LONG ALASKA DAYS

By Brian Brettschneider, Borealis Scientific, LLC, Anchorage

The United States Naval Observatory is the keeper of official astronomical data for the U.S. This article is based on calculations from their online utilities. 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.

Summer is a busy time in the Far North. For both rural and urban Alaskans, long days offer opportunities to harvest wild resources, build things, have fun, visit familiar or new places, and prepare for the inevitable arrival of cold temperatures and snow. People outside of Alaska also flock to our great state by the millions from May through August.

The large number of daylight hours makes all of this possible. Construction crews work around the clock, fishermen and fisherwomen harvest salmon in the middle of the night, boats head out to sea when most people are asleep, and so on. On a more domestic level, kids play outside well past typical bedtime, lawns get mowed after 11:00 p.m., hikers and bikers are up late exploring, etc. Alaska’s long day lengths in summer also drive many weather and climate peculiarities that our Lower 48 brethren do not experience.

Each summer, the vast majority of Alaska (north of 60° latitude) experiences at least 30 days with 24 hours of daylight or 24 hours of daylight plus twilight. Why does this occur, and why does it matter? As any high school-level earth science textbook will tell you, the earth’s tilt causes our seasons by alternately exposing each hemisphere to more sun. During our summer months, when the Northern Hemisphere is tilted toward the sun, we receive a plethora of daylight; the opposite is true during the winter months. Quite simply, more sun equals warmer temperatures.

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Above: This composite photo shows the path of the sun from Finger Mountain on the Dalton Highway as June 22 transitions to June 23, 2015. Finger Mountain is about 19 miles south of the Arctic Circle. Smoke from wildfires is visible (see pages 5-8). Photo courtesy Ian Johnson, www.ianajohnson.com.

Left: Players and fans stand for the National Anthem before the 110th Midnight Sun Baseball Game between the Alaska Goldpanners and the Seattle Studs on Sunday, June 21, 2015, in Fairbanks. The annual game starts at 10:30 p.m. and is played without artificial lights. The Panners won 7-4. Photo by Erin Carmelussen, courtesy Fairbanks Daily News-Miner.
Long Summer Days

Summer Solstice

Day length is the longest in the Northern Hemisphere on the summer solstice. In most years, the summer solstice occurs on June 21. Figure 1 shows the length of daylight on the solstice. Please keep in mind that this map, and subsequent maps, show daylight/day length, not sunshine. Sunshine is a meteorological variable that takes clouds into account, while day length is an astronomical variable. Topographic obstructions (e.g., mountains) and atmospheric refraction were also not considered.

Fairbanks observes nearly 22 hours of daylight on the solstice, while in Anchorage the number of hours peaks at 19.4 and Juneau receives approximately 18.3 hours of daylight. Every place in mainland Alaska receives at least 17 hours of daylight on the summer solstice. Conversely, in the Lower 48, the amount of daylight on the summer solstice is between 14 and 16 hours.

Note the spacing of the lines on Figure 1. As latitude (and day length) increases, the distance between each line decreases. For example, the north-south difference between the 17 hour and 19 hour lines is 489 miles, while it is only 52 miles between the 22 hour and 24 hour lines.

When I first posted a similar version of this map to the Alaska Climate Info Facebook page, it generated a lot of interest. Many people were surprised at the difference between southeast and interior Alaska. Others commented that they knew a difference existed but had never seen it mapped before. The most frequent reaction was that the map was clearly wrong. Both Fairbanksans and Anchorageites were certain that their respective cities receive 24 hours of daylight and asked me to please correct the map. In reality, nowhere in urban Alaska does the sun stay up for 24 hours. When the sun sets on days near the summer solstice, however, it stays close enough to the horizon to provide usable twilight. Therein lies the commenters’ confusion.

Several stages of twilight are officially recognized. This article will cover the brightest of those. Civil twilight is when the sun is below the horizon but by no more than 6°. If no clouds are present, civil twilight provides enough usable light to perform most activities without artificial lighting.

The map in Figure 2 combines the hours of daylight with civil twilight on the summer solstice. This is the measure that coincides with people’s experience of summer day length in Alaska. All areas north of a line from Bethel to Kenai receive 24 hours of combined daylight and civil twilight on the solstice. Even areas as far south as Ketchikan receive 19.5 hours of usable light.
Just as in Figure 1, the spacing of the lines on Figure 2 decreases with increasing latitude. The trend for rapidly increasing daylight extends past the 24 hour line. For example, even though Anchorage is only 44 miles north of the 24 hour line in Figure 2, it has continuous daylight plus civil twilight for 30 days. In Fairbanks, the number of days increases to 50, and by the time you reach Barrow, it increases to 118 consecutive days.

ANNUAL DAYLIGHT

The corollary to long summer days is long winter nights. All Alaskans know that a price must be paid for our luxurious summer daylight. How steep is that price? The simple answer is that the daylight budget evens out over the course of a year. If you assume that the sun is a single point of light and the earth has a circular orbit, every location receives an average of 12 hours of daylight over the course of the year—more in summer and less in winter. But those assumptions are not exactly correct: the sun is not a single point, and the earth’s orbit is not a circle. Everywhere on earth, the average length of daylight over the course of the year is actually slightly over 12 hours.

Sunrise occurs when the top of the sun’s disk breaches the horizon. Remember that the sun is 0.5° diameter as viewed from the earth. Therefore, there are a few minutes of daylight before the center of the sun crosses the horizon. The reverse is true at sunset. These “bonus” minutes at sunrise and sunset mean that, despite what you may have heard, every location on earth does not receive exactly 12 hours of daylight on the vernal and autumnal equinoxes. In fact, every location receives at least 6 minutes more than 12 hours of daylight on the equinoxes, due to the time the sun’s disk takes to cross the horizon.

In addition, since the earth’s rotation speed is slower as latitude increases, the sun’s disk takes proportionally longer to clear the horizon at high latitudes. That means in every season, we receive a few more of these bonus minutes of daylight as latitude increases. Here in Alaska, we receive between 12 hours 9 minutes and 12 hours 17 minutes of daylight on the equinoxes (Figure 3).

This bonus effect peaks at the Arctic Circle, since the sun straddles the horizon for relatively long periods of time during the few days before and after the solstices. Looking at Figure 4, you can see that on an annual basis, the area from the Arctic Circle to the north slope of the Brooks Range receives more daylight than anywhere else in the U.S. The difference is not insignificant. Adding these bonus minutes up over a full year, northern Alaska receives 200 more hours of daylight compared to Texas or Florida.

Looking at average daylight plus civil twilight over the course of the year, the effect is magnified again. The diagonal angle of the sun’s path remains within 6° of the horizon for an extended amount of time for areas at, and just north of, the Arctic Circle (see Figure 5). The resulting difference is staggering. Northern Alaska averages two hours of additional usable light per day (daylight and civil twilight combined) than our friends in the southern Lower 48. That is 700 more hours a year!

Remember also that the orbit of our planet is not circular but instead traces out an ellipse. To conserve angular momentum, a planet orbits slower when it is farther from the sun and faster when it is closer. During the Northern Hemisphere summer, the earth is farther from the sun and therefore orbits more slowly.
What does this mean? It means that during the time when the sun is hugging the horizon near the June solstice, the earth is moving slower through its orbit. Therefore, the “horizon-hugging” period of time around the June solstice includes more days than the horizon-hugging period near the December solstice.

This is demonstrated by the fact that Barrow has no sunset for 82 consecutive days in the summer but only 64 days with no sunrise in the winter (+18 days). Our friends in the Southern Hemisphere move faster during their summer and slower during their winter. The same latitude as Barrow in the Southern Hemisphere has no sunset for 75 consecutive days in the summer but only 66 days with no sunrise in the winter (+9 days).

It also means that the latitude of Alaska (55°N to 71°N) not only receives the most daylight and daylight plus civil twilight than any place in the Northern Hemisphere, but in the entire world. Figure 6 shows just how much light is received by latitude in each hemisphere. The red lines represent the Northern Hemisphere and the blue lines represent the Southern Hemisphere. Notice how much light is received in mainland Alaska (latitudes 60°N to 71°N) compared to everywhere else on earth!

CONCLUSION

Alaska's copious summer daylight is an integral part of our existence, a shared experience that binds Alaskans together—and that non-Alaskans don't quite grasp. A version of the maps shown in Figures 1 and 2 were the most Shared, Liked, and Commented entries on my Facebook page's 2+ year history by a very wide margin when I posted them in early June. Hundreds of thousands of people saw the post and over 10,000 engaged with it (Likes + Shares + Comments). When I posted it to Twitter, which is followed primarily by people from out of state, only three people Favorited the entry. The Weather Channel based a story on the figures that received a grand total of zero Comments and no Shares. On the other hand, the Alaska Dispatch News published the maps in a story this June that became their most Liked and Shared story in the previous 12 months.

In Alaska we like to say that things are different up here. People in the Lower 48 may find our very long days mildly interesting, but they do not get it. Sunshine at 1 a.m. is a foreign concept to most people. It is one thing to read about the extended daylight, but quite another to live with it. Long days in the summer are like fuel in the engine of life in Alaska. So remember, not only is Alaska the biggest state in the U.S., it is also the brightest—literally.

WEATHER AND CLIMATE IMPACTS

Alaska’s long summer days affect our day-to-day weather and climate in important ways. For example, the near-continuous solar energy facilitates the development of a semi-permanent thermal trough of low pressure in Alaska’s Interior. This area of low pressure provides atmospheric lift that aids in the development of summer thunderstorms. Those thunderstorms ignite most of our large Alaska wildland fires—which burn the vegetation dried by extra hours of daylight (pages 5-8). Also, the long days keep summer low temperatures relatively high. A number of places in the Lower 48 have first and last freeze dates that are earlier and later respectively than those in Alaska. A Lower 48 location with nine hours of darkness can cool off overnight much more than an Alaska site with only two hours of twilight.
SUMMER 2015: WEATHER IMPACTS ACROSS ALASKA

By Kevin Galloway¹, Blake Moore¹, Rick Thoman², and Gerd Wendler¹. ¹) Alaska Climate Research Center, Geophysical Institute, UAF; ²) National Weather Service.

This article is based on information from the Alaska Interagency Coordination Center, Alaska Climate Research Center, and National Weather Service. The National Integrated Drought Information System hosts quarterly information on regional climate impacts and outlooks, available at: http://www.drought.gov/drought/content/resources/reports

Although several significant weather events impacted Alaska in June, July, and August, 2015's wildfire season dominated the state (Figures 7-10). Between January 1 and September 15, 766 fires were ignited (54% by lightning, 46% by people) and 5,144,880 acres burned, making 2015 Alaska's top fire season in number of ignitions and second largest in acreage burned. Between June 1 and August 31, 12 incidents consumed 72 homes and at least 22 other structures and forced more than 2,000 people to evacuate. This summary highlights just some of the wildfire incidents as part of a chronological summary of the season's notable weather impacts on Alaskans (Figure 8).

JUNE

June started with a cold front moving into the Interior. About an inch of snow fell in Salcha and Delta Junction. Snow-laden trees and high winds brought down power lines south of Salcha. Frost-level temperatures persisted until the 2nd. Circle Hot Springs recorded a low of 24°F. The front also brought red flag warnings for fire danger in Interior, western and northern areas due to high winds; these warnings persisted in some form through much of June. Gusts up to 50 mph generated travel advisories on the Dalton Highway and knocked down power lines in Stevens Village. Hail fell near Anchorage on the 16th.

Humans started the Cummings Road Fire east of Delta Junction near the Alaska Highway, one of six fires started on June 1; it was controlled at 37 acres by June 6. Lightning ignited the Chisana fire in Wrangell-St Elias National Park on June 9; it grew to 9,000 acres by the 12th, then to 30,000 acres by the 21st.

An illegal debris burn near Willow on the Parks Highway escaped on the 14th and became the Sockeye Fire, which exploded to 6,500 acres the next day in extremely warm and dry conditions (Figure 7). About 1,700 residents evacuated over the next few days, and the fire jumped the highway, forcing its closure periodically. In total, the fire destroyed 55 residences and damaged an additional 44, plus many outbuildings. Early estimates put suppression costs over $8 million. Two Anchorage residents face criminal charges for their role in starting the fire.

Humans also caused the Card Street fire, reported at 75 acres along the Sterling Highway near milepost 77 on June 15. The fire grew to 1,200 acres in just 8 hours, leading to a series of evacuations for residents and nearby campgrounds. It destroyed 3 homes and 8 outbuildings before moving east into the Kenai National Wildlife Refuge. The Governor issued a disaster declaration for the Card Street fire on the 19th.

Figure 7. This combination of natural color (top) and false color (bottom) satellite images by Landsat 8 from June 15 shows the Sockeye fire near Willow. An illegal debris burn escaped on the 14th, and dry and windy conditions allowed the resulting fire to explode to more than 6,500 acres the next day. Images courtesy of the NASA Earth Observatory.
Fireworks and open fires were banned across much of Alaska for the second half of June in the wake of the high fire danger. Beginning on June 16, extensive lightning ignited multiple fires daily, culminating in a three-day period (June 21–23) during which about 50,000 lightning strikes ignited about 200 new fires (Figure 9). By June 23, over 2,000 personnel were assigned to fires, and the season peaked on June 29 with 45 fires staffed by 3,174 personnel. By the end of June, 399 fires had burned an estimated 1.6 million acres, more starts and acreage than in the record year of 2004. Residents of several communities evacuated, including Nulato, Tanana, Chuathbakuk, and Aniak. Smoke affected a number of communities, leading to canceled outdoor events, and also hampered fire aviation operations.

All the activity fully tasked the ability of Alaska’s 49 fire crews and their equipment, and more of both came from the Lower 48 and Canada. For the first time since the inception of Alaska’s Emergency Firefighter (EFF) program in 1977, all EFF crews (about 1,000 people) were assigned and fighting fire in the second half of June.
JULY

As July began, fireworks bans from June remained in effect, and no new fires from fireworks were reported over the weekend of the 4th. Warmer temperatures in the Interior helped fuel the nearly 300 fires burning in early July; only 36 of them were staffed. Despite the warm conditions, crews made progress on several fires, including the Rex Complex near Nenana, Healy Lake near Delta Junction (63% contained), West Fork (100%), and Anaconda (68%), both near Chena Hot Springs. Nearly 500 firefighters were working the Aggie Creek fire near the Elliott Highway north of Fairbanks, which had grown to 13,000 acres and was expected to increase in size with the warmer weather.

As predicted, hot dry weather on July 6 did push the wildfires to new extremes, and total acreage burned exceeded 3 million acres by the 7th. Air quality again dropped to hazardous levels for many Interior areas. The silver lining in the cloud of dense smoke that hung over the Interior was that it helped reduce temperatures over the next few days. By the 7th, the Aggie Creek fire was 17,000 acres, and more personnel (600), as well as air tankers, were assigned. Some evacuations were recommended in the area. One of the Rex complex fires cropped a power line near mile 290 of the Parks Highway, killing power to Anderson School and the incident command post. The Baker fire moved to within 1.5 miles of the Elliot Highway. Similar problems with aggressive behavior were reported at a number of the staffed fires in the Interior. Due to hazardous air quality in the Fairbanks area, the Borough Parks & Recreation canceled all outdoor activities, youth soccer and softball games were scrapped, and Holland-America canceled its Interior flight-seeing tours.

The Aggie Creek fire topped 26,000 acres on July 10, and the fire moved to within a half a mile of the Trans-Alaska Pipeline. The fire was 25% contained at that point, and the 400 personnel assigned to the fire used retardant, sprinklers, and burnouts to protect the pipeline (photo). The Nome Creek valley reopened to camping on the 11th as fire danger dropped due to some rain, then closed again on the 13th as strong winds rekindled the U.S. Creek fire. The fires around Tanana were still quite active, totaling more than 500,000 acres with more than 250 firefighters assigned. By July 11, 86 personnel were assigned to the Long Lake fire (25,000 acres) near Northway. The 75,000 acre Hay Slough fire near Manley threatened mining activity and structures, while the nearby Baker fire grew to over 20,000 acres. Total area burned had reached 4.69 million acres on the 13th, with 300 active wildfires, making 2015 already at least the fifth worst season on record.

Wildfire growth slowed across the region on the 16th due to wetter weather. By that time, more than 2,000 firefighters from Alaska had been joined by more than 3,500 from the Lower 48.

Wildfire-generated smoke worsened the air quality in the Fairbanks area again on the weekend of the 25th. Heavy rain, a ‘50-year rainfall event’ that same weekend in Anchorage resulted in localized flash flooding, the closure of some streets with up to two feet of water on them, and the evacuation of about 30 people from an apartment complex. A weather station at Lake Otis and O’Malley reported 2.56” of rainfall during the event, with the Anchorage International Airport reporting 1.05”.

Figure 10. Wildfire perimeters and lightning-generated fire locations at the end of summer 2015. Data courtesy of the Alaska Interagency Coordination Center.
AUGUST

Wildfire-related news again led off the month when smoke forced a small plane to land on the Dalton Highway on August 1; no one was injured. Warm weather dominated the Southcentral area for the first week of the month and set some new records. Red flag warnings for high winds and thunderstorms were issued for the northern slopes of the Brooks Range on the 5th. The same day saw heavy downpours and lightning in the Fairbanks area. Eielson AFB reported rain totaling 0.43” from the series of thunderstorms. High wind gusts on the morning of the 10th led to several power outages in the Fairbanks area, while snow fell on higher elevations in the Brooks Range. The first frost warnings of the season were issued for low-lying areas of the Interior on August 15.

A series of vigorous storms swinging through the state beginning in mid-August brought heavy rains starting on the 16th in the Southcentral region and in Southeast Alaska on the 18th. Sitka airport reported over 2.5” in 6 hours, triggering several landslides, one of which killed three people. The NWS Anchorage office issued its first severe thunderstorm warnings since June 2009. Hail was reported near Meadow Lakes and Houston on the 18th and in Thompson Pass on the 19th. Strong thunderstorms were reported in the Gulf of Alaska on the 21st. An uncommon lightning strike in Soldotna knocked out power to one business on the 22nd. An unusual 1.50” of rain fell in Tanacross on the 23rd.

A large low-pressure system (Figure 11) brought early winter weather to much of the state in late August, including high surf, gusty winds, and flooding to the Arctic Coast, Norton Sound, and Bering Strait regions. On the 27th, Barrow reported winds over 50 mph and some flooding due to the high surf. The same day saw a series of power outages in the Anchorage area when gusts up to 35 mph blew trees onto lines, including about 5,000 customers in the downtown area. High winds up to 60 mph picked up ash from the Katmai Volcano on the Alaska Peninsula and blew it across the Shelikof Strait into the Kodiak area. The same high winds in the Kodiak area downed a power line, igniting and fanning an unusual and quick-moving wildfire near the small community of Chiniak; some residents evacuated, and 2 homes and the village's library were destroyed.

The storm also produced snow in areas of the Brooks Range and Denali National Park and high winds for the middle Tanana Valley. The Alaska Marine Highway system canceled two ferry sailings on the 28th from Juneau and from Whittier due to high seas. Heavy rains in the Interior led to activation of the Moose Creek Dam on the Chena River on the 29th; it stayed activated for about a week. Humans caused two late-season wildfires in less than 24 hours in the Mat-Su Borough on the 29th and 30th.

Figure 11. This water vapor satellite image for August 25, 2015, shows the weather pattern that resulted in heavy rainfall, high winds, snowfall, and coastal flooding across much of Alaska. Image courtesy of the National Weather Service.
Understanding Seasonal Outlooks

by Rick Thoman, National Weather Service

This article is based on information from NOAA’s Climate Prediction Center (http://www.cpc.ncep.noaa.gov/) and ACCAP’s monthly Alaska Climate Forecast Webinars (https://accap.uaf.edu/NWS_Briefings).

Each month NOAA’s Climate Prediction Center provides seasonal (three month) outlooks for average temperatures and total precipitation from the upcoming season through a year into the future. During ACCAP’s monthly Alaska Climate Forecast Webinars, we discuss how recent forecasts compare to what actually happened and share the forecasts for the upcoming season.

While it seems intuitively obvious to compare what happened to what was forecast, it turns out that for climate outlooks this is not as straightforward as it sounds. Seasonal climate outlooks are quite different from daily weather forecasts. Some of the differences between these products are summarized in Table 1.

Traditionally, seasonal climate outlooks forecast just two elements—average temperature and total precipitation—and they simply indicate how likely each element is to fall into one of three categories—significantly above normal, near normal, and significantly below normal. To define these categories, the observed range of each element (temperature or precipitation) over the base period (usually three decades) is divided into three equal-sized categories, which then are used as the basis for future outlooks. This approach involves several potentially risky assumptions. First, that the base period is representative of the long term. Second, that representative decadal-scale climate variability is captured in the base period, and third, that any underlying climate change is slow and small compared to the base period. It is easy to find individual examples where one or more of these assumptions are not true, but in general it works tolerably well.

When we say that seasonal outlooks are probabilistic, that means that the chances of all outcomes are provided. Since the outlooks are by category, the outlooks indicate the likelihood of each of the three categories. So, an outlook of “45% chance of significantly above normal” is really shorthand for “45% chance of significantly above normal, 33% chance of near normal, and 22% chance of below normal”. As probabilities increase, confidence increases: an outlook of “65% chance of significantly above normal” means that the chance of significantly below normal is only 5%. That is one very confident outlook!

Each month during the ACCAP Climate Forecast Webinar we show how the most recent season turned out compared to what CPC forecast, as seen in Figure 12 for the summer of 2015. So, how could we grade these two forecasts? You might say that the CPC did a better job with the temperature outlook than with precipitation, and that seems to be generally true—precipitation is much harder to forecast than is temperature.

It’s important to recognize that the probabilistic nature of seasonal outlooks makes evaluation of specific outlooks tricky. One way is to simply ignore this and treat any tilt toward a specific category as a forecast for the category. This is simple to do, but completely ignores the breadth of information contained in the forecast. After all, a 45% chance of significantly above normal means that there is a 55% chance of not significantly above normal. Another way is to give greater weight to higher probability values and lower weight to weaker tilts. Finally, a large collection of outlooks and associated observations can be evaluated to determine the extent to which the outlook probabilities (in the long run) are realistic. That’s what we do during each month’s ACCAP’s monthly Alaska Climate Forecast Webinars, and we hope you will join us for one of these soon (https://accap.uaf.edu/NWS_Briefings).

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Table 1. Qualitative attributes of daily forecasts compared to seasonal outlooks.
SUMMER 2015 WEATHER CONDITIONS IN ALASKA

By Gerd Wendler, Blake Moore, and Kevin Galloway
Alaska Climate Research Center, Geophysical Institute, UAF

This article presents a climate summary of summer 2015 (June, July, August), concentrating on temperature and precipitation from the 19 first-order meteorological stations operated by National Weather Service (NWS) meteorologists in Alaska. The deviations from the long-term average are based on the new normal of 1981–2010. All figures and tables are provided by the Alaska Climate Research Center, http://akclimate.org, except as noted.

TEMPERATURE

Most of Alaska experienced summer temperatures slightly above normal (Figure 13). Southcentral Alaska (Anchorage, Kenai Peninsula, and Kodiak) observed the highest positive deviations, exceeding 3°F. Central and northeastern portions of Alaska reported small negative deviations, never reaching -1°F. The rest of Alaska was somewhat warmer than normal, with relatively small deviations.

The seasonal mean temperature deviations of the 19 first-order stations were 1.5°F above normal (Table 2). Kodiak recorded the highest positive deviation with 3.7°F, while Fairbanks and Delta Junction were relatively cold, both 0.8°F below the expected value.

Figure 13. Summer 2015 isotherm map of the deviation in temperature (°F) from the 30-year normal (1981–2010) based on all first-order meteorological stations in Alaska.

Figure 14 shows the mean daily temperature of the 19 stations over the summer. The first three days of June were warmer than normal, followed by a cold spell of nine days. Three days during the second part of June recorded substantial temperature deviations exceeding +8°F. These are indeed large deviations for the mean of 19 stations, covering Alaska from Barrow to Annette. Thereafter, sustained warm temperatures lasted until the first week in August, interrupted only by short spells of slightly below normal temperatures. Most of the last two-thirds of August was relatively cold, especially August 31, with a negative deviation exceeding 5°F, the highest daily negative deviation of the entire season; some low-lying areas in Interior Alaska experienced the first frost.

Looking at the temperatures for each summer month separately, June and July were relatively warm, while August was at the expected temperature level. June continued the state’s persistently warmer-than-normal temperatures; monthly statewide temperatures have remained above normal since July 2014. 16 of the 19 first-order stations observed above-normal June temperatures. The monthly mean temperature of all first-order stations was 54.6°F, 2.9°F above the normal of 51.7°F. This is 4.1°F above the June 2014 mean of 50.5°F. Most of June 2015 was warmer than normal, with a colder than normal period from the 4th to the 12th, and a second short cool spell on the 26th and 27th. The peak warm deviation, a high of 8.5°F, occurred on the 15th and 19th, while the coldest deviation of -3.4°F occurred on the 11th. Homer reported the greatest positive deviation from normal
The warmth continued into July 2015 with above-normal temperatures at 15 of the 19 first-order stations. 22 days of the month were above the 30-year normal. Temperatures were colder than normal until the 3rd, when warmer temperatures persisted until the 13th. The next six days brought mixed temperatures, followed by slightly warmer than normal temperatures for six more days. The end of the month went back to mixed temperatures again. The peak warm deviation, a substantial 7.5°F, occurred on the 6th, while the coldest deviation, only a mild -1.1°F, occurred on the 19th. The monthly mean temperature of all first-order stations was 56.8°F, 1.3°F above the normal of 55.5°F and 1.1°F above the July 2014 mean of 55.7°F. Kotzebue recorded the greatest positive deviation from normal at 4.1°F above its long-term mean of 54.6°F. Annette (3.4°F), Anchorage (3.3°F), Kodiak (2.9°F), Nome (2.7°F), and St Paul (2.1°F) also reported positive deviations exceeding 2°F for July 2015.

The highest July temperature at the first-order stations was 89°F, reported at Fairbanks on the 6th. Fairbanks also had the highest mean July temperature at 62.2°F, although this was slightly colder than its normal. The lowest July temperature was 31°F at Barrow on the 28th and 30th, while Barrow also reported the lowest July mean temperature at 40.5°F.

The daily record temperature events for July were nearly all record highs, with just one record low reported in Bettles on the 4th. Most of the limited number of high events occurred during the warm period around the 6th.

With a slightly warmer than average month, August just barely continued the streak of monthly statewide temperatures above normal since July 2014. The monthly mean temperature of all first-order stations was 53.4°F, just above the normal of 53.3°F and 2.2°F below the August 2014 mean of 55.6°F. Nine of the 19 first-order stations reported above normal temperatures for August. Calculating the mean daily temperatures of the first-order stations, 18 days of the month were above the 30-year normal. Temperatures started the month warmer than normal until the 10th, then mixed temperatures persisted until the 26th, and the month ended with five colder than normal days. The peak warm deviation, a high of 3.9°F, occurred on the 4th, while the coldest deviation of 5.2°F occurred on the 30th. Kodiak had the month’s greatest positive deviation from normal at 3.5°F above its long-term mean of 55.2°F. Anchorage (2.2°F) and St Paul (2.0°F) also reported positive deviations equal to or exceeding 2.0°F. Delta Junction had the greatest negative deviation at -2.5°F. Nome

### Table 2. The summer 2015 means and deviations in temperature (°F) from the 30-year normal (1981–2010) for all first-order stations for each spring month and for the season.

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at a significant 7.2°F above its long-term mean of 50.6°F. Kotzebue (5.6°F), King Salmon (4.9°F), Kodiak (4.7°F), Bethel (4.6°F), Barrow (4.5°F) and Anchorage (4.3°F) also positive deviations equal to or exceeding 4°F for June 2015.

The highest June temperature at any first-order station was 89°F, reported at Talkeetna on the 15th. Fairbanks had the state’s highest mean June temperature with 59.8°F, although this was actually a slight negative deviation for the Golden Heart City. The coldest temperature was 25°F at Barrow on the 30th. Kodiak had the month’s greatest negative deviation at -2.5°F. Nome

Figure B
(-1.6°F), Fairbanks (-1.5°F), Bettles (-1.4°F), and Gulkana (-1.3°F) also recorded negative deviations exceeding -1.0°F.

The highest August temperature of the first-order stations was 84°F, reported at McGrath on the 4th, a new record for that day. Annette had the highest mean temperature for the month at 59.3°F. The coldest temperature was 22°F at Bettles on the 31st, while Barrow reported the lowest August mean temperature at 38.1°F.

August daily record temperature events were mostly all high events, with just two record low events reported at Cold Bay. Most of the limited numbers of high events occurred during the warm period in the first week of the month.

**PRECIPITATION**

Figure 15 shows the precipitation deviations for the 19 first-order stations. Northern, Interior and Southeast Alaska received precipitation at or above normal, while Southwest Alaska stations recorded deficits. The largest positive deviation was observed for Juneau with 23.98", 77% above normal, and the highest amount of all stations for summer 2015. Kodiak reported the greatest negative deviation with 8.41", only 55% of its expected precipitation.

In absolute terms, however, Barrow received the least precipitation at 74% above normal. The greatest positive deviation, with a total of 0.84", or 21% below normal; this period in the first week of the month.

More details are presented in the following paragraphs, month by month.

**June** was notably drier than normal, with the overall precipitation 21% below normal; this calculation was based on the mean of the deviations in percentage. 16 of the first-order stations and 20 days of the month reported below normal values. This is appreciably drier than June 2014, which had a precipitation total 74% above normal. The greatest daily deviation of 134% occurred on the 9th, driven by near record-breaking precipitation at Barrow. Three days in June had no measurable precipitation at any of the 19 first-order stations. Continuing a trend from May 2015, Barrow reported the month’s greatest positive deviation, with a total of 0.84", or 263% of the expected amount of 0.32".
August was also just slightly wetter than normal, with overall precipitation 7% above normal. Nine of the first-order stations and 12 days of the month reported above normal values. This is somewhat wetter than August 2014, which had a precipitation total 2% below normal. The greatest daily deviation of 280% occurred on the 25th, driven by rain and snow experienced across much of the state. Like July, there were no days during August without measurable precipitation at any of the 19 first-order stations. On a monthly basis, Gulkana had the greatest positive deviation from normal, with a total of 3.82”, or 112% above the expected amount of 1.80”. The other stations with precipitation greater than 50% above normal were Kotzebue (83%), Barrow (61%), Bettles (61%), and Juneau (56%). The leading station with a lower than normal precipitation amount was Anchorage, with just 30% of normal. The other stations with less than half of their normal precipitation amount was Anchorage, with just 30% of normal. The other stations with less than half of their normal precipitation are Talkeetna (39%), Cold Bay (44%), Kodiak (44%), and Homer (47%).

The maximum monthly precipitation total reported for a first-order station was 13.91” at Yakutat, while Yakutat also reported the highest daily total of 4.39” on the 17th, a new record for this specific day. August saw a typical number of daily precipitation records set during the wetter second half of the month. Juneau has had above normal precipitation every month in 2015 except May, making 2015 the station’s wettest January-August, with 51.80”, 3.49” above the 48.31” record from 1992 for this time period. The normal for this period is just 33.17”. On a seasonal basis, 23.98” for summer 2015 is the second wettest for Juneau, 0.29” behind the record year of 2014. Haines had its second wettest August on record with 7.73”; the record is 13.69” from 1956.

The only other two stations with precipitation greater than normal were Juneau (144%) and Yakutat (135%). Bethel with just 16% of normal led stations with lower than normal amounts of precipitation. Kotzebue (36%), Cold Bay (41%), and Bettles (46%) also had less than half of their normal precipitation. For June the maximum monthly precipitation total reported for a first-order station was 8.64” at Yakutat, which also reported the highest daily total of 2.10” on the 4th, a new daily record. As might be expected, there were a limited number of daily precipitation records, most set in the wetter first half of June in Southeast. June 2015 was the third driest June on record for Bethel.

July was just slightly wetter than normal, with overall precipitation 7% above normal. Nine of the first-order stations and 18 days of the month reported above normal values. This is drier than July 2014, which had a precipitation total 24% above normal. The greatest daily deviation of 120% occurred on the 17th, driven by rain across much of the state. Every day in July saw measurable precipitation recorded by at least one of the 19 first-order stations. On a monthly basis, Juneau had the greatest positive deviation from normal, with a total of 10.40”, or 126% above the expected amount of 4.60”. The only other two stations with precipitation greater than 50% above normal were Annette (64%) and McGrath (62%). The leading station with a lower than normal precipitation amount was Barrow, with just 22% of normal. The only other station with less than half of their normal precipitation was Kotzebue with 24%.

The maximum monthly precipitation total reported for July for a first-order station was 11.81” at Yakutat, while Annette reported the highest daily total of 2.16” on the 24th, a new daily record. July saw a fair number of daily precipitation records set throughout the month and across the state. Despite setting only one daily record, Juneau had its wettest July on record with a total of 10.4”, 0.04” above the old record from 1997. This monthly record was driven by precipitation on 26 days of the month; seven of those days had more than half an inch of rain. This comes after the wettest January, as well as the driest May, on record for Juneau. It was the second wettest July on record for Sitka with 9.55”; the record is 12.27” from 1959.
SEA ICE: ANOTHER EXTREME SUMMER RETREAT, BUT NOT A RECORD

By John Walsh, Chief Scientist, International Arctic Research Center, UAF

As reported by the National Snow and Ice Data Center, the total pan-Arctic ice extent reached its 2015 minimum, approximately 4.4 million square kilometers, on September 11. The 2015 minimum occurred almost a week earlier than the mean date of the minimum for 1981-2010, although there was little change in ice during the week following the 2015 minimum (Figure 17). While the average for the entire month of September is yet to be determined, it will almost certainly be considerably less than 5.0 million km², which was the median value of the Sea Ice Prediction Network’s forecast issued in early June (see the June issue of the Alaska Climate Dispatch). The mid-September ice extent is quite close to the values of recent years such as 2007 and 2011, and below the values of the past two years, 2013 and 2014. The September 2015 ice extent was more than two standard deviations below the average for the 1981-2010 period. However, the 2015 value is well above the record minimum September extent of 3.6 million km², which was set in 2012 (See Figure 17).

The extremely low pan-Arctic ice extent was primarily a result of the extreme ice retreat in the Kara, Laptev, East Siberian, Chukchi and Beaufort Seas. The edge of the main ice pack was far offshore of the northern Alaska coast in mid-September. As shown in Figure 18, the distance from Barrow to the main pack was about 500 miles. However, remnants of multiyear ice were still present between the main pack and the Alaska coast. These remnants actually constituted a distinct band of remnant ice in the Beaufort and Chukchi Seas during August. It should also be noted that the passive microwave measurements from which Figure 18 is derived tend to underestimate ice concentrations in areas of loose ice with wet (melting) surfaces, so ship traffic and other offshore activity in the peripheral seas are not guaranteed the “clear sailing” implied by the absence of sea ice in the Chukchi and Beaufort Seas in Figure 18.

An additional complication for offshore activities during late August and September was a series of storms that passed through the Chukchi and Beaufort Seas. With the huge expanse of open water, the storms’ gale-force winds had sufficient fetch to generate large waves and swell. Shell’s drilling operations in the Chukchi had to be shut down for several days in late August because of the rough
seas, and shoreline communities including Barrow reported heavy surf and localized flooding (Figure 19). Such occurrences have become increasingly common in the past decade, as there is now a several-month period from July to November when open water extending more than a hundred miles offshore. By contrast, there were many years in the 1970s through the 1990s when the ice edge never receded more than 100 miles offshore (see the online Alaska Historical Sea Ice Atlas, http://seaiceatlas.snap.uaf.edu/). This situation is exacerbated by the fact that August through November are the months when storms in the Chukchi and Beaufort Seas are most common, resulting in an increased risk of high seas, coastal flooding and erosion along the northern coast.

Figure 19. This image from UAF's Barrow Sea Ice Webcam shows the heavy surf encroaching on Barrow's shoreline late on the morning of August 27, 2015.