Subcategory. Online Climate Data Services

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About the Resource

This resource is part of the “Climate Data and Tools” section of the ClimEd Scientific and Educational Platform. It is intended for students, PhD candidates, teachers, researchers, and professionals working in climate-sensitive sectors who use climate data, reanalysis products, climate scenarios and projections, spatial data, and time series. The material can be used in ClimEd courses, practical and laboratory assignments, qualification and research projects, climate risk assessments, and the development of applied climate services.

The resource covers both services for the rapid viewing and downloading of individual climate indicators and specialised platforms for working with large volumes of climate and geospatial data. The description of each service includes its purpose, main functions, available data formats, advantages, limitations, and recommendations for practical use.

Subcategories for subcategory “Online Climate Data Services”

1. Open-Meteo Climate API
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4. IPCC WGI Interactive Atlas
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1. Open-Meteo Climate API

When to use it. For rapidly obtaining time series for a specific point or settlement without downloading large datasets.

Open-Meteo Climate API (https://open-meteo.com/en/docs/climate-api) is a free web-based tool for viewing and obtaining projected climate data through a browser or an API. It enables users to quickly obtain climate indicators for any location in the world by geographic coordinates without downloading large datasets or using specialised software. The service is designed for both software developers and researchers analysing climate change.

The service is based on outputs from the high-resolution climate models of the HighResMIP project (https://highresmip.org/), which is part of CMIP6 (https://wcrp-cmip.org/cmip-phases/cmip6/). To improve the accuracy of the projections, statistical bias correction is applied using the ERA5-Land dataset, bringing the projected data to a spatial resolution of approximately 10 km. This provides a more realistic representation of regional climate characteristics than the original global model outputs.

On the Open-Meteo Climate API webpage, users can select one or more of seven available climate models, a time interval from 1950 to 2050, and the required climate variables. Available parameters include mean, minimum, and maximum air temperature, precipitation, wind speed, relative humidity, cloud cover, solar radiation, evapotranspiration, soil moisture, and other indicators. The data are provided at daily temporal resolution, which is sufficient for most studies of climate trends and climate risk assessment.

Open-Meteo offers a straightforward interface, rapid visual inspection of time series, automatic chart generation, and export of results in CSV, XLSX, or JSON formats for further analysis. The service is especially useful for quickly obtaining climate data for individual settlements or coordinates without working with large NetCDF files or specialised climate archives. However, it is not intended for full-scale spatial analysis or work with raster fields; for such tasks, source datasets such as EURO-CORDEX or ERA5 are more appropriate.

Limitation. Open-Meteo is convenient for point-based time series but does not replace comprehensive spatial datasets and is not intended for complex work with raster fields.

2. WorldClim

When to use it. For mapping, ecological modelling, and working with ready-to-use high-resolution climate surfaces in GeoTIFF format.

WorldClim is one of the world’s most widely used open global climate datasets with high spatial resolution, specifically developed for mapping, spatial analysis, and ecological modelling (https://www.worldclim.org/data/index.html). The project is maintained by researchers at the University of California, Davis, under the leadership of Professor Robert J. Hijmans. The data are freely available for research and are widely used in ecology, biogeography, landscape planning, hydrology, and climate change studies.

Unlike ERA5 or EURO-CORDEX, WorldClim is neither a reanalysis dataset nor the output of regional climate modelling. It consists of spatially interpolated climate surfaces produced from a global network of thousands of meteorological stations using statistical interpolation methods and a digital elevation model. The baseline climatology of the current WorldClim 2.1 version represents average climate conditions for 1970–2000.

One of the principal advantages of WorldClim is its very high spatial detail. Data are available at four spatial resolutions:

- 30 arc-seconds (approximately 1 km);
- 2.5 arc-minutes (approximately 5 km);
- 5 arc-minutes (approximately 10 km);
- 10 arc-minutes (approximately 20 km).

The dataset contains monthly mean values of the main climate parameters:

- mean air temperature;
- minimum temperature;
- maximum temperature;
- precipitation;
- solar radiation;
- wind speed;
- water vapour pressure.

WorldClim is particularly valuable for its 19 bioclimatic variables (BIO1–BIO19), which are automatically calculated from temperature and precipitation. They include annual mean temperature, temperature seasonality, temperatures of the warmest and coldest quarters, annual precipitation, precipitation seasonality, precipitation of the driest and wettest quarters, and other integrated indicators. These variables are widely used as standards in species distribution modelling, ecological niche assessment, biodiversity analysis, and projections of changes in natural ecosystems.

In addition to historical climatology, the portal provides projected climate data derived by statistically downscaling global CMIP climate model outputs. For different models and climate change scenarios, users can download future monthly climate characteristics and corresponding bioclimatic variables, making WorldClim a convenient data source for assessing possible climate change impacts.

All data are distributed in GeoTIFF format and can therefore be opened directly in QGIS, ArcGIS, and other geographic information systems without prior format conversion. Each climate variable is provided as a separate raster layer, which simplifies spatial analysis and the use of raster calculators.

The main advantages of WorldClim are global coverage, very high spatial resolution, ease of use, a broad set of bioclimatic indicators, and data that are ready for use in GIS. Consequently, the dataset has become a de facto standard for ecological modelling, habitat suitability assessment, and analysis of natural ecosystems.

Its limitations must also be considered. WorldClim provides long-term climate averages rather than daily or hourly observation time series and is therefore unsuitable for analysing individual extreme weather events. Data accuracy also depends on the density of the meteorological station network, which varies considerably between regions, while statistical interpolation does not always fully reproduce local climate features in mountainous or coastal areas. Despite these limitations, WorldClim remains one of the most authoritative and widely used global climate data sources for spatial analysis and modelling.

Please note. WorldClim primarily contains long-term climate averages and bioclimatic variables rather than daily or hourly time series.

3. Copernicus Interactive Climate Atlas

When to use it. For interactively comparing observations, reanalysis, and climate projections and for rapidly exporting maps and spatial data.

The Copernicus Interactive Climate Atlas is an interactive web service (https://atlas.climate.copernicus.eu/atlas) developed within the Copernicus Climate Change Service for exploring, visualising, and analysing present and future climate change. It builds upon the Intergovernmental Panel on Climate Change Interactive Atlas (https://interactive-atlas.ipcc.ch/) developed for the IPCC Sixth Assessment Report, but provides a broader range of data, is regularly updated, and is integrated with the Copernicus Climate Data Store infrastructure.

A major advantage of the service is the ability to visualise climate data interactively without downloading them in advance. Users can select a dataset (observations, reanalysis, or climate projections), a climate variable, time period, season, climate scenario, or global warming level, such as 1.5, 2, 3, or 4 °C above the pre-industrial period. The map updates automatically whenever a parameter is changed, enabling rapid analysis of the spatial patterns of climate change.

The service integrates several types of data sources, including historical climate observations, reanalysis datasets, CMIP6 global climate models, and CORDEX regional models. This enables direct comparison of the present climate with projections of future change. The service provides access to dozens of climate variables and extreme indicators, including air temperature, precipitation, wind speed, drought, extreme heat, heavy precipitation, and other indicators commonly used in climate risk assessment.

An important feature of the Copernicus Interactive Climate Atlas is its broad range of visualisation tools. In addition to conventional maps, users can create time series, Climate Stripes, annual-cycle plots, scatterplots, and other interactive charts for individual regions or user-defined areas. The ability to analyse administrative or climate regions as well as custom polygons substantially expands its usefulness for regional studies.

Another significant advantage is that climate data can not only be visualised but also exported for further analysis in geographic information systems. Users first select the required dataset, such as observations or CMIP6 or CORDEX climate projections; a climate indicator, such as temperature, precipitation, wind speed, or an extreme indicator; a period, season, or month; and a climate scenario, such as SSP2-4.5 or SSP5-8.5. The map updates automatically to display the spatial distribution of the selected indicator.

To export data, users select the Download or Export menu in the map toolbar. Depending on the type of data displayed, several export options may be available. The simplest option is to save the map in PNG or PDF format for reports, presentations, and scientific publications. The current map extent, legend, and configured colour scale are retained.

For subsequent spatial analysis, exporting raster data in GeoTIFF format is more useful. The service creates a georeferenced raster file that can be opened directly in QGIS, ArcGIS, or other GIS software. The downloaded GeoTIFF contains numerical values of the climate indicator for each raster cell, enabling raster calculations, clipping to administrative boundaries, statistical analysis, and the production of customised thematic maps.

When exporting data, users should carefully check the parameters selected before download because these determine the contents of the resulting file. In particular, verify:

- the climate dataset (CMIP6, CORDEX, observations, etc.);
- the climate variable;
- the climate change scenario;
- the time period;
- the season or month;
- the units of measurement;
- the type of indicator (absolute values or changes relative to a baseline period).

A GeoTIFF exported from the Atlas usually represents one specific time slice and one climate indicator. If a series of time slices or several variables is required, the export procedure must be repeated for each combination of parameters.

For more advanced studies, the Copernicus Interactive Climate Atlas provides access to source datasets through the Copernicus Climate Data Store (CDS). In many cases, a link to the corresponding CDS dataset appears next to the export button. Users can then download complete climate data arrays in NetCDF or GRIB format rather than an individual GeoTIFF, selecting the required variables, time ranges, climate models, and scenarios. This approach is appropriate for large-scale research involving multi-year time series or extensive areas.

The Copernicus Interactive Climate Atlas can therefore be used both as a visual tool for rapidly exploring climate change and as a source of spatial data for further GIS analysis. Exporting individual GeoTIFF maps may be sufficient for rapid assessment, while comprehensive scientific research is better supported by accessing the Copernicus Climate Data Store and downloading full climate datasets.

Good practice. Before exporting, verify the dataset, variable, scenario, period, season, units, and indicator type. These parameters determine the contents of the downloaded file.

4. IPCC WGI Interactive Atlas

When to use it. When working with officially assessed information underpinning the IPCC Sixth Assessment Report and ensuring consistency with AR6 findings.

The IPCC Interactive Atlas is an interactive web atlas (https://interactive-atlas.ipcc.ch/) developed by the Intergovernmental Panel on Climate Change (IPCC) as part of the Working Group I contribution to the Sixth Assessment Report (AR6). Its primary purpose is to allow users to explore the results underpinning the scientific findings of the IPCC report through interactive maps, graphs, and regional summaries. Like the Copernicus Interactive Climate Atlas, and unlike most climate web services, the IPCC Interactive Atlas is not a separate climate data repository. It is a tool for analysing and visualising evaluated and harmonised data used by IPCC experts.

The Interactive Atlas has two main components. Regional Information supports analysis of the spatial distribution of climate indicators, while Regional Synthesis summarises information on Climatic Impact-Drivers (CIDs), which are used in risk assessments for natural and socio-economic systems. Users can work with recent observations and outputs from CMIP5 and CMIP6 global models and CORDEX regional models, selecting different climate variables, periods, emissions scenarios, or global warming levels (+1.5, +2, +3, or +4 °C).

The principal advantage of the IPCC Interactive Atlas is its exceptionally broad range of interactive visualisation tools. After selecting a dataset, users can:

- view global maps of the spatial distribution of climate indicators;
- analyse time series for individual regions;
- create annual-cycle plots of climate indicators;
- view scatterplots;
- generate tabular summaries;
- use Climate Stripes;
- analyse changes at different global warming levels rather than only by calendar periods.

A distinctive feature of the Atlas is the rapid transition from a global map to regional analysis. After selecting a region, users automatically receive graphs and statistical characteristics for that area without additional calculations. In addition to standard administrative and geographic regions, the Atlas supports IPCC reference regions used throughout AR6, ensuring consistency with the report's findings.

The IPCC Interactive Atlas supports the export of both graphics and spatial data. After configuring the map by selecting a dataset, variable, scenario, period, and other parameters, users can choose Download or Export.

The available export options include:

- PNG — for maps used in presentations or reports;
- PDF — for printed materials;
- GeoTIFF — for further work in QGIS or ArcGIS;
- for selected products, aggregated NetCDF data distributed through the IPCC Data Distribution Centre (IPCC-DDC).

An exported GeoTIFF contains the actual numerical map values, not merely an image, and can therefore be used for further spatial calculations, customised thematic mapping, or integration with other geospatial data.

The implementation of the FAIR principles—Findable, Accessible, Interoperable, and Reusable—is particularly valuable for researchers. Information on data provenance and the open-source code used for processing is available for each product. A substantial proportion of the intermediate harmonised datasets and scripts is also available through an open GitHub repository and the IPCC-DDC, supporting reproducibility.

Although their interfaces are similar, the IPCC Interactive Atlas and the Copernicus Interactive Climate Atlas serve different purposes.

The IPCC Interactive Atlas is directly linked to the IPCC Sixth Assessment Report. It contains only data that were formally assessed by IPCC experts and used to formulate the AR6 findings. Consequently, the selection of variables, time periods, and models is relatively fixed and designed to ensure the reproducibility of the report's results.

In contrast, the Copernicus Interactive Climate Atlas is a contemporary Copernicus Climate Change Service tool that is regularly updated, supports new datasets, offers a wider range of climate products, and is closely integrated with the Copernicus Climate Data Store, where full source datasets can be downloaded for further processing.

Therefore:

- the IPCC Interactive Atlas should be used when it is necessary to reproduce results from the IPCC Sixth Assessment Report, analyse officially assessed climate change scenarios, or prepare materials directly aligned with IPCC findings;
- the Copernicus Interactive Climate Atlas is a more versatile tool for applied research, regional climate risk assessment, teaching, and obtaining current climate data for further GIS analysis.

Choosing between the atlases. Use the IPCC Interactive Atlas to reproduce assessed AR6 results; use the Copernicus Interactive Climate Atlas for broader applied analysis and current datasets.

5. Copernicus Climate Data Store (CDS)

When to use it. For searching and downloading complete climate datasets, including ERA5, ERA5-Land, CMIP, and CORDEX, for further processing in GIS or programming languages.

The Copernicus Climate Data Store (CDS) (https://cds.climate.copernicus.eu/) is the central climate data repository of the Copernicus Climate Change Service, implemented by the European Centre for Medium-Range Weather Forecasts. It is one of the world's largest open climate information portals and provides free access to thousands of datasets, including observations, reanalysis, climate projections, seasonal forecasts, satellite products, and numerous climate indicators. Unlike interactive atlases, CDS is less a visualisation service than a platform for searching, selecting, and downloading complete climate datasets for subsequent scientific processing.

The CDS catalogue contains hundreds of thematic datasets, including:

- ERA5 and ERA5-Land reanalysis;
- CMIP5 and CMIP6 global climate projections;
- CORDEX regional climate projections;
- satellite-based climate products;
- historical climate observations;
- seasonal forecasts;
- numerous derived climate indicators.

Most datasets are available in NetCDF or GRIB formats and can be used directly in QGIS, ArcGIS, Python, R, and other spatial data analysis systems.

Before starting, users must create a free CDS account. After signing in, they can use the search function or browse the dataset catalogue.

After opening a dataset, an interactive form is displayed in which the request parameters are selected. Depending on the dataset, these may include:

- a climate variable, such as temperature, precipitation, or wind speed;
- a time interval;
- a year, month, or specific dates;
- temporal resolution (hourly, daily, or monthly data);
- a climate model or scenario;
- the output file format (NetCDF or GRIB).

For most datasets, users can also define a spatial area by specifying the northern, western, southern, and eastern boundaries. This makes it possible to download only the required region, such as Ukraine, instead of the entire global dataset, substantially reducing file size and preparation time.

After selecting all parameters, users choose Submit or Download. The request is sent to the server, where the required dataset is prepared. Small requests may be completed within a few minutes, whereas large requests, such as several decades of hourly ERA5 data, may take from tens of minutes to several hours. When processing is complete, the file becomes available for download.

One of the most important advantages of CDS is support for the CDS API, which allows data downloads to be automated with Python. After configuring the parameters in the web form, users can select Show API request code at the bottom of the page. The system automatically generates a ready-to-use Python script containing the selected parameters. Users then copy the code, install the cdsapi library, configure their personal API key once, and run the script. This approach is especially efficient for regular data acquisition or downloading large series of climate variables.

Several good practices are recommended when working with CDS:

- download only the required variables rather than an entire dataset;
- limit the time period and study area as much as possible;
- for large projects, download data in separate time blocks, for example by year;
- where possible, use NetCDF, which is particularly convenient for subsequent analysis in GIS and programming languages;
- before automating API requests, first test them manually through the web interface.

Good practice. Before automating requests through the CDS API, first create and test the request in the web interface, and download large datasets in separate time blocks.

6. Google Earth Engine

When to use it. For cloud-based analysis of large geospatial datasets without first downloading them to a local computer.

Google Earth Engine (GEE) is a cloud-based geospatial platform (https://code.earthengine.google.com/) for storing, processing, and analysing large spatial datasets without downloading them to a local computer. Unlike most climate portals, GEE is not simply a data repository; it combines a global geospatial data catalogue with a powerful spatial analysis environment. All computations are performed on Google servers, allowing users to work with terabytes of climate information without relying on local computing resources.

The GEE catalogue contains dozens of global climate datasets that are regularly updated. However, not every dataset is available through the platform; for example, E-OBS and EURO-CORDEX are not currently provided. Frequently used climate datasets include:

- ERA5 and ERA5-Land (ECMWF reanalysis);
- TerraClimate;
- WorldClim (climate normals and bioclimatic variables);
- GRIDMET;
- CHIRPS (precipitation);
- NASA GLDAS;
- FLDAS;
- numerous products for soil moisture, snow cover, evaporation, solar radiation, and other climate characteristics.
- For example, ERA5-Land is available in several forms:
- hourly data;

daily aggregated values;

monthly aggregated values;

1. Selecting a Dataset

These products cover the period from 1950 to near real time, have a spatial resolution of approximately 11 km, and contain around 50 climate variables, including temperature, precipitation, wind, soil moisture, evaporation, runoff, snow cover, and energy fluxes.

- To begin using GEE, users need a Google account and must register for Google Earth Engine. Once access is granted, they can open the Code Editor, the primary working environment for the platform.
- A typical workflow consists of several stages.
- 1. Selecting a Dataset

- Users locate the required climate dataset in the GEE catalogue, using keywords such as ERA5, WorldClim, precipitation, or temperature. Each catalogue entry includes a description, temporal coverage, spatial resolution, available variables, and code examples.

2. Loading the Dataset into a Script

Instead of downloading files, users connect a dataset with a single JavaScript or Python command. The data themselves remain on Google servers.

3. Selecting the Required Data

After connecting the dataset, users can specify:

the time period;

- the study area;
- the required climate variables;
- the aggregation method (mean, maximum, minimum, sum, etc.).
- For example, hourly ERA5-Land data can be used to calculate mean temperature for July 2024 within Ukraine or annual mean precipitation for any multi-year period.
- 4. Spatial Analysis
- After filtering the data, users can perform virtually any spatial analysis operation:

4. Spatial Analysis

construct time series;

identify climate anomalies;

calculate differences between two periods;

perform statistical analysis;

calculate zonal statistics for administrative units or river basins;

- combine climate data with satellite imagery, digital elevation models, or land-cover data.
- Because all operations are performed directly on the server, analysis speed is largely independent of the size of the source datasets.
- 5. Exporting Results
- After completing the analysis, results can be exported in several formats:
- GeoTIFF — for further work in QGIS or ArcGIS;
- CSV — for statistical analysis;

5. Exporting Results

Google Cloud Storage;

- GEE Assets for further calculations in GEE.
- Users can export individual rasters as well as tables containing statistical indicators for large numbers of territorial units.
- A major advantage of GEE is that users do not need to download large climate datasets in advance. For example, calculating mean annual temperature over 40 years does not require downloading hundreds of ERA5 files; a few lines of code are sufficient for the server to perform the calculations and return only the final result.
- Another important advantage is the ability to combine climate data with other global geospatial datasets. ERA5-Land temperature, for example, can be analysed directly alongside Sentinel-2 and Landsat data, digital elevation models, ESA WorldCover land-cover maps, or administrative

boundaries. This makes GEE highly effective for climate risk assessment, water-resource modelling, biodiversity analysis, and climate change research.

- Google Earth Engine does not, however, replace specialised climate archives such as the Copernicus Climate Data Store or ESGF. Some recent climate projections or individual model runs may be unavailable or added with a delay. Researchers therefore often download the latest CMIP or EURO-CORDEX data directly from the relevant archives, while using GEE for rapid analysis, processing, and integration with other spatial datasets.

7. Recommendations for Selecting a Service

An online service should be selected according to the task, required temporal and spatial resolution, output format, and intended method of further analysis—not according to its popularity.

Task	Recommended service
Rapid time series for a point or city	Open-Meteo Climate API
Ready-to-use high-resolution climate surfaces and bioclimatic variables	WorldClim
Interactive comparison of climate changes and projections	Copernicus Interactive Climate Atlas
Results consistent with IPCC AR6 assessments	IPCC WGI Interactive Atlas
Complete reanalysis and climate projection datasets	Copernicus Climate Data Store
Cloud-based analysis of large geospatial datasets	Google Earth Engine