GRIB APIs
Fortran 90 - C - Python interfaces
part 1

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User Support

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Introduction

- Do you really need to write a program to decode GRIB data?
  - Before converting/writing a (Fortran, C or Python) code, you should evaluate whether you could use some grib tools instead
    - Grib tools are optimized and fully supported
    - Grib tools are intended to cover the usual processing of GRIB data
  - Writing programs will remain necessary:
    - Encoding/decoding GRIB messages within a meteorological model or within some post-processing (e.g. MAGICS code).
  - Writing a program will usually be more efficient than trying to achieve the same with tools/scripts.

The GRIB API library - installation

- Written in ANSI C 99
- The only required package is jasper which enables the jpeg2000 packing/unpacking algorithm (GRIB-2). It is however possible to build GRIB API without jasper, by using the '--disable-jpeg' option at configuration (not recommended).
- The GRIB API also needs a version of netCDF (3) for the tool grib_to_netcdf.
- Classical installation based on autotools (configure, make, …) and new experimental installation based on CMake, from version 1.13.0.
- The GRIB API has been ported and tested on all platforms available at ECMWF. We receive and welcome feedback from external sites and will include requested changes, fixes, etc … where possible.

The GRIB API library

- The IFS is using the GRIB API. Metview, magics use the grib_api.
- We have started producing GRIB-2 data (on model levels) on 18 May 2011.
- Some GRIB API tools used operationally.
- New data types (not only on Model levels) are also produced in GRIB-2 format, e.g. some MACC chemical data.
- Support:
  - Installation issues: software.support@ecmwf.int
  - Usage problems/questions: software.support@ecmwf.int or advisory@ecmwf.int.

Usage at ECMWF

- The GRIB API library is available on all ECMWF platforms.
- One library for single and double precision. Within the library, everything is done in double precision. In Fortran 90, the GRIB API will return/use the precision of the data variables defined in your program.
- Three user interfaces supported: Fortran (90), C and Python
  - Fortran 90 interface: use grib_api
- (At ECMWF) Two environment variables GRIB_API_INCLUDE and GRIB_API_LIB are defined to ease the usage of GRIB API.
- On our platforms:
  - ecgate: gfortran myprogram.f90 $GRIB_API_INCLUDE $GRIB_API_LIB
  - cca/ccb: ftn myprogram.f90

Usage at ECMWF – changing version

- On HPCs and ecgate:

  module switch grib_api grib_api/<version>

- This year, we will use version 1.13.0, the default version at ECMWF still being version 1.12.3.
- See change history…

  https://software.ecmwf.int/wiki/display/GRIB/History+of+Changes

General framework

- A (Fortran/C/Python) code will include the following steps:
  - Open one or more GRIB files (to read or write)
    - You cannot use the standard Fortran calls 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 you can use to manipulate the loaded GRIB messages
  - Calls to encode/decode the loaded GRIB messages
    - You can only encode/decode loaded GRIB messages
    - You should only encode/decode 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

Particulars of the F90 GRIB API interface

- All routines have an optional argument for error handling:

```
subroutine grib_new_from_samples(igrib, samplename, status)
    integer, intent(out)                :: igrib
    character(len=*), intent(in)        :: samplename
    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.

Particulars of the F90 GRIB API interface

- Use status to handle error yourself, e.g. necessary for MPI parallel codes)

```
call grib_new_from_samples(igrib, samplename, status)
  if (status /= 0) then
   call grib_get_error_string(status,err_msg)
  print*,'GRIB_API Error: ',trim(err_msg),' (err=',status,')'
  call mpi_finalize(ierr)
  stop
end if
```

Input arguments
Output arguments

- The exit codes and their meanings are available under:

https://software.ecmwf.int/wiki/display/GRIB/Error+codes

Loading/Releasing a GRIB message (1/2)

- It is absolutely necessary to load a message because the GRIB API can only encode/decode loaded GRIB messages.
- 3 main subroutines to load a GRIB message

Input arguments
Output arguments

  - 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_samples(igrib, "GRIB1")

Name of an existing GRIB sample

    Loads a GRIB message from a sample. Used for encoding. See further …

  - grib_new_from_index(indexid, igrib)

    Loads a GRIB message from an index. This index will first have to be built. See further ...

Loading/releasing a GRIB message (2/2)

- The above 3 subroutines will return a unique grib identifier (*igrib*). You will manipulate the loaded GRIB message 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 GRIB message.

Input arguments

Output arguments

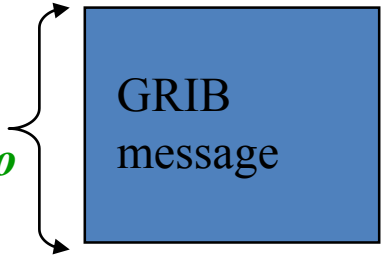
Example – Load from file

Input arguments
Output arguments

```
1   PROGRAM load_message
2    USE grib_api
3    implicit none
4
5    INTEGER                                  :: rfile, igrib
6    CHARACTER(LEN=256), PARAMETER    :: input_file='input.grb‘
7    CHARACTER(LEN=10), PARAMETER      :: open_mode='r‘
8
9    !
10   ! Open GRIB data file for reading.
11   !
12   call grib_open_file(rfile, input_file, open_mode)
13
14   call grib_new_from_file(rfile, igrib)
15
16
17   call grib_release(igrib)
18   call grib_close_file (rfile)
19   END PROGRAM load_message
```

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

Unique link to the buffer loaded in memory. Calls to grib_get/grib_set subroutines are necessary to access and decode/encode this message



Decoding a loaded GRIB message

- The idea is to decode as little as possible! You will never decode the whole loaded GRIB message.

  (use ‘grib_dump –D <grib_file>’ to see how many GRIB API keys there are!)

- One main subroutine to decode:

Input arguments

Output arguments

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

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

Decoding a GRIB message – helper routines

- Get the size of an [array] key:

  grib_get_size(igrib, keyname, size, status)

Input arguments

Output arguments

- Dump the content of a grib_message:

  grib_dump(igrib, status)

- Check if a key is missing or not:

  grib_is_missing(igrib, keyname, missing, status)

- Count messages in file:

  grib_count_in_file(ifile, count, status)

Example – grib_get

Input arguments

Output arguments

```
! Load all the GRIB messages contained in file.grib1
call grib_open_file(ifile, 'file.grib1','r')
n=1
call  grib_new_from_file(ifile,igrib(n), iret)
LOOP: do while (iret /= GRIB_END_OF_FILE)
     n=n+1; call grib_new_from_file(ifile,igrib(n), iret)
end do LOOP
```

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

```
! Decode/encode data from the loaded message
read*, indx                                  ! Choose one loaded GRIB message to decode
call grib_get( igrib(indx) , “dataDate”, date)
call grib_get(igrib(indx), “typeOfLevel”, typeOfLevel)
call grib_get(igrib(indx), “level”, level)
call grib_get_size(igrib(indx), “values”, nb_values); allocate(values(nb_values))
call grib_get(igrib(indx), “values”, values)
print*, date, levelType, level, values(1), values(nb_values)
```

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

```
! Release
do i=1,n
     call grib_release(igrib(i))
end do
deallocate(values)
call grib_close_file(ifile)
```

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 instance:
  - keys (READ-ONLY) to return average, min, max of values, distinct latitudes or longitudes …
  - Subroutines to compute the latitude, longitude and values:

    call grib_get_data(igrib,lats,lons,values,status)
  - Subroutines to extract values closest to given geographical points:

    call grib_find_nearest(igrib, is_lsm, inlat, inlon, outlat, outlon, value, distance, index, status)
  - Subroutine to extract values from a list of indexes:

    call grib_get_element(igrib, key, index, value, status)

Input arguments
Output arguments

How to migrate from GRIBEX to GRIB API?

- All your new GRIB related developments should be made with the GRIB API library.
- For existing codes, the most difficult task is to find a correspondence between GRIBEX ksec0(*), …, ksec4(*), psec2(*),…psec4(*), and GRIB API keys. See conversion tables under:

  https://software.ecmwf.int/wiki/display/GRIB/GRIBEX+keys

- Try to use the "recommended" keys, i.e. keys that are valid for both GRIB-1 and GRIB-2 (for instance "dataDate" instead of "YearOfCentury", "month", "day"). See edition independent keys under:

  https://software.ecmwf.int/wiki/display/GRIB/GRIBEX+keys

C API - Specifics

- #include “grib_api.h“
- module load grib_api to set GRIB_API paths

```
gcc –o myprogram myprogram.c $GRIB_API_INCLUDE $GRIB_API_LIB
```

Main differences:

- C-Interface is more explicit than FORTRAN, e.g. type specific functions such as grib_get_double()
- Some helper functions do not exist, e.g. grib_open_file()

C API – Error checking

- Built-in error checking for a call to a GRIB API function can be achieved with GRIB_CHECK:

```
GRIB_CHECK(grib_get_long(h,"Ni",&Ni),0);
```

- Or if error code is passed as function argument:

```
h = grib_handle_new_from_file(0,in,&err);
GRIB_CHECK(err,0);
```

- Alternatively, one can check the status:

```
err = grib_get_long(h,"Ni",&Ni);
if (err != 0) {
   printf("Error: %s \n unable to get long  variable\n",
          grib_get_error_message(err));
   exit(1);
}
```

C API – Loading/Releasing a GRIB message

- grib_handle *h;
  - structure giving access to parsed grib values.
- grib_handle* grib_handle_new_from_file(grib_context *c, FILE *fp, int *error)
  - Create handle from a file.
  - requires the input file to be opened with fp=fopen(filename,"r") and fclose(fp) to release the file pointer at the end of the program.
  - grib_context *c should usually be set to 0.
- grib_handle * grib_handle_new_from_...
  - samples (grib_context *c, const char *res_name) a message contained in a samples directory.
  - message (grib_context *c, void *data, size_t length) a user message in memory.
- grib_handle_delete(h);
  - Releases the handle.

C API - Decoding

- int grib_get_double(grib_handle *h, const char *key, double *value)
  - Gets a double value from a key, if several keys of the same name are present, the last one is returned. Similar function for long exists.
- int grib_get_string(grib_handle *h, const char *key, char *message, size_t *length)
  - Gets a string value from a key, if several keys of the same name are present, the last one is returned. String will be stored in pre-allocated memory message of size length. Similar function for bytes exists.
- int grib_get_double_array(grib_handle *h, const char *key, double *values, size_t *length)
  - Gets double array values from a key.
  - Use “int grib_get_size(grib_handle *h, const char *key, size_t *length)” to get the number of coded values (length) from a key (if several keys of the same name are present, the total sum is returned). Similar function for long array exists.

C API - Decoding

- int grib_nearest_find(grib_nearest * nearest,
  grib_handle * h,
  double inlat, double inlon, unsigned long flags, double *
  outlats, double * outlons, double * values, double *
  distances, int * indexes, size_t * len)

  - Finds the 4 nearest points and their distance of a given latitude longitude point.
  - flags should be set to 0, or can be set to
    - GRIB_NEAREST_SAME_POINT
    - GRIB_NEAREST_SAME_GRID
  - outlats, outlons, values, distances and indexes have to be allocated and len should be set to 4

Python API - Specifics

- To import, use: import gribapi
- module load grib_api
- Low level, procedural
- Provides almost 1 to 1 mappings to the C API functions
- Uses the NumPy module to efficiently handle data values

Python API – Loading/Releasing a GRIB message

gid = grib_new_from_file(file, headers_only=False)

- Returns a handle to a GRIB message in a file
- Requires the input file to be a Python file object
- The use of the headers_only option is not recommended at the moment

gid = grib_new_from_samples(samplename)

- Returns a handle to a message contained in the samples directory

gid = grib_new_from_message(message)

- Returns a handle to a message in memory

grib_release(gid)

- Releases the handle

Python API - Decoding

value = grib_get(gid, key, type=None)

- Returns the value of the requested key in the message gid is pointing to in its native format. Alternatively, one could choose what format to return the value in (*int*, *str* or *float*) by using the type keyword.

values = grib_get_array(gid, key, type=None)

- Returns the contents of an array key as a NumPy ndarray or Python array. type can only be *int* or *float*.

values = grib_get_values(gid)

- Gets data values as 1D array

On error, a GribInternalError exception (which wraps errors coming from the C API) is thrown.

Python API - Utilities

[outlat, outlon, value, distance, index] = *grib_find_nearest*(gid, inlat, inlon, is_lsm=False, npoints=1)

- Find the nearest point for a given lat/lon
- (Other possibility is npoints=4 which returns a list of the 4 nearest points)

iter_id = *grib_iterator_new*(gid,mode)

[lat,lon,value] = *grib_iterator_next*(iterid)

grib_iterator_delete(iter_id)

References

- GRIB-1, GRIB-2:
  http://www.wmo.int/pages/prog/www/WMOCodes.html

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

- GRIB API Fortran, C or Python interfaces:
  f90: https://software.ecmwf.int/wiki/display/GRIB/Fortran+package+grib_api
  C: https://software.ecmwf.int/wiki/display/GRIB/Module+Index
  Python: https://software.ecmwf.int/wiki/display/GRIB/Python+package+gribapi

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

- GRIBEX – GRIB API conversion:
  https://software.ecmwf.int/wiki/display/GRIB/GRIBEX+keys