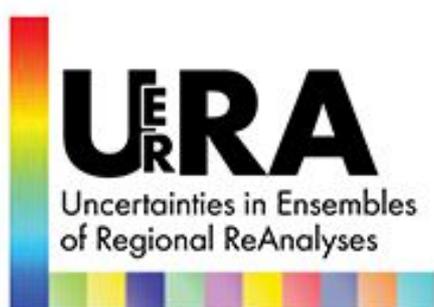Seventh Framework Programme

Theme 6

Project: 607193 UERRA

Deliverable D4.5: Indices based on reanalysis data, including uncertainty information

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Table of Contents

1. Introduction

This document describes the methods used to derive climate indices from a selection of the available reanalyses produced within UERRA. Due to the delayed archiving in MARS and the slow performance of retrieving the data from MARS and transferring it to KNMI limited the calculation of climate indices to only a few years. Climate indices based on daily minimum and maximum temperature and precipitation were calculated.

A recurring problem is the interaction with the MARS archive. Extracting data from MARS is often tedious and slow. A considerable amount of time was wasted on data recovery from MARS which turned out to be incomplete, and therefore useless for further processing (like aggregation). Another issue which slowed progress was the lack of a standard conversion between GRIB and NetCDF. While some software was shared between institutes, the correct configuration of this software was not always clear.

While the MARS archive is valuable, a more efficient and direct data exchange between the producers of reanalyses and the limited amount of users (within the project) would have facilitated this work. Furthermore, putting the obligation to provide software to transfer data from GRIB to NetCDF (or the provision of data in both formats) to the data producers rather than the data users would increase efficiency. An example script to extract e.g. hourly (minimum) temperature values would have been useful as well.

The focus for the indices calculations was on 2006-2010 and on the reanalyses which had an ensemble available, but due to the time available before the end of the project and disc space needed to store the raw data and derived products, this time period was not possible for all ensemble datasets. Unfortunately, trend calculations do not seem realistic with the limited time period that is available for the reanalyses. Also part of the indices cannot be determined since these will need a 30 year reference period for each dataset which is not available in the archive.

2. Downloading data form the ECMWF MARS System

The UERRA datasets created by project partners are stored on the ECMWF Meteorological Archival and Retrieval System (MARS). MARS is the main repository of meteorological data at ECMWF. It contains petabytes of operational and research data, as well as data from Special Projects. Users can browse the Archive catalogue (describing archive data that ECMWF can distribute) or the complete MARS catalogue (authorization required) from dedicated servers. MARS exposes a Web API, which has been used to download the UERRA datasets.

Methods for access to data on the MARS archive are described on the ECMWF web site: .

UERRA data in the MARS archive can be browsed manually with a web browser, for example by pointing your browser to . Data retrieval can also be scripted with Python scripts; this can be useful for large or complex retrievals.

As an example we will use a browser to search hourly maximum temperature model data for the ensemble model analysis by UKMO for the period 2006-2010:

1. Select as version: **prod** for definitive data.
2. Select as origin: **UKMO**.

3. Select **Atmospheric model** from **Ensemble data assimilation**.
4. Select **Forecast** from **Forecasts**.
5. Select the year **2006**
6. Select the month **January**
7. Select the type of level **Surface**
8. Select a date
9. Select all 4 times and 4 steps
10. Select **Maximum temperature at 2 metres since previous post-processing**
11. Select all 20 numbers
12. Select **View the MARS request** to view the input needed to do a MARS request for the selected data. This information could be also used to help making a Python script for retrieving the same data.
    The MARS request for this data retrieval looks like:

retrieve,
class=ur,
date=2006-01-01/to/2006-01-31,
expver=prod,
levtype=sfc,
number=1/2/3/4/5/6/7/8/9/10/11/12/13/14/15/16/17/18/19/20,
origin=egrr,
param=201,
step=1/2/3/4/5/6,
stream=enda,
time=00:00:00/06:00:00/12:00:00/18:00:00,
type=fc,
target="output"

Data can be extracted from the MARS Web API using a Python script. An example script for retrieving the same data, but for the period 2006-2010 is:

```python
#!/usr/bin/env python
from ecmwfapi import ECMWFService
from datetime import date,timedelta
import calendar

server = ECMWFService("mars")

years=[y for y in range(2006,2011)]
months=[m for m in range(1,13,1)]

for yr in years:
 for m in months:
  t_start=date(yr, m, 1)
  dt_start=t_start.strftime("%Y%m%d")
  weekday,monthlength=calendar.monthrange(yr,m)
  t_end=t_start+timedelta(days=(monthlength-1))
  dt_end=t_end.strftime("%Y%m%d")
  server.execute(
  {
   "class":"ur",
   "date":"%s/to/%s"%(t_start.isoformat(), t_end.isoformat()),
   "expver":"prod",
   "levtype":"sfc",
   "number":"0/1/2/3/4/5/6/7/8/9/10/11/12/13/14/15/16/17/18/19/20')",
   "origin":"egrr",
   "param":"201",
```

```
  "step":"1/2/3/4/5/6",
  "stream":"oper",
  "time":"00:00:00/06:00:00/12:00:00/18:00:00",
  "type":"fc",
 },
 "mx2t_fc_egrr_%s_%s_ens.grib"%(dt_start, dt_end))
```

This python script will retrieve monthly GRIB files from the MARS-archive.

3. Data conversion from GRIB to NetCDF

The tool Fimex () is used to convert the grib files to NetCDF files. This tool can also be used to add metadata required for publishing files in the ESGF node at the same time as the NetCDF file is created.

Calling Fimex from the command line:

```
fimex --input.config=cdmGribReaderConfig.xml --input.file="glob: mx2t_fc_egrr_2006*_ens.grib" --input.printCS
--ncml.config=UERRA_mx2t_UKMO_ens.ncml --output.config=cdmWriterConfig.xml --output.file  mx2t_01h_egrr_2006_ens.nc
```

This Fimex call uses an XML configuration file, which specifies the conversion from GRIB to NetCDF. Also a ncml configuration file is used.

An example of the Fimex configuration files used for conversion can be found in Appendix A and B:

4. Reorganising the NetCDF files

Several post-processing steps are done using the Climate Data Operators tool (CDO, https://code.mpimet.mpg.de/projects/cdo/wiki/Cdo#Documentation) and the NetCDF Operators tool (NCO, http://nco.sourceforge.net/nco.html).

The first step is to combine all available years into one file to be able to correctly calculate daily values from the 24 hourly values, especially for the change from one year to the next. This merging was done using *CDO mergetime*. Daily values were derived from the resulting file using *CDO daymax* (or *daymean*, *daymin* or *daysum*, depending on the parameter). The individual ensemble members had to be split up into separate NetCDF files as the indices codes cannot handle this additional dimension. *CDO splitlevel* was used for that.

To remove the ensemble dimension from the individual ensemble files, we used:

```
ncwa -O -C -v longitude,latitude,time,air_temperature_2m -a ensemble_member <inputfile> <outputfile>
```

The original reanalysis files are on a rotated grid. Since the indices code can only handle regular latitude-longitude grid, we had to remap the files onto that regular grid. *CDO remapbil* was used with the following grid definitions:

UKMO:

```
gridtype  = lonlat
xname     = longitude
xlongname = Longitude values
xunits    = degrees_east
yname     = latitude
ylongname = Latitude values
yunits    = degrees_north
xsize     = 928
ysize     = 402
xfirst    = -40.375
```

```
xinc    = 0.125
yfirst  = 25.375
yinc    = 0.125
```

DWD:

```
gridtype  = lonlat
xsize     = 400
ysize     = 370
xfirst    = -13
xinc      = 0.11
yfirst    = 30
yinc      = 0.11
```

Furthermore, the *units*, *standard_name* and *lon_name* attributes had to be added to NetCDF variables for which *ncatted* was used. The last step before the indices could be derived was changing the files to classic NetCDF-4 format using *nccopy -k nc7*.

5. Deriving climate indices

When all the NetCDF files are reorganised the actual climate indices can be derived. The python code ICCLIM (http://icclim.readthedocs.io/en/latest/) was used here. Where possible, the indices were calculated annually and seasonally. The indices used are:

- TX (Maximum temperature)
- TXx (Maximum of daily maximum temperature)
- TXn (Minimum of daily maximum temperature)
- SU (Summer days, days with TX > 25 ˚C)
- CSU (Maximum number of consecutive summer days)
- ID (Ice days, days with TX < 0 ˚C)
- TN (Minimum temperature)
- TNn (Minimum of daily minimum temperature)
- TNx (Maximum of daily minimum temperature)
- FD (Frost days, days with TN < 0 ˚C)
- TR (Tropical nights, days with TN > 20 ˚C)
- CFD (Consecutive frost days)
- PRCPTOT (Total precipitation in wet days (RR ≥ 1 mm))
- RR1 (Number of wet days)
- SDII (Simple daily intensity index, mm/wet day)
- R10mm (Number of days with ≥ 10 mm)
- R20mm (Number of days with ≥ 20 mm)
- RX1day (Maximum 1-day precipitation amount)
- RX5day (Maximum 5-day precipitation amount)
- CDD (Maximum number of consecutive dry days (RR < 1 mm))
- CWD (Maximum number of consecutive wet days)

The final python call looks like:

```
#!/usr/bin/python

import netCDF4
import ctypes
import icclim
import datetime
import icclim.util.callback as callback

icclim.indice(indice_name='TXx',
              in_files='tx_days_2006-2010_UKMO_ens01_latlongrid.nc',
              var_name='tx',
              slice_mode='year',
              time_range=[20060101,20101231],
              out_file='txx_UKMO_ens01_20060101-20101231_year_latlongrid.nc',
              callback=callback.defaultCallback2)
```

To combine the resulting individual ensemble files into one finial NetCDF file, the following commands were used:

```
ncecat -0 txx_UKMO_ens??_20060101-20101231_year_latlongrid.nc txx_UKMO_all_ens_20060101-20101231_year_latlongrid.nc
ncwa -0 –a record txx_UKMO_all_ens_20060101-20101231_year_latlongrid.nc
ncap2 -O -s 'record=array(1,1,$record)' txx_UKMO_all_ens_20060101-20101231_year_latlongrid.nc txx_test.nc
mv txx_test.nc txx_UKMO_all_ens_20060101-20101231_year_latlongrid.nc
```

6. Summary

Several climate indices have been calculated for part of the available UERRA reanalyses datasets. These are the available indices per dataset and time period:

TX (Maximum temperature)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON
DWD (2006-2008, 20 ensemble members)   Annual DJF MAM JJA SON
E-OBS (2006-2010, 100 ensemble members)   Annual DJF MAM JJA SON

TXx (Maximum of daily maximum temperature)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON
DWD (2006-2008, 20 ensemble members)   Annual DJF MAM JJA SON
E-OBS (2006-2010, 100 ensemble members)   Annual DJF MAM JJA SON

Txn (Minimum of daily maximum temperature)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON
DWD (2006-2008, 20 ensemble members)   Annual DJF MAM JJA SON
E-OBS (2006-2010, 100 ensemble members)   Annual DJF MAM JJA SON

SU (Summer days)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON
DWD (2006-2008, 20 ensemble members)   Annual DJF MAM JJA SON
E-OBS (2006-2010, 100 ensemble members)   Annual DJF MAM JJA SON

CSU (Consecutive Summer Days)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON
DWD (2006-2008, 20 ensemble members)   Annual DJF MAM JJA SON

E-OBS (2006-2010, 100 ensemble members)   Annual DJF MAM JJA SON

ID (Ice Days)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON
DWD (2006-2008, 20 ensemble members)   Annual DJF MAM JJA SON
E-OBS (2006-2010, 100 ensemble members)   Annual DJF MAM JJA SON

TN (Minimum temperature)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

TNn (Minimum of daily minimum temperature)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

TNx (Maximum of daily minimum temperature)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

FD (Frost days)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON
E-OBS (2006, 100 ensemble members)   Annual

TR (Tropical nights)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON
E-OBS (2006, 100 ensemble members)   Annual

CFD (Consecutive frost days)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON
E-OBS (2006, 100 ensemble members)   Annual

PRCPTOT (Total precipitation in wet days)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

RR1 (Number of wet days)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

SDII (Simple daily intensity index)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

R10mm (Number of days with >10 mm)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

R20mm (Number of days with >20 mm)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

RX1day (Maximum 1-day precipitation)
UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

RX5day (Maximum 5-day precipitation)

UKMO (2006-2010, 20 ensemble members)	Annual DJF MAM JJA SON

CDD (Consecutive dry days)

UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

CWD (Consecutive wet days)

UKMO (2006-2010, 20 ensemble members)   Annual DJF MAM JJA SON

The gzipped NetCDF files can be downloaded from http://www.ecad.eu/uerra/uerra_indices.php

Visualization for the indices annual summer days and annual ice days is provided as well.

- Go to http://euro4mvis.knmi.nl
- Click on ADAGUC Viewer
- Click on Add layers... (top left corner)
- Click on UERRA

A layer is shown with annual number of Ice Days for DWD. The map shown can be changed by selecting a different layer from the layer dropdown menu, choosing from the directory *NativeLatLonGrid*. The legend can changed by clicking on the cog wheel.

7. Appendices

Appendix A – Fimex XML configuration file for adding DRS Metadata to NetCDF files

```xml
<?xml version="1.0" encoding="UTF-8"?>
<cdmGribReaderConfig xmlns="http://www.met.no/schema/fimex/cdmGribReaderConfig"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<!--         xsi:schemaLocation="http://www.met.no/schema/fimex/cdmGribReaderConfig cdmGribReaderConfig.xsd"> --><processOptions>
  <!-- parameters to select: all, definedOnly -->
  <option name="selectParameters" value="all" />
</processOptions>
<overrule>
  <!-- use these values instead of the values in the grib-messages -->
  <!-- <earthFigure proj4="+ellps=WGS84 +towgs84=0,0,0" /> -->
</overrule>
<global_attributes>
  <attribute name="Conventions" value="CF-1.6" type="string" />
  <attribute name="Activity" value="uerra" type="string" />
  <attribute name="title" value="unknown" type="string" />
  <attribute name="min_time" value="%MIN_DATETIME(%Y-%m-%d %H:%M:%SZ)%" type="string" />
  <attribute name="max_time" value="%MAX_DATETIME(%Y-%m-%d)%" type="string" />
  <attribute name="time_coverage_start" value="%MIN_DATETIME(%Y%m%d)%" type="string" />
  <attribute name="time_coverage_end" value="%MAX_DATETIME(%Y%m%d)%" type="string" />
  <attribute name="cdm_datatype" value="grid" type="string"/>
  <attribute name="references" value="unknown" type="string" />
<!--  <attribute name="history" value="" type="string"/>-->
  <attribute name="comment" value="none" type="string" />
  <attribute name="institution" value="SMHI" type="string" />
  <attribute name="institution_url" value="http://www.smhi.se" type="string" />
  <attribute name="contact" value="per.unden@smhi.se" type="string" />
  <attribute name="contributor_name" value="" type="string" />
  <attribute name="contributor_role" value="" type="string" />
</global_attributes>
```

```xml
<axes>
<time id="time" name="time" type="double">
   <attribute name="long_name" value="time" type="string" />
   <attribute name="standard_name" value="time" type="string" />
<!-- adapt the time-unit as needed, i.e. -->
<!-- <attribute name="units" value="hours since 2007-05-16 00:00:00 +00:00" type="string" /> -->
   <attribute name="units" value="seconds since 1970-01-01 00:00:00 +00:00" type="string" />
</time>
<spatial_axis typeOfGrid="lambert" id="x" name="x" type="float">
   <attribute name="long_name" value="x-coordinate in Cartesian system" type="string" />
   <attribute name="standard_name" value="projection_x_coordinate" type="string" />
   <attribute name="units" value="m" type="string" />
</spatial_axis>
<spatial_axis typeOfGrid="lambert" id="y" name="y" type="float">
   <attribute name="long_name" value="y-coordinate in Cartesian system" type="string" />
   <attribute name="standard_name" value="projection_y_coordinate" type="string" />
   <attribute name="units" value="m" type="string" />
</spatial_axis>
<spatial_axis typeOfGrid="mercator" id="x" name="x" type="float">
   <attribute name="long_name" value="x-coordinate in Cartesian system" type="string" />
   <attribute name="standard_name" value="projection_x_coordinate" type="string" />
   <attribute name="units" value="m" type="string" />
</spatial_axis>
<spatial_axis typeOfGrid="mercator" id="y" name="y" type="float">
   <attribute name="long_name" value="y-coordinate in Cartesian system" type="string" />
   <attribute name="standard_name" value="projection_y_coordinate" type="string" />
   <attribute name="units" value="m" type="string" />
</spatial_axis>
<spatial_axis typeOfGrid="polar_stereographic" id="x" name="x" type="float">
   <attribute name="long_name" value="x-coordinate in Cartesian system" type="string" />
   <attribute name="standard_name" value="projection_x_coordinate" type="string" />
   <attribute name="units" value="m" type="string" />
</spatial_axis>
<spatial_axis typeOfGrid="polar_stereographic" id="y" name="y" type="float">
   <attribute name="long_name" value="y-coordinate in Cartesian system" type="string" />
   <attribute name="standard_name" value="projection_y_coordinate" type="string" />
   <attribute name="units" value="m" type="string" />
</spatial_axis>
<spatial_axis typeOfGrid="regular_ll" id="x" name="longitude" type="float">
   <attribute name="long_name" value="longitude" type="string" />
   <attribute name="units" value="degrees_east" type="string" />
</spatial_axis>
<spatial_axis typeOfGrid="regular_ll" id="y" name="latitude" type="float">
   <attribute name="long_name" value="latitude" type="string" />
   <attribute name="units" value="degrees_north" type="string" />
</spatial_axis>
<spatial_axis typeOfGrid="rotated_ll" id="x" name="rlon" type="float">
   <attribute name="long_name" value="rotated longitude" type="string" />
   <attribute name="standard_name" value="grid_longitude" type="string" />
   <attribute name="units" value="degrees" type="string" />
</spatial_axis>
<spatial_axis typeOfGrid="rotated_ll" id="y" name="rlat" type="float">
   <attribute name="long_name" value="rotated latitude" type="string" />
   <attribute name="standard_name" value="grid_latitude" type="string" />
   <attribute name="units" value="degrees" type="string" />
</spatial_axis>
<spatial_axis id="longitude" name="longitude">
   <attribute name="valid_max" value="180." type="float" />
   <attribute name="valid_min" value="-180." type="float" />
   <attribute name="long_name" value="longitude" type="string" />
   <attribute name="standard_name" value="longitude" type="string" />
   <attribute name="units" value="degree_east" type="string" />
</spatial_axis>
<spatial_axis id="latitude" name="latitude">
   <attribute name="valid_max" value="90." type="float" />
   <attribute name="valid_min" value="-90." type="float" />
   <attribute name="long_name" value="latitude" type="string" />
   <attribute name="standard_name" value="latitude" type="string" />
   <attribute name="units" value="degree_north" type="string" />
```

```xml
</spatial_axis>
<!-- grib2 code table 4.5; grib1 code table 3 / 3a -->
<vertical_axis id="surface" name="surface" grib2_id="1" grib1_id="1" type="short">
  <attribute name="_FillValue" value="-32767" type="short" />
  <attribute name="description" value="ground or water surface" type="string" />
  <attribute name="long_name" value="surface" type="string" />
  <attribute name="positive" value="up" type="string" />
  <attribute name="units" value="m" type="string" />
</vertical_axis>
<vertical_axis id="isotherm_0C_level" name="isotherm_0C_level" grib1_id="4" grib2_id="4" type="short">
  <attribute name="_FillValue" value="-32767" type="short" />
  <attribute name="description" value="level of 0degreeC isotherm" type="string" />
  <attribute name="long_name" value="isotherm 0C" type="string" />
  <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="maximum_wind_level" name="maximum_wind_level" grib1_id="6" grib2_id="6" type="short">
  <attribute name="_FillValue" value="-32767" type="short" />
  <attribute name="long_name" value="max wind level" type="string" />
  <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="tropopause" name="tropopause" grib1_id="7" grib2_id="7" type="short">
  <attribute name="_FillValue" value="-32767" type="short" />
  <attribute name="long_name" value="Tropopause" type="string" />
  <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="top_of_atmosphere" name="top_of_atmosphere" grib2_id="8" grib1_id="8" type="short">
  <attribute name="_FillValue" value="-32767" type="short" />
  <attribute name="long_name" value="nominal top of atmosphere" type="string" />
  <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="isotherm_percK_level" name="isotherm_percK_level" grib1_id="20" type="short">
  <attribute name="_FillValue" value="-32767" type="short" />
  <attribute name="description" value="level of 1/100K isotherm" type="string" />
  <attribute name="long_name" value="isotherm %K" type="string" />
  <attribute name="units" value="1/100 K" type="string" />
  <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="mean_sea_level" name="mean_sea_level" grib2_id="101" grib1_id="102" type="short">
  <attribute name="_FillValue" value="-32767" type="short" />
  <attribute name="description" value="mean sea level" type="string" />
  <attribute name="long_name" value="mean_sea_level" type="string" />
  <attribute name="positive" value="up" type="string" />
  <attribute name="units" value="m" type="string" />
</vertical_axis>
<vertical_axis id="pressure" name="pressure" grib2_id="100" grib1_id="100" type="float">
  <!-- Isobaric level -->
  <attribute name="description" value="pressure" type="string" />
  <attribute name="long_name" value="pressure" type="string" />
  <attribute name="standard_name" value="air_pressure" type="string" />
  <attribute name="positive" value="down" type="string" />
  <grib1>
    <attribute name="units" value="hPa" type="string" />
  </grib1>
  <grib2>
    <attribute name="units" value="Pa" type="string" />
  </grib2>
</vertical_axis>
<vertical_axis id="height_above_msl" name="height_above_msl" grib2_id="102" grib1_id="103" type="float">
  <attribute name="description" value="height above MSL, altitude" type="string" />
  <attribute name="long_name" value="height" type="string" />
  <attribute name="positive" value="up" type="string" />
  <attribute name="units" value="m" type="string" />
</vertical_axis>
<vertical_axis id="layer_between_altitudes" name="layer_between_altitudes" grib1_id="104" type="float">
  <attribute name="description" value="layer between two altitudes" type="string" />
  <attribute name="long_name" value="layer between two altitudes" type="string" />
  <attribute name="positive" value="up" type="string" />
  <attribute name="units" value="100m" type="string" />
</vertical_axis>
```

```xml
<vertical_axis id="height" name="height" grib2_id="103" grib1_id="105" type="float">
  <attribute name="description" value="height above ground" type="string" />
  <attribute name="long_name" value="height" type="string" />
  <attribute name="positive" value="up" type="string" />
  <attribute name="units" value="m" type="string" />
</vertical_axis>
<vertical_axis id="sigma" name="sigma" grib2_id="104" grib1_id="107" type="float">
  <attribute name="description" value="atmosphere sigma coordinate" type="string" />
  <attribute name="long_name" value="atmosphere_sigma_coordinate" type="string" />
  <attribute name="standard_name" value="atmosphere_sigma_coordinate" type="string" />
  <attribute name="positive" value="down" type="string" />
</vertical_axis>
<vertical_axis id="hybrid" name="k" grib2_id="105" grib1_id="109" type="double">
  <attribute name="standard_name" value="atmosphere_hybrid_sigma_pressure_coordinate" type="string" />
  <attribute name="formula" value="p(n,k,j,i) = ap(k) + b(k)*ps(n,j,i)" type="string" />
  <attribute name="formula_terms" value="ap: ap%EXT% b: b%EXT% ps: ps p0: p0%EXT%" type="string" />
  <attribute name="long_name" value="atmosphere_hybrid_sigma_pressure_coordinate" type="string" />
  <attribute name="positive" value="down" type="string" />
  <values mode="hybridSigmaCalc(ap,b,p0)" />
  <!-- optional values, will otherwise be calculated -->
  <!-- <values mode="inline">0.01000025677 0.030167302165 0.0506574118 0.071450009935 0.09252333188 0.1138544163 0.13541913675 0.15719222585 0.17914733025 0.2012570937 0.2234932623 0.24582677445 0.2682278651 0.2906662383 0.31311114455 0.3355315966 0.35789645305 0.38017460195 0.40233509685 0.424347324 0.4461811847 0.4678071633 0.489196539 0.5103215403 0.5311554552 0.55167275145 0.5718492055 0.59166201445 0.61108997355 0.6301135343 0.6487148597 0.66687796335 0.6845887315 0.70183494755 0.71860654485 0.73489551425 0.75069577035 0.7660033971 0.78081677885 0.7951363129 0.80896444377 0.82230582149 0.83516716094 0.847557280535 0.859487003145 0.87096914209 0.882018498895 0.892651686215 0.90288721645 0.912745443885 0.92224845265 0.931419910746 0.9402852619265 0.9488715493425 0.9572073044055 0.96532265475235 0.97331471657385 0.981184395 0.98881774 0.996283525</values> -->
  <additional_axis_variable name="p0" type="double" axis="">
    <attribute name="units" value="Pa" type="string" />
    <values>101325</values>
  </additional_axis_variable>
  <additional_axis_variable name="ap" type="double" axis="k">
    <attribute name="units" value="Pa" type="string" />
    <values mode="extraHalvLevel1" scale_factor="1" />
    <!-- optional values, will otherwise be retrieved from level2 -->
    <!-- <values>1000.025677 3016.7302165 5053.90618 7087.0199935 9093.765188 11053.98013 12949.566675 14764.408585 16484.295025 18096.84587 19591.43773 20959.130445 22192.59551 23286.04683 24235.168455 25037.05066 25690.118305 26194.061695 26549.769185 26759.2609 26825.62347 26752.93383 26546.1954 26211.27253 25754.81752 25184.199145 24507.43255 23733.106445 22870.320355 21928.60293 20917.83697 19848.187335 18730.02765 17573.856255 16390.225985 15189.661425 13982.572535 12779.18721 11589.468885 10423.01579 9288.991377 8196.045649 7152.209594 6164.8270535 5240.4653145 4384.825709 3602.6483895 2897.6316215 2272.348645 1728.1508885 1265.082265 881.7835746 575.42419265 341.59793425 174.23244055 65.519475235 12.368657385 0 0 0</values> -->
  </additional_axis_variable>
  <additional_axis_variable name="b" type="double" axis="k">
    <attribute name="units" value="1" type="string" />
    <values mode="extraHalvLevel2" scale_factor="1" />
    <!-- optional values, will otherwise be retrieved from ident19 -->
    <!-- <values>0 0 0.00011835 0.00057981 0.00158568 0.003314615 0.00592347 0.00954814 0.01430438 0.020288635 0.027578885 0.03623547 0.04630191 0.05780577 0.07075946 0.08516109 0.10099527 0.118233985 0.136837405 0.156754715 0.17792495 0.200277825 0.223734585 0.248208815 0.27360728 0.29983076 0.32677488 0.35433095 0.38238677 0.410827505 0.43953649 0.46839609 0.497288455 0.526096385 0.554704285 0.5829989 0.610870045 0.638211525 0.66492209 0.690906155 0.71607453 0.740345365 0.763645065 0.78590901 0.80708235 0.827120885 0.845992015 0.86367537 0.88016373 0.895463935 0.90959763 0.922602075 0.93453102 0.94545557 0.95546498 0.96466746 0.97319103 0.981184395 0.98881774 0.996283525</values> -->
  </additional_axis_variable>
</vertical_axis>
<vertical_axis id="depth" name="depth" grib2_id="106" type="short">
  <attribute name="description" value="depth below land surface" type="string" />
  <attribute name="long_name" value="depth" type="string" />
  <attribute name="positive" value="down" type="string" />
  <attribute name="standard_name" value="depth" type="string" />
  <grib1>
    <attribute name="units" value="cm" type="string" />
  </grib1>
  <grib2>
    <attribute name="units" value="m" type="string" />
  </grib2>
</vertical_axis>
<vertical_axis id="specified_pressure_difference" name="specified_pressure_difference" grib2_id="108" type="float">
  <attribute name="description" value="Level at specified pressure difference from ground to level" type="string" />
```

```xml
    <attribute name="long_name" value="specified pressure difference from ground" type="string" />
    <attribute name="standard_name" value="air_pressure" type="string" />
    <attribute name="positive" value="up" type="string" />
    <grib2>
      <attribute name="units" value="Pa" type="string" />
    </grib2>
  </vertical_axis>
  <vertical_axis id="potential_vorticity_surface" name="potential_vorticity_surface" grib2_id="109" type="float">
    <attribute name="description" value="Potential vorticity surface" type="string" />
    <attribute name="long_name" value="potential vorticity surface" type="string" />
    <attribute name="standard_name" value="ertel_potential_vorticity" type="string" />
    <attribute name="positive" value="up" type="string" />
    <grib2>
      <attribute name="units" value="K m^2 kg^-1 s^-1" type="string" />
    </grib2>
  </vertical_axis>
  <vertical_axis id="depth_between_layers" name="depth_between_layers" grib1_id="112" type="short">
  <!-- TODO, the 2 layers are not read correctly yet. I need a special function to extract the 2 levels from one grib-field
       like in  hybridSigma -->
    <attribute name="description" value="depth between layers below land surface" type="string" />
    <attribute name="long_name" value="depth between layes" type="string" />
    <attribute name="positive" value="down" type="string" />
    <attribute name="standard_name" value="depth" type="string" />
    <attribute name="units" value="cm" type="string" />
  </vertical_axis>
  <vertical_axis id="theta" name="theta" grib2_id="107" grib1_id="113" type="float">
    <attribute name="description" value="isentropic layer" type="string" />
    <attribute name="units" value="K" type="string" />
  </vertical_axis>
  <vertical_axis id="depth_below_sea" name="depth_below_sea" grib2_id="160" grib1_id="160" type="short">
    <attribute name="description" value="depth below sea surface" type="string" />
    <attribute name="long_name" value="depth_below_sea" type="string" />
    <attribute name="positive" value="down" type="string" />
    <attribute name="standard_name" value="depth" type="string" />
    <attribute name="units" value="m" type="string" />
  </vertical_axis>

  <vertical_axis id="harmoniUnknown117" name="harmoniUnknown117" grib1_id="117" type="short">
    <attribute name="_FillValue" value="-32767" type="short" />
    <attribute name="positive" value="up" type="string" />
  </vertical_axis>

  <vertical_axis id="adiabatic_condensation_level" name="adiabatic_condensation_level" grib1_id="5" type="short">
    <attribute name="_FillValue" value="-32767" type="short" />
    <attribute name="long_name" value="adiabatic condensation level (parcel lifted from surface)" type="string" />
    <attribute name="positive" value="up" type="string" />
  </vertical_axis>

  <vertical_axis id="harmoniUnknown10" name="harmoniUnknown10" grib1_id="10" type="short">
    <attribute name="_FillValue" value="-32767" type="short" />
    <attribute name="positive" value="up" type="string" />
  </vertical_axis>


  <vertical_axis id="total_atmosphere" name="total_atmosphere" grib1_id="200" type="short">
    <attribute name="_FillValue" value="-32767" type="short" />
    <attribute name="long_name" value="total atmosphere as single layer" type="string" />
    <attribute name="positive" value="up" type="string" />
  </vertical_axis>
  <vertical_axis id="local_vertical_level_200" name="local_vertical_level_200" grib2_id="200" type="float">
    <attribute name="description" value="vertical level 200, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 200" type="string" />
    <attribute name="positive" value="up" type="string" />
  </vertical_axis>
  <vertical_axis id="entire_ocean" name="entire_ocean" grib2_id="201" grib1_id="201" type="float">
    <attribute name="long_name" value="entire ocean as single layer" type="string" />
    <attribute name="positive" value="up" type="string" />
  </vertical_axis>
  <vertical_axis id="local_vertical_level_204" name="local_vertical_level_204" grib2_id="204" type="float">
```

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```xml
    <attribute name="description" value="vertical level 204, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 204" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_211" name="local_vertical_level_211" grib2_id="211" type="float">
    <attribute name="description" value="vertical level 211, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 211" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_212" name="local_vertical_level_212" grib2_id="212" type="float">
    <attribute name="description" value="vertical level 212, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 212" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_213" name="local_vertical_level_213" grib2_id="213" type="float">
    <attribute name="description" value="vertical level 213, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 213" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_214" name="local_vertical_level_214" grib2_id="214" type="float">
    <attribute name="description" value="vertical level 214, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 214" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_222" name="local_vertical_level_222" grib2_id="222" type="float">
    <attribute name="description" value="vertical level 222, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 222" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_223" name="local_vertical_level_223" grib2_id="223" type="float">
    <attribute name="description" value="vertical level 223, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 223" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_224" name="local_vertical_level_224" grib2_id="224" type="float">
    <attribute name="description" value="vertical level 224, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 224" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_232" name="local_vertical_level_232" grib2_id="232" type="float">
    <attribute name="description" value="vertical level 232, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 232" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_233" name="local_vertical_level_233" grib2_id="233" type="float">
    <attribute name="description" value="vertical level 233, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 233" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_234" name="local_vertical_level_234" grib2_id="234" type="float">
    <attribute name="description" value="vertical level 234, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 234" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_242" name="local_vertical_level_242" grib2_id="242" type="float">
    <attribute name="description" value="vertical level 242, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 242" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_243" name="local_vertical_level_243" grib2_id="243" type="float">
    <attribute name="description" value="vertical level 243, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 243" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
<vertical_axis id="local_vertical_level_244" name="local_vertical_level_244" grib2_id="244" type="float">
    <attribute name="description" value="vertical level 244, defined locally, ask center" type="string" />
    <attribute name="long_name" value="unknown vertical level 244" type="string" />
    <attribute name="positive" value="up" type="string" />
</vertical_axis>
```

```xml
</axes>

<variables>
    <!-- Pressure () -->
    <parameter name="air_pressure_at_sea_level" type="float">
        <grib1 indicatorOfParameter="151" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98" typeOfLevel="1" levelNo="0"/>
        <grib2 discipline="0" parameterCategory="3" parameterNumber="1" typeOfLevel="1"/>
        <attribute name="long_name" value="Mean Sea Level Pressure (MSLP)" type="string"/>
        <attribute name="standard_name" value="air_pressure_at_sea_level" type="string"/>
        <attribute name="units" value="Pa" type="string"/>
    </parameter>
    <parameter name="surface_air_pressure" type="float">
        <grib1 indicatorOfParameter="134" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98" typeOfLevel="1" levelNo="0"/>
        <grib2 discipline="0" parameterCategory="3" parameterNumber="0" typeOfLevel="1"/>
<attribute name="long_name" value="Surface air pressure" type="string"/>
        <attribute name="standard_name" value="surface_air_pressure" type="string"/>
        <attribute name="units" value="Pa" type="string"/>
    </parameter>
    <!-- logarithmic surface_air_pressure -->
    <parameter name="surface_air_pressure" type="float">
        <grib2 discipline="0" parameterCategory="3" parameterNumber="25" typeOfLevel="105"/>
        <attribute name="long_name" value="Logarithmic surface air pressure (lnsp)" type="string"/>
        <attribute name="standard_name" value="surface_air_pressure" type="string"/>
        <attribute name="units" value="1 ln(re 1Pa)" type="string"/>
    </parameter>

    <parameter name="geopotential_height_pl" type="float">
    <!-- multi-id for grib1 and grib2 -->
        <grib1 indicatorOfParameter="156" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98" timeRangeIndicator="0"/>
    <!-- wmo -->
        <grib1 indicatorOfParameter="7" gribTablesVersionNo="1"/>
        <grib1 indicatorOfParameter="7" gribTablesVersionNo="2"/>
        <grib1 indicatorOfParameter="7" gribTablesVersionNo="3"/>
        <grib2 discipline="0" parameterCategory="3" parameterNumber="5" typeOfLevel="100"/>
        <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
        <attribute name="long_name" value="geopotential_height" type="string" />
        <attribute name="standard_name" value="geopotential_height" type="string" />
        <attribute name="units" value="m" type="string" />
    </parameter>
    <parameter name="geopotential_pl" type="float">
        <grib1 indicatorOfParameter="156" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98" typeOfLevel="100"/>
        <grib2 discipline="0" parameterCategory="3" parameterNumber="4" typeOfLevel="105"/>
        <attribute name="long_name" value="Geopotential pressure levels" type="string"/>
        <attribute name="standard_name" value="geopotential" type="string"/>
        <attribute name="units" value="m^2/s^2" type="string"/>
    </parameter>
    <parameter name="geopotential_ml" type="float">
        <grib1 indicatorOfParameter="129" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98" typeOfLevel="109"/>
        <grib2 discipline="0" parameterCategory="3" parameterNumber="4" typeOfLevel="100"/>
        <attribute name="long_name" value="Geopotential model levels" type="string" />
        <attribute name="standard_name" value="geopotential" type="string" />
        <attribute name="units" value="m^2/s^2" type="string" />
    </parameter>
    <parameter name="surface_geopotential" type="float" constantTime="true">
        <grib1 indicatorOfParameter="129" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98" typeOfLevel="1"/>
        <grib2 discipline="0" parameterCategory="3" parameterNumber="4" typeOfLevel="103"/>
        <attribute name="long_name" value="Surface geopotential (fis)" type="string" />
        <attribute name="standard_name" value="surface_geopotential" type="string" />
        <attribute name="units" value="m^2/s^2" type="string" />
    </parameter>
    <parameter name="surface_altitude" type="float">
        <grib2 discipline="0" parameterCategory="3" parameterNumber="5" typeOfLevel="1"/>
        <grib1 indicatorOfParameter="7" gribTablesVersionNo="253" identificationOfOriginatingGeneratingCentre="233" typeOfLevel="105" levelNo="0"/>
        <attribute name="long_name" value="Orography (ZS)" type="string" />
        <attribute name="standard_name" value="surface_altitude" type="string" />
```

```xml
      <attribute name="units" value="m" type="string" />
    </parameter>

    <parameter name="cloud_cover" type="float">
      <!-- multi-id for grib1 and grib2 -->
      <!-- high clouds -->
      <grib1 indicatorOfParameter="188" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <!-- medium clouds, sigma level-->
      <grib1 typeOfLevel="107" indicatorOfParameter="187" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <!-- below examples allow omission of identificationOfOriginatingGeneratingCentre or gribTablesVersionNo -->
      <!-- low clouds -->
      <grib1 indicatorOfParameter="186" gribTablesVersionNo="128" />
      <!-- fog -->
      <grib1 indicatorOfParameter="248" identificationOfOriginatingGeneratingCentre="98"/>
      <!-- <grib2 discipline="" parameterCategory="" parameterNumber=""/> -->
      <attribute name="long_name" value="cloud coverage" type="string" />
      <attribute name="units" value="%" type="string" />
    </parameter>
    <parameter name="total_precipitation" type="float">
      <grib1 indicatorOfParameter="61" gribTablesVersionNo="3"/>
      <attribute name="long_name" value="total_precipitation" type="string" />
      <attribute name="units" value="kg m^-2" type="string" />
    </parameter>

<!-- from metcoop -->
    <parameter name="x_wind_10m" type="float">
      <grib1 indicatorOfParameter="33" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
      <attribute name="standard_name" value="x_wind" type="string" />
      <attribute name="units" value="m s^-1" type="string" />
    </parameter>
    <parameter name="y_wind_10m" type="float">
      <grib1 indicatorOfParameter="34" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
      <attribute name="standard_name" value="y_wind" type="string" />
      <attribute name="units" value="m s^-1" type="string" />
    </parameter>
    <parameter name="x_wind_10m" type="float">
      <grib1 indicatorOfParameter="33" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="100"/>
      <grib2 discipline="0" parameterCategory="2" parameterNumber="2" typeOfLevel="103" level="10"/>
      <attribute name="standard_name" value="x_wind" type="string" />
      <attribute name="units" value="m s^-1" type="string" />
    </parameter>
    <parameter name="x_wind_pl" type="float">
      <grib2 discipline="0" parameterCategory="2" parameterNumber="2" typeOfLevel="100"/>
      <!-- <grib1 indicatorOfParameter="33" gribTablesVersionNo="253" identificationOfOriginatingGeneratingCentre="233" typeOfLevel="109"/> -->
      <attribute name="long_name" value="Zonal wind model levels" type="string" />
      <attribute name="standard_name" value="x_wind" type="string" />
      <attribute name="units" value="m/s" type="string" />
      <spatial_vector direction="x,longitude" counterpart="y_wind_ml" />
    </parameter>
    <parameter name="x_wind_ml" type="float">
      <grib2 discipline="0" parameterCategory="2" parameterNumber="2" typeOfLevel="105"/>
      <!-- <grib1 indicatorOfParameter="33" gribTablesVersionNo="253" identificationOfOriginatingGeneratingCentre="233" typeOfLevel="109"/> -->
      <attribute name="long_name" value="Zonal wind model levels" type="string" />
      <attribute name="standard_name" value="x_wind" type="string" />
      <attribute name="units" value="m/s" type="string" />
      <spatial_vector direction="x,longitude" counterpart="y_wind_ml" />
    </parameter>

    <parameter name="y_wind_10m" type="float">
      <grib2 discipline="0" parameterCategory="2" parameterNumber="3" typeOfLevel="103" level="10"/>
      <grib1 indicatorOfParameter="34" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="100"/>
      <attribute name="standard_name" value="y_wind" type="string" />
      <attribute name="units" value="m s^-1" type="string" />
    </parameter>
    <parameter name="y_wind_pl" type="float">
      <grib2 discipline="0" parameterCategory="2" parameterNumber="3" typeOfLevel="100"/>
      <grib1 indicatorOfParameter="132" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98" typeOfLevel="100"/>
      <attribute name="long_name" value="Meridional wind pressure levels" type="string"/>
      <attribute name="standard_name" value="y_wind" type="string"/>
```

```xml
        <attribute name="units" value="m/s" type="string"/>
      <spatial_vector direction="y,latitude" counterpart="x_wind_pl"/>
    </parameter>
  <parameter name="y_wind_ml" type="float">
    <grib2 discipline="0" parameterCategory="2" parameterNumber="3" typeOfLevel="105"/>
<!--      <grib1 indicatorOfParameter="34" gribTablesVersionNo="253" identificationOfOriginatingGeneratingCentre="233" typeOfLevel="105"/>
 -->     <attribute name="long_name" value="Meridional wind model levels" type="string" />
    <attribute name="standard_name" value="y_wind" type="string" />
    <attribute name="units" value="m/s" type="string" />
    <spatial_vector direction="y,latitude" counterpart="x_wind_ml" />
  </parameter>
  <!-- skin temperature -->
  <parameter name="surface_temperature" type="float">
    <grib2 discipline="0" parameterCategory="0" parameterNumber="0" typeOfLevel="1" level="0"/>
    <grib1 indicatorOfParameter="235" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98" typeOfLevel="1" levelNo="0"/>
    <attribute name="long_name" value="Surface (skin) temperature (SKT)" type="string"/>
    <attribute name="standard_name" value="surface_temperature" type="string"/>
    <attribute name="units" value="K" type="string"/>
  </parameter>
  <parameter name="air_temperature_2m" type="float">
    <grib2 discipline="0" parameterCategory="0" parameterNumber="0" typeOfLevel="103" level="2"/>
    <grib1 indicatorOfParameter="11" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105" levelNo="2"/>
    <attribute name="standard_name" value="air_temperature" type="string" />
    <attribute name="units" value="K" type="string" />
  </parameter>
  <parameter name="air_temperature_pl" type="float">
    <grib2 discipline="0" parameterCategory="0" parameterNumber="0" typeOfLevel="100"/>
    <attribute name="standard_name" value="air_temperature" type="string" />
    <attribute name="units" value="K" type="string" />
  </parameter>
  <parameter name="tk" type="float">
    <grib1 indicatorOfParameter="11" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="100"/>
    <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
    <attribute name="standard_name" value="air_temperature" type="string" />
    <attribute name="units" value="K" type="string" />
  </parameter>
  <!-- 2m dew point temperature -->
  <parameter name="dew_point_temperature_2m" type="float">
    <grib1 indicatorOfParameter="168" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98" typeOfLevel="1" levelNo="0"/>
    <grib2 discipline="0" parameterCategory="0" parameterNumber="6" typeOfLevel="103" level="2"/>
    <attribute name="standard_name" value="dew_point_temperature" type="string"/>
    <attribute name="units" value="K" type="string"/>
  </parameter>

  <parameter name="fi" type="float" constantTime="true">
    <grib1 indicatorOfParameter="6" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="100"/>
    <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
    <attribute name="standard_name" value="geopotential_height" type="string" />
    <attribute name="units" value="m" type="string" />
  </parameter>
  <parameter name="fis" type="float">
    <grib1 indicatorOfParameter="6" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
    <attribute name="standard_name" value="geopotential_height" type="string" />
    <attribute name="units" value="m" type="string" />
  </parameter>
  <parameter name="q" type="float">
    <grib1 indicatorOfParameter="51" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="100"/>
    <attribute name="standard_name" value="specific_humidity" type="string" />
    <attribute name="units" value="1" type="string" />
  </parameter>
  <parameter name="omega_ml" type="float">
    <grib1 indicatorOfParameter="40" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="100"/>
    <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
    <attribute name="standname_name" value="omega" type="string" />
    <attribute name="units" value="Pa/s" type="string" />
  </parameter>
```

```xml
<parameter name="relative_humidity_2m" type="float">
  <grib2 discipline="0" parameterCategory="1" parameterNumber="1" typeOfLevel="103" level="2"/>
  <grib1 indicatorOfParameter="52" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
  <attribute name="standard_name" value="relative_humidity" type="string" />
  <attribute name="units" value="1" type="string" />
</parameter>
<parameter name="relative_humidity_pl" type="float">
  <grib2 discipline="0" parameterCategory="1" parameterNumber="1" typeOfLevel="100"/>
  <grib1 indicatorOfParameter="52" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="100"/>
  <attribute name="standard_name" value="relative_humidity" type="string" />
  <attribute name="units" value="1" type="string" />
</parameter>
<parameter name="visibility_in_air" type="float">
  <grib2 discipline="0" parameterCategory="19" parameterNumber="0" typeOfLevel="1"/>
  <attribute name="standard_name" value="relative_humidity" type="string" />
  <attribute name="units" value="1" type="string" />
</parameter>
<parameter name="tcc" type="float">
  <grib1 indicatorOfParameter="71" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
  <attribute name="standard_name" value="cloud_area_fraction" type="string" />
  <attribute name="units" value="%" type="string" />
</parameter>
<parameter name="lcc" type="float">
  <grib1 indicatorOfParameter="73" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
  <attribute name="standard_name" value="low_type_cloud_area_fraction" type="string" />
  <attribute name="units" value="%" type="string" />
</parameter>
<parameter name="mcc" type="float">
  <grib1 indicatorOfParameter="74" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
  <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
  <attribute name="standard_name" value="medium_type_cloud_area_fraction" type="string" />
  <attribute name="units" value="%" type="string" />
</parameter>
<parameter name="hcc" type="float">
  <grib1 indicatorOfParameter="75" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
  <attribute name="standard_name" value="high_type_cloud_area_fraction" type="string" />
  <attribute name="units" value="%" type="string" />
</parameter>
<parameter name="lwe_thickness_of_stratiform_precipitation_amount" type="float">
  <grib1 indicatorOfParameter="62" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
  <attribute name="standard_name" value="lwe_thickness_of_stratiform_precipitation_amount" type="string" />
  <attribute name="units" value="m" type="string" />
</parameter>
<parameter name="lwe_thickness_of_convective_precipitation_amount" type="float">
  <grib1 indicatorOfParameter="63" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
  <attribute name="standard_name" value="lwe_thickness_of_convective_precipitation_amount" type="string" />
  <attribute name="units" value="m" type="string" />
</parameter>
<parameter name="air_pressure_at_sea_level" type="float">
  <grib1 indicatorOfParameter="1" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="103"/>
  <attribute name="standard_name" value="air_pressure_at_sea_level" type="string" />
  <attribute name="units" value="Pa" type="string" />
</parameter>
<parameter name="surface_air_pressure" type="float">
  <grib1 indicatorOfParameter="1" gribTablesVersionNo="1" identificationOfOriginatingGeneratingCentre="96" typeOfLevel="105"/>
  <attribute name="standard_name" value="surface_air_pressure" type="string" />
  <attribute name="units" value="Pa" type="string" />
</parameter>

<!-- from MEE ensembles (ec) -->
<parameter name="geopotential" type="float" constantTime="true">
  <grib1 indicatorOfParameter="129" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
  <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
  <attribute name="long_name" value="geopotential" type="string" />
  <attribute name="standard_name" value="geopotential" type="string" />
  <attribute name="units" value="m2/s2" type="string" />
</parameter>
<parameter name="lwe_thickness_of_percipitation_amount" type="float">
  <grib1 indicatorOfParameter="228" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
```

```xml
      <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
      <attribute name="standard_name" value="lwe_thickness_of_percipitation_amount" type="string" />
      <attribute name="units" value="kg/m2" type="string" />
   </parameter>
   <parameter name="lwe_thickness_of_snowfall_amount" type="float">
      <grib1 indicatorOfParameter="144" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
      <attribute name="standard_name" value="lwe_thickness_of_snowfall_amount" type="string" />
      <attribute name="units" value="kg/m2" type="string" />
   </parameter>
   <parameter name="cloud_area_fraction" type="short">
      <grib1 indicatorOfParameter="164" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <attribute name="_FillValue" value="-32767" type="short" />
      <attribute name="scale_factor" value="0.0001" type="float" />
      <attribute name="standard_name" value="cloud_area_fraction" type="string" />
      <attribute name="units" value="1" type="string" />
   </parameter>
   <parameter name="air_temperature" type="float">
      <grib1 indicatorOfParameter="130" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
      <attribute name="standard_name" value="air_temperature" type="string" />
      <attribute name="units" value="K" type="string" />
   </parameter>
   <parameter name="dewpoint_2m" type="float">
      <grib1 indicatorOfParameter="168" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
      <attribute name="units" value="K" type="string" />
   </parameter>
   <parameter name="air_temperature_2m" type="float">
      <grib1 indicatorOfParameter="167" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
      <attribute name="standard_name" value="air_temperature" type="string" />
      <attribute name="units" value="K" type="string" />
   </parameter>
   <parameter name="max_air_temperature_2m" type="float">
      <grib1 indicatorOfParameter="121" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
      <attribute name="standard_name" value="air_temperature" type="string" />
      <attribute name="units" value="K" type="string" />
   </parameter>
   <parameter name="min_air_temperature_2m" type="float">
      <grib1 indicatorOfParameter="122" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
      <attribute name="standard_name" value="air_temperature" type="string" />
      <attribute name="units" value="K" type="string" />
   </parameter>
   <parameter name="x_wind_10m" type="float">
      <grib1 indicatorOfParameter="165" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98">
        <extraKey name="localDefinitionNumber" value="1" /> <!-- just for testing -->
      </grib1>
      <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
      <attribute name="standard_name" value="x_wind" type="string" />
      <attribute name="units" value="m/s" type="string" />
   </parameter>
   <parameter name="y_wind_10m" type="float">
      <grib1 indicatorOfParameter="166" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
      <attribute name="standard_name" value="y_wind" type="string" />
      <attribute name="units" value="m/s" type="string" />
   </parameter>
   <parameter name="max_wind_speed_of_gust_10m" type="float">
      <grib1 indicatorOfParameter="123" gribTablesVersionNo="128" identificationOfOriginatingGeneratingCentre="98"/>
      <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
      <attribute name="standard_name" value="max_wind_speed_of_gust" type="string" />
      <attribute name="units" value="m/s" type="string" />
   </parameter>

   <!-- wave parameters -->
   <parameter name="significant_wave_height" type="float">
```

```xml
  <grib1 indicatorOfParameter="229" gribTablesVersionNo="140" />
  <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
  <attribute name="units" value="m" type="string"/>
  <attribute name="standard_name" value="sea_surface_wave_significant_height" type="string"/>
 </parameter>
 <parameter name="wave_direction" type="float">
  <grib1 indicatorOfParameter="230" gribTablesVersionNo="140"/>
  <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
  <attribute name="units" value="degree" type="string"/>
  <attribute name="standard_name" value="sea_surface_wave_to_direction" type="string"/>
 </parameter>
 <parameter name="peak_wave_period"  type="float">
  <grib1 indicatorOfParameter="231" gribTablesVersionNo="140"/>
  <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
  <attribute name="long_name" value="sea_surface_wave_peak_period" type="string"/>
  <attribute name="units" value="s" type="string"/>
 </parameter>
 <parameter  name="mean_wave_period"  type="float">
  <grib1 indicatorOfParameter="232" gribTablesVersionNo="140"/>
  <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
  <attribute name="units" value="s" type="string"/>
  <attribute name="standard_name" value="sea_surface_wave_mean_period_from_variance_spectral_density_first_frequency_moment" type="string"/>
  <attribute name="long_name" value="sea_surface_wave_significant_period" type="string"/>
 </parameter>
 <parameter  name="cdww"  type="float">
  <grib1 indicatorOfParameter="233" gribTablesVersionNo="140"/>
  <attribute name="units" value="" type="string"/>
  <attribute name="long_name" value="sea_surface_wave_drag_coefficient" type="string"/>
 </parameter>
 <parameter name="wind_speed_10m"  type="float">
  <grib1 indicatorOfParameter="245" gribTablesVersionNo="140"/>
  <attribute name="_FillValue" value="9.9692099683868690e+36f" type="float" />
  <attribute name="units" value="m/s" type="string"/>
  <attribute name="standard_name" value="wind_speed" type="string"/>
 </parameter>
 <parameter name="137Cesium_concentration" type="float">
   <grib1 indicatorOfParameter="200" gribTablesVersionNo="133" identificationOfOriginatingGeneratingCentre="54">
     <extraKey name="isotopeIdentificationNumber" value="169"/>
   </grib1>
  <!-- <attribute name="standard_name" value="geopotential_height" type="string" /> -->
   <attribute name="units" value="Bq*h/m3" type="string" />
 </parameter>
 <parameter name="133Xenon_concentration" type="float">
   <grib1 indicatorOfParameter="200" gribTablesVersionNo="133" identificationOfOriginatingGeneratingCentre="54">
    <extraKey name="isotopeIdentificationNumber" value="158"/>
   </grib1>
  <!-- <attribute name="standard_name" value="geopotential_height" type="string" /> -->
   <attribute name="units" value="Bq*h/m3" type="string" />
 </parameter>


</variables>
</cdmGribReaderConfig>
```

Appendix B – Fimex NCML configuration file

```xml
<?xml version="1.0" encoding="UTF-8"?>
<netcdf xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2 ncml-2.2.xsd ">

<variable name="air_temperature_2m" shape="rlon rlat ensemble_member time" type="float"/>

<remove name="forecast_reference_time" type="variable" />
```

</netcdf>