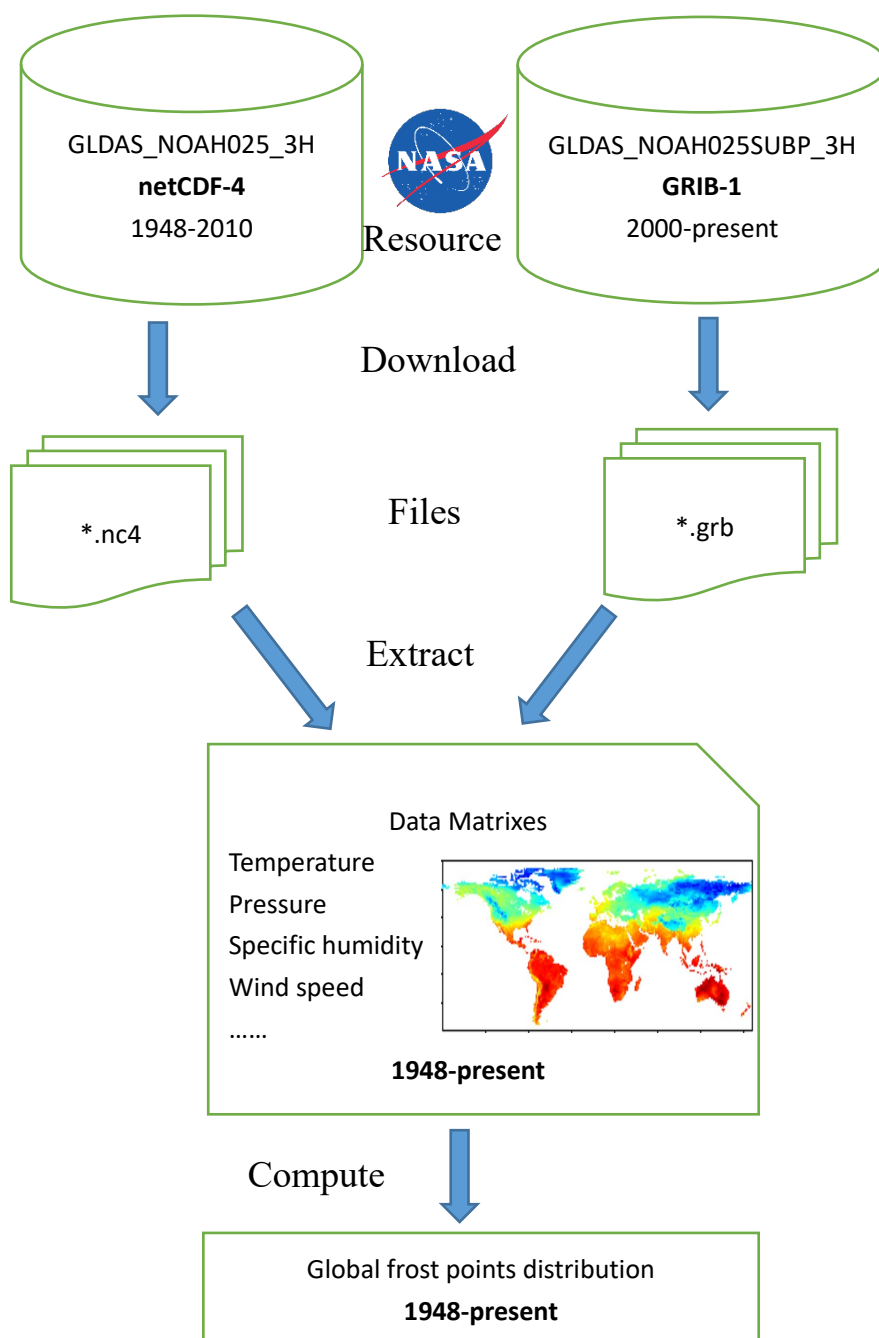


## Frost Point Data Collection Report

### Overall progress



### Dataset description

The dataset we use is [GLDAS\\_NOAH025\\_3H.2.0](#), it is 3-hourly on a 0.25 grid. Its temporal coverage is from January 1, 1948 to December 31, 2010.

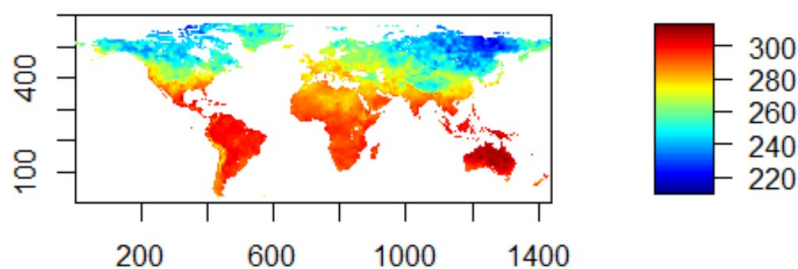
To every data file, the data is for a certain time and date. For example, the file “GLDAS\_NOAH025\_3H.A20100101.0000.020.nc4”, it contains the data for 0Z o'clock in Jan 1, 2010.

The data is formatted by NetCDF4. In one data file, there are 36 1440 by 600 matrixes (1440 lon x 600 lat for the 0.25° data), each matrix contains the data for one field. For example, the matrix labeled “Tair\_f\_inst” has the air temperature data on the ground. More detailed data description can be found in the [README Document](#).

### NCDF-4 Data reading

By using the “ncdf4” package for R, reading the data is quite easy.

And then to draw the matrix T:



Air Temperature (in K) at 0Z o'clock in Jan 1, 2010.

### Frost point calculation

As we know that “the frost point is when the 'dew point' drops below freezing”. Hence the work is to compute the dew point (Td) firstly, and then find the areas whose Td values are less than 0°C (the freezing point).

By referring to the [CEOP Derived Parameter Equations](#), the dew point (Td) can be calculated from surface air pressure (p) and specific humidity (q), which are labeled “Psurf\_f\_inst” and “Qair\_f\_inst” in our dataset.

The formulas are:

$$e = (p * q) / (0.622 + 0.378 * q)$$

$$Td = \log(e / 6.112) * 243.5 / (17.67 - \log(e / 6.112))$$

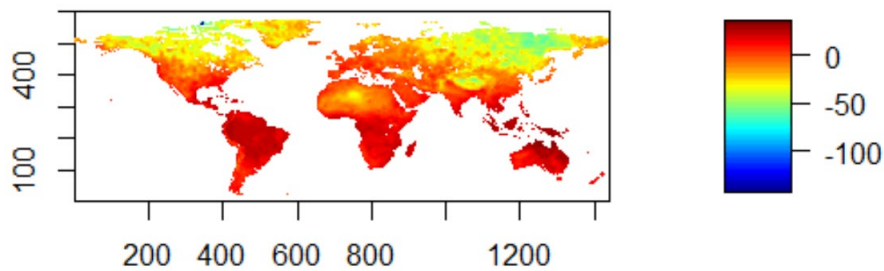
p = surface pressure in mb

$q$  = specific humidity in kg/kg

$e$  = vapor pressure in mb

$T_d$  = dew point in deg-C

$1 Pa = 0.01 mb$ ;  $deg-C = K - 273.15$



Dew point (in °C) at 0Z o'clock in Jan 1, 2010.

As shown in the figure above, in the dew point matrix, some values are less than 0°C.

### 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:	<b>GRIB</b>	<b>netCDF-4</b>
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 <b>Present</b>	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	<a href="#">Data Access</a>	<a href="#">Data Access</a>

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

## 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 from 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:BFV2: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]
```

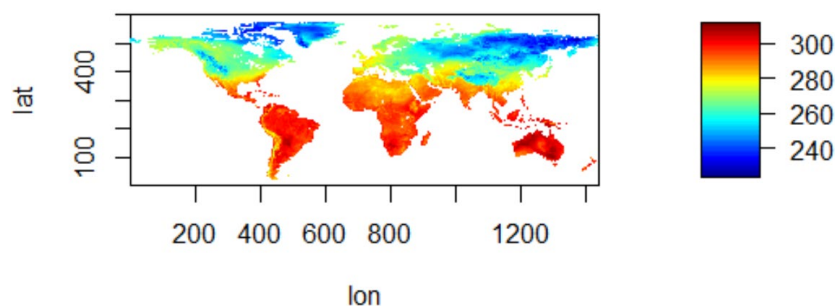
```

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. Then, we apply this function to get the Temperature.

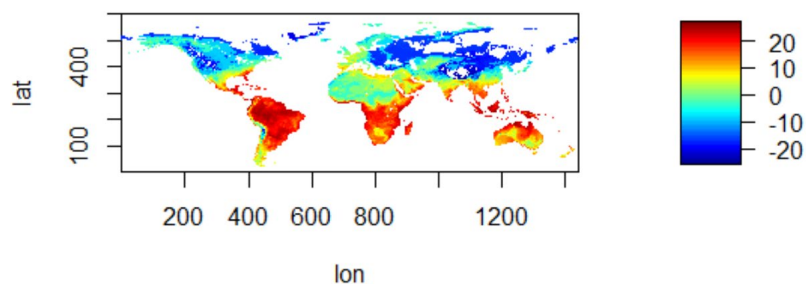
And then to draw the matrix Tt:



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

### 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.



Dew point (in °C) 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 °C.

### Download data

Downloading works are done in R by using the “RCurl” package. The process is briefly described below:

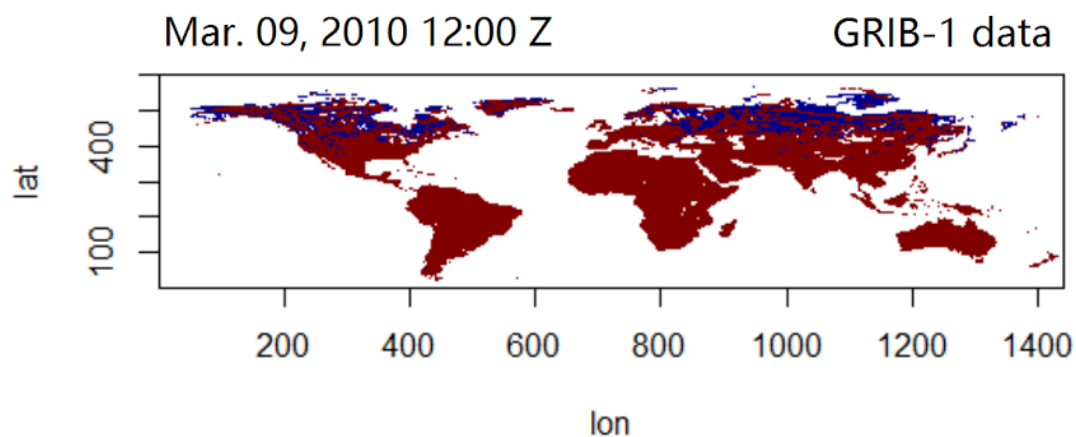
- 1) download the grib data file (about 16 MB for each).
- 2) open grib file by "wgrib.exe" and extract temperature (T), pressure (p) and humidity (q) data from it.
- 3) compute dew point and frost point by T, p and q.
- 4) save T, p, q and dew point data to a Rdata file.

The whole process can be automatically done by the R program, but the downloading and opening files are really time-consuming because there are  $(8*365) = 2920$  grib files for one year. In order to speed the process up, the program have been modified and run in parallel computing by using `%dopar%`.

### Frost points

From the Wikipedia, it says the frost is "If a solid surface is chilled below the dew point of the surrounding humid air and the surface itself is colder than freezing, ice will form on it." So the frost point has two characteristics: 1) temperature is lower than dew point and 2) temperature is lower than freezing point (0 C-deg.) By taking account of the two characteristics, after calculating the dew points, we can compute the frost points.

The frost points for the Mar 09 2010 is shown below.



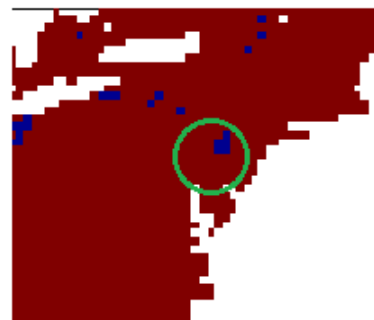
Frost points at 12Z o'clock in Mar 09, 2010.

**An example: Frost occurred in Newark, DE**



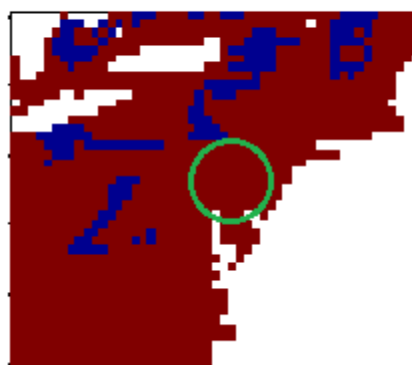
Our data shows (blue points are frost):

**02 EDT April 5th , 2016 08 EDT April 10th, 2016**



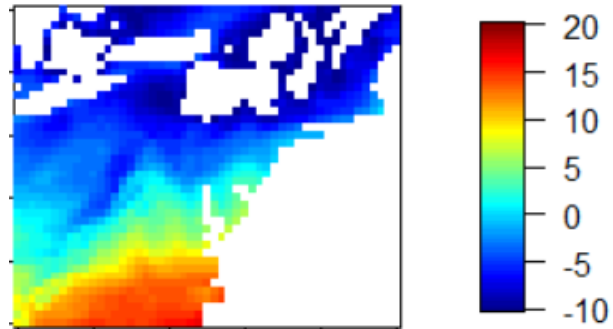
And in other time among April 5th to 10th, there's no frost, for example:

**02 EDT April 8th, 2016**

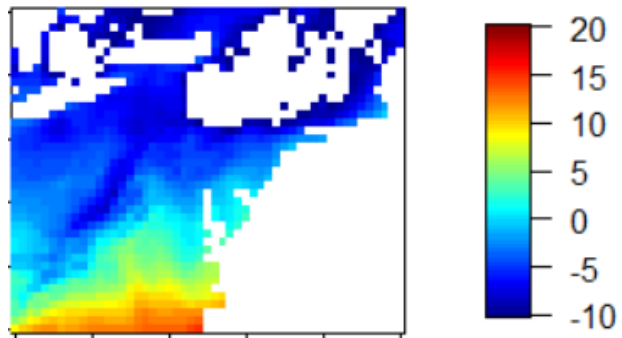


Temperature ( °C):

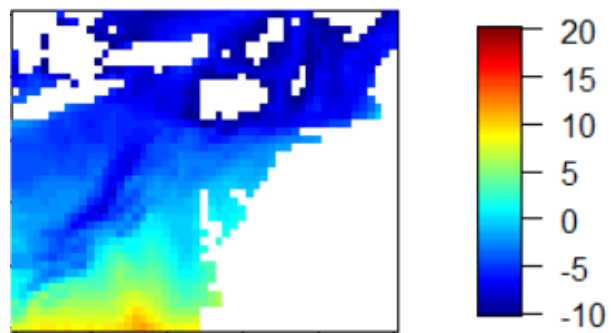
02 EDT, Apr.5, 2016



05 EDT, Apr.5, 2016

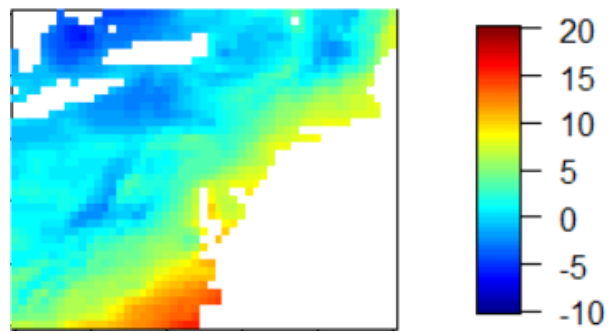


08 EDT, Apr.5, 2016

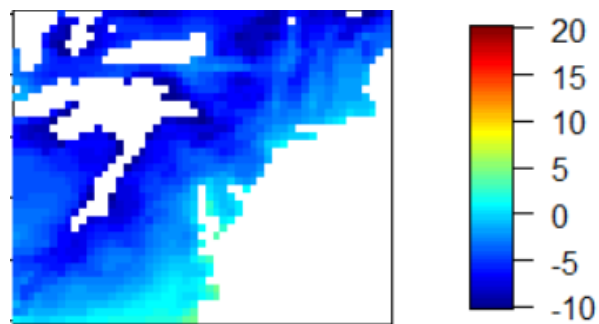




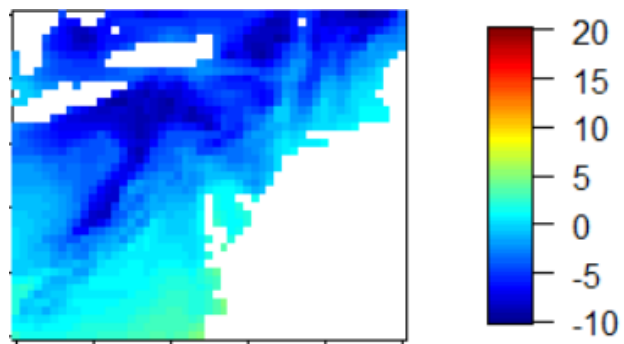
02 EDT, Apr.8, 2016 (NO frost occurred in the Newark, DE)



05 EDT, Apr.10, 2016



08 EDT, Apr.10, 2016



11 EDT, Apr.10, 2016

