ecCodes BUFR decoding

Fortran 90 and Python API – part 1

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ECMWF

Introduction:

- Fortran 90 subroutines to decode BUFR data
- Python subroutines to decode BUFR data
- Practical examples

BUFR Fortran API

ecCodes Fortran decoding BUFR

- Open a file according to a mode

  call codes_open_file (file, filename, mode, status)

  file: the opened file to be used in all file functions
  filename: name of the file to be open
  mode: open mode can be 'r' (read) or 'w' (write)
  status: CODES_SUCCESS if OK, integer value on error

Input arguments
Output arguments

- Close a file

  call codes_close_file (file, status)

  file: the file to be closed
  status: CODES_SUCCESS if OK, integer value on error

Error handling Fortran API

- In case of error, if the status parameter (optional) is not given, the program will exit with an error message.
- The error message can be gathered with codes_get_error_string.

```
if (status /= 0) then
    call codes_get_error_string (status, err_msg)
    print*,'ecCODES Error: ', trim(err_msg),' error=', status
    stop
end if
```

- Error codes are listed under: http://download.ecmwf.int/test-data/eccodes/html/group__errors.html

ecCodes Fortran decoding BUFR

Input arguments
Output arguments

- Load in memory a message from a file

  call codes_bufr_new_from_file (file, ibufr, status)

  file: the file opened with codes_open_file
  ibufr: id of the message loaded in memory
  status: CODES_SUCCESS if OK, CODES_END_OF_FILE at the end of file, or error code

  The message can be accessed through its message ID and it will be available until codes_release.

- Release a BUFR message

  call codes_release(ibufr, status)

  ibufr: the id of the message to be released
  status: CODES_SUCCESS if OK or error code

ecCodes Fortran decoding BUFR

Input arguments
Output arguments

- Get the value of the key in the message

  call codes_get (ibufr, key, value, status)

  ibufr: id of the message loaded in memory
  key: key of a variable
  value: values of variable/array
  status: CODES_SUCCESS if OK, or error code

value can be a integer(4), real(4), real(8) or a character.

Type of the returned values depend on the variable declaration.

```
integer   (kind=4)             ::  integer_values
real      (kind=8)             ::  real_values
character (len=string_size)    ::  string_values
```

ecCodes Fortran decoding BUFR

Input arguments
Output arguments

- This function supports the **allocatable** array attribute.

  call codes_get (ibufr, key, value, status)

Type of the returned value depend on the array declaration.

```
integer    (kind=4),    dimension(:), allocatable ::  integer_array
real       (kind=8),    dimension(:), allocatable ::  real_array
```

if(allocated(array)) deallocate(array)

ecCodes Fortran decoding BUFR

- Get values of string array

  call codes_get_string_array (ibufr, key, value, status)

Input arguments
Output arguments

ibufr: id of the message loaded in memory
key: key of a variable
value: values of variable/array
status: CODES_SUCCESS if OK, or error code

Type of the returned value depend on the array declaration.

```
character (len=string_size), dimension(:), allocatable :: string_array

! The array of strings  must be allocated before is passed to codes_get_string_array

allocate (string_array)

! Remember to deallocate

if(allocated(string_array)) deallocate(string_array)
```

ecCodes Fortran decoding BUFR header

- Getting number of subsets in the message

```
call codes_get(ibufr,'numberOfSubsets',numberOfSubsets)
```

Input arguments
Output arguments

- Getting master table version number

```
call codes_get(ibufr,'masterTablesVersionNumber', masterTablesVersionNumber)
```

- Getting values of expanded descriptors

```
call codes_get(ibufr, ‘expandedDescriptors’, value, status)
```

- Getting originating Centre

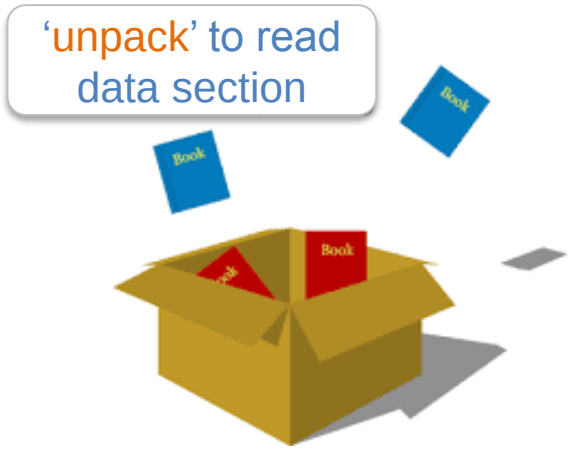
```
call codes_get(ibufr, ‘bufrHeaderCentre’, value, status)
```

ecCodes Fortran ‘unpack’ data section

Input arguments
Output arguments

- We need to instruct ecCodes to unpack the data section

  call codes_set(ibufr,’unpack’,1)



Note: If you do not set ‘unpack’ and want to read data section ecCodes returns

ECCODES ERROR : get: latitude Key/value not found

BUFR API - missing values

- Each element in the data section of a BUFR can be missing.
- ecCodes provides a simple way for the user to check if the value of an element is missing by comparing with two constants:

CODES_MISSING_LONG for integer values

CODES_MISSING_DOUBLE for real values

The constants are available in Python, Fortran 90 and C and the user needs to compare with the appropriate constant depending on the type of the variable used.

Handling missing values

- Declare value as double precision

```
real(kind=8), dimension(:), allocatable :: value
```

- Get the values

```
call codes_get(ibufr,‘key’,value)
do i=1,size(value)
   !compare with double precision missing
   if (value(i)/=CODES_MISSING_DOUBLE) then
   !process non missing values
     else
   !process missing values
   endif
end do
```

ecCodes Fortran decoding BUFR - example

```
call codes_open_file(file,'filename','r')
     call codes_bufr_new_from_file(file,ibufr,status)
     do while (status/=CODES_END_OF_FILE)
         ! Read the BUFR headers info
         call codes_get(ibufr,'numberOfSubsets',numberOfSubsets)
          ! unpack the data values
          call codes_set(ibufr,"unpack",1)
          ! Read the data section
          call codes_get(ibufr,'latitude',lat)
          ! Release the bufr message
          call codes_release(ibufr)
          ! Load the next bufr message
          call codes_bufr_new_from_file(file,ibufr,status)
     end do

call codes_close_file(file)
```

Input arguments
Output arguments

BUFR Python API

Python decoding BUFR

Input arguments
Output arguments

- Open BUFR file

  file = open(filename)

  file: the opened file to be used in all file functions
  filename: name of the file to be opened

- Close BUFR file

  file.close()

  file: the file to be closed

Python decoding BUFR

Input arguments
Output arguments

- Load in memory a message from a file

  ibufr = codes_bufr_new_from_file(file)

  file: the file opened with codes_open_file
  ibufr: id of the message loaded in memory

The message can be accessed through its message ID in all ecCodes functions calls and it will be available until codes_release

- Free the memory for the message referred as ibufr

  codes_release(ibufr)

Python API - Exception handling

All ecCodes functions throw the following exception on error: **CodesInternalError**

```
try:
    example(output_filename)
except CodesInternalError as err:
     sys.stderr.write(err.msg + '\n')
```

Python decoding BUFR

- Get the value of a scalars from a message

  value = codes_get(ibufr, key)

  ibufr: id of the message loaded in memory
  key: key of the variable
  value: value of variable

Input arguments
Output arguments

- Get the array values of a variable from a message

  value = codes_get_array(ibufr, key)

  ibufr: id of the message loaded in memory
  key : key of the variable
  value: an array as a NumPy array or Python array, tuple, list.

Type of the value can only be integer or float.

Python decoding BUFR

Input arguments
Output arguments

- Get the string array from the message

  value = codes_get_string_array(ibufr, key)

  ibufr: id of the message loaded in memory
  key : key of the variable
  value: an string array

Python decoding BUFR header

- Getting number of subsets in the message

  numberOfSubsets = codes_get (ibufr, 'numberOfSubsets')

Input arguments
Output arguments

- Getting master table version number

  masterTablesVersionNumber = codes_get(ibufr, 'masterTablesVersionNumber')

- Getting values of expanded descriptors

  expandedDescriptors = codes_get(ibufr, ‘expandedDescriptors’)

- Getting originating Centre

  centre = codes_get(ibufr, ‘bufrHeaderCentre’)

ecCodes python ‘unpack’ data section

Input arguments
Output arguments

- We need to instruct ecCodes to unpack the data section

  codes_set(ibufr,’unpack’,1)

‘unpack’ to read data section

Note: If you not set ‘unpack’ and want to read data section ecCodes returns

ECCODES ERROR : get: latitude Key/value not found

Python decoding BUFR - example

```
file = open(filename)

# loop over the messages in the file
while 1:

   ibufr = codes_bufr_new_from_file(file)
   if ibufr is None:
      break

   # Read the BUFR headers info
   numberOfSubsets = codes_get (ibufr, 'numberOfSubsets')
   #  unpack the data values
   codes_set(ibufr, 'unpack', 1)

   # Read the data values
   airTemperature = codes_get(ibufr, 'airTemperature')

   codes_release(ibufr)
file.close()
```

Input arguments
Output arguments

Set up environment

- F90 interface

  use eccodes

- Python interface

  from eccodes import *

- At ECMWF environment variables ECCODES_INCLUDE and ECCODES_LIB are used for compilation.

Compile and run the program

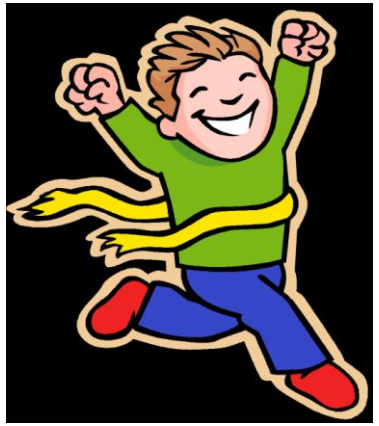
- Fortran 90 interface

  gfortran -o myprogram myprogram.f90 $ECCODES_INCLUDE $ECCODES_LIB

  ./myprogram

- Python interface

  python myprogram.py



Practical

- Navigate to your $SCRATCH

  cd $SCRATCH

- Copy the material for the practical

  cp -r ~trx/ecCodes/2018/bufr_api_decode .

- There are subdirectories for F90 and python
  cd F90
  cd python

- The directories are named by practical number
  e.g. cd bufr_decode_practical1

- Have a look at the README

- Have fun

Practical 1: Decode SYNOP data

1. Open the **synop.bufr** file in read mode
2. Load message
3. Loop over messages
4. Decode and print:
   - unexpandedDescriptors
   - expandedDescriptors
5. '**unpack**' the data section
6. Decode and print:
   - latitude
   - longitude
   - airTemperature
7. Release the message
8. Close the BUFR file

codes_open_file

codes_bufr_new_from_file

codes_set (ibufr,'unpack',1)

codes_get

codes_release

codes_close_file

Try not to set 'unpack'! What is happening?

Assessing value by rank

Input arguments
Output arguments

Fortran API

- Reading value of variable by rank

```
call codes_get(ibufr, '#2#key', value, status)
```

Python API

- Reading value of variable by rank

```
height = codes_get (ibufr, '#2#height' )
```

- Reading array values of variable by rank

```
latitude = codes_get_array (ibufr, '#2#latitude' )
```

Practical 2: Decode TEMP data

1. Open **temp.bufr** in read mode
2. Load message
3. Loop over messages
4. '**unpack**' the data section
5. Get values for:

   'shipOrMobileLandStationIdentifier'
   'latitude',
   'longitude'
   'height'

6. Using accessing variables by rank to decode the second **windSpeed** and **windDirection**
7. Release the message
8. Close the BUFR file

codes_open_file

codes_bufr_new_from_file

codes_set (ibufr,'unpack',1)

codes_get

codes_release

codes_close_file

Practical 3: Decode SYNOP data

1. Open the **synop_2messages.bufr** in read mode
2. Load the messages in memory
3. Loop over messages
4. '**unpack**' the data section
5. Decode and print:
   - '**stationOrSiteName'**
6. Release the message
7. Close the BUFR file

In Fortran API

```
character (len=string_size), dimension(:), allocatable :: stationOrSiteName
! The array of strings  must be allocated before is passed to codes_get_string_array

call codes_get_size(ibufr,'stationOrSiteName',n)
allocate (stationOrSiteName(n))
```

codes_open_file

codes_bufr_new_from_file

codes_set (ibufr,'unpack',1)

codes_get

codes_release

codes_close_file

Practical 4: Decode SYNOP data

1. Open the **synop_with_confidence.bufr** in read mode
2. Load the messages in memory
3. Loop over messages
4. '**unpack**' the data section
5. Decode and print:
   - '**nonCoordinatePressure'**
   - its '**percentConfidence'**
6. Release the message
7. Close the BUFR file

codes_open_file

codes_bufr_new_from_file

codes_set (ibufr,'unpack',1)

codes_get

codes_release

codes_close_file

How to access confidence??

call codes_get(ibufr, 'nonCoordinatePressure->percentConfidence', pressureConfidence)

References

- ecCodes:

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

- BUFR tables:

  https://software.ecmwf.int/wiki/display/ECC/BUFR+tables

- Error codes are listed under:
  http://download.ecmwf.int/test-data/eccodes/html/group__errors.html


рахмат
danke
謝謝
ngiyabonga
spas
teşekkür ederim
Баярлалаа
mersi
kia ora
barka
welalin
tack
mahalo
tapadh leat
спасибо
faafetai lava
vinaka
спасибі
blagodaram
dank je
misaotra
matondo
paldies
grazzi
gracias
thank you
kiitos
dankie
nanni
nandri
dhanyavad
хвала
asante
manana
bedankt
bayarlalaa
gràçie
hvala
mauruuru
köszönöm
dankon
ačiū
akun
obrigada
murakoze
tenki
enkosi
djiere dieuf
tau
mochchakkeram
дякую
mamnun
dziękuję
chnorakaloutioun
gratias ago
gràcies
sulpáy
taiku
go raibh maith agat
chokrane
sobodi
děkuji
sagolun
sukriya
kop khun krap
obrigado
arigatô
takk
dakujem
trugarez
mèsi
didi madloba
ありがとう
tanemirt
grazie
najis tuke
terima kasih
rahmet
shukriya
mercé
мерси
kam sah hamnida
rahmat
diolch
dhanyavadagalu
ευχαριστώ
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감사합니다
xièxie
merci