R package getgrib: an Overview

Reto Stauffer
Universität Innsbruck

Abstract

Once upon a time I was working with Sascha on a small problem on how to efficiently read grib data in R. There is the `raster` package which offers some functionality, however, the `raster` package is neither quick nor does it provide the (often) required meta information of the grib messages or is able to read data from rotated grids (like COSMO).

This was the beginning of this `getgrib` package which offers some grib handling functionalities using the ECMWF GRIB_API and some customized Fortran routines in the backend.

This vignette shows a short overview over the functionalities of the *R* package **getgrib**.

Keywords: R package grib.

Contents

1. Known Problems

Please note that this package is currently in version 1.1 but is still in a development state (or late alpha). There are some known problems which will be fixed somewhen if needed.

COSMO Just as an example: the COSMO grib messages do not contain a "`perturbationNumber`" (while ECMWF HIRES does). This leads to problems reading the data (`getdata` crashes). Has to be re-designed somewhen.

Grid specification note that the getdata operation will stop (if not used with messagenumber) whenever the specification of the grib files change from message 1 to N. This might be a bit restrictive but is what I need at the moment. Adjustments might be possible.

2. Installation

This package is using the ECMWF GRIB_API which requires the api libraries for building the package. Please note that the code below is only an example and the location of the libraries might differ on your system.

```
# Bash/Shell: setting environment variables and flags
export PKG_FCFLAGS="-static-libgfortran -L/usr -I/usr/include -lgrib_api_f90 -lgrib_api"
export PKG_LIBS="-L/usr -I/usr/include -lgrib_api_f90 -lgrib_api"

# Compile and install package
version=`cat getgrib/DESCRIPTION | grep 'Version:' | awk '{print $2}'`
R CMD build --no-build-vignettes getgrib
R CMD INSTALL getgrib_${version}.tar.gz
```

3. Get Nearest Neighbor Grid Point Data

Reto: to test.

This is basically the first method which has been developed and somehow the reason for this package. This method was desidned for Sascha to get nearest neighbor data from COSMO grids in an efficient way. However, I have to test the function and to write a help page.

4. Getting Grib Inventory

The ECMWF GRIB_API offers a console tool called `grib_ls` to create an inventory of a grib file. This function mimiks this tool in R.

```
> # Path to package internal demo file
> file <- paste(path.package("getgrib"),"data/ECEPS_12.grib",sep="/")
> inv  <- grib_ls(file,where='step=12,shortName!=2t')
> print(head(inv))
```

```
  centre dataDate dataTime perturbationNumber shortName step
1   ecmf 20160928        0                 1      10fg   12
2   ecmf 20160928        0                 1       lsp   12
3   ecmf 20160928        0                 1        cp   12
4   ecmf 20160928        0                 1        sf   12
5   ecmf 20160928        0                 1       msl   12
6   ecmf 20160928        0                 1       tcc   12
```

The first line specifies the path to a demo grib file included in this package. `grib_ls` simply returns a `data.frame` containing the inventory of the specified grib file. Note that the two inputs "`parameters=`" and "`where=`" mimik the `grib_ls` inputs "`-p`" and "`-w`" and can be used in a similar way. Please see help page for a more detailed description.

5. gribdata: The Common Data Handling Object

The package is using a special object called `gribdata` for the data handling offering some basic methods for data manipulation. Most methods of the `getgrib` package are based on this object type. It is basically a `matrix` with additional attributes. These attributes are neede for further processing steps.

6. Loading Data from a Grib File Using getdata

This is the main function to read data. The data will be returned as a `gribdata` object. There are currently two different methods on how to get the data. Option one: use the `shortName` selector. In this case the grib file is scanned and all messages with the corresponding `shortName` identifier in the grib message header will be returned. Example:

```
> # Path to package internal demo file
> file <- paste(path.package("getgrib"),"data/ECEPS_12.grib",sep="/")
> # Reading all messages with "t2m"
> gribdata <- getdata(file,'2t') # getting all 2t forecasts
> # Show content
> gribdata

      Matrix dimension:      51 x 7012
      Number of grid points: 7008
      Source file:           /usr/lib/R/user-library/getgrib/data/ECEPS_12.grib

      Initial dates:      1 [20160928]
      Initial hours:      1 [0]
      Steps:              1 [12]
      Members:            51 [0,1,2,...,48,49,50]
      Longitude range:    5.75 - 17.625
      Latitude range:     45 - 54
      Data range (!NA):   282.375 - 299.931
      Number of NA:       0
```

On the other hand data can be loaded via message number. The message number corresponds to the row number from `grib_ls`. Example:

```
> # Path to package internal demo file
> file <- paste(path.package("getgrib"),"data/ECEPS_12.grib",sep="/")
> # Reading all messages with "t2m"
> inv <- grib_ls(file) # getting all 2t forecasts
> print(head(inv,3))

  centre dataDate dataTime perturbationNumber shortName step
1   ecmf 20160928        0                 1      10fg   12
2   ecmf 20160928        0                 1       lsp   12
3   ecmf 20160928        0                 1        cp   12

> # Search for message
> idx <- which( inv$shortName == "mx2t" &
+               inv$perturbationNumber == 5 & inv$step == 12)
> print(idx)

[1] 121

> # Loading data
> gribdata <- getdata(file,idx)
```

Well, as shown above one message has been loaded (message `idx`) and returned the corresponding `gribdata` object. This example is loading a 2m maximum temperature forecast. Originally these data are in Kelvin. You can easily scale the data:

```
> # Loading data
> gribdata <- getdata(file,idx,scale="- 273.15")
> gribdata

      Matrix dimension:      1 x 7012
      Number of grid points: 7008
      Source file:           /usr/lib/R/user-library/getgrib/data/ECEPS_12.grib
      From message number:   121

      Initial dates:      1 [20160928]
      Initial hours:      1 [0]
      Steps:              1 [12]
      Members:            1 [5]
      Longitude range:    5.75 - 17.625
      Latitude range:     45 - 54
      Data range (!NA):   9.669 - 25.615
      Number of NA:       0
```

Please note that the "`scale`" argument can be any valid mathematical expression leading to "`x scale`" where `x` are the data, `scale` the argument specified by you. Useful to e.g., scale precipitation from meters to millimeters, convert Kelvin to Celsius, or geopotential height to height.

7. Convert griddata to RasterStack Objects

Objects of type `gribdata` can easily be converted into `RasterStack` objects by simply calling `gribdata2raster`. Please note that this only works for regular latlon grids (orthogonal longitude latitude grids). This will be checked internally using `is_regular_ll_grid` using grid spacing returned by `get_grid_increments`.

```
> # Path to package internal demo file
> file <- paste(path.package("getgrib"),"data/ECMWF_t2m_demo.grib",sep="/")
> # Path to package internal demo file
> gribdata <- getdata(file,"2t",scale="-273.15")
> is_regular_ll_grid(gribdata)
```

```
[1] TRUE
```

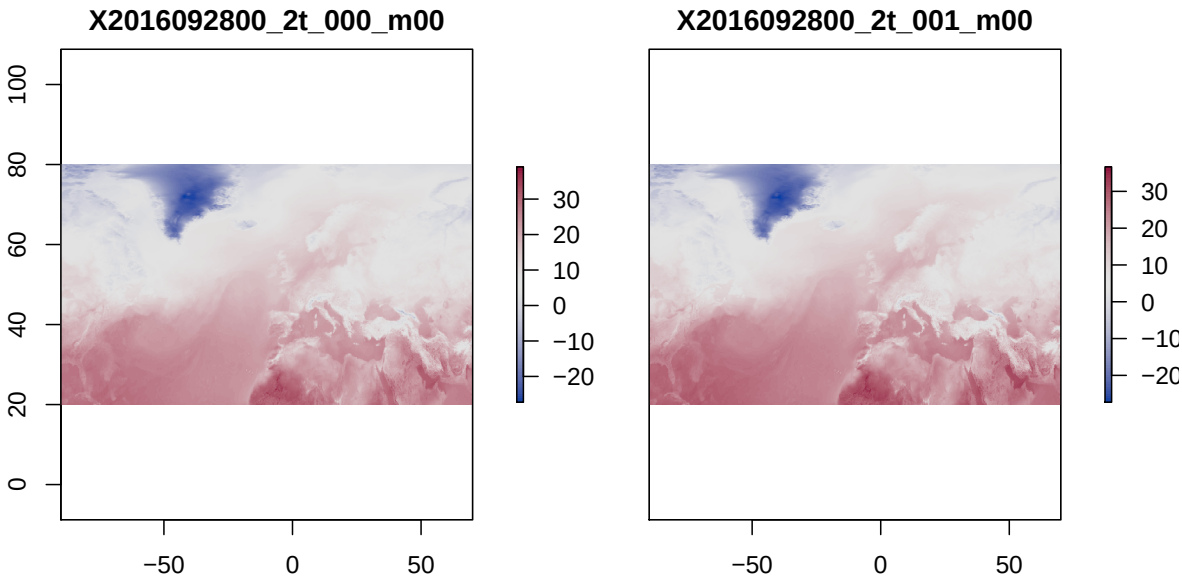
```
> get_grid_increments(gribdata)
```

```
[1] 0.125 0.125
```

```
> # Convert to raster
> rastered <- gribdata2raster(gribdata,silent=T)
> rastered
```

```
class       : RasterStack
dimensions  : 481, 1281, 616161, 3  (nrow, ncol, ncell, nlayers)
resolution  : 0.125, 0.125  (x, y)
extent      : -90.0625, 70.0625, 19.9375, 80.0625  (xmin, xmax, ymin, ymax)
coord. ref. : +proj=longlat +ellps=WGS84 +towgs84=0,0,0,0,0,0,0 +no_defs
names       : X2016092800_2t_000_m00, X2016092800_2t_001_m00, X2016092800_2t_002_m00
min values  :              -27.26075,              -27.38973,              -27.01244
max values  :               39.07714,               38.54972,               36.03248
```

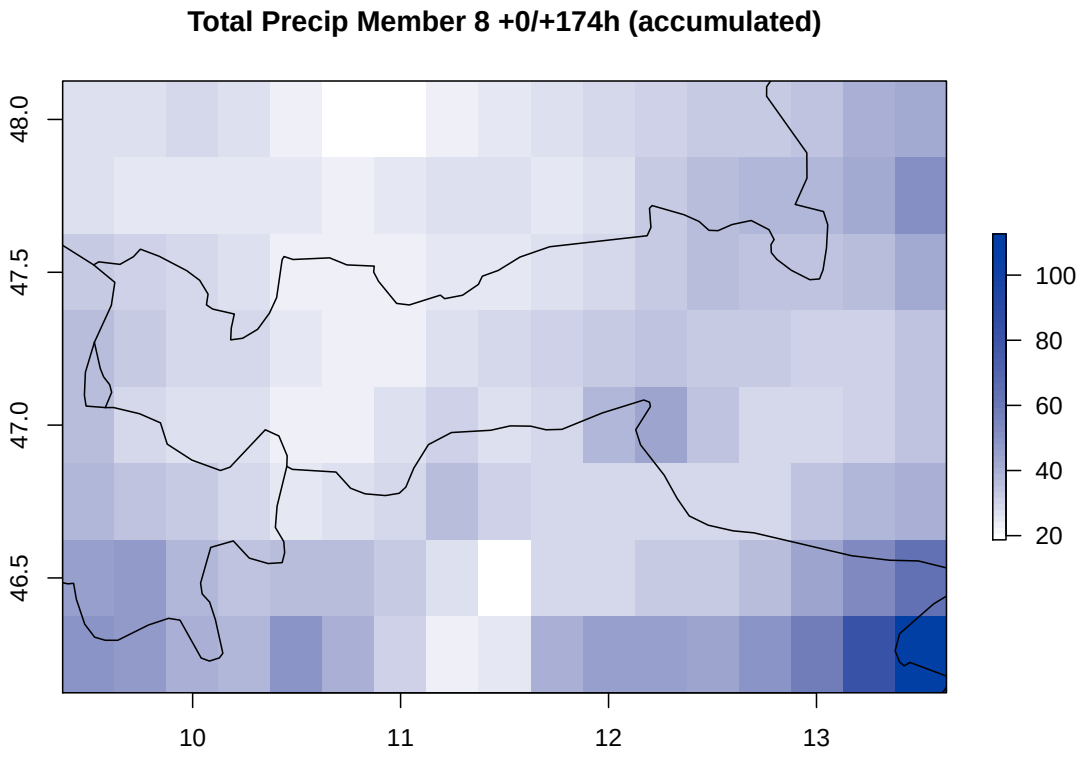
```
> # Plot
> require("colorspace")
> plot( rastered[[1:2]], col=diverge_hcl(101) )
```



8. Deaccumulate Data in gribdata Objects

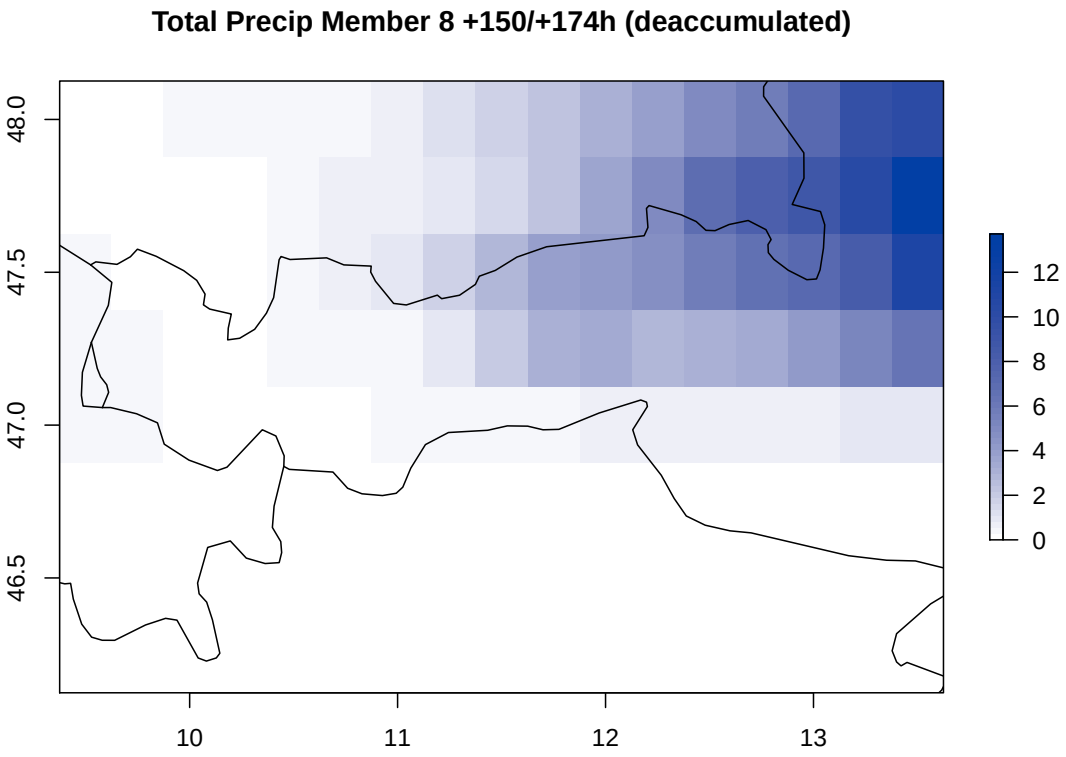
This is fucking quick :). Think of reading precipitation forecast data from a grib file which are accumulated in ECMWF and ECEPS grib files. Maybe you would like to deaccumulate them. Simply do this on the `gribdata` basis. Example:

```
> # Path to package internal demo file
> file <- paste(path.package("getgrib"),
+               "data/SnowSafeHindcast_201610130000.grib",sep="/")
> # Loading file, creates gribdata object. As this is
> # total precipitation I already scale them from meters to
> # millimeters using the 'scale="*1000"' argument.
> gribdata <- getdata(file,'tp',scale='* 1000')
> # Now we can to two things. Watching member 4 accumulated fields:
> require("colorspace"); require("maps")
> cols <- sequential_hcl(51,h=260,c(0,80),l=c(100,30),power=2)
> g1 <- gribdata2raster(gribdata,silent=T)
> plot( g1[["X2015101300_tp_174_m08"]],
+    col=cols, main="Total Precip Member 8 +0/+174h (accumulated)"  )
> map(add=T)
```



Deaccumulate on 24h-basis. Note that the additional options `setzero` and `zeroval` reduce all values below `zeroval` to `0` if `setzero=TRUE`. I used this for precipitation to remove interpolation or roundoff noise (`setzero=0.01` equals `0.01mm` per day).

```
> # Deaccumulate. For details see ?deaccumulate
> gribdata_deaccumulated <- deaccumulate(gribdata,deaccumulation=24,
+                                        setzero=TRUE,zeroval=0.01)
> g2 <- gribdata2raster(gribdata_deaccumulated,silent=T)
> plot( g2[["X2015101300_tp_174_m08"]],
+    col=cols, main="Total Precip Member 8 +150/+174h (deaccumulated)"  )
> map(add=T)
```



Affiliation:

Reto Stauffer
Department of Statistics
Faculty of Economics and Statistics
Universität Innsbruck
Universitätsstraße 15
6020 Innsbruck, Austria, *and*
Institute of Atmospheric and Cryospheric Sciences
Faculty of Geo- and Atmospheric Sciences
Universität Innsbruck
Innrain 52
6020 Innsbruck, Austria
E-mail: Reto.Stauffer@uibk.ac.at