

# Daymet

## Daily Gridded Surface Data

Data Guide

<http://daymet.ornl.gov>

July 11, 2012

### *Overview*

Daymet is a collection of algorithms and computer software designed to interpolate and extrapolate from daily meteorological observations to produce gridded estimates of daily weather parameters over large regions. Weather parameters generated include daily continuous surfaces of minimum and maximum temperature, precipitation, humidity, and radiation. These algorithms and software were developed by Dr. Peter E. Thornton, currently with the Environmental Sciences Division at the Oak Ridge National Laboratory, Oak Ridge, Tennessee. Daymet was developed to fulfill the need for continuous surfaces of daily weather data necessary for plant growth model inputs. In addition, the data generated from the Daymet model has broad applications over a wide variety of scientific and research fields including hydrology, terrestrial vegetation growth models, carbon cycle science, and regional to large scale climate change analysis. The daily time step, 1 km spatial resolution, and broad spatial extent of the dataset make it a unique and valuable contribution to the scientific community.

This document describes the use of the *Daily Gridded Surface Data* routine available from the web site; <http://daymet.ornl.gov>. Daily gridded data is available for Daymet variables that are being distributed as individual files each in a CF compliant (version 1.4) netCDF file format. The Daymet daily gridded variables include; minimum and maximum temperature, precipitation, shortwave radiation, snow water equivalent, water vapor pressure, and day length. The daily gridded data is being distributed in 2 degree x 2 degree “tiles” where all variables are present in the download. In addition, a Thematic Real-time Environmental Data Services (THREDDS) server is available to serve the contents of the CF-Compliant Daymet NetCDF collection. Daymet references and Daymet data use citations are also provided. Please see the ORNL [Daymet](http://daymet.ornl.gov) web site to submit any questions or suggestions through the “Contact Us” link.

### ***Input Specifications***

The Daymet algorithm manages the large number of input data and large spatial extent of the study area by creating a system of 2 degree x 2 degree “tiles” (Figure 1) which are processed individually through the Daymet software. These tiles are identified by a TileID which is derived within the Daymet algorithm and is consistent throughout the temporal period of the Daymet record. The first step for a user is to identify the 2 degree x 2 degree tile and obtain the TileID for their area of interest. This can be done interactively through the web map interface by single-clicking within a tile. A dialog is displayed that shows that Daymet TileID as well as information regarding the latitude and longitude boundaries of that tile.

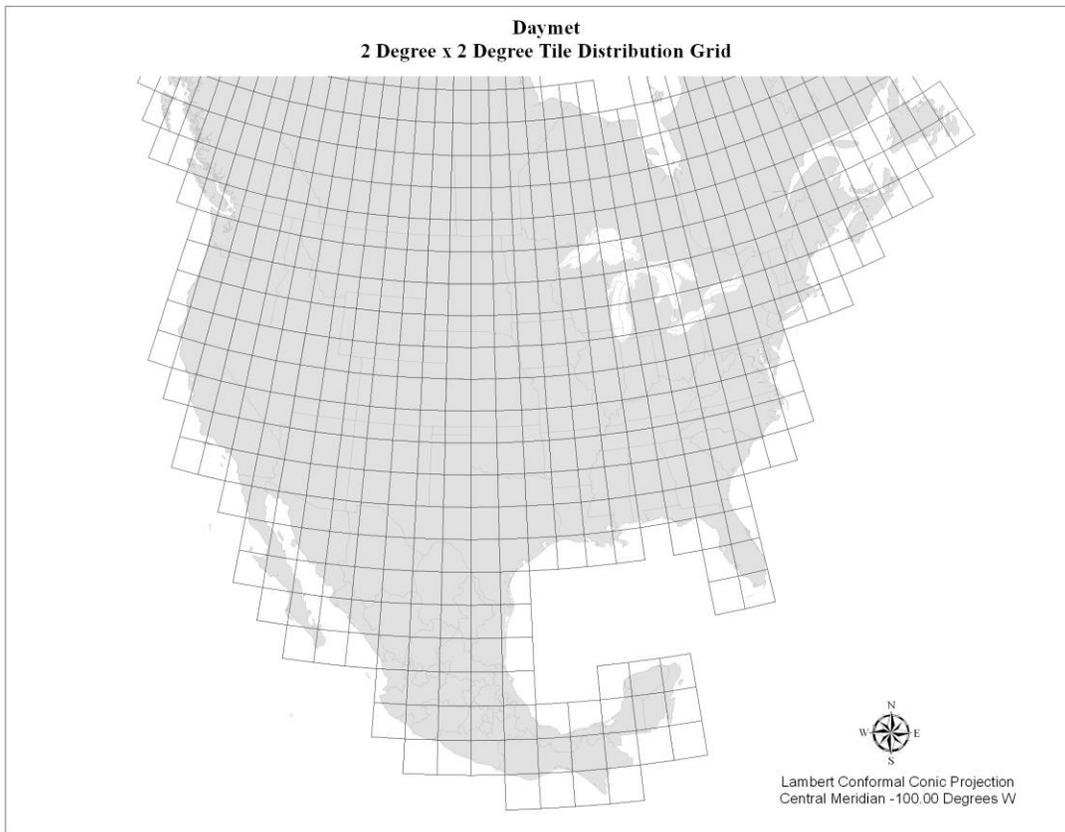


Figure 1. Daymet 2 Degree x 2 Degree Tile System. Note: NOT all tiles shown are currently available.

A user can also enter a latitude and longitude (in decimal degrees). From that, a routine identifies the Daymet TileID contained within the entered values. Note that latitude values are positive for north, negative for south, while longitude values are positive for east, negative for west. All valid data points in the current North America dataset will therefore have positive latitude and negative longitude. A user then identifies a year (or years) and clicks “Get Data”. A routine is executed on the Daymet server that bundles the appropriate CF-Compliant netCDF files for the selected TileID and year(s). A link is provided where the tarred and compressed data can be downloaded.

### ***Daymet Gridded Data Format:***

In the Daymet data processing, binary output files from the Daymet model are passed through QA/QC checks and then reformatted to a CF-Compliant netCDF file format for the Daily Gridded Surface data distribution. Each Daymet Tile per year contains separate files for each of the Daymet variables in a netCDF file format. The netCDF file format is self describing and compliant to the climate and forecast (CF) metadata standards. Each variable, as well as the spatial and temporal properties of the data, is defined within the header file. For example, if a user identified Daymet TileID 12273 as their tile of interest and wanted daily gridded data for 2005, they would make the appropriate query and download the file 12273\_2005.tar.gz. After uncompressing and untarring this file, the user will find separate netCDF files for each of the Daymet variables: dayl.nc, prcp.nc, srاد.nc, swe.nc, tmax.nc, tmin.nc, and vp.nc.

### ***Files and Units***

Daymet CF-netCDF files with units and description of variables:

1. **dayl.nc** (s/day): Duration of the daylight period for the day. This calculation is based on the period of the day during which the sun is above a hypothetical flat horizon.
2. **prcp.nc** (mm/day): Daily total precipitation, sum of all forms converted to water-equivalent.
3. **srاد.nc** (W/m<sup>2</sup>): Incident shortwave radiation flux density, taken as an average over the daylight period of the day.

NOTE: Daily Total Radiation ( $\text{MJ}/\text{m}^2/\text{day}$ ) can be calculated as follows:  
 $((\text{srad} (\text{W}/\text{m}^2) * \text{dayl} (\text{s}/\text{day})) / 1,000,000)$

4. **swe.nc** ( $\text{kg}/\text{m}^2$ ): Snow water equivalent. The amount of water contained within the snowpack.  
Please see below for a more detailed explanation of the SWE variable.
5. **tmax.nc** (degrees C): Daily maximum 2-meter air temperature.
6. **tmin.nc** (degrees C): Daily minimum 2-meter air temperature.
7. **vp.nc** (Pa): Water Vapor Pressure. Daily average partial pressure of water vapor.

*Snow Water Equivalent Clarification:*

Snowpack, quantified as snow water equivalent (SWE), is estimated as part of the Daymet processing in order to reduce biases in shortwave radiation estimates related to multiple reflections between the surface and atmosphere that are especially important when the surface is covered by snow (Thornton et al. 2000). The Daymet (v2.0) dataset includes estimated SWE as an output variable since this quantity may be of interest for research applications in addition to its primary intended use as a component of the Daymet shortwave radiation algorithm. An important caveat in the use of SWE from the Daymet (v2.0) dataset is that the algorithm used to estimate SWE is executed with only a single calendar year of primary surface weather inputs (daily maximum and minimum temperature and daily total precipitation) available for the estimation of a corresponding calendar year of snowpack. Since northern hemisphere snowpack accumulation is commonly underway already at the beginning of the calendar year, the SWE algorithm uses data from a single calendar year to make a two-year sequence of temperature and precipitation, then predicts the evolution of snowpack over this two-year period to provide an estimate of yearday 365 (December 31 for non-leapyears) snowpack as an initial condition for the January 1 time step of the actual calendar year. The problem with this approach is that it ignores the dependence of January 1 snowpack on preceding calendar year temperature and precipitation conditions, and so generates potential biases in mid-season snowpack which can propagate to biases in late-season timing of snow

melt. A better approach would be to calculate snowpack from the continuous stream of calendar years. We intend to apply this improvement in subsequent Daymet releases.

*Daymet Calendar:*

The Daymet calendar is based on a standard calendar year. All Daymet years have 1 – 365 days, including leap years. For leap years, the Daymet database includes leap day. Values for December 31 are discarded from leap years to maintain a 365-day year.

***Daymet NoData netCDF files:***

There are a small number of Daymet tiles which do not run properly through the Daymet algorithm or have been removed from the Daymet data collection due to bad results on all or some of the associated Daymet variables. The cause of the failure of these tiles is almost exclusively due to low surface observation station density in areas that are sparsely populated. In order to maintain the integrity of the Daymet web-based delivery mechanisms that either distribute individual Daymet variable netCDF files (e.g., Daily Gridded Surface Data, THREDDS) or query the Daymet variable netCDF files for tabular results (e.g., Daily Data for a Single Pixel), any Daymet tile that fails or has been removed has been replaced with NoData netCDF files for each of the Daymet variables associated with that tile. In other words, for Daymet Tiles that fail, there are NoData netCDF files for each of the Daymet variables; dayl.nc, prcp.nc, srad.nc, swe.nc, tmax.nc, tmin.nc, and vp.nc. These NoData netCDF files will have the appropriate spatial and temporal extents for each netCDF file for its specific tile location, but contain only the NoData Value of -9999. A list of Daymet NoData Tile by year can be found at:

<http://daymet.ornl.gov/datasupport> .

Note that NoData values also buffer the rectangular extent of each of the Daymet variable netCDF files due to the spatially explicit raster content of the data. For example, pictured below in Figure 2 are two adjacent Daymet tiles showing Day 1 of the maximum temperature variable in year 2008. In Figure 2a., the pixel values on the adjacent edge of each tile match seamlessly. In Figure 2b., the NoData values for the file in Tile 11205 are symbolized in black showing the actual extent of the raster file.

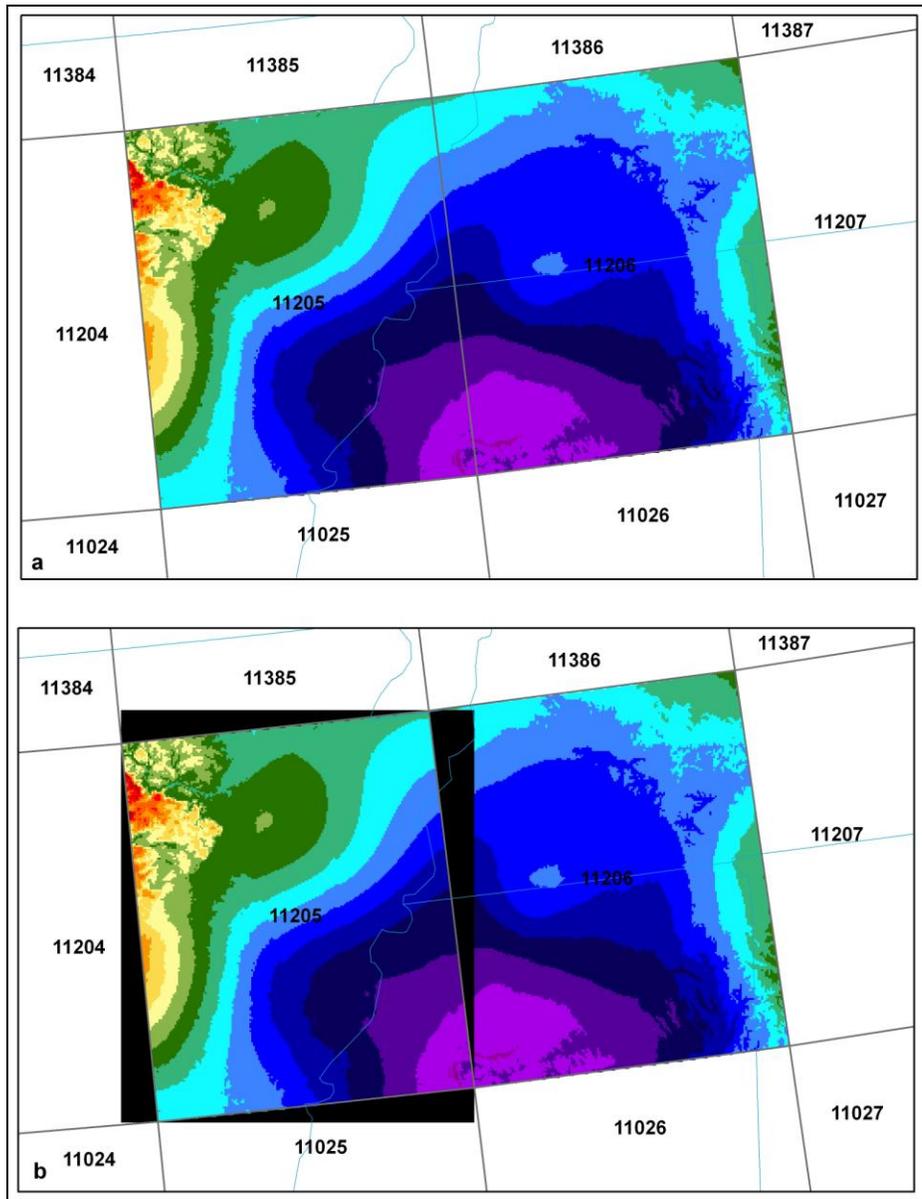


Figure 2. Daymet adjacent tiles and NoData values.

Though the Daymet dataset has been processed through QA/QC routines, it is possible that quality issues have been missed. Please notify us through the Contact Us page on the Daymet web site, <http://daymet.ornl.gov/contact> , if you find any issues with the data.

### ***Daymet Version Information:***

The Daymet dataset is stored as individual CF-Compliant netCDF file for each Daymet variable. The most current Daymet data is being delivered to the user in terms of both Daymet software and Daymet data versions. Version information is recorded in the header file of each of the CF-netCDF files within the Global Attribute fields; Version\_software and Version\_data. Details on Daymet software version and Daymet data version can be found at <http://daymet.ornl.gov>. All Daymet data is provisional and subject to revision.

### ***Daymet Projection Definition:***

The Daymet dataset downloaded from the daymet.ornl.gov web site is spatially referenced to the following projection:

#### ***The North American Daymet projection system and parameters:***

Projection System: Lambert Conformal Conic

Parameters:

projection units:	meters
datum (spheroid):	WGS_84
1 <sup>st</sup> standard parallel:	25 deg N
2 <sup>nd</sup> standard parallel:	60 deg N
Central meridian:	-100 deg (W)
Latitude of origin:	42.5 deg N
false easting:	0
false northing:	0

The spatial resolution of the Daymet gridded dataset is 1 km.

### ***Daymet netCDF Gridded Data in ArcGIS***

NetCDF stands for network Common Data Form and is a file format that allows variables to be stored as multi-dimensional arrays that can include time as a dimension. The daily time step of the spatially gridded Daymet variables makes the netCDF file format a convenient method for storing and distributing Daymet data. ArcGIS supports netCDF files that are stored based on Climate and Forecast (CF) conventions. These conventions define how the data is described through embedded metadata fields.

Through these fields, each variable, including their spatial and temporal properties, is described.

Daymet netCDF files cannot be directly added to the ArcMap window. To visualize and work with netCDF files in ArcGIS, add them with the **Make NetCDF Raster Layer** tool. As an example, the minimum temperature Daymet variable is shown being imported into ArcGIS in Figure 3. For *Variable*, click the appropriate Daymet variable – in this case tmin. Select x and y respectively for the *X and Y Dimension*. Provide an *Output Raster Layer* name. You can select time as the *Band Dimension* or set it later through the netCDF tab within the Layer Properties. When you click OK, an in-memory raster layer is created and added to the table of contents. The in-memory raster layer can be used as input to additional geoprocessing tools that support it.

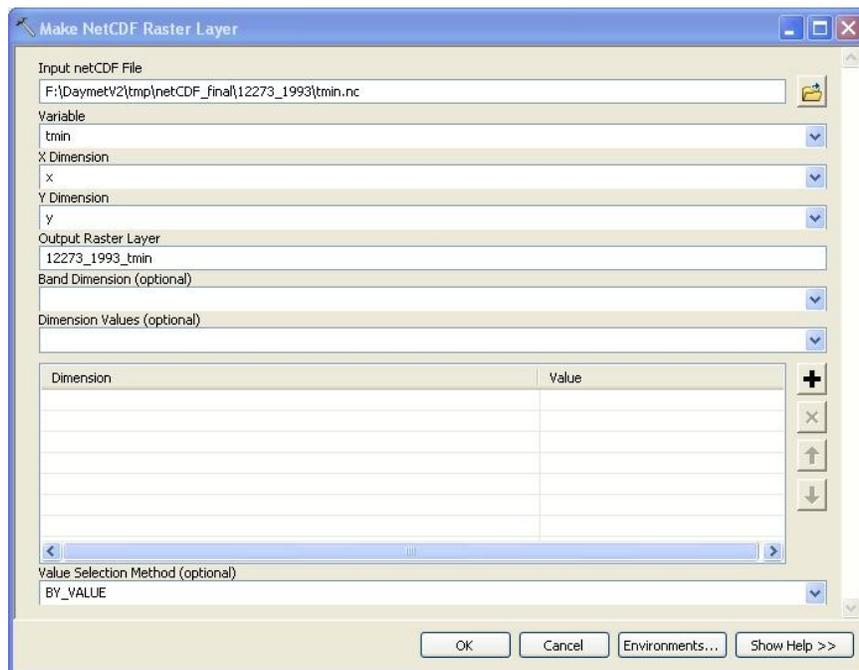


Figure 3. The ArcGIS Make NetCDF Raster Layer tool.

### ***Daymet Data Citation:***

When using the Daymet data acquired from the ORNL web site, please use the following citations:

Thornton, PE, MM Thornton, BW Mayer, N Wilhelmi, Y Wei, RB Cook 2012.  
Daymet: Daily surface weather on a 1 km grid for North America, 1980 - 2008. Acquired online (<http://daymet.ornl.gov/>) on [insert acquisition date]

here: DD/MM/YYYY] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.  
doi:10.3334/ORNLDAAC/Daymet\_V2.

The following should be used as the general citation for the methods used to generate the Daymet database:

Thornton, P.E., S.W. Running, and M.A. White. 1997. Generating surfaces of daily meteorology variables over large regions of complex terrain. *Journal of Hydrology* 190:214-251.

For applications of the radiation and humidity data please include the following citations **in addition** to the general citation:

Thornton, P.E., H. Hasenauer, and M.A. White. 2000. Simultaneous estimation of daily solar radiation and humidity from observed temperature and precipitation: An application over complex terrain in Austria. *Agricultural and Forest Meteorology* 104:255-271.

Thornton, P.E. and S.W. Running. 1999. An improved algorithm for estimating incident daily solar radiation from measurements of temperature, humidity, and precipitation. *Agriculture and Forest Meteorology*. 93:211-228.