2020 U.S. Climate Normals

Daily Gridded Normals

Version 1.0

Documentation

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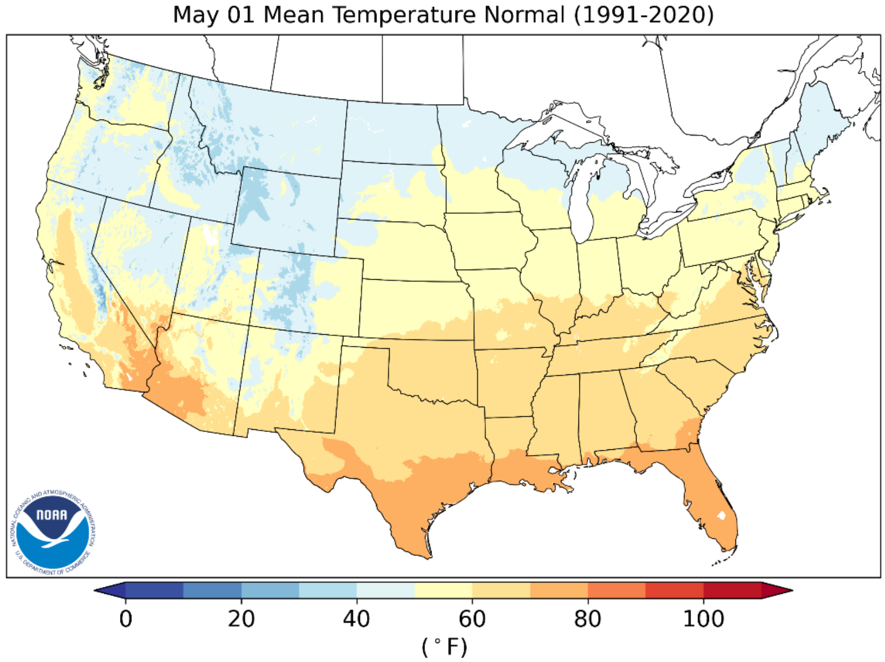
Product Overview

The U.S. Daily Gridded Climate Normals Datasets are derived from the nClimGrid Daily Dataset (Durre et al. 2022) produced by the NOAA National Centers for Environmental Information (NOAA NCEI). Thin-plate smoothing splines were used to transform an extensive set of station temperature and precipitation values into grids at a high spatial resolution of 1/24° latitude/longitude, or approximately 5 km. The variables available as daily gridded normals include daily maximum, minimum, and mean temperatures and daily, month-to-date, and year-to-date precipitation totals. The values for each individual grid cell change smoothly from day-to-day through the application of the same methods used to generate daily normals for observation stations. The averages of all daily gridded temperature normals are constrained by a harmonic fit to equal the monthly gridded normals (Arguez et al. 2013). A moving window averaging technique is used to generate smooth daily gridded precipitation normals which are then also adjusted by month so that the sum of the days would equal the monthly gridded normals (Durre et al. 2012). The internal consistency between the daily and monthly gridded climate normals is a key advantage to the approaches used here.

The set of 30-year normals is derived using daily values from 1991 to 2020. For users who require representation of a period closer to the present, a normal set for 2006–2020 is also provided. The data are found in six netCDF files for each set of normals. Each data file has grids for 365 or 366 calendar days and is approximately 1.2 GB in size. February 29 values are provided for the three temperature normals files and the daily precipitation total normals file; they were derived by averaging February 28 and March 1 values. The month-to-date precipitation file does not contain an entry for February 29, as the February 28 values are required to be equal the month of February totals. Likewise, this also means that there is no February 29 in the year-to-date set.

The U.S. Daily Gridded Climate Normals Datasets for 1991-2020 and 2006-2020 are available to calculate daily anomalies (differences from normal) or simply examine the climatology of individual days of the year based on those periods. These gridded normals are best used to aggregate values for areas consisting of substantially more than one grid location. Results based on a single grid value are not as reliable as those of an actual climate station due to the smoothing effects of data interpolation. However, groupings of grid cells provide a better result than averaging several widely spaced climate stations across a region by accounting for elevation and slope.

[For further information about these U.S. Climate Normals, visit the Gridded Normals tab at: https://www.ncei.noaa.gov/products/land-based-station/us-climate-normals]



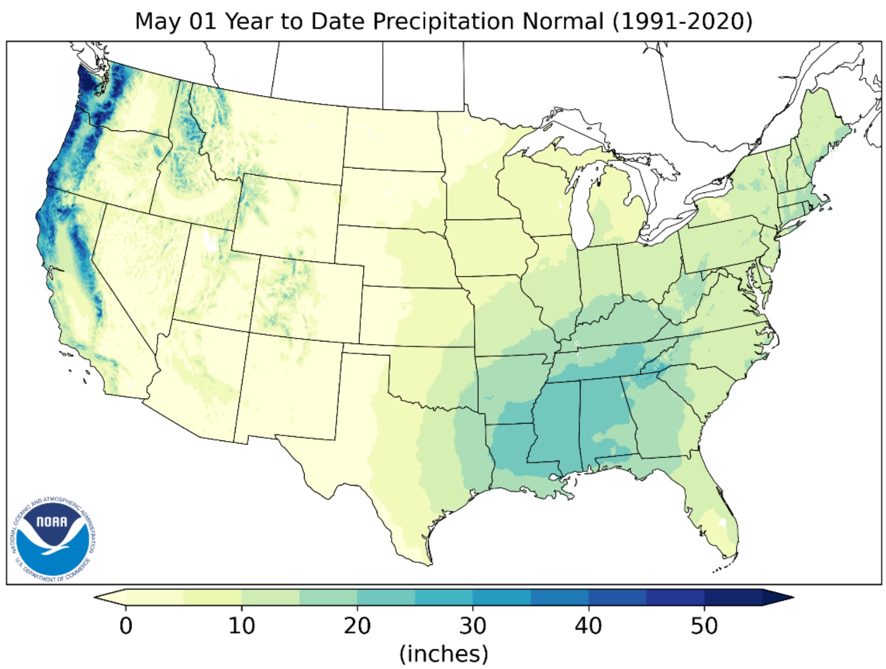


Figure 1. An example of 1991-2020 daily gridded normals for May 1 mean temperature (°F) and year-to-date precipitation (inches). Common units are used for display; the data is stored in metric units of °C and mm.

Data Field Description

Variable names and units in product:	Maximum, Minimum, Mean Temperature (°C) Daily, Month-to-Date, Year-to-Date Precipitation Total (mm)
Spatial resolution:	0.0417° latitude by 0.0417° longitude; nominally 5 km
Temporal resolution and extent:	Daily normals representing 1991-2020 and 2006-2020
Coverage:	CONUS

Data Sources and Processing

The Daily Gridded Climate Normals are derived from the nClimGrid-Daily Dataset (Durre et al. 2022). The underlying source of station observations used to generate nClimGrid-Daily included morning and midnight observations from the Global Historical Climatology Network-Daily (GHCNd) dataset (Menne et al. 2012a,b). The grids were constructed using thin-plate smoothing splines and processed further to reduce the impacts of spatial and temporal variations in station density, observation time, and other factors on the quality and homogeneity of the fields. They were also adjusted prior to the current month so that the daily gridded values accumulated within a month match the monthly averages and totals of the original nClimGrid-Monthly Dataset (Vose et al. 2014).

The daily normals of the temperature and precipitation variables are not simple averages of each calendar day's values over 30 or 15 years. Instead, in order for the normals values to progress smoothly from day-to-day for each individual grid cell, methods developed and used to generate daily normals for observation stations are applied to each grid cell individually. For a temperature variable, a set of raw 30-year (or 15-year) averages are generated for each grid cell and calendar day. Averages of all daily gridded temperature normals are fit to an equation with six harmonics that is also constrained to equal the monthly gridded normals (Arguez et al. 2013), resulting in a smoothly evolving seasonal cycle. For precipitation, a set of raw 30-year (or 15-year) average daily totals is first calculated. Next, these raw daily averages are summed into year-to-date totals and smoothed with a 29-day running mean to generate smooth year-to-date gridded precipitation normals. These are then scaled by month using a ratio so that the sum of the days in each month equals the corresponding monthly gridded normal (Durre et al. 2012). Finally, smoothed daily totals and month-to-date totals are backed out of the year-to-date values. The internal consistency between the daily and monthly gridded climate normals is a key advantage to the approach used here.

Quality Control and Validation

Checks were developed to ensure the accuracy of the final Daily Gridded Climate Normals. These tests were independent of the production software, and ensured the internal consistency and accuracy of the normals datasets. Besides internal consistency, comparisons of monthly averages or totals of daily normals to their monthly normal counterparts were conducted. The daily gridded normals were also compared to station-based normals (operationally released in May 2021). Some highlights of the results are presented here.

Consistency Checks of Daily Gridded Normals

Internal consistency checks of temperature and precipitation, initially developed by Durre et al. (2010) for application to station observations, were applied to this gridded dataset. The primary checks are below:

Check 1: TMAX < TMIN: There should be no cases where a gridded maximum normal is less than the gridded minimum normal.
Check 2: (TMAX + TMIN) / 2 = TAVG. If a gridded maximum normal and gridded minimum normal are averaged, the result should be equal to the gridded average normal.
Check 3: Extremes Check: No value should be outside the range of the world record extreme values. The bounds are as follows:

Temperature: between -89.2°C (-128.6°F) and 56.7°C (134.1°F)
Precipitation: between 0.0 mm (0.00”) and 1825.0 mm (71.8”)

Check 4: Daily Consistency Check (PRCP ONLY): The number of daily grid values >= 0.2” should be less than or equal to the number of daily grid values >= 0.1”. An example of this check is provided in Figure 1.

Analysis was performed for each day of the normals, and Table 1 displays the results. For simplicity, all the days were combined. As a result, there were no grids in any period and any day that failed the above checks.

Period	Check 1	Check 2	Check 3	Check 4
1991-2020	0	0	0	0
2006-2020	0	0	0	0

Table 1: Results of test #1, internal consistency checks, for all normals periods. Number indicates the number of occurrences a check was failed at a grid point.

Comparing Daily Gridded Normals to Monthly Gridded Normals

Because a harmonic constraint was fit using the monthly gridded normals, a monthly average of daily temperature normals (and monthly sum of precipitation) should be equal to the monthly gridded normals, which were released in Spring 2022. These averages and sums were produced for the 1991-2020 and 2006-2020 periods, and the results are shown in Table 2. Results show there were no differences in any cases.

Period	Precipitation	TMean	TMaximum	TMinimum
1991-2020	0	0	0	0
2006-2020	0	0	0	0

Table 2: Results of test #2, comparing averaged (tavg, tmax, tmin) and summed (precipitation) daily normals to monthly normal counterparts, for all available periods. Number indicates the number of times grid points from the daily average/sum differed from the monthly normal.

Validating Daily Gridded Climate Normals Against Station Normals

In this test, the set of daily normals for stations in the conterminous U.S. were compared to the nearest grid cell location. Unlike in the case of external consistency described above, there is no expectation for gridded values to correspond exactly to station values, even when they are located very close to each other. Impacts of smoothing and filtering will lead to differences over space and calendar time.

The overall statistical results are best displayed as histograms of differences. Figure 2 (left) shows a tight distribution mainly to the left of the zero line for gridded precipitation normals minus station normals. This is expected given the tendency of gridding to smooth the results and slightly lower the average below station values that can be subject to localized extreme events (Durre et al. 2022). The histogram of average temperature differences (Figure 2, right), on the other hand, is more symmetrical around zero difference, but with a wider distribution indicating some locations with more substantial differences. Individual observation stations can be impacted by local topographic and land cover influences that are occurring at sub-grid spatial scales and can account for either warmer or colder conditions than at grid scale.

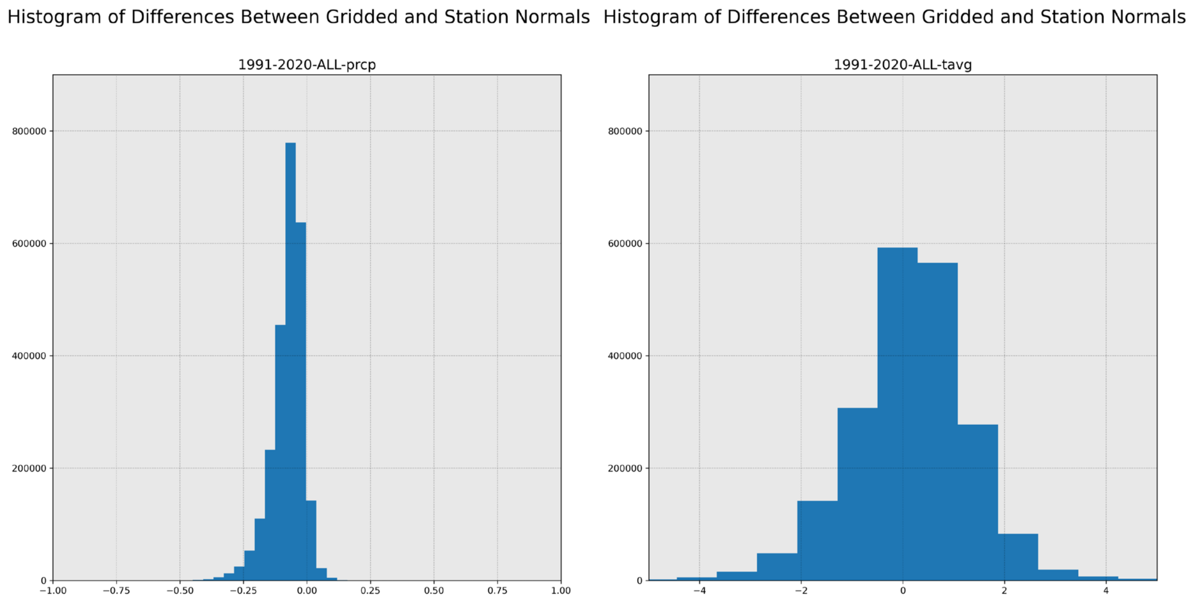


Figure 2. Distributions of differences between gridded normals minus station normals. Results are shown for 1991-2020 precipitation (left), 1991-2020 average temperature (right).

These effects can be seen in the spatial patterns of grid cell minus station differences for individual days. In Figure 3, maps are presented showing these differences for the precipitation total and mean temperature normals for 5 July. The vast majority of daily precipitation normals differences are in the first negative category, indicating they are usually slightly drier than the station normals. Only in the southern Plains is the second more dry category commonly found, probably due to the extremely intense and compact convective precipitation events common in that region during summer that are captured by station normals at point locations, but end up being smoothed by gridding. The mean temperature normals map shows a much more even distribution of red (grid is warmer) and blue (grid is cooler) station locations. A few areas show topographic biases, such as the clusters of blue dots near the Great Salt Lake and red dots near Lake Tahoe. Often, strong warm and cold differences are mixed in areas near mountains and shorelines, indicating that the local topographic effects can be more pronounced in these areas. However, there are no large-scale biases in mean temperature normals as there are in daily precipitation normals for 5 July.

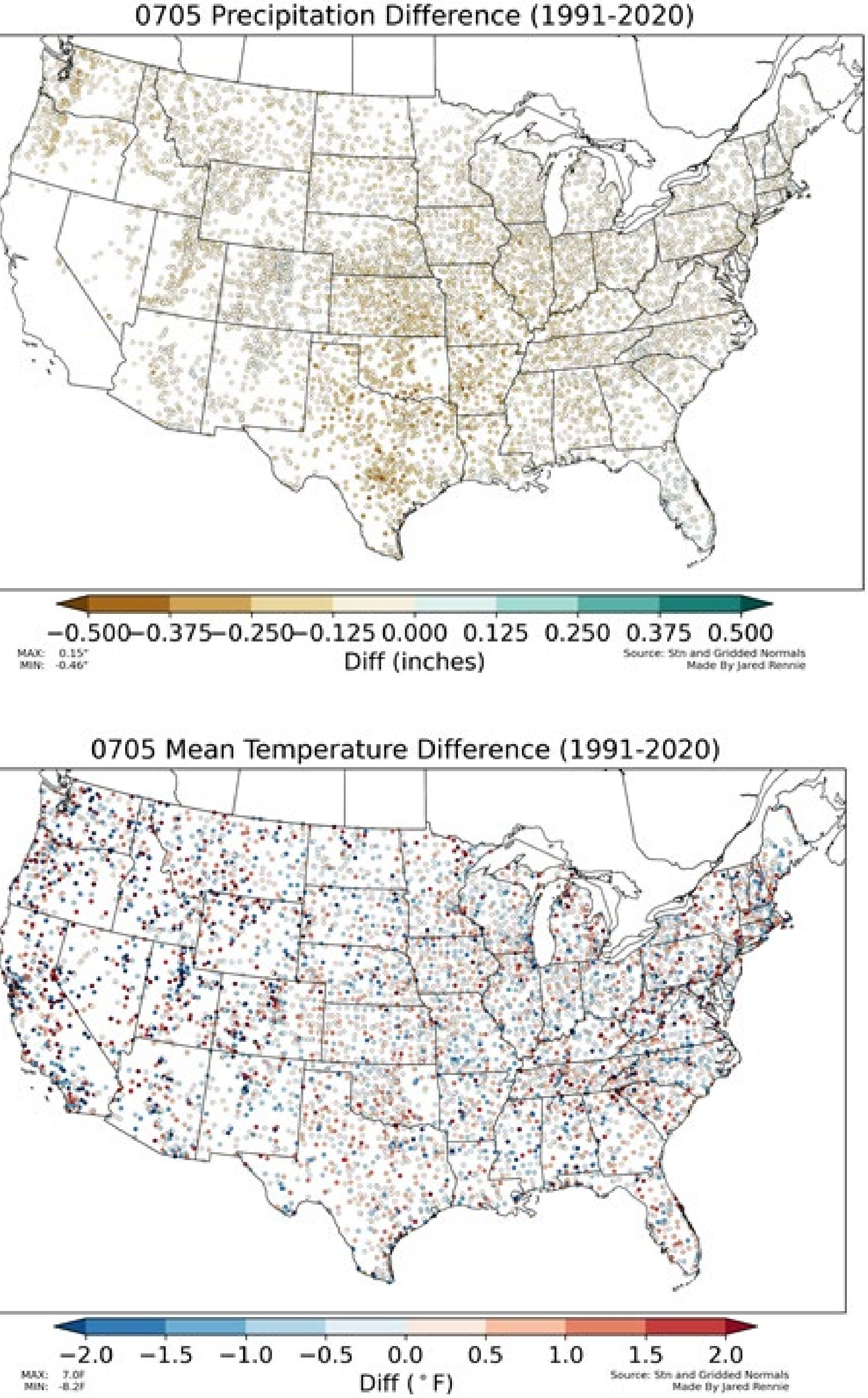


Figure 3. Spatial patterns of gridded normals minus station normals. Results are shown for 1991-2020 precipitation (top), 1991-2020 average temperature (bottom).

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Document Revision History

Rev 0 - 22 Sep 2022 - This is a new document

Dataset Version History

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