## Historical climate data (Historische Klimadaten)

| Region | Thüringen | Sachsen-Anhalt | Sachsen | Klimakonform |
|---|---|---|---|---|
| **Parent data source** | Station-based interpolated gridded ASCII files from ReKIS<br>https://rekisviewer.hydro.tu-dresden.de/fdm/ReKISExpert.jsp#menu-4 | | | |
| **Documentation or/and methods** | Kronenberg, R. and Bernhofer, C. (2015), A method to adapt radar-derived precipitation fields for climatological applications. Met. Apps, 22: 636-649. https://doi.org/10.1002/met.1498 | | | |
| **Variables** | Temperature 2m [$^0$C]: mean, minimum, maximum; global radiation [kWh m$^{-2}$], relative humidity [%], precipitation (Richter-corrected) [mm], wind speed 10m [m s$^{-1}$], atmospheric pressure [hPa] | Temperature 2m [$^0$C]: mean, minimum, maximum; global radiation [kWh m$^{-2}$], relative humidity [%], precipitation (Richter-corrected) [mm], wind speed 10m [m s$^{-1}$], atmospheric pressure [hPa] | Temperature 2m [$^0$C]: mean, minimum, maximum; global radiation [kWh m$^{-2}$], relative humidity [%], precipitation (Richter-corrected) [mm], wind speed 10m [m s$^{-1}$] | Temperature 2m [$^0$C]: mean, minimum, maximum; global radiation [kWh m$^{-2}$], relative humidity [%], precipitation (Richter-corrected) [mm], wind speed 10m [m s$^{-1}$] |
| **Format** | NCDF4 | | | |
| **Spatial resolution** | 1000 m | | | |
| **Projection** | EPSG:31468 – DHDN / 3-degree Gauss-Kruger zone 4<br>https://epsg.io/31468 | | | |
| **Temporal coverage and resolution** | 1961 - 2020, daily | | | |
| **Assess link** | https://klimakonform-dmp.geo.tu-dresden.de/dataset/tn-tagliche-klima | https://klimakonform-dmp.geo.tu-dresden.de/dataset/sa-tagliche-klima | https://klimakonform-dmp.geo.tu-dresden.de/dataset/sn-tagliche-klima | https://klimakonform-dmp.geo.tu-dresden.de/dataset/kk-gebiet-tagliche-klima |
| **Contact** | Technical University of Dresden, Faculty of Environmental Sciences, Institute of Hydrology and Meteorology, Chair of Meteorology<br>Ivan Vorobevskii ( ivan.vorobevskii@tu-dresden.de )<br>Rico Kronenberg ( rico.kronenberg@tu-dresden.de ) | | | |

**Additional info:**

NCDF storage structure: 1 file per each variable (variable name is also stated in the file's name). Each file contains 3 dimensions: X, Y and time (days since 01.01.1961)

A .shp file (could be opened in GIS system) with grids for each dataset is provided. It contains info on coordinates and IDs of the corresponding grid, which could be used to locate the IDs of desired grids in the NCDF file.

To open the files, assess specific coordinates or time-periods, extract data to other format, etc. an R-script is provided.

## Climate projection data (Zukünftige Klimadaten)

| Data | Original | BIAS-corrected | 5 min (precipitation) |
|---|---|---|---|
| **Parent data source** | Mitteldeutsches Kernensemble gridded ASCII files from ReKIS https://rekisviewer.hydro.tu-dresden.de/fdm/ReKISExpert.jsp#menu-5 | | |
| **Documentation or/and methods** | https://rekis.hydro.tu-dresden.de/wp-content/uploads/2020/07/ReKIS_Steckbrief_Klimaprojektionsdaten_2020-07-14.pdf<br>https://rekis.hydro.tu-dresden.de/wp-content/uploads/2020/05/Dokumentation_Mitteldeutsches_Kernensemble_MDK.pdf | BIAS correction is computed within 1961-2020, 1961-1990 and 1991-2020 periods using robust empirical quantile mapping (https://doi.org/10.4090/juee.2014.v8n2.142-154). For each MDK grid cell the mean of superposed RaKliDa grid cells were taken. Diagnostic plots for each projection file and variable are provided. | Vorobevskii I. (2022) Statistical downscaling of daily precipitation from climate projections to 5 min timescale using Radar data. http://dx.doi.org/10.13140/RG.2.2.12083.30243 |
| **Variables** | Temperature 2m [$^0$C]: mean, minimum, maximum; global radiation [J cm$^{-2}$], relative humidity [%], precipitation (Richter-corrected) [mm], mean wind speed 10m [m s$^{-1}$], X and Y coordinate [degree] | Temperature 2m [$^0$C]: mean, minimum, maximum; global radiation [J cm$^{-2}$], relative humidity [%], precipitation (Richter-corrected) [mm], mean wind speed 10m [m s$^{-1}$], X and Y coordinate [degree] | Precipitation [mm], X and Y coordinate [degree] |
| **Format** | NCDF4 | | |
| **Spatial resolution** | 0.11$^0$ (~12.5 km) | | |
| **Projection** | EPSG:4326 – WGS 84<br>https://epsg.io/4326 | | |
| **Temporal coverage and resolution** | 1961 – 2005, daily | 2005 – 2100(2099), daily | 1961/2005 - 2099/2100,<br>5 min |
| **Assess link** | https://klimakonform-dmp.geo.tu-dresden.de/dataset/kk-gebiet-tagliche-mdk-projektion-original | https://klimakonform-dmp.geo.tu-dresden.de/dataset/kk-gebiet-tagliche-mdk-projektion-bias-corrected | https://klimakonform-dmp.geo.tu-dresden.de/dataset/kk-gebiet-mdk-5-minutiger-niederschlag |
| **Contact** | Technical University of Dresden, Faculty of Environmental Sciences, Institute of Hydrology and Meteorology, Chair of Meteorology<br>Ivan Vorobevskii ( ivan.vorobevskii@tu-dresden.de )<br>Rico Kronenberg ( rico.kronenberg@tu-dresden.de ) | | |

**Additional info:**

NCDF storage structure: 1 file per each climate projection (names of global and regional model, RCP scenario and realization are included in filename). Each file contains 3 dimensions: ID of XY grid (coordinates are stored in corresponding variables), time (e.g. days since 01.01.2005).

Bias-corrected NCDF files have additional dimension – reference period used for the correction (1961-2020, 1961-1990 and 1991-2020). Due to big influence of the reference period on the precipitation corrections for the future, it is recommended to use 1961-2020 period as a default one.

5-min precipitation NCDF has another time dimension (5 min intervals since 01.01.1961/2006 00:00)

Keep attention on the calendar type included in description of time dimension: normal, 365-day and 360-day.

A .shp file (could be opened in GIS system) with grids for each climate projection file is provided. It contains info on coordinates and IDs of the corresponding grid, which could be used to locate the IDs of desired grids in the NCDF file.

To open the files, assess specific coordinates or time-periods, extract data to other format, etc. an R-script is provided.

# Short description of global and regional models used in MDK ensemble

**Global Climate models used:**

1. *CanESM2*

The second generation Canadian Earth System Model (CanESM2) consists of the physical coupled atmosphere-ocean model CanCM4 coupled to a terrestrial carbon model (CTEM) and an ocean carbon model (CMOC). The 128x64 grid cells cover global domain according to T42 Gaussian grid. This grid is uniform along the longitude with horizontal resolution of *2.8125*° and nearly uniform along the latitude of roughly *2.8125*°.
https://www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/modeling-projections-analysis/centre-modelling-analysis/models/second-generation-earth-system-model.html

2. *EC-Earth*

EC-Earth is a global climate model system based on the idea to use the world-leading weather forecast model of the ECMWF (European Centre of Medium Range Weather Forecast) in its seasonal prediction configuration as the base of climate model. The model system can be used in several configurations including the classical climate model (atmosphere, soil, ocean, sea ice) and Earth System configurations (adding atmospheric chemistry and aerosols, ocean bio-geo-chemistry, dynamic vegetation and a Greenland ice sheet). The model is developed by the European EC-Earth consortium with SMHI as coordinating partner. The EC-Earth Atmosphere–Ocean General Circulation Model (AOGCM) configuration was employed. The atmosphere was simulated with ~79-km horizontal grid spacings (T255) and 91 vertical levels. The ocean was simulated with 1-degree horizontal resolution and 75 vertical levels.
http://www.ec-earth.org
https://gmd.copernicus.org/articles/15/2973/2022/

3. *HadGEM2-ES*

Hadley Centre Global Environment Model version 2 was developed by Met Office Hadley Centre and includes a coupled atmosphere-ocean configuration, with or without a vertical extension in the atmosphere to include a well-resolved stratosphere, and an Earth-System configuration which includes dynamic vegetation, ocean biology and atmospheric chemistry. The standard atmospheric component has 38 levels extending to ~40km height, with a horizontal resolution of 1.25 degrees of latitude by 1.875 degrees of longitude, which produces a global grid of 192 x 145 grid cells. This is equivalent to a surface resolution of about 208 km x 139 km at the Equator, reducing to 120 km x 139 km at 55 degrees of latitude. A vertically-extended version, with 60 levels extending to 85km height, is also used for investigating stratospheric processes and their influence on global climate. The oceanic component utilizes a latitude-longitude grid with a longitudinal resolution of 1 degree, and latitudinal resolution of 1 degree between the poles and 30 degrees North/South, from which it increases smoothly to one third of a degree at the equator, giving 360 x 216 grid points in total, and 40 unevenly spaced levels in the vertical (a resolution of 10m near the surface).
https://www.inscc.utah.edu/~reichler/publications/papers/Collins_08_MetOffice_74.pdf
https://www.metoffice.gov.uk/research/approach/modelling-systems/unified-model/climate-models/hadgem2

4. *NorESM1-M*

The NorESM family of models are based on the Community Climate System Model version 4 (CCSM4) of the University Corporation for Atmospheric Research, but differs from the latter by, in particular, an isopycnic coordinate ocean model and advanced chemistry–aerosol–cloud–radiation interaction schemes. NorESM1-M has a horizontal resolution of approximately 2° for the atmosphere and land components and 1° for the ocean and ice components.
https://view.es-doc.org/?renderMethod=name&type=cim.1.software.ModelComponent&name=NorESM1-M&project=CMIP5
https://gmd.copernicus.org/articles/6/687/2013/gmd-6-687-2013.html
https://gmd.copernicus.org/articles/6/389/2013/gmd-6-389-2013.html

5. *MPI-M-MPI-ESM-LR*

MPI-ESM couples the atmosphere, ocean and land surface through the exchange of energy, momentum, water and carbon dioxide. It is based on the components of ECHAM6 for atmosphere and MPIOM for ocean as well as JSBACH for terrestrial biosphere and HAMOCC for the ocean´s biogeochemistry. JSBACH is the land component of both MPI-ESM and ICON-ESM. The coupling of atmosphere and land on the one hand and ocean and biogeochemistry on the other hand is made possible by the separate coupling program OASIS3. The LR configuration uses for the atmosphere a T63/1.9° horizontal resolution and 47 hybrid sigma—pressure levels, and for the ocean a bipolar grid with 1.5° resolution (near the equator) and 40 z-levels.
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/jame.20038
https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)1942-2466.MPIESM1
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018MS001400

6. *MIROC5*

Model for Interdisciplinary Research on Climate (MIROC) Version 5 is an atmosphere–ocean general circulation model cooperatively produced by the Japanese research community. It has standard resolution of the T85 atmosphere and 1° ocean models. MIROC5 was developed based on MIROC3.2, but many of the schemes have been replaced and improved. The atmosphere model is the CCSR–NIES–Frontier Research Center for Global Change (FRCGC) AGCM, which is based on a global spectral dynamical core and includes a standard physics package. The ocean model is the CCSR Ocean Component Model, which includes a sea ice model. A land model that includes a river module is also coupled. The ocean general circulation model used for MIROC5 is COCO version 4.5. MIROC5 adopts an updated version of the land surface model called Minimal Advanced Treatments of Surface Interaction and Runoff, which predicts the temperature and water in six soil layers down to a 14-m depth, one canopy layer, and three snow layers. A flux coupler couples these atmosphere, ocean, and land surface components, as well as a river routing scheme.
https://gmd.copernicus.org/articles/4/845/2011/gmd-4-845-2011.pdf
https://journals.ametsoc.org/view/journals/clim/23/23/2010jcli3679.1.xml

**Regional Climate models used:**

1. *EPISODES-2018*

EPISODES is an empirical-statistical method for downscaling (ESD) that has been developed by DWD. It implements the downscaling of global climate models (with a two-step procedure: in the first step, intermediate results are calculated using linear regression method based on the "Perfect-Prog" approach. In the second step, synthetic local time series are generated in daily resolution that are spatially and intervariably consistent. EPISODES is a comparatively simple method that requires relatively little computing time needed. This allows large ensembles with many members to be processed. The target grid corresponded to the EURO-CORDEX resolution of 0.11˚ (~12 km). EPISODES used the DWD observation datasets HYRAS and TRY, which were also aggregated on the target grid. Evaluation experiments show satisfactory agreement between different EPISODES results and observations. For example, the per-grid cell bias of mean annual values is less than 0.1˚C for temperature, and less than 10% for precipitation. Comparisons of the climate change signals derived from the EPISODES results with other downscaling methods, such as regional climate models (RCMs), show overall high agreement.
https://meetingorganizer.copernicus.org/DACH2019/DACH2019-297.pdf
https://www.dwd.de/DE/leistungen/episodes/episodes.html;jsessionid=2DA646E8B6760510B958573344CA7794.live21073?nn=645608
https://link.springer.com/article/10.1007/s00382-018-4276-2

2. *RACMO-22E*

Regional Atmospheric Climate MOdel was developed at KNMI. RACMO22E is the 2012 release of the regional climate model RACMO2. The model dynamics is taken from the numerical weather prediction model HIRLAM, version 6.3.7. The framework of physical parameterizations is taken from IFS-ECMWF CY31r1 but a number of modifications has been applied. The model has a hydrostatic dynamical core and a hybrid-sigma vertical pressure coordinate. The spatial discretization uses a rotated latitude

longitude grid mapping and, in standard configuration, 40 levels in the vertical. RACMO22E employs a tiled land surface scheme. Evaluation showed that RACMO exhibits systematic negative biases for some European regions.
https://cdn.knmi.nl/knmi/pdf/bibliotheek/knmipubTR/TR302.pdf
https://library.wur.nl/WebQuery/wurpubs/fulltext/312258

3. *CCLM-4-8-17*

The COSMO model in CLimate Mode (COSMO-CLM) is a nonhydrostatic regional climate model based on the Local Model (LM) of the Deutscher Wetterdienst and its succesor, the COSMO model. It is based on the primitive thermo-hydrodynamical equations describing compressible flow in a moist atmosphere. The model equations are formulated in rotated geographical coordinates and a generalized terrain following height coordinate. A variety of physical processes are taken into account by parameterization schemes.
https://clmcom.scrollhelp.site/clm-community/COSMO-CLM.2785464.html
http://www.cosmo-model.org/content/model/documentation/core/default.htm
https://www.dwd.de/EN/ourservices/cosmo_documentation/cosmo_documentation.html

4. *WETTREG-2018*

The statistical, regional climate model WETTerlagenbasierte REGionalisierungsmethode was developed by the Climate & Environment Consulting Potsdam GmbH (CEC). WETTREG works according to a conditioning method in which the temporal development of the frequency of weather conditions and the properties of individual weather conditions are specified. It requires modeled dynamic variables of a climate model. In WETTREG, it is not the information at individual grid points that is extracted, but the simulated large-scale atmospheric situation of each day. The time series of the measurement data are divided into above-normally warm and below-normally cold sections based on the key variable temperature. A random generator is used to recombine the weather sections into a simulated time series based on the premise of the best possible approximation to the specified frequency distribution of the weather conditions. Each day of this simulated time series contains an assignment to weather conditions of the temperature and humidity regime and the original date reference. The annual course of the meteorological variables, which is available as a deviation from the station-specific annual course, is then applied to the simulated time series. At this processing stage, the simulated values are in the value range of the measured values, but a different frequency distribution can be applied. WETTREG does not contain any extra coupling such as e.g. melting of glaciers or changes in land use. It assumes that these feedbacks are reflected in the atmospheric properties of the global climate model.
https://publikationen.sachsen.de/bdb/artikel/35082
http://www.cec-potsdam.de/wettreg.html