Progress Report #2: How to calculate the "frost point" from the GRIB-1 data

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1 Problems

The previous dataset we used was GLDAS_NOAH025_3H, its temporal coverage is 1948 to 2010. However, we are interested in the data from 2015 to present. So we turn to use the GLDAS_NOAH025SUBP_3H dataset. Comparison of the two datasets are in the table below.

Table 1: Two datasets

Shortname:	GLDAS_NOAH025SUBP_3H	GLDAS_NOAH025_3H
Longname:	GLDAS Noah Land Surface Model L4 3 Hourly 0.25 x 0.25 degree Subsetted	GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree V2.0
Format:	GRIB	netCDF-4
Spatial Coverage:	(-60.0 to 90.0; -180.0 to 180.0)	(-60.0 to 90.0; -180.0 to 180.0)
Temporal Coverage:	2000-02-24 to **Present**	1948-01-01 to 2010-12-31
Spatial:	0.25 degree x 0.25 degree	0.25 degree x 0.25 degree
Temporal:	3 hourly	3 hourly
Hyperlink	Data Access	Data Access

Besides the temporal coverage, the big difference of the two datasets is format.

2 GRIB data reading

In previous work, we read the NetCDF-4 data by using the "ncdf4" package for R. But to read the GRIB data is not as easy as NetCDF-4. More detailed GRIB data description can be found in the README Document.

The sample GRIB format file we use is:
"GLDAS_NOAH025SUBP_3H.A2016001.0000.001.2016041013331.grb".
It contains the data for 0Z o'clock in Jan 1, 2016.

First, we get the information form the file by wgrib. The wgrib for windows that is provided on the web **does not work** in my Win10 system. So I compiled a new one from its source code wgrib.c, and it works.

It is worth noting that the GRIB files we analyzed is GRIB-1 format. To GRIB-2 format data, we need to use wgrib2.

By running the command:

```
wgrib GLDAS_NOAH025SUBP_3H.A2016001.0000.001.2016041013331.grb -v
```

The information for the GRIB file are shown:

```
1:0:D=2015123121:NSWRS:sfc:kpds=111,1,0:0-3hr ave:winds are N/S:"Net short wave (surface) [W/m^2]
2:624472:D=2015123121:NLWRS:sfc:kpds=112,1,0:0-3hr ave:winds are N/S:"Net long wave (surface) [W/m^2]
3:1188192:D=2015123121:LHTFL:sfc:kpds=121,1,0:0-3hr ave:winds are N/S:"Latent heat flux [W/m^2]
4:1782288:D=2015123121:SHTFL:sfc:kpds=122,1,0:0-3hr ave:winds are N/S:"Sensible heat flux [W/m^2]
5:2406760:D=2015123121:GFLUX:sfc:kpds=155,1,0:0-3hr ave:winds are N/S:"Ground heat flux [W/m^2]
6:3000856:D=2016010100:LFTX:sfc:kpds=131,1,0:anl:winds are N/S:"Surface lifted index [K]
7:3746828:D=2016010100:4LFTX:sfc:kpds=132,1,0:anl:winds are N/S:"Best (4-layer) lifted index [K]
8:4432050:D=2016010100:EVP:sfc:kpds=57,1,0:anl:winds are N/S:"Evaporation [kg/m^2]
9:4995770:D=2016010100:SSRUN:sfc:kpds=235,1,0:anl:winds are N/S:"Storm surface runoff [kg/m^2]
10:5620242:D=2016010100:BGRUN:sfc:kpds=234,1,0:anl:winds are N/S:"Baseflow-groundwater runoff [kg/m^2]
11:6244714:D=2015123121:SNOM:sfc:kpds=99,1,0:0-3hr ave:winds are N/S:"Snow melt [kg/m^2]
12:6747684:D=2016010100:BVF2:sfc:kpds=138,1,0:anl:winds are N/S:"Brunt-Vaisala frequency^2 [1/s^2]
13:7281030:D=2016010100:WEASD:sfc:kpds=65,1,0:anl:winds are N/S:"Accum. snow [kg/m^2]
14:8300382:D=2016010100:TSOIL:0-4 cm down:kpds=85,112,4:anl:winds are N/S:"Soil temp. [K]
15:8833728:D=2016010100:TSOIL:0-3 cm down:kpds=85,112,3:anl:winds are N/S:"Soil temp. [K]
16:9367074:D=2016010100:TSOIL:0-2 cm down:kpds=85,112,2:anl:winds are N/S:"Soil temp. [K]
17:9900420:D=2016010100:TSOIL:0-1 cm down:kpds=85,112,1:anl:winds are N/S:"Soil temp. [K]
18:10433766:D=2016010100:SOILM:0-4 cm down:kpds=86,112,4:anl:winds are N/S:"Soil moisture content [kg/m^2]
19:11118988:D=2016010100:SOILM:0-3 cm down:kpds=86,112,3:anl:winds are N/S:"Soil moisture content [kg/m^2]
20:11864960:D=2016010100:SOILM:0-2 cm down:kpds=86,112,2:anl:winds are N/S:"Soil moisture content [kg/m^2]
21:12641308:D=2016010100:SOILM:0-1 cm down:kpds=86,112,1:anl:winds are N/S:"Soil moisture content [kg/m^2]
22:13448032:D=2016010100:TCDC:sfc:kpds=71,1,0:anl:winds are N/S:"Total cloud cover [%]
23:13951002:D=2016010100:WIND:sfc:kpds=32,1,0:anl:winds are N/S:"Wind speed [m/s]
24:14393222:D=2016010100:TMP:sfc:kpds=11,1,0:anl:winds are N/S:"Temp. [K]
25:14926568:D=2016010100:SPFH:sfc:kpds=51,1,0:anl:winds are N/S:"Specific humidity [kg/kg]
26:15186534:D=2016010100:PRES:sfc:kpds=1,1,0:anl:winds are N/S:"Pressure [Pa]
27:15902132:D=2015123121:DSWRF:sfc:kpds=204,1,0:0-3hr ave:winds are N/S:"Downward short wave flux [W/m^2]
28:16526604:D=2015123121:DLWRF:sfc:kpds=205,1,0:0-3hr ave:winds are N/S:"Downward long wave flux [W/m^2]
```

Now, we know that the band 24-26 (in blue) are important data we may use for computing the "frost point". So we will extract these data (Temperature in K, Specific humidity in kg/kg and Pressure in Pa) out of the file.

Second, useful data are extracted by R.
The function below is to extract one band data from the GRIB file and return a matrix.

```
# read grib1 data file and extract one band data to be a matrix
# input: grib1 file, band number
# output: a certain band data by matrix
# "wgrib.exe" and "cygwin1.dll" file need
grb_extr <- function(fname, band_num) {
  # extract data by wgrib.exe and store in TEMP.txt
  system(paste("wgrib", fname, "-d", band_num, "-text -nh -o TEMP.txt"))
```

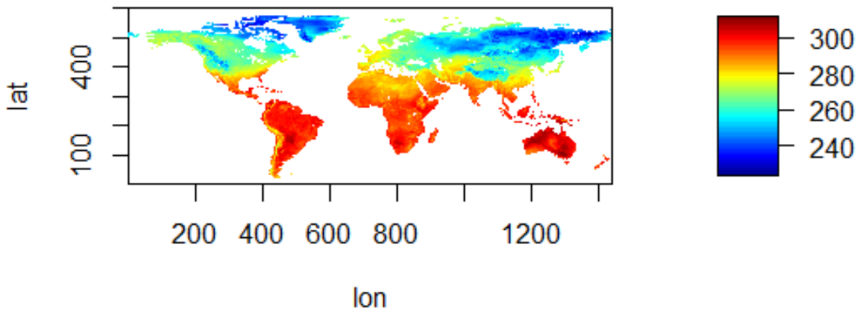
```
  x <- read.table("TEMP.txt") # read the TEMP.txt
  # convert list to matrix
  band <- matrix(unlist(x),
                 nrow = 1440,
                 ncol = 600,
                 byrow = FALSE)
  band[band > 999999] <- NA # mark NA data
  return(band)
}
```

Then, we apply this function to get the Temperature.

R code for getting the Air Temperature (0Z o'clock in Jan 1, 2016)

```
source("grb_extract.R")
fname <- "GLDAS_NOAH025SUBP_3H.A2016001.0000.001.2016041013331.grb"
Tt <- grb_extr(fname, 24)
```

And then to draw the matrix Tt:



Air Temperature (in K) at 0Z o'clock in Jan 1, 2016.

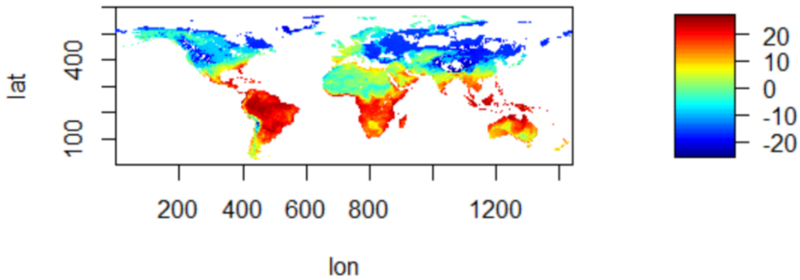
3 Frost point calculation

By the processes in section 2, the surface air pressure (p) and specific humidity (q) data can be extracted from GRIB file and converted to be matrixes. Then we could re-use the code in Progress Report 1 to compute the dew point (Td).

R code for computing Td:

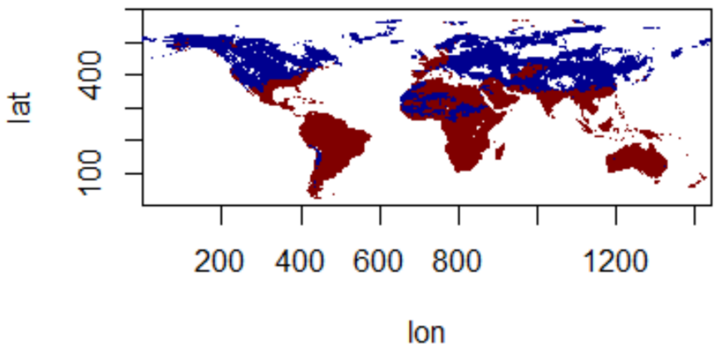
```
source("grb_extract.R")
# import the function for calculating dew point Td(in deg C)  by
# surface pressure p(in mb) and specific humidity q(in kg/kg)
source("dew_point.R")

# fname is "GLDAS_NOAH025SUBP_3H.A2016001.0000.001.2016041013331.grb"
q<-grb_extr(fname, 25) # get Specific humidity (in kg/kg)
p<-grb_extr(fname, 26) # get surface air pressure (in Pa)
```

```
dew<-matrix(data=NA,nrow=1440,ncol=600) # new matrix of dew point
for (i in 1:1440){
  for (j in 1:600){
    a_p<-p[i,j]
    a_q<-q[i,j]
    if ((!is.na(a_p))&(!is.na(a_q))){ # both p and q are not NA
      dew[i,j]<-dew_point(a_p*0.01,a_q) # 1 Pa=0.01 mb
    }
  }
}
```



Dew point (in℃) at 0Z o'clock in Jan 1, 2016.

As shown in the figure above, in the dew point matrix, some values are less than 0℃. They are the frost points. We put the dew point values into two groups by comparing with the freezing point (0℃). The northern hemisphere is winter in January, so most frost point areas are in this region.



Frost point (Blue) at 0Z o'clock in Jan 1, 2016.