



# WEATHER FOR ENERGY TRACKER

## USERS GUIDE

International  
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# INTERNATIONAL ENERGY AGENCY

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This document provides information regarding the July 2023 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).<sup>1</sup>

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

Complete sets of data are available at: [weatherforenergydata.iea.org/](http://weatherforenergydata.iea.org/).

This document can be found online at: [Weather for Energy Tracker: Users Guide](#).

**Please address your comments and inquiries** to [emissions@iea.org](mailto:emissions@iea.org). We are keen to receive user feedback in order to improve further editions of this database.

**Released:** July 2023.

**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](https://doi.org/10.7927/H4JW8BX5) (accessed 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-](http://data.europa.eu/89h/0c6b9751-a71f-4062-830b-43c9f432370f)

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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<sup>1</sup> 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<sup>2</sup> to the latest available month,<sup>3</sup> 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 expected to be updated on a quarterly basis, every January, April, July and October. 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 [weatherforenergydata.iea.org](https://weatherforenergydata.iea.org).
- 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.

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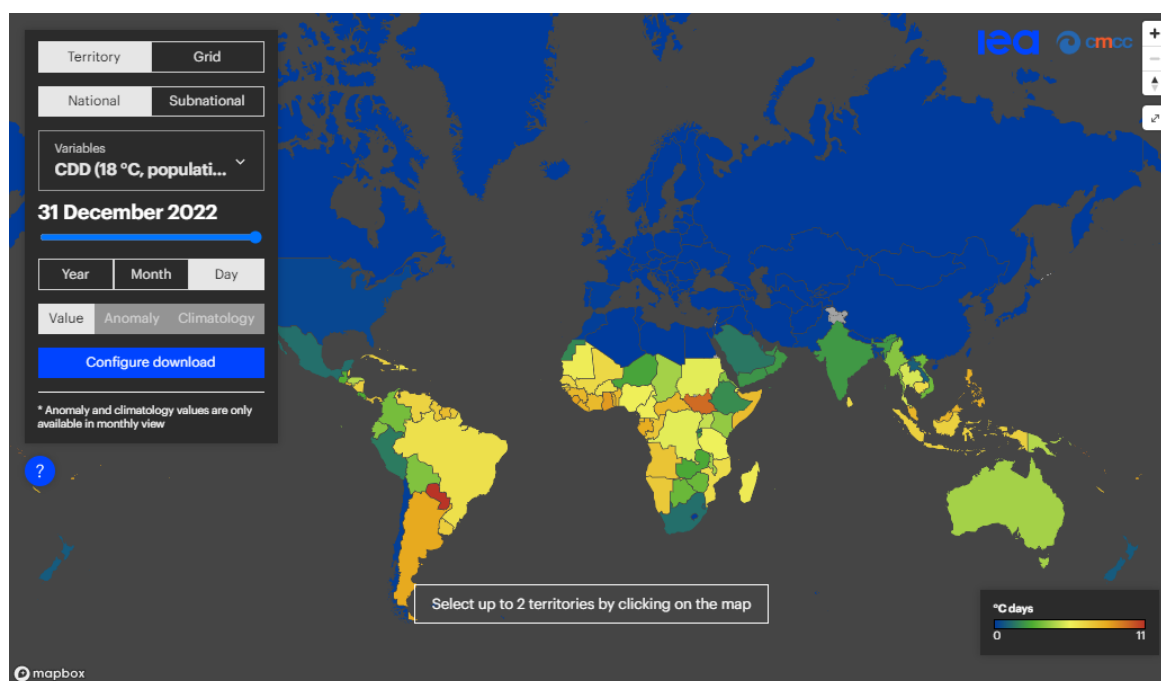
<sup>2</sup> For now, data from 1979 to 1999 are only included in the data repository. It will be made available in the interactive map at a later date.

<sup>3</sup> As of April 2023, the latest available month is March 2023.

## Interactive map

The interactive global map is freely available online at [www.iea.org/data-and-statistics/data-tools/weather-for-energy-tracker](http://www.iea.org/data-and-statistics/data-tools/weather-for-energy-tracker). It is expected to be updated every quarter.

### 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<sup>4</sup> are also available for monthly data.

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

Configure download

<sup>4</sup> *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.

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

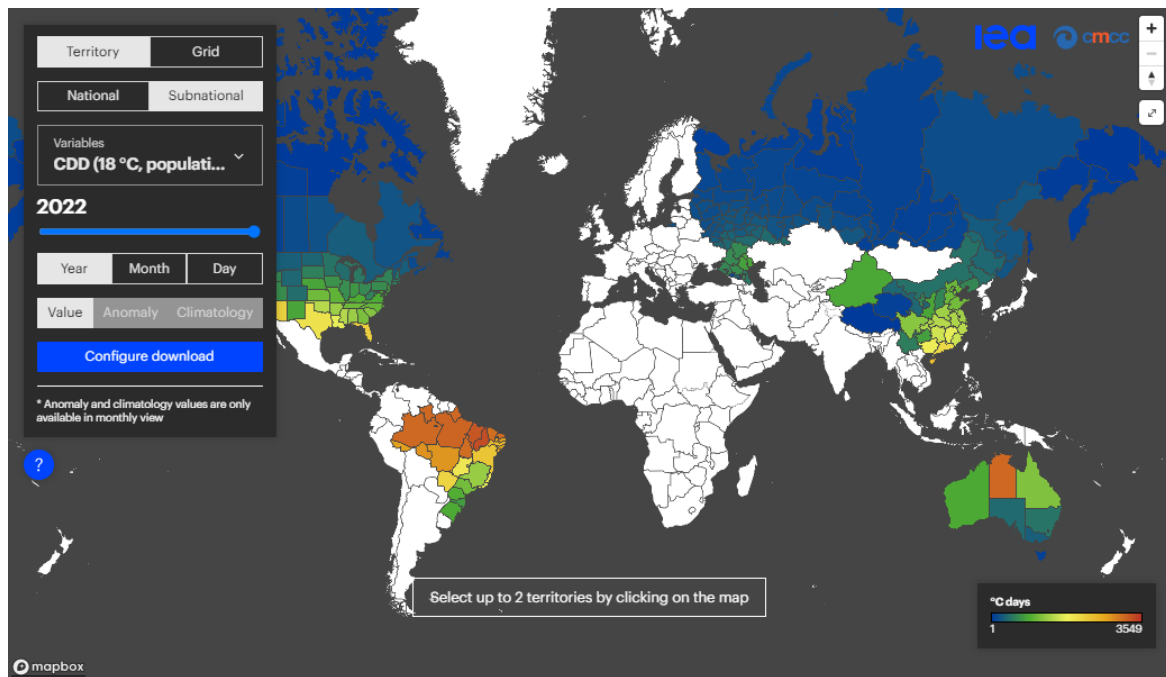
## Humidex (2 m)

## Population

Note: m = metre.

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

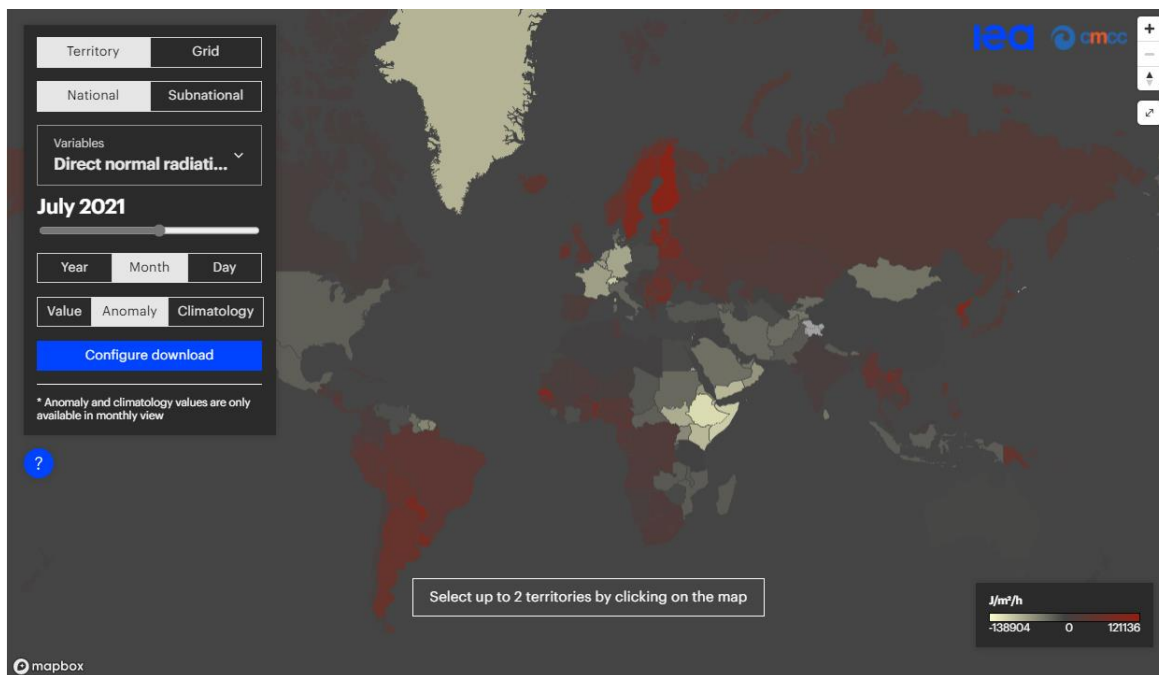
### Territory map, sub-national surface-weighted average of 2-metre temperature, year 2022



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



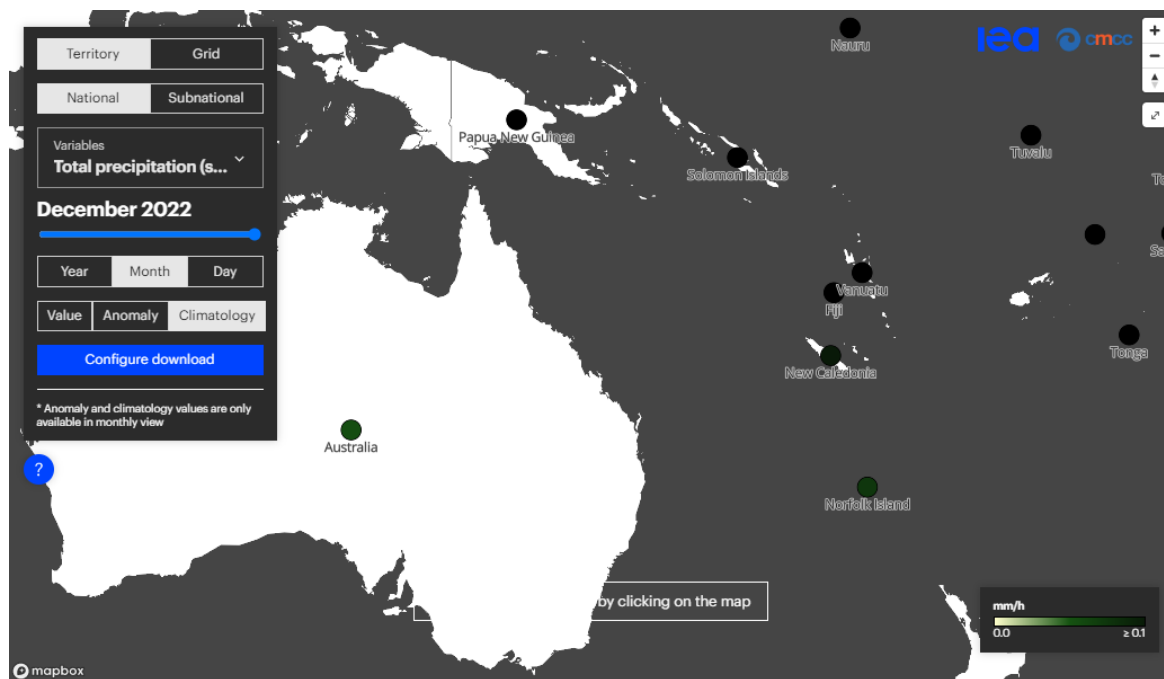
### Territory map, surface-weighted average of national direct normal radiation anomalies for July 2021, global view



For example, the map above shows that in July 2021, direct normal radiation was above average in South America, while it was under in Eastern Africa.

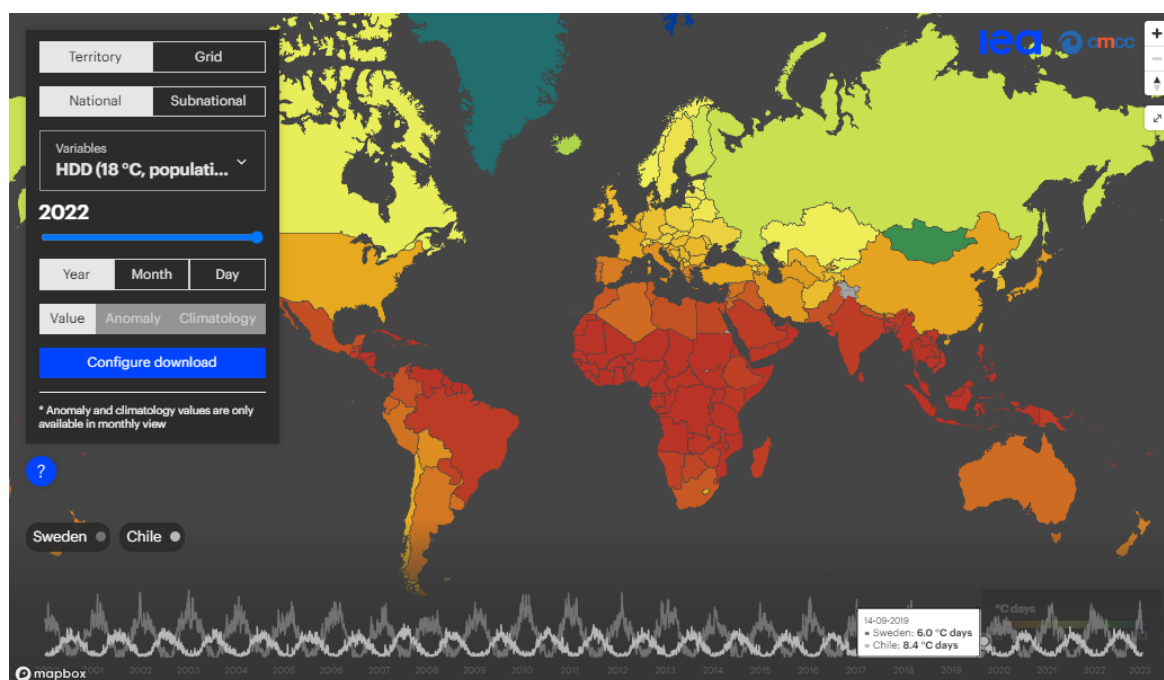
When zooming in, the map colour pattern changes so that the values for small territories are visible despite the relatively small area represented:

### 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 2022, graph-enabled



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

Configure download

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

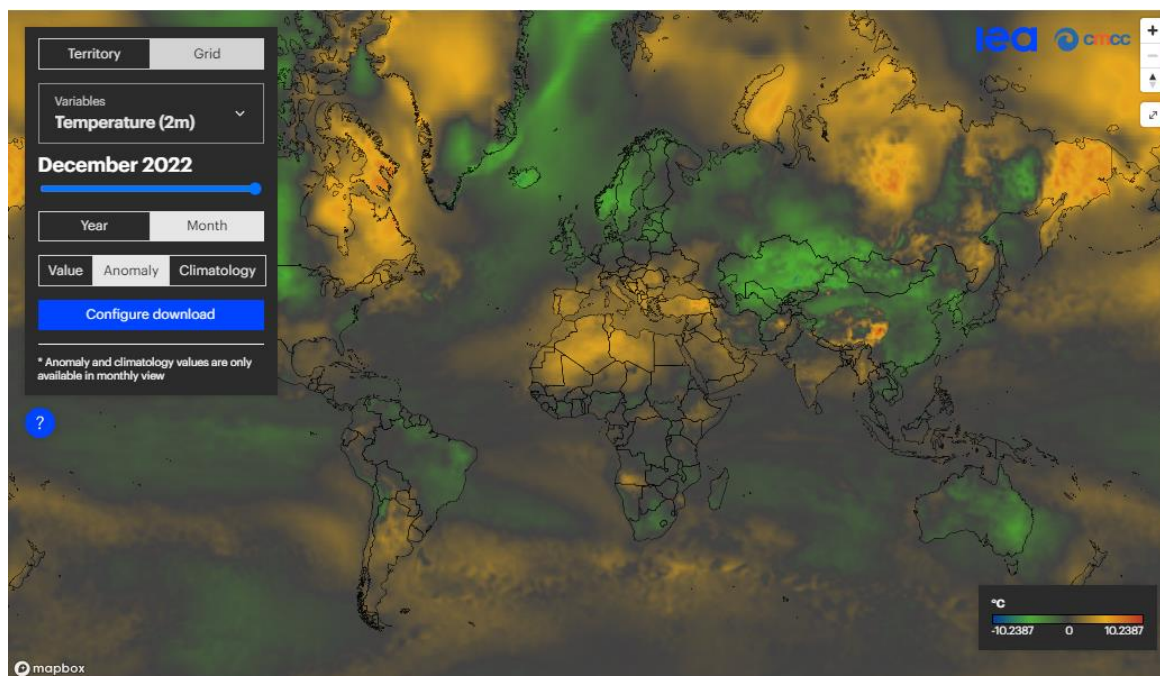
| Variable                     |
|------------------------------|
| CDD (18 °C)                  |
| CDD (18 °C, humidity)        |
| HDD (18 °C)                  |
| Relative humidity            |
| Evaporation                  |
| Total precipitation          |
| Runoff                       |
| Snowfall                     |
| 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)            |

## Variable

Wind capacity factor (100 m)

Note: m = metre.

### Grid map, 2-metre average anomaly of temperature, December 2022



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/](https://unidata.ucar.edu/software/netcdf/).

## Data repository

The data repository, freely available online at [weatherforenergydata.iea.org/](https://weatherforenergydata.iea.org/), 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:

- 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/](https://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](https://www.iea.org/data-and-statistics/data-tools/weather-for-energy-tracker), is expected to be updated every quarter.

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 July 2023 release, with a monthly resolution from January 2010 to the latest month available (June 2023 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.

### 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 (18°C, population)

| Country             | Jan-10  | Feb-10 | Mar-10 | Apr-10  | May-10 | Jun-10 | Jul-10 | Aug-10 | Sep-10  | Oct-10  | Nov-10 | Dec-10 | Jan-11    | Feb-11  | Mar-11 | Apr-11 | May-11 | Jun-11 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Nov-11 | Dec-11  | Jan-12   | Feb-12  | Ma  |   |
|---------------------|---------|--------|--------|---------|--------|--------|--------|--------|---------|---------|--------|--------|-----------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|----------|---------|-----|---|
| Afghanistan         | 0.0204  | 6.469  | 5.123  | 26.31   | 47.4   | 153.5  | 207.1  | 166.5  | 77.31   | 35.71   | 0.3028 | 0      | 1.442E-05 | 0.00713 | 3.134  | 34.87  | 130.3  | 264.7  | 221.7  | 214.1  | 91.7   | 21.69  | 6.7334 | 0       | 0.000262 | 6.01452 | 4.4 |   |
| Albania             | 0       | 0      | 0      | 0       | 0      | 0      | 0      | 0      | 0       | 0       | 0      | 0      | 0         | 0       | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       | 0        | 0       | 0   | 0 |
| Algeria             | 0.99167 | 4.737  | 10.35  | 22.98   | 48.52  | 160    | 309.7  | 291.3  | 161.9   | 63.83   | 2.667  | 2.192  | 0.250     | 0.2178  | 4.206  | 23     | 66.62  | 165.3  | 297    | 308.8  | 193.4  | 43.24  | 0.034  | 0.03688 | 0.00728  | 0.1653  | 3.1 |   |
| American Samoa      | 268.2   | 360    | 310.1  | 262.6   | 301.6  | 276.6  | 271.1  | 260.9  | 247.1   | 255.7   | 257.6  | 237.1  | 259.2     | 226.6   | 266.5  | 272.1  | 277.9  | 291    | 263.6  | 232.8  | 247.8  | 263.3  | 253.6  | 267.5   | 277.9    | 251.6   | 26  |   |
| Anguilla            | 155.3   | 110.5  | 105.9  | 150.9   | 133.9  | 84.21  | 79.74  | 106.5  | 157.4   | 164.9   | 149    | 126    | 134.6     | 134.8   | 158    | 146.4  | 135.1  | 83.53  | 65.13  | 92.16  | 150.1  | 165    | 144.4  | 129.4   | 143.5    | 140.6   | 16  |   |
| Antigua and Barbuda | 237.6   | 210.5  | 249.5  | 240.7   | 276.9  | 291.2  | 296    | 308.8  | 288     | 286.8   | 251.9  | 230.2  | 223.5     | 182.3   | 194.4  | 214.3  | 251.2  | 286.4  | 291.4  | 284    | 250.9  | 234.4  | 260.3  | 194.7   | 19       |         |     |   |
| Argentina           | 241.8   | 220.7  | 258.9  | 246.9   | 280.9  | 283.4  | 300.5  | 305.6  | 290.6   | 289.2   | 256.5  | 239.8  | 224.6     | 187.4   | 203    | 226.8  | 266.1  | 290.9  | 291    | 291.1  | 276.1  | 263.1  | 254.7  | 230     | 217.2    | 199.9   | 20  |   |
| Armenia             | 200.9   | 153.4  | 124.3  | 27.82   | 3.366  | 3.421  | 6.782  | 9.489  | 14.12   | 26.24   | 78.82  | 178.2  | 186.3     | 124.4   | 101.9  | 37.38  | 7.362  | 4.279  | 5.58   | 9.99   | 24.67  | 33.28  | 128.3  | 148.9   | 217.6    | 174.1   | 1   |   |
| Aruba               | 0       | 0      | 0      | 0       | 0      | 0      | 0      | 0      | 0       | 0       | 0      | 0      | 0         | 0       | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       | 0        | 0       | 0   |   |
| Australia           | 250.3   | 222.5  | 270.2  | 269.6   | 296.5  | 294.8  | 300.6  | 319.7  | 291.5   | 297.5   | 256.9  | 250.7  | 248.8     | 212.9   | 234.2  | 236.9  | 276.9  | 287.7  | 286.5  | 306.6  | 301.9  | 286.2  | 283.3  | 254.3   | 236.7    | 218.8   | 23  |   |
| Austria             | 155     | 139.3  | 103.7  | 48.13   | 11.61  | 4.29   | 6.309  | 6.962  | 16.7    | 28.31   | 65.9   | 96.6   | 147.2     | 132.3   | 96.82  | 33.48  | 6.794  | 2.197  | 2.631  | 4.148  | 9.371  | 31.74  | 79.31  | 77.89   | 136.9    | 111.3   | 80  |   |
| Azerbaijan          | 0       | 0      | 0      | 0.00449 | 6.5301 | 34.54  | 83.83  | 211.14 | 0.01114 | 0       | 0      | 0      | 0         | 0       | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       | 0        | 0       | 0   |   |
| Bahamas             | 99.8    | 71.16  | 68.4   | 139.8   | 226.4  | 300.8  | 305.9  | 315.7  | 288.6   | 246.6   | 188.4  | 84.05  | 108.5     | 117.4   | 126.5  | 198.6  | 224.6  | 264.4  | 305.4  | 316.6  | 283.4  | 249.5  | 190.5  | 160.4   | 124.3    | 134.9   | 15  |   |
| Bahrain             | 27.5    | 49.55  | 133    | 226.4   | 336.4  | 424.6  | 485.8  | 500.9  | 459.2   | 380.5   | 209.6  | 76.59  | 10.81     | 17.43   | 67.17  | 180.4  | 352.8  | 422.8  | 469.1  | 501.7  | 437.8  | 334.8  | 141.6  | 4.795   | 6.039    | 7.206   | 32  |   |
| Bangladesh          | 15.26   | 106.1  | 293.5  | 346.8   | 338.7  | 322.9  | 345.3  | 346.7  | 310.3   | 301.6   | 195.6  | 53.55  | 18.09     | 100.5   | 236.4  | 277.5  | 310.3  | 317    | 333.9  | 317    | 313.9  | 299.8  | 149.7  | 56.91   | 21.91    | 88.42   | 24  |   |
| Barbados            | 251     | 227    | 270.9  | 266.1   | 294.1  | 288    | 291.1  | 296.6  | 285.5   | 268.9   | 266.8  | 263.3  | 245.7     | 269     | 231.9  | 238.9  | 265    | 282.5  | 275.7  | 265.7  | 265.4  | 281.9  | 255    | 259.3   | 235.1    | 209.8   | 23  |   |
| Belarus             | 0       | 0      | 0      | 0       | 1.997  | 49.94  | 143.9  | 117.7  | 0       | 0       | 0      | 0      | 0         | 0       | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       | 0        | 0       |     |   |
| Belgium             | 0       | 0      | 0      | 0       | 0.9916 | 1.009  | 23.76  | 72.71  | 12.54   | 0.04201 | 0.7301 | 0      | 0         | 0       | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       | 0        | 0       |     |   |

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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.<sup>5</sup> 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)<sup>6</sup> and GHS population grid from (JRC)<sup>7</sup>.

Data are interpolated to estimate yearly population values from 2000 to 2023. (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.

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<sup>5</sup> Hersbach, H. et 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

<sup>6</sup> 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).

<sup>7</sup> Schiavina, Marcello; Freire, Sergio; MacManus, Kytte (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-43c9f432370f> Concept & Methodology: Freire, Sergio; MacManus, Kytte; 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.

The mask used to aggregate sub-national data is derived from files extracted from DIVA-GIS<sup>8</sup>.

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<sup>8</sup> [Download data by country | DIVA-GIS](#)



# Definitions

Variables are separated in this section into two categories:

- **Primary weather variable:** Those variables are extracted from Copernicus Climate Change Service, 2023; ERA5 hourly data on single levels from 1970 to present ([doi.org/10.24381/cds.adbb2d47](https://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: Temperature dew | 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.*

|                                      |                                  |                    |
|--------------------------------------|----------------------------------|--------------------|
| <b>Web name:</b> Total precipitation | <b>Short name:</b> Precipitation | <b>Units:</b> 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.

|                           |                             |                    |
|---------------------------|-----------------------------|--------------------|
| <b>Web name:</b> Snowfall | <b>Short name:</b> Snowfall | <b>Units:</b> 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.

|                         |                           |                    |
|-------------------------|---------------------------|--------------------|
| <b>Web name:</b> Runoff | <b>Short name:</b> Runoff | <b>Units:</b> 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.

|                              |                                |                    |
|------------------------------|--------------------------------|--------------------|
| <b>Web name:</b> Evaporation | <b>Short name:</b> Evaporation | <b>Units:</b> 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

|                                 |                                   |                 |
|---------------------------------|-----------------------------------|-----------------|
| <b>Web name:</b> Cloud coverage | <b>Short name:</b> Cloud coverage | <b>Units:</b> % |
|---------------------------------|-----------------------------------|-----------------|

**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

|  |                        |                                   |
|--|------------------------|-----------------------------------|
| <b>Web name:</b> Direct normal radiation | <b>Short name:</b> DNI | <b>Units:</b> J/m <sup>2</sup> /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)*

|   |                        |                                   |
|---|------------------------|-----------------------------------|
| <b>Web name:</b> Global horizontal irradiance | <b>Short name:</b> GHI | <b>Units:</b> J/m <sup>2</sup> /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](#).

|                                   |                                     |                  |
|-----------------------------------|-------------------------------------|------------------|
| <b>Web name:</b> Surface pressure | <b>Short name:</b> Surface pressure | <b>Units:</b> 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

|                                       |                                    |                  |
|---------------------------------------|------------------------------------|------------------|
| <b>Variable:</b> Temperature max (2m) | <b>Short name:</b> Temperature max | <b>Units:</b> °C |
|---------------------------------------|------------------------------------|------------------|

Definition 2-metre maximum temperature. It is calculated as the maximum of 2 metre hourly temperature over the period of time considered.

|                                       |                                    |                  |
|---------------------------------------|------------------------------------|------------------|
| <b>Variable:</b> Temperature min (2m) | <b>Short name:</b> Temperature min | <b>Units:</b> °C |
|---------------------------------------|------------------------------------|------------------|

Definition 2-metre minimum temperature. It is calculated as the maximum of 2 metre hourly temperature over the period of time considered.

|                                  |                              |                  |
|----------------------------------|------------------------------|------------------|
| <b>Variable:</b> Heat index (2m) | <b>Short name:</b> HeatIndex | <b>Units:</b> °C |
|----------------------------------|------------------------------|------------------|

Definition Humidity-corrected 2 meter temperature (heat index).  
 More details on methodology [here](#).

|                                |                            |                  |
|--------------------------------|----------------------------|------------------|
| <b>Variable:</b> Humidex (2 m) | <b>Short name:</b> Humidex | <b>Units:</b> °C |
|--------------------------------|----------------------------|------------------|

Definition Humidity-corrected 2 metre temperature (humidex).  
 More details on methodology [here](#).

|                              |                        |                       |
|------------------------------|------------------------|-----------------------|
| <b>Variable:</b> CDD (65 °F) | <b>Short name:</b> CDD | <b>Units:</b> °C days |
|------------------------------|------------------------|-----------------------|

|   |  |                       |
|---|--|-----------------------|
| Definition                                    | Cooling degree days (reference temperature 65 °F). More details on methodology <a href="#">here</a> .  |                       |
| <b>Variable:</b> CDD (10 °C)                  | <b>Short name:</b> CDD10   | <b>Units:</b> C days  |
| Definition                                    | Cooling degree days (reference temperature 10 °C). More details on methodology <a href="#">here</a> .  |                       |
| <b>Variable:</b> CDD (16 °C)                  | <b>Short name:</b> CDD16   | <b>Units:</b> C days  |
| Definition                                    | Cooling degree days (reference temperature 16 °C). More details on methodology <a href="#">here</a> .  |                       |
| Definition                                    | Cooling degree days (reference temperature 18 °C). More details on methodology <a href="#">here</a> .  |                       |
| <b>Variable:</b> CDD (21 °C)                  | <b>Short name:</b> CDD21   | <b>Units:</b> C days  |
| Definition                                    | Cooling degree days (reference temperature 21 °C). More details on methodology <a href="#">here</a> .  |                       |
| <b>Variable:</b> CDD (23 °C)                  | <b>Short name:</b> CDD23   | <b>Units:</b> C days  |
| Definition                                    | Cooling degree days (reference temperature 23 °C). More details on methodology <a href="#">here</a> .  |                       |
| <b>Variable:</b> CDD (26 °C)                  | <b>Short name:</b> CDD26   | <b>Units:</b> °C days |
| Definition                                    | Cooling degree days (reference temperature 26 °C). More details on methodology <a href="#">here</a> .  |                       |
| <b>Variable:</b> CDD (18 °C, 21 °C threshold) | <b>Short name:</b> CDDThold18  | <b>Units:</b> °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 <a href="#">here</a> . |                       |
| <b>Variable:</b> CDD (21 °C, 24 °C threshold) | <b>Short name:</b> CDDThold21  | <b>Units:</b> °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 <a href="#">here</a> .  |                       |
| <b>Variable:</b> CDD (23 °C, 26 °C threshold) | <b>Short name:</b> CDDThold23  | <b>Units:</b> °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 <a href="#">here</a> .  |                       |
| <b>Variable:</b> CDD (variable)               | <b>Short name:</b> CDDVar  | <b>Units:</b> °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 <a href="#">here</a> .   |                       |
| <b>Variable:</b> CDD (65 °F, humidity)        | <b>Short name:</b> CDDhum  | <b>Units:</b> °C days |

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](#).

|  |                             |                       |
|--|-----------------------------|-----------------------|
| <b>Variable:</b> CDD (10 °C, humidity) | <b>Short name:</b> CDDhum10 | <b>Units:</b> °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](#).

|  |                             |                       |
|--|-----------------------------|-----------------------|
| <b>Variable:</b> CDD (16 °C, humidity) | <b>Short name:</b> CDDhum16 | <b>Units:</b> °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](#).

|  |                             |                       |
|--|-----------------------------|-----------------------|
| <b>Variable:</b> CDD (18 °C, humidity) | <b>Short name:</b> CDDhum18 | <b>Units:</b> °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](#).

|  |                             |                      |
|--|-----------------------------|----------------------|
| <b>Variable:</b> CDD (21 °C, humidity) | <b>Short name:</b> CDDhum21 | <b>Units:</b> 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](#).

|  |                             |                      |
|--|-----------------------------|----------------------|
| <b>Variable:</b> CDD (23 °C, humidity) | <b>Short name:</b> CDDhum23 | <b>Units:</b> 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](#).

|  |                             |                      |
|--|-----------------------------|----------------------|
| <b>Variable:</b> CDD (26 °C, humidity) | <b>Short name:</b> CDDhum26 | <b>Units:</b> 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](#).

|   |                                  |                      |
|---|----------------------------------|----------------------|
| <b>Variable:</b> CDD (18 °C, 21 °C threshold, humidity) | <b>Short name:</b> CDDhumThold18 | <b>Units:</b> 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](#).

|   |                                  |               |
|---|----------------------------------|---------------|
| <b>Variable:</b> CDD (21 °C, 24 °C threshold, humidity) | <b>Short name:</b> CDDhumThold21 | <b>Units:</b> |
|---|----------------------------------|---------------|

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](#).

|   |                                  |                      |
|---|----------------------------------|----------------------|
| <b>Variable:</b> CDD (23 °C, 26 °C threshold, humidity) | <b>Short name:</b> CDDhumThold23 | <b>Units:</b> C days |
|---|----------------------------------|----------------------|

|   |   |                       |
|---|---|-----------------------|
| 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 <a href="#">here</a> . |                       |
| <b>Variable:</b> CDD (variable, humidity)     | <b>Short name:</b> CDDhumVar  | <b>Units:</b>         |
| 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 <a href="#">here</a> .   |                       |
| <b>Variable:</b> CDD (65 °F, wet bulb)        | <b>Short name:</b> CDDwet   | <b>Units:</b> °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 <a href="#">here</a> .  |                       |
| <b>Variable:</b> HDD (65 °F)                  | <b>Short name:</b> HDD  | <b>Units:</b> °C days |
| Definition                                    | Heating degree days (reference temperature 65 °F). More details on methodology <a href="#">here</a> .   |                       |
| <b>Variable:</b> HDD (16 °C)                  | <b>Short name:</b> HDD16  | <b>Units:</b> °C days |
| Definition                                    | Heating degree days (reference temperature 16 °C). More details on methodology <a href="#">here</a> .   |                       |
| <b>Variable:</b> HDD (18 °C)                  | <b>Short name:</b> HDD18  | <b>Units:</b> °C days |
| Definition                                    | Heating degree days (reference temperature 18 °C). More details on methodology <a href="#">here</a> .   |                       |
| <b>Variable:</b> HDD (20 °C)                  | <b>Short name:</b> HDD20  | <b>Units:</b> °C days |
| Definition                                    | Heating degree days (reference temperature 20 °C). More details on methodology <a href="#">here</a> .   |                       |
| <b>Variable:</b> HDD (16 °C, 13 °C threshold) | <b>Short name:</b> HDDThold16   | <b>Units:</b> °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 <a href="#">here</a> .  |                       |
| <b>Variable:</b> HDD (18 °C, 15 °C threshold) | <b>Short name:</b> HDDThold18   | <b>Units:</b> °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 <a href="#">here</a> .   |                       |
| <b>Variable:</b> HDD (20 °C, 17 °C threshold) | <b>Short name:</b> HDDThold20   | <b>Units:</b> °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 <a href="#">here</a> .   |                       |
| <b>Variable:</b> HDD (variable)               | <b>Short name:</b> HDDVar   | <b>Units:</b> °C days |

|   |  |   |
|---|--|---|
| 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 <a href="#">here</a> .   |   |
| <b>Variable:</b> HDD (14 °C, wind)            | <b>Short name:</b> HDDwind   | <b>Units:</b> °C days                           |
| Definition                                    | Heating degree days corrected by wind speed (reference temperature 14 °C). More details on methodology <a href="#">here</a> .  |   |
| <b>Variable:</b> Relative humidity            | <b>Short name:</b> RH  | <b>Units:</b> %                                 |
| Definition                                    | Relative humidity based on 2 metres air and dew temperatures. More details on methodology <a href="#">here</a> .   |   |
| <b>Variable:</b> Sun light                    | <b>Short name:</b> Daylight  | <b>Units:</b> %                                 |
| Definition                                    | Minutes of sunlight. More details on methodology <a href="#">here</a> .  |   |
| <b>Variable:</b> Wind speed (100-m )          | <b>Short name:</b> Wind100int  | <b>Units:</b> 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. |   |
| <b>Variable:</b> Wind speed (10-m )           | <b>Short name:</b> Wind10int   | <b>Units:</b> 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.                 |   |
| <b>Variable:</b> Wind direction (100-m)       | <b>Short name:</b> Wind100dir  | <b>Units:</b> 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.  |   |
| <b>Variable:</b> Wind direction (10-m)        | <b>Short name:</b> Wind10dir   | <b>Units:</b> 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.  |   |
| <b>Variable:</b> Wind capacity factor (100-m) | <b>Short name:</b> Wind100power  | <b>Units:</b> %                                 |
| 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 <a href="#">here</a> .   |   |





# Geographical coverage

This document is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area. In this publication, 'country' refers to country or territory, as case may be.

## Countries and territories

This table is available for download in excel format using [this link](#).

| Country/Territory                | Short name | Code |
|----------------------------------|------------|------|
| Afghanistan                      | AFGHANIS   | 4    |
| Aland Islands                    | ALANDISL   | 248  |
| Albania                          | ALBANIA    | 8    |
| Algeria                          | ALGERIA    | 12   |
| American Samoa                   | AMSAMOA    | 16   |
| Angola                           | ANGOLA     | 24   |
| Anguilla                         | ANGUILLA   | 660  |
| Antigua and Barbuda              | ANTIGUA    | 28   |
| Argentina                        | ARGENTINA  | 32   |
| Armenia                          | ARMENIA    | 51   |
| Aruba                            | ARUBA      | 533  |
| Australia                        | AUSTRALI   | 36   |
| Austria                          | AUSTRIA    | 40   |
| Azerbaijan                       | AZERBAIJAN | 31   |
| Bahamas                          | BAHAMAS    | 44   |
| Bahrain                          | BAHRAIN    | 48   |
| Bangladesh                       | BANGLADESH | 50   |
| Barbados                         | BARBADOS   | 52   |
| Belarus                          | BELARUS    | 112  |
| Belgium                          | BELGIUM    | 56   |
| Belize                           | BELIZE     | 84   |
| Benin                            | BENIN      | 204  |
| Bermuda                          | BERMUDA    | 60   |
| Bonaire Saint Eustatius and Saba | BES        | 535  |
| Bhutan                           | BHUTAN     | 64   |
| British Indian Ocean Territory   | BIOT       | 905  |

| Country/Territory                | Short name | Code |
|----------------------------------|------------|------|
| Plurinational State of Bolivia   | BOLIVIA    | 68   |
| Bosnia and Herzegovina           | BOSNIAHERZ | 70   |
| Botswana                         | BOTSWANA   | 72   |
| Bouvet Island                    | BOUVET     | 903  |
| Brazil                           | BRAZIL     | 76   |
| Brunei Darussalam                | BRUNEI     | 96   |
| Bulgaria                         | BULGARIA   | 100  |
| Burkina Faso                     | BURKINA    | 854  |
| Burundi                          | BURUNDI    | 108  |
| British Virgin Islands           | BVI        | 92   |
| Cape Verde                       | CABOVERDE  | 132  |
| Central African Republic         | CAFRICREP  | 140  |
| New Caledonia                    | CALEDONIA  | 540  |
| Cambodia                         | CAMBODIA   | 116  |
| Cameroon                         | CAMEROON   | 120  |
| Canada                           | CANADA     | 124  |
| Cayman Islands                   | CAYMAN     | 136  |
| Chad                             | CHAD       | 148  |
| Chile                            | CHILE      | 152  |
| People's Republic of China       | CHINA      | 156  |
| Colombia                         | COLOMBIA   | 170  |
| Comoros                          | COMOROS    | 174  |
| Republic of the Congo            | CONGO      | 178  |
| Democratic Republic of the Congo | CONGOREP   | 180  |
| Cook Islands                     | COOK       | 184  |
| Costa Rica                       | COSTARICA  | 188  |
| Cote d'Ivoire                    | COTEIVOIRE | 384  |
| Croatia                          | CROATIA    | 191  |
| Cuba                             | CUBA       | 192  |
| Curacao/Netherlands Antilles     | CURACAO    | 531  |
| Cyprus                           | CYPRUS     | 196  |
| Czech Republic                   | CZECH      | 203  |
| Denmark                          | DENMARK    | 208  |
| Djibouti                         | DJIBOUTI   | 262  |
| Dominica                         | DOMINICA   | 212  |
| Dominican Republic               | DOMINICANR | 214  |
| Ecuador                          | ECUADOR    | 218  |
| Egypt                            | EGYPT      | 818  |
| El Salvador                      | ELSALVADOR | 222  |

| Country/Territory                 | Short name | Code |
|-----------------------------------|------------|------|
| Equatorial Guinea                 | EQUINEA    | 226  |
| Eritrea                           | ERITREA    | 232  |
| Estonia                           | ESTONIA    | 233  |
| Swaziland                         | ESWATINI   | 748  |
| Ethiopia                          | ETHIOPIA   | 231  |
| Faeroe Islands                    | FAROE      | 234  |
| French Guiana                     | FGUYANA    | 254  |
| Fiji                              | FIJI       | 242  |
| Finland                           | FINLAND    | 246  |
| French Polynesia                  | FPOLYNESIA | 258  |
| France                            | FRANCE     | 250  |
| French Southern Territories       | FSAT       | 902  |
| Gabon                             | GABON      | 266  |
| Gambia                            | GAMBIA     | 270  |
| Georgia                           | GEORGIA    | 268  |
| Germany                           | GERMANY    | 276  |
| Ghana                             | GHANA      | 288  |
| Greece                            | GREECE     | 300  |
| Greenland                         | GREENLAND  | 304  |
| Grenada                           | GRENADA    | 308  |
| Guadeloupe                        | GUADELOUPE | 312  |
| Guam                              | GUAM       | 316  |
| Guatemala                         | GUATEMALA  | 320  |
| Guernsey                          | GUERNSEY   | 831  |
| Guinea                            | GUINEA     | 324  |
| Guinea-Bissau                     | GUINEABIS  | 624  |
| Guyana                            | GUYANA     | 328  |
| Haiti                             | HAITI      | 332  |
| Heard Island and McDonald Islands | HIMI       | 904  |
| Honduras                          | HONDURAS   | 340  |
| Hong Kong (China)                 | HONGKONG   | 344  |
| Hungary                           | HUNGARY    | 348  |
| Iceland                           | ICELAND    | 352  |
| India                             | INDIA      | 356  |
| Indonesia                         | INDONESIA  | 360  |
| Islamic Republic of Iran          | IRAN       | 364  |
| Iraq                              | IRAQ       | 368  |
| Ireland                           | IRELAND    | 372  |
| Israel                            | ISRAEL     | 376  |

| Country/Territory                     | Short name | Code |
|---------------------------------------|------------|------|
| Italy                                 | ITALY      | 380  |
| Jamaica                               | JAMAICA    | 388  |
| Japan                                 | JAPAN      | 392  |
| Jersey                                | JERSEY     | 832  |
| Jordan                                | JORDAN     | 400  |
| Kazakhstan                            | KAZAKHSTAN | 398  |
| Kenya                                 | KENYA      | 404  |
| Kiribati                              | KIRIBATI   | 296  |
| Korea                                 | KOREA      | 410  |
| Democratic People's Republic of Korea | KOREADPR   | 408  |
| Kosovo                                | KOSOVO     | 999  |
| Kuwait                                | KUWAIT     | 414  |
| Kyrgyzstan                            | KYRGYZSTAN | 417  |
| Lao People's Democratic Republic      | LAO        | 418  |
| Latvia                                | LATVIA     | 428  |
| Lebanon                               | LEBANON    | 422  |
| Lesotho                               | LESOTHO    | 426  |
| Liberia                               | LIBERIA    | 430  |
| Libya                                 | LIBYA      | 434  |
| Lithuania                             | LITHUANIA  | 440  |
| Luxembourg                            | LUXEMBOU   | 442  |
| Madagascar                            | MADAGASCAR | 450  |
| Malawi                                | MALAWI     | 454  |
| Malaysia                              | MALAYSIA   | 458  |
| Maldives                              | MALDIVES   | 462  |
| Mali                                  | MALI       | 466  |
| Malta                                 | MALTA      | 470  |
| Falkland Islands (Malvinas)           | MALVINAS   | 238  |
| Isle of Man                           | MANISLE    | 833  |
| Marshall Islands                      | MARSHALL   | 584  |
| Martinique                            | MARTINIQUE | 474  |
| Mauritania                            | MAURITANIA | 478  |
| Mauritius                             | MAURITIUS  | 480  |
| Mayotte                               | MAYOTTE    | 175  |
| Mexico                                | MEXICO     | 484  |
| Micronesia (Federated States of)      | MICRONESIA | 583  |
| Republic of Moldova                   | MOLDOVA    | 498  |
| Mongolia                              | MONGOLIA   | 496  |

| Country/Territory           | Short name | Code |
|-----------------------------|------------|------|
| Montenegro                  | MONTENEGRO | 499  |
| Montserrat                  | MONTERRAT  | 500  |
| Morocco                     | MOROCCO    | 504  |
| Mozambique                  | MOZAMBIQUE | 508  |
| Myanmar                     | MYANMAR    | 104  |
| Namibia                     | NAMIBIA    | 516  |
| Nauru                       | NAURU      | 520  |
| Nepal                       | NEPAL      | 524  |
| Netherlands                 | NETHLAND   | 528  |
| Nicaragua                   | NICARAGUA  | 558  |
| Niger                       | NIGER      | 562  |
| Nigeria                     | NIGERIA    | 566  |
| Niue                        | NIUE       | 570  |
| Northern Mariana Islands    | NMARIANA   | 580  |
| Norfolk Island              | NORFOLK    | 574  |
| Republic of North Macedonia | NORTHMACED | 807  |
| Norway                      | NORWAY     | 578  |
| New Zealand                 | NZ         | 554  |
| Oman                        | OMAN       | 512  |
| Pakistan                    | PAKISTAN   | 586  |
| Palau                       | PALAU      | 585  |
| State of Palestine          | PALESTINE  | 275  |
| Panama                      | PANAMA     | 591  |
| Papua New Guinea            | PAPUA      | 598  |
| Paraguay                    | PARAGUAY   | 600  |
| Peru                        | PERU       | 604  |
| Philippines                 | PHILIPPINE | 608  |
| Pitcairn                    | PITCAIRN   | 612  |
| Poland                      | POLAND     | 616  |
| Portugal                    | PORTUGAL   | 620  |
| Puerto Rico                 | PUERTORICO | 630  |
| Qatar                       | QATAR      | 634  |
| Reunion                     | REUNION    | 638  |
| Romania                     | ROMANIA    | 642  |
| Russian Federation          | RUSSIA     | 643  |
| Rwanda                      | RWANDA     | 646  |
| Western Samoa               | SAMOA      | 882  |
| Sao Tome and Principe       | SAOTOME    | 678  |
| Saudi Arabia                | SAUDIARABI | 682  |

| Country/Territory                            | Short name | Code |
|--|------------|------|
| Saint-Barthelemy                             | SBARTHEL   | 652  |
| Senegal                                      | SENEGAL    | 686  |
| Serbia                                       | SERBIA     | 688  |
| Seychelles                                   | SEYCHELLES | 690  |
| South Georgia and the South Sandwich Islands | SGEORGIA   | 906  |
| Saint Helena                                 | SHELENA    | 654  |
| Sierra Leone                                 | SIERRALEO  | 694  |
| Singapore                                    | SINGAPORE  | 702  |
| Saint Kitts and Nevis                        | SKITTS     | 659  |
| Slovak Republic                              | SLOVAKIA   | 703  |
| Slovenia                                     | SLOVENIA   | 705  |
| Saint Lucia                                  | SLUCIA     | 662  |
| Sint Maarten (Dutch part)                    | SMAARTEN   | 534  |
| Solomon Islands                              | SOLOMON    | 90   |
| Somalia                                      | SOMALIA    | 706  |
| South Africa                                 | SOUTHAFRIC | 710  |
| Spain  | SPAIN      | 724  |
| Saint Pierre and Miquelon                    | SPIERRE    | 666  |
| Spratly Islands                              | SPRATLY    | 907  |
| Sri Lanka                                    | SRILANKA   | 144  |
| South Sudan                                  | SSUDAN     | 728  |
| Sudan  | SUDAN      | 729  |
| Suriname                                     | SURINAME   | 740  |
| Svalbard and Jan Mayen Islands               | SVALBARD   | 744  |
| Saint Vincent and the Grenadines             | SVINCENT   | 670  |
| Sweden                                       | SWEDEN     | 752  |
| Switzerland                                  | SWITLAND   | 756  |
| Syrian Arab Republic                         | SYRIA      | 760  |
| Chinese Taipei                               | TAIPEI     | 158  |
| Tajikistan                                   | TAJIKISTAN | 762  |
| United Republic of Tanzania                  | TANZANIA   | 834  |
| Thailand                                     | THAILAND   | 764  |
| Timor-Leste                                  | TIMORLESTE | 626  |
| Togo   | TOGO       | 768  |
| Tokelau                                      | TOKELAU    | 772  |
| Tonga  | TONGA      | 776  |
| Trinidad and Tobago                          | TRINIDAD   | 780  |
| Tunisia                                      | TUNISIA    | 788  |

| Country/Territory                    | Short name | Code |
|--------------------------------------|------------|------|
| Turkey                               | TURKEY     | 792  |
| Turkmenistan                         | TURKMENIST | 795  |
| Turks and Caicos Islands             | TURKSCAIC  | 796  |
| Tuvalu                               | TUVALU     | 798  |
| United Arab Emirates                 | UAE        | 784  |
| Uganda                               | UGANDA     | 800  |
| United Kingdom                       | UK         | 826  |
| Ukraine                              | UKRAINE    | 804  |
| Uruguay                              | URUGUAY    | 858  |
| United States                        | USA        | 840  |
| United States Minor Outlying Islands | USMOS      | 908  |
| United States Virgin Islands         | USVI       | 850  |
| Uzbekistan                           | UZBEKISTAN | 860  |
| Vanuatu                              | VANUATU    | 548  |
| Bolivarian Republic of Venezuela     | VENEZUELA  | 862  |
| Viet Nam                             | VIETNAM    | 704  |
| Wallis and Futuna Islands            | WALLIS     | 876  |
| Western Sahara                       | WESSAHARA  | 732  |
| Yemen                                | YEMEN      | 887  |
| Zambia                               | ZAMBIA     | 894  |
| Zimbabwe                             | ZIMBABWE   | 716  |

## Sub-national divisions

This table is available for download in excel format using [this link](#).

| 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              |



| 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              |

| 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              |

| 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              |

| Sub-national division  | Short name | Country ISO code |
|------------------------|------------|------------------|
| 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              |

| 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              |

| 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              |

| 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              |

# Methodology

## Methodology to derive population data

Population primary data are derived from SEDAC and JRC.<sup>9</sup> 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:

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

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 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.

<sup>9</sup> 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](https://doi.org/10.7927/H4JW8BX5). Accessed: 29/05/2020

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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<sup>10</sup>, 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<sup>11</sup>.

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:

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

Where:

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

*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*

<sup>10</sup> 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](https://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-rev11)  
Schiavina, Marcello; Freire, Sergio; MacManus, Kyt (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-43c9f432370f> Concept & Methodology: Freire, Sergio; MacManus, Kyt; 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.

<sup>11</sup> [Download data by country | DIVA-GIS](#)

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:

$$V_k = \frac{\sum_{i,j \in k} \cos(\text{lat}_i) \cdot V_{i,j}}{\sum_{i,j \in k} \cos(\text{lat}_i)} \quad (2)$$

Where:

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

$\text{lat}$ : 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<sup>12</sup>.

The equation to compute population-weighted national averages is:

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

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  $k$

<sup>12</sup> Center for International Earth Science Information Network<sup>12</sup> - CIESIN - Columbia University. 2018. Gridded Population of the World, Version 4 (GPWv4); [sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-rev11](https://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-rev11)  
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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' methodology<sup>13</sup>):

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

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

If  $T \leq T_{ref}$  (standard methodology) or  $T \leq T_{threshold}$  ('Thold' methodology<sup>13</sup>):

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

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

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:

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

<sup>13</sup> 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](https://ec.europa.eu/eurostat/cache/metadata/en/nrg_chdd_esms.html)

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)<sup>14</sup>.

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

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  $RH > 40\%$ :

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

<sup>14</sup> Buck. (s.d.). New Equations for Computing Vapor Pressure and Enhancement Factor

Where:

|                                 |                             |                           |
|---------------------------------|-----------------------------|---------------------------|
| $T$ : air temperature<br>(°F)   | $C_1 = 2.04901523$          | $C_6 = 1.22874 * 10^{-3}$ |
|                                 | $C_2 = 10.14333127$         | $C_7 = 8.5282 * 10^{-4}$  |
| $RH$ : relative humidity<br>(%) | $C_3 = -0.22475541$         | $C_8 = -1.99 * 10^{-6}$   |
|                                 | $C_4 = -6.83783 * 10^{-3}$  |                           |
| $C_0 = -42.379$                 | $C_5 = -5.481717 * 10^{-2}$ |                           |

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<sup>15</sup>:

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

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)<sup>16</sup>:

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

<sup>15</sup> Environment and Climate Change Canada<sup>15</sup> ([climate.weather.gc.ca/glossary\\_e.html](https://climate.weather.gc.ca/glossary_e.html))

<sup>16</sup> Stull, R. (2011). Wet-Bulb Temperature from Relative Humidity and Air Temperature. *Wet-Bulb Temperature from Relative Humidity and Air Temperature*.

Where

|                              |                    |                   |
|------------------------------|--------------------|-------------------|
| $T$ : air temperature (°C)   | $C_1 = 0.151977$   | $C_5 = 0.023101$  |
| $RH$ : relative humidity (%) | $C_2 = 8.313659$   | $C_6 = -4.686035$ |
|                              | $C_3 = -1.676331$  |                   |
|                              | $C_4 = 0.00391838$ |                   |

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:

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

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  $P_{output}^{t,i,j} = f(\text{wind speed } 100m_{t,i,j})$  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<sup>17</sup>.

As reported by the source:

<sup>17</sup> 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](http://www.esrl.noaa.gov/gmd/grad/solcalc/calcdetails.html)

- 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.

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

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

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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