The September minimum of pan-Arctic sea ice extent was the sixth lowest of the 39-year satellite record, which was low but not unprecedented. The unusually late freeze-up of the Chukchi and Bering seas, however, soon became a focus of attention of scientists as well as coastal residents. Historically, the Beaufort and Chukchi Seas have undergone freeze-up in October, with essentially complete ice coverage by early November. Figure 1 (upper panel) shows the ice conditions on November 25 (Thanksgiving weekend) of 2017. While freeze-up had occurred in the Beaufort Sea and in narrow strips along the northern and western coasts of Alaska, the Chukchi Sea was essentially ice-free. The ice edge at 170°W was located at 73°N, more than 400 miles north of Bering Strait. This extent of sea ice in late November was far less than the previous late-November minimum, which occurred in 2014 (Figure 1, lower panel).

The large negative anomalies of sea ice continued into the winter months of 2018. While the Chukchi Sea eventually developed an ice cover by early January, the Bering Sea’s ice cover was astonishingly deficient. As shown in Figure 2, ice extent in the Bering Sea developed slowly, remained at record low levels in January, and then began to decrease after reaching a maximum of about 400,000 km² in early February. By contrast, the ice cover in most past years continued to expand until late April when a seasonal maximum was typically reached. From mid-February through mid-April of 2018, the Bering Sea’s ice extent averaged about 50% of the previous record minimum.

The autumn and winter of 2017-18 will long be remembered for its unprecedented absence of sea ice in the seas surrounding Alaska.
Only six years earlier, during the winter of 2011-12 (blue line in Figure 2), the Bering Sea’s ice extent was 3 to 4 times greater than in 2018 (Figure 3). Figure 4 places the Bering Sea’s anomalous ice cover into a pan-Arctic perspective by showing the ice concentrations relative to the historical (1981-2010) median position of the ice edge. (By convention, the ice edge is defined as the 15% contour of ice concentration). It is apparent from Figure 4 that the vast majority of the normally ice-covered portion of the Bering Sea was ice free in late February of 2018. The ice cover was also notably deficient in the Barents Sea and the region north of Svalbard. The Sea of Okhotsk and the Baffin Bay/Labrador Sea region, however, had relatively normal sea ice coverage by historical standards.

In the longer-term context, the Bering Sea had less sea ice in early 2018 than in any winter since 1850, which is the start of the historical record of Bering Sea ice cover (http://seaiceatlas.snap.uaf.edu). Figure 5 compares the amount of sea ice in February with the past 168 Februaries based on information gathered from various sources: satellites (for the past 39 years), historical ship logs (for the past 39 years), historical ship logs (for the past 39 years), and the U.S. Coast Guard. According to Figure 5, the Bering Sea’s ice “deficit” in February 2018 relative to previous decades was approximately 170,000 square miles, which is larger than the area of California.

Figure 3. Sea ice coverage on March 31 of 2012 (left) and 2018 (right). Ice concentrations range from zero (dark blue) to 100% (brightest white). Source: National Snow and Ice Data Center, ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/north/daily/images/

Figure 4. Sea ice coverage on February 20, 2018. Ice concentrations range from zero (dark blue) to 100% (brightest white). Source: National Snow and Ice Data Center, ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/north/daily/images/
Impacts of the absence of sea ice were widespread in Alaska’s coastal communities. Throughout the Bering Sea, there was a lack of, or extremely late development of, shorefast ice. With little or no sea ice present, coastal communities had little protection from the ocean. Flooding, loss of power, damage to infrastructure, and build-up of ice on-shore occurred during storms. At Utqiagvik, for example, waves pounded the shoreline during a high-wind event on December 21 (Figure 6, upper panel). As recently as the 1990s, Utqiagvik’s shore was “iced in” by mid-October. At Shishmaref, a stretch of open water around the community persisted into January. After the ice initially formed, it repeatedly broke up during storms, allowing the surf to push large ice chunks onto beaches. On Little Diomede Island in the Bering Strait, a late-February storm caused power outages and considerable damage (Figure 6, lower panel). Water and ice rubble covered the beaches and the helipad and damaged the water treatment plant. Near Gambell, vast stretches of open water extended all the way to Russia until mid-March. During this time, local residents reported an unusual absence of walrus in the area.

What caused the unprecedented sea ice season in Alaskan waters? While precise contributions of different factors have not yet been evaluated, several contributors are known. It appears that a “perfect storm” of these acting together led to the absence of sea ice. First, the waters of the Bering Sea were unusually warm. Some of this warmth is attributable to heat imported from the North Pacific and the Gulf of Alaska, where the “blob” of warm water had been noted from 2014-16. The low-ice year of 2016-17 in the Bering Sea also may have allowed more absorption of solar radiation than normal in 2017. In this respect, the ice-albedo feedback may have amplified the gain of heat by the Bering Sea. Second, air temperatures over Alaska and surrounding seas were warmer than normal during the latter half of 2017. While these air temperatures may have been influenced by the below-normal sea ice coverage and warm ocean water in autumn and early winter, southerly winds also played a role. Third, stronger-than-normal storm activity of the autumn and winter also played a role through wind-forcing and mixing of the upper water layers of the Bering Sea. Because many of the storms tracked through the Bering and Chukchi Seas, the winds over the coastal waters had a stronger southerly component than usual. The winds drive the currents (and sea ice) northward, in addition to advecting warm air over the region. Preliminary storminess metrics indicate that the winter of 2017-18 was among the five stormiest (although not “the” stormiest) of the past 70 years. The fact that an unprecedented absence of sea ice occurred during a winter that was not the stormiest on record indicates that the other factors highlighted above were also at work in limiting the sea ice cover.

The sea ice conditions of the past autumn and winter are consistent with climate model projections of diminished ice cover in the future. Although it may be a decade or longer before these winters become typical, there will likely be similar winters in future decades. For the immediate future (i.e., the next few years), winter sea ice formation in Alaska’s western waters will likely remain low if the warm waters in the Bering Sea persist.
ALASKA'S CHANGING SNOW

By Brian Brettschneider, International Arctic Research Center (IARC), UAF

“Let It Snow! Let It Snow! Let It Snow!” – Vaughn Monroe

The two best metrics for describing the severity or intensity of a winter are temperature and seasonal snowfall. As a climatologist working in Alaska, I am asked two questions most often. Alaskans want to know how much snow we will get in the upcoming (or ongoing) winter. People from Outside want to know how much the climate is really changing in Alaska. In this article, we will tackle both subjects at once. Specifically, we will look at changes in snow and snow depth over the decades at several stations around Alaska. Has the amount of snowfall mirrored the changes in temperature? Does snow stick around less than it used to? Does the intraseasonal distribution of snow differ from prior decades?

SNOW MEASUREMENT VARIABILITY

Technique

Of all the daily climate variables, measurements of snow are the most likely to vary as a function of observer technique. Two people, at the same location, measuring at the same time, can record different values for snow and snow depth. This can be due to several factors. First and foremost is the timing and frequency of observations. If 2” of snow falls at 8 a.m., a measurement at noon will record 2”. But if measurements are scheduled only once daily at 6 a.m., the 2” snowfall will have compressed to approximately 1.5” (estimate) over the intervening 22 hours. Over the course of a season, this can really add up. National Weather Service directives allow for snow measurements to be taken every 6 hours to minimize this effect.

Wind

Windy areas are notoriously difficult for measuring new snow. Even with new, modern equipment that allows snow to settle into a recording instrument, snow that falls sideways is often missed. This leads to a significant underestimate of new, daily snow. Alternatively, new snow is often estimated by the change in snow depth over consecutive days. This has its own set of issues related to the variable nature of where snow drifts accumulate and where they do not. While the technique of estimating new snow from changes in depth is generally accurate, the liquid equivalents collected at automated stations suffer from the same undercatch of snow.

Siting

The presence of structures or trees near measurement locations can have a significant effect on snow readings. If the measurement site is near a building, an undercatch of falling snow and an overcatch of snow blowing off a roof can lead to spurious results. For snow depth, the presence of structures greatly affects the thickness of drift piles. Trees are also very important to snow measurements. They slow down wind and allow for the accumulation of drifting snow and provide shade for nearby fields of snow. For example, Anchorage’s official snow station, the NWS office on Sand Lake Road, is surrounded by trees. This provides shade for the snow and prevents Chinook winds from melting snow. Pre-1998, the snow measurements were taken at the Anchorage International Airport—a wide open space. This difference is very apparent in the trends of snow depth for Anchorage.

These slides from the Community Collaborative Rain, Hail & Snow Network (CoCoRaHS) Citizen Science training shows the effect of siting on snow depth measures. From https://cocorahs.org
STATIONS AND METHODOLOGY

To look at changes in snow and snow depth over time, we need to find appropriate time periods to compare and a balance between the length of time versus the number of stations to evaluate. Shorter time periods allow us to capture more stations and thus geographical trends. Longer periods are better for capturing trends over time, but few stations in Alaska have a long record and thus the spatial coverage is sparse. A compromise for this study is to compare the most recent 30-year period (1988-2017) with the preceding 30-year period (1958-1987). In Alaska, 16 of the 19 NWS first-order stations have 20 or more complete seasons of snow and snow depth data during both time periods. These records are long enough to provide meaningful representations of changes in the last 60 years; however, caution is advised when extrapolating these trends as markers of climate change [caveat emptor].

Unlike temperature, precipitation (liquid and frozen) is strongly skewed. Even a very snowy winter might only record measurable snow on 1/3 of all days. Mapping skewed data is fraught with problems. Traditionally, averages/normals are used for annual, monthly, and daily temperatures. For precipitation, averages are not generally the best metric, and medians (the "middle value") are more commonly used. Figure 1 compares using median (panel a) and average (panel b) values side-by-side to reflect changes in snowfall over our two time periods.

![Figure 1. Snowfall change between 1988-2017 and 1958-1987. Upper panel shows the difference between the median values of both time periods and lower panel b shows the difference between the average value of both time periods.](image-url)

CHANGES IN SEASONAL SNOWFALL

TOTAL AMOUNT

In Figure 1, the change in snowfall from 1958-1987 to 1988-2017 is noted by colors ranging from blue (more snowy) to orange (less snowy). Note that these changes are in absolute units (inches) and not percentages. A 5” change in annual snow is much more significant in Kodiak than in Valdez. Since the amount (volume) of snow is important for climate and ecological analyses, changes in inches are used throughout. Figure 1 clearly shows an increase in measured snow in northern and western Alaska, while in Southeast, snowfall has decreased. Central portions of the state show a mixed signal. These transition zones are where the difference between using the median and the average are most apparent.

![Days With Measurable Snow Change: 1988-2017 vs. 1958-87](image-url)

DAYS WITH MEASURABLE SNOW

In far northern Alaska, measurable snow (0.1” or more) falls on 40% (or more) of winter days. With cold temperatures and high humidity, it doesn’t take much to squeeze a little snow out of the air. Farther south, snowy days are less common. How have the number of snowy days in regions of Alaska changed between the two 30-year time periods? Figure 2 shows the change in days with measurable snow. There is an increase in snowy days from south to north generally from Southcentral to the North Slope. Little change is noted along the west coast, and a noticeable drop occurred in Southeast.

![Snowfall Change: 1988-2017 vs. 1958-87](image-url)
DAYS WITH 1"+, 3"+, AND 6"+ OF SNOW

Moving past fleeting snow events to track more substantial snowfalls (1" or more), the patterns change somewhat (Figure 3). A sizeable increase in 1"+ snow event frequencies is noted in most of mainland Alaska except for the area just north of the Alaska Range. Once again, in Southeast, a region-wide drop occurred. Is it noteworthy that we see an increase in 1"+ snowfall days (Figure 3) but not measurable days (Figure 2) along the west coast and North Slope? Looking at Figure 4, a similar pattern emerges when we evaluate the change in heavier (3"+) snowfall days. The pattern is distinct, but does not explain the strong patterns for seasonal snowfall totals shown in Figure 1.

Only when we see Figure 5 (change in 6"+ snowfalls) can we fully understand the increase in annual snowfall totals. Most stations in mainland Alaska show an increase in these very heavy snow events. If a station averages 60" snow per season, the addition of an extra 6" snow event is a substantial contributor to the total. If we assume that the extra 6" snow event “used to be” a 4" or 5" event, that additional 1" or 2" is 2% or 3% of the season total.

DURATION OF THE SNOW SEASON

Having snow on the ground is extremely important for the energy budget of a region—and the planet. Snow is very reflective. Solar rays striking snow are mostly reflected back into space. One of the reasons that the Arctic is warming faster than the rest of the planet is due to loss of snow and ice. Without that snow and ice, particularly in the fall and spring, solar energy is absorbed by the ground and warms the surface.

How do we define the snow season beyond how much snow falls? One metric is the first and last dates that snow falls. For most places in Alaska, measurable snow often falls after the winter snow pack has melted off, making this last snow event important from ecological and planning perspectives. Snowfall dates are also very important for issues related to transportation and transportation infrastructure.

Figure 6 shows the change in first and last dates where at least 1" of snow falls on a day. I chose this value, as opposed to measurable, because very small snow amounts are prone to major outlier events. These outliers can mask true patterns. Again, the colors in Figure 6 represent more wintry (blue) and less wintry (orange). Positive values in the left panel (orange) indicate that the first 1" snow of the season falls later in the most recent 30-year period. Negative values in the right panel (also orange) indicate the last 1" snow of the season falls earlier in the most recent 30-year period. It is plainly apparent that 1" snows are starting later and ending earlier.
When we evaluate a larger snowfall amount—at least 3”—the results are less clear. Since the number of 3” events per season for most locations is small (fewer than 10 for the majority of stations), the variability in the dates is very large. Therefore, even though the data are presented in Figure 7, there is not a lot to be read into the changes due to that small sample size.

Another metric is the number of days with any snow on the ground and how that number has changed. Figure 8 shows the change in the number of such days. With the exception of Anchorage and Valdez, the number of days with snow on the ground has decreased everywhere. In the case of Anchorage, the change in snow depth measurement location from the Anchorage International Airport to the NWS Office in 1998 is largely responsible for the observed increase. The new location is more shaded and sheltered and protects the snow from the wind and sun.

**CHANGES IN SNOW PACK AND DEPTH**

**SNOW PACK**

Another way to think of the snow season is to consider the length of the continuous winter snow pack. The snow that falls very early or very late in the season often melts within a day or two and may not contribute to the winter snow pack. This is important because the snow pack is a hydrologic reserve that largely determines when plants and animals are active. The health of the winter snow pack is threatened by warm temperatures, rain, and the high sun angle once we reach the spring season. A strong snow pack acts as a hydrologic buffer if the spring months are abnormally dry.

The panels in Figure 9 show the changes in the dates of the period of continuous winter snowpack were established (left) and melted out (right). For each season, I chose the longest stretch of days where snow was on the ground continuously. A minimum value of 14 days was required for inclusion.

Little change is noted in the dates where winter snow pack is first established. This matches the findings in the first panels of Figures 6 & 7, which show the change in dates of when the first snows arrive. In western, northern, and southeastern Alaska, the snow pack melts off significantly earlier during this most recent 30-year period. In the central part of the mainland, the patterns are not as distinct. The early melt out of snow shown in Figure 9 leads to the obvious conclusion that the length of continuous snow pack is lower in many areas. Figure 10 (next page) shows that this is indeed the case. Other than the corridor from Anchorage to Fairbanks, every other place else has a shorter period of continuous snow cover.
CHANGES IN SNOW DEPTH

The amount of snow present on the ground is called the snow depth. Snow depth is usually measured around 7:00 a.m. and is always recorded in whole inch increments (plus Trace). As snow falls throughout the season, the depth increases. As warm temperatures, direct sun, or rain falls, the depth decreases. Figure 10 shows the change in number of days with snow at least 6” deep. Unlike the 1”+ depth map in Figure 8, a number of stations have notably increased the number of days with a deep snow cover. This may be a result of larger snow events during the low sun angle season. If more snow falls in October, for example, the sun will directly melt or sublimate some of the snow—even with cold temperatures. On the other hand, if more snow falls in mid-winter when solar radiation is lower, the snow depth will stay higher. Also, wind promotes snow melting/evaporation. If there is a reduction in wind (not analyzed), the snow depth would remain higher.

CONCLUSIONS

Snow and cold define Alaska. As the Earth warms, snow will slowly become less prevalent in the state. Most of the figures presented here show that despite some regional variability, snow is generally holding up fairly well in most places in Alaska—albeit with a slight decline.

But this impression may be something of an illusion. As temperatures rise, areas where a majority of snow events occur near the freezing point, such as Southeast Alaska, will transition to more frequent rain events. In Figure 12, the relationship between changing winter temperatures and snowfall is shown. In Alaska, warming temperatures enable the atmosphere to hold more moisture, but since winter temperatures are still well below freezing in most locations, relatively few of the snow events become pure rain events. This effect allows for an increase in snowfall in many locations, which may be most clearly reflected in the increasing snow amounts (Figure 1) and snow depths (Figure 11).

Outside of mainland Alaska, rising temperatures dramatically impact winter snow totals. Note the overwhelming preponderance of orange and red dots in the Lower 48 in Figure 12. For southeast Alaska, the future is already here. Warming temperatures have dramatically reduced seasonal snowfall totals. There is no reason to expect that this trend will not encroach farther north into mainland Alaska in the coming decades.

Analyses of a broad range of data relating to Alaska climate and weather are available on the Alaska Climate Info Facebook page: https://www.facebook.com/AlaskaClimateFacts
Breakup season in Alaska is a big deal. When the sun starts swinging higher in the springtime sky, temperatures tick upwards, and snow and ice begin to melt. Many of Alaska's rivers are prone to ice jam flooding, where sheets of ice block water like a dam, causing flooding from the jam point and upstream. These floods often lead to big impacts in our rural communities. Most of Alaska's non-coastal villages are on rivers, and many of these are far from the limited Alaska road system.

In fact, the majority of Alaska's most expensive natural disasters have been related to ice jam flooding: the cost of the 2013 ice jam flooding in Galena alone was on the order of $50 million. For these reasons, the State of Alaska's Division of Homeland Security and Emergency Management (DHS&EM) and the National Weather Service's (NWS) Alaska-Pacific River Forecast Center (APRFC) have collaborated on an aircraft reconnaissance program called Riverwatch for over four decades. The Riverwatch program focuses on the large Yukon and Kuskokwim Rivers and pairs NWS hydrologists with DHS&EM personnel. These teams fly over the rivers to assess ice conditions and then communicate that information to local residents through radio, TV, and social media. On occasion, community leaders also participate in these flights to gain a better perspective of the flood potential or extent and may communicate those insights to communities in their native language.

In 2018, though, the most significant ice jam impacts occurred on the Susitna River in mid-May, on a roadless section of the Alaska Railroad corridor, near a place called Curry (Figure 1). When the jam released down towards the more populated area of Talkeetna, residents described it as a 'wall of water and ice' flushing through. The railroad was forced to shut down on May 12 and returned to service on the evening of May 16, with operating losses of $1 million/day, in addition to the cost of repairs. Rail was displaced 25 feet in some sections, and the ballast that holds up the rail ties washed away.

In this stretch of the Susitna River, north of Talkeetna, the railroad follows right along the bank, because the terrain rises on either side of the

![Figure 1: ice boulders left on the bank of the Susitna River after May 2018 ice jam flooding. Photo credit: J. Cherry, NWS/APRFC](image1)

![Figure 2: USGS Gage record from station upstream of flood impacts. Image: NWS/APRFC](image2)
river. This rising terrain ultimately forms Devil’s Canyon further upstream. The railroad’s close proximity to the river near Curry makes it vulnerable to erosion, even in summer, and the shape of the channels tend to trap sheets of ice that come down from Devil’s Canyon. In the 1920s a hotel was built at Curry for summer vacationers, and later for skiing, which operated until it burned in 1957. Now Curry is home to an important gravel quarry that helps the Alaska Railroad Corp (AKRR), a state-owned corporation, maintain the railroad infrastructure.

On the APRFC forecast desk, our first indication of an issue was sharply rising water on a stream gage maintained by the USGS on the Susitna river at Gold Creek, more than 20 miles upstream of Curry on the night of May 11 (Figure 2). AKRR maintenance superintendent Lloyd Tesch discovered the flood on his rounds and called for the southbound train to reverse course back up to Denali Park. A helicopter survey on Saturday, May 12, showed whole mile-long sections of track were devastated, and flooding left behind huge ice pans and chunks along surviving tracks in that area (Figure 3). AKRR environmental analyst Jeanette Holt talked to the APRFC about what was and wasn’t known about the event, and AKRR lead accountant Wendy Richerson invited us to join their team for the flood impacts assessment.

Just a day after service resumed, APRFC staff members boarded a whistle-stop train at Talkeetna and headed to the flood sites with AKRR and other agency personnel. This was a unique opportunity to learn more about how flooding impacts railroad infrastructure, with a team of engineers, accountants, and environmental scientists. The train slowed to a crawl through the lower flooded sections, and we took photos and video from an open box car. At Curry, the team disembarked and got in road-rail vehicles (also called hi-rail trucks) and proceeded to a section of rail where maintenance crews were still working. We talked with the crew about the resources and effort required to maintain the track through this type of ice jam event. Afterward, we boarded a southbound train again at Curry, and rode it back to Talkeetna.

Of course, as hydrologists, we wondered how we might be better able to forecast these events. According to Superintendent Tesch, the USGS gage that operated from 2011-2016 on the Susitna River near Tsusena Creek and Chulitna was used to identify ice damming and water build up some 5 hours before it would get to Gold Creek. This was valuable information for a similar ice jam flood in 2009. Five hours is enough time to get a passenger or freight train to safe grounds. Unfortunately, this Tsusena Creek gage was discontinued after 2016. The USGS still maintains a camera in the area, which takes pictures of the river once an hour throughout breakup, but these images are not telemetered. They remain on that camera until downloaded and are not available to warn stakeholders of ice conditions.

A database maintained by the US Army Corps of Engineers suggests that there have been more than a dozen ice jam floods in this area of Alaska since records began. In some areas of the state, the APRFC uses data from the NWS and partner agencies, like the USGS and the USDA Natural Resources Conservation Service,
to provide an outlook on the likelihood of breakup flooding, compared to average. Unfortunately, despite the importance of railroad infrastructure to the state and the vulnerability of this particular area along the Susitna, there is very little data on snow depth, ice thickness, and even air temperatures in the area near the flooding.

Fish Lake, just south of Talkeetna, is the closest site where the NWS has river ice and snow on ice measurements (Figure 4). This provides some indication that the Susitna River ice may have been thicker than average, with a below-normal snow cover. However, this site, which is not very close to the flood site, did not show particularly thick ice during the prior significant flood in 2009. Freezing degree days (Figure 5, the sum of the average daily degrees below freezing over the cold season) at Talkeetna do not suggest air temperature was a factor in making ice thicker than normal, although Talkeetna is still a long distance from the source region of the ice that jammed in the river. That would have been further upriver, in Devil’s Canyon. We can also look at snow depth on the ground (Figure 6). Snow depths at the start of March, April, and May all show an interesting pattern of anomalies. High elevation sites near the Susitna River headwaters had above normal snowpacks while lower elevation sites near Talkeetna had below normal snowpacks. Finally, air temperatures at Talkeetna and Chulitna offer one last clue (Figure 7a,b), showing a period of relatively cool temperatures during the last week of April and the first week of May, followed by a sharp rise for three above normal temperature days. This may have been the push the river needed to mobilize large sheets of ice prone to jamming, before they could begin melting in place.

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*Figure 4: Ice Thickness and Snow Depth on Fish Lake near Talkeetna, AK. Data: NWS.*

*Figure 5: Freezing degree days in the current and past water years, and the average at Talkeetna airport. Data: NWS.*

*Figure 6: Snowpack observations at the start of April, 2018 in the upper Susitna River basin.*
Here at the APRFC, we will continue to study this event and work with the Alaska Railroad to identify what we call Impact-based Decision Support Services (IDSS) that we can help provide along with our other core partners. Different environmental monitoring methods include Riverwatch-style aerial reconnaissance, more weather stations and river gages, remote cameras that transmit over satellite, and even satellite imagery, but these efforts all cost time and money, and costs of monitoring add up. Other approaches could include AKRR training their maintenance and operations crews to recognize the threat of ice sheets coming down from Devil’s Canyon. Extra precautions may be in order if breakup has not yet occurred when the summer passenger train schedule is set to begin. Breakup in the upper Susitna River was very late this year, in part because of the relatively cool air temperatures in late April and early May. It didn’t take much: just three warm days after that cool spell, and the ice pushed downstream in large sheets. Had a tourist train passed by at that very moment, it certainly would have been a trip to remember.

Figure 7: daily air temperatures from Talkeetna (above) and Chulitna River, AK (left). Data: NWS. Image: xmAcis.
SUMMARY: WINTER 2017-18

The winter of 2017-18 was remarkable in many respects. The 6 month October through March “cold season” was the warmest of record (since 1925) from the Aleutians northward across western Alaska and North Slope. Much of the rest of the state was also unusually mild (Figure 1). The primary exception was the eastern Gulf of Alaska and Southeast, where temperatures were not too far from normal over the 6 month period. At Anchorage, while overall temperatures were close to normal, the low temperature at the Anchorage Airport for the entire winter was only -2°F, on several days in early February. This ties with the winter of 2002-03 as the second mildest winter low temperature. The only winter in Anchorage that failed to have even one day below 0°F was 2000-01, when the low was +2°F. Snowfall at Anchorage Airport was below normal but higher than 3 of the past 4 years. The lowest temperature of the season at Fairbanks was -33°F. This is the fourth highest winter low in more than 110 years of climate observations. Total snowfall at Fairbanks was just over 85”. While not even in the top ten snowiest winters, it was the most snow in the past 25 winters. At Juneau, temperature finished up slightly below normal for the winter. Snowfall was close to average but was more than the past several winters.

Figure 1. Alaska regional average temperatures for October 2017-March of 2018. Much of the state was unusually mild, and a broad area from the Aleutians northward was the warmest on record for the 6 month period.

November was an eventful month over much of Alaska. Western Alaska was quite stormy and mild, while Southeast Alaska was unusually cold and snowy. The average temperature at Utqiāgvik (Barrow) in November was 17.2°F, more than 16.5°F above the 1981-2010 normal and easily the warmest November in the past 98 years. The average temperature at St. Paul of 39.4°F was more than 6°F above normal and made this the second warmest November; the only warmer November was back in 1926. It was a different story over Southcentral and especially the Panhandle. Juneau airport recorded an average temperature of 27.2°F, which is more than 6°F below normal and the coolest November since 2006, while snowfall totaled 26.7”, the highest November total since 2011. The Snettisham Power Plant, southeast of Juneau, totaled over 4’ of snow in November, the highest low elevation snowfall reported in the state. Parts of Interior Alaska were also unusually snowy. Over 2’ of snow fell at Fairbanks, with up to 40” at higher elevations north of town. The Airport total of 24.6” was enough to make this the seventh snowiest November in the past century.
A moderately strong storm moved across the Chukchi Sea November 11 and 12. With near-record low ice cover over the Chukchi for so late in the autumn (see page 1 and Figure 2), the long fetch of winds over the open water brought coastal flooding and severe erosion to several communities. Hardest hit were the northern Seward Peninsula communities of Shishmaref (Figures 3 and 4), where the road to the landfill suffered serious erosion, and Deering, where a home was evacuated and the airstrip cut off for about half a day. Minor flooding also occurred at Kotzebue, where some parking areas were inundated. Another storm November 19 produced a whopping 22” of snow at the Iliamna Airport. A week later a strong, slow-moving storm brought a long period of high winds to the central and eastern Aleutians on November 26. Peak winds were around 90 mph at Adak, Atka, and Dutch Harbor. Wind gusts this strong are high but not excessive by Aleutian standards; notable was the long duration of the high winds. At Atka, the average sustained wind speed between midnight and noon on the 26th was over 50 mph, with winds gusting past hurricane force (75 mph) during that time.

The temperature at Kodiak on November 1 soared to 57°F, easily breaking the previous record high for the date of 52°F set in 2003. Two days later, on November 3, the temperature again topped out at 57°F, breaking the previous record of 54°F set in 1936. Both of these readings are the second highest temperature of record at Kodiak for November (since 1930). The only milder November day was in 2013, when the high temperature on the 14th was a balmy 59°F.
December was an exceptionally mild winter month across much of Alaska, but especially over northern and western portions of the state. A number of long-term climate stations shattered previous records for the mildest December. For the state as a whole, the National Centers for Environmental Information (NCEI) reported that this was the warmest December since records began in 1925, with the average temperature more than 15°F above 20th century average and 2°F above the previous warmest December of 1985. At McGrath, the average temperature for the month of 19.3°F was more than 22°F above normal and was 8°F warmer than the previous warmest December. Both Kotzebue and Utqiagvik (Barrow) were more than 5°F warmer than any previous December. At Fairbanks, the average temperature of +9.0°F made this the mildest December in more than a century.

In Southeast Alaska, December started off with very mild weather. Juneau Airport set or tied daily record highs 5 days during the month, including 54°F on December 8, which tied the all-time monthly record. At Sitka, the low temperature on December 7 was 53°F, easily the warmest low temperature there for any December day. Even milder air pushed into southern Southeast on the 11th, when both Wrangell and Metlakatla reached 60°F or higher. Unlike western Alaska, temperatures in Southeast took a sharp downturn late in the month, and as a result month averages were closer to normal than the remainder of the state.

The same weather pattern that brought the very mild weather to the Panhandle early in the month also brought heavy precipitation to the Prince William Sound area. Thompson Pass, at 2678’ elevation on the Richardson Highway, is one of the snowiest places in Alaska that people regularly access. On December 6 the Alaska Department of Transportation (DOT) reported that 40” of snow fell over 12 hours, including a whopping 15” in just 90 minutes. The heavy snow triggered an avalanche more than 20’ deep over the Richardson Highway, which was closed for more than a day until DOT could clear the road. Valdez received about 18” of snow during this time, but most of the precipitation actually fell as rain. Anchorage saw very little snow during December. The total at the airport was only 2.1”, the third lowest of record and the lowest December snowfall since 1982. Valdez reported the greatest December snowfall from any community in the state, with 51”. However, this is only about 70% of normal. Bettles was quite snowy the first 3 weeks of December, when measurable snow fell on 20 of the first 21 days of the month. The total snowfall for the month was 32.4”, more than twice normal.

Southwest Alaska was buffeted by several storms during December. A storm on the 22nd produced damage in several communities. At Quinhagak, winds gusting to an estimated 85 mph caused half the town to go without power for a day; fuel pumps were damaged, and several structures suffered significant wind damage. Cooler air following this storm was enough to produce more than a foot of wet heavy snow at Cold Bay on the 23rd, even as temperatures never fell below freezing.
JANUARY

After the extraordinarily mild December, January temperatures were generally less extreme in most of Alaska, though virtually the entire state finished up on the warm side of normal. The North Slope was the mildest region relative to normal, while the Cooper River Basin and parts of Southeast were very close to the 1981-2010 average. Precipitation was, as usual, more variable, but much of western Alaska was quite dry, while the North Slope and southeast mainland saw significantly more precipitation than is usual for January. At McGrath, the precipitation of 0.10" is the second lowest January total in the past 75 years. In contrast, Northway's total precipitation of 1.03" was more than 4 times normal and tied for the third wettest January of record.

A northward moving storm in the Gulf of Alaska on January 14 and 15 brought exceptionally mild air to Southeast Alaska, with a number of long-term climate sites reporting record high temperatures for the month. Most notably, the NOAA tide gauge at Ketchikan came in with a maximum temperature of 67°F on the 14th. This is the highest reliable temperature ever recorded in Alaska in January, breaking the previous record of 62°F set multiple times, most recently near Port Alsworth on January 27, 2014. Other all-time January record highs set this month included Annette at 66°F, Craig at 65°F, and Sitka at 63°F.

The Glennallen area is not an especially snowy region, but January 13-15 a total of 18.1" was measured at the NWS cooperative station. This is the greatest 3 day snowfall since November 1-3, 1999. The same storm system brought freezing rain to the greater Fairbanks and Nenana areas on the evening of January 16 before changing to wet snow. Most areas received only a small amount of rain (less than 0.10") but it was enough to glaze surfaces, and on some roadways, the glaze persisted into March.

Late in the month a spell of cold weather over portions of the western Interior and Northwest Alaska brought temperatures in the -50°F range at a number of locations, and there were unofficial reports of temperatures near -60°F in the upper Kobuk valley. However, the cold only lasted a few days before clouds and warmer air aloft caused a return to moderate conditions.

FEBRUARY

February was another exceptionally mild month across northern and western Alaska, while south and east of the Alaska Range temperatures were predominantly near to below normal. Preliminary analysis by NCEI put the statewide average temperature for the month at more than 8°F above the 20th century average. In northwest Alaska, this month was second only to 1989 for the warmest February. At Utqiaġvik (Barrow), the average temperature for the month was +4.0°F, a remarkable 18°F above normal. In contrast, Juneau airport had an average temperature of 23.1°F, more than 7°F below normal and the coldest February since 1994. This also allowed snow cover to last all month in the Capital City, the first time that every day in February has had measurable snow on the ground since 1999. February was unusually snowy in Fairbanks, with a total of 23.4", all falling during the last 2½ weeks of the month. This was more than twice the normal snowfall and enough to rank as the sixth snowiest February in the past century. As is often the case in Southcentral Alaska, precipitation and snowfall varied dramatically in short distances due to the complex interplay of multiple mountain ranges and the waters of Cook Inlet. At the Anchorage Airport, February was unusually wet and snowy. Total precipitation, mostly, but not entirely snow, totaled 2.32", the fourth highest February total in the past 66 years. Snowfall totaled 26.0", more than twice normal and enough to be the sixth snowiest February since 1953. In contrast, Chugach and Kenai Peninsula mountain snowfall was well below normal.

A series of storms moved through the Bering Sea during the middle of the month, culminating in a February 19-20 storm that moved northward just west of the dateline before crossing Chukotka and into the East Siberian Sea (Figure 8). This storm produced wind gusts in excess of 60 mph on St. Lawrence Island and over 75 mph in the Bering Strait. With record low sea ice extent (Figure 9), the storm brought unprecedented mid-winter coastal flooding to Little Diomede that briefly inundated the community's power plant and storm surge waters.
brought huge ice boulder onshore, closing the community helipad until the ice could be removed. Another storm late in the month brought strong west winds to the north side of the Alaska Peninsula. At Port Heiden, winds gusted 45 to 55 mph for more than half a day, and high waves produced extensive erosion that cut through a road to the old village of Meshik. Significant snow reports included 16” reported on the 11th and 12th at Chulitna and 15” near Talkeetna, and the following days the storm brought up to 10” of snow in the Juneau area.

What little cold weather there was in February was found in the eastern Interior during the first week of the month. Some normally colder valleys reported overnight lows in the -40°F range, including -46°F at Northway and -45°F at Tok, as well as the lowest official temperature in the state during the month of -50°F at Chicken.

MARCH

Northern and western Alaska was very mild relative to normal in March, with record or near record high temperatures for the month. This was the mildest March in the 98 years of climate observations at Utqiagvik (Barrow). The average temperature of -0.7°F is 12°F above the 1981-2010 average. The previous mildest March was in 2002 when the average temperature was -2.2°F. The average temperature at Kotzebue in March was 12.8°F. This is 11.7°F warmer than normal and ranks as the second warmest March of record. The average temperature at St. Paul Island for March was 33.3°F, making this the warmest March in more than 80 years. Temperatures were closer to normal over Southcentral and Southeast Alaska, but southern Southeast had a couple of very mild days near mid-month. At Ketchikan, only one March day in the past century has been milder than the 65°F recorded on the 13th.

Southeast Alaska was drier than normal again this month, continuing the trend since autumn. From October through March, Ketchikan received 59” of rain and melted snow. This is just 67% of normal and was not sufficient to keep area reservoirs at useful levels for hydropower generation. As a result, backup generators had to be used, resulting in much higher utility costs for regional residents. At Wrangell, a combination of equipment problems and low reservoir levels resulted in water use restrictions in place for much of the month.

Western Alaska was quite stormy after mid-month. Nome received 19.3” of snow from a couple of storms between the 17th and 23rd. This is the third highest one-week snowfall in March in Nome in more than a century of climate observations. Parts of southern Alaska also saw significant snowfall in March. Heavy snow fell in the Bristol Bay region March 6 through 8. King Salmon reported 15.9” of snow March 7-8, the fourth highest 2-day total of record. A storm total of 17” was reported from Iliamna. Heavy snow was reported across the eastern Kenai Peninsula and upper Turnagain Arm area March 8-9.

In Seward there was an estimated 12” of snow and Whittier reported 25”. As is often the case, the storm brought much lighter amounts to the immediate Anchorage area, with generally 2 to 4” reported. Not to be outdone, heavy snow fell late in the month over parts of Southeast Alaska on March 26-27. Total snowfalls included 9.6” at Elfin Cove and 9.2” at the Juneau Airport.
Temperatures again in April were mildest relative to normal over northwest and western Alaska. Both St. Paul (35.2°F) and Cold Bay (38.3°F) had their fifth warmest April of record. In contrast, some parts of the Interior and Southeast Alaska were slightly below normal. At Fairbanks, the month finished up 1.2°F cooler than normal. That’s hardly dramatic, but does mark the first month since March 2017 to be even a little cooler than normal in the Golden Heart City. For Alaska as a whole, NCEI reported the average statewide temperature about 3°F above the 20th century average.

Rainfall was near to even a bit above normal in southern Southeast Alaska in April and was enough to ameliorate water restrictions and partially refill power plant reservoirs. Ketchikan received more than 13” of rain (almost 140% of normal), including a daily record 3.18” on the 23rd.

Southern Southeast Alaska received a late season snow on April 3. Accumulations of 6” were reported from Ward Cove, north of Ketchikan, and 5” in Ketchikan City. Parts of inland Alaska also had significant snow during the month. On the south side of the Alaska Range, the cooperative climate station near Chulitna received 31” of wet snow during the last ten days of the month, and the month ended with 54” of snow on the ground. More clouds than usual and a lack of especially warm temperatures left plenty of snow remaining in the higher elevations of the Interior at the end of the month, and was the most since 2013. This also was a factor in a comparatively slow start to river breakup, with little movement of ice during the month. However, on the 30th an ice jam on the Tanana River near Salcha produced localized flooding.

An unusually strong storm for so late in the season in the southeast Bering Sea brought very strong winds to the Anchorage area on April 24. Winds gusted to 55 mph at Anchorage Airport and 60 mph at Merrill Field, and hillside winds were clocked to 90 to 100 mph in some places. Numerous trees came down in the wind, and there was some structure damage reported and nearly 25,000 customers from Anchorage to Chugak lost electrical power, some for more than 12 hours.