ERA5: surface elevation and orography

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In ERA5, and often in meteorology, altitudes (the altitude of the land and sea surface, or specific altitudes in the atmosphere) are not represented as geometric altitude (in metres above the spheroid), but as geopotential height (in metres above the geoid). However, ECMWF archive the geopotential (in m^2/s^2), not the geopotential height. Notice geopotential is called orography in the Climate Data Store (CDS).

How to calculate surface geopotential height

In order to calculate the geopotential height of the land and sea surface (the so called surface geopotential height, or orography):

- First, download orography (i.e. surface geopotential, the geopotential of the land and sea surface).
- Then divide the surface geopotential by g=9.80665 to obtain the surface geopotential height in metres.

Surface elevation datasets used by ERA5

In order to define the surface geopotential in ERA5, the ECMWF model uses surface elevation data interpolated from a combination of SRTM30 and other surface elevation datasets. For more details please see the IFS model documentation, Cycle 41r2, Part IV. Physical processes, section 11.2.2 Surface elevation data at 30 arc seconds.

Spatial reference systems

The ECMWF model assumes the Earth is a perfect sphere, but the geodetic latitude/longitude of the surface elevation datasets are used as if they were the spherical latitude/longitude of the ECMWF model.

ECMWF data is referenced in the horizontal with respect to the WGS84 ellipse (which defines the major/minor axes) but in the vertical it is referenced to the Geoid (EGM96).

Earth model

For data in GRIB1 format the earth model is a sphere with radius = 6367.47 km, as defined in the WMO GRIB Edition 1 specifications, Table 7, GDS Octet 17

For data in GRIB2 format the earth model is a sphere with radius = 6371.2290 km, as defined in the WMO GRIB2 specifications, section 2.2.1, Code Table 3.2, Code figure 6.

For data in NetCDF format (i.e. converted from the native GRIB format to NetCDF), the earth model is inherited from the GRIB data.

Notes

- The surface geopotential is also available on model levels (at level=1), where it is archived in spectral form.
- For further documentation on surface and single level parameters see the ERA5 data documentation.
- The model levels are hybrid pressure/sigma. See the documentation of the underlying model, ECMWF's IFS, cycle 41R2, Part III. Dynamics and numerical procedures, Chapter 2 Basic equations and discretisation
- The definition of the 137 model levels used in ERA5, and the corresponding half-level, ph, and full-level, pf, values of pressure (for a standard atmosphere with a surface pressure of 1013.250 hPa), geometric and geopotential heights can be found at https://www.ecmwf.int/en/forecasts/documentation-and-support/137-model-levels

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