# GRIB decoding

## Computer User Training Course 2015

**Paul Dando**

**User Support**

**advisory@ecmwf.int**

ECMWF

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- Decoding GRIB messages with Fortran 90 … and Python

# GRIB

- GRIB – “General Regularly-distributed Information in Binary form”
- Code defined by the WMO / CBS in 1985
- Designed to exchange and store large volumes of gridded data
- Machine independent
- Requires software for encoding and decoding
- Currently there are two different coding standards

  GRIB edition 1

  - Currently used for ECMWF operational surface and pressure level data

  GRIB edition 2

  - Recent format now being used by some centres and for the TIGGE archive
  - Used for ECMWF operational model level data since 18 May 2011

# GRIB edition 1 overview

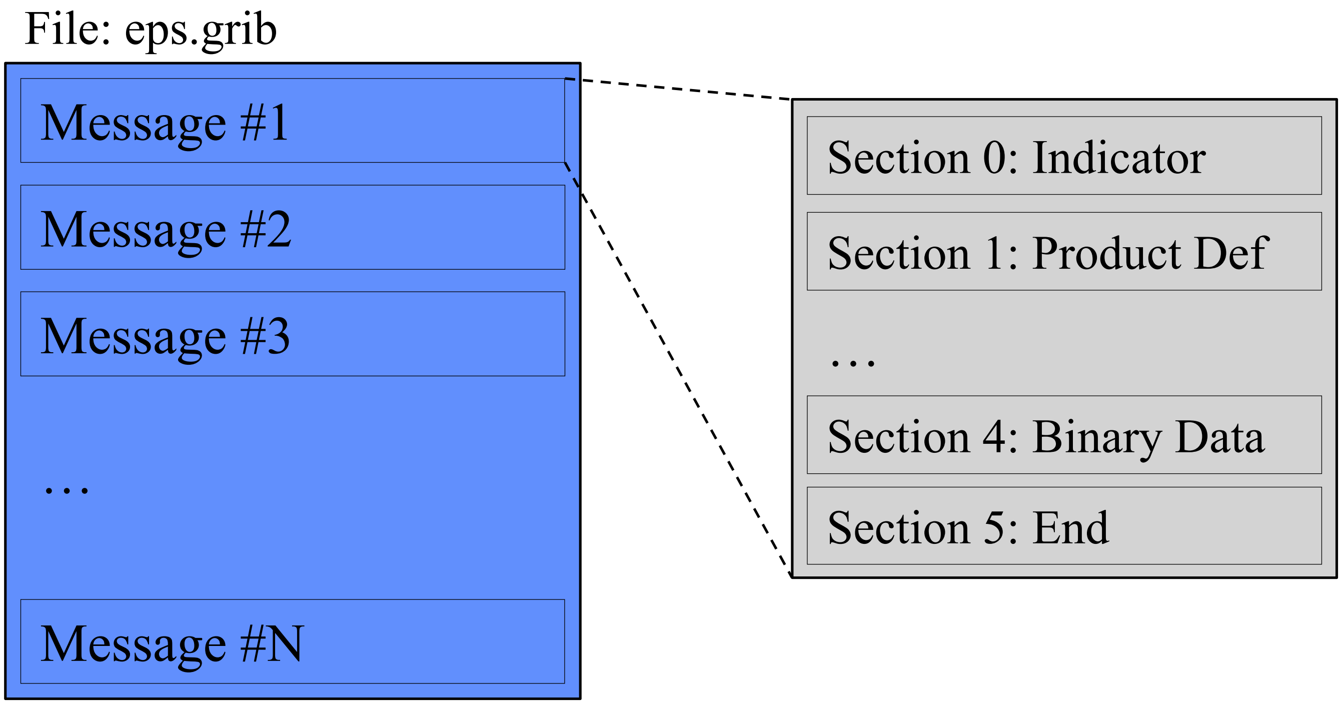
Main feature of GRIB is that data descriptors are self-defining

- Section 0 – Indicator section
- Section 1 – Product definition section
- Section 2 – [ Grid description section ]
- Section 3 – [ Bit map section ]
- Section 4 – Binary data section
- Section 5 – 7777 (End of GRIB message)

In the above [  ] indicates an optional section

# GRIB Structure

- A file may contain one or more GRIB messages
- Each message contains several sections
- Note: A file can contain a mix of editions 1 and 2



File: eps.grib

Message #1

Message #2

Message #3

…

Message #N

Section 0: Indicator

Section 1: Product Def

…

Section 4: Binary Data

Section 5: End

# GRIB 1 & GRIB 2 – Different Structure

## GRIB 1

SECTION 0 Indicator

SECTION 1 Product Definition

SECTION 2 [ Grid Description ]

SECTION 3 [ Bitmap ]

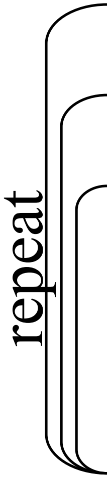
SECTION 4 Binary Data

SECTION 5 End (7777)

## GRIB 2

SECTION 0 Indicator

SECTION 1 Identification



SECTION 2 [ Local Use ]

SECTION 3 Grid Definition

SECTION 4 Product Definition

SECTION 5 Data Representation

SECTION 6 Bitmap

SECTION 7 Binary Data

SECTION 8 End (7777)

Optional sections are indicated by [ ]

# 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 milli-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 !

# Use of GRIB 2 at ECMWF

## What is currently affected ?

- Since 18 May 2011 all model level fields for HRES and ENS (including the monthly extension) are encoded in GRIB 2
  - GRIB 1 model level data are no longer produced or disseminated
- Most surface and all pressure level fields are encoded in GRIB 1
  - Some recently introduced surface fields are encoded in GRIB 2
- Staged migration of remaining GRIB 1 fields to GRIB 2 will follow

## And what's not ?

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

# Introducing GRIB API

- GRIB API Library is an application programming interface developed by ECMWF
- GRIB API hides the binary layer of the message providing the user with a higher level of access
- It provides an easy and reliable way of encoding and decoding both GRIB 1 and GRIB 2 messages
- GRIB API decodes / encodes both GRIB editions with the SAME function calls
- Command line tools (the GRIB Tools) provide a quick and easy way to manipulate data
- Fortran 90, C and Python interfaces give access to the main features of the library

# GRIB API approach

- GRIB API uses a key / value approach to access the information in a GRIB message

  numberOfPointsAlongAParallel ➔ Number of points along a parallel

  numberOfPointsAlongAMeridan ➔ Number of points along a meridian

  …

- The set of keys available changes from one message to another depending on:
  - the GRIB edition
  - the content of the message

- Changing the values of some keys can cause some other keys to disappear and new keys to become available

# GRIB API – coded and computed keys

- The value of a key is not always coded in the GRIB message
- Some keys are combinations of several other keys and provided through a given algorithm or can be just temporary (transient)
- Therefore we talk about
  - CODED keys ( coded in the message as they are )
  - COMPUTED keys ( temporary or computed from other keys )
- Alternative names (“aliases”) are provided for several keys

# GRIB API – coded and computed keys

- Coded keys
  - Linked directly to the octets of the GRIB message
  - Values obtained by decoding the octet e.g. indicatorOfParameter
- Computed keys
  - Obtained by combining other keys (coded or computed)
  - Provide a synthesis of the information contained in the message
  - Provide a convenient way to access complex attributes
  - Setting the value of a computed key sets all related keys in a cascade
    - e.g. setting typeOfGrid=regular_ll will set all the various keys in the Grid Definition Section for a regular lat-long grid
  - MARS keywords are available as computed keys

# GRIB API keys – parameter

- The definition of the parameter is very different in the two editions

| GRIB 1 keys | GRIB 2 keys |
|---|---|
| centre | discipline |
| table2Version | parameterCategory |
| indicatorOfParameter | parameterNumber |
| levelType | typeOfFirstFixedSurface |
| level | scaleFactorOfFirstFixedSurface |
| … | scaledValueOfFirstFixedSurface |
| | typeOfSecondFixedSurface |
| | scaleFactorOfSecondFixedSurface |
| | scaledValueOfSecondFixedSurface |
| | productDefinitionTemplateNumber |
| | … |

# GRIB API keys – parameter

- GRIB API provides some edition-independent keys to identify a parameter

| Key name | Example value |
|---|---|
| paramId | 151 |
| shortName | msl |
| centre | ecmf (or 98) |
| name | Mean sea level pressure |
| unit | Pa |

- This set of keys is the parameter *namespace*

# The parameter database

- The parameter database stores information about the GRIB 1, GRIB 2 and, for some parameters, netCDF encoding of all parameters recognised by GRIB API

- The database is accessible via a web interface at:
  - http://old.ecmwf.int/publications/manuals/d/gribapi/param

# GRIB API – namespace

- A namespace is a name for a set of keys.
- There are several different namespaces
  - parameter
  - time
  - geography
  - vertical
  - statistics
  - mars

# GRIB API keys – time

- Start of forecast run

| Key name | Example values |
|---|---|
| dataDate | 20140305 (YYYYMMDD) |
| dataTime | 0, 600, 1200, 1800 |

- Forecast Step

| Key name | Example values |
|---|---|
| stepType | instant, accum, avg, max, min, … |
| stepUnits | s, m, h, 3h, 6h, 12h, D, M, Y, 10Y, 30Y, C |
| startStep | 0, 3, … |
| endStep (= step) | 0, 3, .. |
| stepRange | 3-6, 6 (“startStep-endStep” , “endStep” ) |

- Validity of the forecast

| Key name | Example values |
|---|---|
| validityDate | 20140305 (YYYYMMDD) |
| validityTime | 0, 300, 1200, 1800 |

# GRIB API keys – MARS

- There is a namespace consisting of all the MARS keywords

| Key name | Example values |
|---|---|
| date | 20140305 (YYYYMMDD) |
| time | 0000, 0600, 1200, 1800 |
| step | 3, 6, 9, 12, … |
| class | od, … |
| stream | oper, enfo,… |
| expver | 0001 |
| type | an, fc, cf, pf, … |
| levtype | sfc, pl, ml |
| levelist | 500, 850, … |
| param | 151.128 |

# GRIB API keys – THE Reference

- GRIB 1 keys

  http://old.ecmwf.int/publications/manuals/d/gribapi/fm92/grib1/

- GRIB 2 keys

  http://old.ecmwf.int/publications/manuals/d/gribapi/fm92/grib2/

- Edition independent keys

  http://old.ecmwf.int/publications/manuals/d/gribapi/keys/

- Use edition independent keys where possible !

# GRIB API keys

- The easiest way to inspect a GRIB file and to find the keys available is to use the GRIB Tools

  - grib_ls to get a summary of the content
  - grib_dump to get a more detailed view

# GRIB Tools – basic concepts

- The GRIB tools are part of the ECMWF GRIB API Library
- They are a set of command line programs for interactive and batch decoding and processing of GRIB data
- They provide ready and tested solutions to the most common processing of GRIB data
  - They work with both GRIB edition 1 and GRIB edition 2
- Their use will avoid the need to write new code and thus speed up your work
  - Consider using GRIB Tools instead of writing your own programs
- The tools are provided with many common options so that it is quick to apply the same options to different tools
- Use of the tools is recommended whenever possible !

# GRIB Tools – more basics

- All of the tools use a common syntax

```
grib_<tool> [options] grib_file grib_file … [output_grib]
```

- There are tools for getting information about the GRIB API installation and the keys available
  - grib_info,   grib_keys
- There are tools to inspect the content of and compare GRIB messages
  - grib_ls,   grib_dump,   grib_get,   grib_get_data,  grib_compare
- There are tools for counting and copying some messages
  - grib_count,   grib_copy
- There are tools for making changes to the content of a GRIB message and converting GRIB to netCDF
  - grib_set,   grib_filter,   grib_to_netcdf

# GRIB Tools – getting help

- UNIX ‘man’-style pages are available for each tool by running the tool without any options or input file

```
> grib_dump
NAME    grib_dump

DESCRIPTION
        Dump the content of a grib file in different formats.

USAGE
        grib_dump [options] grib_file grib_file ...

OPTIONS
        -O      Octet mode. WMO documentation style dump.
        -D      Debug mode.
        -d      Print all data values.
…
```

# grib_ls – list the content of GRIB files

- Use grib_ls to get a summary of the content of GRIB files
- Without options grib_ls prints a default list of keys
- Options exist to specify the set of keys to print or to print other keys in addition to the default set
- Output can be ordered
  - e.g. order by ascending or descending step
- grib_ls does not fail if a key is not found
- grib_ls can also be used to find the grid point(s) nearest to a specified latitude-longitude and print the value of the field at that point
  - Modes available to obtain one or four nearest grid points

# grib_ls – usage

```
grib_ls [options] grib_file grib_file ...
```

Basic options

| | |
|---|---|
| `-p key1,key2,…` | Keys to print |
| `-P key1,key2,…` | Additional keys to print |
| `-w key1=val1,key2!=val2…` | Where option |
| `-B “key asc, key desc”` | Order by: “step asc, centre desc” |
| `-n namespace` | Print keys for `namespace` |
| `-m` | Print MARS keys |
| `-i index` | Print data value at given index |
| `-l lat,lon[,MODE,FILE]` | Value(s) nearest to lat-lon point |
| `-F format` | Format for floating point values |
| `-W width` | Minimum column width (default 10) |

# grib_ls – examples

```
> grib_ls file.grib1
file.grib1
edition   centre   typeOfLevel   level   dataDate ... dataType  shortName packingType   gridType
1         ecmf     isobaricInhPa  1000   20140304 ...  an         t       spectral_complex  sh
1         ecmf     isobaricInhPa  500    20140304 ...  an         t       spectral_complex  sh
1         ecmf     isobaricInhPa  200    20140304 ...  an         t       spectral_complex  sh
1         ecmf     isobaricInhPa  100    20140304 ...  an         t       spectral_complex  sh
4 of 4 grib messages in file.grib1

4 of 4 total grib messages in 1 files
```

- Use **-p** option to specify a list of keys to be printed

```
> grib_ls -p centre,dataDate,shortName,paramId,typeOfLevel,level file.grib1
file.grib1
centre      dataDate     shortName    paramId       typeOfLevel         level
ecmf          20140304     t            130         isobaricInhPa       1000
ecmf          20140304     t            130         isobaricInhPa       500
ecmf          20140304     t            130         isobaricInhPa       200
ecmf          20140304     t            130         isobaricInhPa       100
4 of 4 grib messages in file.grib1

4 of 4 total grib messages in 1 files
```

# grib_ls – examples

- When a key is not present in the GRIB file, it returns “not found” for this key

```
> grib_ls -p my_key  file.grib1
file.grib1
my_key
not_found

> echo $?
0
```

*exit code returned = 0*

- Similar behaviour to grib_get (see later)
  - grib_ls is more for interactive use
  - use grib_get within scripts

# Using the ‘where’ option

- The where option **-w** can be used with all the GRIB Tools
- Constraints are of the form key=value or key!=value or key=value1/value2/value2

```
-w key1=value1,key2:i!=value2,key3:s=value3
```

- Messages are processed only if they match ALL the key / value constraints

```
> grib_ls -w level=100 file.grib1                              “IS”
…
> grib_ls -w level!=100 file.grib1                             “NOT”
…
> grib_ls -w level=100,stepRange=3 file.grib1                 “AND”
…
> grib_ls -w level=100/200/300/500 file.grib1                  “OR”
…
```

# Specifying the type of the key

- All grib_api keys have a default type
  - e.g. string, integer, floating point
- The type of the key can be specified as follows:
  - **key** -> native type
  - **key:i** -> integer (or **key:l –** the “el” is for “long” !)
  - **key:s** -> string
  - **key:d** -> double

```
> grib_ls -p centre:i,dataDate,shortName,paramId,typeOfLevel,level file.grib1
file.grib1
centre      dataDate    shortName   paramId       typeOfLevel         level
98          20140304    t           130           isobaricInhPa       1000
98          20140304    t           130           isobaricInhPa       500
98          20140304    t           130           isobaricInhPa       200
98          20140304    t           130           isobaricInhPa       100
4 of 4 grib messages in file.grib1

4 of 4 total grib messages in 1 files
```

# grib_dump – dump content of GRIB files

- Use grib_dump to get a detailed view of the content of a file containing one or more GRIB messages
- Various output formats are supported
  - Octet mode provides a WMO documentation style dump
  - Debug mode prints all keys available in the GRIB file
  - Octet and Debug modes cannot be used together
  - Octet content can also be printed in hexadecimal format
- Options also exist to print key aliases and key type information

# grib_dump – usage

```
grib_dump [options] grib_file grib_file ...
```

Basic options

| | |
|---|---|
| `-O` | Octet mode (WMO Documentation style) |
| `-D` | Debug mode |
| `-a` | Print key alias information |
| `-t` | Print key type information |
| `-H` | Print octet content in hexadecimal |
| `-w key{=/!=}value,…` | Where option |
| `-d` | Print all data values |
| `...` | |

# grib_dump – examples

```
> grib_dump file.grib1
***** FILE: file.grib1
#==============   MESSAGE 1 ( length=4284072 )              ==============
GRIB {
  editionNumber = 1;
  table2Version = 128;
  # European Center for Medium-Range Weather Forecasts (grib1/0.table)
  centre = 98;
  generatingProcessIdentifier = 141;
  # Geopotential  (m**2 s**-2)  (grib1/2.98.128.table)
  indicatorOfParameter = 129;
  # Surface  (of the Earth, which includes sea surface)  (grib1/3.table)
  indicatorOfTypeOfLevel = 1;
  level = 0;
  # Forecast product valid at reference time + P1  (P1>0)  (grib1/5.table)
  timeRangeIndicator = 0;
  # Unknown code table entry (grib1/0.ecmf.table)
  subCentre = 0;
  paramId = 129;
  #-READ ONLY- units = m**2 s**-2;
  #-READ ONLY- nameECMF = Geopotential;
  #-READ ONLY- name = Geopotential;
  decimalScaleFactor = 0;
  dataDate = 20140304;
  dataTime = 0; ...
```

*Some keys are read only*

*keys are case sensitive:*

*dataDate, dataTime*

# grib_dump – examples

```
> grib_dump -O file.grib1
***** FILE: file.grib1
==============   MESSAGE 1 ( length=4284072 )         ==============
1-4         identifier = GRIB
5-7         totalLength = 4284072
8           editionNumber = 1
====================== SECTION_1 ( length=52, padding=0 ) ======================
1-3         section1Length = 52
4           table2Version = 128
5           centre = 98 [European Center for Medium-Range Weather Forecasts
                                                                  (grib1/0.table) ]
6           generatingProcessIdentifier = 141
7           gridDefinition = 255
8           section1Flags = 128 [10000000]
9           indicatorOfParameter = 129 [Geopotential  (m**2 s**-2)
                                                          (grib1/2.98.128.table) ]
10          indicatorOfTypeOfLevel = 1 [Surface  (of the Earth, which includes sea
                                                       surface)  (grib1/3.table) ]
11-12       level = 0
13          yearOfCentury = 14
14          month = 3
15          day = 4
16          hour = 0
17          minute = 0
18          unitOfTimeRange = 1 [Hour (grib1/4.table) ] ...
```

# grib_dump – examples

```
> grib_dump -OtaH  file.grib1

***** FILE: file.grib1
==============   MESSAGE 1 ( length=4284072 )             ==============
1-4       ascii identifier = GRIB ( 0x47 0x52 0x49 0x42 )
5-7       g1_message_length totalLength = 4284072 ( 0x41 0x5E 0xA8 )
8         unsigned editionNumber = 1 ( 0x01 ) [ls.edition]
====================== SECTION_1 ( length=52, padding=0 ) ======================
1-3       section_length section1Length = 52 ( 0x00 0x00 0x34 )
4         unsigned table2Version = 128 ( 0x80 ) [gribTablesVersionNo]
5         codetable centre = 98 ( 0x62 ) [European Center for Medium-Range Weather
          Forecasts (grib1/0.table) ] [identificationOfOriginatingGeneratingCentre,
                              originatingCentre, ls.centre, centreForTable2]
6         unsigned generatingProcessIdentifier = 141 ( 0x88 )
                              [generatingProcessIdentificationNumber, process]
7         unsigned gridDefinition = 255 ( 0xFF )
8         codeflag section1Flags = 128 [10000000] ( 0x80 )
9         codetable indicatorOfParameter = 129 ( 0x81 ) [Geopotential (m**2 s**-2)
                                                        (grib1/2.98.128.table) ]
10        codetable indicatorOfTypeOfLevel = 1 ( 0x01 ) [Surface  (of the Earth,
          which includes sea surface)  (grib1/3.table) ] [levelType, mars.levtype]
11-12     unsigned level = 0 ( 0x00 0x00 ) [vertical.topLevel,
                                          vertical.bottomLevel, ls.level, lev]
13        unsigned yearOfCentury = 14 ( 0x0E )
14        unsigned month = 3 ( 0x03 )
15        unsigned day = 4 ( 0x04 ) …
```

# Practicals

- Work in your $SCRATCH

```
cd $SCRATCH
```

- Make a copy of the practicals directory in your $SCRATCH

```
tar -xvf /scratch/ectrain/trx/grib_practicals.tar
```

- This will create a directory in your $SCRATCH containing the GRIB data files for all today's practicals
- There are sub-directories for each practical:

```
ls $SCRATCH/grib_practicals
practical1 practical2 practical3
practical4 practical5 practical6
```

# Practical 1: using grib_ls and grib_dump

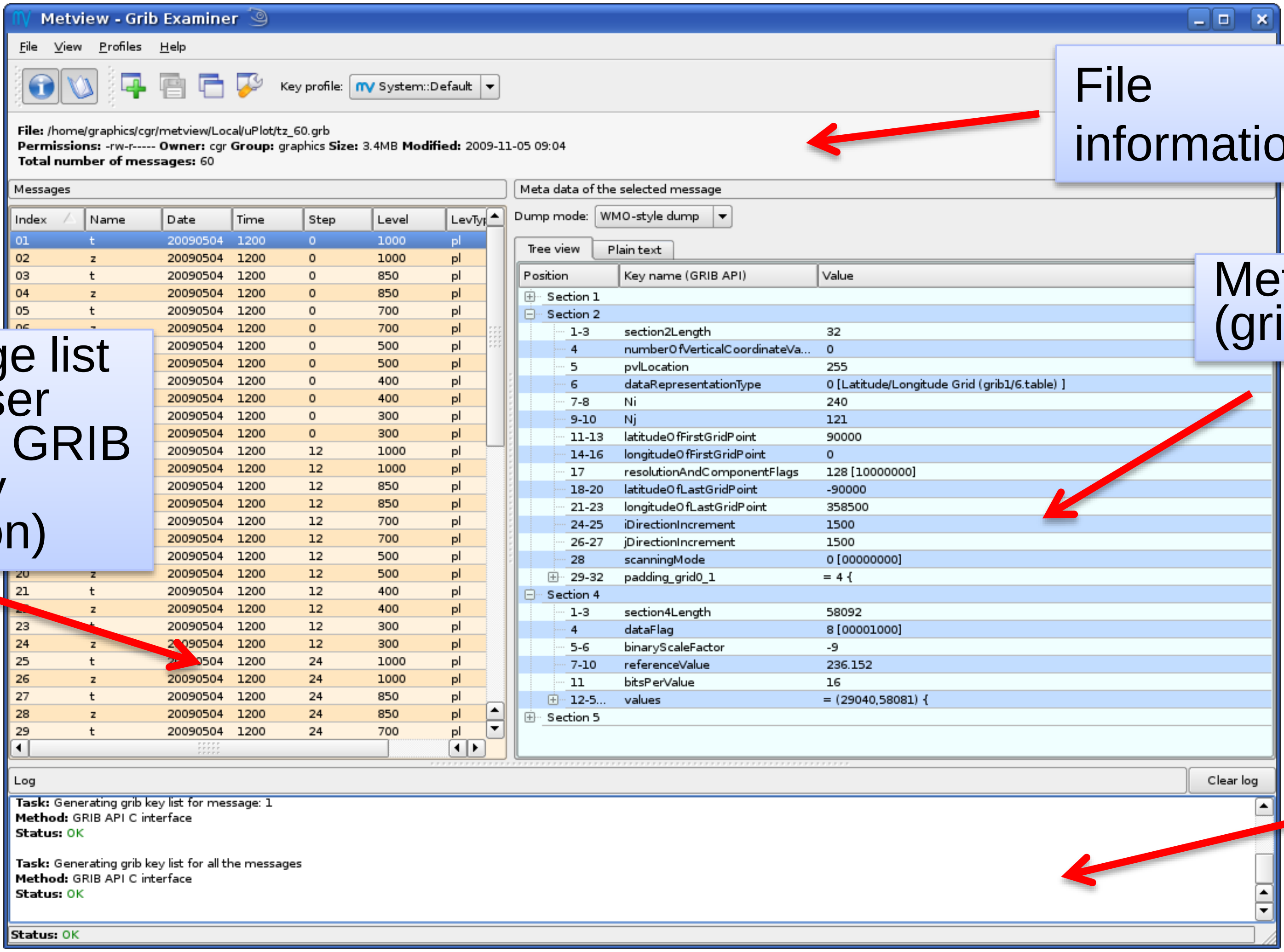
1. Use grib_ls to inspect the content of the files msl.grib1 and msl.grib2
   - Which keys does grib_ls show by default ?
   - What fields do the GRIB messages contain ?
   - Print the MARS keys.  Add the shortName to the output
   - Order the output in descending step order
2. Use grib_ls to print the centre, dataDate, stepRange, typeOfLevel and shortName for forecast step 6 only
   - Output the centre as both a string and an integer
3. Use grib_dump to inspect the fourth (count=4) GRIB message in both files
   - Experiment with the different grib_dump options:  `-O`, `-a` and `-t`
   - Identify the parameter, date, time, forecast step and the grid geometry

# GRIB Examiner (Metview 4)

- Interactive examiner using GRIB API
- Actively developed and maintained by the Metview team
- Can be started up from the command line. E.g. on ecgate use

```
metview4 -e grib your_grib_file
```

# GRIB Examiner: The user interface



**File:** /home/graphics/cgr/metview/Local/uPlot/tz_60.grb
**Permissions:** -rw-r----- **Owner:** cgr **Group:** graphics **Size:** 3.4MB **Modified:** 2009-11-05 09:04
**Total number of messages:** 60

Messages

| Index | Name | Date | Time | Step | Level | LevTyp |
|---|---|---|---|---|---|---|
| 01 | t | 20090504 | 1200 | 0 | 1000 | pl |
| 02 | z | 20090504 | 1200 | 0 | 1000 | pl |
| 03 | t | 20090504 | 1200 | 0 | 850 | pl |
| 04 | z | 20090504 | 1200 | 0 | 850 | pl |
| 05 | t | 20090504 | 1200 | 0 | 700 | pl |
| 06 | z | 20090504 | 1200 | 0 | 700 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 0 | 500 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 0 | 500 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 0 | 400 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 0 | 400 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 0 | 300 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 0 | 300 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 12 | 1000 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 12 | 1000 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 12 | 850 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 12 | 850 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 12 | 700 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 12 | 700 | pl |
| [illegible] | [illegible] | 20090504 | 1200 | 12 | 500 | pl |
| 20 | z | 20090504 | 1200 | 12 | 500 | pl |
| 21 | t | 20090504 | 1200 | 12 | 400 | pl |
| 22 | z | 20090504 | 1200 | 12 | 400 | pl |
| 23 | t | 20090504 | 1200 | 12 | 300 | pl |
| 24 | z | 20090504 | 1200 | 12 | 300 | pl |
| 25 | t | 20090504 | 1200 | 24 | 1000 | pl |
| 26 | z | 20090504 | 1200 | 24 | 1000 | pl |
| 27 | t | 20090504 | 1200 | 24 | 850 | pl |
| 28 | z | 20090504 | 1200 | 24 | 850 | pl |
| 29 | t | 20090504 | 1200 | 24 | 700 | pl |

Meta data of the selected message

Dump mode: WMO-style dump

| Position | Key name (GRIB API) | Value |
|---|---|---|
| Section 1 | | |
| Section 2 | | |
| 1-3 | section2Length | 32 |
| 4 | numberOfVerticalCoordinateVa... | 0 |
| 5 | pvlLocation | 255 |
| 6 | dataRepresentationType | 0 [Latitude/Longitude Grid (grib1/6.table) ] |
| 7-8 | Ni | 240 |
| 9-10 | Nj | 121 |
| 11-13 | latitudeOfFirstGridPoint | 90000 |
| 14-16 | longitudeOfFirstGridPoint | 0 |
| 17 | resolutionAndComponentFlags | 128 [10000000] |
| 18-20 | latitudeOfLastGridPoint | -90000 |
| 21-23 | longitudeOfLastGridPoint | 358500 |
| 24-25 | iDirectionIncrement | 1500 |
| 26-27 | jDirectionIncrement | 1500 |
| 28 | scanningMode | 0 [00000000] |
| 29-32 | padding_grid0_1 | = 4 { |
| Section 4 | | |
| 1-3 | section4Length | 58092 |
| 4 | dataFlag | 8 [00001000] |
| 5-6 | binaryScaleFactor | -9 |
| 7-10 | referenceValue | 236.152 |
| 11 | bitsPerValue | 16 |
| 12-5... | values | = (29040,58081) { |
| Section 5 | | |

Log

```
Task: Generating grib key list for message: 1
Method: GRIB API C interface
Status: OK

Task: Generating grib key list for all the messages
Method: GRIB API C interface
Status: OK
```

**Status:** OK

File information

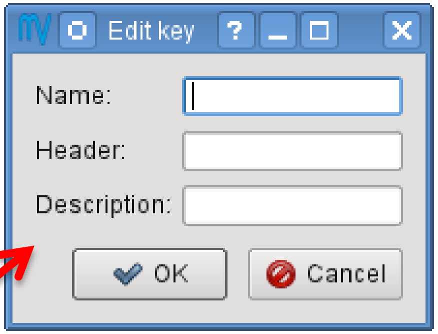
Meta data (grib_dump)

Message list (with user defined GRIB API key selection)

Log

# GRIB Examiner: managing GRIB API keys

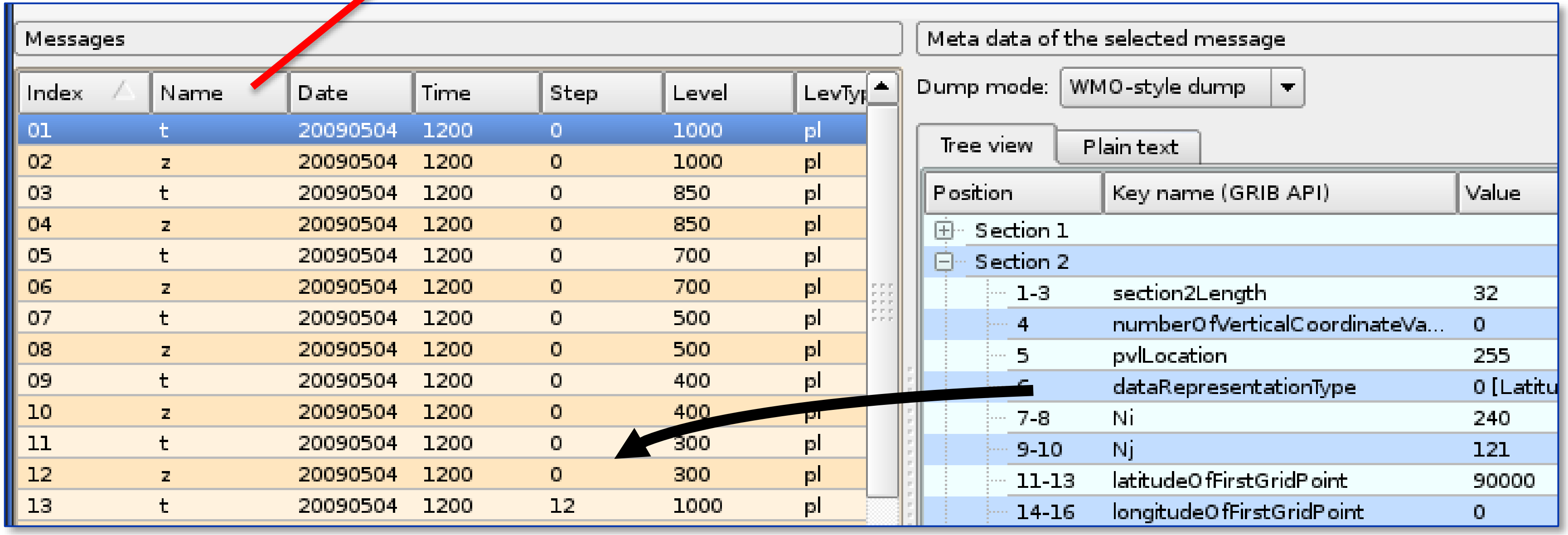
Insert/edit keys from header menu



Name:

Header:

Description:



| Index | Name | Date | Time | Step | Level | LevTyp |
|---|---|---|---|---|---|---|
| 01 | t | 20090504 | 1200 | 0 | 1000 | pl |
| 02 | z | 20090504 | 1200 | 0 | 1000 | pl |
| 03 | t | 20090504 | 1200 | 0 | 850 | pl |
| 04 | z | 20090504 | 1200 | 0 | 850 | pl |
| 05 | t | 20090504 | 1200 | 0 | 700 | pl |
| 06 | z | 20090504 | 1200 | 0 | 700 | pl |
| 07 | t | 20090504 | 1200 | 0 | 500 | pl |
| 08 | z | 20090504 | 1200 | 0 | 500 | pl |
| 09 | t | 20090504 | 1200 | 0 | 400 | pl |
| 10 | z | 20090504 | 1200 | 0 | 400 | pl |
| 11 | t | 20090504 | 1200 | 0 | 300 | pl |
| 12 | z | 20090504 | 1200 | 0 | 300 | pl |
| 13 | t | 20090504 | 1200 | 12 | 1000 | pl |

Dump mode: WMO-style dump

| Position | Key name (GRIB API) | Value |
|---|---|---|
| Section 1 | | |
| Section 2 | | |
| 1-3 | section2Length | 32 |
| 4 | numberOfVerticalCoordinateVa... | 0 |
| 5 | pvlLocation | 255 |
| 6 | dataRepresentationType | 0 [Latitu |
| 7-8 | Ni | 240 |
| 9-10 | Nj | 121 |
| 11-13 | latitudeOfFirstGridPoint | 90000 |
| 14-16 | longitudeOfFirstGridPoint | 0 |

Drag and drop a new key

# Finding nearest grid points with grib_ls

- The value of a GRIB field close to a specified Latitude/Longitude point can be found with grib_ls

```
grib_ls -l Latitude,Longitude[,MODE,file] grib_file
```

**MODE** Can take the values

4 Print values at the 4 nearest grid points (default)
1 Print value at the closest grid point

**file** Specifies a GRIB file to use as a mask
The closest *land* point (with mask ≥ 0.5) is printed

- GRIB files specified must contain grid point data

# Practical 2: using grib_ls –l

1. The file msl.grib1 contains the mean sea-level pressure from the EPS control forecast at 6-hourly time steps for the first 24 hours on a N320 reduced Gaussian grid
2. Find the value of the MSLP at the grid point nearest to ECMWF (Lat 51.42°N, Lon 0.95° W) at each forecast step
   - What is the lat-lon value of the grid point nearest to ECMWF ?
   - How far is the chosen grid point from ECMWF ?
3. Change the command used to output only the forecast step and the MSLP value at the nearest grid point
4. Change the command to output the MSLP values at the four grid points nearest to ECMWF
5. Use the file lsm.grib1 to provide a land-sea mask
   - Are all four nearest grid points land points (mask ≥ 0.5) ?

# grib_get – get key / value pairs

- Use grib_get to get the values of one or more keys from one or more GRIB files – very similar to grib_ls
- By default grib_get fails if an error occurs (e.g. key not found) returning a non-zero exit code
  - Suitable for use in scripts to obtain key values from GRIB messages
  - Can force grib_get not to fail on error
- Options available to get all MARS keys or all keys for a particular namespace
  - Can get other keys in addition to the default set
- Format of floating point values can be controlled with a C-style format statement

# grib_get – usage

```
grib_get [options] grib_file grib_file ...
```

Options

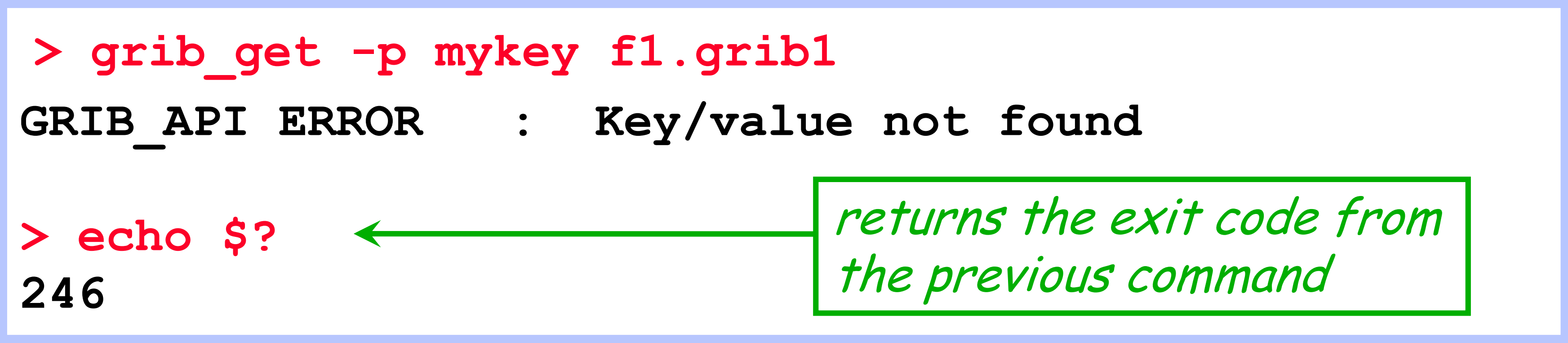
| | |
|---|---|
| `-p key1,key2,…` | Keys to get |
| `-P key1,key2,…` | Additional keys to get with `–m`, `-n` |
| `-w key1=val1,key2!=val2,…` | Where option |
| `-s key1=val1,…` | Keys to set |
| `-n namespace` | Get all keys for `namespace` |
| `-m` | Get all MARS keys |
| `-l lat,lon[,MODE,FILE]` | Value(s) nearest to lat-lon point |
| `-F format` | Format for floating point values |
| `-f` | Do *not* fail on error |
| `...` | |

# grib_get – examples

- To get the centre of the first (`count=1`) GRIB message in a file (both as a ‘string’ and a ‘long’)

```
> grib_get -w count=1 -p centre f1.grib1
ecmf

> grib_get -w count=1 -p centre:i f1.grib1
98
```

- grib_get fails if there is an error



```
> grib_get -p mykey f1.grib1
GRIB_API ERROR   :  Key/value not found

> echo $?
246
```

*returns the exit code from the previous command*

# grib_get – examples

- To get all the MARS keys, optionally printing the shortName

```
> grib_get –m f1.grib1
g sfc 20150223 1200 0 167.128 od an oper 0001

> grib_get –m –P shortName f1.grib1
2t g sfc 20150223 1200 0 167.128 od an oper 0001
```

- To get all keys belonging to the statistics namespace

```
 > grib_get -n statistics f1.grib1
314.24 214.613 277.111 21.0494 41379.8 2.48314e-05 0
```

- grib_get –m is the same as grib_get –n mars

# grib_get – controlling output format

- The format of floating point values can be controlled by using a C-style format statement with the `–F` option

  `-F “%.4f”` - Decimal format with 4 decimal places (1.2345)

  `-F “%.4e”` - Exponent format with 4 decimal places (1.2345E-03)

```
> grib_get –F “%.6f” –p maximum f1.grib1

314.240280

> grib_get –F “%.4e” –p maximum f1.grib1

3.1424e+02
```

- Default format is `–F “%.10e”`

# grib_get – stepRange and stepUnits

- The step is always printed as an integer value
- By default the units of the step are printed in hours
- To obtain the step in other units set the stepUnits appropriately with the **-s** option

```
> grib_get -p stepRange f1.grib1
6
12

> grib_get -s stepUnits=m -p stepRange f1.grib1
360
720
```

*stepUnits can be s, m, h, 3h, 6h, 12h, D, M, Y, 10Y, 30Y, C*

# Finding nearest grid points with grib_get

- The value of a GRIB field close to a specified Latitude/Longitude point can be found with grib_get
  - Works in the same way as grib_ls

```
> grib_get -l 52.0,-1.43 f1.grib1

273.58 272.375 273.17 273.531


> grib_get -F “%.5f” -P stepRange -l 52.0,-1.43,1 f1.grib1

0 272.37505
```

- GRIB files specified must contain grid point data

# Getting data values at an index point

- The value of a GRIB field at a particular index point can be printed using grib_get with the `-i` option
- For example, find the index of a nearest grid point with grib_ls and then use this with grib_get to build a list of values at that point:

```
> grib_get -F "%.2f" -i 2159 -p step,dummy:s f1.grib1

6 99429.31
12 99360.25
18 99232.31
24 99325.56
```

*Forces a space between step and value*

- Also returns a value for non-grid point data !

# grib_get_data – print data values

- Use grib_get_data to print a list of latitude, longitude (for grid point data) and data values from one or more GRIB files
- The format of the output can be controlled by using a C-style format statement with the **–F** option

  **-F "%.4f"** – Decimal format with 4 decimal places (1.2345)

  **-F "%.4e"** – Exponent format with 4 decimal places (1.2345E-03)

  The default format is **–F "%.10e"**
- By default missing values are not printed
  - A user-provided string can be printed in place of any missing values
- By default grib_get_data fails if there is an error
  - Use the **–f** option to force grib_get_data not to fail on error

# grib_get_data – usage

```
grib_get_data [options] grib_file grib_file ...
```

Options

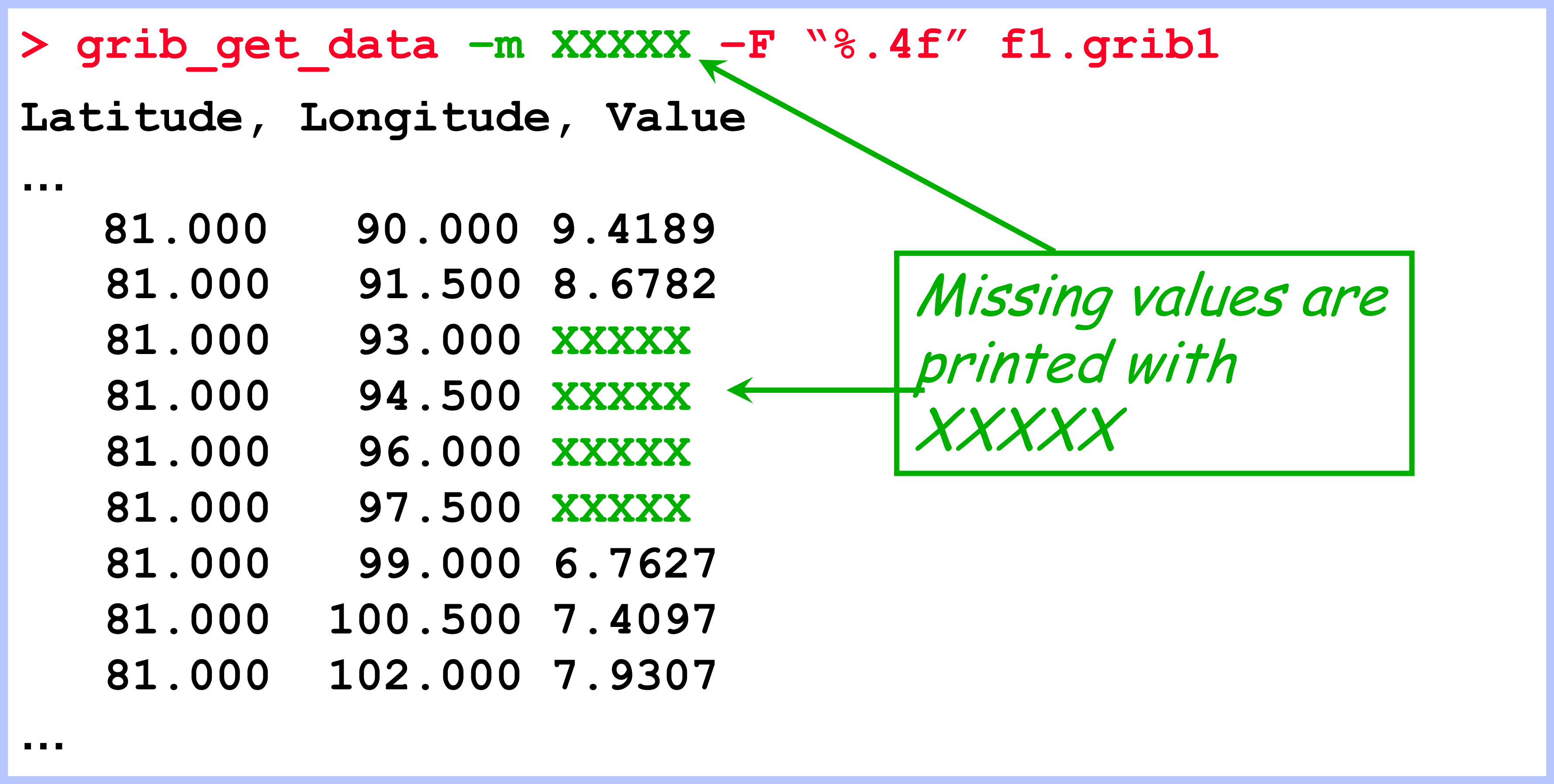
| | |
|---|---|
| `-p key1,key2,…` | Keys to print |
| `-w key1=val1,key2!=val2,…` | Where clause |
| `-m missingValue` | Specify missing value string |
| `-F format` | C-style format for output values |
| `-f` | Do *not* fail on error |
| `-V` | Print GRIB API Version |
| `...` | |

# grib_get_data – example

```
> grib_get_data -F "%.4f" f1.grib1
Latitude, Longitude, Value
   81.000     0.000 22.5957
   81.000     1.500 22.9009
   81.000     3.000 22.8359
   81.000     4.500 22.3379
   81.000     6.000 21.5547
   81.000     7.500 20.7344
   81.000     9.000 19.8916
   81.000    10.500 18.5747
   81.000    12.000 17.2578
   81.000    13.500 16.1343
   81.000    15.000 14.9785
   81.000    16.500 13.8296
...
```

*Format option applies to values only - not to the Latitudes and Longitudes*

# grib_get_data – missing values example



```
> grib_get_data -m XXXXX -F “%.4f” f1.grib1
Latitude, Longitude, Value
…
   81.000    90.000 9.4189
   81.000    91.500 8.6782
   81.000    93.000 XXXXX
   81.000    94.500 XXXXX
   81.000    96.000 XXXXX
   81.000    97.500 XXXXX
   81.000    99.000 6.7627
   81.000   100.500 7.4097
   81.000   102.000 7.9307
…
```

*Missing values are printed with XXXXX*

# Practical 3: using grib_get & grib_get_data

1. Use grib_get to obtain a list of all the pressure levels available for parameter T in the file tz_an_pl.grib1
2. Use grib_get to print the stepRange for the field in the file surface.grib1 in (a) hours (b) minutes and (c) seconds
3. Repeat 2. for surface2.grib1
4. Use grib_get_data to print the latitude, longitude and values for the field in surface.grib1
   - Output results in decimal format with 5 decimal places
   - Output results in exponential format with 10 decimal places
   - Are there any missing values ?
5. Use grib_get_data to print the data values for the temperature at 500 hPa only from the file tz_an_pl.grib1 ?
   - Make sure you print only the data for T500 ! What is printed ?

# grib_copy – copy contents of GRIB files

- Use grib_copy to copy selected contents of GRIB files optionally printing some key values
- Without options grib_copy prints no key information
- Options exist to specify the set of keys to print
    - Use verbose option (`–v` ) to print keys
- Output can be ordered
    - E.g. order by ascending or descending step
- Key values can be used to specify the output file names
- grib_copy fails if a key is not found
    - Use the `–f` option to force grib_copy not to fail on error

# grib_copy – usage

```
grib_copy [options] grib_file grib_file … out_grib_file
```

## Options

| | |
|---|---|
| `-p key1,key2,…` | Keys to print (only with `–v`) |
| `-w key1=val1,key2!=val2,…` | Where option |
| `-B "key asc, key desc"` | Order by: “step asc, centre desc” |
| `-v` | Verbose |
| `-f` | Do *not* fail on error |
| `...` | |

# grib_copy – examples

- To copy only fields at 100 hPa from a file

```
> grib_copy –w level=100 in.grib1 out.grib1
```

- To copy only those fields that are not at 100 hPa

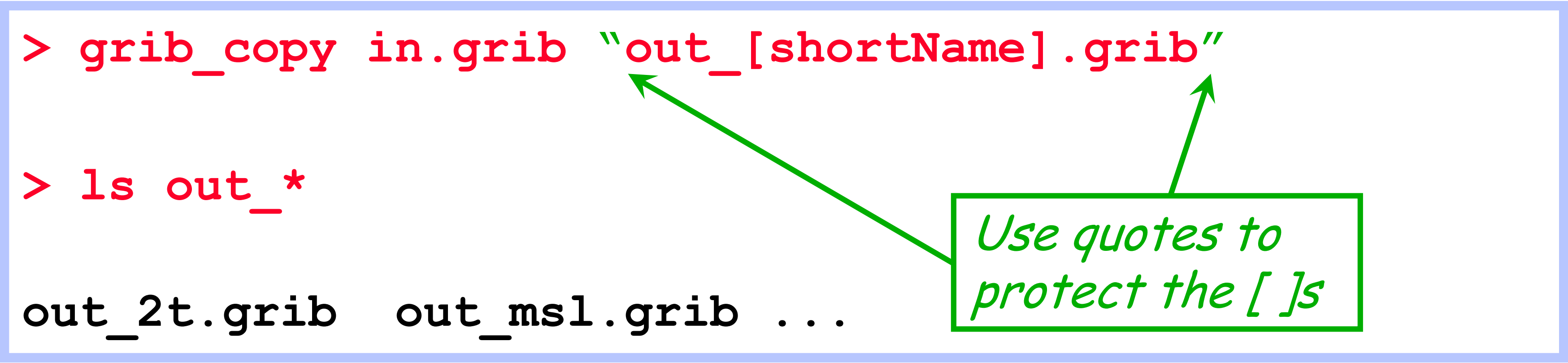
```
> grib_copy –w level!=100 in.grib1 out.grib1
```

- Information can be output using the –v and –p options

```
> grib_copy –v –p shortName in.grib1 out.grib1
in.grib1
shortName
t
1 of 1 grib messages in in.grib1
1 of 1 total grib messages in 1 files
```

# grib_copy – using key values in output file

- Key values can be used to specify the output file name



```
> grib_copy in.grib “out_[shortName].grib”

> ls out_*

out_2t.grib  out_msl.grib ...
```

*Use quotes to protect the [ ]s*

- This provides a convenient way to filter GRIB messages into separate files

# grib_set – set key / value pairs

- Use grib_set to
  - Set key / value pairs in the input GRIB file
  - Make simple changes to key / value pairs in the input GRIB file
- Each GRIB message is written to the output file
  - By default this includes messages for which no keys are changed
  - With **–S** (strict) option only messages matching all constraints in the where clause are copied
- An option exists to repack data
  - Sometimes after setting some keys involving properties of the packing algorithm the data needs to be repacked
- grib_set fails when an error occurs
  - e.g. when a key is not found

# grib_set – usage

```
grib_set [options] grib_file grib_file … out_grib_file
```

Options

| | |
|---|---|
| `-s key1=val1,key2=val2,…` | List of key / values to set |
| `-p key1,key2,…` | Keys to print (only with `–v`) |
| `-w key1=val1,key2!=val2…` | Where option |
| `-d value` | Set all data values to `value` |
| `-f` | Do *not* fail on error |
| `-v` | Verbose |
| `-S` | Strict |
| `-r` | Repack data |
| `...` | |

# grib_set – examples

- To set the parameter value of a field to 10m wind speed (10si)

```
> grib_set -s shortName=10si in.grib1 out.grib1
```

- This changes e.g.
  - shortName to 10si
  - paramId to 207
  - name / parameterName to ‘10 metre wind speed’
  - units / parameterUnits to ‘m s ** -1’

  - indicatorOfParameter to 207
  - marsParam to 207.128

# grib_set – examples

- Some keys are read-only and cannot be changed directly

```
> grib_set –s name=“10 metre wind speed” in.grib1 out.grib1

GRIB_API ERROR   :  grib_set_values[0] name (3) failed:
  Value is read only
```

- The read-only keys can only be set by setting one of the other keys, e.g.
  - shortName=10si
  - paramId=207
  - indicatorOfParameter=207          GRIB edition dependent !

# grib_set – modify data values

- An offset can be added to all data values in a GRIB message by setting the key offsetValuesBy

```
> grib_get -F "%.5f" -p max,min,average TK.grib
315.44727 216.96680 286.34257

> grib_set -s offsetValuesBy=-273.15 TK.grib TC.grib

> grib_get -F "%.5f" -p max,min,average TC.grib
42.29726 -56.18321 13.19257
```

# grib_set – modify data values

- The data values in a GRIB message can be multiplied by a factor by setting the key scaleValuesBy

```
> grib_get –F “%.2f” –p max,min,average Z.grib
65035.92 -3626.08 2286.30

> grib_set –s scaleValuesBy=0.102 Z.grib1 orog.grib1

> grib_get –F “%.2f” –p max,min,average orog.grib1
6633.64 -369.86 233.20
```

# grib_set – using key values in output file

- Key values can be used to specify the output file

```
> grib_set -s time=0000 in.grib “out_[shortName].grib”


> ls out_*
out_2t.grib  out_msl.grib ...
```

- Remember:  Use quotes to protect the [ ]s !

# What cannot be done with grib_set

- grib_set cannot be used for making transformations to the data representation
  - It cannot be used to transform data from spectral to grid-point representation (and vice-versa)
- grib_set cannot be used transform data from one grid representation to another
  - It cannot be used to transform data from regular or reduced Gaussian grids to regular latitude-longitude grids
- grib_set cannot be used to select sub-areas of data
  - It will change the value of, e.g. latitudeOfFirstGridPointInDegrees etc, but the data will still be defined on the original grid
- The GRIB tools cannot be used to interpolate the data

# grib_to_netcdf – convert to netCDF

- Use grib_to_netcdf to convert GRIB messages to netCDF
- Input GRIB fields must be on a regular grid
  - typeOfGrid=regular_ll or regular_gg
- Options allow user to specify the netCDF data type:
  - NC_BYTE, NC_SHORT, NC_INT, NC_FLOAT or NC_DOUBLE
  - NC_SHORT is the default
- Options allow the user to specify the reference date
  - Default is 19000101
- Used in the MARS web interface and the public Data Servers to provide data in netCDF

# grib_to_netcdf – usage

```
grib_to_netcdf [options] grib_file grib_file …
```

- Options

| | |
|---|---|
| `-o output_file` | Output netCDF file |
| `-R YYYYMMDD` | Use `YYYYMMDD` as reference date |
| `-D NC_DATATYPE` | netCDF data type |
| `-I key1,key2,…` | Ignore keys.<br>Default: method, type, stream, refdate, hdate |
| `-S key1,key2,…` | Split according to keys. Default: param,expver |
| `-T` | Do not use time of validity. |
| `-u dimension` | Set `dimension` to be an unlimited dimension |
| `-f` | Do *not* fail on error |

`...`

# grib_to_netcdf – examples

- To convert the fields in file.grib1 to netCDF

```
> grib_to_netcdf -o out.nc file.grib1
grib_to_netcdf: Version 1.13.0
grib_to_netcdf: Processing input file 'file.grib1'.
grib_to_netcdf: Found 1 GRIB fields in 1 file.
grib_to_netcdf: Ignoring key(s): method, type, stream,
  refdate, hdate
grib_to_netcdf: Creating netcdf file 'out.nc'
grib_to_netcdf: NetCDF library version: "3.6.3" of Jul  2
  2014 12:12:00 $
grib_to_netcdf: Defining variable 't'.
grib_to_netcdf: Done.

> ls -s out.nc
132 out.nc
```

# grib_to_netcdf – examples

- To convert the fields in file.grib1 to netCDF with data type set to NC_FLOAT

```
> grib_to_netcdf -D NC_FLOAT -o out.nc file.grib1
grib_to_netcdf: Version 1.13.0
grib_to_netcdf: Processing input file 'file.grib1'.
grib_to_netcdf: Found 1 GRIB fields in 1 file.
grib_to_netcdf: Ignoring key(s): method, type, stream,
   refdate, hdate
grib_to_netcdf: Creating netcdf file 'out.nc'
grib_to_netcdf: NetCDF library version: "3.6.3" of Jul  2
   2014 12:12:00 $
grib_to_netcdf: Defining variable 't'.
grib_to_netcdf: Done.

> ls -s out.nc
260 out.nc
```

*Output netCDF file is about twice the size*

# Practical 4: modifying GRIB messages

1. The file tz_an_pl.grib1 contains parameters T and Z on five pressure levels. Use grib_copy to create two files, one containing all the pressure levels for parameter T, the other for Z. Check the content of the new files with grib_ls
2. Use grib_ls to inspect the contents of tp.grib  What is the parameter set to ?  Use grib_set to change the parameter for the message in the file tp.grib to total precipitation (‘tp’ – parameter 228). Check the new message with grib_ls.
3. Use grib_to_netcdf to convert the GRIB messages in file1.grib to netCDF. Try with both the default data type (NC_SHORT) and NC_FLOAT. Check the data values in each case with ncdump.
4. Use grib_to_netcdf to convert the GRIB messages in file2.grib to netCDF. What happens … and why ?

# GRIB API user interfaces

- For some processing it is more convenient – or even necessary – to write a program
- The GRIB API library supports three user interfaces:
  - C: `#include <grib_api.h>`
  - Fortran 90 interface: `use grib_api`
  - Python interface: `import gribapi`
- At ECMWF two environment variables GRIB_API_INCLUDE and GRIB_API_LIB are defined to aid compilation and linking of Fortran 90 and C programs
- On ecgate:

```
gcc  myprog.c $GRIB_API_INCLUDE $GRIB_API_LIB -lm
gfortran myprog.f90 $GRIB_API_INCLUDE $GRIB_API_LIB
```

# General framework

- A (Fortran) code will generally include the following steps:
  - Open one or more GRIB files (for read or write)
    - Standard Fortran calls cannot be used to open or close a GRIB file. You have to call grib_open_file / grib_close_file
  - Calls to load one or more GRIB messages into memory
    - These subroutines will return a unique grib identifier which can be used to manipulate the loaded GRIB messages
  - Calls to encode / decode the loaded GRIB messages
    - Only loaded GRIB messages can be encoded / decoded
    - You should encode / decode only what you need (not the full message)
  - Calls to write one or more GRIB messages into a file (encoding only)
  - Release the loaded GRIB messages
  - Close the opened GRIB files

# Specifics of the GRIB API F90 interface

- Only subroutine names starting with grib_
  - grib_get, grib_set, grib_new_from_file, etc …
- All routines have an optional argument for error handling:

```
subroutine grib_new_from_file(ifile, igrib, status)
    integer, intent (in)                    ::  ifile
    integer, intent (out)              ::  igrib
    integer, optional, intent (out)         :: status
```

- If status is not present and an error occurs, the program stops and returns the error code to the shell
- Use *status* to handle errors yourself (e.g. necessary for MPI parallel codes)

```
call grib_new_from_file(ifile, igrib, status)
```

Input arguments

Output arguments

# Loading / Releasing a GRIB message (1/2)

- GRIB API can decode only loaded GRIB messages
- Two main subroutines to load a GRIB message for decoding

  - grib_new_from_file (ifile, igrib)

    Loads a GRIB message from a file already opened with grib_open_file

    Use grib_close_file to close this file

  - grib_new_from_index (indexid, igrib)

    Loads a GRIB message from an index

    This index will first have been built

Input arguments

Output arguments

# Loading / Releasing a GRIB message (2/2)

- These subroutines return a unique grib identifier (*igrib*)
  - Loaded messages are manipulated through this identifier
- You do not have access to the buffer containing the loaded GRIB message
  - This buffer is internal to the GRIB API library
- The buffer occupied by any GRIB message is kept in memory
- Therefore, the routine grib_release(*igrib*) should always be used to free the buffer containing a loaded buffer message**.**

Input arguments

Output arguments

Input arguments

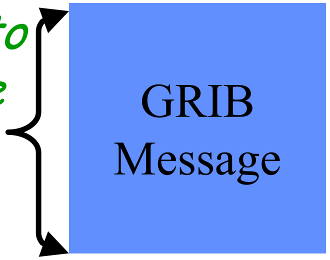
Output arguments

# Example – Load from file

```
PROGRAM load_message
 USE grib_api
 IMPLICIT NONE

 INTEGER                                      :: rfile, igrib
 CHARACTER(LEN=256), PARAMETER    :: input_file='input.grb‘
 CHARACTER(LEN=10), PARAMETER      :: open_mode='r‘

 !
 ! Open GRIB data file for reading.
 !
 CALL grib_open_file(rfile, input_file, open_mode)

 CALL grib_new_from_file(rfile, igrib)


 CALL grib_release (igrib)
 CALL grib_close_file (rfile)
 END PROGRAM load_message
```

'r' to read, 'w' to write (C naming convention)

Unique link to the buffer loaded in memory. Calls to grib_get subroutine are needed to access and decode this message



# Decoding a loaded GRIB message

- The idea is to decode as little as possible !
- You will never decode all the loaded GRIB message
  - use grib_dump for this !
- One subroutine for decoding:

Input arguments

Output arguments

```
grib_get (igrib, keyname, values, status)
      integer, intent (in)                   ::  igrib
      character(len=*), intent (in)          :: keyname
      <type>,[dimension(:),] intent (out)    ::  values
      integer, optional, intent (out)        :: status
```

*Where <type> is integer or single / double precision real or character*

# Fortran example – grib_get

Input arguments
Output arguments

```
! Load all the GRIB messages contained in file.grib1
call grib_open_file(ifile, 'file.grib1','r')

call  grib_new_from_file(ifile,igrib, iret)
LOOP: do while (iret /= GRIB_END_OF_FILE)
! Decode/encode data from the loaded message
      call grib_get(igrib , “dataDate”, date)
      call grib_get(igrib, “typeOfLevel”, levtype)
      call grib_get(igrib, “level”, level)
      call grib_get_size(igrib, “values”, nb_values)
      allocate(values(nb_values))
      call grib_get(igrib, “values”, values)

      print*, date, levtype, level, values(1), values(nb_values)
! Release
      deallocate(values)
      call grib_release(igrib)
! Next message
     call grib_new_from_file(ifile,igrib, iret)
end do LOOP
call grib_close_file(ifile)
```

*Loop on all the messages in a file. A new grib message is loaded from file. igrib is the grib id to be used in subsequent calls*

*Values is declared as real, dimension(:), allocatable:: values*

*Release the memory !*

# Python example – grib_get

Input arguments
Output arguments

```
#!/usr/bin/env python
import sys
from gribapi import *

# Load all the GRIB messages contained in file.grib1
ifile = open('file.grib1‘)
while 1:
    igrib = grib_new_from_file(ifile)
    if igrib is None: break

    # Decode/encode data from the loaded message
    date = grib_get( igrib , “dataDate”)
    levtype = grib_get(igrib, “typeOfLevel”)
    level = grib_get(igrib, “level”)
    values = grib_get_values(igrib)
    print  date, levtype, level, values[0], values[len(values)-1]

    # Release
    grib_release(igrib)
ifile.close()
```

*Loop on all the messages in a file. A new grib message is loaded from file. igrib is the grib id to be used in subsequent calls*

*Values returned as an array*

*Release the memory !*

# Practical 5: GRIB decoding with Fortran 90

- Work on ecgate
- The practical5 directory contains the program grib_api_demo.f90, a Makefile and some data in grib_file.grib
- Build an executable and run with

```
> make
> ./grib_api_demo > output
```

- Look at the GRIB contents in the output file. Use grib_ls and grib_dump to examine the file grib_file.grib
- Change the program, replacing the call to grib_dump with several calls to grib_get to decode the values for the edition, date, time, paramId (or shortName) and level
- Add your own ‘WRITE’ or ‘PRINT ’statements to output this information

# GRIB API can do more…

- The idea is to provide a set of high-level keys or subroutines to derive / compute extra information from a loaded GRIB message
- For example:
  - keys (READ-ONLY) to return average, min, max of values, distinct latitudes or longitudes, etc …
  - Subroutines to compute the latitude, longitude and values
    - grib_get_data

*For lat/lon, Gaussian, reduced Gaussian grids. It is similar to the grib_get_data GRIB tool*

  - Subroutines to extract values
    - grib_find_nearest: extract values closest to given geographical points

*Like "grib_ls -l "or "grib_get -l"*

    - grib_get_element: extract values from a list of indexes
  - Subroutines for indexed access
    - Usually much faster than sequential access for “random” access

# GRIB decoding – summary

- Use GRIB Tools where possible
  - It is not always necessary to write a program !
- Use edition-independent keys
  - This will make the migration to GRIB 2 easier
- ECMWF introduced GRIB 2 encoding for all its model level fields in May 2011
- If you do need to write a program think carefully about how the fields are accessed
  - Indexed access can be much faster than sequential access
- If you want to learn more about GRIB API then we hold a course each year – GRIB API: library and tools

# Documentation

- The WMO FM 92 GRIB Manuals can be obtained from

  www.wmo.int/pages/prog/www/WMOCodes.html

- The ECMWF GRIB API manual is available at

  https://software.ecmwf.int/wiki/display/GRIB/Home/

- The GRIB Tools are documented at

  https://software.ecmwf.int/wiki/display/GRIB/GRIB+tools

- GRIB API Fortran 90 interface:

  https://software.ecmwf.int/wiki/display/GRIB/Fortran+package+grib_api

- GRIB API examples

  https://software.ecmwf.int/wiki/display/GRIB/GRIB+API+examples