WEATHER FOR ENERGY TRACKER

USERS GUIDE

International Energy Agency

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This document provides information regarding the November 2026 edition of the **Weather for Energy Tracker** platform and its database (the **Tracker**), developed by the International Energy Agency (IEA) in collaboration with Fondazione Euro-Mediterraneo Sui Cambiamenti Climatici (CMCC).[1]

Selected data are displayed and available for download at: www.iea.org/data-and-statistics/data-tools/weather-for-energy-tracker.

Complete sets of data are available at: https://ieaweatherdata.z28.web.core.windows.net/.

This document can be found online at: Weather for Energy Tracker: Users Guide.

Please address your comments and inquiries to weather@iea.org. We are keen to receive user feedback in order to improve further editions of this database.

Released: November 2026.

Note: *The Tracker is the result of a collaborative effort between the International Energy Agency (IEA) and the Fondazione Euro-Mediterraneo Sui Cambiamenti Climatici (CMCC). The Tracker reflects the views of the IEA Secretariat and CMCC but does not necessarily reflect those of their respective individual member countries. The Tracker does not constitute professional advice on any specific issue or situation. CMCC and the IEA make no representation or warranty, express or implied, in respect of the Tracker (including its completeness or accuracy) and shall not be responsible for any use of, or reliance on, the Tracker. Furthermore, neither the European Commission nor the European Centre for Medium-Range Weather Forecasts ECMWF is responsible for any use that may be made of the Copernicus information or data contained in the Tracker.*

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***Population data derive from**:*

Center for International Earth Science Information Network (*CIESIN*), *Columbia University* (*2018*), *Gridded Population of the World, Version 4 (GPWv4): Population Count, Revision 11*; NASA Socioeconomic Data and Applications Center (SEDAC), *Palisades, NY*; *doi.org/10.7927/H4JW8BX5* (a*ccessed 29/06/2020*).

Schiavina, Marcello; Freire, Sergio; MacManus, Kytt (2019): GHS population grid multitemporal (1975, 1990, 2000, 2015) R2019A. European Commission, Joint Research Centre (JRC) DOI: 10.2905/42E8BE89-54FF-464E-BE7B-BF9E64DA5218 PID: http://data.europa.eu/89h/0c6b9751-a71f-4062-830b-43c9f432370fConcept & Methodology:
Freire, Sergio; MacManus, Kytt; Pesaresi, Martino; Doxsey-Whitfield, Erin; Mills, Jane (2016): Development of new open and free multi-temporal global population grids at 250 m resolution. Geospatial Data in a Changing World; Association of Geographic Information Laboratories in Europe (AGILE). AGILE 2016.

[1] We would like to acknowledge Dr Silvio Gualdi, Dr. Ritika Kapoor and Dr. Enrico Scoccimarro (Centro Euro-Mediterraneo sui cambiamenti climatici) for their valuable insights and contribution to the design of this database.

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Overview

The IEA and CMCC Weather for Energy Tracker is a new, free platform, which showcases global data on weather-related variables that can be useful for understanding, analysing and modelling the energy sector, from generation to use across sectors. Data are available at grid, country and sub-national levels, with a daily and monthly resolution from the year 1979[2] to the latest available month,[3] and including monthly climatologies and anomalies.

Given the strong interlinkage between energy generation and demand with weather variables, reliable, consistent and easily accessible data on an expanded portfolio of weather variables, e.g. temperatures, degree days, solar radiation and precipitation, are becoming more and more important. We believe that this product will help statisticians, researchers, modellers and analysts around the world as well as a broader audience interested in the energy sector.

The Weather for Energy Tracker includes data for 51 variables at global gridded level and monthly resolution (including monthly climatologies and monthly anomalies); and data for 50 variables at nationally and sub-nationally averaged levels at daily and monthly resolution (including monthly climatologies and monthly anomalies). The complete database is updated every month. The data are available through the different options below:

- Interactive map. Users can select and download *ad hoc* data, at grid level and nationally and sub-nationally averaged, through the selection box for a selection of variables.
- Data repository. Complete sets of grid-level, nationally and sub-nationally averaged data are available for download at ieaweatherdata.z28.web.core.windows.net/.
- Interactive Excel file, the *Weather for Energy Tracker: Highlights*. Condensed, selected information in a user-friendly format.

For more details on sources, variable definitions, and methodologies, please refer to the relevant sections of this document.

2 For now, data from 1979 to 1999 are only included in the data repository. It will be made available in the interactive map at a later date.

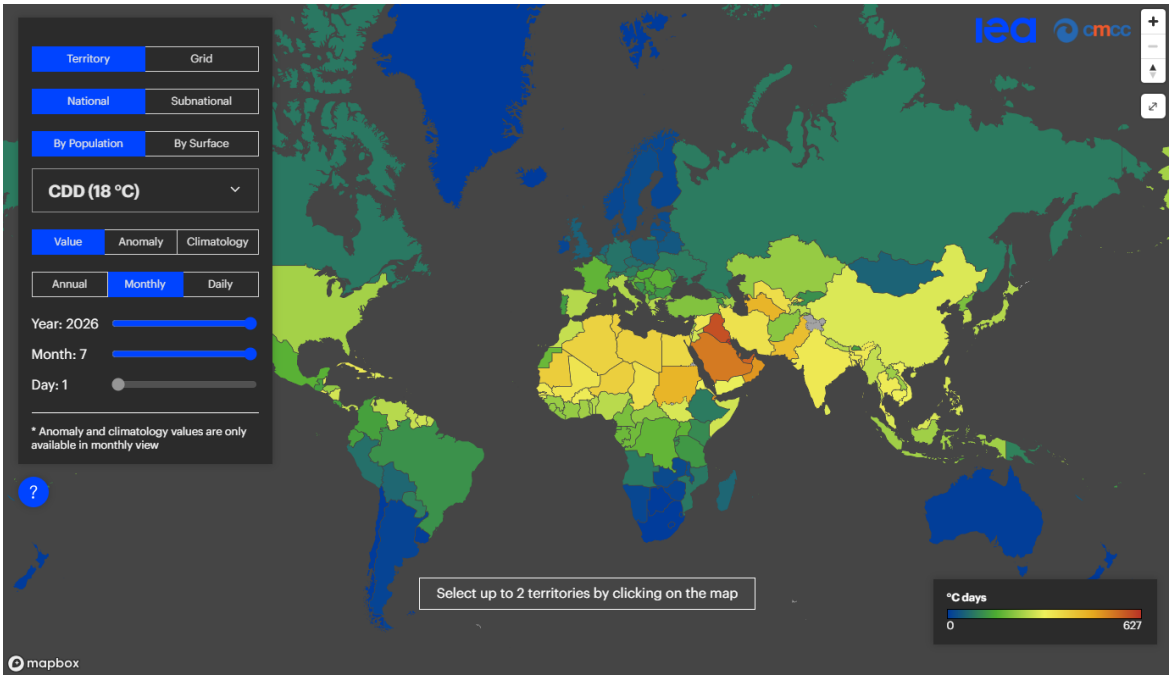
3 As of November 2026, the latest available month is October 2026.

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Interactive map

The interactive global map is freely available online at www.iea.org/data-and-statistics/data-tools/weather-for-energy-tracker. It is expected to be updated every month.

Interactive map homepage



The full list of variables available through the map is shown in the menu. The map displays data in three views, which are accessible through the menu tabs *Territory*, which displays nationally averaged data for over 200 countries and sub-nationally averaged data for selected countries; and *Grid*, which displays gridded data for over 1 million geographical points around the world. The selection of variables is adapted to each of the two formats.

The data displayed in the interactive map spans from 1 January 2000 until the last day of the month prior to the release. Monthly anomalies and associated climatologies[4] are also available for monthly data.

[4] *Climatologies* are averages of monthly values over a reference period (2000-2019 in this database). *Anomalies* are the differences between a given monthly value and its corresponding monthly climatology. For more details, please refer to the **Methodology** section.

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Through the interactive map, selected data can be retrieved by clicking on the following button: Configure download

More information on the dataset is available through the ? button.

Territory view

The territory view includes two maps: national map for displaying nationally-averaged indicators for over 200 countries in the world, and sub-national map that includes data for six countries (Australia, Brazil, Canada, People's Republic of China, Russian Federation and the United States).

In his view data are available for 19 selected variables, some of which are available using two averaging methods: *surface* (surface weighting) and *population* (population weighting).

The list of variables accessible for the territory map is presented in the table below. For more information on definitions of variables, please refer to the Definitions section.

Variables available in the territory map view

Variable	Averaging method
CDD (18 °C)	Population
CDD (21 °C)	Population
CDD (18 °C, humidity)	Population
HDD (16 °C)	Population
HDD (18 °C)	Population
Relative humidity	Surface
Total precipitation	Surface
Cloud coverage	Surface
Sunlight	Surface
Direct normal radiation	Surface
Global horizontal irradiance	Surface
Temperature (2 m)	Surface, population

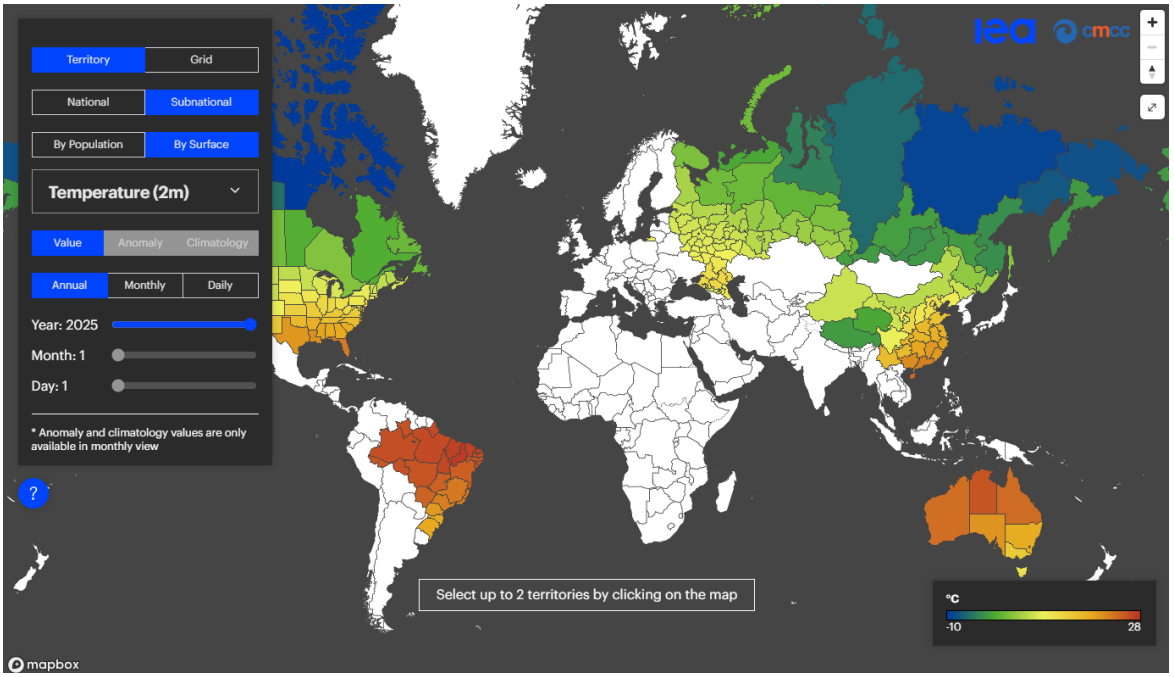
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Temperature max (2 m)	Surface, population
Temperature min (2 m)	Surface, population
Heat index (2 m)	Population
Humidex (2 m)	Population

Note: m = metre.

Please note that more variables are available on the grid map view than are on the territory map view.

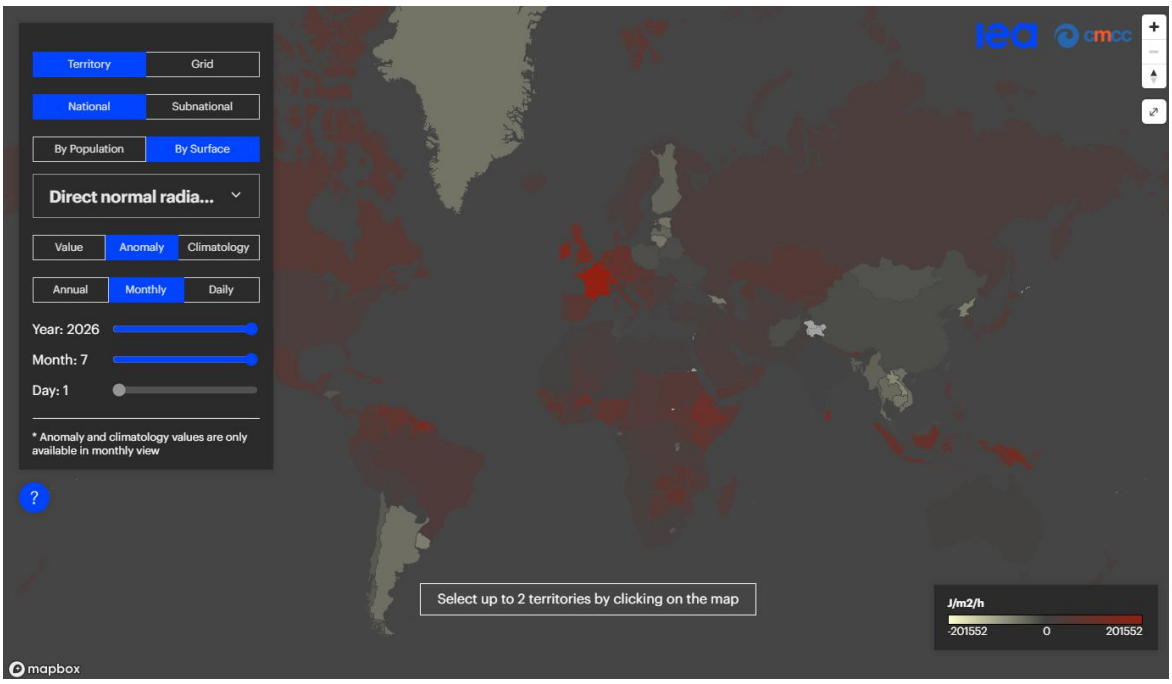
Territory map, sub-national surface-weighted average of 2-metre temperature, year 2025



In the territory map, data are displayed at daily, monthly or annual resolution. At the monthly resolution, anomalies and climatologies are also available.

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Territory map, surface-weighted average of national direct normal radiation anomalies for July 2026, global view

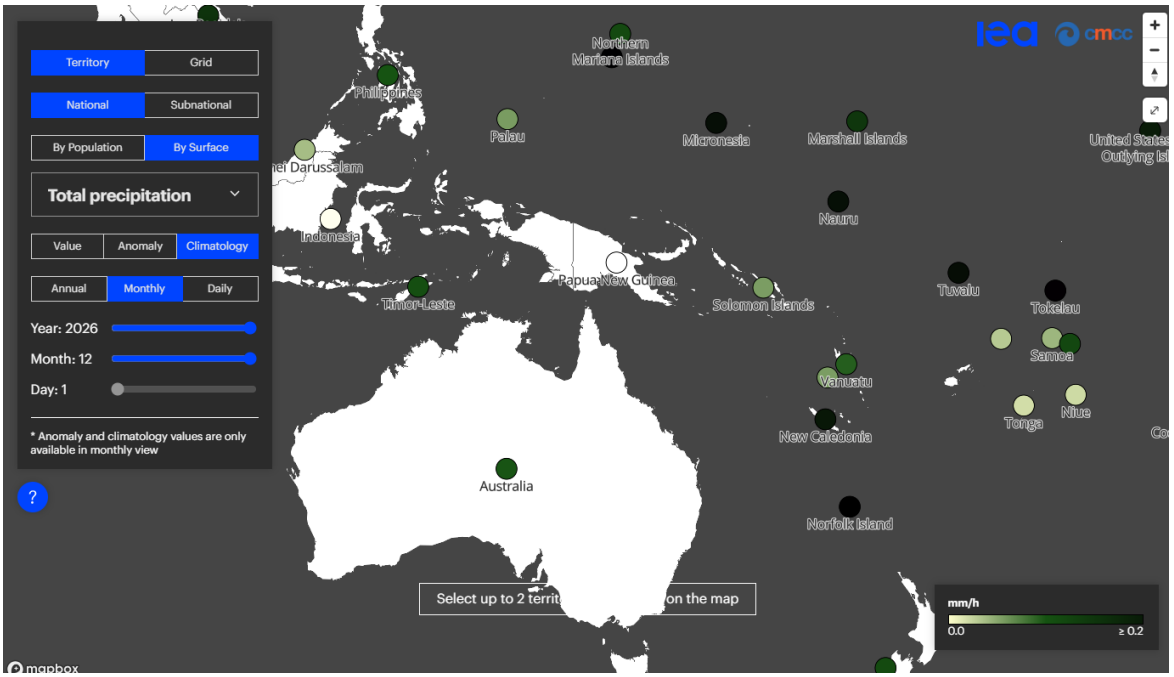


For example, the map above shows that in July 2026, direct normal radiation was above average in Western Europe, while it was below average in Southeast Asia.

When zooming in, the map colour pattern changes so that the values for small territories are visible despite the relatively small area represented:

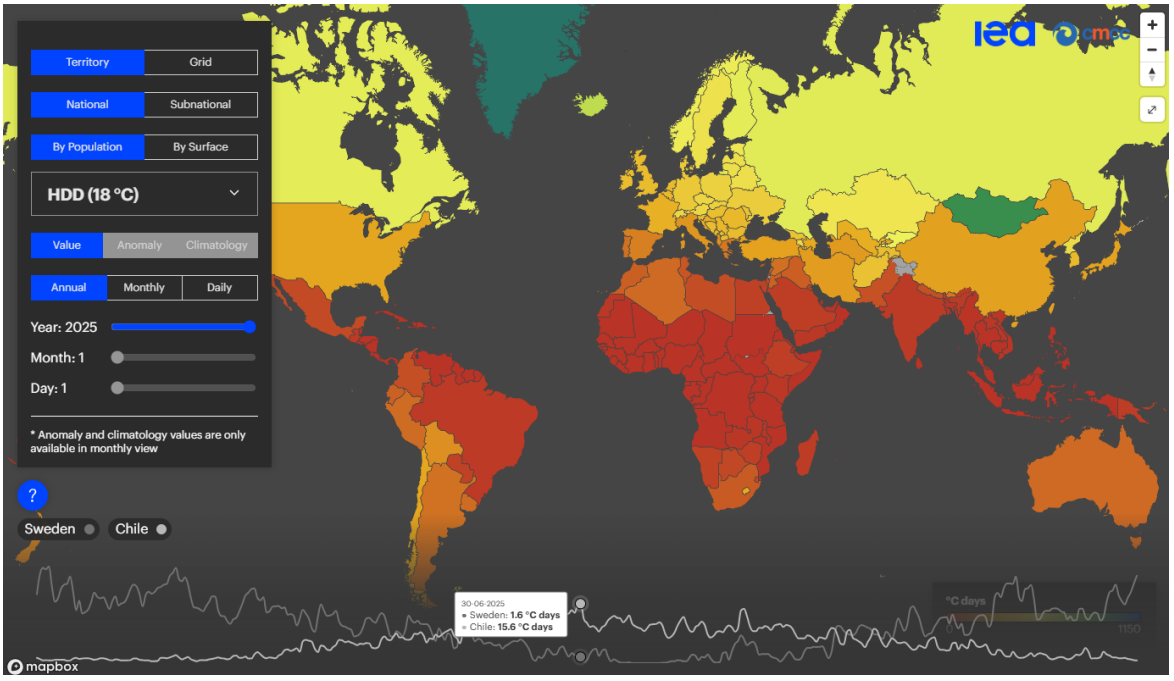
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Territory map, national precipitation climatologies for December, regional zoom view



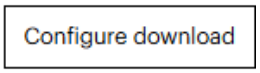
When selecting a territory, a graph at the bottom of the map displays the relevant time series. It is possible to plot two countries on the graph for quick comparisons.

Territory map, national HDD (18°C, population) for year 2025, graph-enabled



Data can be retrieved in CSV format by clicking the “Configure download” button:

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The list of countries/regions can be customised, as well as the time range. For extracting the full time series of the dataset, it is advised not to select all countries/regions in a single file for size reasons, but instead to download it through the Data repository.

Grid map

The grid map displays data for 20 variables on a gridded view. The map is composed of more than one million data points around the world: the resolution of the meshing is as fine as 0.25 degree by latitude and longitude. The list of variables accessible through the grid map is presented in the table below. For more information on variables definitions, please refer to the Definitions section.

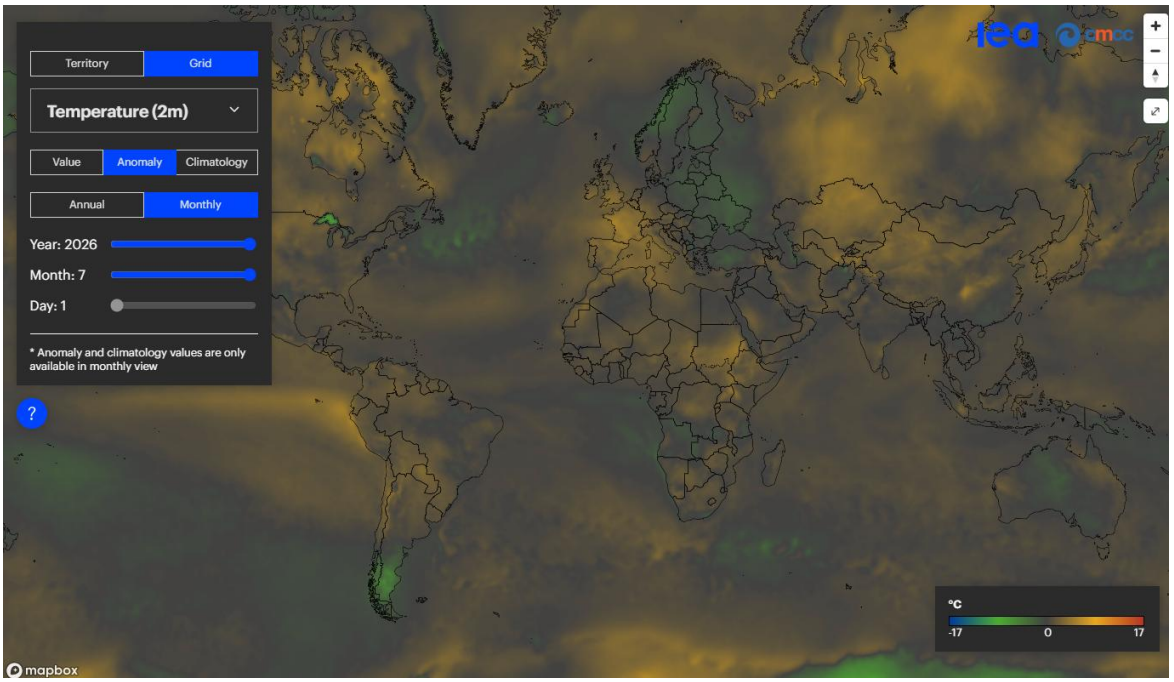
Variables available in the grid map view

Variable
CDD (18 °C)
CDD (18 °C, humidity)
HDD (18 °C)
Relative humidity
Evaporation
Total precipitation
Runoff
Snowfall
Cloud coverage
Sunlight
Direct normal radiation
Global horizontal irradiance
Temperature (2 m)
Temperature max (2 m)
Temperature min (2 m)
Heat index (2 m)
Humidex (2 m)
Wind speed (100 m)
Wind speed (10 m)
Wind capacity factor (100 m)

Note: m = metre.

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Grid map, 2-metre average anomaly of temperature, July 2026



Data are displayed as monthly or annual values. For monthly data, anomalies and climatologies are also available.

Data can be retrieved by clicking the “Configure download” button, pointing to the Data repository:

Configure download

Due to the large amount of data embedded, the files for gridded data downloaded are in NetCDF format (Network Common Data Form – .nc). The NetCDF file includes data for the selected variable for all data points in the world, and at the selected time. For more information on the NetCDF format, please refer to unidata.ucar.edu/software/netcdf/.

Data repository

The data repository, freely available online at ieaweatherdata.z28.web.core.windows.net, includes the full set of monthly data, at grid level and at nationally and sub-nationally averaged level. Biannual updates are expected. The data repository spans from January 1979 to the month prior to the release (included).

The data repository contains:

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- Monthly averages, anomalies and climatologies of gridded data for the entire time series for 51 variables. Each file corresponds to a variable and is composed of three dimensions: latitude, longitude and time. Data are available in NetCDF format.
- Daily and monthly nationally and sub-nationally averaged data for the entire time series for 50 variables. Each file corresponds to a variable and is composed of three dimensions: latitude, longitude and time. Data are available in CSV and NetCDF format.
- A name containing the wording *bysurf* (respectively, *bypop*), which implies that the means national values are computed using a surface (respectively, *population*) weighted averaging method.

Please note that size of gridded files can exceed 1 GB of size.

Whereas nationally and sub-nationally averaged files are available in CSV format, gridded data are only available in the data repository in NetCDF format, due to the large amount of data embedded. The NetCDF file for grid includes data for the selected variable for all data points in the world for the selected month. For more details on NetCDF format, please refer to unidata.ucar.edu/software/netcdf/.

Note that for territorial data, co-ordinates are given through codes (and not longitude and latitude). Please find the code descriptions in the Geographical Coverage section of this document or in the Excel file, "Country codes.xlsx" for national data and "Subnational codes.xlsx" for sub-national data, which are available in the data repository.

Users must not remove any sourcing and disclaimer notices within the files.

Interactive Excel file

The interactive Excel file, freely available at www.iea.org/data-and-statistics/data-tools/weather-for-energy-tracker, is expected to be updated every quarter in January, April, July and October.

This file offers users the possibility to easily access monthly data for selected variables, averaged at country level for over 200 countries. Selected variables are displayed here as of the November 2026 release, with a monthly resolution from January 2010 to the latest month available (October 2026 as of release).

The list of variables accessible through the interactive Excel file is presented in the table below. For more information on variables definitions, please refer to the Definitions sections and, for more information, on the averaging methods, please refer to the Methodology section.

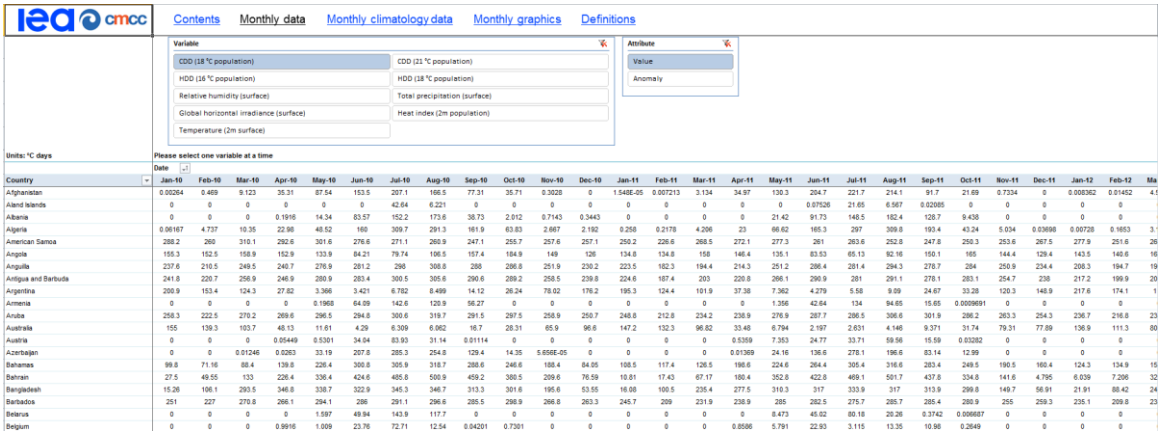
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Variables available in the interactive Excel file

Variable	Averaging method
CDD (18 °C)	Population
CDD (21 °C)	Population
HDD (16 °C)	Population
HDD (18 °C)	Population
Relative humidity	Surface
Total precipitation	Surface
Global horizontal irradiance	Surface
Temperature (2 m)	Surface
Heat index (2 m)	Population

The file is composed of two main data tabs and a graphical one: “Monthly data”, “Monthly climatology data” and “Monthly graphics”. In the “Monthly data” tab, users can select a variable and an attribute (value or anomaly). In the “Monthly climatology data” tab, climatologies for the selected variable are displayed. In the “Monthly graphics” tab, users can display the values and anomalies for the selected variable in an interactive chart.

Excel file: sample view of the Data display tab, Anomalies for CDD (18ºC, population)



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Data sources

This database makes use of primary data for weather variable and population to derive various indicators.

Weather primary variables are extracted from ERA5 hourly dataset.[5] Fourteen variables are used as a source of 10 primary variables published as well as 42 derived indicators (more details can be found in Definitions section).

Data are retrieved using the Climate Data Store Application Program Interface (CDS API). Please find further documentation on the dedicated CDS API webpage.

The dataset is retrieved with the following parameters:

- Dataset short name: reanalysis-era5-single-levels
- Product type: reanalysis
- Space resolution: 0.25° x 0.25° longitude and latitude
- Format: netCDF files
- Time series: hourly data from 1 January 1979 to last hour of month prior to publication date

Population data are derived from the Center for International Earth Science Information Network (CIESIN), Columbia University, 2018, Gridded Population of the World, Version 4 (GPWv4)[6] and GHS population grid from (JRC)[7].

Data are interpolated to estimate yearly population values from 2000 to 2024. (more details in Methodology section). Those data are used to compute population weighted territorial averages for all indicators.

The mask embedded in the population dataset is also used to aggregate gridded data into national data.

[5] Hersbach, H. at al. (2018), ERA5 hourly data on single levels from 1959 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS), (accessed: 9 November 2020), 10.24381/cds.adbb2d47

[6] Center for International Earth Science Information Network (CIESIN), Columbia University (2018), Gridded Population of the World, Version 4 (GPWv4): Population Count, Revision 11. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC), doi.org/10.7927/H4JW8BX5 (accessed: 29 May 2020).

[7] Schiavina, Marcello; Freire, Sergio; MacManus, Kytt (2019): GHS population grid multitemporal (1975, 1990, 2000, 2015) R2019A. European Commission, Joint Research Centre (JRC) DOI: 10.2905/42E8BE89-54FF-464E-BE7B-BF9E64DA5218 PID: http://data.europa.eu/89h/0c6b9751-a71f-4062-830b-43c9f432370fConcept & Methodology: Freire, Sergio; MacManus, Kytt; Pesaresi, Martino; Doxsey-Whitfield, Erin; Mills, Jane (2016): Development of new open and free multi-temporal global population grids at 250 m resolution. Geospatial Data in a Changing World; Association of Geographic Information Laboratories in Europe (AGILE). AGILE 2016.

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The mask used to aggregate sub-national data is derived from files extracted from DIVA-GIS[8].

[8] Download data by country | DIVA-GIS

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Definitions

Variables are separated in this section into two categories:

- Primary weather variable: Those variables are extracted from Copernicus Climate Change Service, 2026; ERA5 hourly data on single levels from 1970 to present (doi.org/10.24381/cds.adbb2d47), European Centre for Medium-Range Weather Forecasts. They are not manipulated further than resizing the units to more convenient units, and are used as input to derived indicators. The first table contains web and short names, definition and unit of each variable. The definition column contains a descriptive name of the variable, the corresponding ID to ERA5 dataset, and the unit conversion done if applicable. Link to ERA5 documentation
- Derived indicators: are relevant indicators derived from primary weather variables. The dedicated table contains web and short names, definitions and units of each variable. Methodologies used are more detailed under the methodological section of this document.

Primary weather variables

Web name: Temperature (2m)	**Short name:** Temperature	**Units:** °C
Definition	2 meters mean temperature. This parameter corresponds to item n°167 of ERA5 dataset, described as: *This parameter is the temperature of air at 2m above the surface of land, sea or inland waters. 2m temperature is calculated by interpolating between the lowest model level and the earth's surface, taking account of the atmospheric conditions.*	

Web name: Dew temperature (2m)	**Short name:** Temperaturedew	**Units:** °C
Definition	2 meters mean dew temperature. This parameter corresponds to item n°168 of ERA5 dataset, described as: *This parameter is the temperature to which the air, at 2 metres above the surface of the earth, would have to be cooled for saturation to occur. It is a measure of the humidity of the air. Combined with temperature and pressure, it can be used to calculate the relative humidity. 2m dew point temperature is calculated by interpolating between the lowest model level and the earth's surface, taking account of the atmospheric conditions.*	

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Web name: Total precipitation	**Short name:** Precipitation	**Units:** mm/h
Definition	Total precipitation. This parameter corresponds to item n°228 of ERA5 dataset, described as: This parameter is the accumulated liquid and frozen water, comprising the rain and snow that falls to the earth's surface. It is the sum of large-scale precipitation and convective precipitation. Large-scale precipitation is generated by the cloud scheme in the ECMWF Integrated Forecasting System (IFS). The cloud scheme represents the formation and dissipation of clouds and large-scale precipitation due to changes in atmospheric quantities (such as pressure, temperature and moisture) predicted directly by the IFS at spatial scales of the grid box or larger. Convective precipitation is generated by the convection scheme in the IFS, which represents convection at spatial scales smaller than the grid box. This parameter does not include fog, dew or the precipitation that evaporates in the atmosphere before it lands at the surface of the earth. This parameter is the total amount of water accumulated over a particular time period which depends on the data extracted. The units of this parameter are depth in metres of water equivalent. It is the depth the water would have if it were spread evenly over the grid box. Care should be taken when comparing model parameters with observations, because observations are often local to a particular point in space and time, rather than representing averages over a model grid box. Unit is converted from m/h to mm/h.

Web name: Snowfall	**Short name:** Snowfall	**Units:** mm/h
Definition	Snowfall. This parameter corresponds to item n°144 of ERA5 dataset, described as: This parameter is the accumulated snow that falls to the earth's surface. It is the sum of large-scale snowfall and convective snowfall. Large-scale snowfall is generated by the cloud scheme in the ECMWF Integrated Forecasting System (IFS). The cloud scheme represents the formation and dissipation of clouds and large-scale precipitation due to changes in atmospheric quantities (such as pressure, temperature and moisture) predicted directly by the IFS at spatial scales of the grid box or larger. Convective snowfall is generated by the convection scheme in the IFS, which represents convection at spatial scales smaller than the grid box. See further information. This parameter is the total amount of water accumulated over a particular time period which depends on the data extracted. The units of this parameter are depth in metres of water equivalent. It is the depth the water would have if it were spread evenly over the grid box. Care should be taken when comparing model parameters with observations, because observations are often local to a particular point in space and time, rather than representing averages over a model grid box. Unit is converted from m/h to mm/h.

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Web name: Runoff	**Short name:** Runoff	**Units:** mm/h
Definition	This parameter corresponds to item n°205 of ERA5 dataset, described as: Some water from rainfall, melting snow, or deep in the soil, stays stored in the soil. Otherwise, the water drains away, either over the surface (surface runoff), or under the ground (sub-surface runoff) and the sum of these two is simply called “runoff”. This parameter is the total amount of water accumulated over a particular time period which depends on the data extracted. The units of runoff are depth in metres. This is the depth the water would have if it were spread evenly over the grid box. Care should be taken when comparing model parameters with observations, because observations are often local to a particular point rather than averaged over a grid square area. Observations are also often taken in different units, such as mm/day, rather than the accumulated metres produced here. Runoff is a measure of the availability of water in the soil, and can, for example, be used as an indicator of drought or flood. Unit is converted from m/h to mm/h.	

Web name: Evaporation	**Short name:** Evaporation	**Units:** mm/h
Definition	Evaporation. This parameter corresponds to item n°182 of ERA5 dataset, described as: This parameter is the accumulated amount of water that has evaporated from the earth's surface, including a simplified representation of transpiration (from vegetation), into vapour in the air above. This parameter is accumulated over a particular time period which depends on the data extracted. The ECMWF Integrated Forecasting System convention is that downward fluxes are positive. Therefore, negative values indicate evaporation and positive values indicate condensation	

Web name: Cloud coverage	**Short name:** Cloud coverage	**Units:** %
Definition	Cloud coverage. This parameter corresponds to item n°164 of ERA5 dataset, described as: This parameter is the proportion of a grid box covered by cloud. Total cloud cover is a single level field calculated from the cloud occurring at different model levels through the at-mosphere. Assumptions are made about the degree of overlap/randomness between clouds at different heights	

Web name: Direct normal radiation	**Short name:** DNI	**Units:** J/m^2/h
Definition	Direct normal radiation. This parameter corresponds to item n° 228021 (Total sky direct solar radiation at surface) of ERA5 dataset, described as: *This parameter is the amount of direct solar radiation (also known as shortwave radiation) reaching the surface of the earth. It is the amount of radiation passing through a horizontal plane, not a plane perpendicular to the direction of the Sun. Solar radiation at the surface can be direct or diffuse. Solar radiation can be scattered in all directions by particles in the atmosphere, some of which reaches the surface (diffuse solar radiation). Some solar radiation reaches the surface without being scattered (direct solar radiation)*	

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Web name: Global horizontal irradiance	**Short name:** GHI	**Units:** J/m²/h
Definition	Global horizontal irradiance. This parameter corresponds to item n° 169 (Surface solar radiation downwards) of ERA5 dataset, described as: *This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the earth. This parameter comprises both direct and diffuse solar radiation. Radiation from the Sun (solar, or shortwave, radiation) is partly reflected back to space by clouds and particles in the atmosphere (aerosols) and some of it is absorbed. The rest is incident on the earth's surface (represented by this parameter).* https://www.ecmwf.int/sites/default/files/elibrary/2015/18490-radiation-quantities-ecmwf-model-and-mars.pdf *To a reasonably good approximation, this parameter is the model equivalent of what would be measured by a pyranometer (an instrument used for measuring solar radiation) at the surface. However, care should be taken when comparing model parameters with observations, because observations are often local to a particular point in space and time, rather than representing averages over a* model grid box.	

Web name: Surface pressure	**Short name:** Surface pressure	**Units:** Pa
Definition	Surface pressure. This parameter corresponds to item n° 134 of ERA5 dataset, described as: *This parameter is the pressure (force per unit area) of the atmosphere on the surface of land, sea and in-land water. It is a measure of the weight of all the air in a column vertically above the area of the earth's surface represented at a fixed point. Surface pressure is often used in combination with temperature to calculate air density. The strong variation of pressure with altitude makes it difficult to see the low and high pressure systems over mountainous areas, so mean sea level pressure, rather than surface pressure, is normally used for this purpose.*	

Derived indicators

Variable: Temperature max (2m)	**Short name:** Temperature max	**Units:** °C
Definition	2-metre maximum temperature. It is calculated as the maximum of 2 metre hourly temperature over the period of time considered.	

Variable: Temperature min (2m)	**Short name:** Temperature min	**Units:** °C
Definition	2-metre minimum temperature. It is calculated as the minimum of 2 metre hourly temperature over the period of time considered.	

Variable: Heat index (2m)	**Short name:** HeatIndex	**Units:** °C
Definition	Humidity-corrected 2 meter temperature (heat index). More details on methodology here.	

Variable: Humidex (2 m)	**Short name:** Humidex	**Units:** °C
Definition	Humidity-corrected 2 metre temperature (humidex). More details on methodology here.	

Variable: CDD (65 °F)	**Short name:** CDD	**Units:** °C days

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Definition	Cooling degree days (reference temperature 65 °F). More details on methodology here.

Variable: CDD (10 °C)	**Short name:** CDD10	**Units:** C days
Definition	Cooling degree days (reference temperature 10 °C). More details on methodology here.	

Variable: CDD (16 °C	**Short name:** CDD16	**Units:** C days
Definition	Cooling degree days (reference temperature 16 °C). More details on methodology here.	

Definition	Cooling degree days (reference temperature 18 °C). More details on methodology here.

Variable: CDD (21 °C)	**Short name:** CDD21	**Units:** C days
Definition	Cooling degree days (reference temperature 21 °C). More details on methodology here.	

Variable: CDD (23 °C)	**Short name:** CDD23	**Units:** C days
Definition	Cooling degree days (reference temperature 23 °C). More details on methodology here.	

Variable: CDD (26 °C)	**Short name:** CDD26	**Units:** °C days
Definition	Cooling degree days (reference temperature 26 °C). More details on methodology here.	

Variable: CDD (18 °C, 21 °C threshold)	**Short name:** CDDThold18	**Units:** °C days
Definition	Cooling degree days (reference temperature 18 °C and threshold temperature 21 °C. Examples: if the daily mean air temperature is 24°C, for that day the value of the CDD is 6 (24 °C-18 °C). If the daily mean air temperature is 20 °C, for that day the CDD is 0.). More details on methodology here.	

Variable: CDD (21 °C, 24 °C threshold)	**Short name:** CDDThold21	**Units:** °C days
Definition	Cooling degree days (reference temperature 21 °C and threshold temperature 24 °C. Examples: if the daily mean air temperature is 26°C, for that day the value of the CDD is 5 (26 °C-21 °C). If the daily mean air temperature is 22 °C, for that day the CDD is 0). More details on methodology here.	

Variable: CDD (23 °C, 26 °C threshold)	**Short name:** CDDThold23	**Units:** °C days
Definition	Cooling degree days (reference temperature 23 °C and threshold temperature 26 °C. Examples: if the daily mean air temperature is 30°C, for that day the value of the CDD is 7 (30 °C-26 °C). If the daily mean air temperature is 25 °C, for that day the CDD is 0). More details on methodology here.	

Variable: CDD (variable)	**Short name:** CDDVar	**Units:** °C days
Definition	Cooling degree days (reference temperature variable per region. Japan, India 21 °C; Rest of the World 18 °C). More details on methodology here.	

Variable: CDD (65 °F, humidity)	**Short name:** CDDhum	**Units:** °C days

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Definition	Cooling degree days from temperature corrected by humidity (reference temperature 65 °F). Heat Index is used as input temperature. More details on methodology here.

Variable: CDD (10 °C, humidity)	**Short name:** CDDhum10	**Units:** °C days
Definition	Cooling degree days from temperature corrected by humidity (reference temperature 10 °C). Heat Index is used as input temperature. More details on methodology here.	

Variable: CDD (16 °C, humidity)	**Short name:** CDDhum16	**Units:** °C days
Definition	Cooling degree days from temperature corrected by humidity (reference temperature 16 °C). Heat Index is used as input temperature. More details on methodology here.	

Variable: CDD (18 °C, humidity)	**Short name:** CDDhum18	**Units:** °C days
Definition	Cooling degree days from temperature corrected by humidity (reference temperature 18 °C). Heat Index is used as input temperature. More details on methodology here.	

Variable: CDD (21 °C, humidity)	**Short name:** CDDhum21	**Units:** C days
Definition	Cooling degree days from temperature corrected by humidity (reference temperature 21 °C). Heat Index is used as input temperature. More details on methodology here.	

Variable: CDD (23 °C, humidity)	**Short name:** CDDhum23	**Units:** C days
Definition	Cooling degree days from temperature corrected by humidity (reference temperature 23 °C). Heat Index is used as input temperature. More details on methodology here.	

Variable: CDD (26 °C, humidity)	**Short name:** CDDhum26	**Units:** C days
Definition	Cooling degree days from temperature corrected by humidity (reference temperature 26 °C). Heat Index is used as input temperature. More details on methodology here.	

Variable: CDD (18 °C, 21 °C threshold, humidity)	**Short name:** CDDhumThold18	**Units:** C days
Definition	Cooling degree days from temperature corrected by humidity (reference temperature 18 °C and threshold temperature 21 °C). Heat Index is used as input temperature. Examples: if the daily mean air temperature is 24 °C, for that day the value of the CDD is 6 (24 °C-18 °C). If the daily mean air temperature is 20 °C, for that day the CDD is 0). More details on methodology here.	

Variable: CDD (21 °C, 24 °C threshold, humidity)	**Short name:** CDDhumThold21	**Units:**
Definition	Cooling degree days from temperature corrected by humidity (reference temperature 21 °C and threshold temperature 24 °C). Heat Index is used as input temperature. Examples: if the daily mean air temperature is 26 °C, for that day the value of the CDD is 5 (26 °C-21 °C). If the daily mean air temperature is 22 °C, for that day the CDD is 0). More details on methodology here.	

Variable: CDD (23 °C, 26 °C threshold, humidity)	**Short name:** CDDhumThold23	**Units:** C days

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Definition	Cooling degree days from temperature corrected by humidity (reference temperature 23 °C and threshold temperature 26 °C). Heat Index is used as input temperature. Examples: if the daily mean air temperature is 30 °C, for that day the value of the CDD is 4 (30 °C-26 °C). If the daily mean air temperature is 25 °C, for that day the CDD is 0). More details on methodology here.

Variable: CDD (variable, humidity)	**Short name:** CDDhumVar	**Units:**
Definition	Cooling degree days from temperature corrected by humidity (reference temperature variable per region). Heat Index is used as input temperature. Japan, India 21 °C; Rest of the World 18 °C). More details on methodology here.	

Variable: CDD (65 °F, wet bulb)	**Short name:** CDDwet	**Units:** °C days
Definition	Cooling degree days from wet bulb temperature (reference temperature 65 °F). Wet bulb temperature is used as input temperature. More details on methodology here.	

Variable: HDD (65 °F)	**Short name:** HDD	**Units:** °C days
Definition	Heating degree days (reference temperature 65 °F). More details on methodology here.	

Variable: HDD (16 °C)	**Short name:** HDD16	**Units:** °C days
Definition	Heating degree days (reference temperature 16 °C). More details on methodology here.	

Variable: HDD (18 °C)	**Short name:** HDD18	**Units:** °C days
Definition	Heating degree days (reference temperature 18 °C). More details on methodology here.	

Variable: HDD (20 °C)	**Short name:** HDD20	**Units:** °C days
Definition	Heating degree days (reference temperature 20 °C). More details on methodology here.	

Variable: HDD (16 °C, 13 °C threshold)	**Short name:** HDDThold16	**Units:** °C days
Definition	Heating degree days (reference temperature 16 °C and threshold temperature 13 °C). Examples: if the daily mean air temperature is 12°C, for that day the value of the HDD is 4 (16 °C-12 °C). If the daily mean air temperature is 14 °C, for that day the HDD is 0). More details on methodology here.	

Variable: HDD (18 °C, 15 °C threshold)	**Short name:** HDDThold18	**Units:** °C days
Definition	Heating degree days (reference temperature 18 °C and threshold temperature 15 °C. Examples: if the daily mean air temperature is 12°C, for that day the value of the HDD is 6 (18 °C-12 °C). If the daily mean air temperature is 16 °C, for that day the HDD is 0.) More details on methodology here.	

Variable: HDD (20 °C, 17 °C threshold)	**Short name:** HDDThold20	**Units:** °C days
Definition	Heating degree days (reference temperature 20 °C and threshold temperature 17 °C. Examples: if the daily mean air temperature is 12°C, for that day the value of the HDD is 8 (20 °C-12 °C). If the daily mean air temperature is 19 °C, for that day the HDD is 0). More details on methodology here.	

Variable: HDD (variable)	**Short name:** HDDVar	**Units:** °C days

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Definition	Heating degree days (reference temperature variable per region. Japan, Europe 16 °C; United States 11 °C; Rest of the World 18 °C). More details on methodology here.

Variable: HDD (14 °C, wind)	**Short name:** HDDwind	**Units:** °C days
Definition	Heating degree days corrected by wind speed (reference temperature 14 °C). More details on methodology here.	

Variable: Relative humidity	**Short name:** RH	**Units:** %
Definition	Relative humidity based on 2 metres air and dew temperatures. More details on methodology here.	

Variable: Sun light	**Short name:** Daylight	**Units:** minute
Definition	Minutes of sunlight. More details on methodology here.	

Variable: Wind speed (100-m)	**Short name:** Wind100int	**Units:** m/s
Definition	100 metres wind speed is calculated using the eastward components (item 228246) and northward component (item 228247) of the 100 m wind. It is the horizontal speed of air, at a height of one hundred meters above the surface of the earth. Care should be taken when comparing this parameter with observations, because wind observations vary on small space and time scales and are affected by the local terrain, vegetation and buildings that are represented only on average in the ECMWF Integrated Forecasting System.	

Variable: Wind speed (10-m)	**Short name:** Wind10int	**Units:** m/s
Definition	10 metres wind speed is calculated using the eastward components (item 165) and northward component (item 166) of the 10 m wind. It is the horizontal speed of air, at a height of ten meters above the surface of the earth. Care should be taken when comparing this parameter with observations, because wind observations vary on small space and time scales and are affected by the local terrain, vegetation and buildings that are represented only on average in the ECMWF Integrated Forecasting System.	

Variable: Wind direction (100-m)	**Short name:** Wind100dir	**Units:** degree - anticlockwise, 0 is east
Definition	100 metres wind direction is calculated using the eastward components (item 228246) and northward component (item 228247) of the 100 m wind. This parameter is the direction from which the wind blows, in degrees anticlockwise from the east, at a height of a hundred meters above the surface of the earth.	

Variable: Wind direction (10-m)	**Short name:** Wind10dir	**Units:** degree - anticlockwise, 0 is east
Definition	10 metres wind direction is calculated using the eastward components (item 165) and northward component (item 166) of the 10 m wind. This parameter is the direction from which the wind blows, in degrees anticlockwise from the east, at a height of ten meters above the surface of the earth.	

Variable: Wind capacity factor (100-m)	**Short name:** Wind100power	**Units:** %
Definition	The wind capacity factor represents the percentage of power output over nominal power expected from a wind turbine on a specific point of the grid for a specific time. More details on methodology here.	

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Geographical coverage

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Countries and territories

This table is available for download in excel format using this link.

Country/Territory	Short name	Code
Afghanistan	AFG	4
Aland Islands	ALA	248
Albania	ALB	8
Algeria	DZA	12
American Samoa	ASM	16
Angola	AGO	24
Anguilla	AIA	660
Antigua and Barbuda	ATG	28
Argentina	ARG	32
Armenia	ARM	51
Aruba	ABW	533
Australia	AUS	36
Austria	AUT	40
Azerbaijan	AZE	31
Bahamas	BHS	44
Bahrain	BHR	48
Bangladesh	BGD	50
Barbados	BRB	52
Belarus	BLR	112
Belgium	BEL	56
Belize	BLZ	84
Benin	BEN	204
Bermuda	BMU	60
Bonaire Saint Eustatius and Saba	BES	535
Bhutan	BTN	64
British Indian Ocean Territory	IOT	905

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Country/Territory	Short name	Code
Plurinational State of Bolivia	BOL	68
Bosnia and Herzegovina	BIH	70
Botswana	BWA	72
Bouvet Island	BVT	903
Brazil	BRA	76
Brunei Darussalam	BRN	96
Bulgaria	BGR	100
Burkina Faso	BFA	854
Burundi	BDI	108
British Virgin Islands	VGB	92
Cape Verde	CPV	132
Central African Republic	CAF	140
New Caledonia	NCL	540
Cambodia	KHM	116
Cameroon	CMR	120
Canada	CAN	124
Cayman Islands	CYM	136
Chad	TCD	148
Chile	CHL	152
People's Republic of China	CHN	156
Colombia	COL	170
Comoros	COM	174
Republic of the Congo	COG	178
Democratic Republic of the Congo	COD	180
Cook Islands	COK	184
Costa Rica	CRI	188
Cote d'Ivoire	CIV	384
Croatia	HRV	191
Cuba	CUB	192
Curacao/Netherlands Antilles	CUW	531
Cyprus	CYP	196
Czech Republic	CZE	203
Denmark	DNK	208
Djibouti	DJI	262
Dominica	DMA	212
Dominican Republic	DOM	214
Ecuador	ECU	218
Egypt	EGY	818
El Salvador	SLV	222

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Country/Territory	Short name	Code
Equatorial Guinea	GNQ	226
Eritrea	ERI	232
Estonia	EST	233
Swaziland	SWZ	748
Ethiopia	ETH	231
Faeroe Islands	FRO	234
French Guiana	GUF	254
Fiji	FJI	242
Finland	FIN	246
French Polynesia	PYF	258
France	FRA	250
French Southern Territories	ATF	902
Gabon	GAB	266
Gambia	GMB	270
Georgia	GEO	268
Germany	DEU	276
Ghana	GHA	288
Greece	GRC	300
Greenland	GRL	304
Grenada	GRD	308
Guadeloupe	GLP	312
Guam	GUM	316
Guatemala	GTM	320
Guernsey	GGY	831
Guinea	GIN	324
Guinea-Bissau	GNB	624
Guyana	GUY	328
Haiti	HTI	332
Heard Island and McDonald Islands	HMD	904
Honduras	HND	340
Hong Kong (China)	HKG	344
Hungary	HUN	348
Iceland	ISL	352
India	IND	356
Indonesia	IDN	360
Islamic Republic of Iran	IRN	364
Iraq	IRQ	368
Ireland	IRL	372
Israel	ISR	376

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Country/Territory	Short name	Code
Italy	ITA	380
Jamaica	JAM	388
Japan	JPN	392
Jersey	JEY	832
Jordan	JOR	400
Kazakhstan	KAZ	398
Kenya	KEN	404
Kiribati	KIR	296
Korea	KOR	410
Democratic People's Republic of Korea	PRK	408
Kosovo	XKX	999
Kuwait	KWT	414
Kyrgyzstan	KGZ	417
Lao People's Democratic Republic	LAO	418
Latvia	LVA	428
Lebanon	LBN	422
Lesotho	LSO	426
Liberia	LBR	430
Libya	LBY	434
Lithuania	LTU	440
Luxembourg	LUX	442
Madagascar	MDG	450
Malawi	MWI	454
Malaysia	MYS	458
Maldives	MDV	462
Mali	MLI	466
Malta	MLT	470
Falkland Islands (Malvinas)	FLK	238
Isle of Man	IMN	833
Marshall Islands	MHL	584
Martinique	MTQ	474
Mauritania	MRT	478
Mauritius	MUS	480
Mayotte	MYT	175
Mexico	MEX	484
Micronesia (Federated States of)	FSM	583
Republic of Moldova	MDA	498
Mongolia	MNG	496

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Country/Territory	Short name	Code
Montenegro	MNE	499
Montserrat	MSR	500
Morocco	MAR	504
Mozambique	MOZ	508
Myanmar	MMR	104
Namibia	NAM	516
Nauru	NRU	520
Nepal	NPL	524
Netherlands	NLD	528
Nicaragua	NIC	558
Niger	NER	562
Nigeria	NGA	566
Niue	NIU	570
Northern Mariana Islands	MNP	580
Norfolk Island	NFK	574
Republic of North Macedonia	MKD	807
Norway	NOR	578
New Zealand	NZL	554
Oman	OMN	512
Pakistan	PAK	586
Palau	PLW	585
State of Palestine	PSE	275
Panama	PAN	591
Papua New Guinea	PNG	598
Paraguay	PRY	600
Peru	PER	604
Philippines	PHL	608
Pitcairn	PCN	612
Poland	POL	616
Portugal	PRT	620
Puerto Rico	PRI	630
Qatar	QAT	634
Reunion	REU	638
Romania	ROU	642
Russian Federation	RUS	643
Rwanda	RWA	646
Western Samoa	WSM	882
Sao Tome and Principe	STP	678
Saudi Arabia	SAU	682

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Country/Territory	Short name	Code
Saint-Barthelemy	BLM	652
Senegal	SEN	686
Serbia	SRB	688
Seychelles	SYC	690
South Georgia and the South Sandwich Islands	SGS	906
Saint Helena	SHN	654
Sierra Leone	SLE	694
Singapore	SGP	702
Saint Kitts and Nevis	KNA	659
Slovak Republic	SVK	703
Slovenia	SVN	705
Saint Lucia	LCA	662
Sint Maarten (Dutch part)	SXM	534
Solomon Islands	SLB	90
Somalia	SOM	706
South Africa	ZAF	710
Spain	ESP	724
Saint Pierre and Miquelon	SPM	666
Spratly Islands	SPR	907
Sri Lanka	LKA	144
South Sudan	SSD	728
Sudan	SDN	729
Suriname	SUR	740
Svalbard and Jan Mayen Islands	SJM	744
Saint Vincent and the Grenadines	VCT	670
Sweden	SWE	752
Switzerland	CHE	756
Syrian Arab Republic	SYR	760
Chinese Taipei	TWN	158
Tajikistan	TJK	762
United Republic of Tanzania	TZA	834
Thailand	THA	764
Timor-Leste	TLS	626
Togo	TGO	768
Tokelau	TKL	772
Tonga	TON	776
Trinidad and Tobago	TTO	780
Tunisia	TUN	788

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Country/Territory	Short name	Code
Turkey	TUR	792
Turkmenistan	TKM	795
Turks and Caicos Islands	TCA	796
Tuvalu	TUV	798
United Arab Emirates	ARE	784
Uganda	UGA	800
United Kingdom	GBR	826
Ukraine	UKR	804
Uruguay	URY	858
United States	USA	840
United States Minor Outlying Islands	UMI	908
United States Virgin Islands	VIR	850
Uzbekistan	UZB	860
Vanuatu	VUT	548
Bolivarian Republic of Venezuela	VEN	862
Viet Nam	VNM	704
Wallis and Futuna Islands	WLF	876
Western Sahara	ESH	732
Yemen	YEM	887
Zambia	ZMB	894
Zimbabwe	ZWE	716

Sub-national divisions

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Sub-national division	Short name	Country ISO code
Minnesota	US-MN	USA
Washington	US-WA	USA
Idaho	US-ID	USA
Montana	US-MT	USA
North Dakota	US-ND	USA
Michigan	US-MI	USA
Maine	US-ME	USA
Ohio	US-OH	USA
New Hampshire	US-NH	USA
New York	US-NY	USA
Vermont	US-VT	USA

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Sub-national division	Short name	Country ISO code
Pennsylvania	US-PA	USA
Arizona	US-AZ	USA
California	US-CA	USA
New Mexico	US-NM	USA
Texas	US-TX	USA
Alaska	US-AK	USA
Louisiana	US-LA	USA
Mississippi	US-MS	USA
Alabama	US-AL	USA
Florida	US-FL	USA
Georgia	US-GA	USA
South Carolina	US-SC	USA
North Carolina	US-NC	USA
Virginia	US-VA	USA
Maryland	US-MD	USA
Delaware	US-DE	USA
New Jersey	US-NJ	USA
Connecticut	US-CT	USA
Rhode Island	US-RI	USA
Massachussets	US-MA	USA
Oregon	US-OR	USA
Hawaii	US-HI	USA
Utah	US-UT	USA
Wyoming	US-WY	USA
Nevada	US-NV	USA
Colorado	US-CO	USA
South Dakota	US-SD	USA
Nebraska	US-NE	USA
Kansas	US-KS	USA
Oklahoma	US-OK	USA
Iowa	US-IA	USA
Missouri	US-MO	USA
Wisconsin	US-WI	USA
Illinois	US-IL	USA
Kentucky	US-KY	USA
Arkansas	US-AR	USA
Tennessee	US-TN	USA
West Virginia	US-WV	USA

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Sub-national division	Short name	Country ISO code
Indiana	US-IN	USA
Acre	BR-AC	BRA
Alagoas	BR-AL	BRA
Amapa	BR-AP	BRA
Amazonas	BR-AM	BRA
Bahia	BR-BA	BRA
Ceara	BR-CE	BRA
Distrito Federal	BR-DF	BRA
Espirito Santo	BR-ES	BRA
Goias	BR-GO	BRA
Maranhao	BR-MA	BRA
Mato Grosso do Sul	BR-MS	BRA
Mato Grosso	BR-MT	BRA
Minas Gerais	BR-MG	BRA
Para	BR-PA	BRA
Paraiba	BR-PB	BRA
Parana	BR-PR	BRA
Pernambuco	BR-PE	BRA
Piaui	BR-PI	BRA
Rio de Janeiro	BR-RJ	BRA
Rio Grande do Norte	BR-RN	BRA
Rio Grande do Sul	BR-RS	BRA
Rondonia	BR-RO	BRA
Roraima	BR-RR	BRA
Sao Paulo	BR-SP	BRA
Santa Catarina	BR-SC	BRA
Sergipe	BR-SE	BRA
Tocantins	BR-TO	BRA
Australian Capital Territory	AU-ACT	AUS
New South Wales	AU-NSW	AUS
Northern Territory	AU-NT	AUS
Queensland	AU-QLD	AUS
South Australia	AU-SA	AUS
Tasmania	AU-TAS	AUS
Victoria	AU-VIC	AUS
Western Australia	AU-WA	AUS
Alberta	CA-AB	CAN
British Columbia	CA-BC	CAN

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Sub-national division	Short name	Country ISO code
Manitoba	CA-MB	CAN
New Brunswick	CA-NB	CAN
Newfoundland and Labrador	CA-NL	CAN
Northwest Territories	CA-NT	CAN
Nova Scotia	CA-NS	CAN
Nunavut	CA-NU	CAN
Ontario	CA-ON	CAN
Prince Edward Island	CA-PE	CAN
Quebec	CA-QC	CAN
Saskatchewan	CA-SK	CAN
Yukon	CA-YT	CAN
Anhui	CN-AH	CHN
Beijing	CN-BJ	CHN
Chongqing	CN-CQ	CHN
Fujian	CN-FJ	CHN
Gansu	CN-GS	CHN
Guangdong	CN-GD	CHN
Guangxi	CN-GX	CHN
Guizhou	CN-GZ	CHN
Hainan	CN-HI	CHN
Hebei	CN-HE	CHN
Heilongjiang	CN-HL	CHN
Henan	CN-HA	CHN
Hubei	CN-HB	CHN
Hunan	CN-HN	CHN
Jiangsu	CN-JS	CHN
Jiangxi	CN-JX	CHN
Jilin	CN-JL	CHN
Liaoning	CN-LN	CHN
Nei Mongol	CN-NM	CHN
Ningxia Hui	CN-NX	CHN
Qinghai	CN-QH	CHN
Shaanxi	CN-SN	CHN
Shandong	CN-SD	CHN
Shanghai	CN-SH	CHN
Shanxi	CN-SX	CHN
Sichuan	CN-SC	CHN
Tianjin	CN-TJ	CHN

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Xinjiang Uygur	CN-XJ	CHN
Xizang	CN-XZ	CHN
Yunnan	CN-YN	CHN
Zhejiang	CN-ZJ	CHN
Andaman and Nicobar	IN-AN	IND
Andhra Pradesh	IN-AP	IND
Assam	IN-AS	IND
Bihar	IN-BR	IND
Chhattisgarh	IN-CT	IND
Dadra and Nagar Haveli	IN-DN	IND
Daman and Diu	IN-DD	IND
Delhi	IN-DL	IND
Goa	IN-GA	IND
Gujarat	IN-GJ	IND
Haryana	IN-HR	IND
Himachal Pradesh	IN-HP	IND
Jharkhand	IN-JH*	IND
Karnataka	IN-KA	IND
Kerala	IN-KL	IND
Madhya Pradesh	IN-MP	IND
Maharashtra	IN-MH	IND
Manipur	IN-MN	IND
Meghalaya	IN-ML	IND
Mizoram	IN-MZ	IND
Nagaland	IN-NL	IND
Orissa	IN-OR	IND
Puducherry	IN-PY	IND
Punjab	IN-PB	IND
Rajasthan	IN-RJ	IND
Sikkim	IN-SK	IND
Tamil Nadu	IN-TN	IND
Telangana	IN-TG	IND
Tripura	IN-TR	IND
Uttar Pradesh	IN-UP	IND
Uttaranchal	IN-UT	IND
West Bengal	IN-WB	IND
Adygey	RU-AD	RUS
Altay	RU-AL	RUS

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Sub-national division	Short name	Country ISO code
Amur	RU-AMU	RUS
Arkhangel'sk	RU-ARK	RUS
Astrakhan'	RU-AST	RUS
Bashkortostan	RU-BA	RUS
Belgorod	RU-BEL	RUS
Bryansk	RU-BRY	RUS
Buryat	RU-BU	RUS
Chechnya	RU-CE	RUS
Chelyabinsk	RU-CHE	RUS
Chukot	RU-CHU	RUS
Chuvash	RU-CU	RUS
City of St. Petersburg	RU-SPE	RUS
Dagestan	RU-DA	RUS
Gorno-Altay	RU-GA	RUS
Ingush	RU-IN	RUS
Irkutsk	RU-IRK	RUS
Ivanovo	RU-IVA	RUS
Kabardin-Balkar	RU-KB	RUS
Kaliningrad	RU-KGD	RUS
Kalmyk	RU-KL	RUS
Kaluga	RU-KLU	RUS
Kamchatka	RU-KAM	RUS
Karachay-Cherkess	RU-KC	RUS
Karelia	RU-KR	RUS
Kemerovo	RU-KEM	RUS
Khabarovsk	RU-KHA	RUS
Khakass	RU-KK	RUS
Khanty-Mansiy	RU-KHM	RUS
Kirov	RU-KIR	RUS
Komi	RU-KO	RUS
Kostroma	RU-KOS	RUS
Krasnodar	RU-KDA	RUS
Krasnoyarsk	RU-KYA	RUS
Kurgan	RU-KGN	RUS
Kursk	RU-KRS	RUS
Leningrad	RU-LEN	RUS
Lipetsk	RU-LIP	RUS
Maga Buryatdan	RU-MAG	RUS

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Sub-national division	Short name	Country ISO code
Mariy-El	RU-ME	RUS
Mordovia	RU-MO	RUS
Moscow City	RU-MOW	RUS
Moskva	RU-MOS	RUS
Murmansk	RU-MUR	RUS
Nenets	RU-NEN	RUS
Nizhegorod	RU-NIZ	RUS
North Ossetia	RU-SE	RUS
Novgorod	RU-NGR	RUS
Novosibirsk	RU-NVS	RUS
Omsk	RU-OMS	RUS
Orel	RU-ORL	RUS
Orenburg	RU-ORE	RUS
Penza	RU-PNZ	RUS
Perm'	RU-PER	RUS
Primor'ye	RU-PRI	RUS
Pskov	RU-PSK	RUS
Rostov	RU-ROS	RUS
Ryazan'	RU-RYA	RUS
Sakhalin	RU-SAK	RUS
Sakha	RU-SA	RUS
Samara	RU-SAM	RUS
Saratov	RU-SAR	RUS
Smolensk	RU-SMO	RUS
Stavropol'	RU-STA	RUS
Sverdlovsk	RU-SVE	RUS
Tambov	RU-TAM	RUS
Tatarstan	RU-TA	RUS
Tomsk	RU-TOM	RUS
Tula	RU-TUL	RUS
Tuva	RU-TY	RUS
Tver'	RU-TVE	RUS
Tyumen'	RU-TYU	RUS
Udmurt	RU-UD	RUS
Ul'yanovsk	RU-ULY	RUS
Vladimir	RU-VLA	RUS
Volgograd	RU-VGG	RUS
Vologda	RU-VLG	RUS

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Sub-national division	Short name	Country ISO code
Voronezh	RU-VOR	RUS
Yamal-Nenets	RU-YAN	RUS
Yaroslavl'	RU-YAR	RUS
Yevrey	RU-YEV	RUS
Zabaykal'ye	RU-ZAB	RUS
Aisén del General Carlos Ibáñez del Campo	CL-AI	CHL
Antofagasta	CL-AN	CHL
Araucanía	CL-AR	CHL
Arica y Parinacota	CL-AP	CHL
Atacama	CL-AT	CHL
Bío-Bío	CL-BI	CHL
Coquimbo	CL-CO	CHL
Libertador General Bernardo O'Higgins	CL-LI	CHL
Los Lagos	CL-LL	CHL
Los Ríos	CL-LR	CHL
Magallanes y Antártica Chilena	CL-MA	CHL
Maule	CL-ML	CHL
Región Metropolitana de Santiago	CL-RM	CHL
Tarapacá	CL-TA	CHL
Valparaíso	CL-VS	CHL
Amazonas	CO-AMA	COL
Antioquia	CO-ANT	COL
Arauca	CO-ARA	COL
Atlántico	CO-ATL	COL
Bolívar	CO-BOL	COL
Boyacá	CO-BOY	COL
Córdoba	CO-COR	COL
Caldas	CO-CAL	COL
Caquetá	CO-CAQ	COL
Casanare	CO-CAS	COL
Cauca	CO-CAU	COL
Cesar	CO-CES	COL
Chocó	CO-CHO	COL
Cundinamarca	CO-CUN	COL
Guainía	CO-GUA	COL
Guaviare	CO-GUV	COL
Huila	CO-HUI	COL

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Sub-national division	Short name	Country ISO code
La Guajira	CO-LAG	COL
Magdalena	CO-MAG	COL
Meta	CO-MET	COL
Nariño	CO-NAR	COL
Norte de Santander	CO-NSA	COL
Putumayo	CO-PUT	COL
Quindío	CO-QUI	COL
Risaralda	CO-RIS	COL
Santander	CO-SAN	COL
Sucre	CO-SUC	COL
Tolima	CO-TOL	COL
Valle del Cauca	CO-VAC	COL
Vaupés	CO-VAU	COL
Vichada	CO-VID	COL

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Methodology

Methodology to derive population data

Population primary data are derived from SEDAC and JRC.[9] JRC is used for years 1979-1999 and SEDAC is used from 2000 onwards. It consists of estimates of human population (number of persons per pixel), consistent with national censuses and population registers, for the years 1975, 1990, 2000 (JRC) and 2000, 2005, 2010, 2015, 2020 (SEDAC). The 15 arc-minute resolution (equal to 0.25°) is selected, matching space resolution of weather data.

A linear interpolation is applied to estimate values for all years in between; such interpolation is done through the following equation:

$$P_{i,j,t} = P_{i,j,t=2000} + \frac{(\mathrm{t} - 2000)}{2005 - 2000} \cdot (P_{i,j,t=2005} - P_{i,j,t=2000})$$

Where:

$P_{i,j,t}$: population inside the grid cell defined by latitude i and longitude j in year t

i,j: latitude i and longitude j of the grid point

The same equation is applied similarly to the other periods of time.

Population for years after 2021 are extrapolated using 2015 and 2020 data.

Methodology to derive nationally-averaged values

The primary data are provided as gridded values: each datapoint represents data for a specific location on the globe, the meshing being as fine as 0.25° of latitude

[9] Center for International Earth Science Information Network - CIESIN - Columbia University. 2018. Gridded Population of the World, Version 4 (GPWv4): Population Count, Revision 11. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). doi.org/10.7927/H4JW8BX5. Accessed: 29/05/2020
Schiavina, Marcello; Freire, Sergio; MacManus, Kytt (2019): GHS population grid multitemporal (1975, 1990, 2000, 2015) R2019A. European Commission, Joint Research Centre (JRC) DOI: 10.2905/42E8BE89-54FF-464E-BE7B-BF9E64DA5218 PID: http://data.europa.eu/89h/0c6b9751-a71f-4062-830b-43c9f432370fConcept & Methodology:
Freire, Sergio; MacManus, Kytt; Pesaresi, Martino; Doxsey-Whitfield, Erin; Mills, Jane (2016): Development of new open and free multi-temporal global population grids at 250 m resolution. Geospatial Data in a Changing World; Association of Geographic Information Laboratories in Europe (AGILE). AGILE 2016.

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and longitude. Hence values are present at each node of a meshing of the world with 1440 values of longitude and 720 values of latitude.

Every land point of the meshing is associated with a country. For this, a mask is created in Python using the file provided together with the population dataset[10], with the same resolution as for weather variables, i.e. 0.25° by 0.25°.

The same procedure applies to sub-national aggregates, using a mask derived from data from DIVA-GIS[11].

National values are derived from gridded values – calculating from a weighted average of values from all datapoints within the land boundaries of each country. The average is presented with two weighing methods:

- Surface-weighted average
- Population-weighted average

Depending on the variable, national data are available for only one or for both of the above methods. When national data are calculated using surface weighted average, the name of variable contains “surface”, while it contains “population” if population weighted average method is used.

Surface-weighted average

This method is chosen when the implications on the energy sector of the variable do not depend on where the population is located.

The equation to compute national surface-weighted averages is:

$$V_k = \frac{\sum_{i,j}^{i,j\in k} A_{i,j} \cdot V_{i,j}}{\sum_{i,j}^{i,j\in k} A_{i,j}} \qquad (1)$$

Where:

V: weather variable to be average, e.g. temperature, wind speed, solar radiation, precipitation, etc.

[10] Center for International Earth Science Information Network - CIESIN - Columbia University. 2018. Gridded Population of the World, Version 4 (GPWv4); sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-rev11
Schiavina, Marcello; Freire, Sergio; MacManus, Kytt (2019): GHS population grid multitemporal (1975, 1990, 2000, 2015) R2019A. European Commission, Joint Research Centre (JRC) DOI: 10.2905/42E8BE89-54FF-464E-BE7B-BF9E64DA5218 PID: http://data.europa.eu/89h/0c6b9751-a71f-4062-830b-43c9f432370fConcept & Methodology:
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[11] Download data by country | DIVA-GIS

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A: area of the grid box around the grid point i,j

k: country identifier

i,j: latitude and longitude of the grid points that fall inside the domain of k

As for homogeneous grids on a sphere the area of the grid box is proportional to the cosine of the latitude, equation (1) can be re-written as:

$$V_k = \frac{\sum_{i,j}^{i,j\in k} cos(lat_i)\cdot V_{i,j}}{\sum_{i,j}^{i,j\in k} cos(lat_i)} \qquad (2)$$

Where:

V: weather variable to be averaged, e.g. temperature, wind speed, solar radiation, precipitation, etc.

lat: latitude

Population-weighted average

This method is chosen when the implications on the energy sector of the weather variable or indicator depend on where the population is located.

The population dataset used is from the Center for International Earth Science Information Network for years 2000 to latest and from Joint Research Centre from 1979 to 1999[12].

The equation to compute population-weighted national averages is:

$$V_k = \frac{\sum_{i,j}^{i,j\in k} P_{i,j}\cdot V_{i,j}}{\sum_{i,j}^{i,j\in k} P_{i,j}} \qquad (3)$$

Where:

V: weather variable to be average, e.g. temperature, wind speed, solar radiation, precipitation, etc.

P: population inside the grid box defined by latitude *i* and longitude *j*

k: country identifier

i,j: latitude *i* and longitude *j* of the grid box that falls inside the domain of k

[12] Center for International Earth Science Information Network[12] - CIESIN - Columbia University. 2018. Gridded Population of the World, Version 4 (GPWv4); sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-rev11
Schiavina, Marcello; Freire, Sergio; MacManus, Kytt (2019): GHS population grid multitemporal (1975, 1990, 2000, 2015) R2019A. European Commission, Joint Research Centre (JRC) DOI: 10.2905/42E8BE89-54FF-464E-BE7B-BF9E64DA5218 PID: http://data.europa.eu/89h/0c6b9751-a71f-4062-830b-43c9f432370fConcept & Methodology:
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Methodology to derive indicators from primary data

Heating Degree Days (HDD) and Cooling Degree Days (CDD)

If $T \geq T_{ref}$ (standard methodology) or $T \geq T_{threshold}$ ('Thold' methodology13[13]):

$$HDD = 0 \quad (4)$$

$$CDD = T - T_{ref} \quad (5)$$

If $T \leq T_{ref}$ (standard methodology) or $T \leq T_{threshold}$ ('Thold' methodology[13]):

$$HDD = T_{ref} - T \quad (6)$$

$$CDD = 0 \quad (7)$$

Where

T: Air temperature for standard and 'Thold' methodology, Heat Index if corrected by humidity, wet bulb temperature if corrected using wet bulb temperature or wind corrected temperature as described below (°C)

T_{ref}: Reference temperature (°C)

$T_{threshold}$: Threshold temperature for 'Thold' methodology (°C)

Monthly HDD and CDD are sums of daily values.

To calculate HDD corrected by wind speed, the wind-corrected temperature is calculated as below, in accordance with the EuroDutch Gas Act methodology:

$$T_{correctedwind} = T - \frac{W_{10}}{1.5} \quad (8)$$

[13] The 'Thold' methodology uses both T_{ref} and $T_{threshold}$ for the calculation of degree days as showed by the equations above. For example, if the reference temperature is set to 18°C and the threshold temperature to 21°C: when the daily mean air temperature is 24°C, the value of the CDD is 6 (24 °C-18 °C); when the daily mean air temperature is 20 °C, the CDD is 0. The same applies to HDD: if the daily mean air temperature is 12°C, for that day the value of the HDD is 6 (18 °C-12 °C); if the daily mean air temperature is 16 °C, for that day the HDD is 0. This methodology is aligned with the one used by Eurostat to calculate degree days at the national level; see ec.europa.eu/eurostat/cache/metadata/en/nrg_chdd_esms.html

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Where

T: 2 meter air temperature (°C)

W_{10}: Wind speed at 10 meters (m/s)

Relative Humidity

The relative humidity was calculated using the Arden Buck equations (Buck)[14].

$$RH = \left(\frac{e^{C_1 * \frac{T_{dew}}{C_2 + T_{dew}}}}{e^{C_1 * \frac{T}{C_2 + T}}} \right) * 100 \quad (9)$$

Where:

T: air temperature (K)

T_{dew}: dew temperature (K)

$C_1 = 17.052$

$C_2 = 240.97$

Heat Index

The Heat Index was developed by the U.S. National Oceanographic and Atmospheric Administration (NOAA) in 1978 and later adopted by the USA National Weather Service. It aims at combining the effects of air temperature and relative humidity into a single parameter that provides a measure of the perceived temperature. It was empirically derived by for specific conditions of temperature and relative humidity and later expanded by NOAA's Climate Prediction Center to be defined at all values. Higher values of Heat Index correspond to hotter perceived environmental conditions. The Heat Index is not defined when T<80 °F and RH<40%. The heat index can be used as index representative of severe weather conditions on its own or used to feed the calculation of heating degree days corrected suing heat indexes.

It can be calculated using equation (10) for all the grid points for which T>80 °F and RH>40%:

$$Heat\ Index\ (F) = C_0 + C_1 * T + C_2 * RH + C_3 * RH * T \mp C_4 * T^2 + C_5 * RH^2 + C_6 * T^2 * RH + C_7 * T * RH^2 + C_8 * T^2 * RH^2 \quad (10)$$

[14] Buck. (s.d.). New Equations for Computing Vapor Pressure and Enhancement Factor

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Where:

T: air temperature (°F)

RH: relative humidity (%)

$C_0 = -42.379$

$C_1 = 2.04901523$

$C_2 = 10.14333127$

$C_3 = -0.22475541$

$C_4 = -6.83783 * 10^{-3}$

$C_5 = -5.481717 * 10^{-2}$

$C_6 = 1.22874 * 10^{-3}$

$C_7 = 8.5282 * 10^{-4}$

$C_8 = -1.99 * 10^{-6}$

If T<80 °F or RH<40%, the Heat Index is equal to the air temperature.

Humidex

Humidex is calculated using the standard Humidex formula used by the Environment and Climate Change Canada[15]:

$$Humidex = T + C_1 * (C_2 * e^{C_3 * \left(\frac{1}{C_4} - \frac{1}{C_4 + T_{dew}}\right)} - 10) \quad (11)$$

Where

T: 2 meter air temperature (°C)

T_{dew}: 2 meter dew temperature (°C)

$C_1 = 0.555$

$C_2 = 6.11$

$C_3 = 5417.730$

$C_4 = 273.15$

Wet bulb temperature

Web bulb temperature is calculated using the following formula (Stull, 2011)[16]:

$$T_{wetbulb} = T * \arctan(C_1 * (RH + C_2)^{0.5} + \arctan(T + RH) - \arctan(RH + C_3) + C_4 * RH^{1.5} * \arctan(C_5 * RH) + C_6 \quad (12)$$

[15] Environment and Climate Change Canada[15] (climate.weather.gc.ca/glossary_e.html)
[16] Stull, R. (2011). Wet-Bulb Temperature from Relative Humidity and Air Temperature. *Wet-Bulb Temperature from Relative Humidity and Air Temperature*.

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Where

T: air temperature (°C)

RH: relative humidity (%)

$C_1 = 0.151977$

$C_2 = 8.313659$

$C_3 = -1.676331$

$C_4 = 0.00391838$

$C_5 = 0.023101$

$C_6 = -4.686035$

Values are calculated for daily means.

Wind capacity factor

The wind capacity factor represents the percentage of power output over nominal power expected from a wind turbine on a specific point of the grid for a specific time. It is calculated using hourly wind speed as follow:

$$CF_{t,i,j} = \frac{1}{n} \sum_{t \in T} \frac{P_{output}^{t,i,j}\left(W_{100}^{t,i,j}\right)}{P_{nominal}} \qquad (13)$$

Where

$W_{100}^{t,i,j}$: wind speed at 100 meters above surface at time *t*, latitude *i* and longitude *j* (m/s)

$P_{output}^{t,i,j}$: net electrical power output at time *t*, latitude *i* and longitude *j* (MW)

$P_{nominal}$: nominal output of the wind turbine (MW)

T: time considered, e.g. day

t: hours in the interval *T*

n: number of hours in *T*

i,j: latitude *i* and longitude *j* of the grid point

The function $P_{output}^{t,i,j} = f(wind\ speed\ 100m_{t,i,j})$ is the power curve of the selected wind turbine, in our case the Vestas V110-2 MW.

Day light

The length of day light is calculated using the method used by NOAA[17].

As reported by the source:

[17] Based on the equations from Astronomical Algorithms by Jean Meeus, as presented in the file "NOAA_Sola_Calculations_day.xls". Further details are available at : www.esrl.noaa.gov/gmd/grad/solcalc/calcdetails.html

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- The sunrise and sunset results are theoretically accurate to within a minute for locations between +/- 72° latitude, and within 10 minutes outside of those latitudes. However, due to variations in atmospheric composition, temperature, pressure and conditions, observed values may vary from calculations.
- The following spreadsheets can be used to calculate solar data for a day or a year at a specified site. They are available in Microsoft Excel and Open Office format. Please note that calculations in the spreadsheets are only valid for dates between 1901 and 2099, due to an approximation used in the Julian Day calculation.

Methodology to compute monthly climatologies and anomalies

Monthly climatologies are averaged values for a specific month over the reference period 2000 to 2019 here.

Monthly anomalies of each variable are calculated as the difference between a monthly value and the climatology of that variable for that specific month.

$$Climatology_{v,j} = \frac{\sum_{i \in R} V_{j,i}^{m}}{n} \qquad (14)$$

$$Anomaly_{v,j,i} = V_{j,i}^{m} - Climatology_{v,j} \qquad (15)$$

Where

V^m: monthly value of the weather variable for which the climatology and the anomaly are calculated

j: month

i: year

R: reference period, 2000 to 2019

n: number of years in the reference period

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EuroDutch Gas Act

Environment and Climate Change Canada (climate.weather.gc.ca/glossary_e.html)

Jean Meeus, Astronomical Algorithms, www.esrl.noaa.gov/gmd/grad/solcalc/calcdetails.html

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