

Variable: Total precipitation

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Dataset overview		Last update on 29/06/2021
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	
Physical quantity name	Total precipitation	
Physical quantity unit	m	

Definition of physical quantity	<p>This parameter is the accumulated liquid and frozen water, comprising 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 accumulated over a particular time period which depends on the data extracted. For the monthly averaged reanalysis and ensemble members, the accumulation period is 1 day. For the monthly averaged reanalysis by hour of day, the accumulation period is 1 hour (3 hours for the ensemble members). For the hourly reanalysis, the accumulation period is over the 1 hour (3 hours for the ensemble members, mean and spread) up to the validity date and time. 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.</p>
Summary description of the dataset	<p>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.</p>
How to cite this dataset?	<p>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</p>
Are there licence conditions or terms of agreement which regulate the use of this dataset?	<p>Yes</p>
Licence	<p>https://cds.climate.copernicus.eu/api/v2/terms/static/licence-to-use-copernicus...</p>
Is the licence a Creative Commons licence?	<p>CC BY (only attribution requested)</p>
Variable domain	<p>Atmosphere</p>
Key limitations of the dataset	<p>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.</p>

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 29/06/2021

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. For monthly means over all hours, reanalysis and ensemble, this parameter is scaled to be accumulated over 1 day. For sub-daily data, this parameter is accumulated over the previous hour (reanalysis) or 3 hours (ensemble) up to the validity date and time

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 29/06/2021
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 29/06/2021
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 29/06/2021
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 appear around the end of 2021.	

User guide

Last update on 29/06/2021

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 29/06/2021

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

Is there a reanalysis technical documentation?	Yes
Link 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	https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3803 https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation https://www.ecmwf.int/en/newsletter/159/meteorology/global-reanalysis-goodbye-e...
Further details about the main system components?	Yes
Model component name	atmospheric model
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 reference document	https://www.ecmwf.int/en/elibrary/16648-part-iv-physical-processes https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3803 https://www.ecmwf.int/en/elibrary/16647-part-iii-dynamics-and-numerical-procedu...
Model component name	land surface model
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 reference document	https://www.hydrol-earth-syst-sci.net/19/389/2015/ https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3803
Model component name	wave model

Short description of the Model component	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).
Link reference document	https://rmets.onlinelibrary.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	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).
Link reference document	https://rmets.onlinelibrary.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 reference document	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?	Yes
Specify method of interpolation	Linear interpolation from the native model hybrid levels.
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 29/06/2021

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 29/06/2021

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

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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

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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-total_precipitation-toolbox.pdf
Document (daily/sub-daily)	reanalysis_era5_single_levels-era5-total_precipitation-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

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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-total_precipitation-standard_compliance_grib.pdf
Document (daily/sub-daily)	reanalysis_era5_single_levels-era5-total_precipitation-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-total_precipitation-standard_compliance_netcdf.pdf
Document (daily/sub-daily)	reanalysis_era5_single_levels-era5-total_precipitation-standard_compliance_netcdf.pdf
Space and time completeness (monthly)	Not available yet
Space and time completeness (daily/sub-daily)	Not available yet
Is (are) the data file(s) temporally consistent with the metadata?	Not available yet
Document (monthly)	Not available yet
Document (daily/sub-daily)	Not available yet
Is (are) the data file(s) spatially consistent with the metadata?	Not available yet
Document (monthly)	Not available yet
Document (daily/sub-daily)	Not available yet
Physical plausibility ranges (monthly)	Not available yet
Physical plausibility ranges (daily/sub-daily)	Not available yet

Expert evaluation

Last update on 29/06/2021

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

Not available yet

Not available yet

Dataset maturity

Last update on 29/06/2021

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 29/06/2021

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	Not available yet
Evaluator names	Not available yet