Daymet: Annual Climate Summaries on a 1-km Grid for North America, Version 4 R1

Get Data

Documentation Revision Date: 2024-04-23

Dataset Version: 4.1

Summary

This dataset provides annual climate summaries derived from Daymet Version 4 R1 daily data at a 1 km x 1 km spatial resolution for five Daymet variables: minimum and maximum temperature, precipitation, vapor pressure, and snow water equivalent. Annual averages are provided for minimum and maximum temperature, vapor pressure, and snow water equivalent, and annual totals are provided for the precipitation variable. Each data file is provided as a single year by variable and covers the same period of record as the Daymet V4 R1 daily data. The annual climatology files are derived from the larger datasets of daily weather parameters produced on a 1 km x 1 km grid for North America (including Canada, the United States, and Mexico), Hawaii, and Puerto Rico. Separate annual files are provided for the land areas of continental North America, Hawaii, and Puerto Rico. Data are distributed in standardized Climate and Forecast (CF)-compliant netCDF (*.nc) and Cloud Optimized GeoTIFF (*.tif) file formats. In Version 4 R1, all 2020 and 2021 files (60 total) were updated to improve predictions especially in high-latitude areas. It was found that input files used for deriving 2020 and 2021 data had, for a significant portion of Canadian weather stations, missing daily variable readings for the month of January. NCEI has corrected issues with the Environment Canada ingest feed which led to the missing readings. The revised 2020 and 2021 Daymet V4 R1 files were derived with new GHCNd inputs. Files outside of 2020 and 2021 have not changed from the previous V4 release.

Files are available in CF-compliant netCDF (*.nc) and Cloud-Optimized GeoTIFF (*.tif) formats for three separate spatial areas: continental North America (including Canada, the United States, and Mexico), Hawaii, and Puerto Rico. Data for Puerto Rico include years 1950–2023. Data for continental North America and Hawaii are provided for years 1980–2023.

There are a total of 1,620 files. Both netCDF and GeoTIFF files are provided: 810 files in netCDF file format and 810 files in Cloud Optimized GeoTIFF (COG) file format. Files are arranged by year, spatial area, and variable.

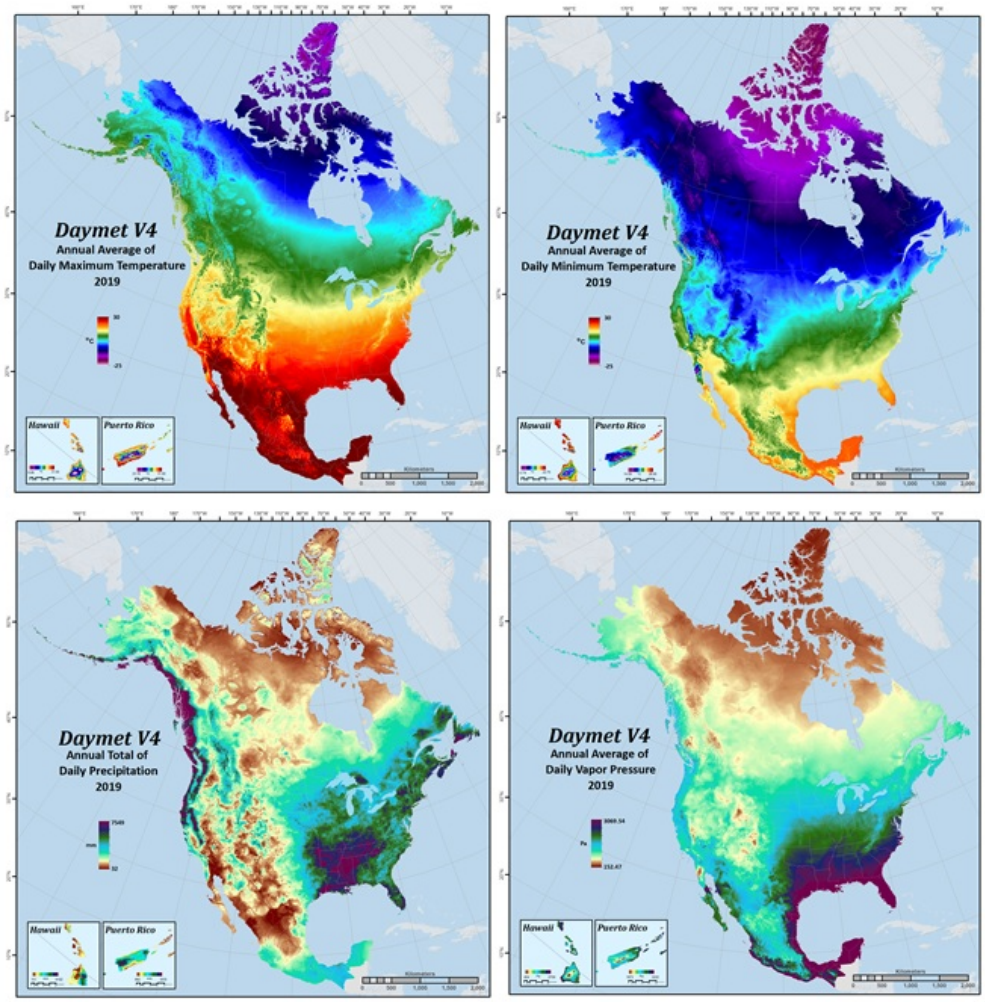

Figure 1. Daymet V4 annual climatologies for 2019 for maximum and minimum temperature, precipitation, and vapor pressure.

Citation

Thornton, M.M., R. Shrestha, Y. Wei, P.E. Thornton, and S-C. Kao. 2022. Daymet: Annual Climate Summaries on a 1-km Grid for North America, Version 4 R1. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2130

Table of Contents

1. Dataset Overview

This dataset provides annual climate summaries derived from Daymet Version 4 R1 daily data at a 1 km x 1 km spatial resolution for five Daymet variables: minimum and maximum temperature, precipitation, vapor pressure, and snow water equivalent. Annual averages are provided for minimum and maximum temperature, vapor pressure, and snow water equivalent, and annual totals are provided for the precipitation variable. Each data file is provided as a single year by variable and covers the same period of record as the Daymet V4 R1 daily data. The annual climatology files are derived from the larger datasets of daily weather parameters produced on a 1 km x 1 km grid for North America (including Canada, the United States, and Mexico), Hawaii, and Puerto Rico. Separate annual files are provided for the land areas of continental North America, Hawaii, and Puerto Rico. Data are distributed in standardized Climate and Forecast (CF)-compliant netCDF (*.nc) and Cloud Optimized GeoTIFF (*.tif) file formats. In Version 4 R1, all 2020 and 2021 files (60 total) were updated to improve predictions especially in high-latitude areas. It was found that input files used for deriving 2020 and 2021 data had, for a significant portion of Canadian weather stations, missing daily variable readings for the month of January. NCEI has corrected issues with the Environment Canada ingest feed which led to the missing readings. The revised 2020 and 2021 Daymet V4 R1 files were derived with new GHCNd inputs. Files outside of 2020 and 2021 have not changed from the previous V4 release.

Daymet V4 R1 annual climatologies are available for download from the ORNL DAAC through website search and order tools. In addition, the ORNL DAAC supports a separate Daymet Project website which provides customized tools for accessing the data. The Daymet algorithms and data processing implemented for V4 R1 are the same for the previous V4 release and are described in detail in the related publication Thornton et al. (2021).

Project: Daymet

Daymet provides long-term, continuous, gridded estimates of daily weather and climatology variables by interpolating and extrapolating ground-based observations through statistical modeling techniques. The Daymet data products provide driver data for biogeochemical terrestrial modeling and have myriad applications in many Earth science, natural resource, biodiversity, and agricultural research areas. Daymet weather variables include daily minimum and maximum temperature, precipitation, vapor pressure, shortwave radiation, snow water equivalent, and day length produced on a 1 km x 1 km gridded surface over continental North America and Hawaii from 1980 and over Puerto Rico from 1950 through the end of the most recent full calendar year.

Daymet is a research product of the Environmental Sciences Division at Oak Ridge National Laboratory, Oak Ridge, TN. Daymet is supported by NASA through the Earth Science Data and Information System (ESDIS) and the Terrestrial Ecology Program. Daymet algorithm and processing development is also supported by the Office of Biological and Environmental Research within the U.S. Department of Energy's Office of Science.

Related Publication

Thornton, P. E., R. Shrestha, M. Thornton, S. Kao, Y. Wei, and B. E. Wilson. 2021. Gridded daily weather data for North America with comprehensive uncertainty quantification. Scientific Data 8:190. https://doi.org/10.1038/s41597-021-00973-0

Related Datasets

Thornton, M.M., R. Shrestha, Y. Wei, P.E. Thornton, and S. Kao. 2022. Daymet: Daily Surface Weather Data on a 1-km Grid for North America, Version 4 R1. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2129

Thornton, M.M., R. Shrestha, Y. Wei, P.E. Thornton, and S. Kao. 2022. Daymet: Monthly Climate Summaries on a 1-km Grid for North America, Version 4 R1. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2131

Thornton, M.M., R. Shrestha, Y. Wei, P.E. Thornton, and S. Kao. 2022. Daymet: Station-Level Inputs and Cross-Validation for North America, Version 4 R1. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2132

Acknowledgments

The continued development of the Daymet algorithm and processing is supported by the Energy Exascale Earth System Model (E3SM) project, funded by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research.

Puerto Rico data for Daymet V4 is available for an extended temporal period starting in 1950. Support was provided by the DOE NGEE Tropics Phase 2 funding to extend the temporal period.

2. Data Characteristics

Spatial Coverage: Continental North America (Mexico, United States, Canada), Hawaii, and Puerto Rico

Spatial Resolution: 1 km grid

Temporal Coverage

Continental North America (Mexico, United States, Canada) and Hawaii: 1980–2023

Puerto Rico: 1950–2023

Temporal Resolution: Annual

Study Areas (All latitude and longitude given in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Continental North America	-178.13	-53.06	82.91	14.07
Puerto Rico	-67.99	-64.12	19.94	16.84
Hawaii	-160.31	-154.77	23.52	17.95

Data File Information

Filename format: daymet_v4_<pppp>_ann<xxx>_<region>_<yyyy>.<ext>, where

<pppp> is the respective parameter abbreviation (prcp, swe, tmax, tmin, and vp),
<xxx> is the summary, either 'avg' (average) or 'ttl' (total),
<region> is either 'na' (for continental North America), 'hi' (for hawaii), or 'pr' (for Puerto Rico),
<yyyy> is year (1950 through 2023), and
<ext> is file format extension, either 'nc' (netCDF) or 'tif' (Cloud-Optimized GeoTIFF)

Example filename: daymet_v4_tmax_annavg_na_2014.nc

Table 1. Parameters, abbreviations, units, and descriptions.

Parameter	Abbr	Units	Description
Precipitation	prcp	mm	The total accumulated precipitation over the annual period of the daily total precipitation. Sum of all forms of precipitation converted to a water-equivalent depth.
Maximum air temperature	tmax	degrees C	The average maximum temperature for a daily period over the annual period.
Minimum air temperature	tmin	degrees C	The average minimum temperature for a daily period over the annual period.
Water vapor pressure	vp	Pa	The average of the daily average partial pressure of water vapor over the annual period.

Snow water equivalent	swe	kg m^{-2}	The average of the daily snow water equivalent (the amount of water contained within the snowpack) in kilograms per square meter over the annual period.

Projection System: Lambert Conformal Conic

Parameters
Projection units: meters
Datum (spheroid): WGS_84
1st standard parallel: 25 deg N
2nd standard parallel: 60 deg N
Central meridian: -100 deg (W)
Latitude of origin: 42.5 deg N
False easting: 0
False northing: 0

PROJ.4: +proj=lcc +lat_1=25 +lat_2=60 +lat_0=42.5 +lon_0=-100 +x_0=0 +y_0=0 +ellps=WGS84 +units=m +no_defs

The Daymet Calendar

The Daymet calendar is based on a standard calendar year. All Daymet years, including leap years, have 1–365 days. For leap years, the Daymet data include leap day (February 29) and December 31 is discarded from leap years to maintain a 365-day year.

Version Information

The data are stored and distributed as individual CF-compliant netCDF files for each parameter. The most current Daymet data are being delivered to the user in both Daymet software and Daymet data versions.

3. Application and Derivation

The Daymet data have broad applications over a wide variety of research fields including hydrology, terrestrial vegetation growth models, carbon cycle science, and regional to large scale climate change analysis. Measurements of near-surface meteorological conditions are made at many locations, but researchers are often faced with having to perform ecosystem process simulations in areas where no meteorological measurements have been taken. The continuous gridded surfaces of the Daymet dataset were developed to overcome these limitations.

4. Quality Assessment

Within the Daymet algorithm, the Daymet cross-validation analyses were used to test the sensitivity of Daymet methods to the variation of parameters and to estimate the prediction errors associated with the final selected parameters. The general cross-validation protocol is to withhold one observation at a time from a sample, generate a prediction error for the withheld case by comparison with observed values within the sample, and repeat over all observations in the sample to generate an average prediction error. Interest is in both the absolute value and the sign of prediction errors generated in this manner.

5. Data Acquisition, Materials, and Methods

All versions of the Daymet algorithm, including this Version 4 R1, use as its core input daily observations of minimum temperature, maximum temperature, and precipitation from a network of ground-based weather stations. The surface weather input observations for processing Daymet were obtained from the NOAA National Centers for Environmental Information's Global Historical Climatology Network (GHCN)-Daily data set (Menne et al., 2012). Three separate input station files were generated for the continental North America, Puerto Rico, and Hawaii study areas and these three spatially distinct areas were applied separately through the Daymet algorithm.

GHCN-Daily Version Download Dates:

- Daymet V4 for years 1980 - 2019 (or 1950 - 2019 (Puerto Rico only)) used GHCN Daily version 3.27 downloaded on February 5, 2020.
- Daymet V4 for year 2020 used GHCN Daily version 3.28 downloaded on February 14, 2021.
- Daymet V4 for year 2021 used GHCN Daily version 3.28 downloaded on February 16, 2022.
- Daymet V4 R1 for year 2020 used GHCN Daily version 3.29 downloaded on October 6, 2022.
- Daymet V4 R1 for year 2021 used GHCN Daily version 3.29 downloaded on September 18, 2022
- Daymet V4 R1 for year 2022 used GHCN Daily version 3.29 downloaded on February 11, 2023
- Daymet V4 R1 for year 2022 used GHCN Daily version 3.31 downloaded on February 18, 2024

The Daymet approach to estimating daily surface weather parameters at locations lacking instrumentation is based on a combination of interpolation and extrapolation, using inputs from multiple instrumented sites and weights for each site that reflect the spatial and temporal relationships of the estimation location to the instrumental observations. The approximate number of instrumental observations to use for each estimation is defined as a parameter for each of the primary Daymet variables. As part of a series of algorithm modifications intended to improve robustness in regions of very low station density, the Daymet V4 algorithm drops the iterative station density calculation and instead defines a search radius for each estimation location which is sized to capture exactly the average number of input stations, based on pre-calculated arrays of station distances. Given the pre-processed input station observations and the pre-calculated station lists and interpolation weights for each location in the estimation grid, two separate workflows are used to produce the primary Daymet output variables: one for the daily temperature variables (Tmax and Tmin) and another for the daily precipitation variable (Prcp).

The Daymet Version 4 methodology and dataset is described in Thornton, et al. (2021).

In addition to daily maximum and minimum temperature and daily total precipitation, the Daymet data record includes estimates of other important surface weather quantities that are not routinely observed, or are available as observations from only a small fraction of the temperature and precipitation observing stations. These secondary output variables are daily total shortwave radiation (srad), daily average water vapor pressure (vp), duration of the daylight period (daylength), and a simple estimate of accumulated snowpack, measured as snowpack water equivalent (swe). The daylength estimate is based on geographic location and time of year. Estimates for the other secondary variables (srad, vp, and swe) are derived from the primary temperature and precipitation variables on the basis of theory and empirical relationships, as further described in Thornton et al. (2021).

Annual climate summaries included in this dataset were derived from Daymet Version 4 daily data (h ttps://doi.org/10.3334/ORNLDAAC/2129) at a 1 km x 1 km spatial resolution for five Daymet variables. Annual averages are provided for minimum and maximum temperature, vapor pressure, and snow water equivalent, and annual totals are provided for the precipitation variable.

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Daymet: Annual Climate Summaries on a 1-km Grid for North America, Version 4 R1

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

Menne, M.J., I. Durre, B. Korzeniewski, S. McNeal, K. Thomas, X. Yin, S. Anthony, R. Ray, R.S. Vose, B.E. Gleason, and T.G. Houston. 2012. Global Historical Climatology Network - Daily (GHCN-Daily), Version 3. NOAA National Climatic Data Center. Version 3.27-upd-2020020523. https://doi.org/10.7289/V5D21VHZ

Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston. 2012. An overview of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric and Oceanic Technology 29:897-910. http://doi.org/10.7289/V5D21VHZ

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8. Dataset Revisions

Note: *The ORNL DAAC revised its methods for versioning datasets to be more consistent with data versioning practices at the NASA Earth Science Data and Information System (ESDIS) and the general Earth Science data community. With the revised versioning strategy, the dataset version number (including both major and minor version numbers) remain unchanged when a release only appends new data and existing data are not changed. At the time of publication of 2023 Daymet data, the version numbers of Daymet datasets, including the Version 4 and prior versions are updated as shown in the revision tables below.*

ORNL DAAC Release Record for Version 4.1

ORNL DAAC Release Date	Daymet Product Version	Description
April 23rd, 2024	Version 4.1 (V4 R1)	This release added annual climatologies for 2023 for each Daymet Version 4.1 variable.
March 5, 2023		This release added annual climatologies for 2022 for each Daymet Version 4.1 variable.
November 1, 2022		In this Version 4.1 all 2020 and 2021 files (60 total) were updated to improve predictions especially in high-latitude areas. It was found that input files used for deriving 2020 and 2021 data had, for a significant portion of Canadian weather stations, missing daily variable readings for the month of January. The missing readings have been verified by the National Centers for Environmental Information (NCEI) who maintain the Global Historical Climatology Network daily (GHCNd) database. NCEI has corrected issues with the Environment Canada ingest feed which led to the missing readings and has built in more protections to prevent the loss of data. The revised 2020 and 2021 Daymet V4 files were derived with new GHCNd inputs. Files outside of 2020 and 2021 have not changed.

ORNL DAAC Release Record for Version 4

ORNL DAAC Release Date	Daymet Product Version	Description
April 7, 2022	Version 4	This release added annual climatologies for 2021 for each Daymet Version 4 variable.
April 7, 2021		This release added annual climatologies for 2020 for each Daymet Version 4 variable.
December 15, 2020		This release provided daily gridded mosaics for Continental North America (Mexico, United States, Canada) and Hawaii for 1980–2019 and for Puerto Rico for 1950–2019 for each Daymet Version 4 variable. Version 4 annual climatologies are provided for five Daymet variables; minimum and maximum temperature, precipitation, vapor pressure, and snow water equivalent (new in V4).

ORNL DAAC Release Record for Version 3

ORNL DAAC Release Date	Daymet Product Version	Description
March 17, 2020	Version 3	This release added annual climatologies for 2019 for each Daymet Version 3 variable.
April 3, 2019		This release added annual climatologies for 2018 for each Daymet Version 3 variable.
April 19, 2018		This release added annual climatologies for 2017 for each Daymet Version 3 variable.
April 20, 2017		This release added annual climatologies for 2016 for each Daymet Version 3 variable.
July 15, 2016		Initial release of the Version 3 of Daymet annual Climatologies.

ORNL DAAC Release Record for Version 2

ORNL DAAC Release Date	Daymet Product Version	Description
March, 2016	Version 2	This release added annual climatologies for 2015 for each Daymet variable.
July, 2015		Initial release of Version 2 of Daymet North American annual summary climate data, 1980-2014