Using GRIB Tools

Computer User Training Course 2014

Paul Dando & Carsten Maass

User Support Section

advisory@ecmwf.int

Contents

- GRIB Tools basics and getting help
- Information tools
- Inspection tools
- Modification tools
- Getting key / value pairs
- Getting data values
- Comparing messages
- Copying messages
- Setting key / value pairs

GRIB Tools – basic concepts

- **The GRIB tools are a set of command line programs for interactive and batch processing of GRIB data**
- **They provide ready and tested solutions to the most common processing of GRIB data**
- **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 program**
- **The tools are provided with a common set of 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 is a tool for getting information about the GRIB API installation**
  - **grib_info**

- **There is a tool to count the messages in a GRIB file**
  - **grib_count**

GRIB Tools – more basics

- **There are tools to inspect the content of and compare GRIB files**
  - **grib_ls, grib_dump, grib_get, grib_get_data, grib_compare**
- **There is a tool to copy some messages**
  - **grib_copy**
- **There are tools to change the content of a GRIB message**
  - **grib_set, grib_filter**
- **There is a tool to convert a GRIB file to netCDF format**
  - **grib_to_netcdf**

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.
        -C      C code mode. A C code program generating the
…
```

Documentation

- **The GRIB API manual is available on the ECMWF website at**

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

- **The GRIB Tools are documented at**

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

  Includes some examples of how to use the tools

- **The WMO FM 92 GRIB Edition 1 and GRIB Edition 2 Manuals can be obtained from**

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

- **The GRIB API software can be downloaded from**

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

grib_info – information about GRIB API

- **The grib_info tool gives basic information about the GRIB API package being used**
  - **GRIB API Version**
  - **Path to definition files: GRIB_DEFINITION_PATH**
  - **Path to sample files: GRIB_SAMPLES_PATH**

```
> grib_info
grib_api Version 1.11.0

Default definition files path is used:
   /usr/local/apps/grib_api/1.11.0/share/grib_api/definitions
Definition files path can be changed setting GRIB_DEFINITION_PATH
   environment variable

Default SAMPLES path is used:
   /usr/local/apps/grib_api/1.11.0/share/grib_api/samples
SAMPLES path can be changed setting GRIB_SAMPLES_PATH environment
   variable
```

GRIB keys

- **For definitions of edition independent keys, GRIB1or GRIB2 keys see**

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

- **Usage of edition independent keys should be preferred**

grib_count – counts messages

- **Counts (very quickly) the number of messages in a list of GRIB files**
- **Syntax**

```
grib_count grib_file1 [grib_file2 …]
```

(takes wildcards)

grib_dump – dump content of GRIB files

- **Use grib_dump to dump 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 can also output an example C program which will generate the GRIB (with or without data values)**
  - **Code output can be used as a template to create programs for generating similar GRIB output**

grib_dump – usage

```
grib_dump [options] grib_file grib_file …
```

Basic options

`-O`	Octet mode (WMO documentation style)
`-a`	Print key alias information
`-t`	Print key type information
`-H`	Octet content in Hexadecimal
`-D`	Debug mode
`-w key[:{s|l|d}]{=|!=}value,…`	Where clause
`-V`	Print GRIB API Version
…	

grib_dump – examples

```
> grib_dump file.grib1
***** FILE: file.grib1
#==============   MESSAGE 1 ( length=3280398 )             ==============
GRIB {
  editionNumber = 1;
  table2Version = 128;
  # European Center for Medium-Range Weather Forecasts (grib1/0.table)
  centre = 98;
  generatingProcessIdentifier = 139;
  # Geopotential  (m**2 s**-2)  (grib1/2.98.128.table)
  indicatorOfParameter = 129;
  # Isobaric level pressure in hectoPascals  (hPa)  (grib1/3.table)
  indicatorOfTypeOfLevel = 100;
  level = 1000;
  # 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 = 20110223;
  dataTime = 1200; …
```

grib_dump – examples

```
> grib_dump -O file.grib1
***** FILE: file.grib1
#==============   MESSAGE 1 ( length=3280398 )             ==============
1-4       identifier = GRIB
5-7       totalLength = 3280398
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 = 139
7         gridDefinition = 255
8         section1Flags = 128 [10000000]
9         indicatorOfParameter = 129 [Geopotential  (m**2 s**-2)
                                                    (grib1/2.98.128.table) ]
10        indicatorOfTypeOfLevel = 100 [Isobaric level pressure in hectoPascals
                                                    (hPa)  (grib1/3.table) ]
11-12     level = 1000
13        yearOfCentury = 11
14        month = 2
15        day = 23
16        hour = 12 …
```

grib_dump – examples

```
> grib_dump -OtaH  file.grib1
***** FILE: file.grib1
#==============   MESSAGE 1 ( length=3280398 )             ==============
1-4       ascii identifier = GRIB ( 0x47 0x52 0x49 0x42 )
5-7       g1_message_length totalLength = 3280398 ( 0x32 0x0E 0x0E )
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 = 139 ( 0x8B )
                                       [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 = 100 ( 0x64 ) [Isobaric level pressure in
                     hectoPascals  (hPa)  (grib1/3.table) ] [levelType, mars.levtype]
11-12     unsigned level = 1000 ( 0x03 0xE8 ) [vertical.topLevel,
                                    vertical.bottomLevel, ls.level, lev, mars.levelist]
13        unsigned yearOfCentury = 11 ( 0x0B )
14        unsigned month = 2 ( 0x02 )
15        unsigned day = 23 ( 0x17 )
16        unsigned hour = 12 ( 0x0C )
17        unsigned minute = 0 ( 0x00 ). . .
```

grib_dump – examples

```
> grib_dump -D  file.grib1
***** FILE: file.grib1
#==============   MESSAGE 1 ( length=9358 )
  :
======> section GRIB (9358,9358,0)
   0-0 constant ieeeFloats = 0
   ======> section section_0 (0,0,0)
      ----> label empty
   <===== section section_0
   0-4 ascii identifier = GRIB
   4-7 g1_message_length totalLength = 9358
   7-8 unsigned editionNumber = 1 [ls.edition]
   ======> section section_1 (52,52,0)
      :
      36-36 g1date dataDate = 20110223 [mars.date, time.dataDate]
      36-36 evaluate year = 2011
      36-36 time dataTime = 1200 [mars.time]
      36-36 julian_day julianDay = 2.45562e+06
      36-36 codetable stepUnits = 1 [Hour (stepUnits.table) ]
      36-36 concept stepType = instant
      36-36 g1step_range stepRange = 0 [time.stepRange]
      36-36 long_vector startStep = 0
      36-36 long_vector endStep = 0 [stepInHours, mars.step]
      36-36 mars_param marsParam = 129.128 [mars.param]
      36-36 validity_date validityDate = 20110223
      36-36 validity_time validityTime = 1200
    ...
```

In debug mode computed keys are shown

ls.<key> , mars.<key> and time.<key> denote keys in namespaces

C code example with grib_dump

```
> grib_dump -C [-d] file.grib [> foo.c]
```

```
#include <grib_api.h>

/* This code was generated automatically */

int main(int argc,const char** argv)
{
    grib_handle *h     = NULL;
    size_t size        = 0;
    double* vdouble    = NULL;
    long* vlong        = NULL;
    FILE* f            = NULL;
    const char* p      = NULL;
    const void* buffer = NULL;

    if(argc != 2) {
       fprintf(stderr,"usage: %s out\n",argv[0]);
        exit(1);
    }

    h = grib_handle_new_from_samples(NULL,"GRIB1");
…
```

-d option includes all data values

Compile: `gcc -o foo foo.c $GRIB_API_INCLUDE $GRIB_API_LIB -lm`

Practicals

- **Work in your $SCRATCH**

```
cd $SCRATCH
```

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

```
tar –xvf /home/ectrain/trx/grib_api/grib_tools.tar
```

- **This will create a directory in your $SCRATCH containing the GRIB data files for all the practicals**
- **There is a sub-directory for each practical:**

```
ls $SCRATCH/grib_tools

grib_compare  grib_copy   grib_dump   grib_get  grib_ls

grib_set  . . .
```

Practical: using grib_dump

- **Use the web documentation to look at the different keys available for type GRIB1 and type GRIB2 messages**
  - **Identify some `keys common to both GRIB1 and GRIB2**

- **Experiment with using the different grib_dump options (`-0`, `-a` and `-t`). Inspect the GRIB message in the files file1.grib1 and file1.grib2 and identify:**
  - **the GRIB edition used to encode the messages**
  - **the (MARS)parameter ID, date, time, forecast step and the grid geometry**

- **What are the maximum, minimum and average values of the fields?**

grib_ls – list the content of GRIB files

- Use grib_ls to list the content of GRIB files
- Without options grib_ls prints a default list of keys
  - The default list printed is different for GRIB 1 and GRIB 2
- 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(s)
  - Modes available to obtain one or four nearest grid points

grib_ls – usage

```
grib_ls [options] grib_file grib file …
```

Options

`-p key[:{s|l|d}],…`	Keys to print
`-P key[:{s|l|d}],…`	Additional keys to print
`-w key[:{s|l|d}]{=|!=}value,…`	Where clause
`-B "key asc, key desc…"`	Order by: "step asc, centre desc"
`-n namespace`	Print all the keys belonging to namespace
`-m`	Print MARS keys
`-W width`	Minimum column width (default 10)
…	

grib_ls – examples

```
> grib_ls file.grib2
file.grib2
edition centre date     … gridType   …  typeOfLevel   level    shortName  packingType
2       ecmf   20110226 … reduced_gg …  isobaricInhPa  1000    q          grid_simple
2       ecmf   20110226 … reduced_gg …  isobaricInhPa  850     q          grid_simple
2       ecmf   20110226 … reduced_gg …  isobaricInhPa  700     q          grid_simple
2       ecmf   20110226 … reduced_gg …  isobaricInhPa  500     q          grid_simple
4 of 4 grib messages in file1.grib2

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:l,dataDate,shortName,paramId,typeOfLevel,level file.grib2
file.grib2
Centre     dataDate     shortName    paramId      typeOfLevel    level
98         20110226     q            133          isobaricInhPa  1000
98         20110226     q            133          isobaricInhPa  850
98         20110226     q            133          isobaricInhPa  700
98         20110226     q            133          isobaricInhPa  500
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 GRIB Tools**
- **Constraints are of the form key=value or key!=value**

```
-w key[:{s|l|d}]=value, key[:{s|l|d}]!=value
```

- **Messages are processed only if they match ALL key/value constraints**
- **Values separated by / represent “OR” condition**

```
> grib_ls -w levelType=pl file.grib1
…
> grib_ls -w step!=6,level=700/850 file.grib1
…
> grib_ls -w count=3 file.grib1
```

Practical: using grib_ls

- Use grib_ls to inspect the files msl.grib1 and msl.grib2
  - Which keys does grib_ls show by default for the two files ?
  - What fields do they contain ?
- Use grib_ls to print the MARS keys
- Use grib_ls with other namespaces
- Use grib_ls to order the output in descending step order
- Use grib_ls to print the centre, dataDate, stepRange, levelType, shortName and paramId for both files
  - Experiment with both –P and –p options and 'key:l', 'key:s'

Finding nearest grid points with grib_ls

- **The value(s) of a GRIB field close to the point of a Latitude/Longitude 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: using grib_ls –l

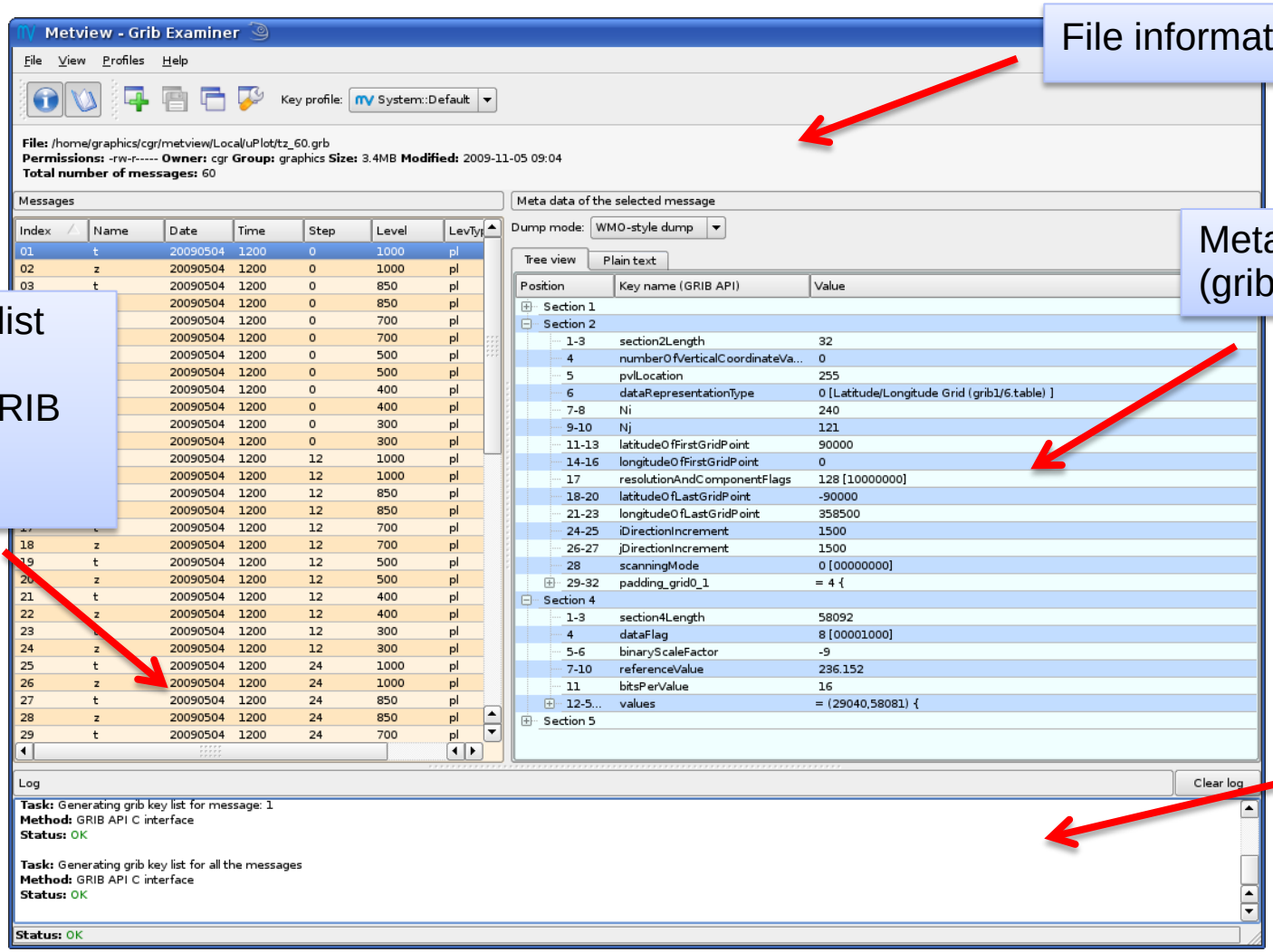
- **The file msl.grib1 contains the mean sea-level pressure from the EPS control forecast at 6-hourly time steps for the first 24 hours on a N100 regular Gaussian grid**
- **Find the value of the MSLP at the grid point nearest to ECMWF (Lat 51.42°N, Lon 0.95° W) at each forecast step**
  - **What is the lat-lon value of the grid point nearest to ECMWF ?**
  - **How far is the chosen grid point from ECMWF ?**
- **Change the command used to output only the forecast step and the MSLP value at the nearest grid point**
- **Change the command to output the MSLP values at the four grid points nearest to ECMWF**
- **Use the file lsm.grib1 to provide a land-sea mask**
  - **Are all four nearest grid points land points (mask ≥ 0.5) ?**

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**

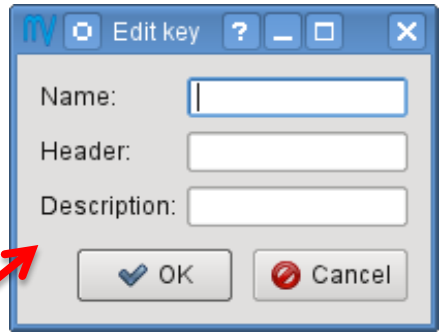
```
metview4 -e grib your_grib_file
```

GRIB Examiner: The user interface



GRIB Examiner: Managing GRIB API keys

Insert/edit keys from header menu



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
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	
13	t	20090504	1200	12	100	

Meta data of the selected message

Dump mode: WMO-style dump

Tree view | Plain text

Position	Key name (GRIB API)	Value
Section 1		
Section 2		
1-3	section2Length	32
4	numberOfVerticalCoordinateVa...	0
5	pvlLocation	255
	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

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 key[:{s|l|d}],…`	Keys to get
`-P key[:{s|l|d}],…`	Additional keys to get with `-m`, `-n`
`-w key[:{s|l|d}]{=/!=}value,…`	Where option
`-s key[:{s/l/d}]=value,…`	Keys to set
`-m`	Get all MARS keys
`-n namespace`	Get all keys for `namespace`
`-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:l 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 20140225 1200 0 167.128 od an oper 0001

> grib_get -m -P shortName f1.grib1
2t g sfc 20140225 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 – 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

- 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
```

Finding nearest grid points with grib_get

- The value of a GRIB field close to a specified point of Latitude/Longitude 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 a grid point

- The value of a GRIB field at a particular grid 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 stepRange f1.grib1

6 99429.31
12 99360.25
18 99232.31
24 99325.56
```

- 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 key[:{s|l|d}],…`	Keys to print
`-w key[:{s|l|d}]{=/!=}value,…`	Where option
`-m missingValue`	Specify missing value string
`-F format`	C-style format for output values
`-f`	Do *not* fail on error
`...`	

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

Practicals

- Work in your $SCRATCH

```
cd $SCRATCH
```

- There is a sub-directory for each practical:

```
ls $SCRATCH/grib_tools
grib_compare  grib_copy  grib_dump
grib_filter   grib_get   grib_ls  grib_set
grib_to_netcdf
```

Practical: 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 get the dataDate for the 500 &1000 hPa levels only
3. Use grib_get to print the stepRange for the fields in the file surface.grib1 in (a) hours (b) minutes and (c) seconds
4. Use grib_get_data to print the latitude, longitude and values for the first field in surface.grib1
   - Output results in decimal format with 5 decimal places
   - Output results in exponential format with 10 decimal places
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_compare – compare GRIB messages

- Use grib_compare to compare the GRIB messages contained in two files
- By default, messages are compared in the same order, bit-by-bit and with floating point values compared exactly
  - Tolerances for data values can be specified based on the absolute, relative or packing error
  - Default tolerance is absolute error = 0
- If differences are found grib_compare
  - switches to a key-based mode to find out which coded keys are different
  - fails returning a non-zero exit code
- Options are available to compare only specific keys or sets of keys

grib_compare – basic usage

```
grib_compare [options] grib_file grib_file
```

- Options

`-b key,key,…`	All keys in this list are skipped when comparing files
`-c key[:{s|l|d|n}],…`	Compare these keys only
`-H`	Compare message headers only
`-e`	Edition-independent compare
`-w key[:{s|l|d}]{=/!=}value,…`	Where option
`-f`	Do *not* fail on error
`-r`	Messages not in the same order
`-v`	Verbose
`...`	

grib_compare – a simple example

- Two GRIB messages in f1.grib1 and f2.grib1 contain the land-sea mask at different forecast time steps

```
> grib_compare f1.grib1 f2.grib1
-- GRIB #1 -- shortName=lsm paramId=172 stepRange=3
   levelType=sfc level=0 packingType=grid_simple
   gridType=reduced_gg --
long [P1]: [3] != [6]

> echo $?

1
```

- The exit code is set to 1 because the comparison failed

grib_compare – a simple example

- If we blacklist the key P1 and compare the files again

```
> grib_compare -b P1 f1.grib1 f2.grib1

> echo $?

0
```

- The exit code is set to 0 because the comparison is successful according to the blacklist

grib_compare – verbose output

- The verbose option shows details of all keys being compared

```
> grib_compare –v f1.grib1 f2.grib1
f1.grib1
    comparing totalLength as long
    comparing editionNumber as long
    comparing section1Length as long
    comparing table2Version as long
    comparing centre as string
    comparing generatingProcessIdentifier as long
    comparing gridDefinition as long
         ...
    comparing P1 as long
-- GRIB #1 -- shortName=lsm paramId=172 stepRange=3 levelType=sfc
evel=0 packingType=grid_simple gridType=reduced_gg --
long [P1]: [3] != [6]
    comparing P2 as long
    ...
```

grib_compare – limit the keys compared

- The **-c** option can be used to compare only specific keys

```
> grib_compare -c dataDate f1.grib1 f2.grib1
-- GRIB #1 -- shortName=2t paramId=167 stepRange=0
   levelType=sfc level=0 packingType=grid_simple
   gridType=reduced_gg --
long [dataDate]: [20140223] != [20140224]
```

- Or a set of keys in a particular namespace

```
> grib_compare -c time:n  f1.grib1 f2.grib1
-- GRIB #1 -- shortName=2t paramId=167 stepRange=0
   levelType=sfc level=0 packingType=grid_simple
   gridType=reduced_gg --
long [dataDate]: [20140223] != [20140224]
long [validityDate]: [20140223] != [20140224]
```

grib_compare – compare headers only

- To compare only the headers of two GRIB messages use the **-H** option

```
> grib_compare -H  f1.grib1 f2.grib1
-- GRIB #1 -- shortName=2t paramId=167 stepRange=0
   levelType=sfc level=0 packingType= gridType= --
long [day]: [23] != [24]
```

- The **-H** option cannot be used with the **-c** option

grib_compare – edition-independent

- Two GRIB messages are very different if they are encoded with different editions

```
> grib_compare sp.grib1 sp.grib2
-- GRIB #1 -- shortName=sp paramId=134 stepRange=0 levelType=sfc
   level=0 packingType=grid_simple gridType=reduced_gg --
long [totalLength]: [4284072] != [4284160]
long [editionNumber]: [1] != [2]
long [section1Length]: [52] != [21]
[table2Version] not found in 2nd field
[gridDefinition] not found in 2nd field
[indicatorOfParameter] not found in 2nd field
[indicatorOfTypeOfLevel] not found in 2nd field
[yearOfCentury] not found in 2nd field
[unitOfTimeRange] not found in 2nd field
[P1] not found in 2nd field
[P2] not found in 2nd field
...
```

grib_compare – edition-independent

- Using the **-e** option grib_compare compares only the higher level information common to the two messages

```
> grib_compare -e sp.grib1 sp.grib2
-- GRIB #1 -- shortName=sp paramId=134 stepRange=0
   levelType=sfc level=0 packingType=grid_simple
   gridType=reduced_gg --
string [param]: [134.128] != [134]
```

- The two messages contain the same information encoded in two different ways
- Only the MARS param is different

grib_compare – summary of differences

- When files contain several fields and some keys are different, it is useful to have a summary report

```
> grib_compare –f f1.grib1 f2.grib1
-- GRIB #1 -- shortName=z paramId=129 stepRange=0 levelType=pl
   level=1000 packingType=spectral_complex gridType=sh --
long [marsType]: [an] != [fc]

-- GRIB #3 -- shortName=z paramId=129 stepRange=0 levelType=pl
   level=850 packingType=spectral_complex gridType=sh --
long [marsType]: [an] != [fc]
...
## ERRORS SUMMARY #######
##
## Summary of different key values
## marsType ( 6 different )
##
## 6 different messages out of 12
```

grib_compare – order-independent compare

- There are many errors if two files are compared which contain the same messages but in a different order

```
> grib_compare -f -H f1.grib1 f2.grib1
...
## ERRORS SUMMARY #######
##
## Summary of different key values
## indicatorOfParameter ( 6 different )
## level ( 7 different )
##
## 10 different messages out of 12
```

By default grib_compare assumes messages are in the same order

- To compare messages when they are not in the same order, use the **-r** option – this is VERY time expensive

```
> grib_compare -r -f -H f1.grib1 f2.grib1
```

grib_compare – comparing data values

- By default floating point values are compared exactly
- Different tolerances can be provided using one of the following options

`-A absolute_error`	Use absolute error as tolerance
`-R key=rel_error,…`	Use relative error as tolerance for **`key`**
`-P`	Use packing error as tolerance
`-T factor`	Compare data values using tolerance specified in options **`–A`**, **`-R`**, **`-P`** multiplied by an integer **`factor`**

grib_compare – setting the tolerance

- Comparison of the data values in two files shows that one of the seven values is different with the default absolute error tolerance of zero

```
> grib_compare -c data:n f1.grib1 f2.grib1
-- GRIB #1 -- shortName=2t paramId=167 stepRange=0 levelType=sfc level=0
   packingType=grid_simple gridType=reduced_gg --
double [packedValues]: 1 out of 7 different
 max absolute diff. = 2.0000000000000000e+00, relative diff. = 0.4
        max diff. element 2: 3.0000000000000000000e+00
   5.0000000000000000000e+00
        tolerance=0.0000000000000000e+00 packingError: [0.0625005] [0.0625005]
        values max= [70]  [70]         min= [1] [1]
```

- Set the absolute error tolerance to 2.0 and the comparison is successful

```
> grib_compare -A 2.0 -c data:n  f1.grib1 f2.grib1
```

grib_compare – setting the tolerance

- We can also set a relative error as tolerance for each key

```
> grib_compare -c data:n f1.grib1 f2.grib1
-- GRIB #1 -- shortName=2t paramId=167 stepRange=0 levelType=sfc level=0
   packingType=grid_simple gridType=reduced_gg --
double [packedValues]: 1 out of 7 different
 max absolute diff. = 2.0000000000000000e+00, relative diff. = 0.4
        max diff. element 2: 3.0000000000000000000e+00
   5.0000000000000000000e+00
        tolerance=0.0000000000000000e+00 packingError: [0.0625005] [0.0625005]
        values max= [70]  [70]         min= [1] [1]
values max= [70]  [70]         min= [1] [1]
```

- Set a relative error of 0.4 as the tolerance for **packedValues**

```
> grib_compare -R packedValues=0.4 -c data:n  f1.grib1 f2.grib1
```

- The comparison is successful because the relative tolerance is greater than the relative difference

grib_compare – setting the tolerance

- Different packing precision can give different data values

```
> grib_compare -c data:n f1.grib1 f3.grib1
-- GRIB #1 -- shortName=2t paramId=167 stepRange=0 levelType=sfc level=0
   packingType=grid_simple gridType=reduced_gg --
double [packedValues]: 1 out of 7 different
 max absolute diff. = 5.0000000000000000e-01, relative diff. = 0.166667
        max diff. element 1: 2.5000000000000000000e+00
   3.0000000000000000000e+00
        tolerance=0.0000000000000000e+00 packingError: [0.0625005] [0.5]
        values max= [70]  [70]         min= [1] [1]
values max= [70]  [70]         min= [1] [1]
```

- Here we can use the packing error as the tolerance

```
> grib_compare -P -c data:n  f1.grib1 f3.grib1
```

- The comparison is successful because the maximum absolute difference is within the larger of the two packing errors – only the packing precision has changed

Practical: using grib_compare

1. Use grib_compare to compare the GRIB messages contained in the files file1.grib and file2.grib
   - Which keys does grib_compare report as different ? What is the exit code returned ?
2. Now use the **-b** option to 'black list' the keys that you know are different and use grib_compare to compare the messages again
   - Are any keys reported as different ? What is the exit code ?
3. Compare the data namespaces for file1.grib and file2.grib. What values need to be set for the absolute (with **-A**) and relative (with **-R**) error tolerances for the comparison to be successful ?

grib_copy – copy contents of GRIB files

- Use grib_copy to copy selected messages from 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 key[:{s|l|d}],…	Keys to print (only with **-v**)
-w key[:{s|l|d}]{=/!=}value,…	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 the analysis fields from a file

```
> grib_copy -w dataType=an in.grib1 out.grib1
```

- To copy only those fields that are not analysis fields

```
> grib_copy -w dataType!=an 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
```

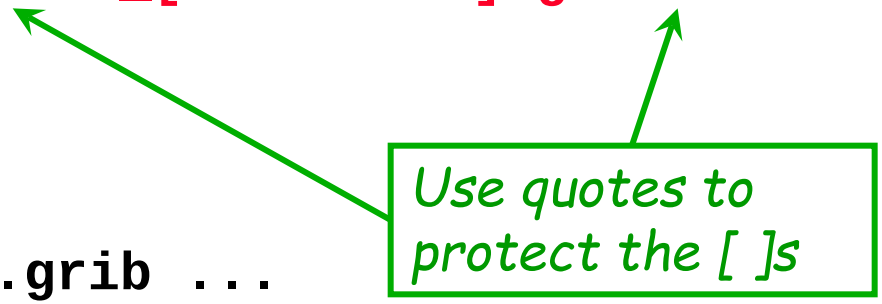
grib_copy – using key values in output file

- 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 ...
```



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

Practical: using grib_copy

1. The file tz_an_pl.grib1 contains parameters T and Z on a a set of pressure levels
   - Use grib_copy to create two files, one containing only the parameter T, the other containing the parameter Z
   - Check the content of the new files with grib_ls
   - Repeat, but output the messages so that the pressure levels in the new files are in increasing numerical order
2. Use grib_copy to split tz_an_pl.grib1 into separate files for each parameter/level combination
   - Create files named t_500.grib1, z_500,grib1, etc

grib_set – set key / value pairs

- Use grib_set to
  - Set key / value pairs in the input GRIB file(s)
  - Make simple changes to key / value pairs in the input GRIB file(s)
- 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 option 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 key[:{s|l|d}]=value,…	List of key / values to set
-p key[:{s|l|d}],…	Keys to print (only with **-v**)
-w key[:{s|l|d}]{=/!=}value,…	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 marsParam=207.128 in.grib1 out.grib1

GRIB_API ERROR   :  grib_set_values[0] marsParam (2)
  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

grib_set – set key values to missing

- When a key is not used all the bits of its value should be set to 1 to indicate that it is ‘missing’
- Different keys have different lengths so the value that needs to be coded for missing keys is not unique
- To set a key to missing a string "missing" or "MISSING" is accepted by grib_set

```
> grib_set –s Ni=missing in.grib2 out.grib2
```

- Note that some values cannot be set to “missing” !

```
> grib_set –s dataDate=missing file1.grib2 file2.grib2
GRIB_API ERROR   :  unable to set dataDate=missing (Value cannot
   be missing)
GRIB_API ERROR   :  grib_set_values[0] dataDate (7) failed: Value
   cannot be missing
```

grib_set – changing decimal precision

- To pack a temperature expressed in Kelvin with 1 digit of precision after the decimal point we can set changeDecimalPrecision=1
  - N.B. this is different to setting the number of significant digits !

```
> grib_set -s changeDecimalPrecision=1 T.grib1 T1.grib1
```

- Use grib_compare to see the differences

```
> grib_compare -c data:n T.grib1 T1.grib1
-- GRIB #1 -- shortName=2t paramId=167 stepRange=0 levelType=sfc level=0
   packingType=grid_simple gridType=reduced_gg --
double [packedValues]: 2132215 out of 2140702 different
 max absolute diff. = 5.0000000000011369e-02, relative diff. = 0.000207239
        max diff. element 17: 2.4121679687500000000e+02
   2.4126679687500011369e+02
        tolerance=0.0000000000000000e+00 packingError: [0.000984192]
   [0.0500122]
        values max= [315.447]  [315.467]         min= [216.967] [216.967]
```

grib_set – changing the packing algorithm

- grib_set can be used to change the packing algorithm used from grid_simple (simple packing) to grid_second_order (2nd order packing)

```
> grib_set –r –s packingType=grid_second_order f1.grib2 \
   f1_packed.grib2
```

- This can provide a very efficient level of compression

```
> ls –s f1.grib2 f1_packed.grib2 f1.grib2.bz2 | sort

1000 f1_packed.grib2
1116 f1.grib2.bz2
2616 f1.grib2
```

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 name

```
> 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

Practical: using grib_set

1. The GRIB messages in file.grib1 have been encoded with an incorrect date and time
   - Use grib_set to change the date to 25 February 2014 and the time to 00UTC. Check the new files with grib_ls
   - Repeat but change the date and time for T at 500hPa only
   - Repeat so that T at 500hPa only is written to the output file
2. An SST field has been created by masking the Soil Temperature at Level 1 (STL1) with the Land-Sea Mask and is included with other messages in the file surface.grib
   - Use grib_set to change the parameter for the field from STL1 to SST and level type to ‘surface’
   - Be careful not to change the other parameters !
   - Repeat with each different message output to a separate file