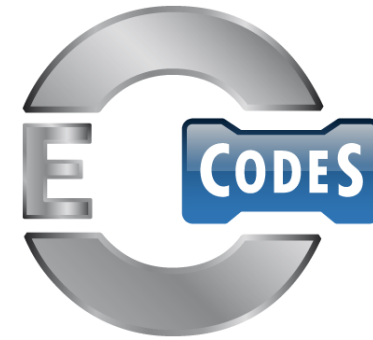


Introduction to GRIB and ecCodes

ecCodes GRIB Training Course

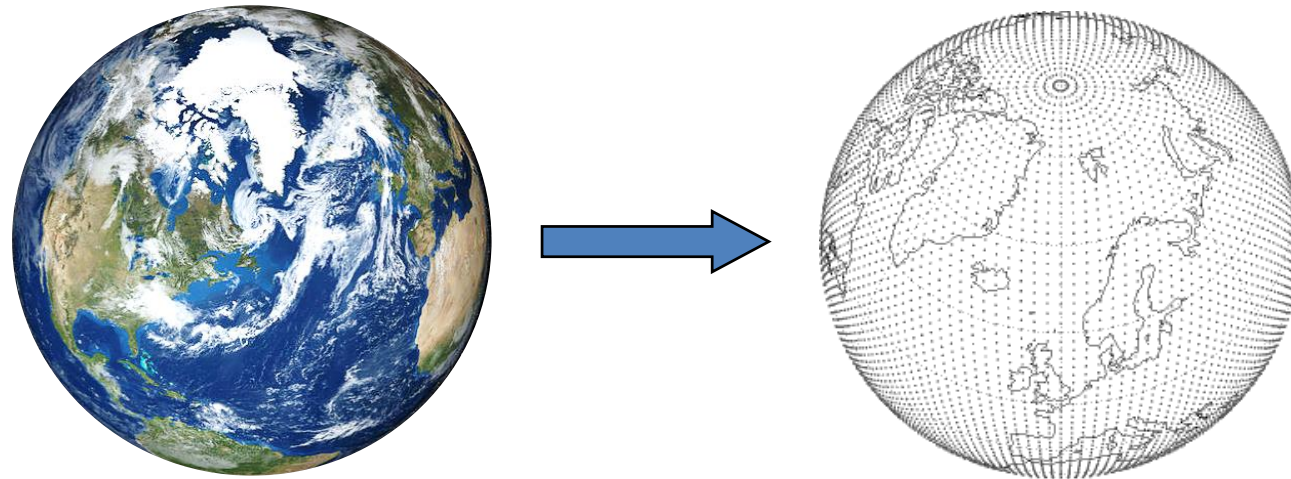
Xavier Abellan

Xavier.Abellan@ecmwf.int



What is GRIB?

GRIB is a **binary** format maintained by the **World Meteorological Organization** (WMO). It was designed to encode data produced by **numerical weather prediction** models



Acronyms:

GRIB => Initially “**G**RIdded **B**inary” but later expanded to “**G**eneral **R**egularly-distributed **I**nformation in **B**inary form”

What does it look like?

GRIB is a **byte-oriented** data exchange format and has to be decoded by software according to the WMO standard rules.

It is not human-readable!

47 52 49 42	00 00 66 01	00 00 1C 01	62 01 FF 80	33 6D 00 01	06 0C	GRIB f b ^Ä3m
05 0C 00 0C	00 C8 05 00	00 00 15 00	00 00 00 00	32 02 2B 0A	00 F8	» 2 + ^
01 90 80 33	C2 00 16 76	88 00 68 1A	00 76 F2 00	64 00 64 40	00 00	éÄ3- v à h vÚ d d@
00 00 80 55	F0 80 9C 40	00 00 00 00	43 3E B0 71	00 00 00 00	00 00	ÄU•Äú@ C>∞q
0C 08 80 11	3C 1F 09 7C	00 00 37 37	37 37			Ä < 7777

WMO Binary Codes

- Fully describes the GRIB coding standards
- It is the only authoritative source for the WMO binary codes GRIB
- It is publicly accessible on the WMO web site:

<http://www.wmo.int/pages/prog/www/WMOCodes.html>

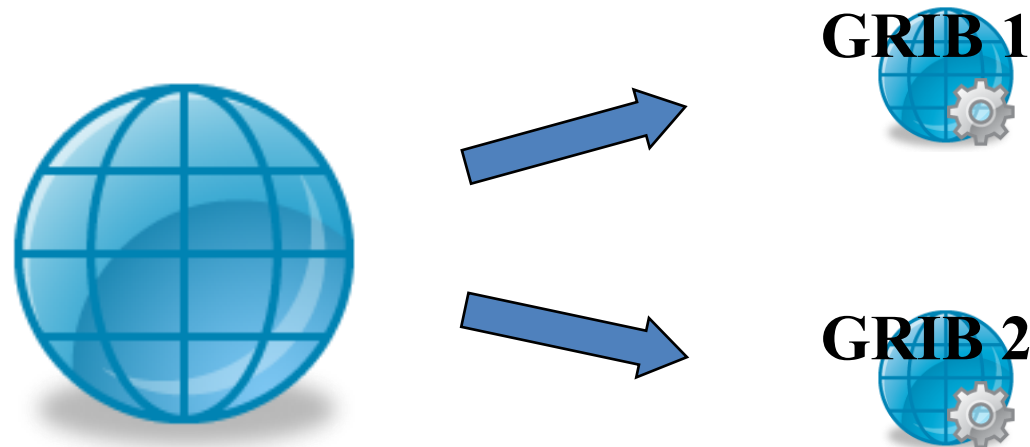
- A **revision of the full manual** is published **every three years**
- A **new version of the tables** which are part of the manual is released externally **twice a year**
- Latest version of the tables is accessible in several formats from the WMO web site:

http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vl2/LatestVERSION/LatestVERSION.html



GRIB Edition 1 vs. 2

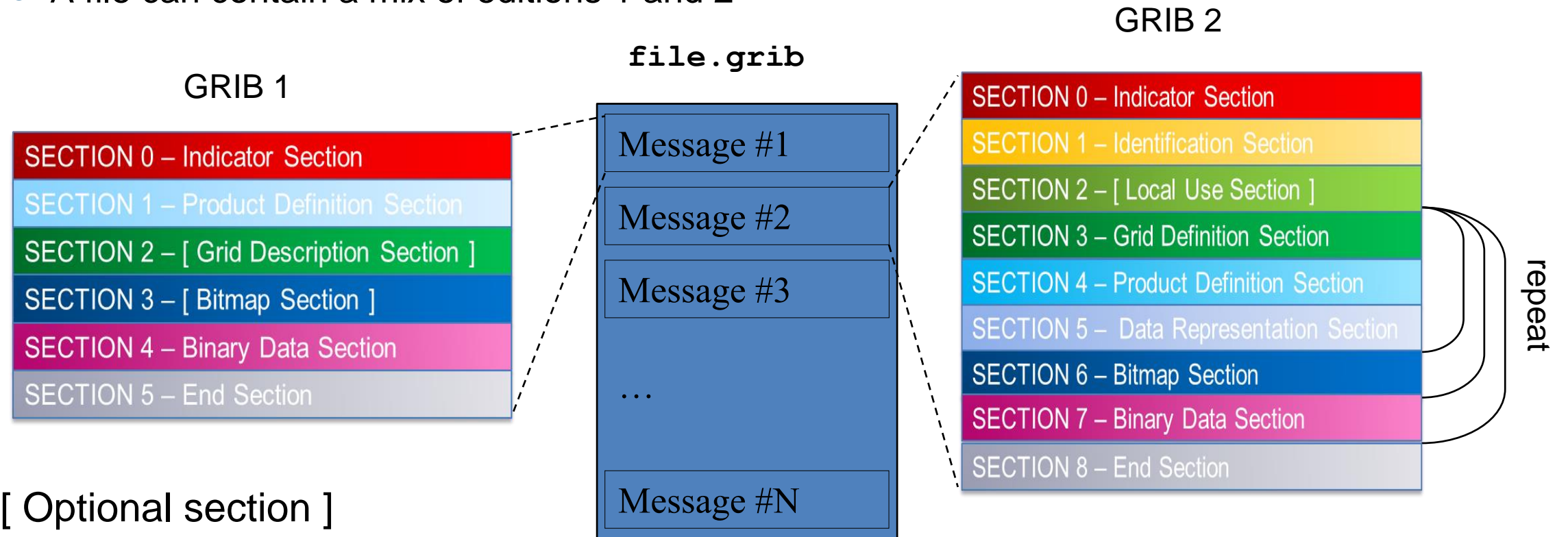
- Two different versions of the GRIB coding standard are available at the moment
 - edition 1 and 2
- The **coding principles** in both editions are similar, but their **implementation is very different**



GRIB Structure

- A **file** may contain one or more GRIB **messages**
- Each message contains several **sections**
- Data descriptors are self-defining
- A file can contain a mix of editions 1 and 2

47 52 49 42 00 00 66 01 00 00 1C 01 62 01 FF 80 33 6D 00 01 06 0C	GRIB f b ~Ä3m
05 0C 00 0C 00 C8 05 00 00 00 15 00 00 00 00 00 32 02 2B 0A 00 F8	» 2 + -
01 90 80 33 C2 00 16 76 88 00 68 1A 00 76 F2 00 64 00 64 40 00 00	éÄ3- v à h vÚ d d@
00 00 80 55 F0 80 9C 40 00 00 00 00 43 3E B0 71 00 00 00 00 00 00	ÄUÄú@ C>∞q
0C 08 80 11 3C 1F 09 7C 00 00 37 37 37 37	Ä < 7777



[Optional section]

GRIB 1 & GRIB 2 – Major differences

- The coding principles for GRIB edition 1 and 2 are similar but their implementation is **very different**
- The structure of GRIB 1 and GRIB 2 messages is different
 - Both have sections but with **different meanings**
- In GRIB 2 several variables are defined with more precision
 - In GRIB 1 latitudes and longitudes are in mili-degrees
 - In GRIB 2 latitudes and longitudes are in micro-degrees
- In GRIB 2 longitude values must lie between 0° and 360°
- Encoding of the parameter is **very** different
- In GRIB 2 the description of the data (parameter, time, statistics, grid...) is template / table based
 - More flexible ... but also more complex !

GRIB 1 & GRIB 2 – Legacy

- GRIB edition 1 is a legacy WMO Code which is not accepted for GTS exchange anymore
- New versions of the tables/templates are only issued for GRIB edition 2

Usage of GRIB 2 at ECMWF?

- Since **18 May 2011** all model level fields for HRES and are encoded in GRIB 2
- Most surface and all pressure level fields are encoded in GRIB 1
 - Some recently introduced surface fields are encoded in GRIB 2 (e.g. ptype)
- Staged migration of remaining GRIB 1 fields to GRIB 2 “will follow”

And what’s not affected by this migration?

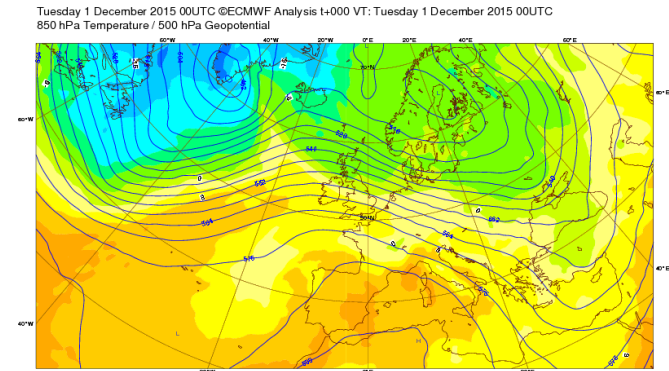
- The wave model
- The System-4 seasonal forecast model
- ERA-Interim

Introducing ecCodes

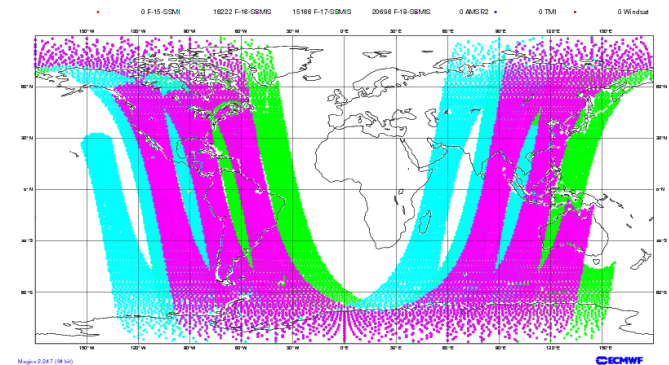
ecCodes is a package developed by ECMWF for decoding and encoding messages in the following formats:

- WMO FM-92 **GRIB** edition 1 and edition 2
- WMO FM-94 BUFR edition 3 and edition 4
- WMO GTS abbreviated header

We will cover only **GRIB** in this training course.



ECMWF Data Coverage (All obs DA) - Microwave imager
01/Dec/2015; 00 UTC
Total number of obs = 52084

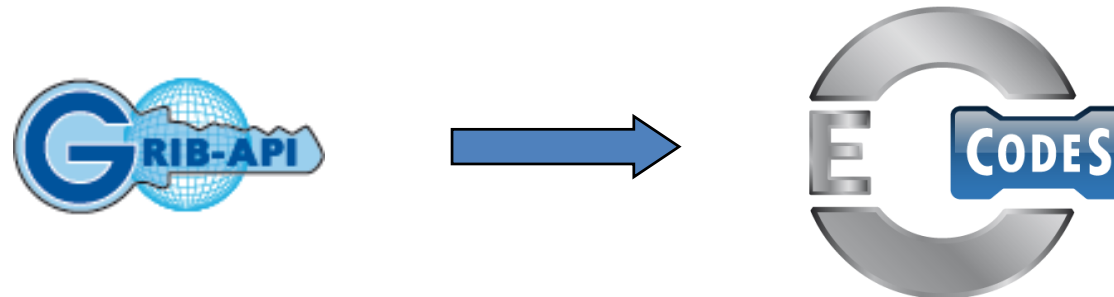


Introducing ecCodes

- The library includes:
 - a set of command line tools (the GRIB Tools) to provide a quick and easy way to manipulate data
 - Fortran 90, C and Python APIs
- It provides the user with a higher level of access, hiding the binary layer of the message
- It provides an easy and reliable way of encoding and decoding both GRIB 1 and GRIB 2 messages
- It decodes / encodes both GRIB editions with the **SAME** function calls
- Easily updated with new templates and tables.

ecCodes: Formerly known as GRIB-API

- ecCodes is an **evolution** of GRIB-API (with additional support for BUFR)
- For GRIB encoding and decoding, ecCodes provides the same functionality as GRIB-API
- ecCodes is now the primary GRIB decoding/encoding package used at ECMWF
- It is released under the Apache 2.0 license

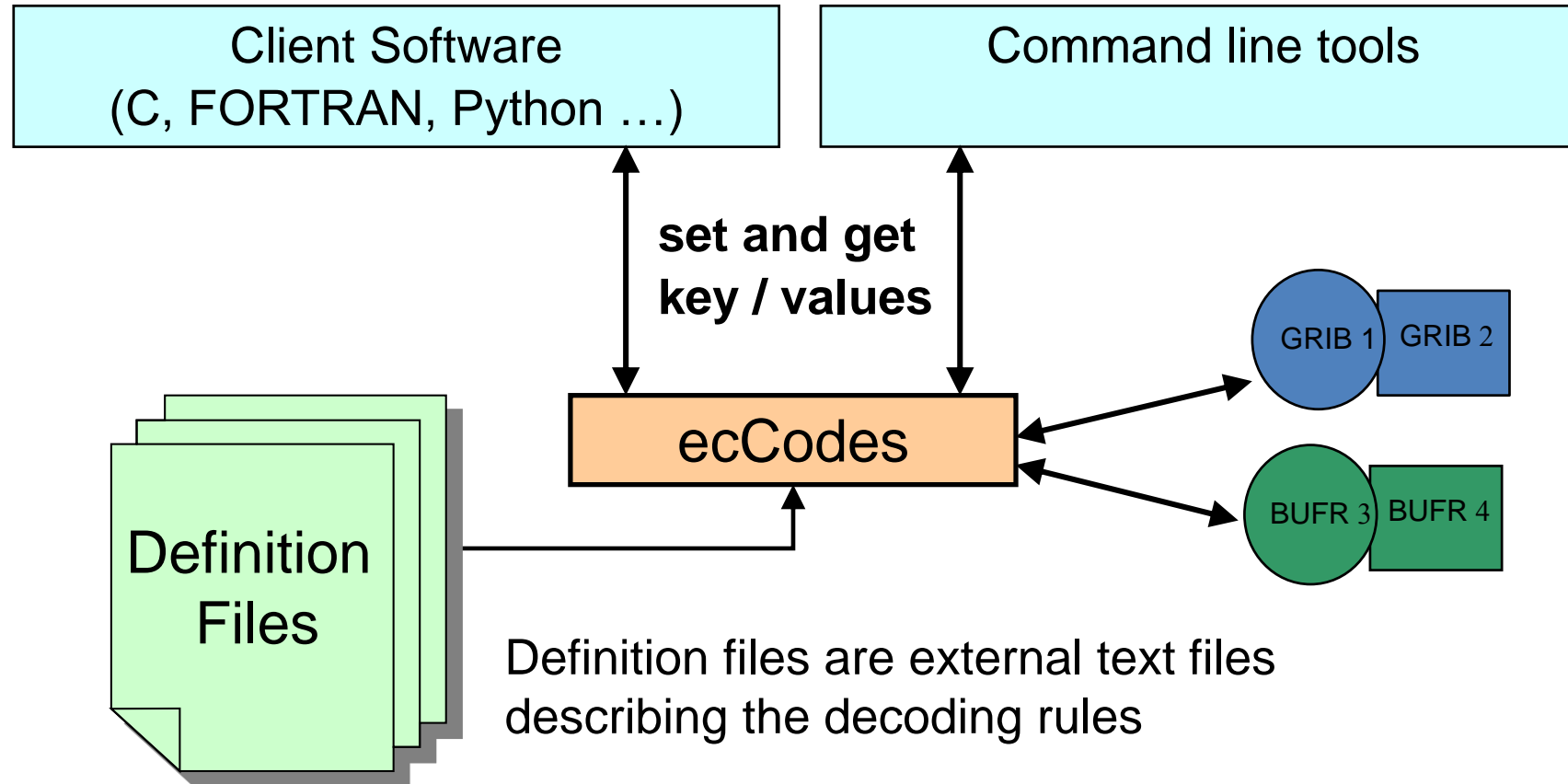


GRIB-API will not be supported after end of 2018

ecCodes vs. older software

- Previous Fortran-based packages provided array-based access to the message.
 - `ksec2(2)` => Number of points along a parallel
 - `ksec2(3)` => Number of points along a meridian
 - ...
- ecCodes provides a **key/value** based approach
 - `numberOfPointsAlongAParallel` => Number of points along a parallel
 - `numberOfPointsAlongAMeridan` => Number of points along a meridian
 - ...

ecCodes architecture



Definition files are external text files describing the decoding rules

New decoding rules can be added without rebuilding ecCodes

ecCodes and GRIB editions 1 and 2

GRIB 1 coded	<code>latitudeOfFirstGridPoint=40000</code>
GRIB 2 coded	<code>latitudeOfFirstGridPoint=40000000</code>
Computed by ecCodes	<code>latitudeOfFirstGridPointInDegrees=40</code>
GRIB 1 coded	<code>dataRepresentationType=4</code> <code>numberOfPointAlongAParallel=MISSING</code> <code>ijDirectionIncrementGiven=0</code> <code>p1 = {...}</code>
GRIB 2 coded	<code>gridDefinitionTemplateNumber=40</code> <code>numberOfPointsAlongAParallel=MISSING</code> <code>iDirectionIncrementGiven=0</code> <code>iDirectionIncrement=MISSING</code> <code>p1={...}</code>
Computed by ecCodes	<code>gridType=reduced_gg</code>

ecCodes: available interfaces

- **C native interface** exposes all the functionality (the engine itself is written in C)
- **Fortran 90** provides an easy access to the main functionality of the library from Fortran 90
- **Python** provides access to the C functions from Python
- **Tools** provide a command line interface to the API
- All the interfaces provide a way to **set/get** the same **key/values** pairs from the messages

ecCodes: available interfaces (C)

```
h = codes_handle_new_from_file(context, in, PRODUCT_GRIB, &err);
```

```
codes_get_double(h, "latitudeOfFirstGridPointInDegrees", &lat1);
```

```
codes_set_long(h, "centre", centre);
```

```
codes_set_string(h, "date", date, &len);
```

```
codes_handle_delete(h);
```

Note: The functions with the “grib_” prefix are also supported for backward compatibility with grib_api

ecCodes: available interfaces (Fortran 90)

```
call codes_new_from_file(ifile, igrib, CODES_PRODUCT_GRIB, iret)
```

```
call codes_get(igrib, 'latitudeOfFirstGridPointInDegrees', lat1)
```

```
call codes_set(igrib, 'centre', centre)
```

```
call codes_set(igrib, 'date', '20070212')
```

```
call codes_release(igrib)
```

Note: The functions with the “grib_” prefix are also supported for backward compatibility with grib_api

ecCodes: available interfaces (Python)

```
gid = codes_new_from_file(f, CODES_PRODUCT_GRIB)
```

```
lat = codes_get(gid, 'latitudeOfFirstGridPointInDegrees')
```

```
codes_set(gid, 'centre', centre)
```

```
codes_set(gid, 'date', date)
```

```
codes_release(gid)
```

Note: The functions with the “grib_” prefix are also supported for backward compatibility with grib_api

ecCodes: available interfaces (tools)

```
grib_get -p latitudeOfFirstGridPointInDegrees input.grib
```

```
grib_set -s centre=ecmf,date=20070212 input.grib out.grib
```

ecCodes: downloading and installing

- ecCodes uses **CMake** for compilation and installation
- CMake is a cross-platform free software program for managing the build process of software using a compiler-independent method

- Download ecCodes from:

<https://software.ecmwf.int/wiki/display/ECC/Releases>

- Installation instructions:

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



ecCodes: Installation

- Linux or Mac platforms
 - Fairly recent **cmake** ($\geq 2.8.11$) and GNU **make**
 - **C compiler** (gcc, icc, craycc)
- Optional, but recommended:
 - **Fortran compiler** for the Fortran bindings / **Python** for the Python bindings
 - **Jasper** / OpenJPEG for jpeg encoding
 - **netCDF** or **netCDF4** for the grib_to_netcdf conversion tool

```
$> tar -xzf eccodes-x.y.z-Source.tar.gz
$> mkdir build ; cd build
$> PREFIX=/path/to/where/you/install/eccodes
$> cmake -DCMAKE_INSTALL_PREFIX=$PREFIX ../eccodes-x.y.z-Source
...
$> make
$> ctest
$> make install
```

ecCodes: What now?

- On a standard installation of ecCodes, in “/path/to/where/you/install/eccodes”:

- Before you can use the tools, add the relevant bit to the \$PATH variable:

```
$> export ECCODES_DIR=/path/to/where/you/install/eccodes
$> export PATH=$ECCODES_DIR/bin:$PATH
```

- You can compile and link your own program against ecCodes:

```
$> gfortran -o my_grib_program my_grib_program.f90 \
-I$ECCODES_DIR/include -L$ECCODES_DIR/lib -Wl,-rpath,$ECCODES_DIR/lib -leccodes_f90 -leccodes
```

- To use the python interface, add the relevant bit to the \$PYTHONPATH variable:

```
$> export PYTHONPATH=$ECCODES_DIR/lib/python2.7/site-packages:$PYTHONPATH
```

- **If working at ECMWF...**

- No need to define PATH or PYTHONPATH. The software modules define some useful environment variables:

```
$> module load eccodes
$> gfortran -o my_grib_program my_grib_program.f90 $ECCODES_INCLUDE $ECCODES_LIB
```

Help and support

- For issues, bugs and requests:

Software.Support@ecmwf.int

- E-learning introductory module:

https://www.ecmwf.int/assets/elearning/eccodes/eccodes1/story_html5.html

- Wiki:

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

- Please use the Forums for general discussions:

<https://software.ecmwf.int/wiki/display/ECC/Forums>