ERA5 terminology: analysis and forecast; time and steps; instantaneous and accumulated and mean rates and min /max parameters

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This article applies to the ERA5 sub-daily datasets:

- ERA5 high resolution (HRES), containing
  - sub-daily atmospheric data (stream oper)
  - sub-daily ocean wave data (stream wave)
- ERA5 ensemble (EDA), containing
  - sub-daily atmospheric data (stream enda)
  - sub-daily ocean wave data (stream ewda)

This article does not apply to ERA5 monthly data. What streams are available? (Section 'Data organisation').

Before continuing with this article you might want to read:

- ERA5 Family
- What is Ensemble forecasting
- ERA5: data documentation
- How to download ERA5

Analysis and forecast

If you access ERA5 data in the C3S Climate Data Store (CDS), you will not see the concept of type 'analysis' and 'forecast'. However, behind the scene, ERA5 data archive has two types of data available, 'analysis' (an) and 'forecast' (fc). This article will help you understand the differences between these two types.

- An **analysis,** of the atmospheric conditions, is a blend of observations with a previous forecast. **An analysis can only provide instantaneous parameters (parameters valid at a specific time, e.g temperature *at* 12:00), but not accumulated parameters, mean rates or min/max parameters**.
- A **forecast** starts with an analysis at a specific time (the 'initialization time'), and a model computes the atmospheric conditions for a number of 'forecast steps', at increasing 'validity times', into the future. A forecast can provide instantaneous parameters, accumulated parameters, mean rates, and min/max parameters.

To see which parameters are available as analysis (an) and/or forecasts (fc) see ERA5: data documentation, section 'Parameter listings'.

Instantaneous, accumulated, mean rate and min/max parameters

Each parameter is classed as either 'instantaneous', 'accumulated', 'mean rate' or 'min/max', depending on the temporal properties of the parameter:

- **Instantaneous parameters** refer to a specific *point in time* , for example temperature *at* 12:00. For a list of available surface and single level instantaneous parameters see ERA5: data documentation, Table 2.
- **Accumulated parameters** are accumulations during a particular *time period*, for example precipitation *between* 17:00 and 18:00. For a list of available accumulated parameters see ERA5: data documentation, Table 3.
- **Mean rate parameters** are temporally averaged rates over a particular *time period*, for example the mean snowfall rate *between* 17:00 and 18:00. For a list of available mean rate parameters see ERA5: data documentation, Table 4.
- **Min/max parameters** are the minimum or maximum 'instantaneous' value within a particular *time period*, for example minimum temperature *between* 17:00 and 18:00. For a list of available min/max parameters see ERA5: data documentation, Table 5.

Time and Step

'time' in analyses

Each analysis has a validity time, i.e. the time the data values refer to (not the time when the analysis was computed).

All validity times are in hours UTC.

Depending on the selected stream, ERA5 daily analysis data is available hourly (i.e. for the HRES, with validity time 00:00, 01:00, 02:00, ... , 23:00) or 3-hourly (i.e. for the EDA, with validity time 00:00, 03:00, 06:00, ... , 21:00). See also the ERA5: data documentation, 'Temporal resolution' and the ERA5 Catalogue, streams.

The concept of 'step' does not apply to analyses.

'time' in forecasts

Each forecast starts with the atmospheric conditions at a specific 'initialization time'. In ERA5 a new forecast is computed twice a day, with initialization times of 06:00 and 18:00 UTC.

In the ERA5 data archive, for forecasts, 'time' (and date) refers to the initialization time.

'step' in forecasts

Each forecast computes the future atmospheric conditions, and at certain "points", or "steps", during this computation the data is post-processed, and stored in the ERA5 data archive. In ERA5 there is a step every 1 or 3 hours, depending on the selected stream. **Note, when downloading data from the C3S Climate Data Store (CDS), 'step' does not need to be specified because data is selected according to the valid time automatically, assuming steps from 1 to 12 hours.**

Steps are referenced in hours from the forecast initialization time. This is regardless of the step interval. For example, for time=06:00, step 3 is always at 09:00 (06:00+3h).
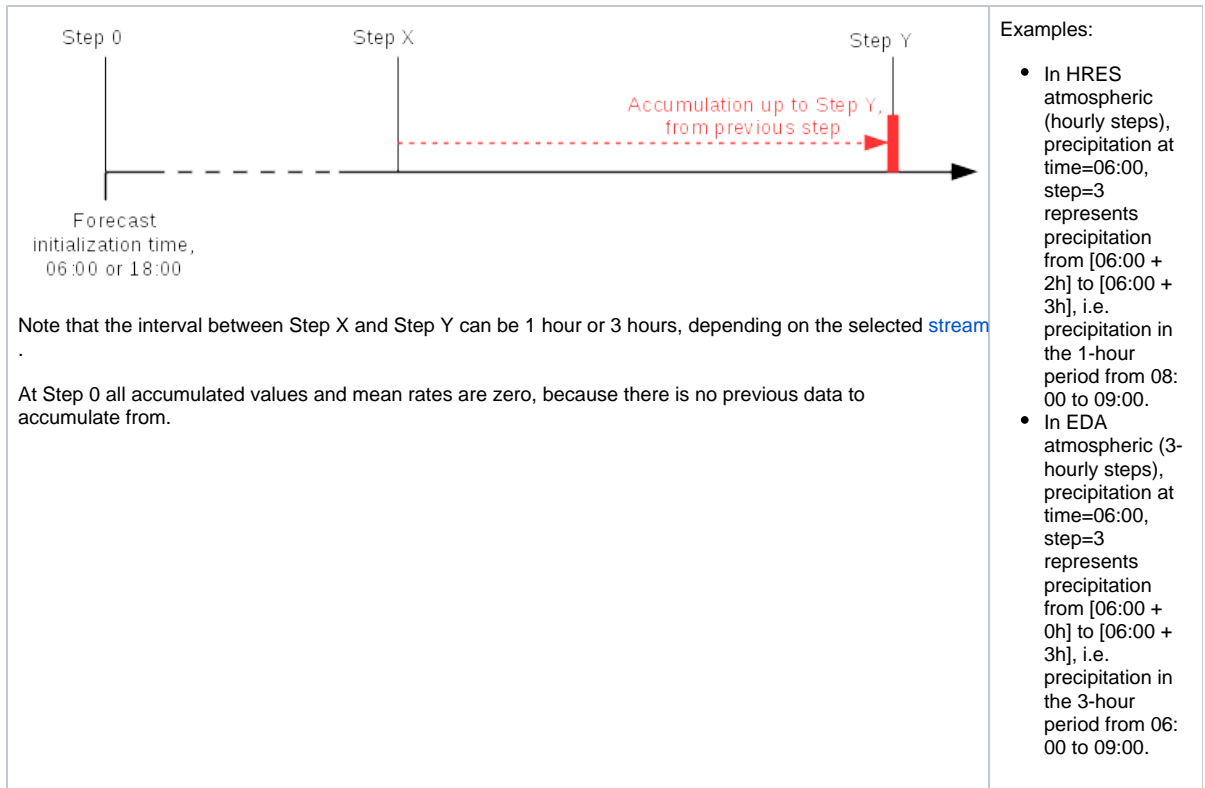
The step interval in ERA5 is:

- Every 1 hour in the HRES atmospheric (stream=oper), HRES wave (stream=wave) and EDA wave (stream=ewda) forecasts. Hence data is available with validity times 06:00 (step 0, initialization), 07:00 (step 1, i.e. initialization + 1h), 08:00 (step 2, i.e. initialization + 2h), and so on, and equivalent for the 18:00 initialization.
- Every 3 hours in the EDA atmospheric (stream=enda) forecasts. Hence data is available with validity times 06:00 (step 0, initialization), 09:00 (step 3, i.e. initialization +3h), 12:00 (step 6, i.e. initialization + 6h), and so on, and equivalent for the 18:00 initialization.

'step' and instantaneous, accumulated and min/max parameters

The interpretation of 'step' also depends on the parameter:

- **Instantaneous parameters** are valid at the time indicated by time+step. For example, temperature from the forecast at time=06:00, step=3, represents the temperature at 06:00 + 3h, i.e. at 09:00.

- **Accumulated parameters** are aggregated up to a Step Y, starting at the previous Step X:

Note that the interval between Step X and Step Y can be 1 hour or 3 hours, depending on the selected stream.

At Step 0 all accumulated values and mean rates are zero, because there is no previous data to accumulate from.

Examples:

- In HRES atmospheric (hourly steps), precipitation at time=06:00, step=3 represents precipitation from [06:00 + 2h] to [06:00 + 3h], i.e. precipitation in the 1-hour period from 08:00 to 09:00.
- In EDA atmospheric (3-hourly steps), precipitation at time=06:00, step=3 represents precipitation from [06:00 + 0h] to [06:00 + 3h], i.e. precipitation in the 3-hour period from 06:00 to 09:00.

- **Mean rate parameters** are similar to accumulated parameters, except that the quantities are averaged, instead of accumulated, up to a Step Y , from the previous Step X, so the units include "per second". For example:
    - In HRES atmospheric (hourly steps), mean rate precipitation at time=06:00, step=3 represents the average precipitation rate in the 1-hour period from 08:00 to 09:00,.
    - In EDA atmospheric (3-hourly steps), mean rate precipitation at time=06:00, step=3 represents the average precipitation rate in the 3-hour period from 06:00 to 09:00.

- **Min/max parameters** (parameters named 'Minimum/Maximum ... since previous post-processing') are similar to accumulated parameters, except that instead of accumulating, only the min/max value during the period from Step X to Step Y is archived.

Summary

- If you download ERA5 data hosted on the C3S Climate Data Store (CDS), you can either download the data using the web interface or CDS API. If you go for CDS API, you should use the web interface to help you build up the download script by making selections and then clicking the 'Show API request' button towards the end of a download form.
- If you download ERA5 data hosted outside of CDS, you can download the data using CDS API. You should then use the ERA5 catalogue to help you build up your script by making selections and then clicking the 'View the MARS request' link.

The following table summarizes the different parameter types available in ERA5 from analysis and forecast:

	Instantaneous parameters, e.g. 2m temperature	Accumulated parameters, e.g. precipitation	Mean rate parameters	Minimum/maximum parameters named 'Minimum/Maximum ... since previous post-processing'
Analysis *Calculated from observations and previous forecasts* *'time' indicates a specific point in time for which a data analysis is carried out* *'time' is hourly, HH:00* *'step' does not apply*	For example '2 metre temperature'. Values are valid at 'time'	n.a.	n.a.	n.a.

Forecast *Calculated from analysis and the forecast model* *'time' indicate a specific point in time at which a forecast starts (initialization time)* *'time' can be 06:00 or 18:00* *'step' indicates hours after the initialization time.*	For example '2 metre temperature'. Values are valid at 'time'+'step' 'step' is in the range 0 to 18 (hours after initialization)	For example 'Total precipitation'. Values represent the accumulation up to 'time'+'step', from the previous 'step' 'step' is in the range 0 to 18 (hours after initialization) At 'step' 0 all data is zero.	For example 'Mean total precipitation rate'. Values represent the average rate up to 'time'+'step', from the previous 'step' 'step' is in the range 0 to 18 (hours after initialization) At 'step' 0 all data is zero.	For example 'Maximum temperature at 2 metres since previous post-processing'. Values represent the Min/Max in the period up to 'time'+'step', starting from the previous 'step' 'step' is in the range 0 to 18 (hours after initialization) At 'step' 0 all data is zero.

See also

The family of ERA5 datasets

ERA5: data documentation

How to download ERA5 data via the ECMWF Web API

Related articles

- C3S Documentation Centre
- C3S Knowledge Base (CKB)
- C3S Seasonal Forecast known issues
- C3S User Support Journey
- Climate Data Store (CDS) API Keywords