

# Lecture and exercise: Assessment of future climate change

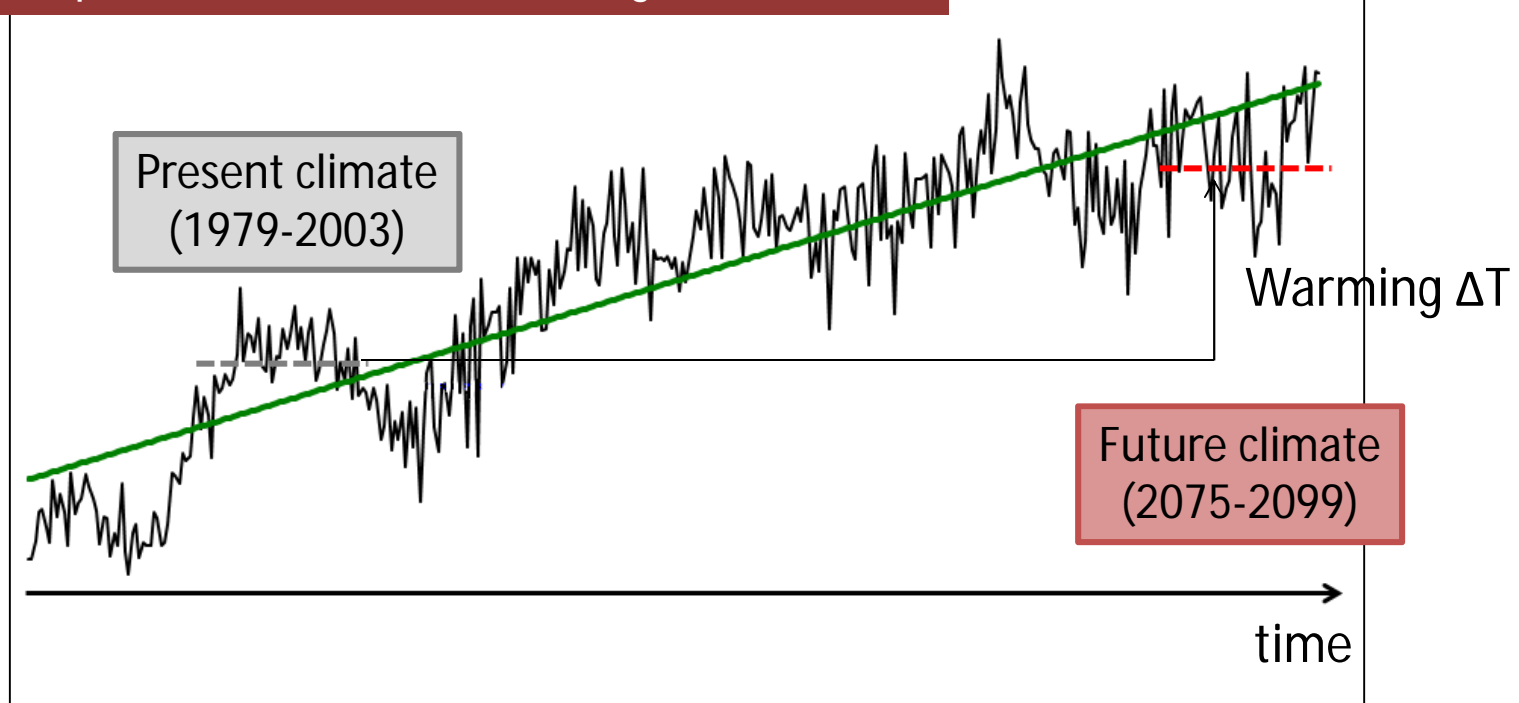
TCC Training Seminar on Global Warming Projection Information  
Climate Prediction Division JMA  
27 January 2015



# Future climate change

- Compare **future climate (2079-2099)** with **present climate(1979-2003)** .

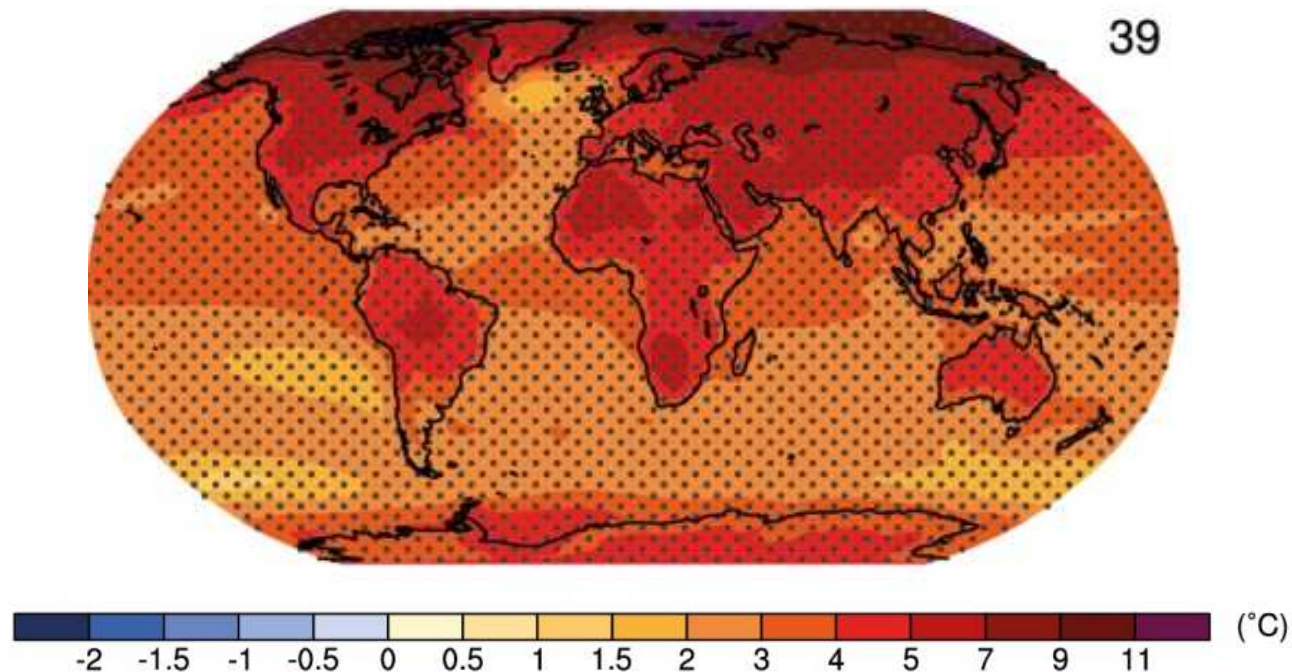
Temperature (each month, each grid of model)



- “Future climate” will be partially determined by external forcing due to human activity.
- Climate models driven with external forcing has **an ability to predict future climate.**

# IPCC AR5 : change in temperature

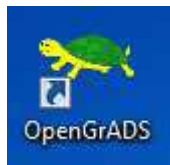
Projected surface air temperature change in future climate relative to present climate



- Temperature will continue to rise over the 21st century if greenhouse gas emissions continue unabated.
- Temperature change will not be regionally uniform.
- Warming over land will be larger than over the ocean.
- The region at high latitude will warm more rapidly.

# Future climate change using GrADS

Click the icon “OpenGrADS” on your desktop.

A screenshot of the OpenGrADS application window. The window title is "OpenGrADS". The terminal text shows the program starting an X server and OPENGR~1, displaying version information (2.8.2.nga.2), copyright (c) 1988-2011 by Brian Doty and the Institute for Global Environment and Society (IGES), and a configuration file path. The prompt "ga->" is visible at the bottom.

```
GrADS 2.0.2.oga.2

Starting X server under C:\OPENGR~1\Contents\Resources\Xming
Starting OPENGR~1 under C:\OPENGR~1\Contents\Cygwin\Versions\2020GA~1.2\i686 ...

Grid Analysis and Display System (GrADS) Version 2.8.2.nga.2
Copyright (c) 1988-2011 by Brian Doty and the
Institute for Global Environment and Society (IGES)
GrADS comes with ABSOLUTELY NO WARRANTY
See file COPYRIGHT for more information

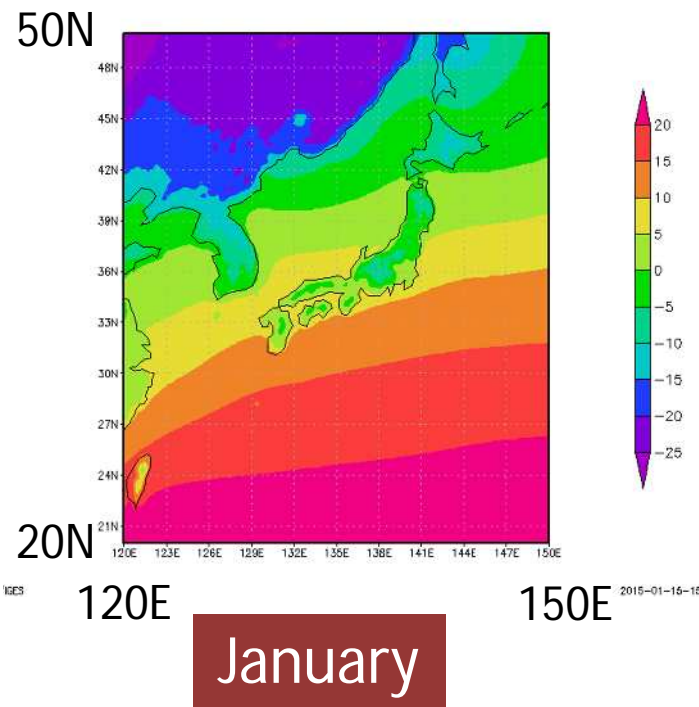
Config: v2.8.2.nga.2 little-endian readline printim gei62 netcdf hdf4-nc hdf5 o
pandag-grids.ctn athena geotiff shapelib
Issue 'q nonfig' command for more detailed configuration information.
Loading User Defined Extensions table </cygdrive/c/OPENGR~1/Contents/Cygwin/Vers
ions/2020GA~1.2/i686/gex/udxt> ... ok.
Landscape mode? <'n' for portrait>:
GX Package Initialization: Size = 11 8.5
Command line history in \Users\kc/.grads.log
ga->
```

Try to draw following figures.

- Present climate
- Future climate
- Comparison of future climate with present climate

# Present climate in temperature using GrADS

Present climate  
(1979-2003)



Open the GrADS control files

```
ga-> open AGCM/ta-P.ctl
```

Modify the area of interest  
(ex. Japan)

```
ga-> set lat 20 50
```

```
ga-> set lon 120 150
```

Set monthly (ex. January)

```
ga-> set t 1
```

Set graphics output types  
Set contour levels

```
gs-> set gxout shaded
```

```
ga-> set clevs -25 -20 -15 -10 -5 0 5 10 15 20
```

Display Present climate (K->deg C)

```
ga-> d ta-273.15
```

Use GrADS Scripts to draw a color  
bar next to shaded plots

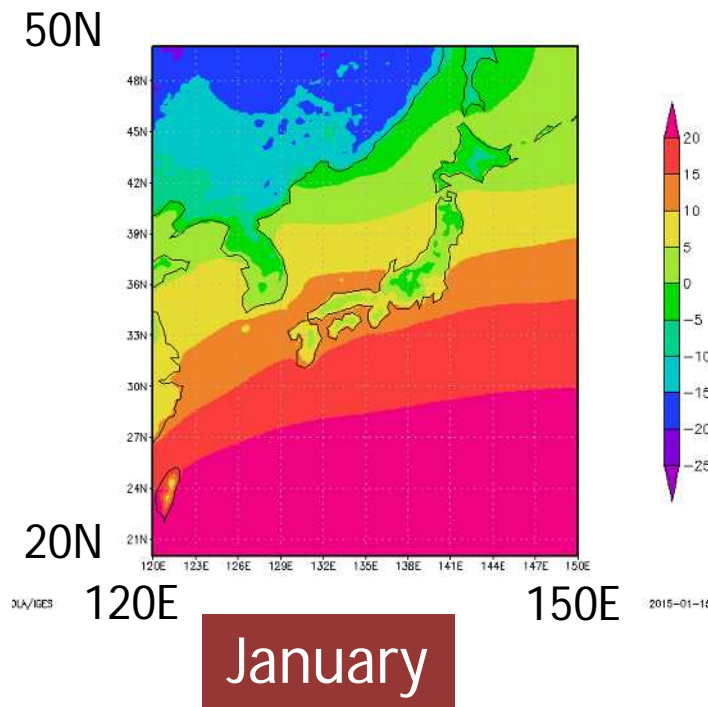
```
ga-> cbarn
```

```
ga-> printim ta-P_jan.png white
```

Save your map

# Future climate in temperature using GrADS

Future climate  
(2075-2099)



```
ga-> reinit  
ga-> open AGCM/ta-F.ctl
```

Open the GrADS control files

```
ga-> set lat 20 50  
ga-> set lon 120 150
```

Modify the area of interest  
(ex. Japan)

```
ga-> set t 1
```

Set monthly (ex. January)

```
gs-> set gxout shaded
```

Set graphics output types  
Set contour levels

```
ga-> set clevs -25 -20 -15 -10 -5 0 5 10 15 20
```

```
ga-> d ta-273.15
```

Display future climate (K->deg C)

```
ga-> cbarn
```

Use GrADS Scripts to draw a color  
bar next to shaded plots

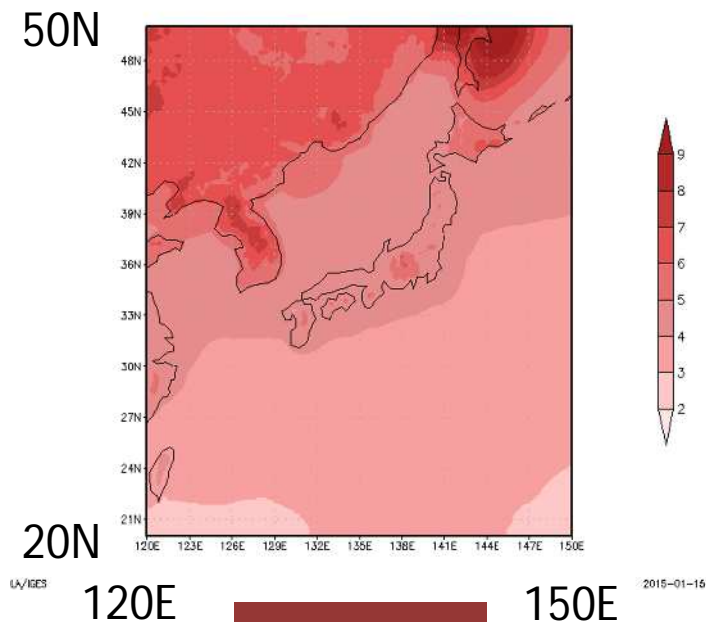
```
ga-> printim ta-F_jan.png white
```

Save your map



# Future change in temperature using GrADS

Change  
(Future - Present)



January

(t=1): Set monthly

```
ga-> reinit  
ga-> open AGCM/ta-P.ctl  
ga-> open AGCM/ta-F.ctl
```

Open the GrADS control files

```
ga-> set lat 20 50  
ga-> set lon 120 150
```

Modify the area of interest  
(ex. Japan)

```
gs-> set gxout shaded  
gs-> define_colors  
ga-> set clevs 2 3 4 5 6 7 8 9  
ga-> set ccols 61 62 63 64 65 66 67 68 69
```

Set graphics output types  
Set contour levels  
Set color numbers

```
ga-> d ta.2(t=1)-ta.1(t=1)
```

Calculate the difference  
between Future climate and  
Present climate

```
ga-> cbarn
```

Use GrADS Scripts to  
draw a color bar next  
to shaded plots

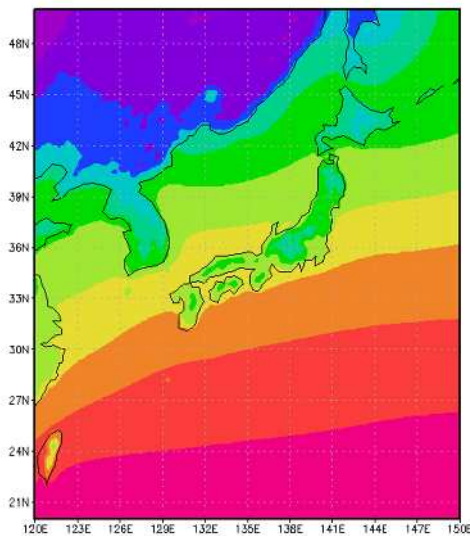
```
ga-> printim ta-F-P_jan.png white
```

Save your map

# Discussion : change in surface air temperature

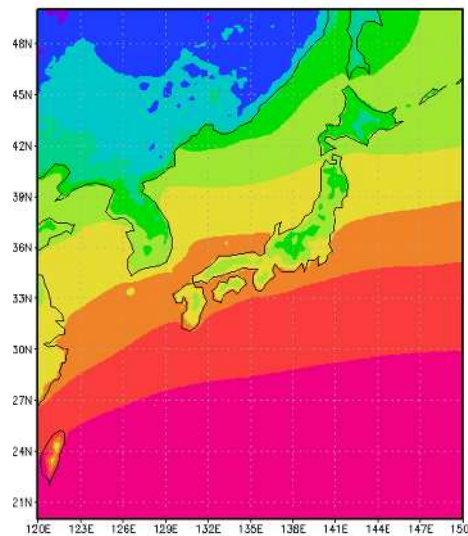
January

Present climate  
(1979-2003)



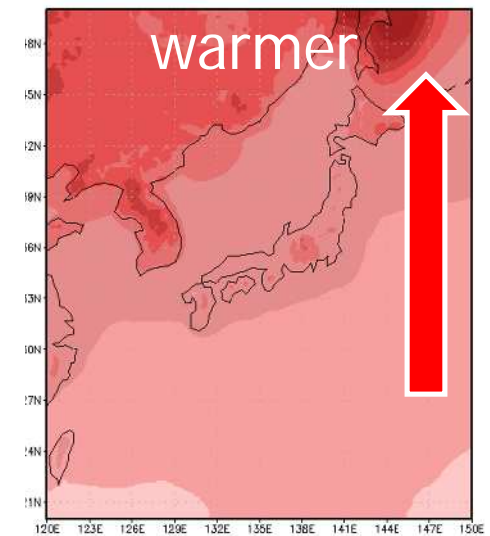
2015-01-16-16:42

Future climate  
(2075-2099)



2015-01-16-16:37

Change  
(Future - Present)



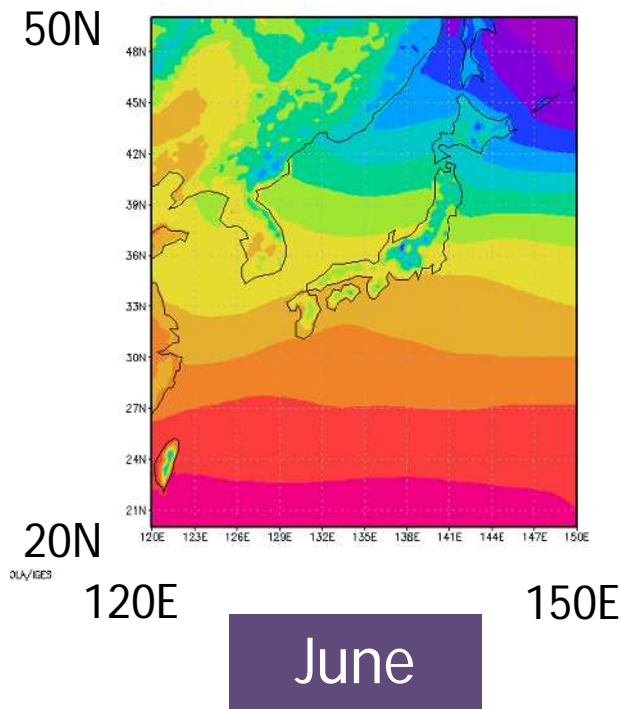
2015-01-16-

- ✓ Temperature in Japan is projected to increase between 3 to 5 degC.
- ✓ The region at high latitude will warm more rapidly.



# Present climate in temperature using GrADS

Present climate  
(1979-2003)



```
ga-> reinit  
ga-> open AGCM/ta-P.ctl
```

Open the GrADS control files

```
ga-> set lat 20 50  
ga-> set lon 120 150
```

Modify the area of interest  
(ex. Japan)

```
ga-> set t 6
```

Set monthly (ex. June)

```
gs-> set gxout shaded
```

Set graphics output types  
Set contour levels

```
ga-> set clevs 8 10 12 14 16 18 20 22 24 26 28
```

```
ga-> d ta-273.15
```

Display Present climate (K->deg C)

```
ga-> cbarn
```

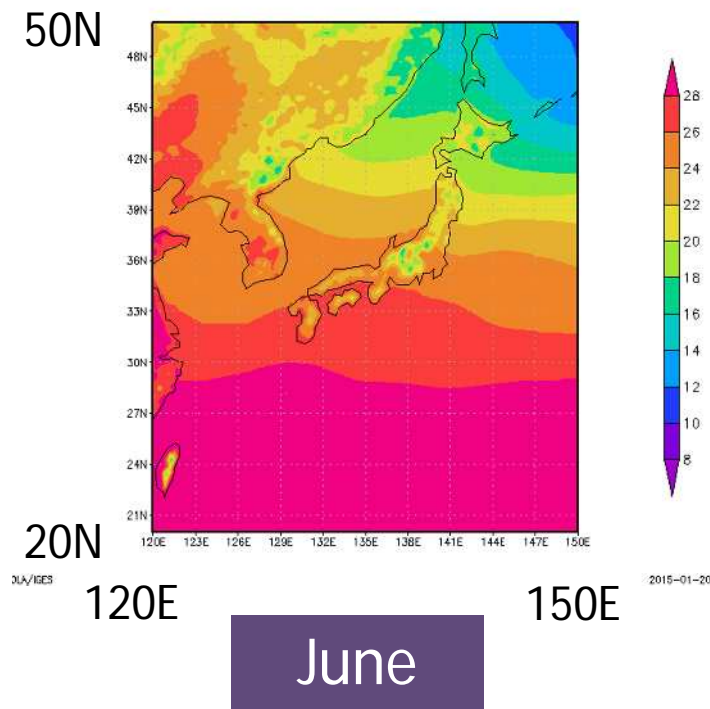
Use GrADS Scripts to draw a color  
bar next to shaded plots

```
ga-> printim ta-P_jun.png white
```

Save your map

# Future climate in temperature using GrADS

Future climate  
(2075-2099)



```
ga-> reinit  
ga-> open AGCM/ta-F.ctl
```

Open the GrADS control files

```
ga-> set lat 20 50  
ga-> set lon 120 150
```

Modify the area of interest  
(ex. Japan)

```
ga-> set t 6
```

Set monthly (ex. June)

```
gs-> set gxout shaded
```

Set graphics output types  
Set contour levels

```
ga-> set clevs -25 -20 -15 -10 -5 0 5 10 15 20
```

```
ga-> d ta-273.15
```

Display future climate (K->deg C)

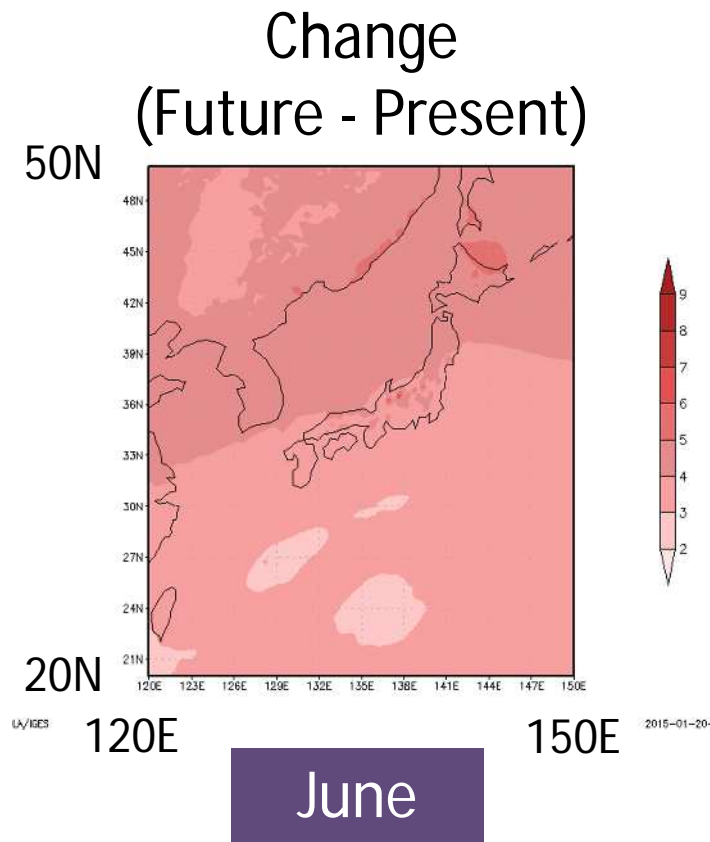
```
ga-> cbarn
```

Use GrADS Scripts to draw a color  
bar next to shaded plots

```
ga-> printim ta-F_jun.png white
```

Save your map

# Future change in temperature using GrADS



(t=6): Set monthly

```
ga-> reinit  
ga-> open AGCM/ta-P.ctl  
ga-> open AGCM/ta-F.ctl
```

Open the GrADS control files

```
ga-> set lat 20 50  
ga-> set lon 120 150
```

Modify the area of interest  
(ex. Japan)

```
gs-> set gxout shaded  
gs-> define_colors  
ga-> set clevs 2 3 4 5 6 7 8 9  
ga-> set ccols 61 62 63 64 65 66 67 68 69
```

Set graphics output types  
Set contour levels  
Set color numbers

```
ga-> d ta.2(t=6)-ta.1(t=6)
```

Calculate the difference  
between Future climate and  
Present climate

```
ga-> cbarn
```

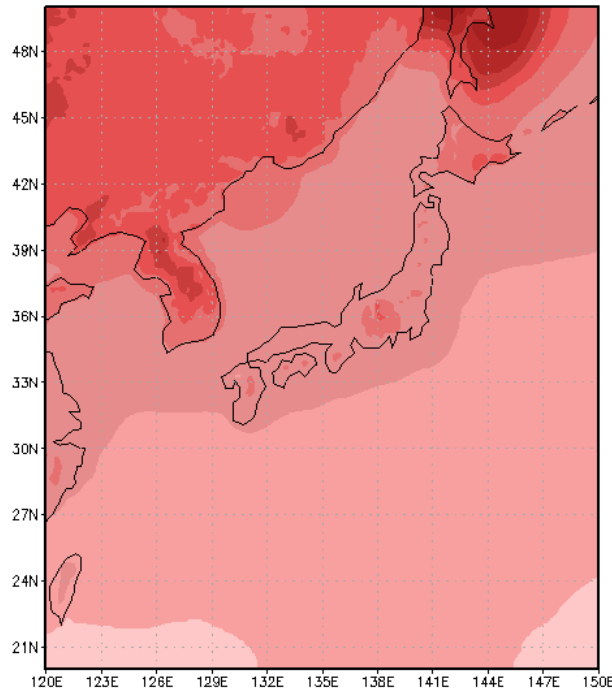
Use GrADS Scripts to  
draw a color bar next to  
shaded plots

```
ga-> printim ta-F-P_jan.png white
```

Save your map

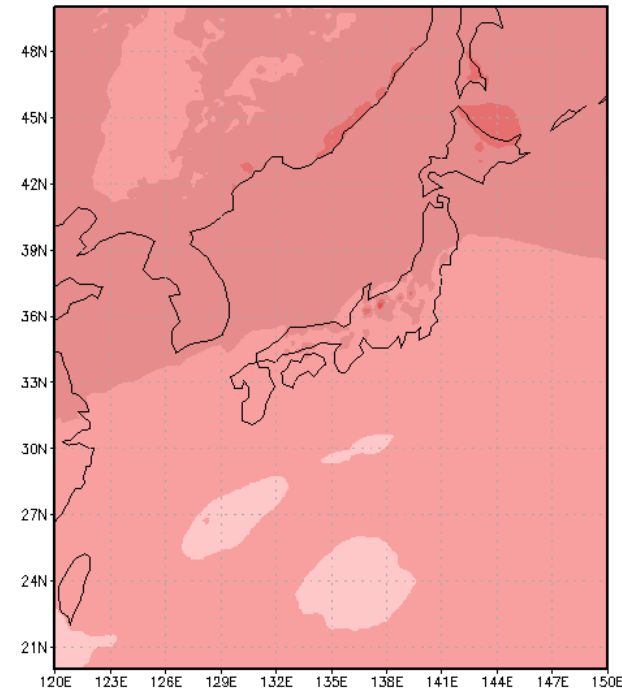
# Discussion : change in surface air temperature

Change(Future - Present)  
In January

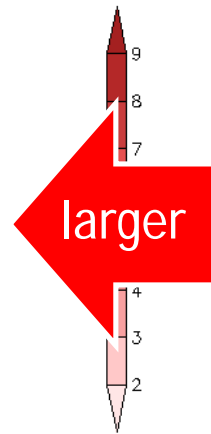


2015-01-16-16:43

Change(Future - Present)  
In June



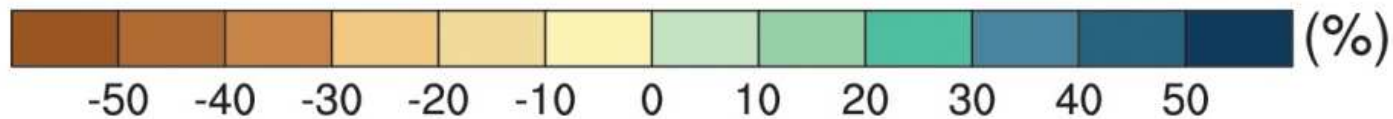
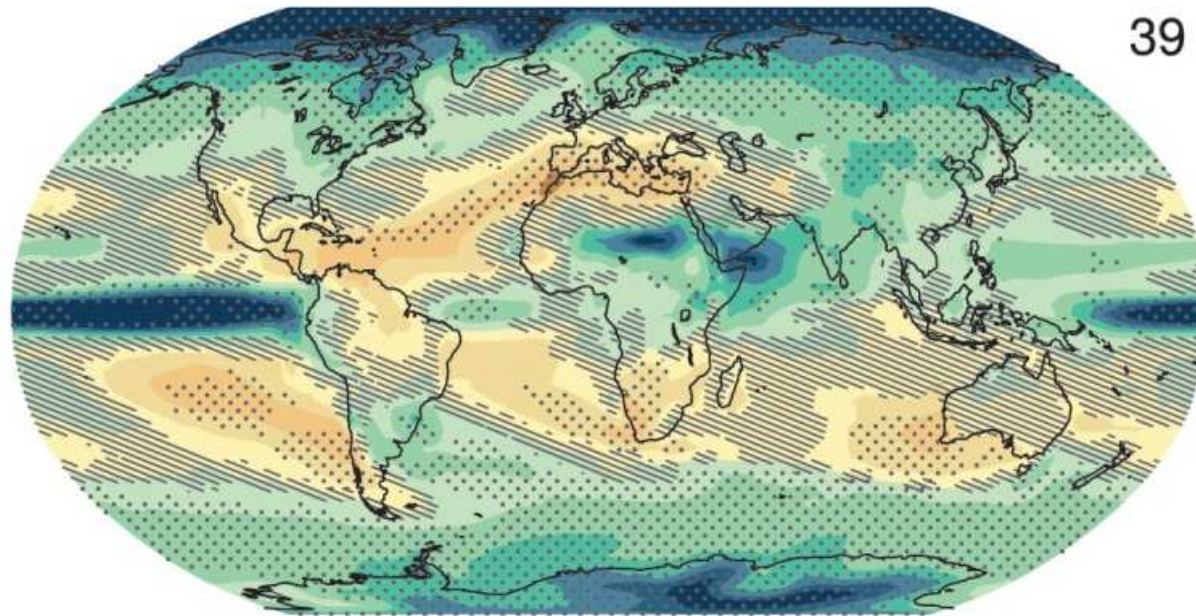
2015-01-20-10:47



- ✓ Temperature in June is projected to increase between 2 to 4 degC.
- ✓ Warming in January will be larger than in June.

# IPCC AR5 : change in precipitation

Projected precipitation change in future climate relative to present climate

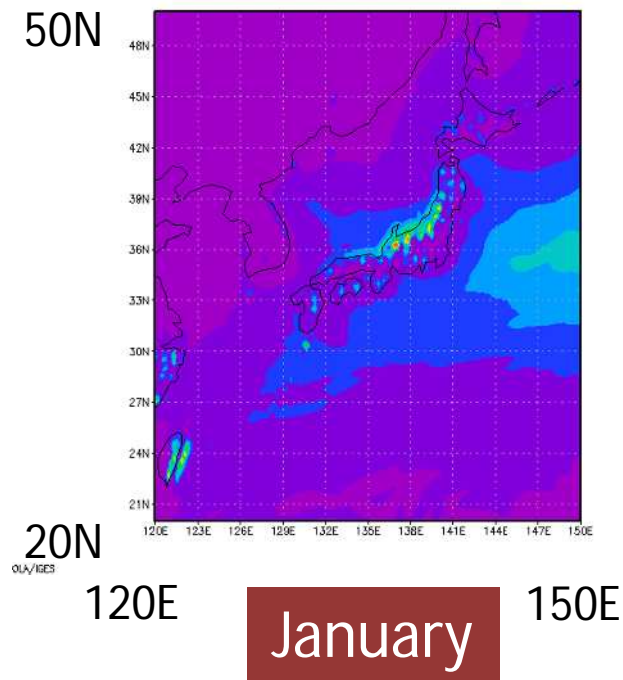


- The high latitudes and the equatorial Pacific Ocean will likely increase in annual mean precipitation.
- In many mid-latitude and subtropical dry regions, mean precipitation will likely decrease.
- In many mid-latitude wet regions, mean precipitation will likely increase.



# Present climate in precipitation using GrADS

Present climate  
(1979-2003)



```
ga-> reinit
ga-> open AGCM/precipi-P.ctl

ga-> set lat 20 50
ga-> set lon 120 150

ga-> set t 1

gs-> set gxout shaded
ga-> set clevs 2 4 6 8 10 12 14 16 18 20 22 24

ga-> d precipi

ga-> cbarn

ga-> printim precipi-P_jan.png white
```

Open the GrADS control files

Modify the area of interest  
(ex. Japan)

Set monthly (ex. January)

Set graphics output types  
Set contour levels

Display Present climate

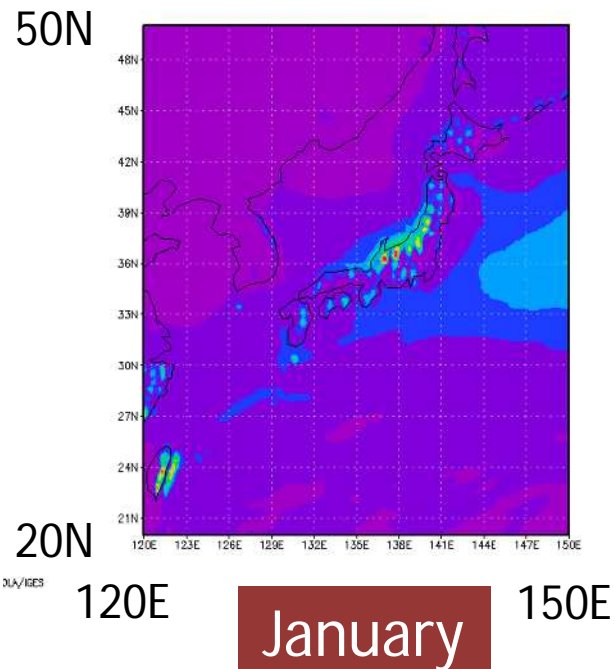
Use GrADS Scripts to draw a color  
bar next to shaded plots

Save your map



# Future climate in precipitation using GrADS

Future climate  
(2075-2099)



```
ga-> reinit
```

Open the GrADS control files

```
ga-> open AGCM/precipi-F.ctl
```

Modify the area of interest  
(ex. Japan)

```
ga-> set lat 20 50
```

```
ga-> set lon 120 150
```

Set monthly (ex. January)

```
ga-> set t 1
```

Set graphics output types  
Set contour levels

```
gs-> set gxout shaded
```

```
ga-> set clevs 2 4 6 8 10 12 14 16 18 20 22 24
```

```
ga-> d precipi
```

Display future climate

```
ga-> cbarn
```

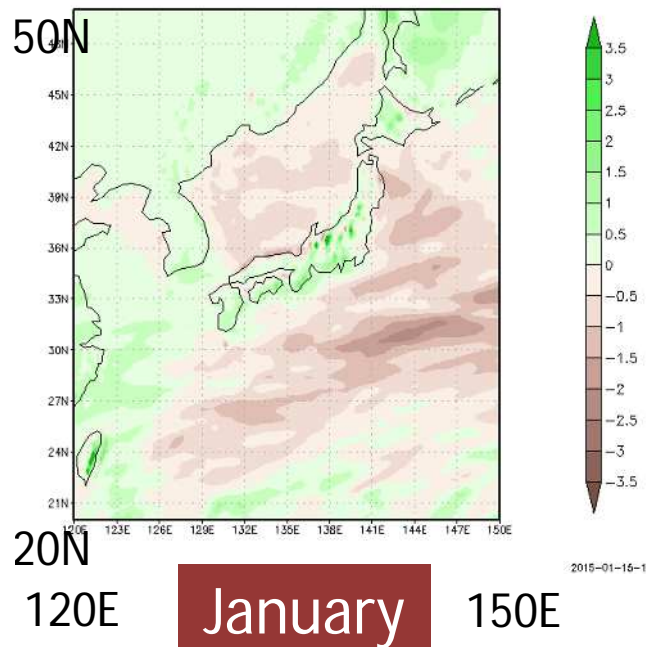
Use GrADS Scripts to draw a color  
bar next to shaded plots

```
ga-> printim precipi-F_jan.png white
```

Save your map

# Future change in precipitation using GrADS

Change  
(Future - Present)



(t=1): Set monthly

```
ga-> reinit
ga-> open AGCM/precipi-P.ctl
ga-> open AGCM/precipi-F.ctl

ga-> set lat 20 50
ga-> set lon 120 150

gs-> set gxout shaded
gs-> define_colors
ga-> set clevs -3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5
ga-> set ccols 78 77 76 75 74 73 72 71 31 32 33 34 35 36 37 38

ga-> d precipi.2(t=1)-precipi.1(t=1)

ga-> cbarn

ga-> printim precipi-F-P_jan.png white
```

Open the GrADS control files

Modify the area of interest  
(ex. Japan)

Set graphics output types  
Set contour levels  
Set color numbers

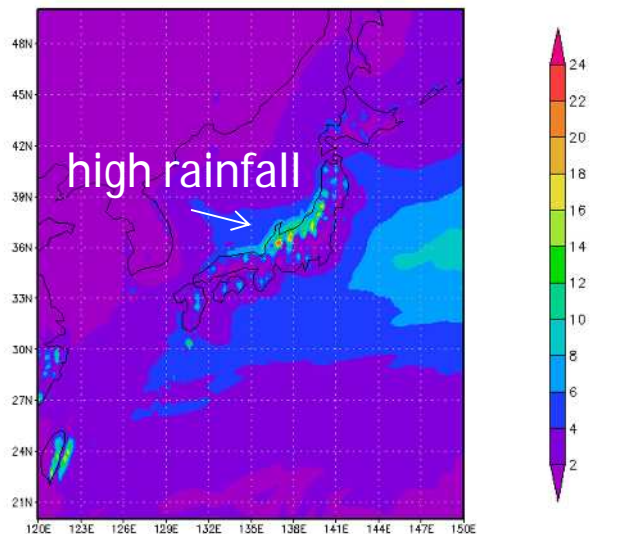
Calculate the  
difference between  
Future climate and  
Present climate

Use GrADS  
Scripts to draw a  
color bar next to  
shaded plots

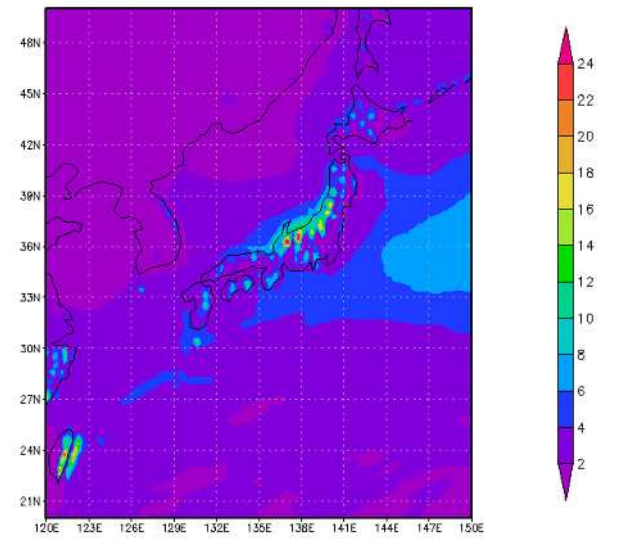
Save your map

# Discussion : change in surface air temperature

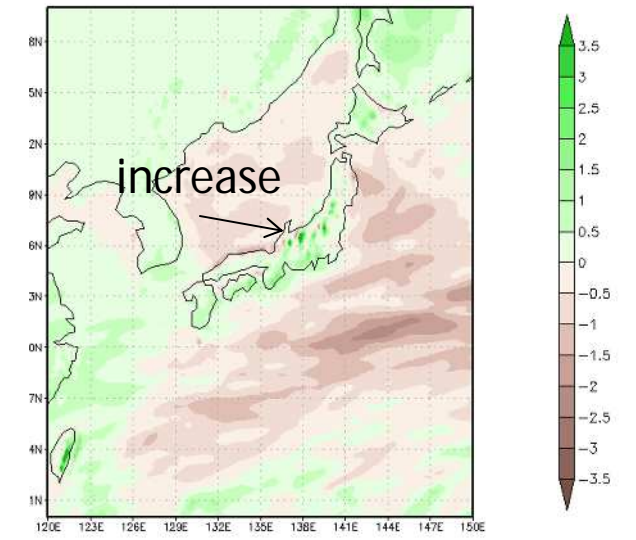
Present climate  
(1979-2003)



Future climate  
(2075-2099)



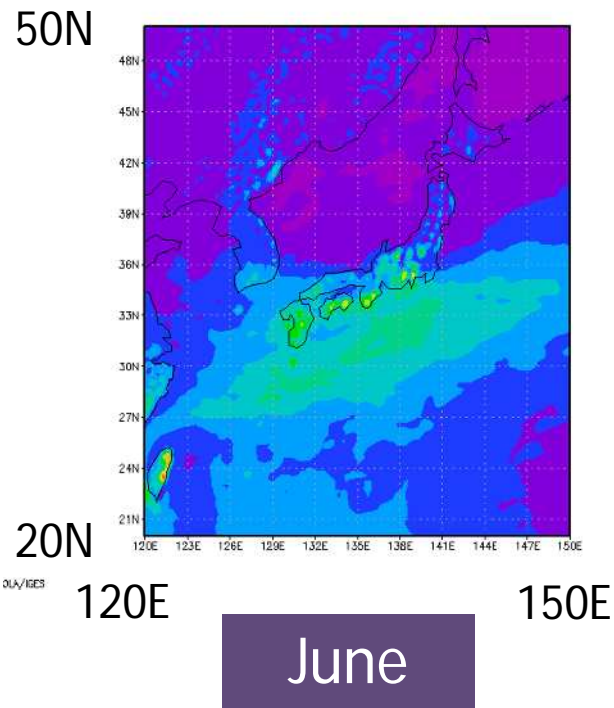
Change  
(Future - Present)



✓ Precipitation is projected to increase in area of high rainfall over land.

# Present climate in precipitation using GrADS

Present climate  
(1979-2003)



```
ga-> reinit
ga-> open AGCM/precipi-P.ctl

ga-> set lat 20 50
ga-> set lon 120 150

ga-> set t 6

gs-> set gxout shaded
ga-> set clevs 2 4 6 8 10 12 14 16 18 20 22 24

ga-> d precipi

ga-> cbarn

ga-> printim precipi-P_jun.png white
```

Open the GrADS control files

Modify the area of interest  
(ex. Japan)

Set monthly (ex. June)

Set graphics output types  
Set contour levels

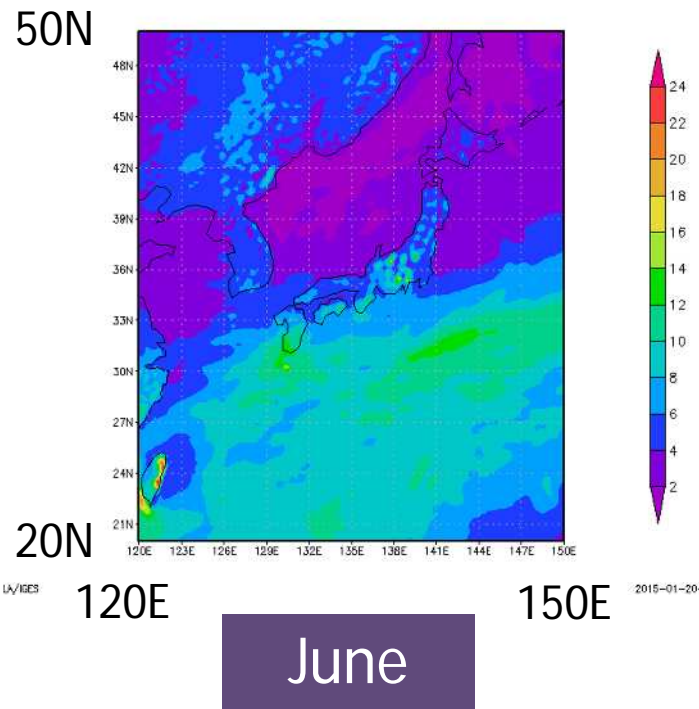
Display Present climate

Use GrADS Scripts to draw a color  
bar next to shaded plots

Save your map

# Future climate in precipitation using GrADS

Future climate  
(2075-2099)



```
ga-> reinit
```

Open the GrADS control files

```
ga-> open AGCM/precipi-F.ctl
```

Modify the area of interest  
(ex. Japan)

```
ga-> set lat 20 50
```

```
ga-> set lon 120 150
```

Set monthly (ex. June)

```
ga-> set t 6
```

Set graphics output types  
Set contour levels

```
gs-> set gxout shaded
```

```
ga-> set clevs 2 4 6 8 10 12 14 16 18 20 22 24
```

Display future climate

```
ga-> d precipi
```

Use GrADS Scripts to draw a color  
bar next to shaded plots

```
ga-> cbarn
```

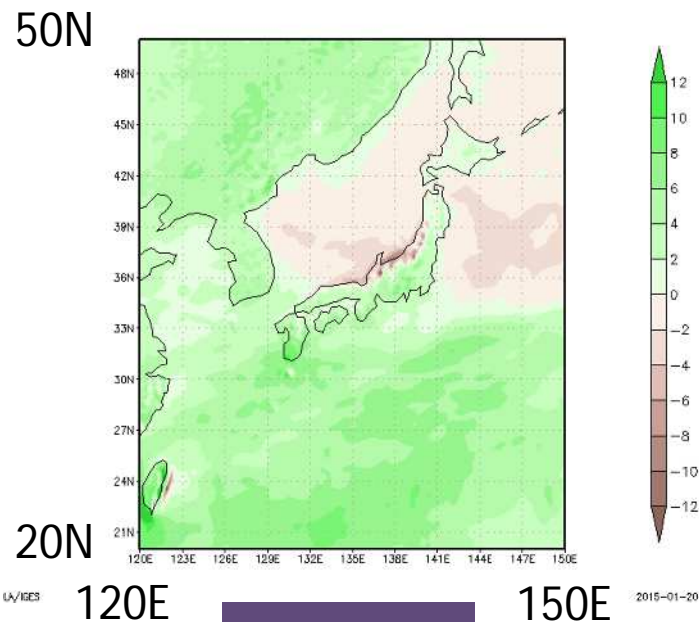
```
ga-> printim precipi-F_jun.png white
```

Save your map



# Future change in precipitation using GrADS

Change  
(Future - Present)



June

(t=6): Set monthly

```
ga-> reinit  
ga-> open AGCM/precipi-P.ctl  
ga-> open AGCM/precipi-F.ctl
```

Open the GrADS control files

```
ga-> set lat 20 50  
ga-> set lon 120 150
```

Modify the area of interest  
(ex. Japan)

```
gs-> set gxout shaded  
gs-> define_colors
```

Set graphics output types  
Set contour levels  
Set color numbers

```
ga-> set clevs -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12  
ga-> set ccols 77 76 75 74 73 72 71 31 32 33 34 35 36 37
```

```
ga-> d precipi.2(t=6)-precipi.1(t=6)
```

Calculate the  
difference between  
Future climate and  
Present climate

```
ga-> cbarn
```

```
ga-> printim precipi-F-P_jun.png white
```

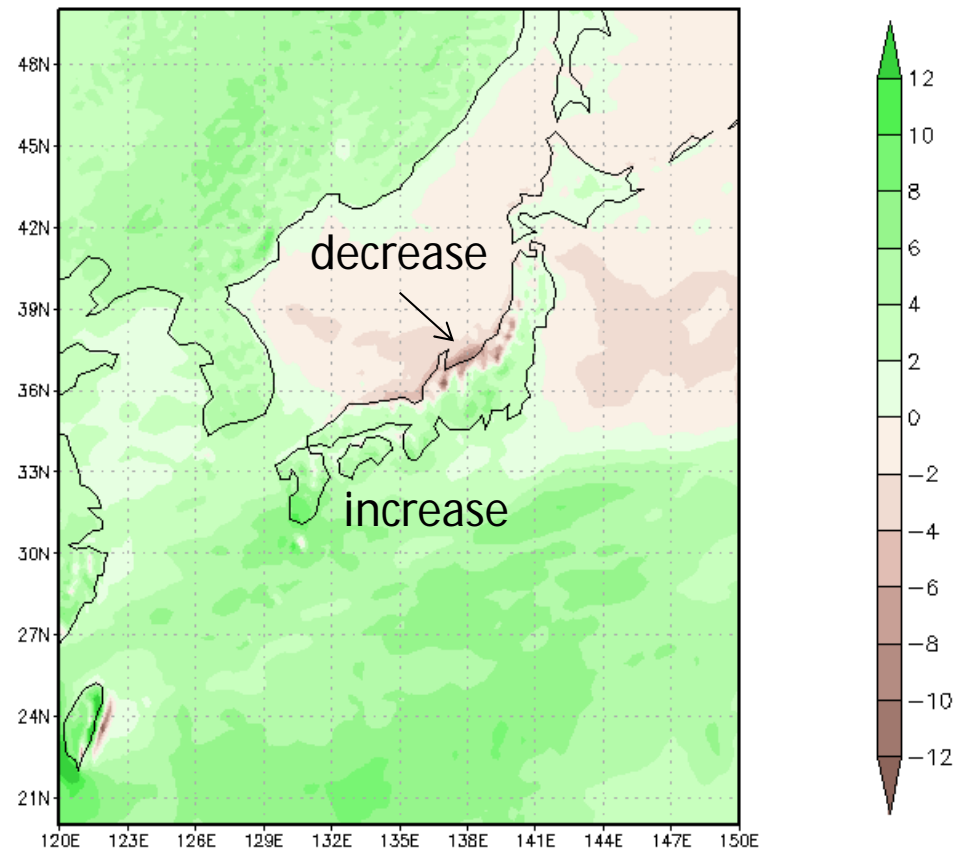
Use GrADS Scripts  
to draw a color  
bar next to  
shaded plots

Save your map



# Discussion : change in surface air temperature

Change(Future - Present)  
In June



- ✓ Precipitation is projected to increase *on the pacific side* in June, On the other hand, precipitation is projected to decrease *on the Sea of Japan side of eastern Japan*.



END