# pyg2p 2.1

| | |
|---|---|
| Version | 2.1 |
| **Author** | Domenico Nappo (domenico.nappo(at)gmail.com) |
| **Release Date** | 2016-09 |

## Table of Contents

# Introduction

**pyg2p** is a tool to convert GRIB files into PCRASTER maps.

It reads georeferenced variables from GRIB version 1 and 2 files and it produces PCRaster maps, after some manipulation steps (conversion, aggregation). Execution parameters are passed via command line arguments and/or JSON template files.

Manipulations are completely configurable in execution JSON files and are of three types:

- conversion (formulas are to configure in parameters.json)
- correction (correction formulas are based on DEM maps and geopotential message and are to be configured in templates)
- aggregation (accumulation or average).

The interpolation mode is also configurable and it's needed to resample the input GRIB grid to the PCRaster target grid (which is determined by latitude and longitudes maps).

What you need to execute conversion with pyg2p version 2.0 is enlisted below:

1. The input grib file that contains the variable you want to convert, identified by its shortName
2. The geopotential message in a separate grib file (if not included with input grib file), for temperature altitude correction.
3. PCRaster coordinate maps (latitudes and longitudes) of target GRID for interpolation. DEM of target GRID for correction.

# Installation

To install package, you can use a python virtual environment or directly install dependencies and package at system level (executable script will be saved into `/usr/local/bin` in this case).

**IMPORTANT**: Before to launch setup, you need to configure geopotentials and intertables paths in `configuration/global/global_conf.json`. These paths are used by pyg2p to read geopotentials and intertables already configured. You may need to download files from FTP (use -W option for this). Users running pyg2p installed by a different user (ie. root) will configure similar paths for their own intertables and geopotentials under his home folder. These paths will need write permissions.

Grab last archive and follow these steps:

```
$ tar xzvf pyg2p.tar.gz
$ cd pyg2p
$ vim configuration/global/global_conf.json  # to edit shared paths !!!
$ python setup.py install
```

After installation, you will have all dependencies installed and an executable script 'pyg2p' (in a virtual environment, script is located under `<VIRTUALENV_PATH>/bin` folder otherwise under `/usr/local/bin`). Some python packages can be problematic to install at first shot. Read following paragraph for details.

## Manual installation of dependencies

Default setup.py may have troubles in installing dependencies or you may prefer to install them manually.

Check this table to install dependencies manually (follow the order) and try to install again.

| **Python packages** | |
|---|---|
| NumPy>=1.10.1<br>Numexpr>=2.4.6<br>SciPy>=0.16<br>gribapi*<br>GDAL python** | Scientific packages for array operations and reading/writing encoded files. They depends on several C libraries that must exist on your system before to proceed.<br>`$pip install numpy>=1.10.1`<br>`$pip install numexpr`<br>`$pip install scipy>=0.16.0`<br>`$pip install GDAL`<br><br>`* If you have GDAL C/C++ libraries already installed on your system, you might need to install the exact GDAL python matching the C GDAL version.`<br>`** For gribapi python package, please refer to GRIB API documentation.` |
| netcdf4-python | Please, refer to [http://unidata.github.io/netcdf4-python/](http://unidata.github.io/netcdf4-python/) for details |
| dask[array]<br>dask[bag]<br>toolz | Light packages for parallelization (used in GRIB API interpolation methods):<br>`$pip install toolz`<br>`$pip install dask[bag]`<br>`$pip install dask[array]` |
| xmljson | Used only to convert old XML pyg2p v1 to v2 JSON format (-C command line argument):<br>`$pip install xmljson` |
| memory_profiler (optional) | Memory usage information for test suite (for development).<br>`$pip install memory_profiler`<br>`$pip install psutil` |

## Migrating from v 1.x

If you migrate from a pyg2p version 1.x, you can convert existing XML configuration files to json (execution command files, parameters.xml and geopotentials.xml) and also convert old intertables (only grib api methods intertables).

1. Copy all your old XML configuration into a folder ./xml_backup. You can create different subfolders for convenience because conversion will be recursive.
2. Convert files (recursively) from XML to JSON with command:
   `$pyg2p.py -C ./xml_backup`
3. Copy parameters.json and geopotentials.json from ./xml_backup into user folder ~/.pyg2p/
4. Copy your geopotential files to folder defined in your .conf file in GEOPOTENTIALS variable.

You can also convert your existing interpolation tables made with pyg2p version 1.x GRIB_API methods to be compliant with new format. New files will be copied under folder defined in INTERTABLES variable and intertables.json configuration will be updated during conversion.

```
$pyg2p.py -z <path_to_convert>
```

```
Note: Intertables for rotated grids are not valid (GRIB_API 1.14.4) so they won't
be converted. You need to configure scipy interpolation methods for this kind of
grid for the time being.
```

Intertables created with scipy methods cannot be converted but they are generally quite fast to create (seconds or minutes).

# Configuration

One of the things to configure for any user running pyg2p, is `GEOPOTENTIALS` and `INTERTABLES` variables with paths to folders with write permissions.

```
NOTE: From version 2.1, the user needs to setup these variables only if he/she
needs to write new interpolation tables (option -B [-X]) or to add new
geopotentials from grib files (option -g).
```

These variables contains user paths and must be configured in a .conf file (e.g. *paths.conf*) under *~/.pyg2p/* directory. This can look like:

```
GEOPOTENTIALS=/dataset/pyg2p_data_user/geopotentials
INTERTABLES=/dataset/pyg2p_data_user/intertables
```

User intertables (for interpolation) are read/write from `INTERTABLES` and geopotentials (for correction) are read from `GEOPOTENTIALS`.

Pyg2p will use its default configuration for available intertables and geopotentials. These are read from paths configured during installation in global_conf.json.

If you need to download default files from ECMWF FTP, just launch pyg2p with -W option and the dataset argument (argument can be *`geopotentials`* or *`intertables`*) and files are saved in user paths configured above:

```
$pyg2p -W intertables
```

You can edit FTP authentication parameters in ~/.pyg2p/ftp.json

## Advanced configuration

User json configuration files are empty. If you need a new parameter or geopotential that is not configured internally in pyg2p, you can setup new items (or overwrite internal configuration).

### *Adding a parameter to ~/.pyg2p/parameters.json*

If you are extracting a parameter with shortName xy from a grib file that is not already globally configured, add an element as shown below (only part in **bold** has been added):

```
{
      "xy": { "@description": "Variable description",
       "@shortName": "xy",
```

```
        "@unit": "unitstring"
       },

}
```

You can configure (more than) a conversion element with different ids and functions. You will use shortName and conversionId in the execution JSON templates.

```
{
       "xy": {  "@description": "Variable description",
        "@shortName": "xy",
        "@unit": "unitstring"
       },

       "xyz": {

       "@description": "Variable description",
       "@shortName": "xyz",
       "@unit": "unitstring/unistring2",
       "Conversion": [
         {
             "@cutOffNegative": true,
             "@function": "x=x*(-0.13)**2",
             "@id": "conv_xyz1",
             "@unit": ”g/d"
         },
         {
             "@cutOffNegative": true,
             "@function": "x=x/5466 - (x**2)",
             "@id": "conv_xyz2",
             "@unit": "g/h"
         }
        ]
       },



}
```

```
Note: Aware the syntax of conversion functions. They must start with x= followed
by the actual conversion formula where x is the value to convert. Units are only
used for logging.
```

### *Adding a geopotential for correction*

If the input grib file has a geopotential message, pyg2p will use it for correction. Otherwise, it will read the file from user data paths or global data paths.

To add a geopotential GRIB file to pyg2p configuration, use this command:

`$pyg2p -g path_to_geopotential_grib`

This will copy the file to folder defined in `GEOPOTENTIALS` variable and will update geopotentials.json with the new item.

### *Interpolation tables*

Interpolation tables are read from user or global data folders.

If the table is missing, it will create it into user data folder for future interpolations (you must pass -B option to pyg2p).

Depending on source and target grids size, and on interpolation method, table creation can take from minutes to days. To speed up interpolation table creation, use parallel option -X to have up to x6 speed gain.

## Execution templates

Execution templates are JSON files that you will use to configure a conversion. You will pass path to the file to pyg2p with command line option'-c'.

Most of options can be both defined in this JSON file and from command line. Note that command line options overwrite JSON template.

If you have a large set of conversions for same parameters, it's more convenient to define a single template where you define parameter, interpolation and aggregation and pass the rest of parameters from command line.

Here some examples of JSON commands files:

```
{
 "Execution": {
     "@name": "Octahedral test 1",
     "Aggregation": {
         "@step": 24,
         "@type": "average"
     },
     "OutMaps": {
         "@cloneMap": "/dataset/maps/europe5km/dem.map",
         "@ext": 1,
         "@fmap": 1,
         "@namePrefix": "t2",
         "@unitTime": 24,
         "Interpolation": {
             "@latMap": "/dataset/maps/europe5km/lat.map",
             "@lonMap": "/dataset/maps/europe5km/long.map",
```

```
                "@mode": "grib_nearest"
            }
        },
        "Parameter": {
            "@applyConversion": "k2c",
            "@correctionFormula": "p+gem-dem*0.0065",
            "@demMap":  "/dataset/maps/europe5km/dem.map",
            "@gem": "(z/9.81)*0.0065",
            "@shortName": "2t"
        }
    }
}
```

There are four sections of configuration.

### *Aggregation*

Defines the aggregation method and step. Method can be *accumulation*, *average* or *instantaneous*.

### *OutMaps*

Here you define interpolation method and paths to coordinates PCRaster maps, output unit time, the clone map etc.

### *Interpolation*

This is a subelement of OutMaps. Here you define interpolation method (see later for details), paths to coordinates maps.

### *Parameter*

In this section, you configure the parameter to select by using its shortName, as stored in GRIB file. You also configure conversion with *applyConversion* property set to a conversion id. Parameter *shortName* must be already configured in ~/.pyg2p/parameters.json along with conversion ids.

If you need to apply correction based on DEM files and geopotentials, you can configure formulas and the path to DEM map.

### *Path configuration*

You can use variables in JSON files to define paths. Variables can be configured in .conf files under ~/.pyg2p/ folder.

/home/domenico/.pyg2p/myconf.conf

```
EUROPE_MAPS=/dataset/maps/europe5km
DEM_MAP=/dataset/maps/dem05.map
EUROPE_DEM=/dataset/maps/europe/dem.map
EUROPE_LAT=/dataset/maps/europe/lat.map
EUROPE_LON=/dataset/maps/europe/long.map
```

Usage of user defined paths in JSON command file:

```
{  "Execution": {
        "@name": "eue_t24",
        "Aggregation": {
             "@step": 24,
             "@type": "average"
        },
        "OutMaps": {
             "@format": "netcdf",
             "@cloneMap": "{EUROPE_MAPS}/lat.map",
             "@ext": 1,
             "@fmap": 1,
             "@namePrefix": "pT24",
             "@unitTime": 24,
             "Interpolation": {
                  "@latMap": "{EUROPE_MAPS}/lat.map",
                  "@lonMap": "{EUROPE_MAPS}/long.map",
                  "@mode": "grib_nearest"
             }
        },
        "Parameter": {
             "@applyConversion": "k2c",
             "@correctionFormula": "p+gem-dem*0.0065",
             "@demMap": "{DEM_MAP}",
             "@gem": "(z/9.81)*0.0065",
             "@shortName": "2t"
        }
    }
}
```

## Full list of options

### *Main structure*

| Attribute/Tag | Details |
|---|---|
| name | The short name of the parameter, as it is in the grib file. The application use this to select messages. |

| | |
|---|---|
| **Parameter** | See relative table |
| Aggregation | See relative table |
| **OutMaps** | See relative table |

### *Parameter property*

| Attribute/Tag | Details |
|---|---|
| **shortName** | The parameter short name, as it is in the grib file. Must be configured in the parameters.json file, otherwise the application exits with an error. Main grib selector. |
| tstart | Optional grib selectors perturbationNumber, tstart, tend, dataDate and dataTime can also be issued via command line arguments (-m, -s, -e, -D, -T), which overwrite the ones in the execution JSON file. |
| tend | |
| perturbationNumber | |
| dataDate | |
| dataTime | |
| level | |
| applyConversion | The conversion id to apply, as in the parameters.json file for the parameter to select. The combination parameter/conversion must be properly configured in parmaters.json file, otherwise the application exits with an error. |
| correctionFormula[1] | Formula to use for parameter correction with p, gem, dem variables, representing parameter value, converted geopotential to gem, and DEM map value. E.g.: p+gem*0.0065-dem*0.0065 |
| demMap | The dem map used for correction. |
| gem | Formula for geopotential conversion for correction. |

### *OutMaps property*

| Attribute/Tag | Details |
|---|---|
| **cloneMap** | The clone map with area (<u>must have a REAL cell type and missing values for points outside area of interest. A dem map works fine. A typical area boolean map will not</u>). |

1 When configuring correction, all properties *gem*, *correctionFormula*, and *demMap* must be present.

| | |
|---|---|
| **unitTime** | Time unit in hours of output maps. Tipical value is 24 (daily maps). |
| **format** | Output file format. Default 'pcraster'. Available formats are 'pcraster', 'netcdf'. |
| namePrefix | Prefix for maps. Default is parameter *shortName.* |
| fmap | First map number. Default 1. |
| Interpolation | See relative table. |
| ext | Extension mode. It's the integer number defining the step numbers to skip when writing maps. Same as old grib2pcraster. Default 1. |

### *Aggregation property*

| Attribute/Tag | Details |
|---|---|
| **step** | Step of aggregation in hours. |
| **type** | Type of aggregation (it was Manipulation in grib2pcraster). It can be *average* or *accumulation.* |
| forceZeroArray | *Optional*. In case of “accumulation”, and only then, if this attribute is set to”y” (or any value different from “false”, “False”, “FALSE”, “no”, “NO”, “No”, “0”), the program will use a zero array as message at step 0 to compute the first map, even if the GRIB file has a step 0 message. |

### *Interpolation property*

| Attribute/Tag | Details |
|---|---|
| **mode** | Interpolation mode. Possible values are: “nearest”, “invdist”, “grib_nearest”, “grib_invdist” |
| **latMap** | PCRaster map of target latitudes. |
| **lonMap** | PCRaster map of target longitudes. |
| intertableDir | Alternative home folder for interpolation lookup tables, where pyg2p will load/save intertables. Folder must be existing. If not set, pyg2p will use intertables from ~/.pyg2p/intertables/ |

# Usage

To use the application, after the main configuration you need to configure a template JSON file for each type of extraction you need to perform.

## Grabbing information from GRIB files.

To configure the application and compile your JSON templates, you might need to know the variable shortName as stored in the input GRIB file you're using or in the geopotential GRIB. Just execute the following GRIB tool command:

```
grib_get -p shortName /path/to/grib
```

Other keys you would to know for configuration or debugging purposes are:

- startStep
- endStep (for instantaneous messages, it can be the same of startStep)
- perturbationNumber (the EPS member number)
- stepType (type of field: instantaneous: 'instant', average: 'avg', cumulated: 'cumul')
- longitudeOfFirstGridPointInDegrees
- longitudeOfLastGridPointInDegrees
- latitudeOfFirstGridPointInDegrees
- latiitudeOfLastGridPointInDegrees
- Ni (it can be missing)
- Nj (it states the resolution: it's the number of points along the meridian)
- numberOfValues
- gridType (e.g.: regular_ll, reduced_gg, rotated_ll)

See Mapping variables section in Appendix C – mapping between grib2pcraster and pyg2p for further information.

## Input arguments

If you run `pyg2p` without arguments, it shows help of all input arguments.

```
usage: pyg2p [-h] [-c json_file] [-o out_dir] [-i input_file]
             [-I input_file_2nd] [-s tstart] [-e tend] [-m eps_member]
             [-T data_time] [-D data_date] [-f fmap] [-F format] [-x extension_step]
             [-n outfiles_prefix] [-l log_level] [-N intertable_dir] [-B] [-X]
             [-t cmds_file] [-g geopotential] [-C path] [-z path] [-W dataset]

Execute the grib to pcraster conversion using parameters from the input json
```

```
configuration. Read user manual.

optional arguments:
  -h, --help            show this help message and exit
  -c json_file, --commandsFile json_file
                        Path to json command file
  -o out_dir, --outDir out_dir
                        Path where output maps will be created.
  -i input_file, --inputFile input_file
                        Path to input grib.
  -I input_file_2nd, --inputFile2 input_file_2nd
                        Path to 2nd resolution input grib.
  -s tstart, --start tstart
                        Grib timestep start. It overwrites the tstart in json
                        execution file.
  -e tend, --end tend   Grib timestep end. It overwrites the tend in json
                        execution file.
  -m eps_member, --perturbationNumber eps_member
                        eps member number
  -T data_time, --dataTime data_time
                        To select messages by dataTime key value
  -D data_date, --dataDate data_date
                        <YYYYMMDD> to select messages by dataDate key value
  -f fmap, --fmap fmap  First map number
  -F format, --format format
                        Output format. Available options: netcdf, pcraster.
                        Default pcraster
  -x extension_step, --ext extension_step
                        Extension number step
  -n outfiles_prefix, --namePrefix outfiles_prefix
                        Prefix name for maps
  -l log_level, --loggerLevel log_level
                        Console logging level
  -N intertable_dir, --intertableDir intertable_dir
                        interpolation tables dir
  -B, --createIntertable
                        create intertable file
  -X, --interpolationParallel
                        Use parallelization tools to make interpolation
                        faster.If -B option is not passed or intertable
                        already exists it does not have any effect.
  -t cmds_file, --test cmds_file
                        Path to a text file containing list of commands,
                        defining a battery of tests. Then it will create diff
                        pcraster maps and log alerts if differences are higher
                        than a threshold (edit configuration in test.json)
  -g geopotential, --addGeopotential geopotential
                        Add the file to geopotentials.json configuration file,
```

```
                    to use for correction. The file will be copied into
                    the right folder (configuration/geopotentials) Note:
                    shortName of geopotential must be "fis" or "z"
-C path, --convertConf path
                    Convert old xml configuration to new json format
-z path, --convertIntertables path
                    Convert old pyg2p intertables to new version and copy
                    to user folders
-W dataset, --downloadConf dataset
                    Download intertables and geopotentials (FTP settings
                    defined in ftp.json)
```

**Usage examples**:

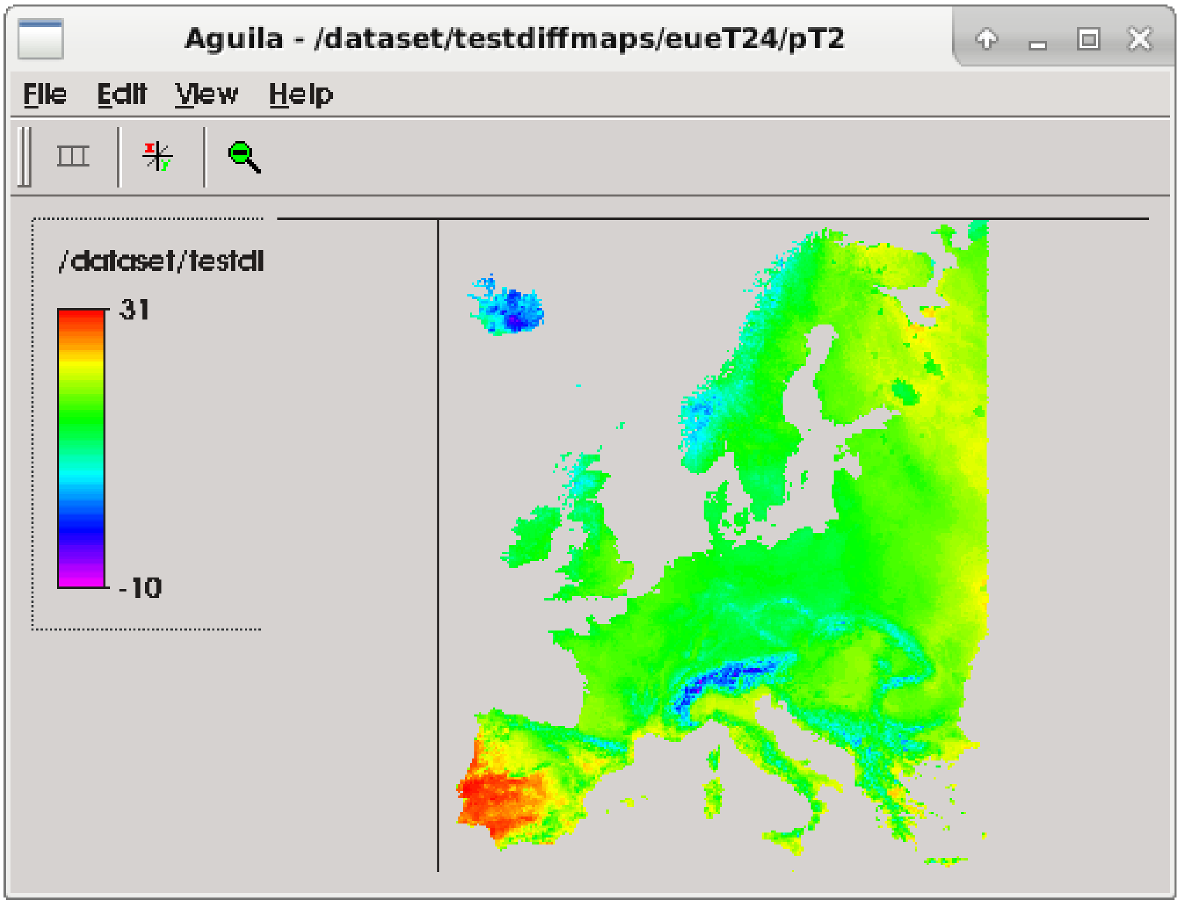
```
pyg2p -c ./exec1.json -i ./input.grib -o /out/dir -s 12 -e 36 -F netcdf
pyg2p -c ./exec2.json -i ./input.grib -o /out/dir -m 10 -l INFO --format netcdf
pyg2p -c ./exec3.json -i ./input.grib -I /input2ndres.grib -o /out/dir -m 10 -l DEBUG
pyg2p -g /path/to/geopotential/grib/file  # add geopotential to configuration
pyg2p -t /path/to/test/commands.txt
pyg2p -h
```

**Note**: Even if 'netcdf' format is used for output, paths to PCRaster clone/area, latitudes and longitudes maps have to be setup in any case.

## Check output maps

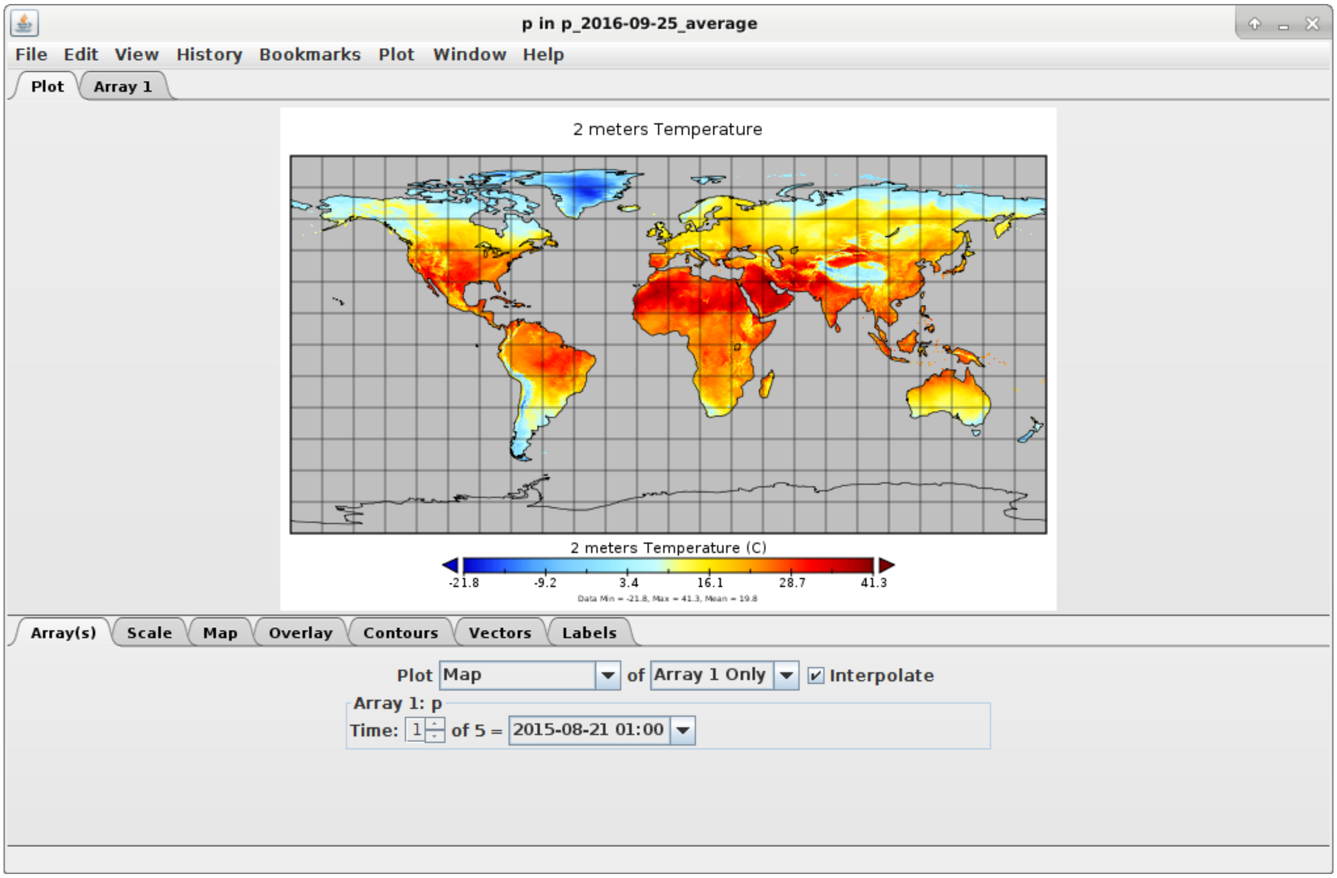
After the execution, you can check output maps by using the PCRaster[2] Aguila viewer for PCRaster maps or the NASA Panoply[3] viewer for NetCDF files.

```
aguila /dataset/testdiffmaps/eueT24/pT240000.001
```




2 http://pcraster.geo.uu.nl/
3 http://www.giss.nasa.gov/tools/panoply/

```
./panoply.sh /dataset/octahedral/out/grib_vs_scipy/global/ta/p_2016-09-25_average.nc
```




Maps will be written in the folder specified by **-o** input argument. If this is missing, you will find maps in the folder where you launched the application (./).

Refer to official documentation for further information about Aguila and Panoply.

# Interpolation modes

Interpolation is configured in JSON execution templates using the *Interpolation* attribute inside *OutMaps*.

There are four interpolation methods available. Two are using GRIB_API nearest neighbours routines while the other two leverage on Scipy kd_tree module.

**Note**: GRIB_API does not implement nearest neighbours routing for rotated grids. You have to use scipy methods and regular target grids (i.e.: latitudes and longitudes PCRaster maps).

## Intertable creation

Interpolation will use precompiled intertables. They will be found in the path configured in `INTERTABLES` folder (take into account that can potentially contains gigabytes of files) or in global data path. You can also define an alternate intertables directory with -N argument (or @intertableDir attribute in JSON template).

If interlookup table doesn't exist, the application will create one into `INTERTABLES` folder and update intertables.json configuration **only if -B option is passed**, otherwise program will exit.

Be aware that for certain combination of grid and maps, the creation of the interlookup table (which is a numpy array saved in a binary file) could take several hours or even days for GRIB interpolation methods. To have better performances (up to x6 of gain) you can pass -X option to enable parallel processing.

Performances are not comparable with scipy based interpolation (seconds or minutes) but this option could not be viable for all GRIB inputs.

## GRIB API interpolation methods

To configure the interpolation method for conversion, set the @mode attribute in Execution/OutMaps/Interpolation property.

#### grib_nearest:

This method uses GRIB API to perform nearest neighbour query.

To configure this method, define:

```
"Interpolation": {
    "@latMap": "/dataset/maps/europe5km/lat.map",
    "@lonMap": "/dataset/maps/europe5km/long.map",
    "@mode": "grib_nearest"
}
```

### grib_invdist:

It uses GRIB_API to query for four neighbours and relative distances. It applies inverse distance calculation to compute the final value.

To configure this method:

```
"Interpolation": {
      "@latMap": "/dataset/maps/europe5km/lat.map",
      "@lonMap": "/dataset/maps/europe5km/long.map",
      "@mode": "grib_invdist"
}
```

## Scipy interpolation methods

### nearest:

It's the same nearest neighbour algorithm of  grib_nearest but it uses the *scipy kd_tree*[4] module to obtain neighbours and distances.

```
"Interpolation": {
      "@latMap": "/dataset/maps/europe5km/lat.map",
      "@lonMap": "/dataset/maps/europe5km/long.map",
      "@mode": "nearest"
}
```

### invdist:

It's the inverse distance algorithm with *scipy.kd_tree* , using 8 neighbours.

```
"Interpolation": {
      "@latMap": "/dataset/maps/europe5km/lat.map",
      "@lonMap": "/dataset/maps/europe5km/long.map",
      "@mode": "invdist"
}
```

Attributes *p*, *leafsize* and *eps*  for the kd tree algorithm are default in scipy library:

| Attribute | Details |
|---|---|
| p | 2 (Euclidean metric) |
| eps | 0 |
| leafsize | 10 |

4 http://docs.scipy.org/doc/scipy/reference/generated/scipy.spatial.KDTree.html

## OutMaps configuration

Interpolation is configured under the **outMaps** tag. With additional attributes, you also configure resulting PCRaster maps. Output dir is ./ by default or you can set it via command line using the option -o (--outDir).

| Attribute | Details |
|---|---|
| namePrefix | Prefix name for output map files. Default is the value of shortName key. |
| **unitTime** | Unit time in hours for results. This is used during aggregation operations. |
| fmap | Extension number for the first map. Default 1. |
| ext | Extension mode. It's the integer number defining the step numbers to skip when writing maps. Same as old grib2pcraster. Default 1. |
| **cloneMap** | Path to a PCRaster clone map, needed by PCRaster libraries to write a new map on disk. |

# Aggregation

Values from grib files can be aggregated before to write the final PCRaster maps. There are two kinds of aggregation available: average and accumulation. The JSON configuration in the execution file will look like:

```
"Aggregation": {
    "@type": "average"
},
```

To better understand what these two types of aggregations do, the DEBUG output of execution is presented later in same paragraph.

## Average

Temperatures are often extracted as averages on 24 hours or 6 hours. Here's a typical execution configuration and the output of interest:

***cosmo_t24.json:***

```
{
    "Execution": {
        "@name": "cosmo_T24",
        "Aggregation": {
            "@step": 24,
            "@type": "average"
        },
        "OutMaps": {
            "@cloneMap": "/dataset/maps/europe/dem.map",
            "@ext": 4,
            "@fmap": 1,
            "@namePrefix": "T24",
            "@unitTime": 24,
            "Interpolation": {
                "@latMap": "/dataset/maps/europe/lat.map",
                "@lonMap": "/dataset/maps/europe/lon.map",
                "@mode": "nearest"
            }
        },
        "Parameter": {
```

```
            "@applyConversion": "k2c",
            "@correctionFormula": "p+gem-dem*0.0065",
            "@demMap": "/dataset/maps/europe/dem.map",
            "@gem": "(z/9.81)*0.0065",
            "@shortName": "2t"
        }
    }
}
```

***Command:***

```
pyg2p -l DEBUG -c /execution_templates/cosmo_t24.json -i
/dataset/cosmo/2012111912_pf10_t2.grb -o ./cosmo -m 10
```

***ext parameter***

ext value will affect numbering of output maps.

```
[2013-07-12 00:06:18,545] :./cosmo/T24a0000.001 written!
[2013-07-12 00:06:18,811] :./cosmo/T24a0000.005 written!
[2013-07-12 00:06:19,079] :./cosmo/T24a0000.009 written!
[2013-07-12 00:06:19,349] :./cosmo/T24a0000.013 written!
[2013-07-12 00:06:19,620] :./cosmo/T24a0000.017 written!
```

This is needed because we performed 24 hours average over 6 hourly steps.

## Accumulation

For precipitation values, accumulation over 6 or 24 hours is often performed. Here's an example of configuration and execution output in DEBUG mode.

***Configuration dwd_r06.json:***

```
{
    {"Execution": {
        "@name": "dwd_rain_gsp",
        "Aggregation": {
            "@step": 6,
            "@type": "accumulation"
        },
        "OutMaps": {
            "@cloneMap": "/dataset/maps/europe/dem.map",
```

```
            "@fmap": 1,
            "@namePrefix": "pR06",
            "@unitTime": 24,
            "Interpolation": {
                "@latMap": "/dataset/maps/europe/lat.map",
                "@lonMap": "/dataset/maps/europe/lon.map",
                "@mode": "nearest"
            }
        },
        "Parameter": {
            "@shortName": "RAIN_GSP",
            "@tend": 18,
            "@tstart": 12
        }
    }
}
```


***Command:***

```
pyg2p -l DEBUG -c /execution_templates/dwd_r06.json -i
/dataset/dwd/2012111912_pf10_tp.grb -o ./cosmo -m 10
```

***Output:***

```
[2013-07-11 23:33:19,646] : Opening the GRIBReader for
/dataset/dwd/grib/dwd_grib1_ispra_LME_2012111900
[2013-07-11 23:33:19,859] : Grib input step 1 [type of step: accum]
[2013-07-11 23:33:19,859] : Gribs from 0 to 78
...
...
[2013-07-11 23:33:20,299] : ******** **** MANIPULATION **** *************
[2013-07-11 23:33:20,299] : Accumulation at resolution: 657
[2013-07-11 23:33:20,300] : out[s:6 e:12 res:657 step-lenght:6] = grib:12 - grib:6  *
(24/6))
[2013-07-11 23:33:20,316] : out[s:12 e:18 res:657 step-lenght:6] = grib:18 - grib:12  *
(24/6))
```

**Note:** If you want to perform **accumulation** from Ts to Te with an aggregation step Ta, and **Ts-Ta=0** (e.g. Ts=6h, Te=48h, Ta=6h), the program will select the first message at step 0 if present in the GRIB file, while you would use a zero values message instead.

To use a zero values array, set the attribute *forceZeroArray* to ”true” in the Aggregation configuration element.

For some DWD[5] and COSMO[6] accumulated precipitation files, the first zero message is an instant precipitation and the decision at EFAS was to use a zero message, as it happens for UKMO[7] extractions, where input GRIB files don't have a first zero step message.

```
$ grib_get -p units,name,stepRange,shortName,stepType 2012111912_pf10_tp.grb

kg m**-2 Total Precipitation 0       tp instant
kg m**-2 Total Precipitation 0-6    tp accum
kg m**-2 Total Precipitation 0-12  tp accum
kg m**-2 Total Precipitation 0-18  tp accum
…
kg m**-2 Total Precipitation 0-48 tp accum
```

5 http://www.dwd.de/
6 http://www.cosmo-model.org/
7 http://www.metoffice.gov.uk/

# Correction

Values from grib files can be corrected with respect to their altitude coordinate (Lapse rate formulas). Formulas will use also a geopotential value (to read from a GRIB file, see later in this chapter for configuration).

Correction has to be configured in the Parameter element, with three mandatory attributes.

- correctionFormula (the formula used for correction, with input variables parameter value (p), gem, and dem value.
- gem (the formula to obtain gem value from geopotential z value)
- demMap (path to the DEM PCRaster map)

`Note: formulas must be written in python notation.`

Tested configurations are only for temperature and are specified as follows:

**Temperature correction:**

```
"Parameter": {
     "@applyConversion": "k2c",
     "@correctionFormula": "p+gem-dem*0.0065",
     "@demMap": "/dataset/maps/europe/dem.map",
     "@gem": "(z/9.81)*0.0065",
     "@shortName": "2t"
}
```

**A more complicated correction formula:**

```
"Parameter": {
     "@applyConversion": "k2c",
     "@correctionFormula": "p/gem*(10**((-0.159)*dem/1000))",
     "@demMap": "/dataset/maps/europe/dem.map",
     "@gem": "(10**((-0.159)*(z/9.81)/1000))",
     "@shortName": "2t"
}
```

## How to write formulas

***z*** is the geopotential value as read from the grib file

***gem*** is the value resulting from the formula specified in gem attribute
*I.e.: (gem="(10**((-0.159)*(z/9.81)/1000)))"*

***dem*** is the dem value as read from the PCRaster map

Be aware that if your dem map has directions values, those will be replicated in the final map.

## Which geopotential file is used?

The application will try to find a geopotential message in input GRIB file. If a geopotential message is not found, pyg2p will select a geopotential file from user or global data paths, by selecting filename from configuration according the geodetic attributes of GRIB message. If it doesn't find any suitable grib file, application will exit with an error message.

Geodetic attributes compose the key *id* in the JSON configuration (note the $ delimiter):

```
longitudeOfFirstGridPointInDegrees$longitudeOfLastGridPointInDegrees$Ni$Nj$numberOfValues$gridType
```

If you want to add another geopotential file to the configuration, just execute the command:

```
pyg2p -g /path/to/geopotential/grib/file
```

The application will copy the geopotential GRIB file into `GEOPOTENTIALS` folder (under user home directory) and will also add the proper JSON configuration to geopotentials.json file.

# Conversion

Values from GRIB files can be converted before to write final output maps. Conversions are configured in the *parameters.json* file for each parameter (ie. shortName). The right conversion formula will be selected using the id specified in the *applyConversion* attribute, and the *shortName* attribute of the parameter that is going to be extracted and converted.

Refer to Parameter configuration paragraph for details.

# Logging

Console logger level is INFO by default and can be optionally set by using **-l** (or **–loggerLevel**) input argument.

Possible logger level values are ERROR, WARN, INFO, DEBUG, in increasing order of verbosity .

# pyg2p API

From version 1.3, pyg2p comes with a simple API to import and use from other python programs (e.g. pyEfas).

The pyg2p API is intended to mimic the pyg2p.py script execution from command line so it provides a Command class with methods to set input parameters and a *run_command(cmd)* module level function to execute pyg2p.

## Setting execution parameters

First, create a pyg2p command:

```
>>> from pyg2p.main import api
>>> command = api.command()
```

Then, set up the execution parameters using a chain of methods or single calls:

```
>>>command.with_cmdpath('a.json')
>>>command.with_inputfile('0.grb')
>>>command.with_log_level('ERROR').with_out_format('netcdf')
>>>command.with_outdir('/dataout/').with_tstart('6').with_tend('24').with_eps('10').with_
fmap('1')
>>>command.with_ext('4')
>>> print(str(command))
pyg2p.py -c a.json -e 240 -f 1 -i 0.grb -l ERROR -m 10 -o /dataout/test -s 6 -x 4 -F netcdf
```

You can also create a command object using the input arguments as you would do when execute pyg2p from shell:

```
>>>args_string = '-l ERROR -c /pyg2p_git/execution_templates_devel/eue_t24.json -i
/dataset/test_2013330702/EpsN320-2013063000.grb -o /dataset/testdiffmaps/eueT24 -m
10'
 >>>command2 = api.command(args_string)
```

## Execute

Use the *run_command* function from pyg2p module. This will delegate the main method, without shell execution.

```
>>>ret = api.run_command(command)
```

The function returns the same value pyg2p returns if executed from shell (0 for correct executions, included those for which messages are not found).

## Adding geopotential file to configuration

You can add a geopotential file to configuration from pyg2p API as well, using Configuration classes:

```
>>> from pyg2p.main.config import UserConfiguration, GeopotentialsConfiguration
>>> user=UserConfiguration()
>>> geopotentials=GeopotentialsConfiguration(user)
>>> geopotentials.add('path/to/geopotential.grib')
```

The result will be the same of pyg2p -g  path/to/geopotential.grib.

# Appendix A - Execution JSON files Examples

This paragraph will explain typical execution json configurations.

***Example 1: Correction with dem and geopotentials***

**pyg2p -c example1.json -i /dataset/cosmo/2012111912_pf2_t2.grb -o ./out_1**

**example1.json**

```json
{
     "Execution": {
          "@name": "eue_t24",
          "Aggregation": {
               "@step": 24,
               "@type": "average"
          },
          "OutMaps": {
               "@cloneMap": "{EUROPE_MAPS}/lat.map",
               "@ext": 1,
               "@fmap": 1,
               "@namePrefix": "pT24",
               "@unitTime": 24,
               "Interpolation": {
                    "@latMap": "{EUROPE_MAPS}/lat.map",
                    "@lonMap": "{EUROPE_MAPS}/long.map",
                    "@mode": "grib_nearest"
               }
          },
          "Parameter": {
               "@applyConversion": "k2c",
               "@correctionFormula": "p+gem-dem*0.0065",
               "@demMap": "{DEM_MAP}",
               "@gem": "(z/9.81)*0.0065",
               "@shortName": "2t"
          }
     }
}
```

This configuration, will select the 2t parameter from time step 0 to 12, out of a cosmo t2 file. Values will be corrected using the dem map and a geopotential file as in geopotentials.json configuration.

Maps will be written under ./out_1 folder (the folder will be created if not existing yet). The clone map is set as same as dem.map. Note that paths to maps uses variables `EUROPE_MAPS` and

`DEM_MAP`. You will set these variables in myconf.conf file under ~/.pyg2p/ folder.

The original values will be converted using the conversion “k2c”. This conversion must be configured in the parameters.json file for the variable which is being extracted (2t). See Parameter property configuration at Parameter.

The interpolation method is *grib_nearest*. Latitudes and longitudes values will be used only if the interpolation lookup table (intertable) hasn't be created yet but it's mandatory to set latMap and lonMap because the application uses their metadata raster attributes to select the right intertable.

The table filename to be read and used for interpolation is automatically found by the application, so there is no need to specify it in configuration. However, lat and lon maps are mandatory configuration attributes.

### *Example 2: Dealing with multiresolution files*

**pyg2p -c example1.json -i 20130325_en0to10.grib -I 20130325_en11to15.grib -o ./out_2**

Performs accumulation 24 hours out of sro values of two input grib files having different vertical resolutions. You can also feed pyg2p with a single multiresolution file.

**pyg2p -c example1.json -i 20130325_sro_0to15.grib o ./out_2 -m 0**

```
    {"Execution": {
        "@name": "multi_sro",
        "Aggregation": {
            "@step": 24,
            "@type": "accumulation"
        },
        "OutMaps": {
            "@cloneMap": "/dataset/maps/global/dem.map",
            "@fmap": 1,
            "@namePrefix": "psro",
            "@unitTime": 24,
            "Interpolation": {
                "@latMap": "/dataset/maps/global/lat.map",
                "@lonMap": "/dataset/maps/global/lon.map",
                "@mode": "grib_nearest"
            }
        },
        "Parameter": {
            "@applyConversion": "m2mm",
            "@shortName": "sro",
            "@tend": 360,
            "@tstart": 0
        }
    }
}
```

This execution configuration will extract global overlapping messages sro (perturbation number 0) from two files at different resolution.

Values will be converted using “tomm” conversion and maps (interpolation used here is grib_nearest) will be written under ./out_6 folder.

### *Example 3: Accumulation 24 hours*

**./pyg2p.py -i /dataset/eue/EpsN320-2012112000.grb -o ./out_eue -c execution_file_examples/execution_9.json**

```
{   "Execution": {
        "@name": "eue_tp",
        "Aggregation": {
            "@step": 24,
            "@type": "accumulation"
        },
        "OutMaps": {
            "@cloneMap": "/dataset/maps/europe5km/lat.map",
            "@fmap": 1,
            "@namePrefix": "pR24",
            "@unitTime": 24,
            "Interpolation": {
                "@latMap": "/dataset/maps/europe5km/lat.map",
                "@lonMap": "/dataset/maps/europe5km/long.map",
                "@mode": "grib_nearest"
            }
        },
        "Parameter": {
            "@applyConversion": "tomm",
            "@shortName": "tp"
        }
    }
}
```

# Appendix B – Netcdf format output

Format: NETCDF4_CLASSIC.

Convention: CF-1.6

Dimensions:

- xc: Number of rows of area/clone map
- yc: Number of cols of area/clone map
- time: Unlimited dimension for time steps

Variables:

- lon: 2D array with shape (yc, xc)
- lat: 2D array with shape (yc, xc)
- time_nc: 1D array of values representing hours since dataDate of first grib message (endStep)
- values_nc: a 3D array of dimensions (time, yc, xc), with coordinates set to 'lon, lat'.

# Appendix C – mapping between grib2pcraster and pyg2p

This appendix aims to help to migrate from grib2pcraster to pyg2p.

## Differences in glossary

- The Manipulation as intended in grib2pcraster becomes Aggregation in pyg2c; if you read the term manipulation in the pyg2c documentation, that means a more generic term, including correction and conversion. Anyway, if you read the python code, the python class which performs aggregation is called Manipulator itself.
- What it's called TypeOfField in grib2pcraster becomes stepType in pyg2p (as for the GRIB standard). It defines the aggregated nature of the variable which can be instant, averaged, or cumulated.
- In grib2pcraster, the variable to extract is called parameter and it's referenced by a couple of numbers: **x.y**, where:
    - **x** is the value of the *indicatorOfParameter* key as found in the GRIB message
    - **y** is an internal number identifying the TableVersion as found in the parameters.xml file of grib2pcraster.
- In pyg2p, while the Parameter term was retained, it is identified by the *shortName* key as found in the GRIB message. This is an independent version key and it's only related to the variable itself and not to the *generating centre* of the file, since this is already coded in GRIB API tables. That is, in pyg2p the concepts of generating centre and table parameter versions don't need to exist.

## Mapping variables

To “translate” the parameter code **x.y** used in grib2pcraster to the ***shortName*** form of pyg2c, just follow these simple steps:

1. Identify the parameter in grib2pcraster's parameters.xml file using **y** to find the *gribTablesVersionNo* and **x** to find the single item *Param*.
2. Take note of abbreviation and field description strings of the Param above.
3. Use some basic GRIB tools (and meteorological) skills to find the ***shortName*** value of the grib:

```
grib_get -p shortName,parameterName /path/to/grib/file.grib2
```

## Known parameters mapping with conversions

| **Variable** | **grib2pcraster selectors (indicatorOfParameter.gribTablesVersionNo)** | **pyg2p.py shortName** | **Configured conversions in grib2pcraster** |
|---|---|---|---|
| 2 meters Dew-point | • 17.2<br>• 168.128 | • 2D | • x-273.15 |
| 2 meters Temperature | • 11.2<br>• 500011.0<br>• 167.128 | • t_2m<br>• td_2m<br>• 2t | • x-273.15 |
| Total precipitation | • 61.2<br>• 228.128 | • tp | • Only cut off<br>• x*1000 + cut off |
| Latent heat flux | • 500086.0<br>• 121.2 | • alhfl_s | • **x*(-0.0353) + cut off [default]**<br>• x*(-0.00147) + cut off |
| Surface Latent heat flux | • 147.128 | • slhf | No conversion |
| Surface Runoff | • 8.230<br>• 8.128 | • sro | • x*1000 + cut off |
| Sub-Surface Runoff | • 9.230<br>• 9.128 | • ssro | • x*1000 + cut off |
| Large scale precipitation | • 142.128 | • lsp | • x*1000 + cut off |
| Convective precipitation | • 143.128 | *Not tested. It needs to be added to parameters.xml if used.* | • x*1000 + cut off |
| Evaporation | • 182.128 | • e | • x*(-1000) |
| Runoff | • 205.128 | *Not tested. It needs to be added to parameters.xml if used.* | • x*1000 + cut off *(not as default, it needs to be set by command line with --unit parameter)* |
| Surface precipitation amount, rain, grid scale | • 102.201 | • rain_gsp | • Only cut off |
| Surface precipitation amount, rain, | • 113.201 | • rain_con | • Only cut off |

| | | | |
|---|---|---|---|
| convective | | | |
| Large scale rain rate | • 500134.0 | *Not tested. It needs to be added to parameters.xml if used.* | • Only cut off |
| Snow fall | • 144.128 | *Not tested. It needs to be added to parameters.xml if used.* | • x*1000 |
| Snow depth | • 141.128 | *Not tested. It needs to be added to parameters.xml if used.* | • X*1000 (not as default, it needs to be set by command line with --unit parameter) |

## Execution parameters mapping

| **Argument** | **grib2pcraster** | **pyg2p.py** |
|---|---|---|
| Input file | -i | -i |
| Variable | -p x.y | json[8] (shortName) |
| Output directory | -o | -o |
| EPS perturbationNumber | -m | -m |
| Variable level | --level | json |
| Aggregation type | Default in parameters.xml. Overwriting with --ma | json (type) |
| Aggregation step | -t | json (step) |
| Start step | -s | -s or json (tstart) |
| End step | -e | -e or json (tend) |
| Output map unittime | --unittime | json (unitTime) |
| Interpolation | -r,-l,-a or –intertable | json (see relative section in this manual). |
| Conversion | parameters.xml | parameters.json and json command file (applyConversion) |
| Correction | Two formulas hardcoded and configured | json (attributes |

8 In this table, “json” means that the corresponding parameter configuration is in the execution json template where you configure your extraction and pass to the pyg2p with the -c input argument. If not indicated otherwise, the json tag/attribute name is the same as the grib2pcraster input argument (e.g.: --level=10 becomes the json attribute level=”10”).

| | | |
|---|---|---|
| | by default in parameters.xml or with --temp and --evap. | correctionFormula, gem, dem) |
| Map extension naming | --fmap, --ext | json |
| Map prefix name | -n | json |
| Logging | --report. Loggers directory is under program installation folder | Console logger level overwritable with -l (default is INFO). |

## Difference in dealing with multiresolution

Multiresolution extraction can be made in one step with pyg2p, using both -i and -I for input files or even a single multiresolution file. The grib2pcraster application needs to perform two executions, instead.

## Differences in Correction

There is a sort of bug in grib2pcraster when come to correction, since the dem values it uses are stored in its interlookup tables and, if the DEM has changed for some reasons, the corrected values will be wrong unless the interlookup table is not regenerated using the new DEM map.

However, here the main difference is that the correction formulas are editable directly by the user in pyg2p.

## Differences in Aggregation

The type of aggregation and its step window must be specified in pyg2p, using the ***Aggregation*** attribute.

In grib2pcraster, instead, the type of aggregation for the specific variable is being extract (i.e. manipulation) is read from *ManipulationFlag* attribute in *parameters.xml* file: “1” for average and “2” for accumulation. The step window is 24 hours by default and it can be overwritten with -t parameter.

## Differences in Interpolation

Resampling of grids in **grib2pcraster** is made using GRIB API. Available interpolation methods are:

- nearest neighbours
- inverse distance

The interpolation table file is declared with the input argument –intertable, or otherwise by configuration, using one of the tables in *interpolation.xml*.

In **pyg2p** there are two additional resampling modes (see the relative Interpolation modes paragraph in this document). Results are very similar to GRIB_API based interpolation methods but interlookup table is  being created in seconds rather than hours (in our tests, interlookup table creation for high resolution or global scale grids take almost two days with GRIB_API methods while it takes one minute with scipy based methods).

They are *nearest* and *invdist* modes, performed using scipy routines to find neighbours and distances.

Interlookup tables are read/written by default using ~/.pyg2p/intertables as folder where to load existing intertables or save new ones. An alternative folder can be specified using the intertableDir attribute in the *Interpolation* property of the json template configuration.

# Appendix D – Glossary

Brief description of terms you find in this manual, with their synonims.

| Term | Synonims | Description |
|---|---|---|
| Interpolation lookup table | Intertable, interlookup table | It's a numpy binary file containing indexes correspondences and coefficients/distances. Each combination of **GRIB grid**/PCRaster target coordinates maps/Interpolation mode has its own intertable. Since there are four interpolation modes using intertables, there can be four different intertables for each combination of **GRIB grid**/PCRaster lat/lon maps. |
| Aggregation | | Average or accumulation |
| Interpolation | Resampling | Resampling between the original **GRIB grid** and the target raster lat/lon coordinates. |
| Execution JSON template file | Execution template, commands file, execution file, json template, json configuration | The JSON file where most of **execution parameters** are configured. It's being passed by the mandatory CLI argument ***-c***. |
| Parameter | Variable | The meteorological variable stored in the input grib file. |
| Command line Input argument | Input argument, CLI argument, option | Input arguments to the application passed via command line. They are ***-i***,-*I*,-*o*,-*m*,-*l*,-*d*,***-c*** |
| Execution parameter | Parameter, input argument | All configured options (via CLI or json files) that define the execution context. |
| GRIB grid | Grid | It's the set of geodetic attributes identifying the coordinate system and the specific projected area. The set includes **gridType**, first and last values of latitude and longitudes, number of |

| Term | Synonims | Description |
|---|---|---|
| | | points along the meridian. |
| GRIB message's gridType | Grid type, grid | It's the specific grid type of the **GRIB message** and can be regular_rr, regular_ll, rotated_rr, rotated_ll, reduced_ll and so on. |
| GRIB message | Grib | It's a single message extracted from a **GRIB file**. |
| GRIB API | | C library (and its wrappers) from ECMWF to deal with **grib files**. |
| GRIB file | Grib | An input file encoded using GRIB format. |
| Geopotential GRIB values | Geopotential | Geopotential values encoded in grib files, used for correction. |
| Gem value | Gem | In correction, the **gem value** is being obtained using the formula configured with *gem* property, where *z* is the geopotential value.<br>E.g. gem = “(z/9.81)*0.0065” |

# Appendix E – Developer notes

## Developer notes about correction formulas

Previous correction formulas were derived directly from grib2pcraster C code. The need to set up two formulas – one for the gem value and one for the final corrected value (which uses the previously formulated gem value) – exists because the correction formulas are based on DEM and geopotential values. DEM values are in PCRaster format while geopotential data is a GRIB message, which needs to be interpolated before to put it into the correction formula. That means that the correction process is applied in two steps with a split formula as configured.

### Grib2pcraster correction process:

In this paragraph, some C code is shown from the original grib2pcraster C application.

Geopotential value is read from a grib file as (note the correction):

```
//correction formula is applied here (it's the gem in pyg2p)
if (intCorrectionFlag == 1)//temperature correction
	{
		for (i = 0; i < values_len; i++) {
			pgeopotential[i] = (pgeopotential[i] / 9.81) * 0.0065;
```

```
        }
    } else if (intCorrectionFlag == 2)//evap correction
    {
        for (i = 0; i < values_len; i++) {
            pgeopotential[i] = pgeopotential[i] / 9.81;
            pgeopotential[i] = pow(10, ((-0.159) * (pgeopotential[i]) / 1000));
        }
    }
```

Then, the actual correction is made during the interpolation process (some not relevant code was removed and comments added to the real code):

```
//interpolation
float tmpValue = (pGRIBValues[grid[i].indexInGRIBArrNode1]) *
(grid[i].CoefficientNode1) + (pGRIBValues[grid[i].indexInGRIBArrNode2]) *
(grid[i].CoefficientNode2) + (pGRIBValues[grid[i].indexInGRIBArrNode3]) *
(grid[i].CoefficientNode3)
                        + (pGRIBValues[grid[i].indexInGRIBArrNode4]) *
(grid[i].CoefficientNode4);


if (intCorrectionFlag != 0) {
  //interpolation of geopotential as read before
  float tmpGeo = (geopotential[grid[i].indexInGRIBArrNode1]) *
(grid[i].CoefficientNode1) +      (geopotential[grid[i].indexInGRIBArrNode2]) *
(grid[i].CoefficientNode2) + (geopotential[grid[i].indexInGRIBArrNode3]) *
(grid[i].CoefficientNode3)
+ (geopotential[grid[i].indexInGRIBArrNode4]) * (grid[i].CoefficientNode4);

   //correction formula is applied here (the correctionFormula in pyg2p)
   if (intCorrectionFlag == 1)//temperature correction
              tmpValue = (tmpValue + tmpGeo) - (grid[i].demValue * 0.0065);
   if (intCorrectionFlag == 2)//evap correction
                tmpValue = (tmpValue / tmpGeo) * (pow(10, ((-0.159) *
(grid[i].demValue) / 1000)));
}

//store value in the output array
pPCRasterValues[grid[i].indexInPCRasterArr] = tmpValue;
```

### pyg2p correction process

The process in pyg2p is almost the same, that means:

- read geopotential from grib, and apply the correction formula as configured in json execution file (gem=”(z/9.81)*0.0065”)

- interpolate the gem values so obtained to the PCRaster output grid
- read grib values and interpolate them
- apply the final correction formula as configured (correctionFormula=”p+gem-dem*0.0065”)

The only difference is that in pyg2p formulas are configurable, as explained in this chapter (read Configuration manual as well), while in grib2pcraster you can choose, with a binary flag in parameters.json file, between two hard coded formulas (one for temperature and one for evaporation).