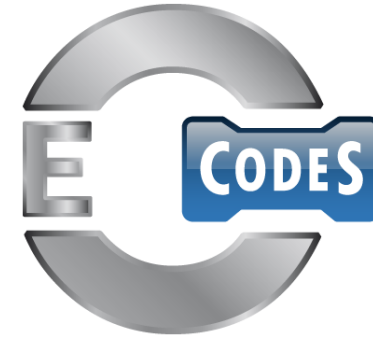# Introduction to GRIB and ecCodes

ecCodes GRIB Training Course
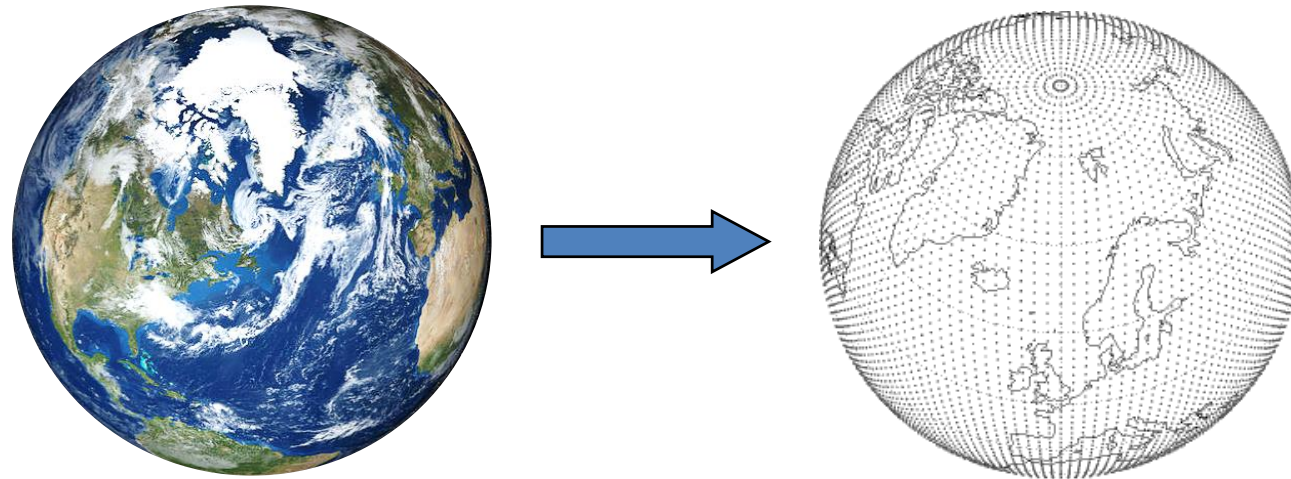
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What is GRIB?

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 "GRIdded Binary" but later expanded to "General Regularly-distributed Information in Binary 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!

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_vI2/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 1

GRIB 2
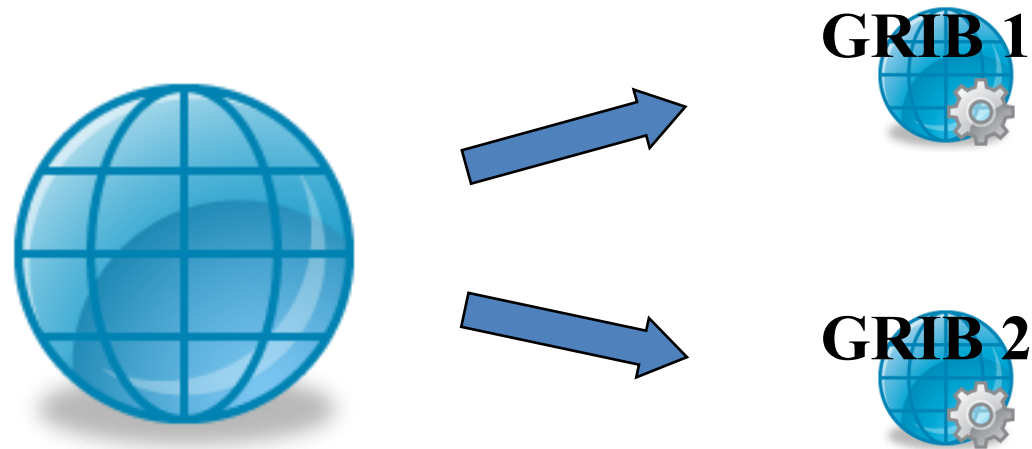
GRIB Structure

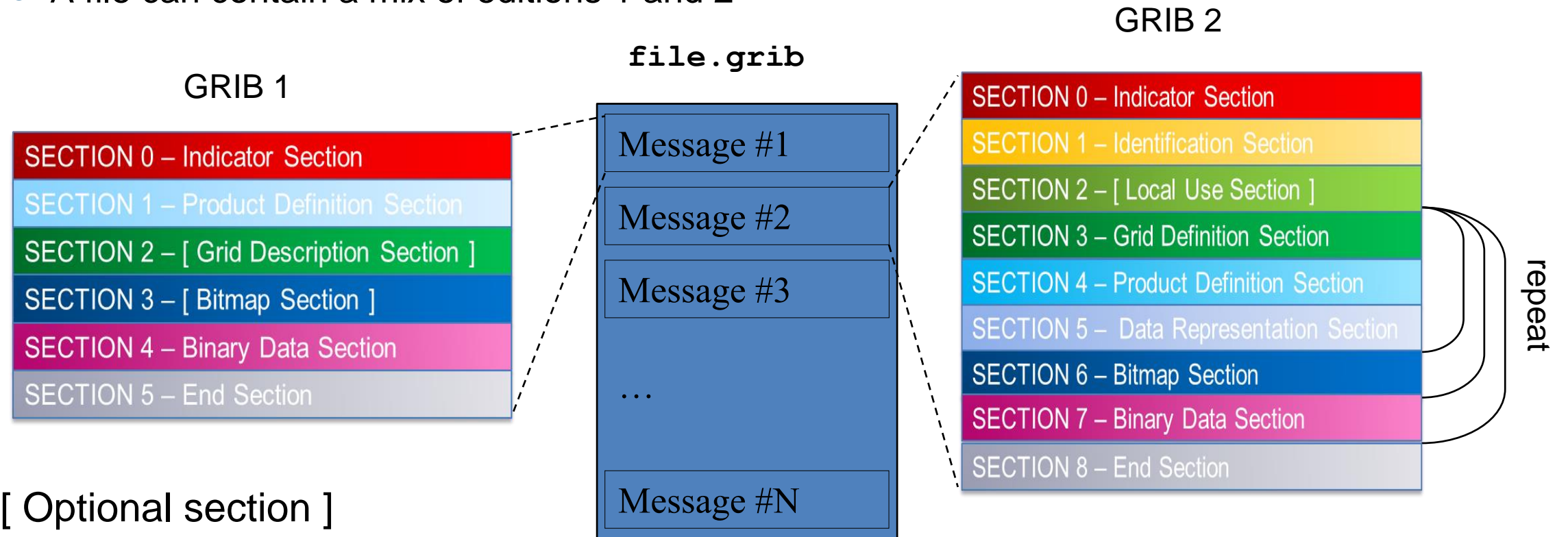- A file may contain one or more GRIB messages

- 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    êÄ3¬  và 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
```

GRIB 2

file.grib

GRIB 1

SECTION 0 – Indicator Section
SECTION 1 – Product Definition Section
SECTION 2 – [Grid Description Section]
SECTION 3 – [Bitmap Section]
SECTION 4 – Binary Data Section
SECTION 5 – End Section

Message #1
Message #2
Message #3
…
Message #N

SECTION 0 – Indicator Section
SECTION 1 – Identification Section
SECTION 2 – [Local Use Section]
SECTION 3 – Grid Definition Section
SECTION 4 – Product Definition Section
SECTION 5 – Data Representation Section
SECTION 6 – Bitmap Section
SECTION 7 – Binary Data Section
SECTION 8 – End Section

repeat

[Optional section]

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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"

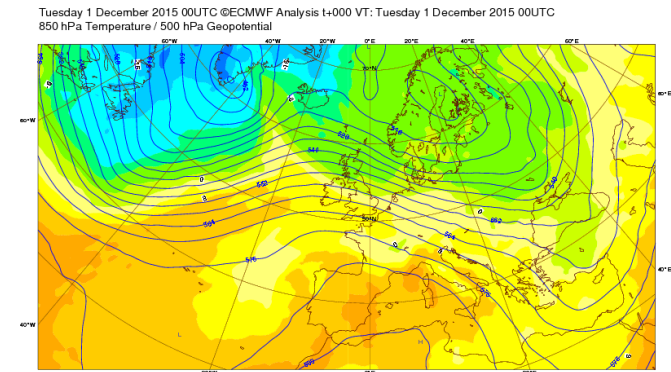**And what's not affected by this migration?**

- The wave model

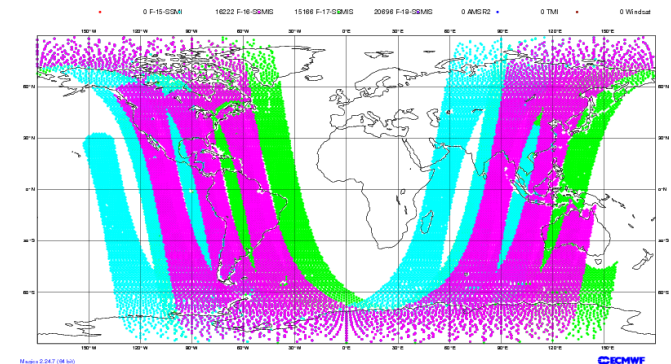- The System-4 seasonal forecast model

- 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.

Tuesday 1 December 2015 00UTC ©ECMWF Analysis t+000 VT: Tuesday 1 December 2015 00UTC
850 hPa Temperature / 500 hPa Geopotential

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

- ecCodes will eventually replace GRIB-API

- It is released under the Apache 2.0 license
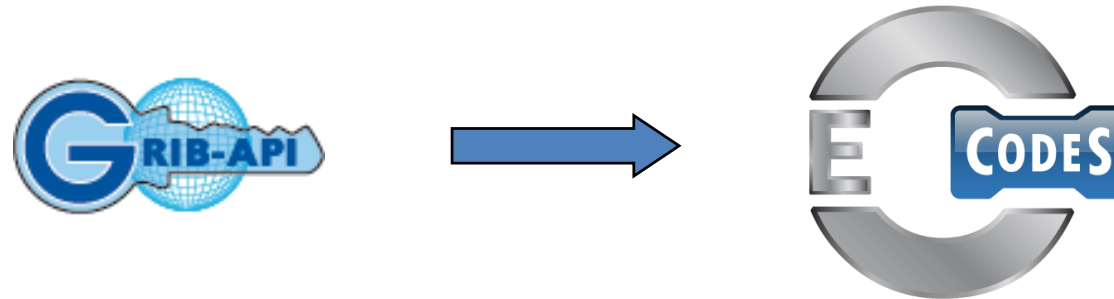
ecCodes vs. older software

- 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
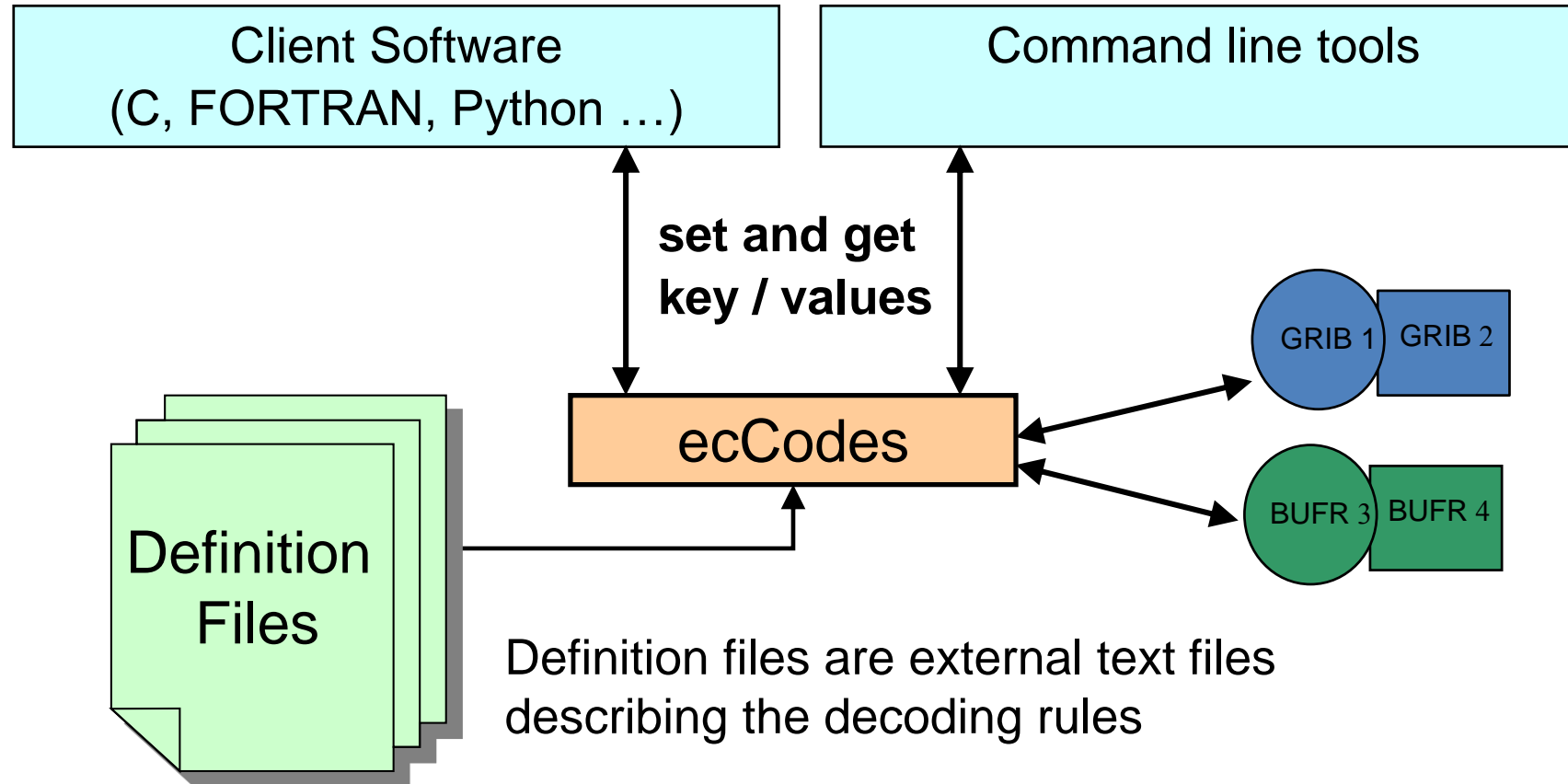
Definition files are external text files describing the decoding rules

New decoding rules can be added without rebuilding ecCodes

ecCodes and GRIB editions 1 and 2

GRIB 1 coded	`latitudeOfFirstGridPoint=40000`
GRIB 2 coded	`latitudeOfFirstGridPoint=40000000`
Computed by ecCodes	`latitudeOfFirstGridPointInDegrees=40`

GRIB 1 coded	`dataRepresentationType=4`
	`numberOfPointAlongAParallel=MISSING`
	`ijDirectionIncrementGiven=0`
	`pl ={…}`

GRIB 2 coded	`gridDefinitionTemplateNumber=40`
	`numberOfPointsAlongAParallel=MISSING`
	`iDirectionIncrementGiven=0`
	`iDirectionIncrement=MISSING`
	`pl={…}`

Computed by ecCodes	`gridType=reduced_gg`

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)

```fortran
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)

```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** (>= 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