

Variable: 2m temperature

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Dataset overview

Last update on 21/09/2021

Basic information about the data (e.g. format, name)

Catalogue entry category	Reanalysis
Description of the catalogue entry category	A reanalysis provides a synthesized estimate of the climate state generated from a combination of a numerical model and as many observations as possible of the Earth system. Observations can be directly assimilated into the numerical simulation or used indirectly through the forcings of the simulation. The climate estimates can be global or regional, spanning from a few years to almost two centuries.
Data format	GRIB, NetCDF
Variable domain	Atmosphere
Physical quantity name	2m temperature
Physical quantity unit	K
Definition of physical quantity	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. This parameter has units of kelvin (K). Temperature measured in kelvin can be converted to degrees Celsius (°C) by subtracting 273.15.

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Summary description of the dataset	ERA5 is the fifth generation ECMWF reanalysis for the global climate and weather from the twentieth century to present. ERA5 provides hourly global estimates for a large number of atmospheric, ocean-wave and land-surface quantities. An uncertainty estimate is sampled by an underlying 10-member ensemble at three-hourly intervals and reduced spatial resolution.
How to cite this dataset?	Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2018): ERA5 hourly data on single levels from 1979 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). (Accessed on < DD-MMM-YYYY >), 10.24381/cds.adbb2d47; Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2019): ERA5 monthly averaged data on single levels from 1979 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). (Accessed on < DD-MMM-YYYY >), 10.24381/cds.f17050d7
Are there licence conditions or terms of agreement which regulate the use of this dataset?	Yes
Licence	https://cds.climate.copernicus.eu/api/v2/terms/static/licence-to-use-copernicus...
Is the licence a Creative Commons licence?	CC BY (only attribution requested)
Key limitations of the dataset	Changes in the amounts and types of observational data that are assimilated may produce artificial trends or variability. Observed values at local scales can differ from the values provided by the reanalysis, which represent a statistical summary of the area surrounding a grid point.
Does the dataset originate from several production streams?	Yes
Description including starting and ending dates for the streams	Given the constraints of the available time frame, the production is split into a number of parallel streams, each of them completing around 7 reanalysis days per day. The production of ERA5 was originally planned to be comprised by 4 parallel streams. However, due to several difficulties, the distribution of these streams is more complex. These are the main ERA5 streams for both the high resolution and the ensemble member: 1979-1986, 1986-1993, 1993-2000, 2000-2018, ERA5T: 2018- .

Temporal and spatial coverage and resolution

Last update on 21/09/2021

Time and space characteristics of the data

Temporal coverage	Past, Present
Record start date	1979-01
Record end date	Ongoing
Temporal resolution	One monthly average over all hours or monthly averages by hour (24 or 8 values) for monthly data. One value per hour (reanalysis) or every 3 hours (ensemble) for sub-daily data. This parameter is instantaneous
Geographical coverage	Global
Horizontal resolution	0.25° x 0.25° (reanalysis); 0.5° x 0.5° (ensemble members); 0.5° x 0.5° (wave parameters reanalysis); 1° x 1° (wave parameters ensemble members)
Vertical levels	Single levels
Grid description	Regular latitude-longitude grid

Providers

Last update on 21/09/2021

Data provider and contact points

Organization of the producer	ECMWF
Point of contact	Copernicus User support (copernicus-support@ecmwf.int)
Is the dataset brokered?	No

Dataset version

Last update on 21/09/2021

Current version of the data and associated DOI

System	ERA5
Has the dataset DOI associated?	Yes
Report DOI	DOI: 10.24381/cds.adbb2d47 (hourly); DOI: 10.24381/cds.f17050d7 (monthly)

Data update

Last update on 21/09/2021

Data status and next releases

Dataset status	Operational
Date/frequency new data is made available in the CDS	Daily updates are available about 5 days behind real time
Date of dataset availability in the CDS	2018-06-14 (hourly); 2019-04-18 (monthly)
Is there a future update planned?	Yes
Please specify update plan	A preliminary version of the ERA5 reanalysis back extension from 1950 to 1978 has been released in 2020. An updated version will be available around Q1 2022.

User guide

Last update on 21/09/2021

Overview of input data and methods, general guidelines for the data usage, etc

Is there a User Guide?	Yes
Link to User Guide	https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation
Is there a user forum provided for the dataset?	Yes
Key references	https://confluence.ecmwf.int/display/CUSF/forum
Does the dataset have a 'known issues' register?	Yes
Please provide a description	A list is maintained at the online documentation.
Key references	https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation#ERA5:datado...

Scientific methodology

Last update on 21/09/2021

Description of the physical basis, the algorithm or model used to produce the data record, etc

Is there a reanalysis technical documentation?	Yes
Link(s) to documentation	https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3803

Short description of the Methodology and/or Models	<p>ERA5 is produced using 4D-Var data assimilation with the CY41R2 of ECMWF's Integrated Forecast System (IFS) model, with 137 hybrid sigma/pressure (model) levels in the vertical, with the top level at 0.01 hPa. Atmospheric data are available on these levels and they are also interpolated to 37 pressure, 16 potential temperature and 1 potential vorticity level(s). "Surface or single level" data are also available, containing two-dimensional parameters such as precipitation, 2m temperature, top of atmosphere radiation and vertical integrals over the entire atmosphere. The IFS is coupled to a land-surface model, the parameters of which are also designated as surface parameters, and an ocean wave model.</p> <p>The ERA5 dataset contains one (31 km) high resolution realisation (HRES) and a reduced resolution ten member ensemble (EDA). The model time step is 12 minutes for the HRES and 20 minutes for the Ensemble Data Assimilation (EDA), though occasionally these numbers are adjusted to cope with instabilities. Generally, the data are available at a sub-daily and monthly frequency and consist of analyses and short (18 hour) forecasts, initialised twice daily from analyses at 06 and 18 UTC. Most analysed parameters are also available from the forecasts. There are several forecast parameters, e.g. mean rates and accumulations, that are not available from the analyses.</p>
Key references	<p>https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3803</p> <p>https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation</p> <p>https://www.ecmwf.int/en/newsletter/159/meteorology/global-reanalysis-goodbye-e...</p>
Further details about the main system components?	<p>Yes</p>
Model component name	<p>atmospheric model</p>
Short description of the Model component	<p>The forecast model of the ERA5 is the IFS Cycle 41r2. The atmospheric component of the model comprises parameterizations schemes representing the physical processes associated with radiative transfer, turbulent mixing, convection, clouds, surface exchange, subgrid-scale orographic drag and non-orographic gravity wave drag. Parameterization schemes are necessary in order to properly describe the impact of subgrid-scale processes on the large scale flow. More details can be found in Part IV of the IFS documentation linked below, and information on the dynamical part of the model can be found in Part III of the IFS documentation.</p> <p>In the ten-year period between ERA-Interim (Cy31r2) and ERA5 (Cy41r2), many significant improvements have been made to the representation of atmospheric physical processes. For further details, see Section 4 of Hersbach et al. (2020).</p>
Link(s) reference document(s)	<p>https://www.ecmwf.int/en/elibrary/16648-part-iv-physical-processes</p> <p>https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3803</p> <p>https://www.ecmwf.int/en/elibrary/16647-part-iii-dynamics-and-numerical-procedu...</p>
Model component name	<p>land surface model</p>
Short description of the Model component	<p>In ERA5 the HTESSEL land surface scheme (Balsamo et al., 2015) is used. Some of the most significant changes from ERA-Interim to ERA5 are related to (a) the introduction of the soil texture map and (b) an improved representation of bare soil evaporation. The new scheme also accounts for seasonally varying monthly vegetation maps specified from a MODIS-based satellite dataset. In addition, an enhanced snowpack parameterization allows a more realistic timing of runoff and terrestrial water storage variations and a better match of the albedo to satellite products. The chosen parametrization for lakes (FLake), allows consideration of both subgrid and resolved water bodies. This series of changes contributes to significant improvements in the soil moisture and land surface fluxes consistency, which allowed for the usage of satellite data in ERA5 to analyse soil moisture.</p>

Link(s) reference document(s)	https://www.hydrol-earth-syst-sci.net/19/389/2015/ https://rmetsonline.wiley.com/doi/full/10.1002/qj.3803
Model component name	wave model
Short description of the Model component	<p>The wave model used in ERA5 is the WAM model. The native grid is on a 0.36 degrees (~40km) reduced latitude-longitude grid. However data available through the CDS is interpolated to a regular latitude-longitude grid of 0.5° x 0.5° for the high resolution member and 1° x 1° resolution for the ensemble members. Some important improvements from previous reanalysis generation include: an updated model bathymetry with a more recent version of ETOPO2 and a revised unresolved bathymetry scheme to better account for the propagation along coastlines and to better model the impact of unresolved islands. More details can be found in Section 4 of Hersbach et al. (2020).</p>
Link(s) reference document(s)	https://rmetsonline.wiley.com/doi/full/10.1002/qj.3803
Are there physical parameterizations needing further description?	No
Are there Boundary Conditions or External forcings needing further description?	Yes
Boundary Condition / External Forcing Name	Sea surface temperature, sea ice cover, greenhouse gases, aerosols, total solar irradiance.
Short description of the Boundary Condition / External Forcing	<p>Boundary conditions are required to constrain the atmosphere near the sea surface and to model the radiation. A detailed description of these forcing is included in Section 6 of Hersbach et al. (2020).</p>
Link(s) reference document(s)	https://rmetsonline.wiley.com/doi/full/10.1002/qj.3803
Are there Ensemble Members?	Yes

Short description of the ensemble configuration	The ensemble component of ERA5 is an Ensemble Data Assimilation (EDA) of 10 low resolution members which provides background-error estimates for the deterministic HRES 4D-Var Data Assimilation system. The analysis method is the same for each EDA member and follows that of the HRES. Each member (except the control) is run with different random perturbations added to the observations. Likewise, the model physical tendencies are perturbed in the short forecasts that link subsequent analysis windows.
Number of EM	The ensemble contains a total of 10 members (1 control member and 9 perturbed members)
Spatial and Temporal Resolution of EM	0.5° x 0.5° horizontal resolution (1° x 1° for ocean-wave parameters); 3 hours temporal resolution.
Additional details	The perturbations of observations are sampled from a zero-mean Gaussian distribution with variance equal to the expected variances of the observation errors. Perturbations in SST and SIC are taken from the spread within the range of available products. The perturbations applied to the observations, the SST, SIC and the model imply that the short-range forecast (i.e. the resulting background) of each member is implicitly perturbed, thus avoiding the need for explicitly perturbing the background fields.
Link(s) reference document(s)	https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3803
Parameters used in dataset generation	Based on the Ensemble of Data Assimilation (EDA) system as also implemented in the operational NWP model at ECMWF, though at: 1) lower resolution, and 2) on the system that was operational in 2016 (IFS Cy41r2).
Is the data interpolated horizontally?	Yes
Specify method of interpolation	Interpolation from native reduced Gaussian grid to regular lat/lon grid.
Is the data interpolated vertically?	No
Is the data gap-filled horizontally?	No
Is the data gap-filled vertically?	No
Is the data gap-filled temporally?	No
Is any data assimilation performed?	Yes

Description of input datasets, including sources, starting and ending

The multi-variate method of 4D-Var interrelates observations for all geophysical quantities in a consistent manner. It used about 0.75 million observations per day in 1979 and about 24 Million in 2018. The 2D-OI uses surface observations at 'screen level'. The complete list of satellite and in-situ observations input datasets can be found in the corresponding links.

Short description of methodology

The ERA5 atmospheric analysis is based on a hybrid incremental 4-dimensional variational data assimilation (4D-Var) system including variational bias correction (VarBias). The objective of 4D-Var is to find the best estimate of the state of the atmosphere within an assimilation time window, given a background forecast valid at the start of the window and observations falling within that window. The 4D-Var data assimilation uses 12 hour windows from 09 UTC to 21 UTC and 21 UTC to 09 UTC (the following day). See section 2.2 of Hersbach et al. (2020) for further details.

Description of Quality Control procedure

The ERA5 production is monitored in weekly meetings. A large range of diagnostics is explored, ranging from:
 1) Checks that data are ingested.
 2) Checks that ingested data is of sufficiently high quality.
 3) Checks that the resulting gridded products do not show any anomalous behaviour.

Key references

- <https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3803>
- <https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation#ERA5:datado...>
- <https://www.ecmwf.int/en/elibrary/10125-ensemble-data-assimilations-ecmwf>

Uncertainty quantification

Last update on 21/09/2021

General practices and findings used to characterize and represent uncertainty in the data record

Has an uncertainty characterisation been performed?	No
Is the uncertainty characterisation based on validation data?	No

Validation Last update on 21/09/2021

Details on the validation activities performed to assess the fidelity of the data record

Have validation activities been performed?	Yes
Is there any validation material publicly available?	Yes
Short description of the methodology, including how uncertainties are dealt with	Comparison with observations, inter-comparison with other reanalysis products, scrutiny of anomalies and analysis increments. Further details can be found in Hersbach et al. (2020) and in the studies published under the special issue of the SPARC Reanalysis Intercomparison Project.
Reanalysis system bias summary, include spatial and temporal ranges over which the bias(es) applies	ERA5 bias has been assessed for specific variables and diverse spatial and temporal domains. Some of these analyses can be found in Hersbach et al. (2020), and in the studies published under the special issue of the SPARC Reanalysis Intercomparison Project (S-RIP).
One-off or routine validation	Not available yet
Key references	https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3803

 Inter-comparison Last update on 21/09/2021

Description of the comparison activities performed against peer datasets

Has a known inter-comparison activity been completed for this reanalysis system?	Yes
Inter-comparison activity	The SPARC Reanalysis Intercomparison Project (S-RIP)
Description of methods	Several diagnostics are used to assess multiple reanalyses datasets, focusing on the stratosphere, upper troposphere and lower mesosphere.
One-off or routine inter-comparison activity	One-off
Results of inter-comparison	Results for specific variables and processes are provided in the S-RIP papers and report chapters.
Key references	https://s-rip.ees.hokudai.ac.jp/index.html , https://www.atmos-chem-phys.net/special_issue829.html

Toolbox compatibility

Last update on 21/09/2021

Get to know whether the variable can be served through the Toolbox

Is (are) the data file(s) compatible with the toolbox?	monthly: Yes - daily/sub-daily: Yes
Document (monthly)	reanalysis_era5_single_levels_monthly_means-era5-2m_temperature-toolbox.pdf
Document (daily/sub-daily)	reanalysis_era5_single_levels-era5-2m_temperature-toolbox.pdf

Archive

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Archiving is associated with the capability to preserve and access CDS data, i.e. data are safeguarded against loss and kept accessible and usable for current and future applications

Description of the archiving and recovery functions and capabilities	All dataset is available in the CDS disks and can be rebuilt from the ECMWF Meteorological Archival and Retrieval System (MARS) tapes, which are physically located in a place where the Copernicus Regulation and related delegated legislation, e.g. the Copernicus Data Policy, can be enforced. The ECMWF MARS tapes have a backup as well.
Duration of the archiving period	The CDS aims to provide access to the data during a period of a few years (between 3 and 7 years). Data on the ECMWF MARS tapes are kept indefinitely.
Are archived data duplicated?	There is more than one copy of the same operational dataset, stored at different geographical locations.

Data check

Last update on 21/09/2021

Data and metadata checks performed

File(s) format(s)	grib1, netcdf3
Standard identified for the dataset category	GRIB2 standard (under development)
Is(are) the file(s) compliant with the standard identified above?	monthly: No - daily/sub-daily: No
Document (monthly)	reanalysis_era5_single_levels_monthly_means-era5-2m_temperature-standard_compliance_grib.pdf
Document (daily/sub-daily)	reanalysis_era5_single_levels-era5-2m_temperature-standard_compliance_grib.pdf
Standard identified for the dataset category	Climate and Forecast Metadata Convention v1.6 (CF-v1.6)
Is(are) the file(s) compliant with the standard identified above?	monthly: Yes - daily/sub-daily: Yes
Document (monthly)	reanalysis_era5_single_levels_monthly_means-era5-2m_temperature-standard_compliance_netcdf.pdf
Document (daily/sub-daily)	reanalysis_era5_single_levels-era5-2m_temperature-standard_compliance_netcdf.pdf
Space and time completeness (monthly)	reanalysis_era5_single_levels_monthly_means-era5-2m_temperature-spatial_temporal_completeness.pdf
Space and time completeness (daily/sub-daily)	reanalysis_era5_single_levels-era5-2m_temperature-spatial_temporal_completeness.pdf
Is (are) the data file(s) temporally consistent with the metadata?	monthly: Yes - daily/sub-daily: Yes
Document (monthly)	reanalysis_era5_single_levels_monthly_means-era5-2m_temperature-temporal_consistency.pdf
Document (daily/sub-daily)	reanalysis_era5_single_levels-era5-2m_temperature-temporal_consistency.pdf
Is (are) the data file(s) spatially consistent with the metadata?	monthly: Yes - daily/sub-daily: Yes
Document (monthly)	reanalysis_era5_single_levels_monthly_means-era5-2m_temperature-spatial_consistency.pdf
Document (daily/sub-daily)	reanalysis_era5_single_levels-era5-2m_temperature-spatial_consistency.pdf
Physical plausibility ranges (monthly)	reanalysis_era5_single_levels_monthly_means-era5-2m_temperature-valid_ranges.html
Physical plausibility ranges (daily/sub-daily)	reanalysis_era5_single_levels-era5-2m_temperature-valid_ranges.html

Expert evaluation

Last update on 21/09/2021

Scientific soundness of the data through standard diagnostics, as evaluated by field experts in the quality control function of C3S independently of the data provider

Scientific use cases

General description

Description Presentation of the methodology and set of metrics applied for the independent assessment. This assessment is an external and basic revision of the data, which is independent of the provider

Document Not available yet

Means and variability

Description Describe the fitness of the data record for calculating spatial and temporal means and variability

Document Not available yet

Trends and their limits

Description Describe the fitness of the data record for calculating trends and their limits

Document Not available yet

Applicability for Earth System Models (ESMs) evaluation

Description Describe the fitness of the data record for Earth System Models (ESMs) evaluation

Document Not available yet

Inter-comparison

General description

Description Presentation of the methodology and set of metrics applied for the independent assessment. This assessment is an external and basic revision of the data, which is independent of the provider

Document Not available yet

Inter-comparison analysis

Description Comparison of the same variable across different data records

Document Not available yet

Performance metrics

General description

Description Presentation of the methodology and set of metrics applied for the independent assessment. This assessment is an external and basic revision of the data, which is independent of the provider

Document [reanalysis_era5_single_levels_monthly_means-general_description.pdf](#)

Dynamic plots available online.

Dataset maturity

Last update on 21/09/2021

The maturity assessment of the dataset variable is performed in the following five categories: metadata, user documentation, uncertainty characterization, public access/feedback/update, usage. This entry is still under development because there is not an agreed methodology to score the maturity of all dataset types available in the CDS.

Maturity matrix

Description The maturity assessment of the dataset variable is performed in the following five categories: metadata, user documentation, uncertainty characterization, public access/feedback/update, usage. This assessment establishes to what extent the production of a data record follows best practices, based on accumulated experience by the scientific and engineering communities.

Document Not available yet

Maturity matrix inter-comparison

Description Maturity assessment of the same variable for different dataset sources

Document Not available yet

Guidance document on applying the maturity matrix

Description This is the guidance document used to assess the maturity matrix of the dataset

Document Not available yet

Key strengths and limitations

Last update on 21/09/2021

Concluding remarks and highlights arising from a basic assessment performed independently of the data provider

The independent assessment is an external and basic revision of the data, which is independent of the provider and is performed by the Evaluation and Quality Control (EQC) function of C3S. The assessment seeks to determine compliance of metadata against community standards, data consistency and unexpected gaps in space and time, data physical plausibility, dataset performance through standard diagnostics and whether the data producer follows good practices. All the details are available in the table cells above. The resulting concluding remarks are reported below and identify key strengths and limitations associated with the dataset that further guide its usage.

Key strengths and limitations

Description	Main conclusions of the independent assessment and dataset variable highlights.
Document	reanalysis_era5_single_levels-reanalysis_era5_single_levels_monthly_means-era5-2m_temperature-key_strengths_limitations.pdf
Evaluator names	reanalysis_era5_single_levels-reanalysis_era5_single_levels_monthly_means-era5-2m_temperature-evaluators.pdf