesday, August 25. 2020 was the warmest year in the Arctic since record keeping began.

A workplace for volcanologists, glaciologists, seismologists, aurora-ologists and other types of scientists, the Geophysical Institute at the University of Alaska Fairbanks has endured since the 1940s. ADN reported on the origins of the Institute in an August article.

September: With climate change, Arctic communities will face longer seasons of more extreme tides.

New research shows that fluctuations of major wind and ocean circulation systems can temporarily accelerate or reverse the rate of ocean acidification in the Gulf of Alaska.

Western Alaska, a region already known for its high winds, is projected to get even windier, which could accelerate erosion through stronger waves.

October: Halfway along the Denali park road, the movement of frozen ground has carried a 300 feet section of the road bed downhill. The road is closed and park operations are substantially affected.

A La Niña developed and will extend through the second winter in a row according to NOAA's Climate Prediction Center.

November: High winds and dry, snow-free conditions kicked up loose volcanic ash from an eruption more than a century ago in southwest Alaska.

Data gathered during a surge of the Muldrow Glacier this summer may offer a greater understanding about receding glaciers, as warming temperatures cause them to become unstable and to surge.

Through the weekend of November 13, sea ice extent in northern Alaska waters was the highest it's been in November since 2001.

Areas across the Bristol Bay region broke negative daily and monthly temperature records during November. For King Salmon, it was the coldest November sind measurements began.

December: A new NOAA report on Alaska's oceans highlights how disruptive warming is affecting the marine environment. "Sustained warm conditions" are affecting the environmental dynamics of sea ice and water columns, as well as the composition of animal stocks thriving and failing in recent years.

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Appendix

	J	F	M	A	M	J	J	A	S	O	N	D
Anchorage	22.26	14.25	19.18	34.82	47.98	56.45	59.08	57.31	47.43	37.87	15.75	17.05
Bethel	10.16	9.59	13.58	27.38	45.76	52.02	54.56	52.84	44.18	31.48	0.73	18.58
Bettles	-1.89	-18.61	-1.52	19.78	44.97	57.85	59.44	51.34	39.87	27.19	-4.88	-7.65
Cold Bay	29.4	36.18	32.81	38.27	42.85	48.67	51.97	53.11	47.97	40.39	27.68	34.93
Delta Junction	11.69	-3.54	7.98	27.34	47.1	59.83	61.92	53.92	40.23	28.03	-0.52	3.95
Fairbanks	-1.45	-9.23	5.87	26.58	51.87	63.12	64.76	56.79	44.08	30.79	0.62	1.47
Gulkana	2.24	-4.88	9.27	28.79	45.0	55.0	58.61	53.74	41.8	28.92	0.03	-1.97
Homer	31.52	25.91	25.53	37.37	44.92	51.55	55.48	53.89	46.75	39.94	20.62	23.73
Juneau	33.85	25.8	32.79	40.02	47.61	56.27	58.84	57.02	50.57	41.37	34.75	21.29
Ketchikan	37.71	32.61	37.02	43.3	49.05	57.52	60.03	58.56	52.48	44.48	40.88	25.92
King Salmon	22.35	20.8	18.94	33.95	44.27	51.35	55.15	52.15	43.12	34.66	3.97	17.86
Kodiak	34.21	31.87	32.4	38.98	44.24	51.25	56.27	55.6	49.62	43.4	25.52	31.58
Kotzebue	1.39	-13.29	-0.66	14.05	33.74	48.4	53.37	49.55	40.4	26.29	-4.15	0.47
McGrath	1.69	-3.2	7.79	27.85	48.69	56.85	58.26	52.25	38.09	28.45	-2.4	4.67
Nome	9.24	1.88	5.97	21.42	42.31	47.93	50.56	49.19	42.25	29.77	4.27	8.45
St. Paul Island	27.73	34.28	30.98	34.48	39.0	44.48	48.27	50.06	45.97	38.87	28.63	33.63
Talkeetna	19.74	11.12	15.47	33.17	48.39	57.78	59.77	56.5	45.57	34.74	11.42	11.56
Utqiaġvik	-6.85	-19.43	-9.69	5.25	23.02	36.93	41.63	38.56	33.47	23.66	6.78	-6.45
Yakutat	33.07	25.86	29.53	36.77	44.06	51.15	54.47	54.5	49.37	41.06	30.43	21.9

Table A1: Monthly mean temperature (in °F) at the 19 selected stations. The highest and lowest monthly means are colored in red and blue, respectively.

	J	F	M	A	M	J	J	A	S	O	N	D
Anchorage	5.41	-7.0	-6.62	-2.69	-0.16	0.56	-0.47	-0.15	-1.87	1.52	-7.84	-2.35
Bethel	3.21	-3.73	-0.91	-1.68	2.71	-1.28	-1.73	-1.06	-1.88	-0.67	-17.82	8.57
Bettles	8.76	-15.21	-5.21	-4.77	0.0	-0.74	-0.36	-1.31	-1.33	5.84	-5.18	-1.64
Cold Bay	0.96	5.93	2.9	3.27	1.85	1.61	0.41	0.46	-0.44	-0.91	-7.56	4.12
Delta Junction	12.64	-10.89	-6.16	-6.3	-1.36	1.38	1.22	-1.68	-4.61	1.58	-8.77	1.55
Fairbanks	6.85	-9.42	-4.87	-7.07	1.53	2.11	1.85	-0.21	-1.68	4.53	-3.48	5.82
Gulkana	5.6	-10.48	-5.42	-3.55	-0.8	0.09	0.7	0.2	-1.84	1.82	-6.77	-1.77
Homer	6.12	-2.38	-4.57	-1.33	-1.09	-0.44	-0.66	-1.41	-2.75	-0.27	-10.58	-3.96
Juneau	5.41	-4.34	-0.1	-0.78	-1.33	1.67	1.79	1.02	0.47	-0.83	1.01	-9.02
Ketchikan	2.11	-3.6	-0.98	-0.21	-1.05	2.22	1.18	-0.43	-1.13	-1.72	1.24	-10.49
King Salmon	5.71	-1.3	-4.56	-2.1	-1.38	-1.45	-1.61	-3.51	-5.53	-1.74	-21.08	-0.76
Kodiak	3.05	-0.48	-0.78	-0.16	-1.56	-0.1	0.12	-0.95	-1.05	1.25	-10.18	-0.32
Kotzebue	3.34	-14.68	-2.2	-2.25	0.59	0.89	-1.93	-2.6	-2.7	-0.61	-14.9	-1.93
McGrath	7.44	-7.75	-4.12	-4.34	0.28	-1.86	-2.55	-3.67	-6.24	0.0	-10.63	6.74
Nome	3.64	-7.17	-3.63	-1.23	5.05	-0.37	-1.44	-1.01	-0.85	-0.66	-13.98	-0.65
St. Paul Island	2.46	9.0	5.83	4.42	2.1	1.39	0.38	0.51	-0.04	-0.58	-5.26	4.73
Talkeetna	6.14	-7.68	-8.05	-3.03	0.68	0.74	-0.28	-0.0	-1.87	0.58	-9.14	-4.04
Utqiaġvik	4.65	-7.54	0.81	1.2	0.32	0.93	-0.02	-1.24	-0.23	2.45	1.09	-0.15
Yakutat	4.48	-4.79	-2.38	-1.83	-1.59	-0.75	-0.93	-0.15	-0.03	-0.79	-3.27	-8.77

Table A2: Monthly temperature deviations (in °F) from normal at the 19 selected stations. The highest and lowest deviations are colored in red and blue, respectively.