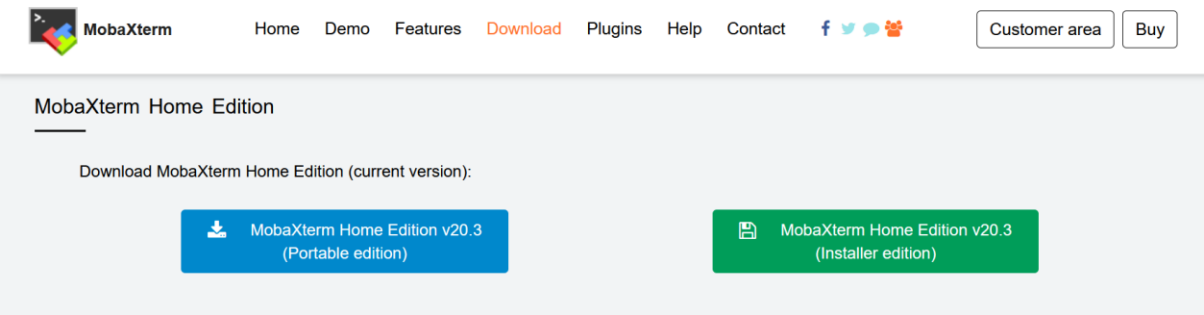
# Rainfall Forecasting Training Notes

## Requirements

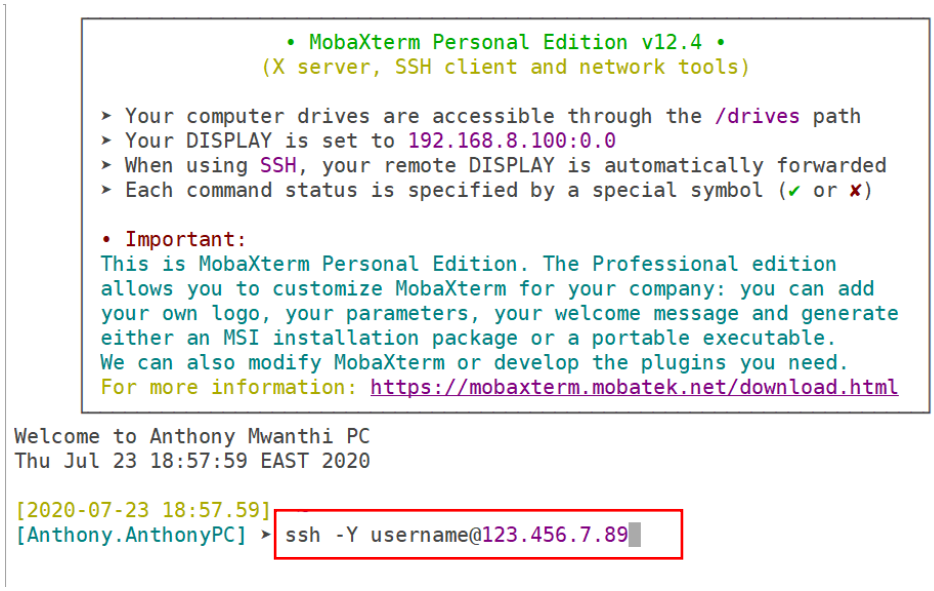
1. Download and install MobaXtem on a Windows PC (https://mobaxterm.mobatek.net/download-home-edition.html )




2. Select the installer edition and double click the executable & follow the prompts.

**NB: Skip this step if you're using Linux OS**

To login in to the server, launch the MobaXterm terminal and type the username and IP address as shown below




3. When prompted, enter the password.

***NB: These credentials will be provided during the training***

**Introduction**

These notes will take you through the following: -

- Generation of Rainfall Forecasts from WRF
- Assessment of WRF forecast bias
- On-web use of real time satellite data

Tools used in this exercise are NCAR Command Language, NCL (https://www.ncl.ucar.edu/) and Climate Data Operators, CDO (https://code.mpimet.mpg.de/projects/cdo) which are already installed in the ICPAC cluster.

**Requirements:** ENTRO System Admin will provide you with the Server access details

**Activity I: Generation of Rainfall Forecast from WRF**

This activity is automated in the operational ENTRO WRF. However, for training purposes, a manual system will be used.

Once logged in, launched the terminal using CTRL + ALT + T

Navigate to /home/entro/training/20190821 by using the command

```
cd /home/entro/training/20190821
```

We are going to generate a forecast for 3days starting 21st August 2019

The above directories are described as follow.

gfs – contains model input data

wps – contains executables for pre-processing the GFS data into WRF format

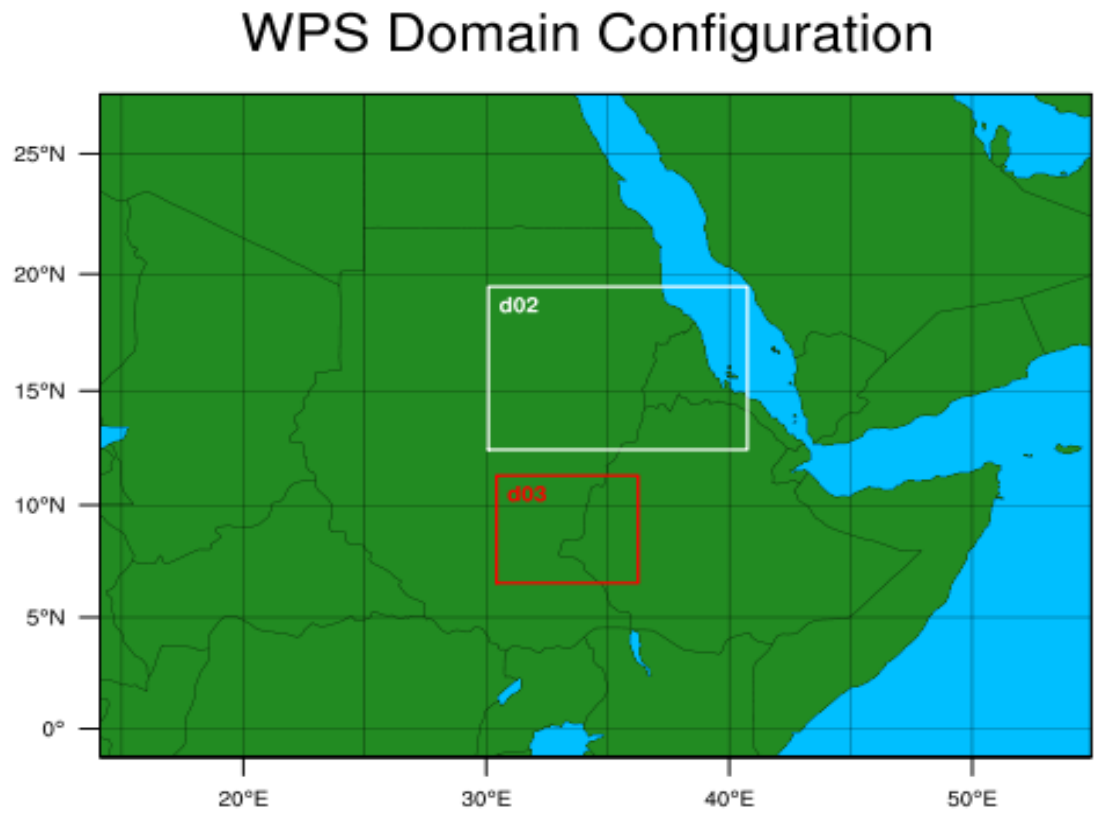
wrf – contains executables to run the WRF forecast

navigated into wps

```
cd wps
```

Plot the domain using the command

```
ncl util/plotgrids_new.ncl
```




nano namelist.wps

```
&share
 wrf_core = 'ARW',
 max_dom = 3,
 start_date = '2019-08-21_00:00:00', '2019-08-21_00:00:00', '2019-08-21_00:00:00', '2019-08-21_00:00:00',
 end_date   = '2019-08-24_00:00:00', '2019-08-24_00:00:00', '2019-08-24_00:00:00', '2019-08-24_00:00:00',
 interval_seconds = 10800,
 io_form_geogrid = 2,
 debug_level = 0,
/

&geogrid
 parent_id         =   1,   1,    1,    1,
 parent_grid_ratio =   1,   3,    3,    3,
 i_parent_start    =   1,  97,   99,   70,
 j_parent_start    =   1,  84,   48,   56,
 e_we              = 246,  193,  106,   73,
 e_sn              = 180,  133,  88,   79,
 !geog_data_res     = '5m','30s','30s', '30s'
 geog_data_res     = 'default','default','default', 'default'
 !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!! IMPORTANT NOTE !!!!!!!!!!!!!!!!!!!!!!!!!!!!
 ! The default datasets used to produce the MAXSNOALB and ALBEDO12M
 ! fields have changed in WPS v4.0. These fields are now interpolated
 ! from MODIS-based datasets.
 !
 ! To match the output given by the default namelist.wps in WPS v3.9.1,
 ! the following setting for geog_data_res may be used:
 !
 ! geog_data_res = 'maxsnowalb_ncep+albedo_ncep+default', 'maxsnowalb_ncep+albedo_ncep+default',
 !
 !!!!!!!!!!!!!!!!!!!!!!!!!!!! IMPORTANT NOTE !!!!!!!!!!!!!!!!!!!!!!!!!!!!

^G Get Help    ^O Write Out   ^W Where Is    ^K Cut Text    ^J Justify     ^C Cur Pos     M-U Undo       M-A Mark Text   M-] To Bracket
^X Exit        ^R Read File   ^\ Replace     ^U Uncut Text  ^T To Spell    ^_ Go To Line  M-E Redo       M-6 Copy Text   M-W WhereIs Next
```

Run geogrid as by the command ./geogrid.exe

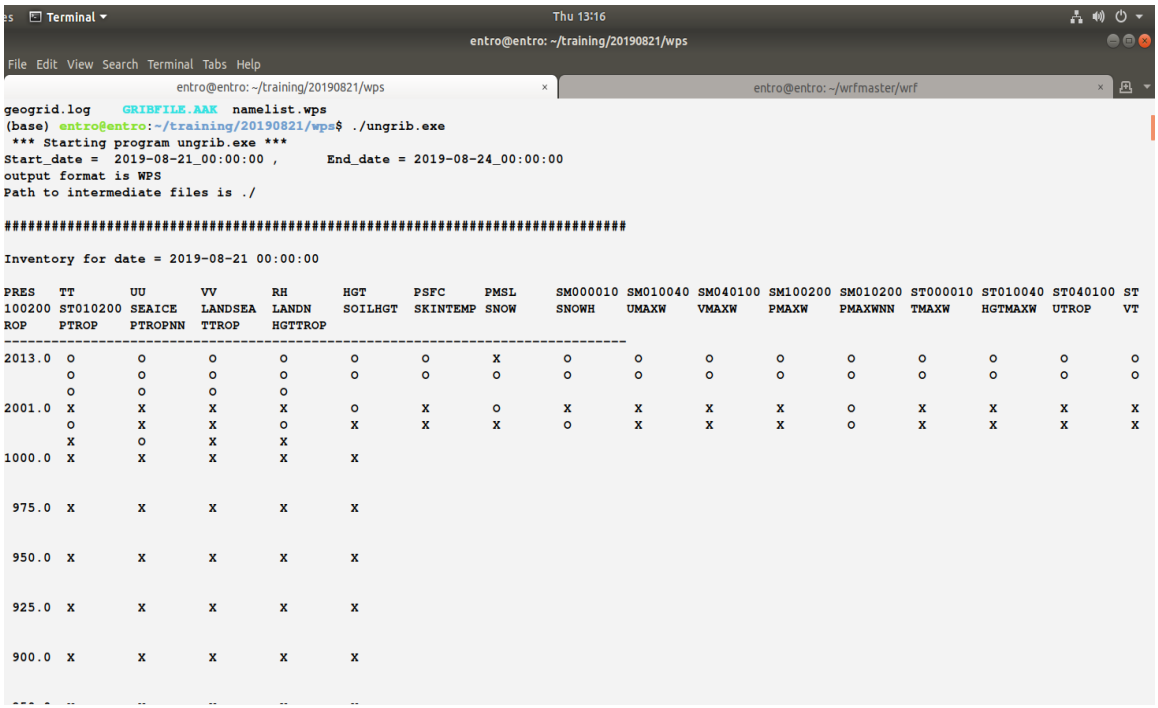
cdo vardes geo_em.d01.nc

This will provide with a list of variables

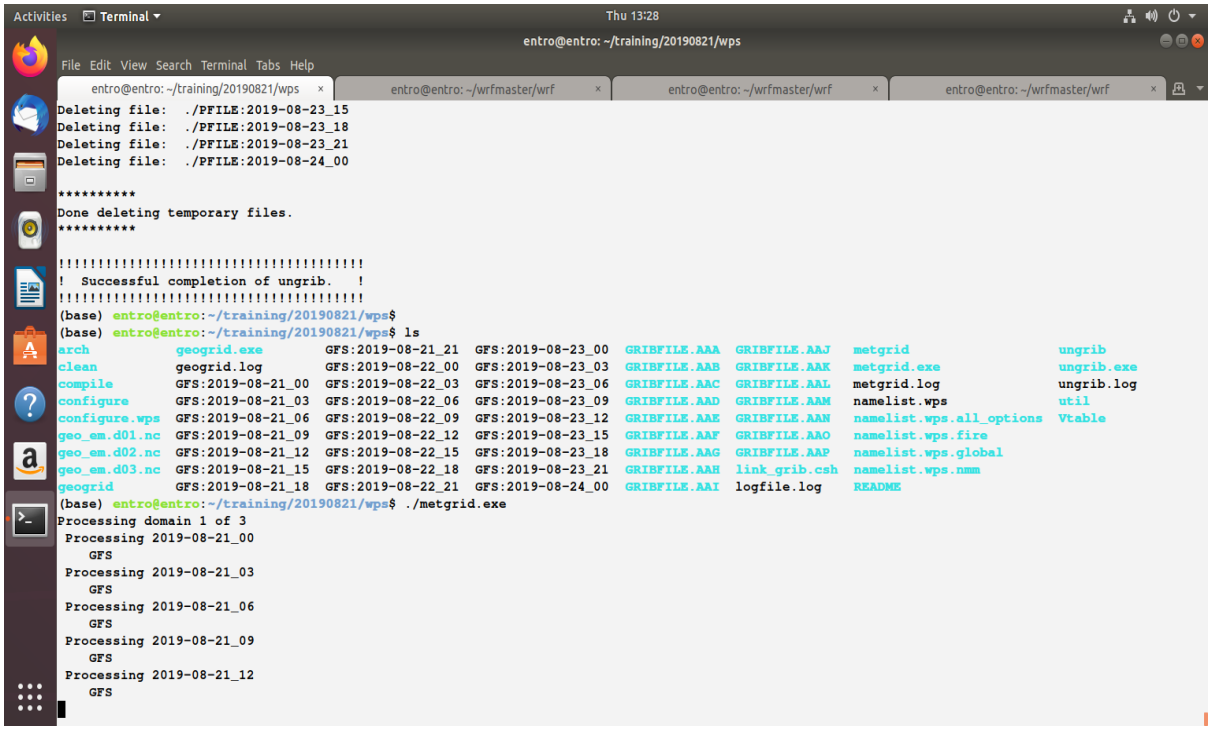
./link_grib.csh ../gfs/*

List the content of WPS and the linked files are given names starting with GRIBFILLE.???

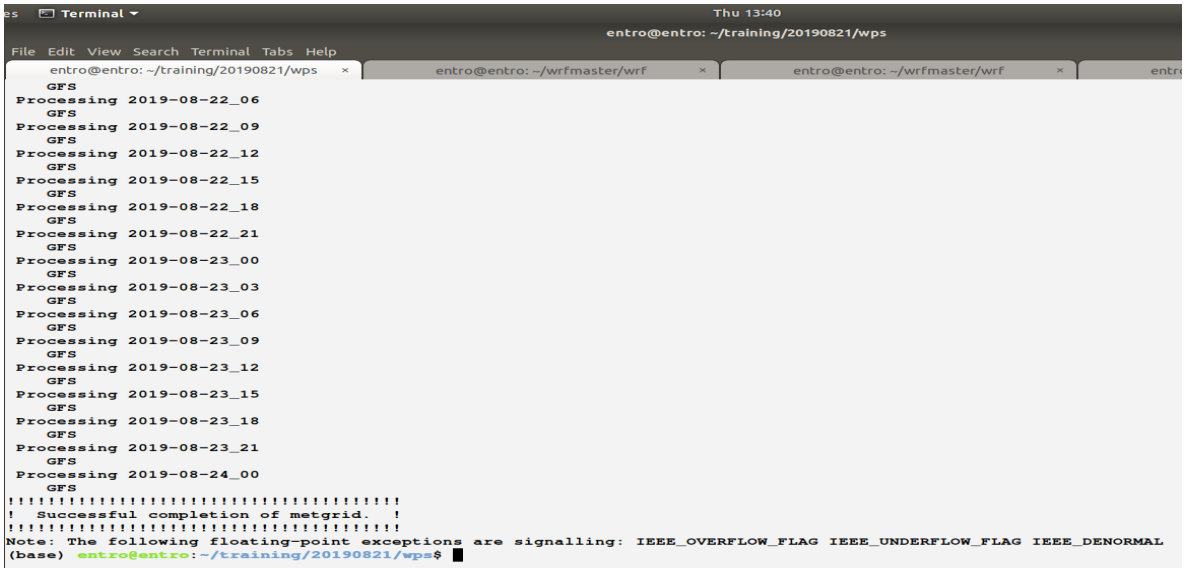

Run ungrib with ./ungrib.exe



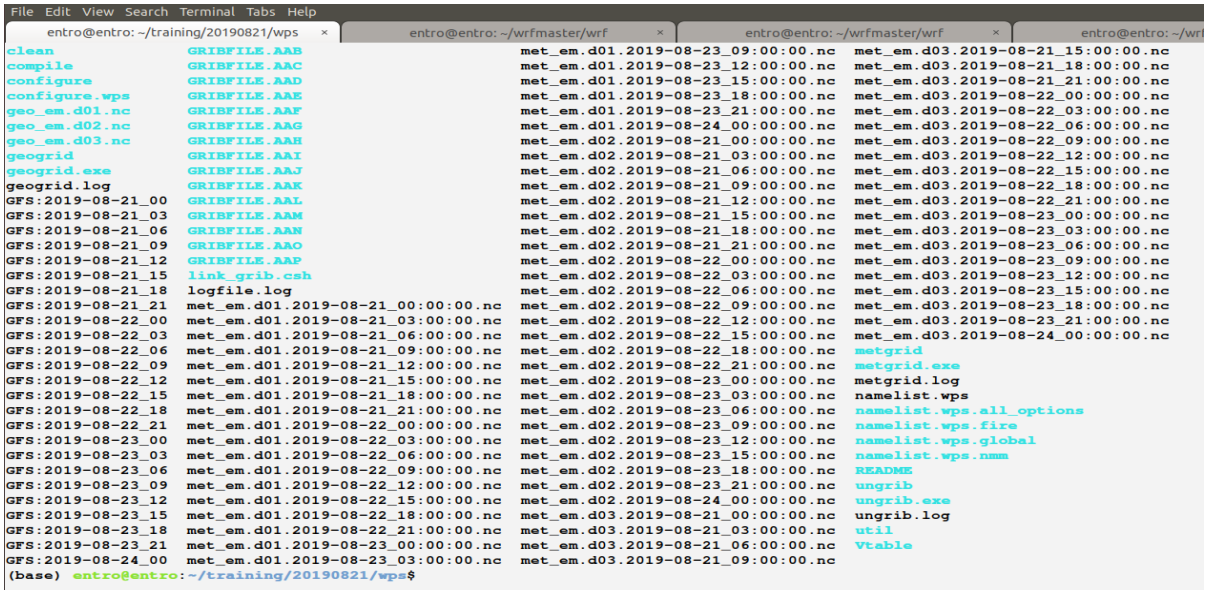

Once ungrib is done, it will produce files by the naming format GFS:YYYY-MM-DD_HH for the next step is to run metgrid by the command ./metgrid.exe




The metgrid interpolates, the wrf input data into the domain.




Successful execution prints the output above and will produce files by the domains with the names met_em.d01*.



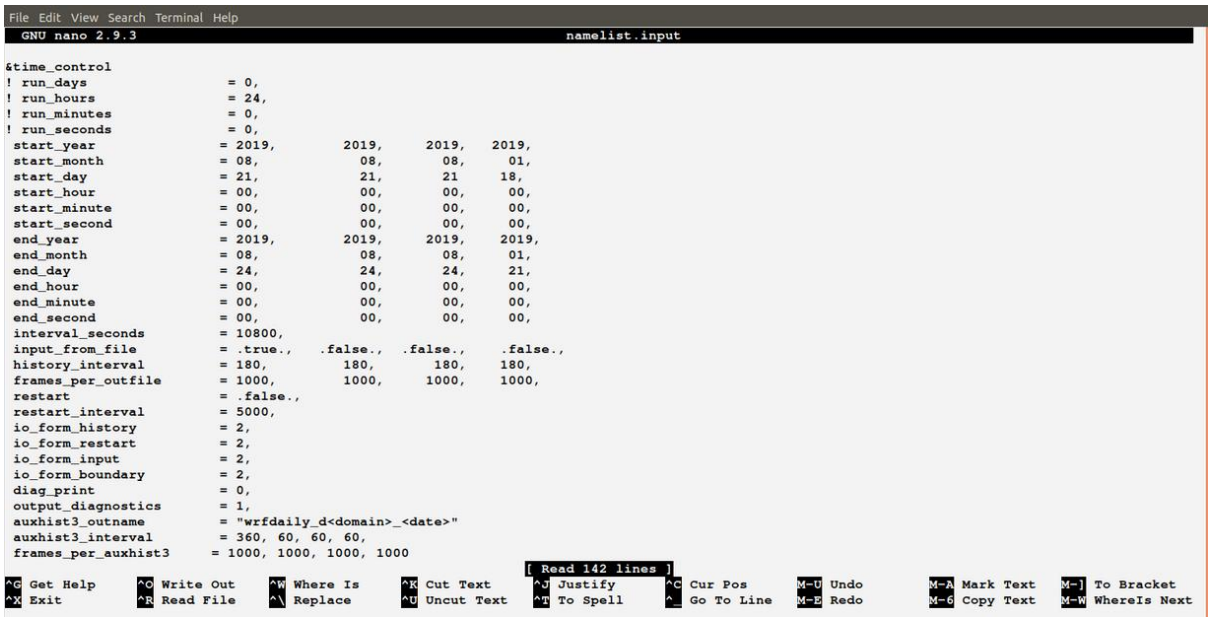

The metgrid outputs, which holds the right meteorological data for WRF input are named from the start to end of the forecast. This should also conform in the namelist.input

The next step is to navigate into the wrf the directory

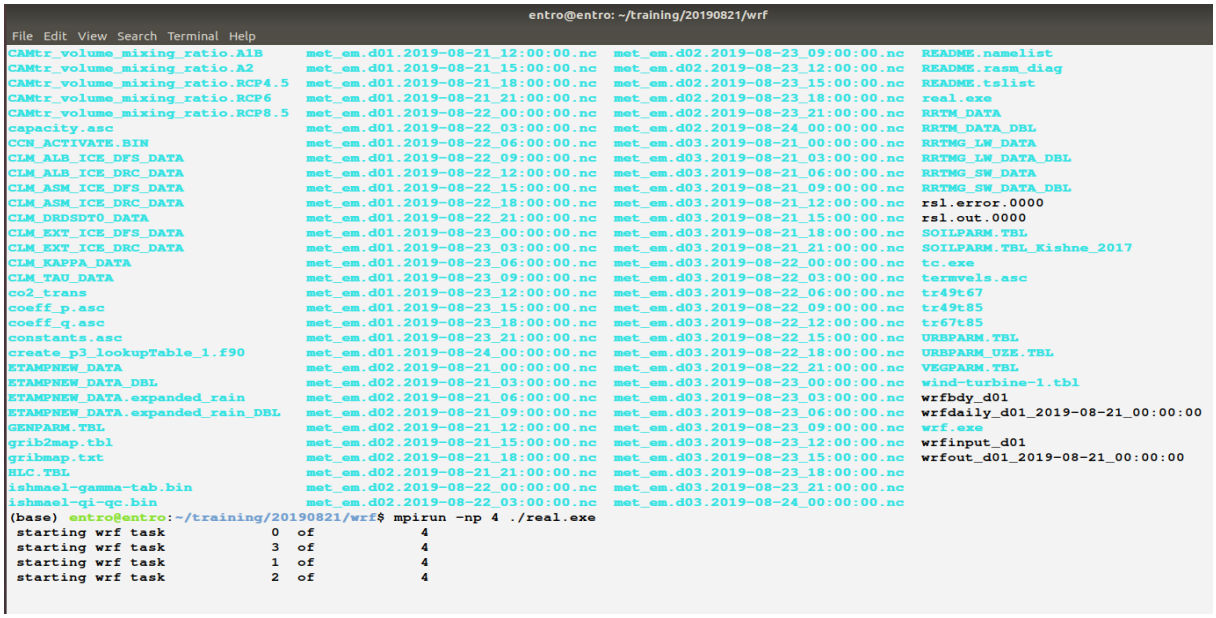
```
cd ../wrf
```

Link the products of metgrid in wps to wrf as follows

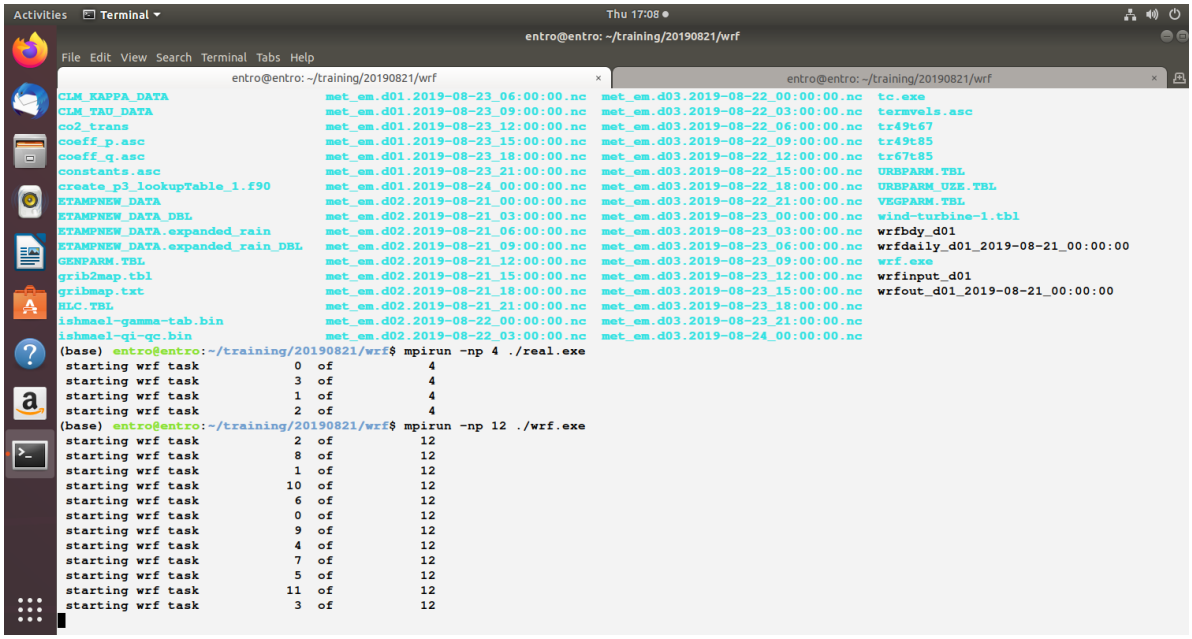
```
ln -s ../wps/met_em.d0* .
```




Execute real.exe by the command `mpirun -np 4 ./real.exe` as shown below.

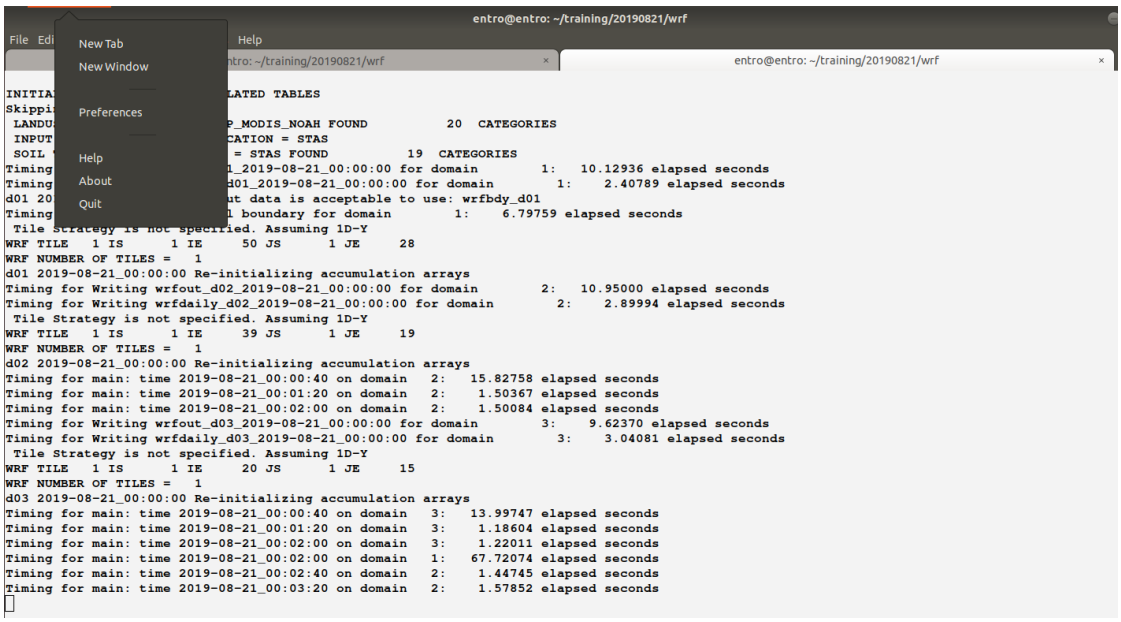



Execute wrf.exe by the command mpirun -np 12 ./wrf.exe as shown below. This implies run wrf in parallel using 12 processors




Open another terminal to monitor the progress to the WRF using the command

tail -f rsl.out.0000 and sample output is below




After say 2-3 hours, WRF run will be complete. The rainfall forecasts will be contained in files named wrfdaily_d0* for the respective domains.

Successful completion prints the message

SUCCESS COMPLETE WRF

The next steps involve plotting daily WRF rainfall data.

This is achieved by using the script *6EN_WRF_Precip_plot.ncl which is provided in the* available in the */home/entro/training/20190821/plots/* directory

The user is only used to edit the following sections:-

**Data & Plot directory**

```
10
11    DATADir    = "/home/entro/training/20190821/wrf/"
12    plts       = "/home/entro/training/20190821/plots/"
```

**Plot domain, type of plot and shapefiles to use**

```
27  ; Set the domain
28    latS = 2.000
29    latN = 23.00
30    lonW = 21.40
31    lonE = 48.00
32
33  ; We generate plots, but what kind do we prefer?
34   type = "x11"
35  ; type = "pdf"
36    type = "png"
37  ; type = "eps"
38
39  ; shape files
40    dirSHP       = "/home/entro/shapefiles/"
41    f1   = "SouthSudan.shp"
42    rv   = "nile_river_6ca.shp"
```

**Plot colors and levels**

```
164
165    wetlevels    = (/0.1,1,2,5,10,15,20,25,30,50/) ; "mm/day"
166    wetcolors = (/"gray98"    \
167              ,"PaleTurquoise","PaleGreen","SeaGreen3" ,"Yellow"  \
168              ,"Orange","HotPink","Red","Violet", "Purple", "Brown"/)
```

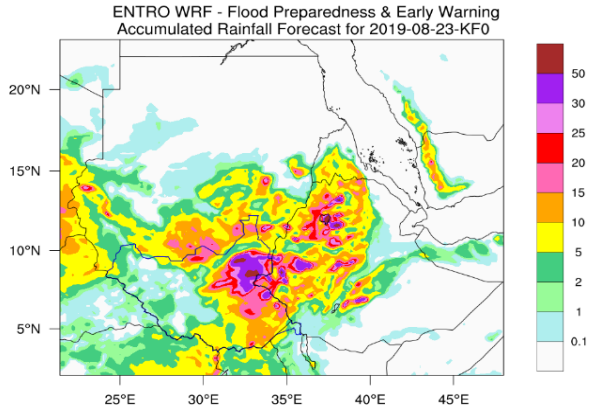
**WRF rainfall & largesclae rainfall**

```
90    ; Get non-convective, convective and total precipitation
91  ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
92    rain_exp = wrf_user_getvar(a,"RAINNCVMEAN",-1)
93    rain_con = wrf_user_getvar(a,"RAINCVMEAN",-1)
94    rain_tot = rain_exp + rain_con
95
```

It is important to note that to get total rainfall, once has to sum the convective and non-convective rainfall as shown above.

Once edited, the script is ready for use to plot WRF rainfall data

The script is executed from the terminal using the command ncl *6EN_WRF_Precip_plot.ncl* *to generate sample plots similar to the plot shown below*




**Activity III: Assessment of WRF forecast bias**

From the operational forecast directory /home/entro/forecasts/YYYYMMDD we take a case of 20200411.

The extracted WRF forecasted rainfall for the Eastern Nile is located at /home/entro/forecasts/YYYYMMDD/post bearing the name wrf-ppt_202004-11_EN.nc being the forecast for the next three days.

a) Download CHIRPS data so the forecast period.

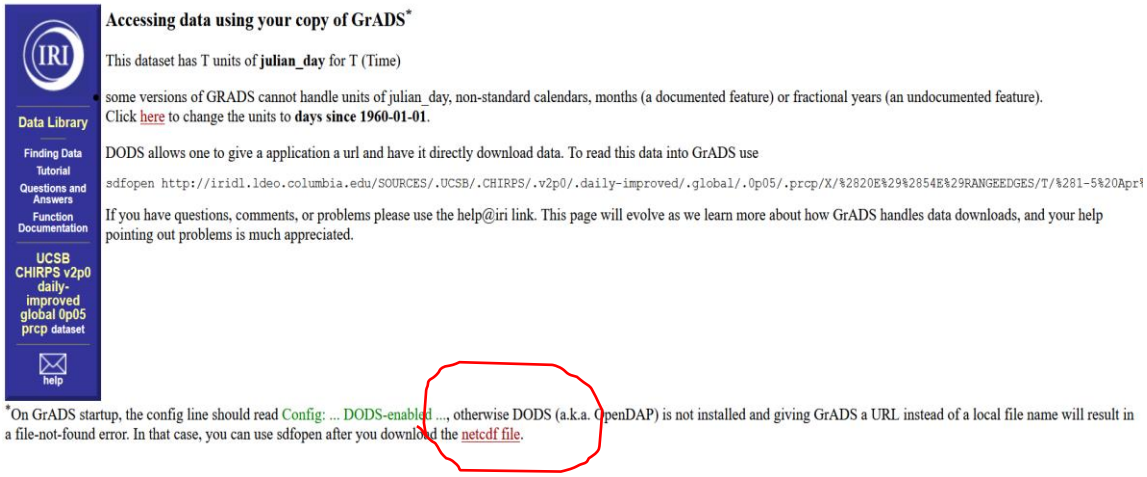
We need to download CHIRPS rainfall data for the same period as the forecast.

To achieve this, paste the link below in your browser (paste and go!)

https://iridl.ldeo.columbia.edu/SOURCES/.UCSB/.CHIRPS/.v2p0/.daily-improved/.global/.0p05/.prcp/X/%2820E%29%2852E%29RANGEEDGES/T/%28**11-13**%20**Apr**%202020%29VALUES/Y/%2826N%29%284N%29RANGEEDGES/downloadsGrADS.html

NB: Modify the highlighted sections (**in Bold**) to match your forecast period (i.e. the dates 11-13 and month, Apr.

Select netcdf file to download the rainfall data




Rename the file from data.nc to chirpsYYYYMMDDs-DDe.nc e.g. chirps202004-11_13.nc for rainfall for the period 11-13 of April 2020.

b) Confirm the WRF grids to the CHIRPS

The WRF is at 6km while the CHIRPS is at 5km. A uniform grid is necessary for comparative analysis. Re-griding the WRF data to the CHIRPS grid is done as follows: -

The CHIRPS grids are contained in the file named chirpsgrid.txt

Using the chirpsgrid.txt, we remap the WRF grids as shown below; -

cdo remapbil,chirpsgrids.txt wrf-ppt_20200411-13_EN.nc wrf-ppt_20200411-13_ENrgd.nc

Both wrf-ppt_20200411-13_ENrgd.nc and chirps20200411-13.nc should available at /home/entro/forecasts/YYYYMMDD/post

At this point, your data is ready for Bias Analysis

c) Compute & Plot the Bias Map using NCL

We shall compute the Mean Bias i.e. (Forecast Ave. – Obs Ave) to get the bias in mm of rainfall per day.

A script by name WRFPrecipBias.ncl is prepared for you. However, the following sections need to be modified to match the data utilized/user preference

The user is required to set the domain as defined in latS=, latN=, lonW= and lonE= in the previous section and the valid date, vdate = "2020-04-11-13"

```
vdate = "20200411-13"
type ="PNG"
imgDir  = "./"

; Define your domai, just as in wrf
latS           = 4.1
latN           = 24
lonW           = 21.4
lonE           = 42.0

levs   = ispan(-20,20,5)
colors = "NCV_blu_red"
```

In Summary the user is required to defined the above section

- valid dates – 20200411-13
- plot type – PNG
- plot location – "./" for current directory
- analysis domains – as defined by longitude-latitude extends
- plot levels – ispan(-20,20,5) indicates -20 to 20 at at an interval of 5
- color scheme to use – "NCV_blu_red". The use can choose other color schemes from the web link https://www.ncl.ucar.edu/Document/Graphics/color_table_gallery.shtml

**Activity III: For your consideration**

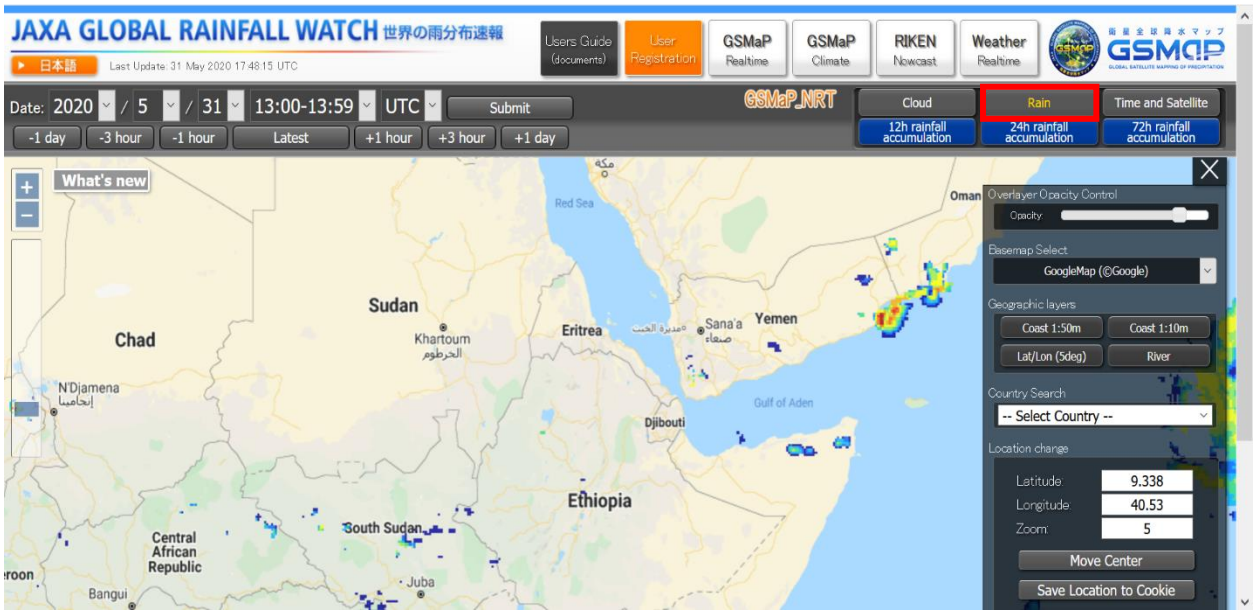
(i) Discuss the spatial distribution of the biases?

(ii) What are the minimum and maximum values of the biases score? What does this imply in forecasting?

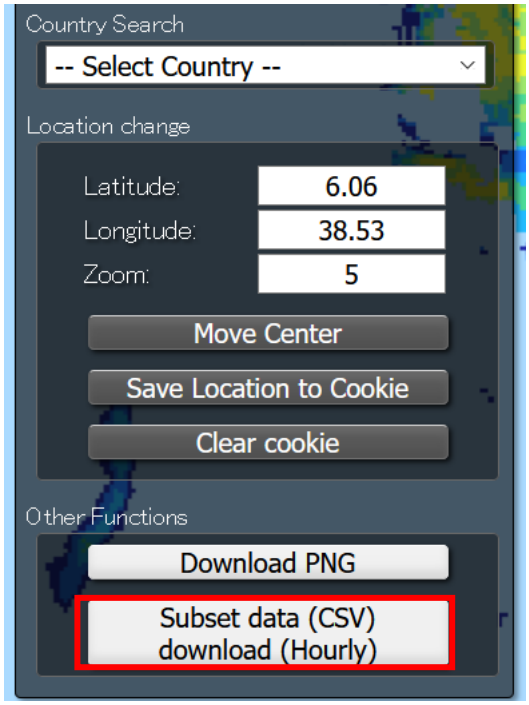
**Near-Real Time Satellite Rainfall data**

This example demonstrates how to utilize JAXA's GSMaP near-realtime satellite rainfall data from the webpage https://sharaku.eorc.jaxa.jp/GSMaP/index.htm

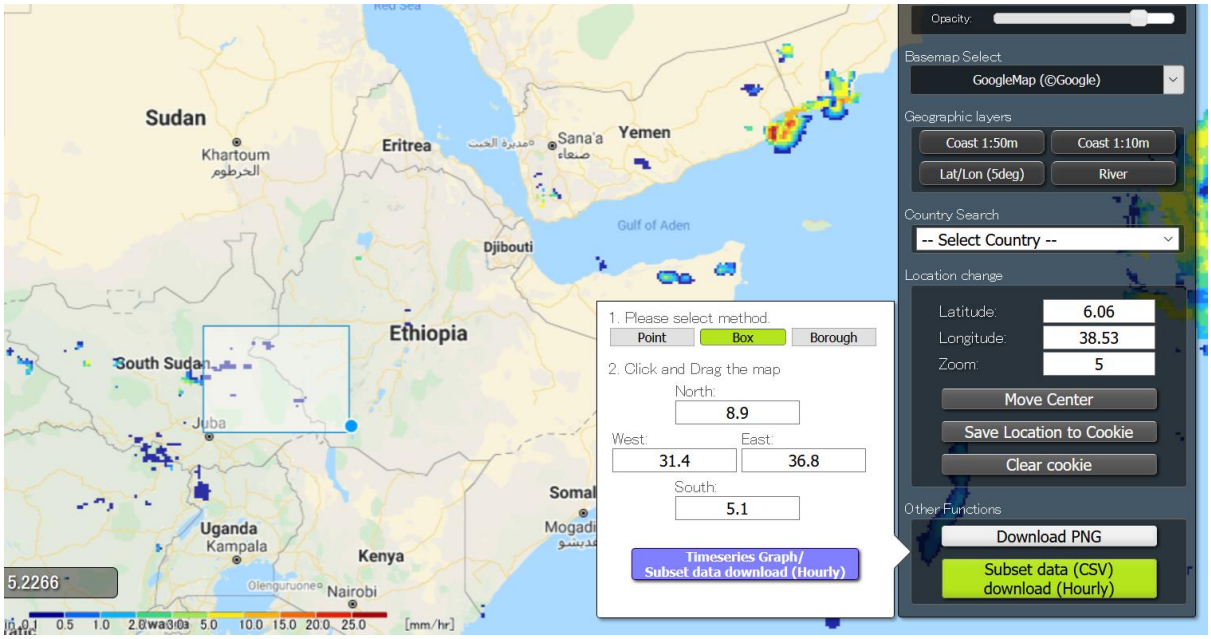
Zoom to the Eastern Nile region using the mouse and select the '**Rain**' tab as highlighted below.




From the tab on the right, scroll down to the Subset data (CSV) download (Hourly) section highlighted below

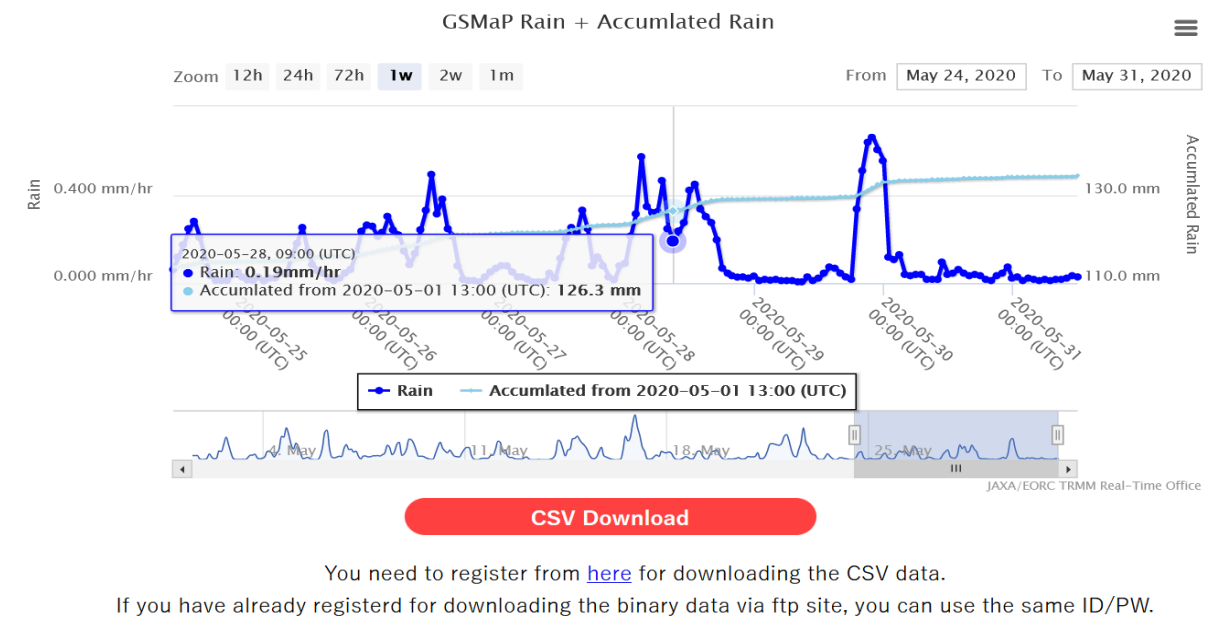



Thereafter, either set the latitude and longitude for a given location using the **point** option. In this example, we select the **Box** option. Subsequently, make a regional section on the map using the cursor and the domain extend will be indicated as below, for the BAS region.




Once the spatial selection is made, generate the **Timeseries Graph**

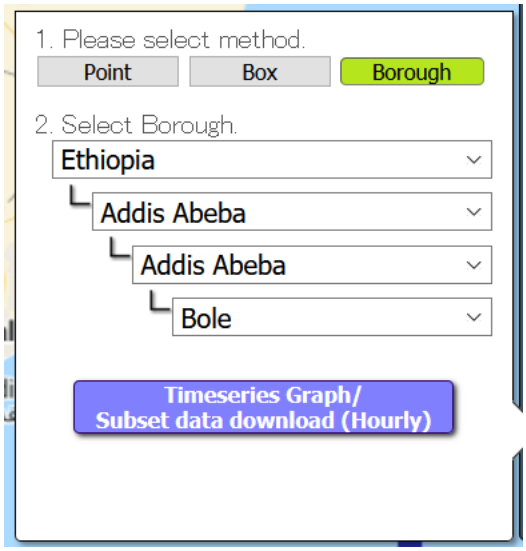
The averaged rainfall over the selected domain will be displayed such as the time series below. The plot can be adjusted from a range of **12hour** to **1month** since the current date.




You need to register from here for downloading the CSV data.
If you have already registerd for downloading the binary data via ftp site, you can use the same ID/PW.

For registered users, one can download the timeseries data in CSV format by using the **CSV Download** option.

**Work Further:** Generate a similar timeseries using Country and sub-country regions as an example given below by using the **Borough** option.




END OF THE EXERCISE!

Questions/Feedback?