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in climate services

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1. Introduction

Within the European Union funded project UERRA, various long-term period reanalysis data sets were produced with a focus on the uncertainties of reanalyses. The intent of this document is to give an initial aid for the handling of the UERRA data output and to answer frequently asked questions. The included topics show how to get the data, handle it and use it for climate applications. An overview of the reanalysis products can be found in the deliverable reports D3.8 (User friendly synthesis report, delivered in January 2018) and D8.4 (Guidance material), including the temporal and spatial coverage or resolution, the used NWP models and assimilation systems.

2. Getting Data access

The UERRA products are freely available at the MARS archive of ECMWF <https://apps.ecmwf.int/datasets/data/uerra>. Data of interest can be downloaded via the web-based user interface or a MARS request. For larger amount of data the use of MARS request is recommended. Specific information for an efficient request is provided under <https://software.ecmwf.int/wiki/display/WEBAPI/Retrieval+efficiency>. Example of an UERRA request for the COSMO-REA12 global radiation forecast fields is shown below:

```
retrieve,
  class=ur,                ( class ur denotes the UERRA data sets)
  date=2008-01-01/to/2008-08-31, ( this specifies the selected time steps)
  expver=prod,            ( names the production datasets)
  levtype=sfc,           (choose between pressure, height, soil or surface lev)
  number=0,              ( number of ens. Member; 0 is the control run)
  origin=edzw,           (edzw=COSMO, eswi=Harmonie, eswi=Mesan,
                          ifpw=Mescan/Surfex, egr=UM)

  param=169,             (parameter 169 named the global radiation)
  step=1/2/3/4/5/6,     ( which forecast steps are chosen)
  stream=enda,          (deterministic or ensemble data)
  time=00:00:00/06:00:00/12:00:00/18:00:00,
  type=fc,              ( forecast or analysis files are provided)

target="CENREA12_globalRadiation_fc_2008-01.grb"
```

A short description of the model parameters, the output frequency and basic information on the participating models can be found at:

<https://software.ecmwf.int/wiki/display/UER/Description>



3. Handling the data format

The UERRA data sets in the MARS archive are saved in standard binary format GRIB Version 2 (General Regularly-distributed Information in Binary form), which is the WMO compliant format. The files are self-explanatory, in the sense that all required metadata is included. In contrast to the old GRIB Version 1 format, Version 2 also allows the encoding of ensemble forecasts or unstructured grid types. For the handling of GRIB data various programs are available, for example wgrib/wgrib2 (NOAA), GRIB-API/ecCodes (ECMWF) or climate data operators (CDO, by MPI-Meteorology Hamburg). In the following, a list of helpful commands is shown, including the basic tools for reading and manipulating the data.

CDO (Climate data operators)

CDO provides many operators for selection, modification or statistical computation of GRIB and NetCDF data. For the use with GRIB2 data CDO has to be installed with

GRIB-API <https://software.ecmwf.int/wiki/display/GRIB/Releases> or ecCodes <https://software.ecmwf.int/wiki/display/ECC/Releases>.

Download: <https://code.mpimet.mpg.de/projects/cdo/files>

Documentation: https://code.mpimet.mpg.de/projects/cdo/embedded/cdo_refcard.pdf

Examples:

- Checking for correct installation and required libraries:

```
cdo -- version
```

- Converting GRIB to NetCDF file:

```
cdo -f nc copy file.grb file.nc
```

- Cutting a smaller model area with specific corners in southwest (lon1,lat1) and northeast (lon2,lat2):

```
cdo sellonlatbox,lon1,lon2,lat1,lat2 infile outfile
```

- Information about model grid and model variables:

```
cdo griddes infile or cdo sinfon infile
```



- Computing wind speed from horizontal wind components U, named `uwnd` in `infile1`, and V, named `vwnd` in `infile2` and save it with variable name `ws` in `outfile`:

```
cdo chname,uwnd,ws -sqrt -add -sqr -selname,uwnd infile1 -sqr -selname,vwnd infile2 outfile
```

- Selecting specific time steps, here day three to five of `infile`:

```
cdo selday,3,4,5 infile outfile
```

- Projecting rotated grid to regular lon-lat grid:

```
cdo remapcon,outgrid.txt infile.grb outfile.remap.grb
```

The text file `outgrid.txt` contains the properties of the new grid. The example below shows a non-rotated lon-lat grid with 500x500 grid cells, a resolution of 0.11° and the corner in southwest has the coordinates 30°W and 30°N.

outgrid.txt:

gridtype =	lonlat
xsize =	500
ysize =	500
xfirst =	-30
yfirst =	30
xinc =	0.11
yinc =	0.11

GRIB-API und ecCodes

ecCodes is a software tool, developed by ECMWF. It is the further development of GRIB-API and can be used for decoding data in GRIB and BUFR format. The support for GRIB-API will discontinue at the end of 2018, so the preference of ecCodes is strongly recommended.

Download and documentation:

<https://software.ecmwf.int/wiki/display/ECC/ecCodes+Home>



Examples:

- Converting GRIB to NetCDF file:

```
grib_to_netcdf -o output.nc input.grib
```

- Listing data input and further information e.g. date, level, name of variables, gridtype, ...

```
grib_ls input.grb
```

- Finding next point to specific longitude-latitude (here: 50.5N, 12.34E). This operator can be used for non-rotated grids only. For application to UERRA fields first a projection via cdo to non-rotated grid has to be done.

```
grib_ls -l 50.5,12.34,1 input.grb
```

- Selecting first three time steps and saving to new file:

```
grib_copy -w count=1/2/3 input.grb output.grb
```

Python

For further processing of UERRA data with Python, special libraries for handling GRIB data can be used:

<https://pypi.python.org/pypi/pygrib>

R

For further processing with R, the conversion of GRIB to NetCDF may be sensible, in order to use available and conventional libraries for reading NetCDF files:

```
library(ncdf4) or library(RNetCDF)
```

Matlab

Download and documentation of routines for Matlab NetCDF/GRIB reader:

<http://www.mathworks.com/matlabcentral/fileexchange/21579-netcdf-grib-reader>

IDL

Download and documentation of routines for IDL:

http://www.harrisgeospatial.com/docs/GRIB_Routines.html



4. Getting the ‘right’ coordinates

The UERRA data sets are saved with non regular grids. Model data based on the COSMO model (by UB and DWD) and those based on the Unified model (by MetOffice) are saved with a rotated pole grid. The rotation of the pole minimizes the converging of the longitudes and thus ensures that the grid cells are nearly uniform. The Harmonie and the Mescan model use a Lambert conformal conic projection. For the comparison of model data with observations the longitude and latitude information in the observation space is needed. Therefore, a python script developed at ECMWF <https://software.ecmwf.int/wiki/display/GRIB/iterator.py> is used. It computes the longitude-latitude information for each grid cell, using the metadata grid information that is saved in the GRIB file. The output will be an ASCII file, with pairs of lon-lat coordinates in the non rotated grid for each grid cell of the input data file. The python script is used as follows:

1. Adapt the name of the input file in the python script. The input file should only include one time step.
2. Execute the python script and select the name of the output file.

```
./iterator.py > output.txt
```
3. Be aware of different grids for various variables but the same model. This difficulty occurs due to the use of Arakawa B and C grid for the storage of different output variables.

5. Working with aggregated variables

For precipitation, evaporation, snow water equivalent or radiation parameters the UERRA datasets only provide aggregated values for 6-hour forecast cycles. The parameter definition (instantaneous or aggregated) can be checked at: <https://software.ecmwf.int/wiki/display/UER/Surface+level+parameters>. All aggregated parameters are only available for the forecast data files, (type=fc in MARS request). For the computation of hourly values the following step is helpful and applicable for each 6-hour forecast cycle:

```
cdo abs -sub infile.hour.grb infile.hour-1.grb outfile.hour.grb
```

This CDO command calculates the absolute deviation between a selected time step and the previous one. The procedure guarantees that the accumulated variable from time steps 0-6 (or 7-12, 13-18, 19-24) is split into 6 hourly values. The first, seventh, thirteenth or nineteenth time step do not need any further calculation because no summation is existent for these time steps. When using CDO for the splitting of accumulated variables it is recommended to check the variables *dataTime* and *dataDate* afterwards, because the correct use of time stamps for the accumulated time periods is important.



6. Plotting parameter fields

At the very beginning it is often helpful to view the new datasets to get a first impression of the model domain, the value ranges or the large scale structures. Also for visual intercomparison with other datasets a simple view of the data is useful. Therefore the software ncview (download and documentation under http://meteora.ucsd.edu/~pierce/ncview_home_page.html) offers a simple and quick solution, although it is only applicable for NetCDF files. A simple example of the ncview menu and the plot of the COSMO-REA12 10m windspeed in January 2007 is shown here:

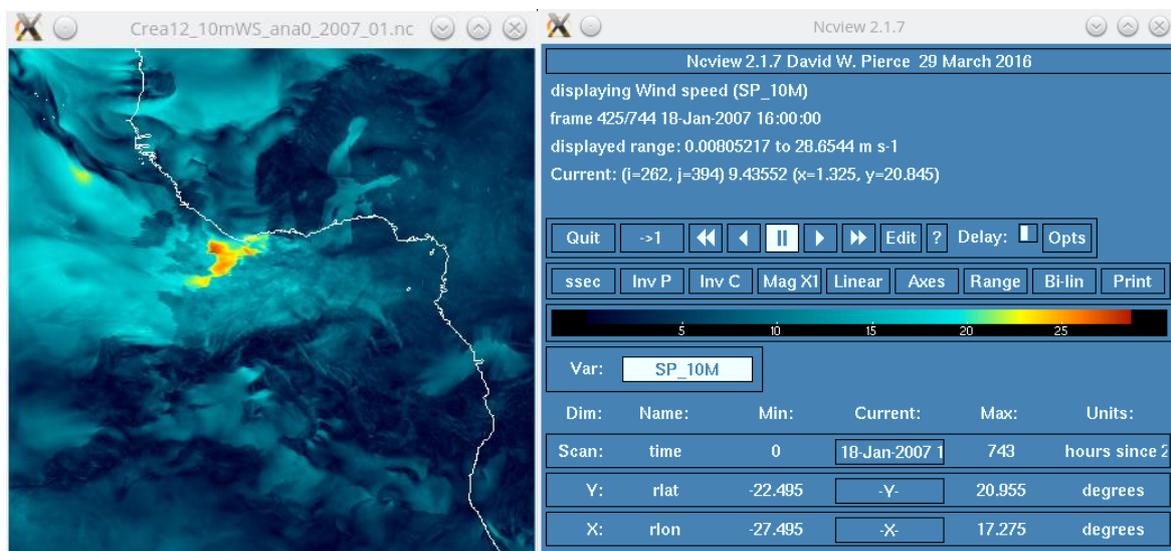


Figure 1: Menu of ncview (right) and example plot (left)

The menu offers information about the shown time step (18.1.2007 16:00), the colour scale, the variable name in the NetCDF file (SP_10M), and the dimensions of the field. In this example a white line, illustrating the coastline of Western Africa, is visible, which is an indicator for the rotated grid of the reanalysis field. Using the “opts” button in the menu, the coastlines can be turned off and also the colour range can be adapted.

7. Summary

After getting used to downloading and handling the data format, the clear structure of the UERRA data archive should allow a convenient use of UERRA reanalysis data sets. The various products have all the same data format definitions and variable names. In addition to the model specific model levels, they also provide parameter fields at the commonly defined height levels and pressure levels. This simplifies the comparison of the different models and should allow users to extend evaluation towards other data sets with little effort.