Introduction to GrADS

First International Training Workshop
WMO RCC-Washington

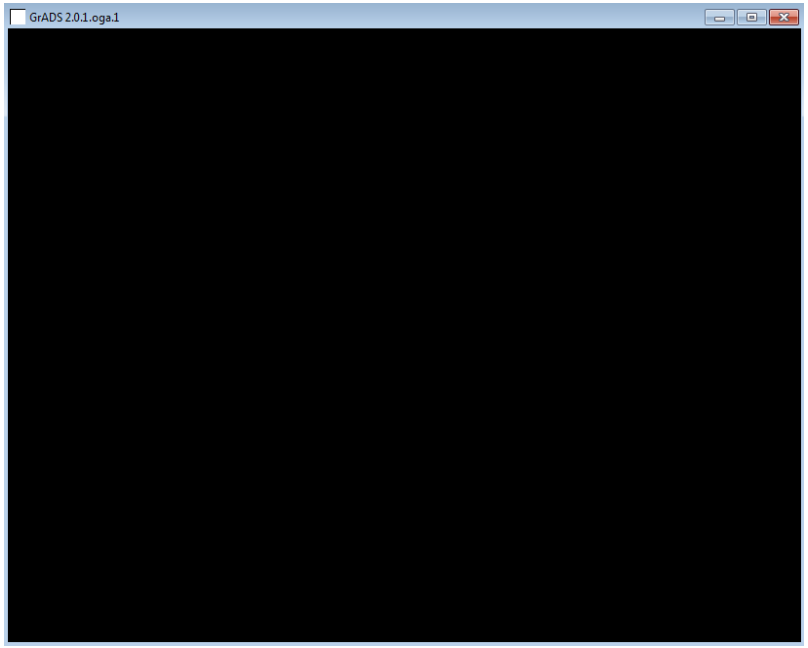
NOAA's CPC International Desks

Washington, USA, 30 September – 4 October 2019

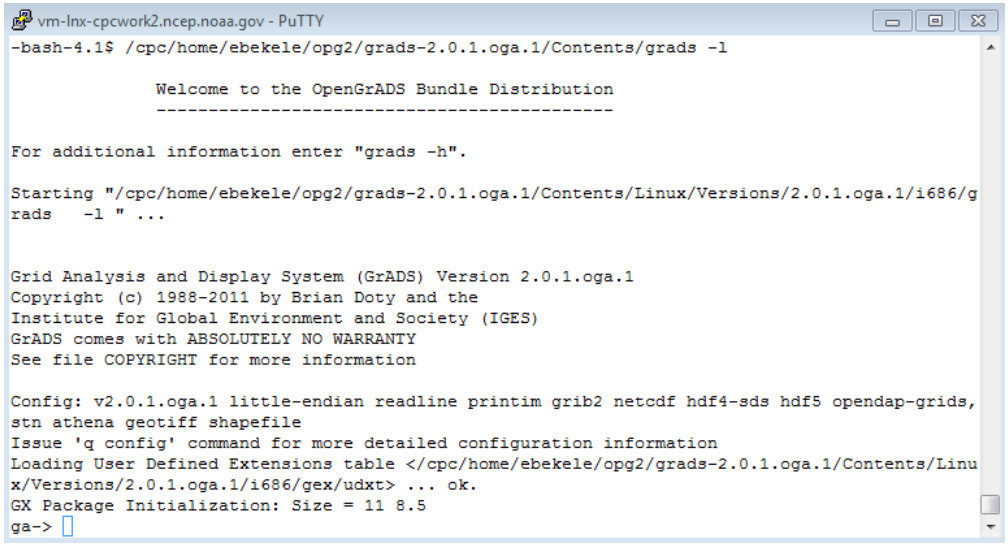
GrADS

Grid **A**nalysis and **D**isplay **S**ystem – **GrADS**

- GrADS is an interactive software to manipulate and visualize geophysical data.



Graphic window



Command window (console or terminal)

GrADS

- GrADS works with data sets in different formats, including binary (.dat), GRIB (.grib), NetCDF (.nc), etc.

- It works with 2 main files:
  - data file (example: ***name_file.dat***)
  - descriptor file (example: ***name_file.ctl***)

Download directory

1. Download the directory ***introduction_grads.zip*** from the NOAA's CPC ftp server

```
wget --no-check-certificate
https://ftp.cpc.ncep.noaa.gov/International/usrcc/training/2019/day3/
introduction_grads.zip
```

2. List files/directories

```
ls
```

3. Unzip the directory ***introduction_grads***

```
unzip introduction_grads.zip -d introduction_grads
```

4. List files/directories

```
ls
```

5. Go to the directory ***introduction_grads***

```
cd introduction_grads
```

6. List files/directories

```
ls
```

Descriptor file: cmorph.ctl

Descriptor files ***(.ctl)*** are text-type files, in which all specifications of the dimension of data file are described.

Open the descriptor file ***cmorph.ctl*** (add `&` enables to open `gedit` in background and allow you to continue to use the terminal at the same time)

Linux: `gedit cmorph.ctl &`
Cygwin: `npp cmorph.ctl &`

```
dset ^cmorph.dat
title  Sample of CMORPH Daily Precipitation
undef  -999.0
xdef 1440 linear 0.125 0.25
ydef 480 linear -59.875 0.25
zdef 1 levels 1
tdef 61 linear 01Sep2017 1dy
vars 1
precip 1 99 CMORPH Daily Precipitation [mm]
endvars
```

binary data file

cover the world
with a spatial resolution of 0.25° x 0.25°

daily data
from 01 September to 31 October 2017

1 variable

Exercise 1

Open the descriptor file in GrADS

1. Open GrADS

```
grads -l
```

2. Open the file ***cmorph.ctl***

open cmorph.ctl

```
ga-> open cmorph.ctl
Scanning description file:  cmorph.ctl
Data file cmorph.dat is open as file 1
LON set to 0 360
LAT set to -59.875 59.875
LEV set to 1 1
Time values set: 2017:9:1:0 2017:9:1:0
E set to 1 1
```

Exercise 1

Query information about the current file

3. Get information about the file

query file or q file

```
ga-> query file
File 1 : Sample of CMORPH Daily Precipitation
  Descriptor: cmorph.ctl
  Binary: cmorph.dat
  Type = Gridded
  Xsize = 1440  Ysize = 480  Zsize = 1  Tsize = 61  Esize = 1
  Number of Variables = 1
     precip  1  99  CMORPH Daily Precipitation [mm]
```

4. Get more information about the file

query ctlinfo or q ctlinfo

```
ga-> query ctlinfo
dset cmorph.dat
title Sample of CMORPH Daily Precipitation
undef -999
xdef 1440 linear 0.125 0.25
ydef 480 linear -59.875 0.25
zdef 1 linear 1 1
tdef 61 linear 00Z01SEP2017 1440mn
vars 1
precip  1  99  CMORPH Daily Precipitation [mm]
endvars
```

Exercise 1

Change the time

5. Set the first time step

set t 1

6. Set the second time step

set t 2

7. Set the latest time step

set t last

8. Set time 11 October 2017

set time 11Oct2017

9. Set time 11 October 2017

set t 41

2 ways to set the time

```
set time daymonthyear
set t number
```

Exercise 1

Display a variable

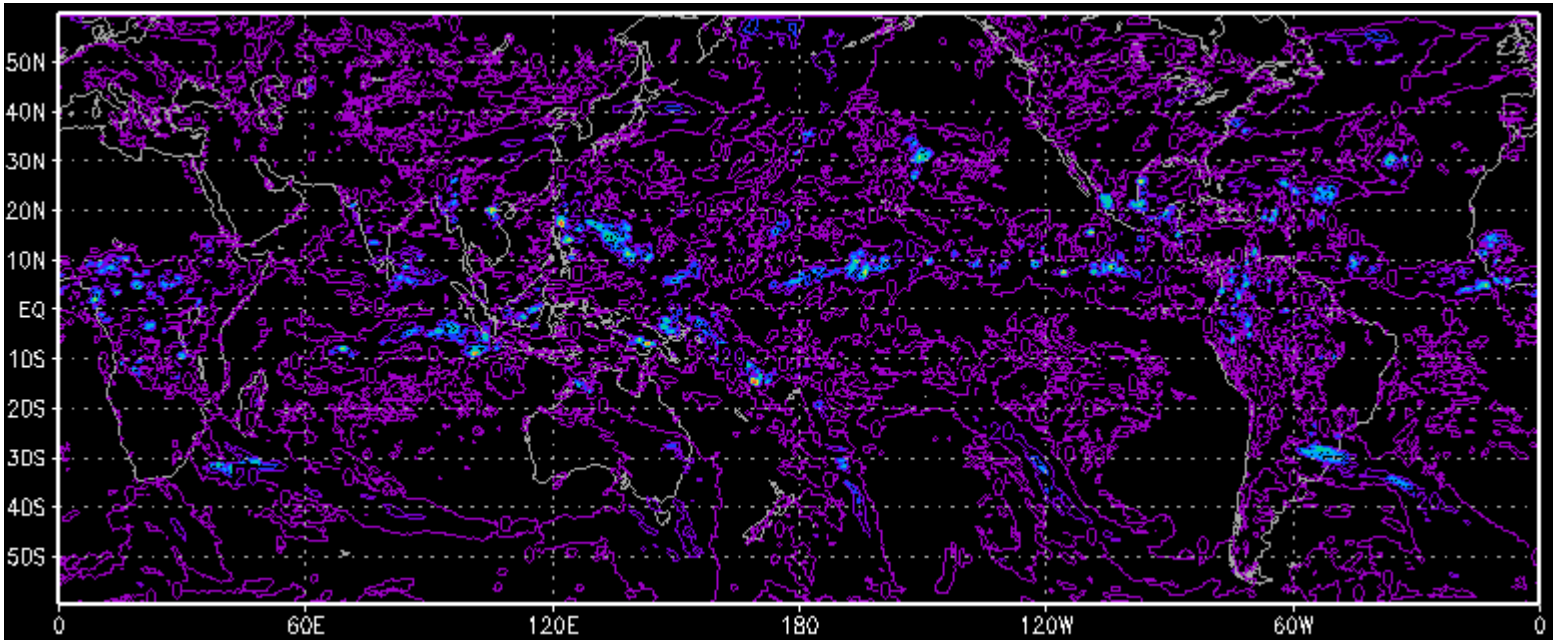
10. Display precipitation field

display precip or d precip

What day corresponds the precipitation fields?

→ 11 October 2017

`set time` stays until changed



Exercise 1

Change the time

11. Set time 12 September 2017
set time 12Sep2017

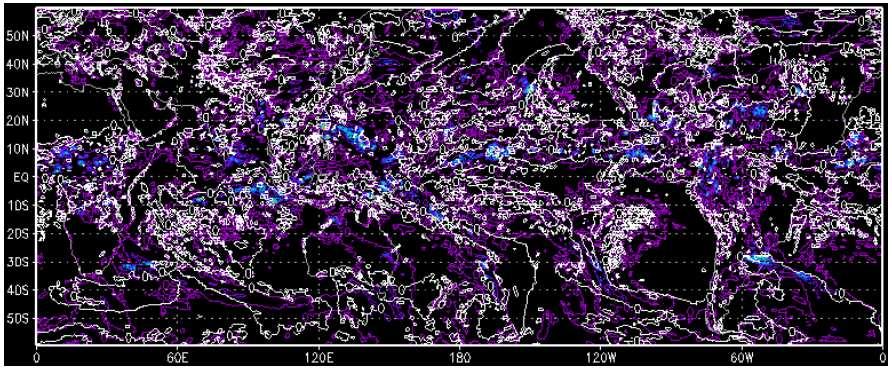
12. Display precipitation
d precip

The precipitation fields are overlapped!

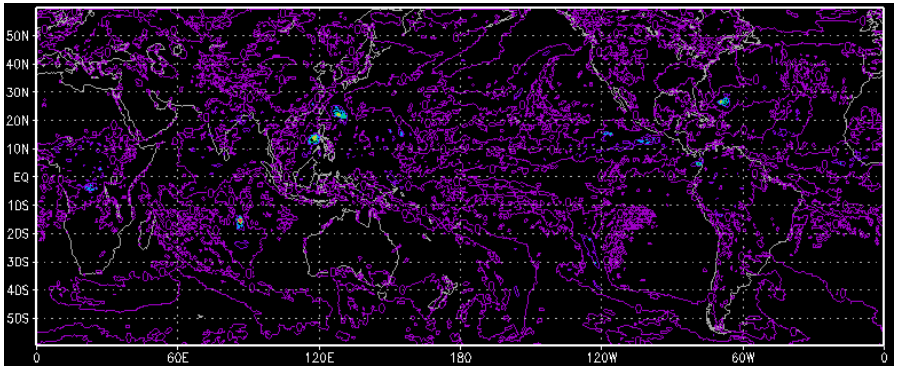
13. Delete the plot
clear or c

14. Display precipitation
d precip

Precipitation of 11 October 2017 (purple contours) and 12 September 2017 (white contours)



Precipitation of 12 September 2017



Exercise 1

Remove black background

15. Remove the black background

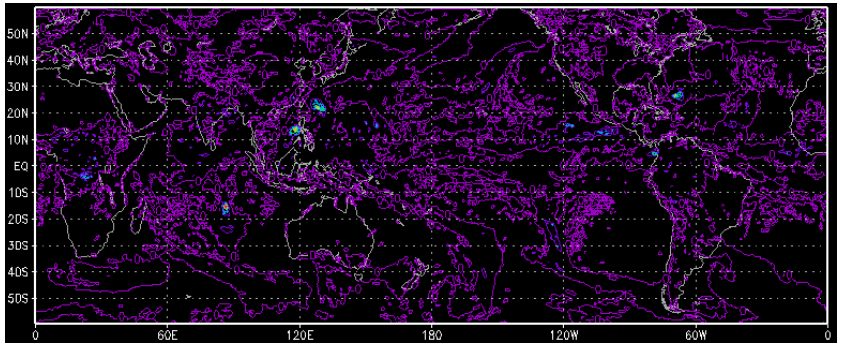
set display color white

c

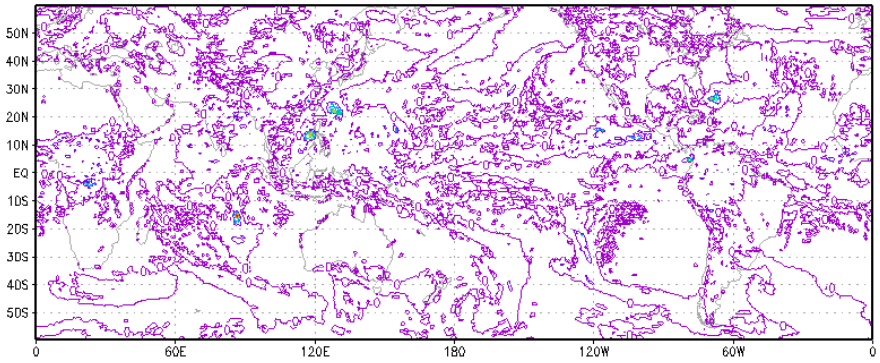
16. Display precipitation

d precip

Precipitation of 12 September 2017



Precipitation of 12 September 2017



Exercise 1

Make an animation

17. Delete plot

clear or c

18. Set time from 01 September 2017 to 15 September 2017

set time 01Sep2017 15Sep2017

19. Display precipitation

d precip

Exercise 1

Display variable at a given grid point

20. Delete plot

clear or c

21. Set time 13 October 2017

set time 13Oct2017

22. Set the latitude at 19.375°N

set lat 19.375

23. Set the longitude at 99.125°W

set lon -99.125

24. Display precipitation

d precip

You should get one value.

```
ga-> set time 13Oct2017
Time values set: 2017:10:13:0 2017:10:13:0
ga-> set lat 19.375
LAT set to 19.375 19.375
ga-> set lon -99.125
LON set to -99.125 -99.125
ga-> d precip
Result value = 0.288889
```

Exercise 1

Display variable for a spatial domain

25. Delete the plot

clear or c

26. Set time 21 September 2017

set time 21Sep2017

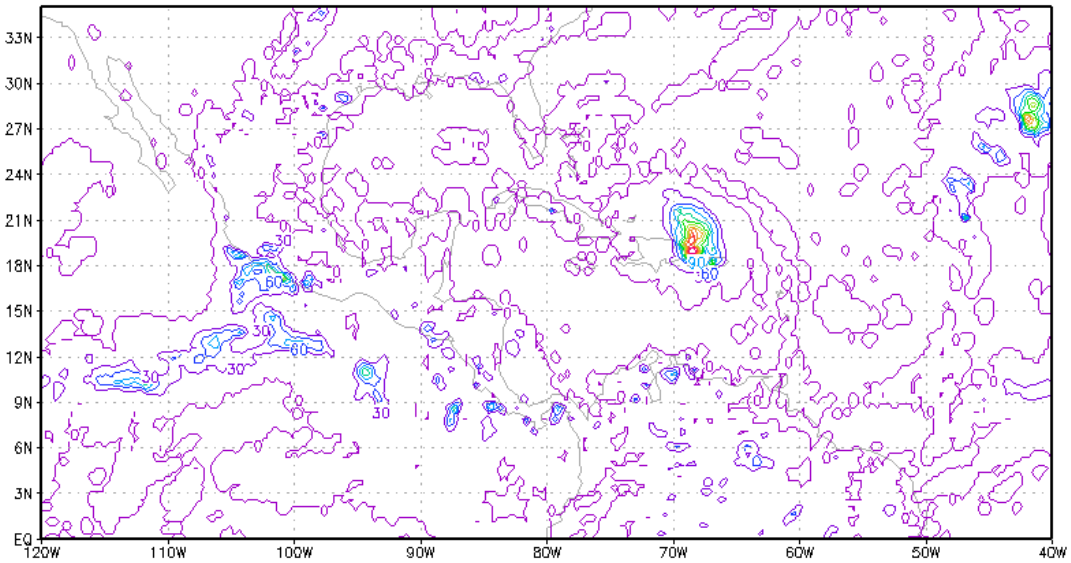
27. Change the latitude and longitude

set lat 0 35

set lon -120 -40

28. Display precipitation

d precip



Exercise 1

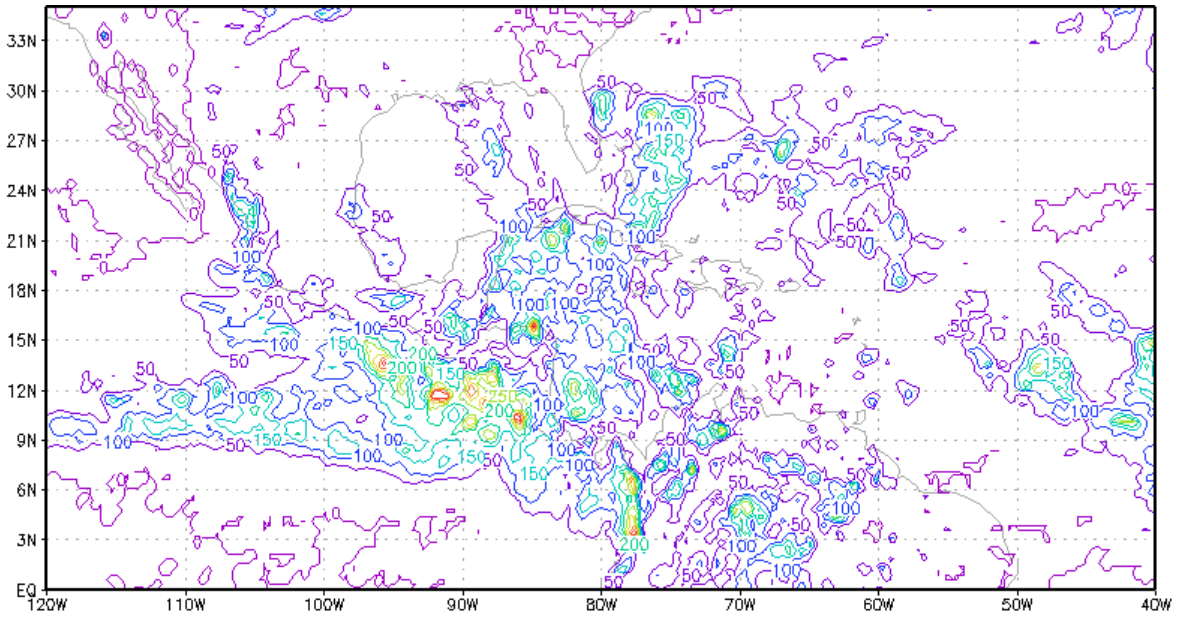
Function *sum*

29. Delete the plot

clear or c

30. Plot the 7-day accumulated precipitation between 1 October 2017 and 7 October 2017

d sum(precip, time = 01Oct2017, time = 07Oct2017)



Exercise 1

Option *minimum values*

31. Delete the plot

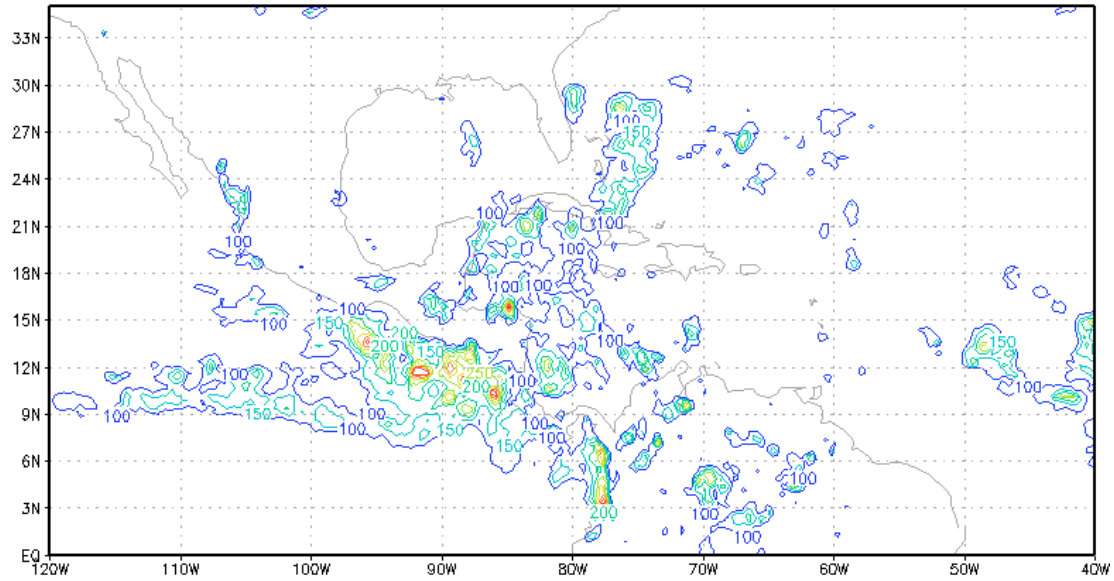
clear or c

32. Display 7-day accumulated precipitation above 75 mm between 1 October 2017 and 7 October 2017

set cmin 75

d sum(precip, time = 01Oct2017, time = 07Oct2017)

`cmin` option stay until `clear` command is issued



Exercise 1

Shaded areas

33. Delete the plot

clear or c

`cmin` option stay until `clear` command is issued

34. Set graphic type as shaded contour plot

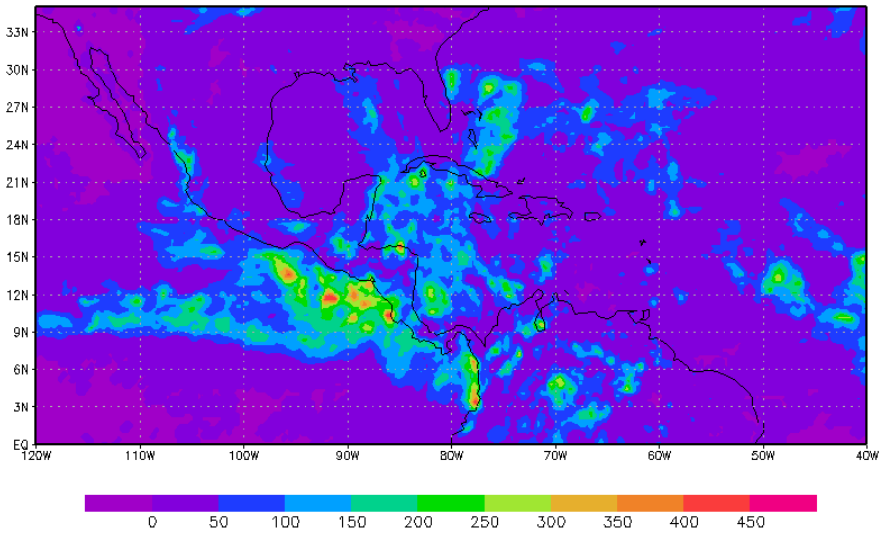
set gxout shaded

35. Display the 7-day accumulated precipitation between 1 October 2017 and 7 October 2017

d sum(precip, time = 01Oct2017, time = 07Oct2017)

36. Add the color bar

cbar



Exercise 1

Shaded areas

37. Delete the plot

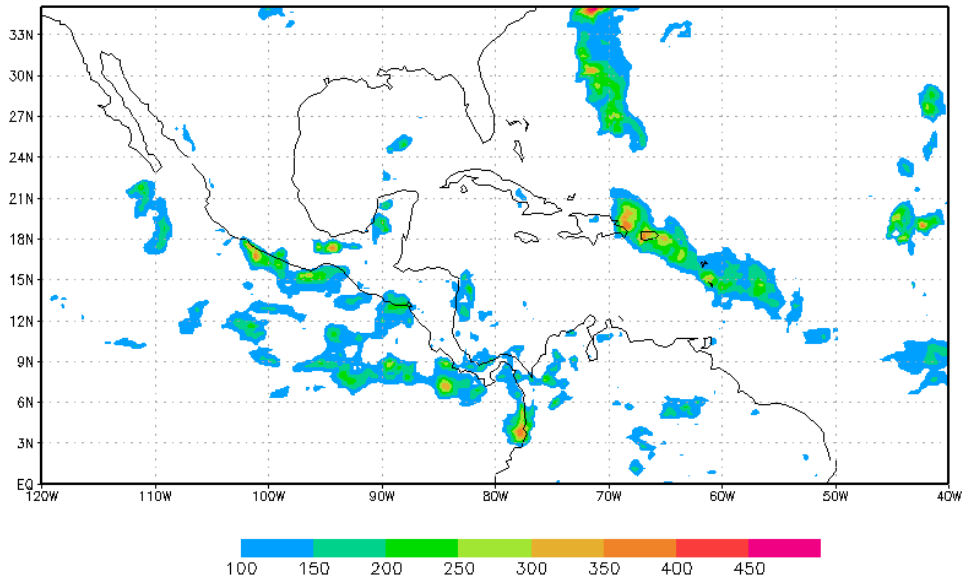
clear or c

38. **Plot the 7-day accumulated precipitation above 100 mm from 15 September to 21 September 2017.**

set cmin 100

d sum(precip, time = 15Sep2017, time = 21Sep2017)

cbar



Exercise 1

Add title and save map

39. Add a title

draw title 7-day accumulated precipitation 15-21 Sep. 2017

40. Save your map as .png

printim 7day_precip_sep2017.png

41. Close the file

close 1

42. Exit GrADS

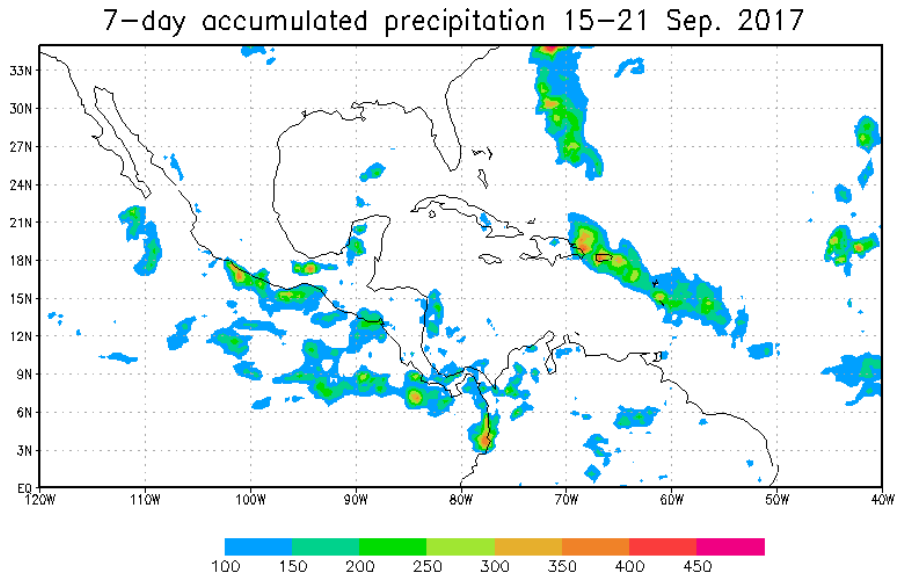
quit

43. List files/directories

```
ls
```

44. Check your plot

```
display 7day_precip_sep2017.png
```



Summary – Basic GrADS commands

- `open` command opens a file (.dat) in GrADS.

- `query` or `q` command allows the user to get information about the current GrADS session.
  example: `q file` or `q ctlinfo`

- `set` command specifies *when*, *where* and *how* options.
  example: *when* – `set time 14Oct2018`
  where – `set lat 20`
  how – `set gxout shaded`

- `display` or `d` command enables to display a variable graphically.

- `clear` or `c` command clears the graphic window.

- `quit` command enables to exit GrADS session.

Descriptor file: reanalysis.ctl

Open the descriptor file ***reanalysis.ctl***

Linux: `gedit reanalysis.ctl &`
Cygwin: `npp reanalysis.ctl &`

```
dset ^reanalysis.dat
title Sample of NCEP Reanalysis Data
undef 9.999E+20
xdef 161 linear -120 0.5
ydef 71 linear 0 0.5
tdef 32 linear 00Z15Sep2017 6hr
zdef 10 levels 1000 925 850 700 600 500 400 300 250 200
vars 4
TMP2m 0 99 2m above ground Temperature [K]
HGTprs 10 99 Geopotential Height [gpm]
UGRDprs 10 99 U-Component of Wind [m/s]
VGRDprs 10 99 V-Component of Wind [m/s]
endvars
```

cover the spatial from (0 – 35°N; 120°W – 40°W)
with a spatial resolution of 0.5° x 0.5°

Exercise 2

Open several files in GrADS

1. Open GrADS

```
grads -l
```

2. Open the file ***cmorph.ctl***

open cmorph.ctl

```
ga-> open cmorph.ctl
Scanning description file:  cmorph.ctl
Data file cmorph.dat is open as file 1
LON set to 0 360
LAT set to -59.875 59.875
LEV set to 1 1
Time values set: 2017:9:1:0 2017:9:1:0
E set to 1 1
ga-> open reanalysis.ctl
```

3. Open the file ***reanalysis.ctl***

open reanalysis.ctl

```
ga-> open reanalysis.ctl
Scanning description file:  reanalysis.ctl
Data file reanalysis.dat is open as file 2
```

Exercise 2

Query information about the files

4. Get more about the first file (***cmorph.ctl***) opened in GrADS

q ctlinfo 1

```
ga-> q ctlinfo 1
dset cmorph.dat
title Sample of CMORPH Daily Precipitation
undef -999
xdef 1440 linear 0.125 0.25
ydef 480 linear -59.875 0.25
zdef 1 linear 1 1
tdef 61 linear 00Z01SEP2017 1440mn
vars 1
precip  1  99  CMORPH Daily Precipitation [mm]
endvars
```

cmorph.ctl

- spatial domain: global
- spatial resolution: 0.25° x 0.25°
- temporal resolution: 1440 min = 1 day
- starting date: 01 September 2017 at 00Z

5. Get more about the second file (***reanalysis.ctl***) opened in GrADS

q ctlinfo 2

```
ga-> q ctlinfo 2
dset reanalysis.dat
title Sample of NCEP Reanalysis Data
undef 9.999e+20
xdef 161 linear -120 0.5
ydef 71 linear 0 0.5
zdef 10 levels 1000 925 850 700 600 500 400 300
 250 200
tdef 32 linear 00Z15SEP2017 360mn
vars 4
tmp2m  0  99  2m above ground Temperature [K]
hgtprs  10  99  Geopotential Height [gpm]
ugrdprs  10  99  U-Component of Wind [m/s]
vgrdprs  10  99  V-Component of Wind [m/s]
endvars
```

reanalysis.ctl

- spatial domain: 0 – 35°N; 120°W – 40°W
- spatial resolution: 0.5° x 0.5°
- temporal resolution: 360 min = 6 h
- starting date : 15 September 2017 at 00Z

Exercise 2

Change time

6. Set the first time step

set t 1

By default, GrADS refers to the first file (*cmorph.ctl*) opened in GrADS!

7. Refers to the second descriptor file ***reanalysis.ctl***

set dfile 2

8. Set the first time step

set t 1

9. Set the first time step

set t 2

10. Set the last time step

set t last

Exercise 2

Change spatial domain

11. Remove black background

```
set display color white
c
```

12. Refer to the first file ***cmorph.ctl***

```
set dfile 1
```

13. Define the following geographical domain

```
set lat 0 35
set lon -120 -40
```

Exercise 2

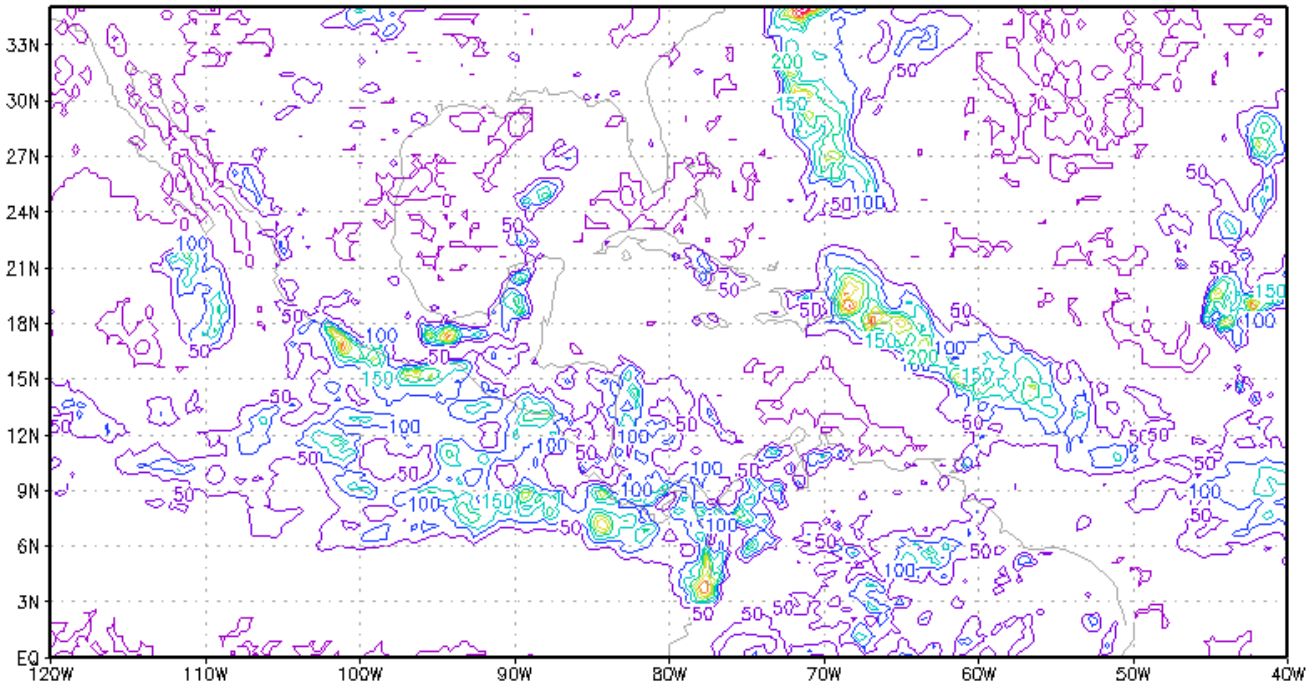
Define and display the variable ***rain***

14. Define a variable ***rain*** as the 7-day accumulated rainfall from 15 September to 21 September 2017 from the file ***cmorph.ctl***

```
define rain = sum(precip.1, time = 15Sep2017, time = 21Sep2017)
```

15. Display the variable ***rain***

```
d rain
```



Exercise 2

Shaded area

16. Delete the plot

c

17. Set graphic type as shaded contour plot

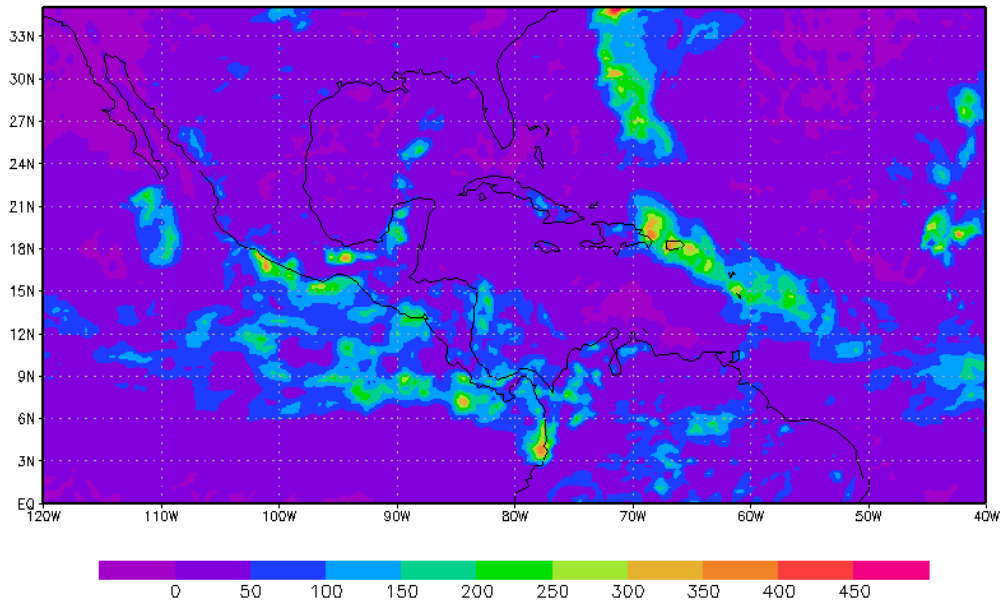
set gxout shaded

18. Display the variable ***rain***

d rain

19. Add the color bar

cbar



Exercise 2

Define variables of wind components at different levels

20. Delete the plot

```
c
```

21. Refer to the second file ***reanalysis.ctl***

```
set dfile 2
```

22. Set the level 850 hPa

```
set lev 850
```

23. Define a variable ***u850*** as the averaged zonal wind at 850 hPa

```
define u850 = ave(ugrdprs.2, time = 00Z15sep2017, time = 18Z21sep2017)
```

24. Define a variable ***v850*** as the averaged meridian wind at 850 hPa

```
define v850 = ave(vgrdprs.2, time = 00Z15sep2017, time = 18Z21sep2017)
```

25. Set the level 200 hPa

```
set lev 200
```

26. Define a variable ***u200*** as the averaged zonal wind at 200 hPa

```
define u200 = ave(ugrdprs.2, time = 00Z15sep2017, time = 18Z21sep2017)
```

27. Define a variable ***v200*** as the averaged meridian wind at 200 hPa

```
define v200 = ave(vgrdprs.2, time = 00Z15sep2017, time = 18Z21sep2017)
```

Exercise 2

Display wind as vector arrows

28. Display wind at 850 hPa as vector arrows

d u850;v850

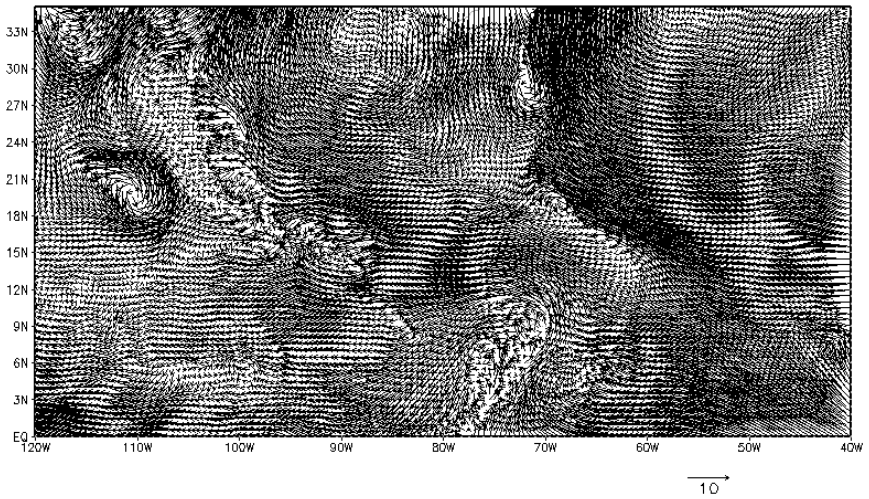
29. Delete the plot

c

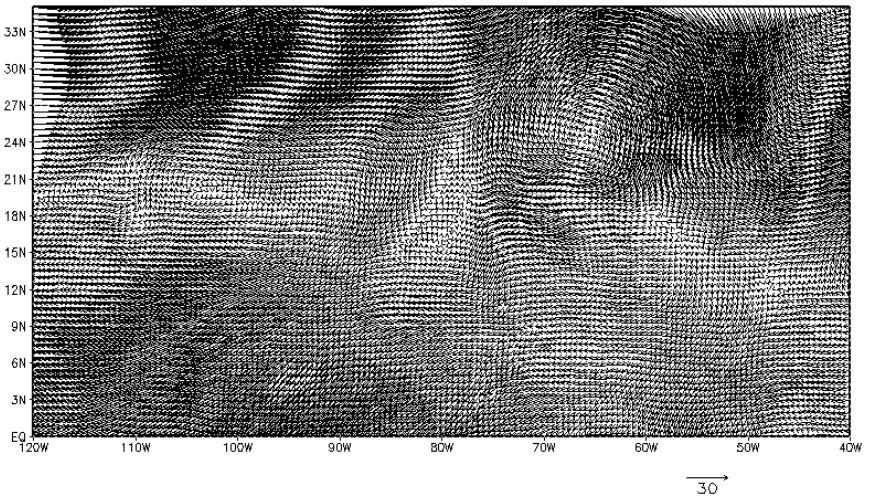
30. Display wind at 200 hPa as vector arrows

d u200;v200

850 hPa Wind



200 hPa Wind



Exercise 2

Display wind as vector arrows

31. Clear the plot

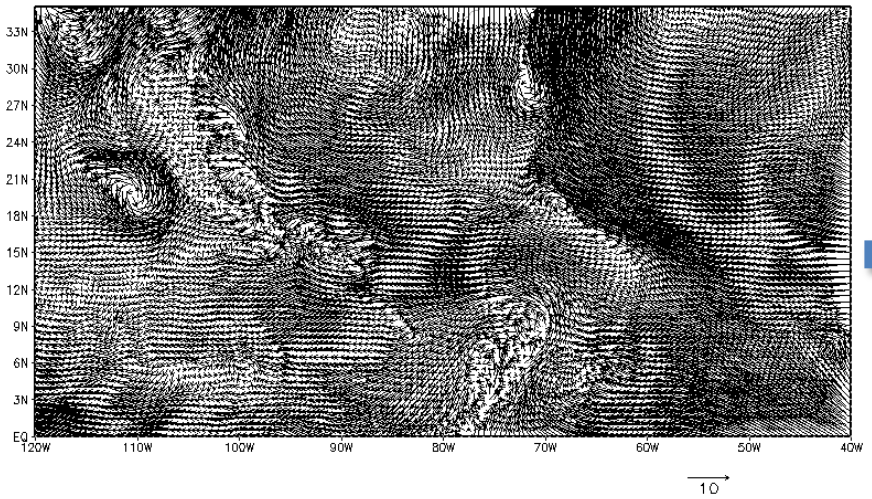
c

32. Display the wind at 850 hPa every 5th grid point in the longitude and every 4th grid point in the latitude

d skip(u850,5,4);v850

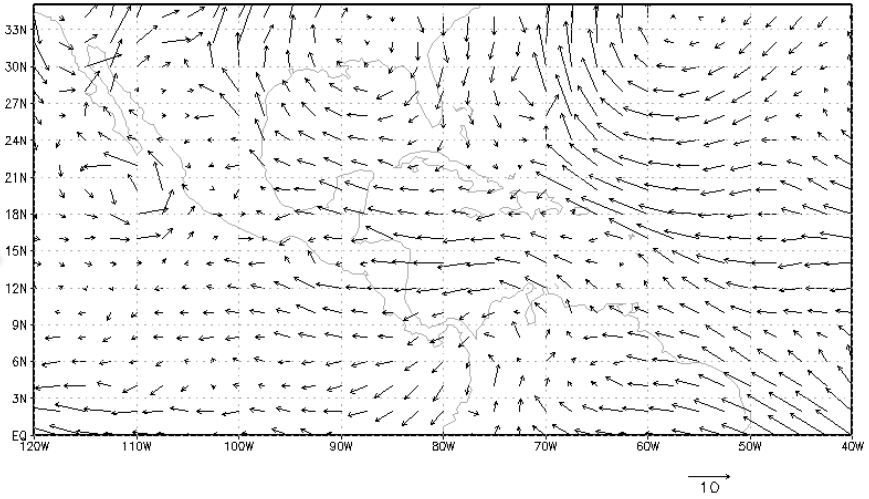
850 hPa Wind

d u850;v850



850 hPa Wind

d skip(u850,5,4);v850



Exercise 2

Display wind as barb

33. Clear the plot

c

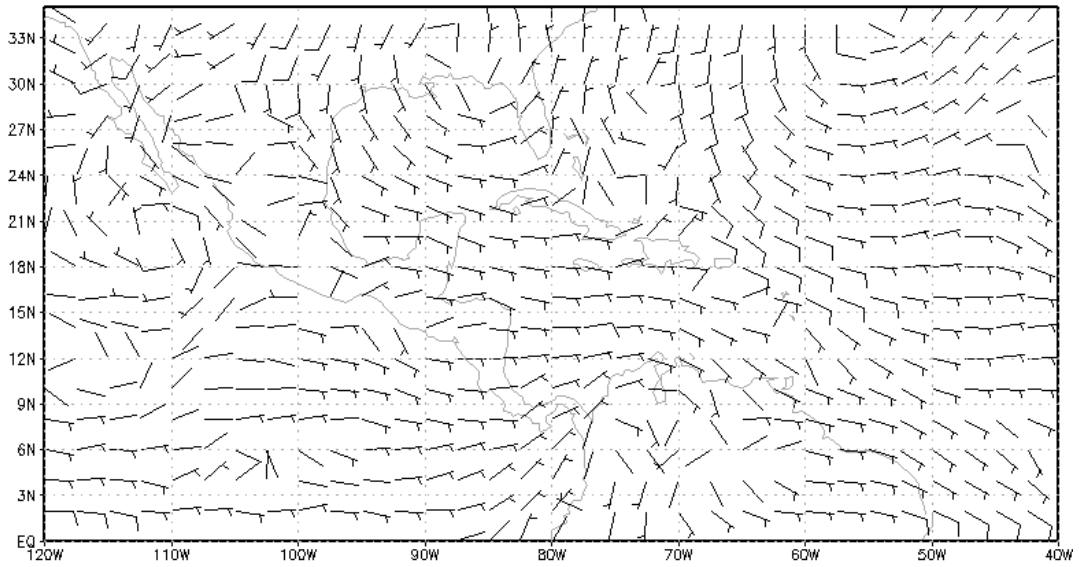
34. Set graphic type as barb

set gxout barb

`set gxout` stays until changed

35. Display every 5th grid point in the longitude and every 4th grid point in the latitude

d skip(u850,5,4);v850



Exercise 2

Display wind as stream lines

36. Clear the plot

c

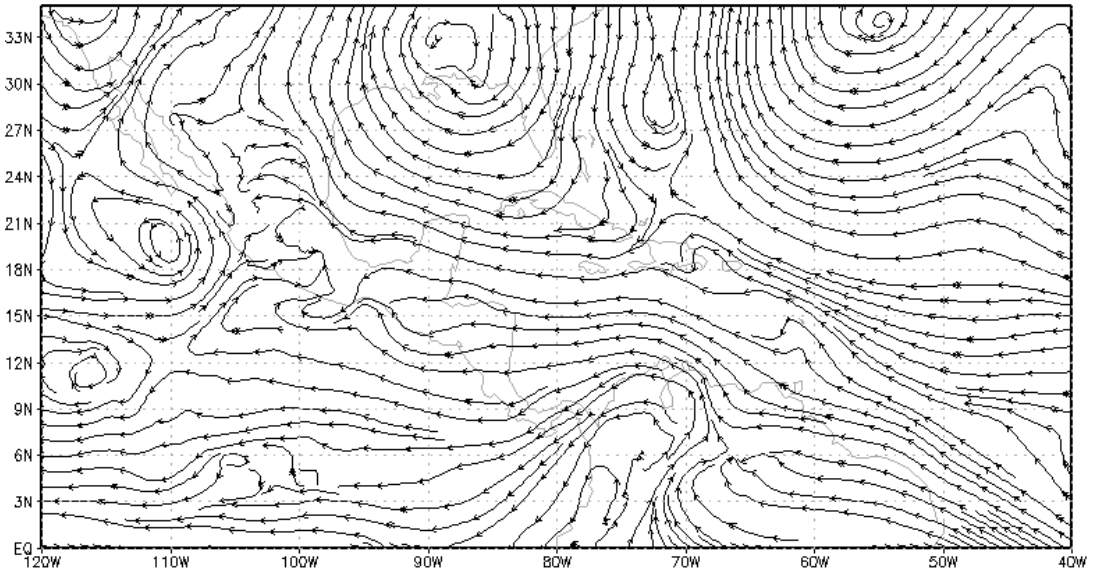
37. Set graphic type as stream lines

set gxout stream

`set gxout` stays until changed

38. Display wind at 850 hPa

d u850;v850

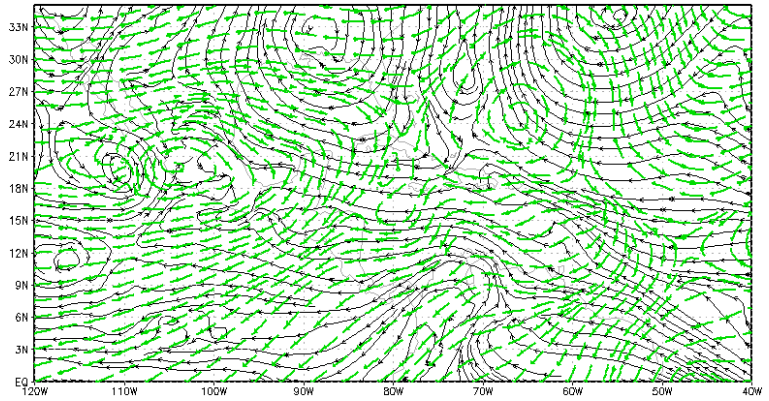


Exercise 2

Display wind as stream lines

39. Overlap on the wind at 850 hPa, the wind at 200 hPa with green ***(ccolor)*** thick ***(cthick)*** long dash ***(cstyle)*** lines

set ccolor ? → set ccolor 3
set cthick ? → set cthick 6
set cstyle ? → set cstyle 2
d u200;v200



GrADS colors

0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Line thickness

The *thickness* arg must be an integer in the range of `1 to 12`

Line styles

`0` - no contours
`1` - solid
`2` - long dash
`3` - short dash
`4` - long dash, short dash
`5` - dotted
`6` - dot dash
`7` - dot dot dash

Exercise 2

Overlap precipitation and wind fields

40. Delete the plot

c

41. Plot the variable ***rain***, overlap wind field at 850 hPa as vector arrows and add the color bar

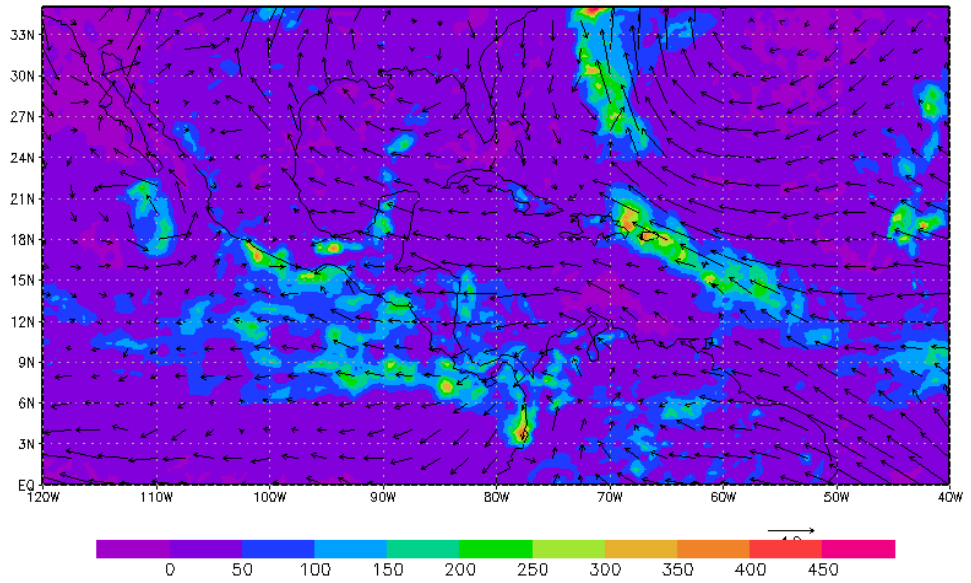
d rain

set gxout vector

d skip(u850,5,4);v850

cbar

`set gxout` stays until changed



Exercise 2

Display temperature fields

42. Delete the plot

c

43. Define a variable ***tmp*** as the mean temperature from 15 September to 21 September 2017

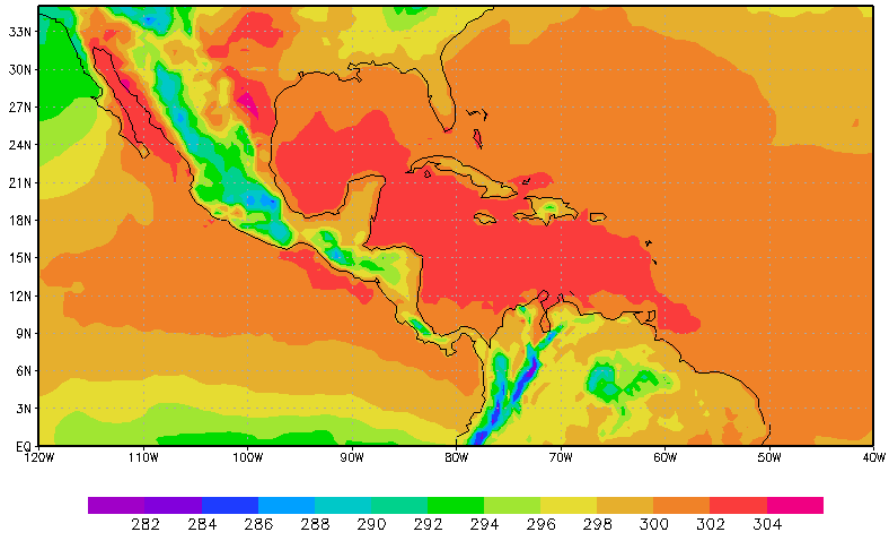
define tmp = ave(tmp2m.2, time = 00Z15sep2017, time = 18Z21sep2017)

44. Display the variable ***tmp***

d tmp

45. Add the color bar

cbar



Exercise 2

Display temperature fields

46. Delete the plot

c

47. Define a variable ***t2m*** as the mean temperature in degree celsius, from 15 September to 21 September 2017

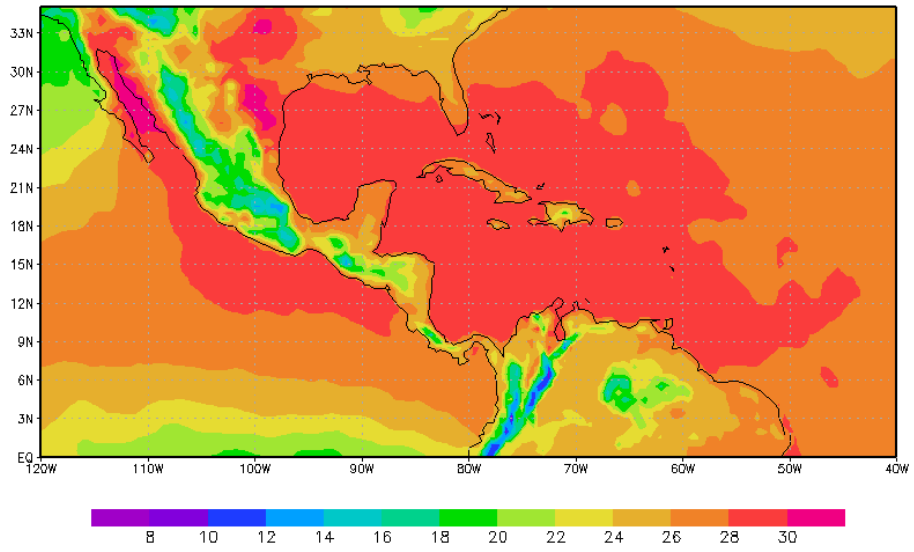
define t2m = ave(tmp2m.2 - 273.15, time = 00Z15sep2017, time = 18Z21sep2017)

48. Display the temperature ***t2m***

d t2m

49. Add the color bar

cbar



Exercise 2

Display a cross section of geopotential height

50. Delete the plot

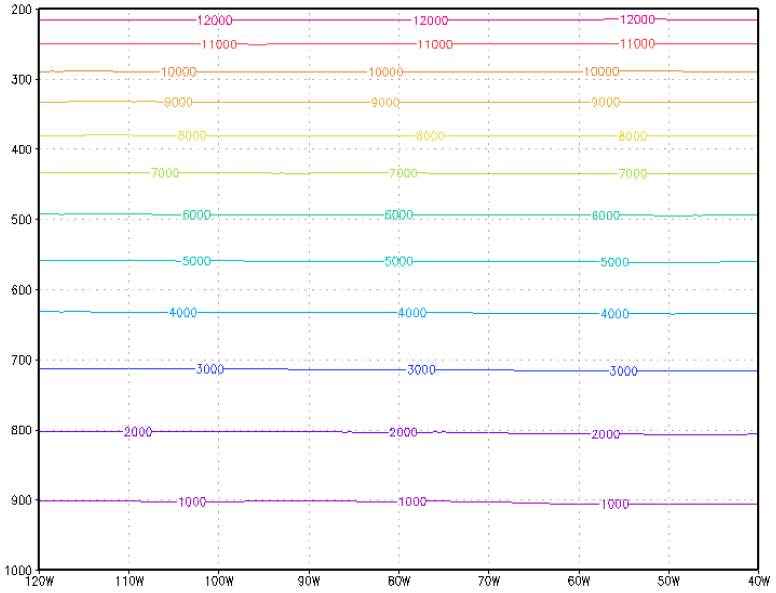
c

51. Set the time on 15 September 2017 at 00UTC

set time 00Z15Sep2017

52. Plot a cross section of the geopotential height at 12°N

set lat 12
set lon -120 -40
set lev 1000 200
set gxout contour
d hgtprs.2



Exercise 2

Display a cross section of geopotential height

53. Delete the plot

c

54. Set logarithm scaling of the z dimension

set zlog on

55. Plot a cross section of the geopotential height at 12°N

d hgtprs.2

56. Add label on the x-axis

draw xlab Longitude

57. Add label on the y-axis

draw ylab Pressure level (hPa)

58. Add title

draw title Geopotential height at 12N