



The Denali HQ weather station buried under five feet of snow on December 29, 2021 (left). The 60" snow stake used to measure the snow depth going under (right). NPS Photos.

Historic Storms In Denali

Denali December 2021

A series of storms brought an unprecedented amount of snow and rain to Denali Park headquarters in December. The first wave of snow started just before solstice and by December 23rd had deposited two feet of snow bringing the snow depth to 37 inches. . .and then came the Christmas storm. This storm started on the 25th and brought heavy wet snow and rain to areas north of the Alaska Range in Denali. The temperatures hovered around freezing and the snow kept accumulating until it reached a peak of 60 inches – a record five feet of snow! The December snowfall and precipitation totals have shattered previous records; quite extraordinary considering this record dates back almost a century. Check out these numbers:

78 inches: December 2021 Snowfall Total

- Snowiest December on record (Figure 1).
- Second snowiest month on record (Figure 2).

8.65 inches: December Precipitation Total (rain & melted snow)

- Wettest December on record (Figure 3).
- More than half of the total annual precipitation.
- More than what usually falls in an average summer.

60 inches: December Snow Depth (on the ground on December 29 and 30)

- Highest on record*; Average snow depth for December is 17 inches. (* no depth data for Feb 1932).

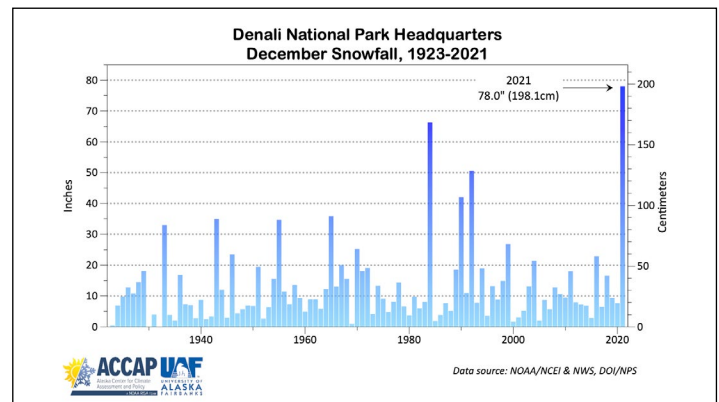


Figure 1. December 2021 was the snowiest December of this (almost) century long record. Graph courtesy of Rick Thoman UAF/ACCAP (uaf-accap.org).

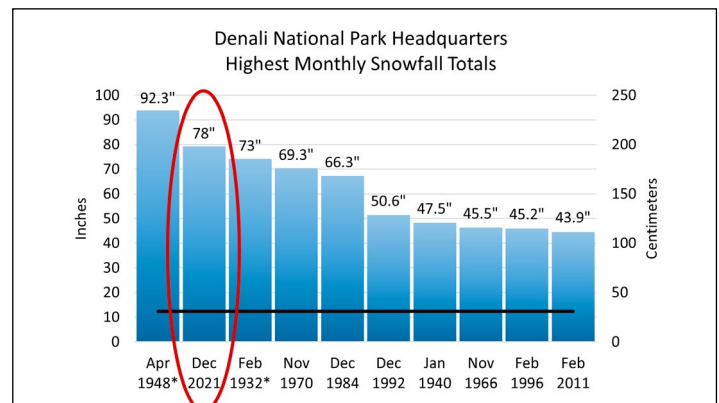


Figure 2. December 2021 (red oval) was the second snowiest month on record in almost a century (1923-2021). Normal December snowfall is 12.4 inches (black line). *Note: There are data quality issues with April 1948 & February 1932 observations. Totals here are the best estimate.

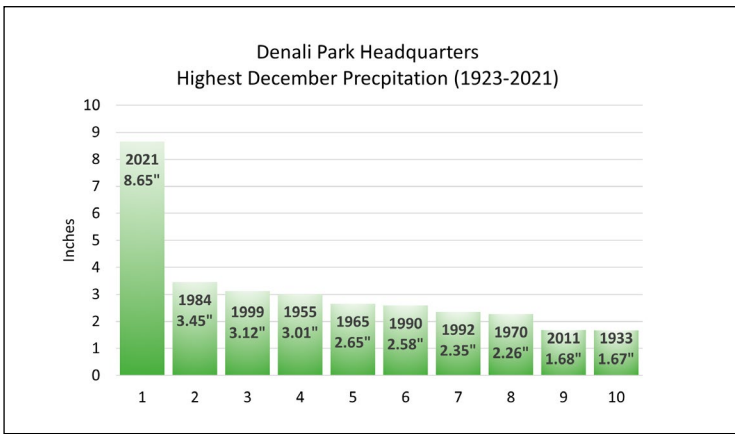


Figure 3. December 2021 was the wettest December by far with records dating back to 1923.

A Few More Notable Numbers:

- Second highest *daily* precipitation total of any month: 2.75 inches (water content of snow plus rain) recorded the morning of December 27 for the previous 24-hour period (this was not a typo; this was confirmed by the kennel’s folks the day after the event!). The second wettest day on record was July 24, 1967.
- During the last week of December (25-31), a whopping 46.6 inches of snow fell. The water content of that snow, plus the liquid precipitation that fell (rain, freezing rain), totaled just over 6 inches!

Several Weeks of the Pineapple Express

It is not unprecedented to have warm air flowing directly north from the tropics to Alaska; there’s even a name for it – the ‘pineapple express’. But the system in late December was unusual in its persistence. There was a continuous stream of moist tropical air riding up and over a very stable record high pressure system in the north Pacific. The result was unseasonably warm temperatures and an incredible amount snow and rain for Interior Alaska (Figure 4). The area north of the Alaska Range in Denali was one of the wettest/snowiest areas in the state (Figure 5). This type of precipitation event is more characteristic of a warm season rain than a mid-winter rain-on-snow event.



Figure 4. The Murie Science and Learning Center at Denali with heaps of snow on December 30, 2021. NPS Photo.

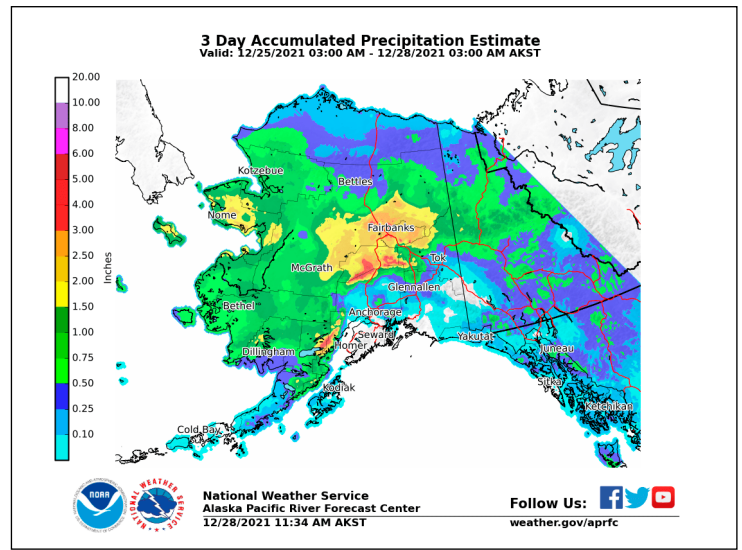


Figure 5. December 25-28 precipitation accumulation estimates for Alaska. The dark red areas = 3-6” of precipitation. The largest red area is the north side of the Alaska Range in Denali National Park and Preserve. Graphic generated from the [Alaska Pacific River Forecast Center \(weather.gov\) site](http://Alaska Pacific River Forecast Center (weather.gov) site).

Wet Out West: Wonder Lake and Kantishna

Automated weather stations designed to handle winter precipitation measurements at Wonder Lake and Kantishna also recorded anomalously high precipitation totals for December 2021. The site at Wonder Lake, just west of the campground, recorded 6.14 inches of total precipitation (water content) for December. Kantishna recorded 6.60 inches, making it the wettest cold season month (Oct-Apr) on record and six times wetter than the average December precipitation (with 17 years on record). Fairbanks and Nenana also had very wet Decembers, but the highest precipitation deviations were recorded north of the Alaska Range in Denali (Figure 6 and 7).

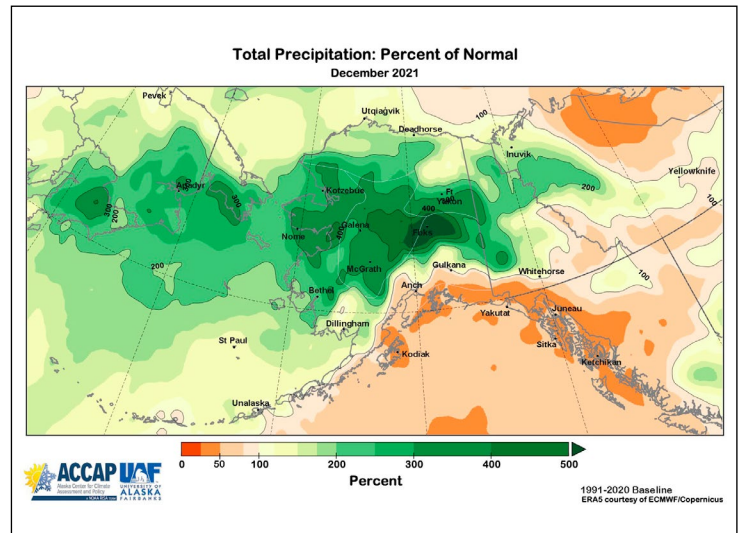


Figure 6. Map showing the stark differences in total precipitation deviations between the very wet Interior (dark green) and the very dry Gulf of Alaska Coast (orange) for December 2021. Graphic courtesy of Rick Thoman, Alaska climate specialist, UAF/ACCAP (uaf-accap.org).

Accumulated Precipitation December 2021

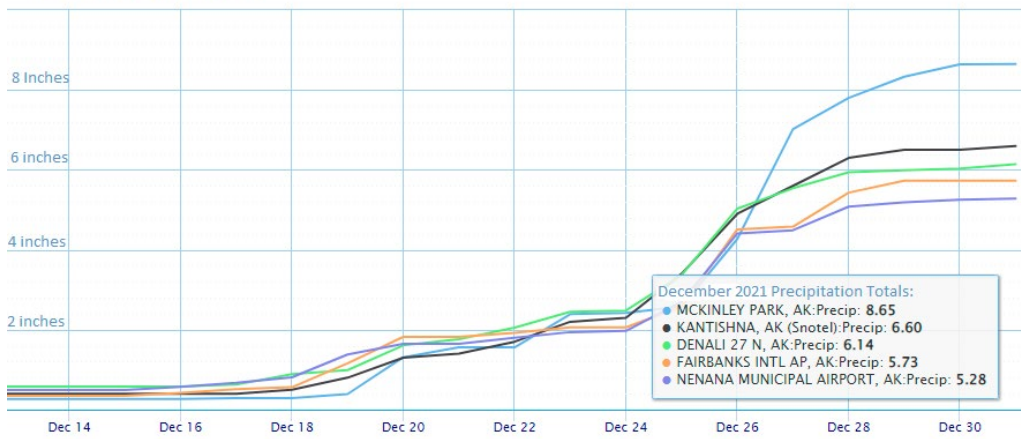


Figure 7. Late December precipitation accumulation in Denali, Fairbanks, and Nenana. Denali Park HQ was the wettest location (blue line), followed by Kantishna (black line), Wonder Lake (Denali 27N - green line), Fairbanks (orange line), and Nenana (purple line). Data source: xmACIS2 (rcc-acis.org).



Denali Mountain Observations

We are fortunate to have sporadic data streaming in from the weather stations on Denali this winter. Preliminary numbers show that the 14 camp weather station got about 12 inches of snow in mid-December and 16 inches during the three-day Christmas storm event. Another 11 inches accumulated the last few days of the month. Base camp snowfall readings were more sporadic, but preliminary totals for the storm events were less than at 14 camp. This is a reversal of the usual pattern of heavier snow at base camp than at 14 camp (Contact Mike Loso for more information). This unusual pattern is likely due to the storm track that followed the north side of the Alaska Range.

Christmas Storm Rainfall (!) Totals

Measurable rain in winter is rare. When more than an inch of rain falls on top of an established snowpack in December it is an extreme event. Rick Thoman, Alaska climate specialist with the University of Alaska Fairbanks (UAF) Alaska Center for Climate Assessment and Policy (ACCAP), produced a map of total rainfall for the December 25-28th period (total precipitation minus the snow water equivalent) which highlights the band of liquid precipitation that fell across the northern flanks of the Alaska Range during the three day storm event. Darker blue areas = more rain, directly impacting the north side of Denali (Figure 9).

Rain-on-Snow at Toklat

Temperatures at the Toklat automated weather station climbed above freezing on December 19th and 26th. It was warm enough on both occasions to record liquid water movement through the summer rain gage. It is unusual for us to see any precipitation signal from the rain gage in the cold season, but on December 26 several inches of liquid water was recorded (Figure 8). We use the rain gage to record summer rainfall when temperatures are consistently above freezing. However, it is verification that on December 19 and especially December 26 there was liquid water flowing through the snow at Toklat.

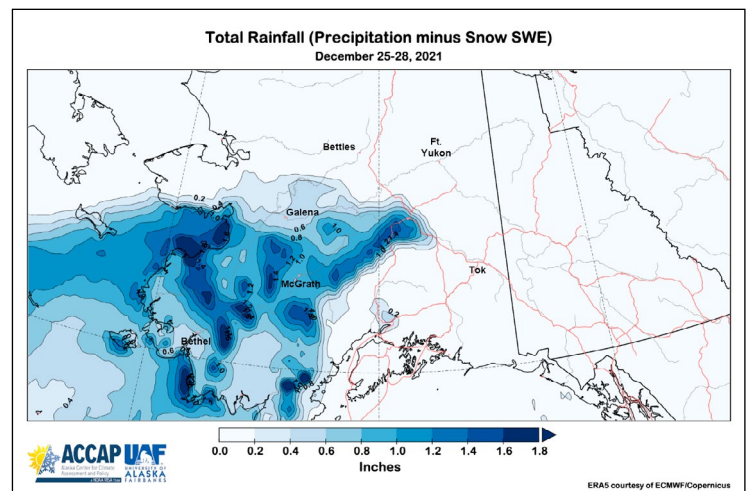


Figure 9. Total rainfall (!) December 25-28. Graphic courtesy of Rick Thoman, Alaska climate specialist, UAF/ACCAP (uaf-accap.org) Data source: ERA5 Reanalysis Climate Data/Copernicus.

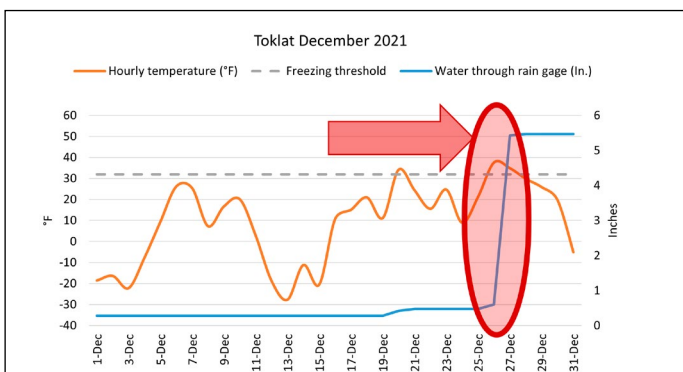


Figure 8. Hourly air temperatures (orange line) and a spike in liquid water (blue line) recorded at the Toklat weather station in December 2021.



Storm aftermath. Digging out five feet of snow around the dog houses at the Denali National Park Sled Dog Kennels late December 2021. NPS Photo.

Impacts of Rain-on-Snow Events in Winter

The December 2021 combination of deep snow and rain-on-snow was an extreme event with cascading problems for people and the park's wildlife. For people, an ice storm can lead to power outages, home damage, and dangerous walking and driving conditions.

“On December 27 it rained for several hours, turning the snow into a thick layer of slush! I estimate about 2.5” of rain based on the water that accumulated in dog bowls. This slush layer has now frozen into a thick hard layer of ice!” – personal observation from Dave Schirokauer from his home on Stampede Road in Healy.

These conditions make for tough going for wildlife, especially moose. “The moose are stressed and look for the most energy efficient places to be. Often, those places are cleared roads, driveways, and walkways. They may be feeding, resting, or bedded down anywhere and reluctant to move very far. In these instances, people need to give moose their space (from park wildlife biologist Pat Owen’s message to park staff on moose interactions, January 3, 2022).

A severe winter icing event for foragers such as caribou and Dall’s sheep could prove deadly if they can’t get to their food source under the ice layer. Winter rain that penetrates the snow layer can also alter the subnivean habitat for many of the park’s smaller mammals. It also presents a problem for boreal and great-gray owls that secure their prey by plunging into the snow to capture it. A hard ice layer creates a barrier that makes it very difficult to plunge into the snow (ouch!). The ice layer also makes it difficult for species that use snow-burrows for shelter including grouse and redpolls. The seed eating species also need to work harder to remove the ice layer from the seeds. Another potential impact comes later in the spring when species that re-use stick nests, such bald eagles, golden eagles, and common ravens return to find their nest sites buried beneath the heavy snow or destroyed by the weight of the snow and ice (thanks to park wildlife biologist, Carol McIntyre, for providing these insights).

“This wet winter storm is likely to have major implications for the park’s wildlife. . . Rare extreme weather events have significant and enduring effects on the park’s ecosystem, and it will be insightful to observe the effects of this winter over the next few years.” From Dave Schirokauer, Science and Resources Team Lead - message to park staff after the storm event, January 3, 2022.

Daily Weather since 1925

Weather observations have been recorded by National Park Service staff at Denali Park Headquarters since August of 1925. Each morning ‘cooperative observers’ record the high and low temperature, the total snowfall, and the total amount of liquid precipitation (rain and melted snow) for the previous 24-hour

period. The current snow depth is also recorded. Over the past several decades the park sled dog kennel’s crew have taken the daily measurements. Because the ‘canine rangers’ need to be fed every day, we can count on someone being there to record the weather. The official station name is McKinley Park (named when the park was still known as Mt. McKinley National Park). Measurements actually began for this station back in 1923 at the Alaska Railroad Commission camp near the confluence of Riley Creek and Hines Creek, about 3 kilometers ENE of the current location and 130 meters lower in elevation. In winter the difference in elevation can mean several degrees difference in temperature due to the presence of persistent winter inversions. There are only a few sites in Alaska that have such a long and valuable record, and very few that have a continuous record of daily snowfall.

The Big Snow of 1932

Park archives and the long weather record provide a glimpse of the past and notes on a similar storm. February 1932 was the second snowiest winter month at park headquarters. According to the weather observers, 73 inches of snow was recorded between February 1 and 6 (Figure 10). High temperatures reached 30°F that week; unfortunately, they did not record the snow depth that month. No precipitation was recorded after February 6, which means the rest of the month was dry or they did not record what fell after that first week.

Implications, similar to the 2021 storm, are revealed in excerpts from the Superintendent’s Monthly Report:

- *February 1, 1932 – this winter will be remembered as the “year of the big snow” and. . . “due to big snow, the losses to the wild game will be severe.”*
- *February 2, 1932– 4 feet of snow at HQ – “luckily we escaped with the loss of a small tent frame building, which was to have been torn down in the spring.”*
- *February 4, 1932 - “snow, then rain, hence a crust “which has caused untold suffering amongst the wild animals in the interior of the park. Esp. the moose. “The mountain sheep are hard pressed for forage, but it is thought that sufficient amount to carry them through to spring can be obtained. . .”*



Moose resting on the cleared path outside the main entrance of the Murie Science and Learning Center that serves as the Winter Visitor Center for Denali. NPS Photo.

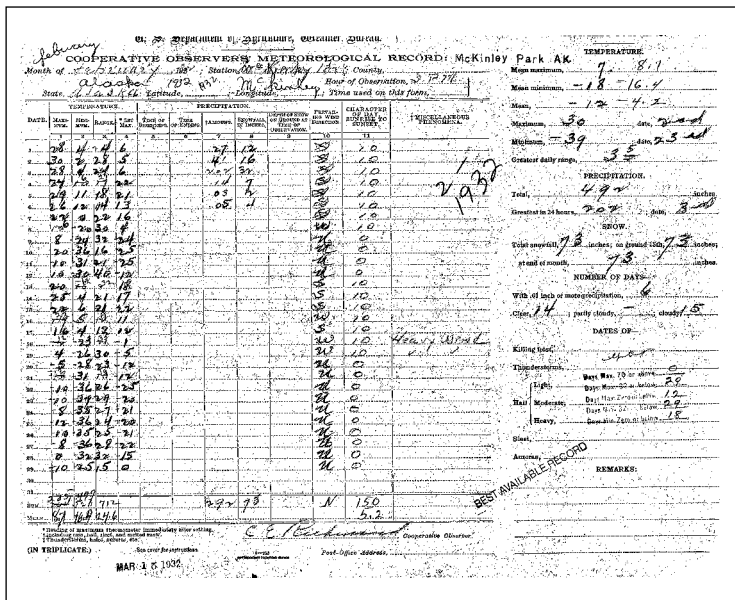


Figure 10. Copy of the original National Weather Service Cooperative Observer weather data form, McKinley Park, February 1932.

Late December Storm Forecasts - Spot On

The National Weather Service (NWS) and local climatologists should be credited with providing accurate forecasts and appropriate and repeated warnings for the late December storms.

From the Fairbanks NWS on December 24th: “A significant and high impact snow and freezing rain event is expected from Fairbanks to Denali Park over the Christmas weekend. Areas west of the Parks Hwy will also be impacted.”



NPS Photo

Documenting an Historic Event

It was one of those rare events where if you didn't see it you wouldn't necessarily believe it. Can it really rain that much in December in Interior Alaska? The measurements and statistics are captured above. Here are a few links to media coverage of the storm, dubbed by some as the 'Snowpocalypse' or 'Icemageddon' of 2021.

Great summary of the storm by local climatologists Brian Brettschneider (NWS Anchorage) and Rick Thoman (UAF/ACCAP):

[Podcast: Summary of Late December 2021 Storm in Alaska](#)

Fairbanks Daily Newsminer – Local article about impacts to Fairbanks community:

[Thousands lose power in freezing rain, heavy snow | Alaska News | newsminer.com](#)

Kris Capps, local Fairbanks Daily Newsminer reporter shared many informative posts during and after the December storms:

[“Denali Park area: One more storm Friday-Saturday. Just 3-5 inches of snow, but big wind so blowing snow and drifting and life-threatening wind chill of -60. Then, deep freeze in the -38 range. Ah, winter in Alaska.”](#)

Alaska Department of Transportation and Alaska State Troopers provided continuous updates on the poor travel conditions during the storm:

December 26, 2021: “The Parks Highway is temporarily CLOSED between Nenana and Healy. If you live in Interior Alaska, please do not drive unless it is absolutely necessary.

Perspective from Julie Collins printed in Fairbanks Daily Newsminer January 16, 2022:

[December storm presents a different set of problems in rural Alaska | In The Bush | newsminer.com](#)

Thank You to the Kennel's Crew!

Many thanks to the Denali Park Kennel's crew who record the daily weather observations (through snow, rain, sleet, and sunshine) and keep the park's 96-year climate record going strong!



NPS Photo

For more information contact: Pam_Sousanes@nps.gov