9. Lecture and Exercise: Check of Reproducibility

CLIMATE PREDICTION DIVISION
JAPAN METEOROLOGICAL AGENCY

TCC Training Course,
27 January 2015 (JMA, Tokyo)

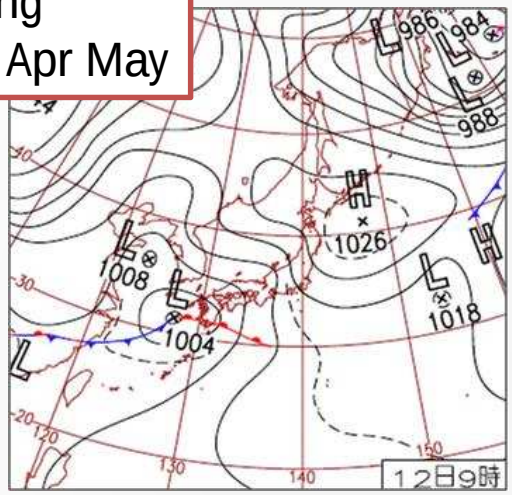
Why should we check the reproducibility?

- The reproducibility is judged by calculating the bias. Bias is defined here as Simulation minus Reanalysis.
  - $B = S - R$
  - Simulation is the forecast which is conducted by climate models.
  - Reanalysis is nearly the same as observation which we think of as true value.
- Simulation and Reanalysis cannot be exactly the same result. Every model has its own bias.
  - Based on physics, parameterizations and so on.
- If there are the areas the bias is very different from the climatology, you should mention it when you say something about future changes in that area.
  - Bias correction is the way to overcome the problem, which adjusts present simulation to observation. For example, a simple way is:
    - $\mathrm{Future}_{\mathrm{Bias\ corrected}} = \mathrm{Future} - (\mathrm{Present} - \mathrm{Observation})$

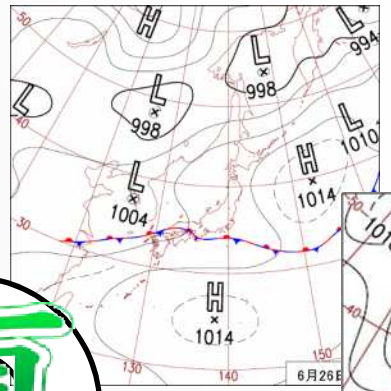
We focus on Japan's climatology of January and June

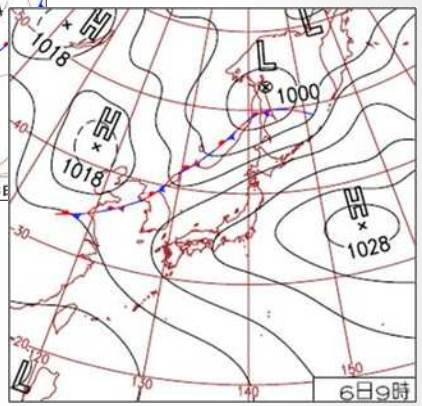
- **Here we focus on analyzing the Japan's climatology of January (Winter) and June (Summer).**

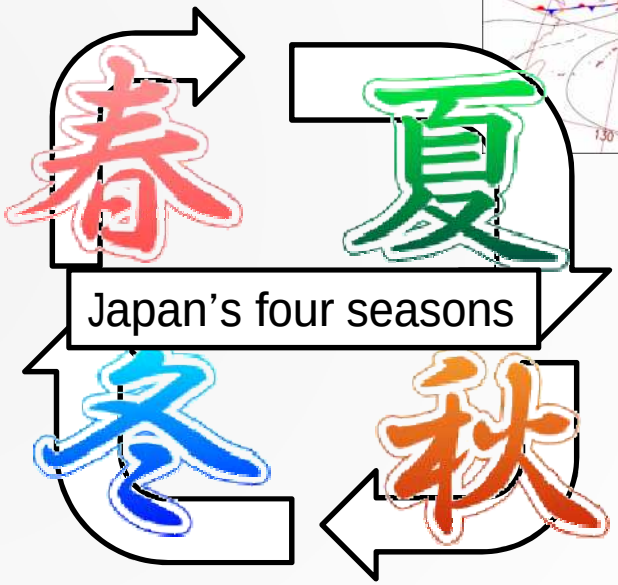
Spring
Mar Apr May

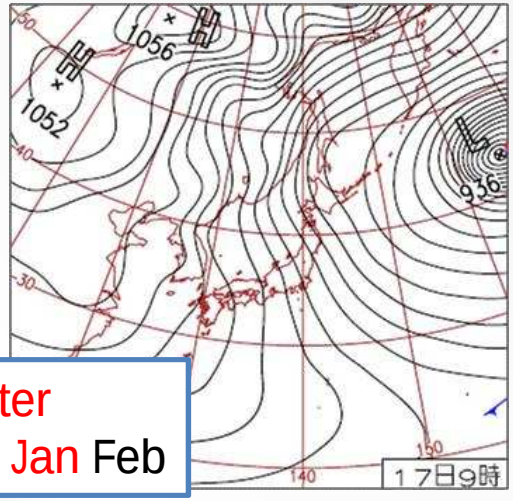


Summer
Jun Jul Aug

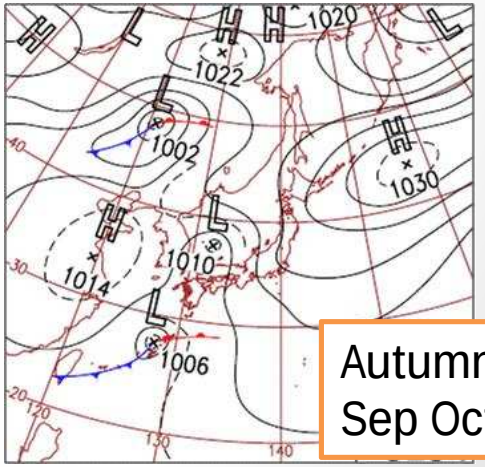








Winter
Dec Jan Feb

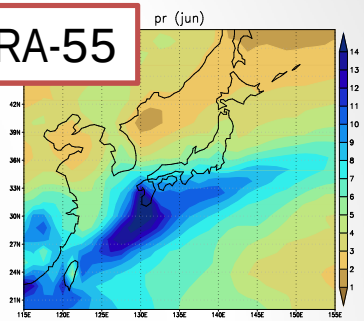


Autumn
Sep Oct Nov

Outline

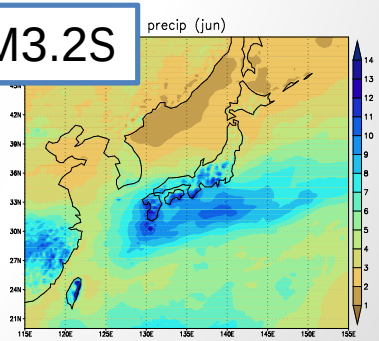
1. Draw monthly mean climatology of Japan using **JRA-55** reanalysis data.
   - ☐Monthly mean precipitation (mm/day)
   - ☐Monthly mean 2m temperature (°C)

JRA-55



2. Compare the present climate simulated by **MRI-AGCM3.2S** with the JRA-55 climatology.
   - ☐Based on the reproducibility of MRI-AGCM3.2S, we have to analyze its future climate change.

MRI-AGCM3.2S

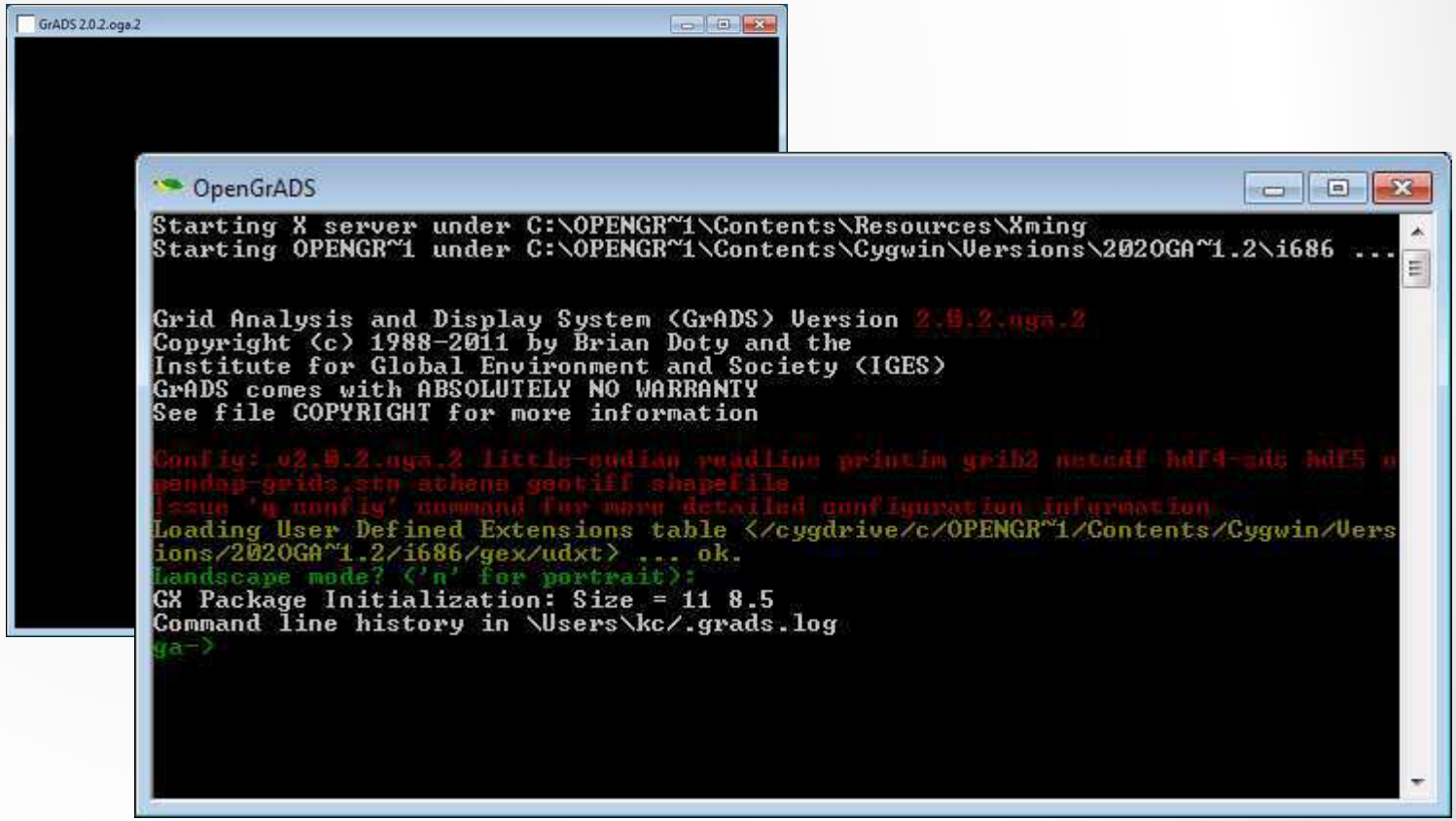


FROM JRA-55

DRAW MONTHLY MEAN CLIMATOLOGY OF JAPAN

Using JRA-55 reanalysis data

1. **Click the icon “OpenGrADS” on your desktop.**
2. **Type “Enter” to set Landscape mode.**
3. **Type “cd /cygdrive/c/TCC_2015/Data”.**

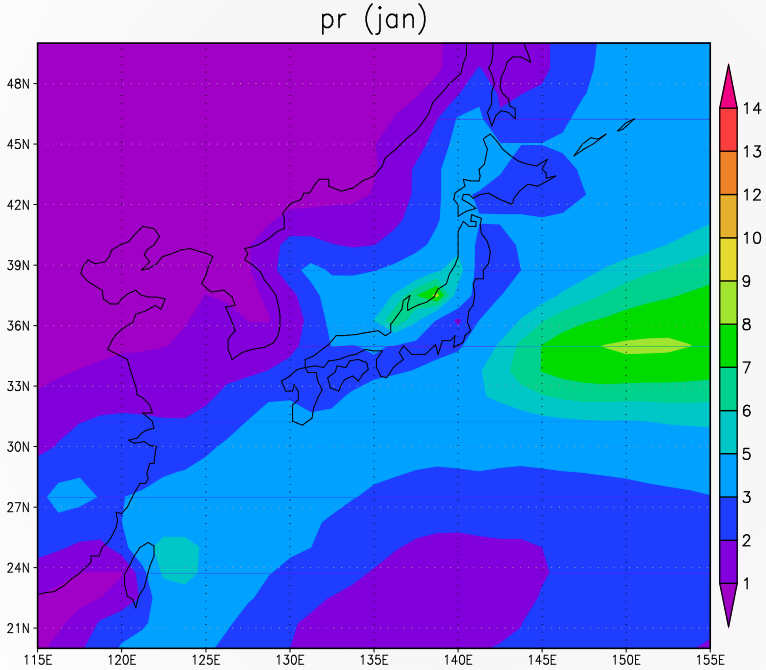


Data description

Control File Name	Description	Run	Duration
JRA55/pr.clim.ctl	JRA55 Precipitation (mm/day)	Climatology	1981-2010
JRA55/tas.clim.ctl	JRA55 2m Temperature (K)	Climatology	1981-2010
JRA55/psl.cim.ctl	JRA55 Sea Level Pressure (Pa)	Climatology	1981-2010
JRA55/ua.clim.ctl	JRA55 Eastward Wind (m/s)	Climatology	1981-2010
JRA55/va.clim.ctl	JRA55 Northward Wind (m/s)	Climatology	1981-2010
JRA55/uas.clim.ctl	JRA55 Eastward Near-Surface Wind (m/s)	Climatology	1981-2010
JRA55/vas.clim.ctl	JRA55 Northward Near-Surface Wind (m/s)	Climatology	1981-2010
AGCM/precipi-P.ctl	AGCM Precipitation (mm/day)	Present Simulation	1979-2003
AGCM/ta-P.ctl	AGCM 2m Temperature (K)	Present Simulation	1979-2003
AGCM/slp-P.ctl	AGCM Sea Level Pressure (Pa)	Present Simulation	1979-2003
AGCM/u-P.ctl	AGCM Eastward Wind (m/s)	Present Simulation	1979-2003
AGCM/v-P.ctl	AGCM Northward Wind (m/s)	Present Simulation	1979-2003
AGCM/ua-P.ctl	AGCM Eastward Near-Surface Wind (m/s)	Present Simulation	1979-2003
AGCM/va-P.ctl	AGCM Northward Near-Surface Wind (m/s)	Present Simulation	1979-2003
AGCM/precipi-F.ctl	AGCM Precipitation (mm/day)	Future Simulation	2075-2099
AGCM/ta-F.ctl	AGCM 2m Temperature (K)	Future Simulation	2075-2099
AGCM/slp-F.ctl	AGCM Sea Level Pressure (Pa)	Future Simulation	2075-2099
AGCM/u-F.ctl	AGCM Eastward Wind (m/s)	Future Simulation	2075-2099
AGCM/v-F.ctl	AGCM Northward Wind (m/s)	Future Simulation	2075-2099
AGCM/ua-F.ctl	AGCM Eastward Near-Surface Wind (m/s)	Future Simulation	2075-2099
AGCM/va-F.ctl	AGCM Northward Near-Surface Wind (m/s)	Future Simulation	2075-2099

JRA-55 monthly mean precipitation (mm/day) (January)

JRA-55




```
reinit
open JRA55/pr.clim.ctl
set gxout shaded
set grads off

set lon 115 155
set lat 20 50

set clevs 1 2 3 4 5 6 7 8 9 10 11 12 13 14

set t 1

d pr
cbarn

printim pr-jan.png white
```

Reinitializing the state

Open a file

Shaded contour plot

Longitude and latitude
(115E~155E, 20N~50N)

January

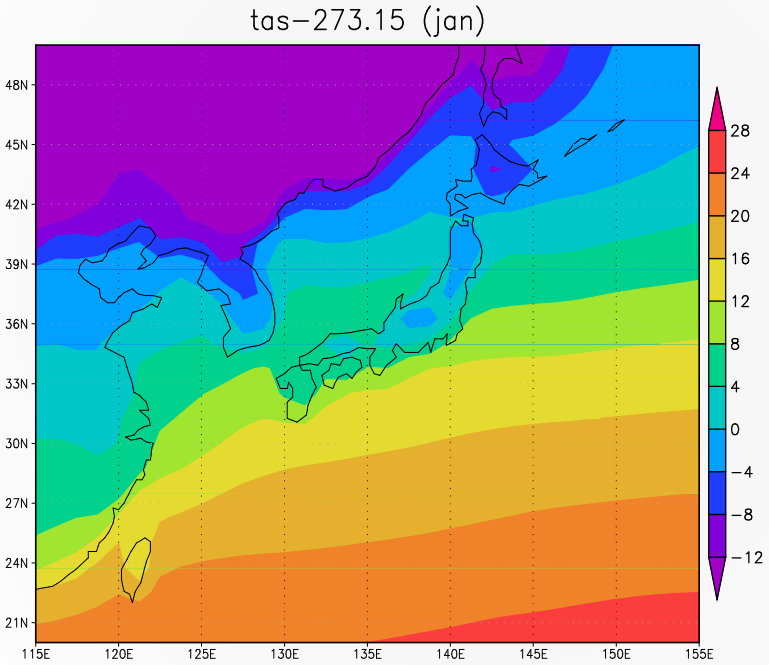
Display data

Color bar script
To use simply, just type “cbarn”.

Save as png

JRA-55 monthly mean 2m temperature (℃) (January)

JRA-55

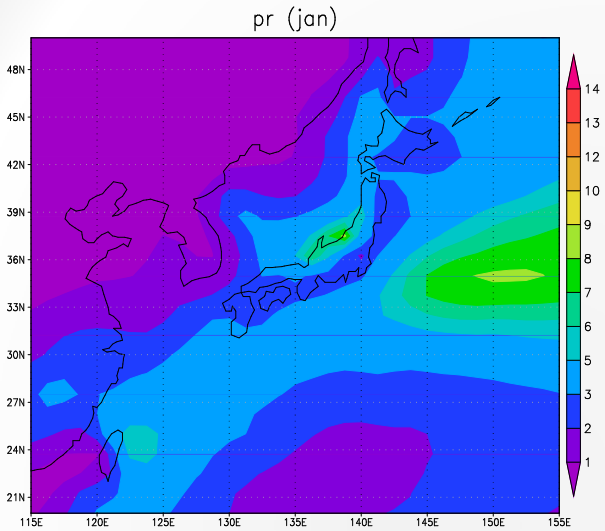



```
reinit
open JRA55/tas.clim.ctl
set gxout shaded
set grads off

set lon 115 155
set lat 20 50

set clevs -12 -8 -4 0 4 8 12 16 20 24 28

set t 1

d tas-273.15
cbarn

printim tas-jan.png white
```

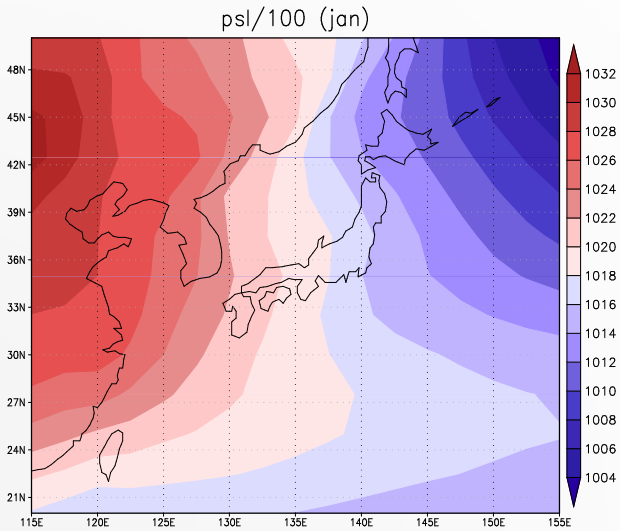
K → degC

JRA-55 monthly mean climatology of Japan (January)

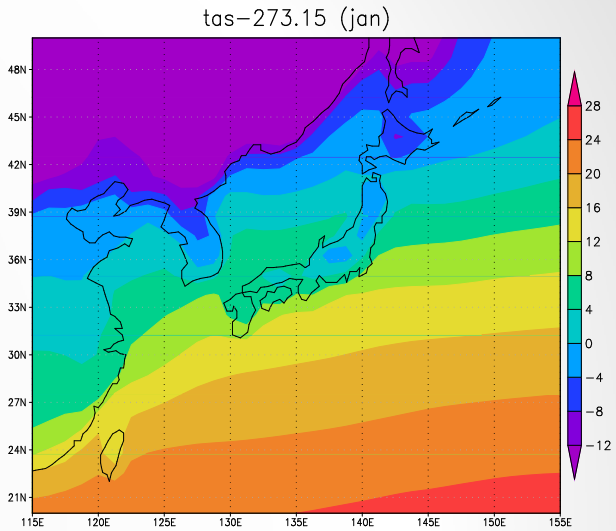
Precipitation (mm/day)



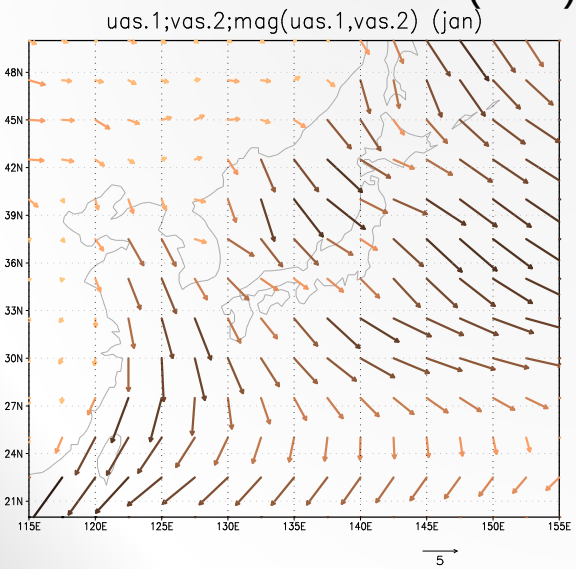
Sea Level Pressure (hPa)



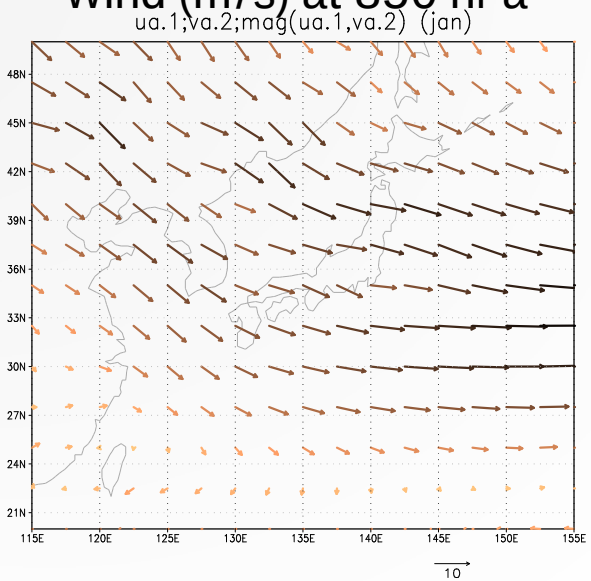
2m Temperature (°C)



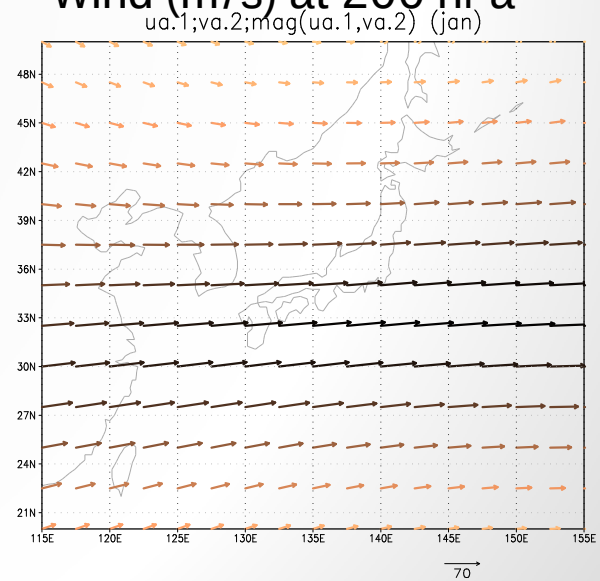
Near-Surface Wind (m/s)



Wind (m/s) at 850 hPa

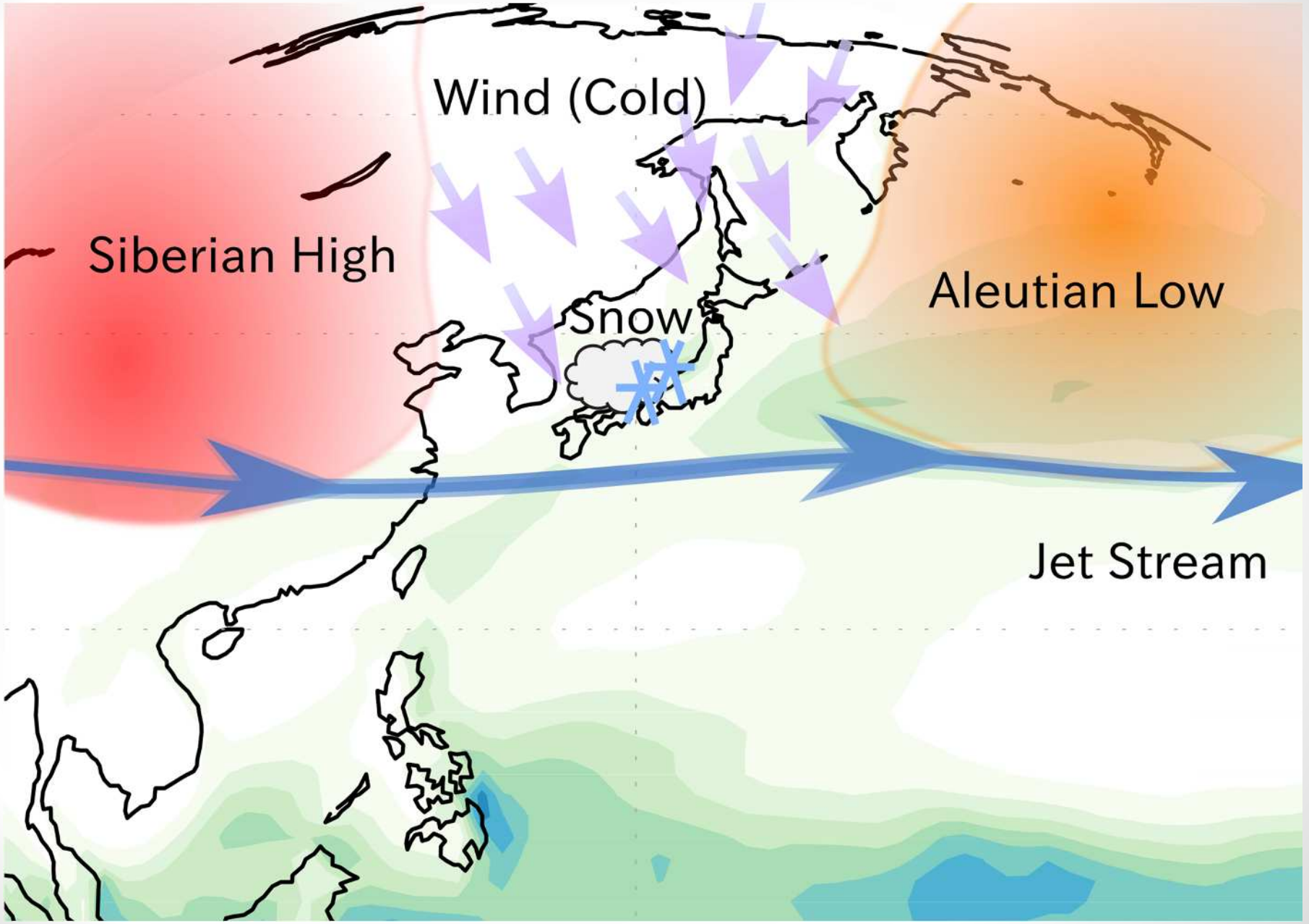


Wind (m/s) at 200 hPa



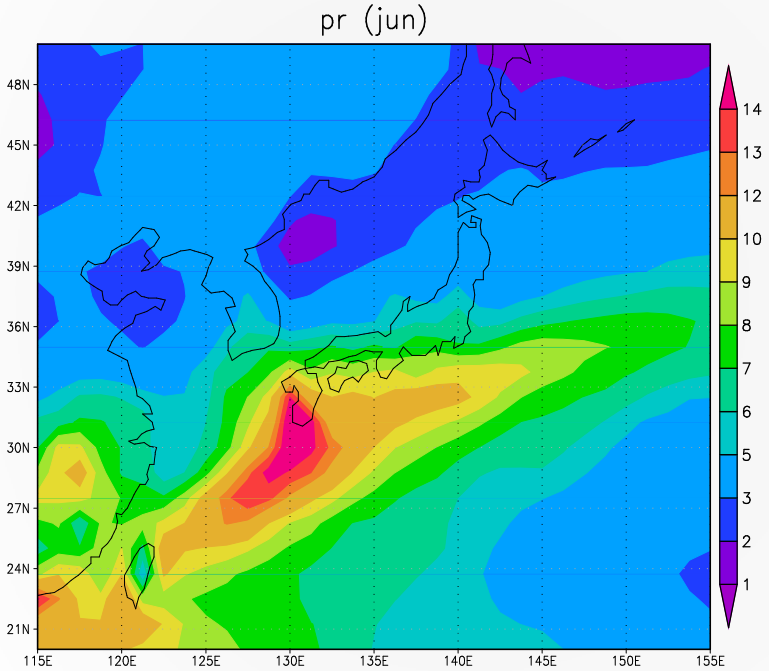
To display the Sea Level Pressure and Winds, see the distributed slideshows.

Schematic climatology of Japan (January)



JRA-55 monthly mean precipitation (mm/day) (June)

JRA-55

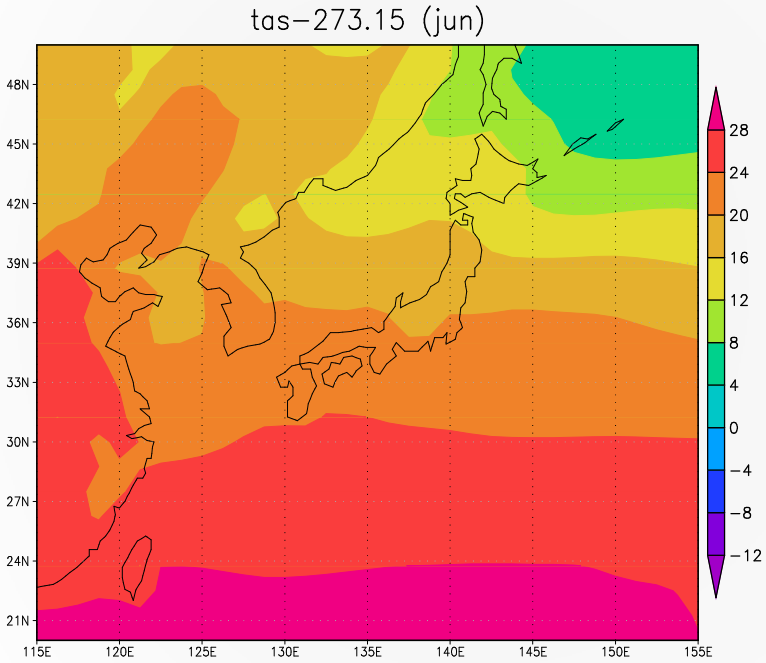



```
reinit
open JRA55/pr.clim.ctl
set gxout shaded
set grads off

set lon 115 155
set lat 20 50

set clevs 1 2 3 4 5 6 7 8 9 10 11 12 13 14

set t 6

d pr
cbarn

printim pr-jun.png white
```

June

JRA-55 monthly mean 2m temperature (℃) (June)

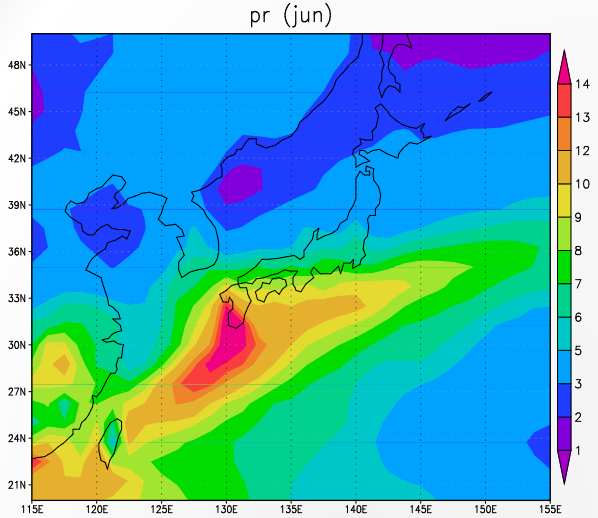
JRA-55



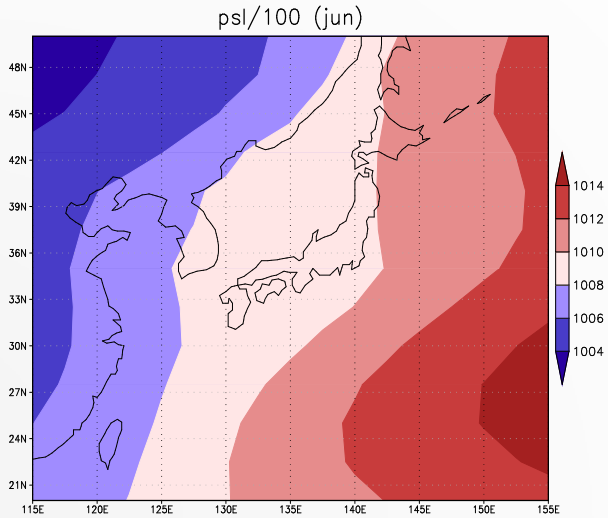

```
reinit
open JRA55/tas.clim.ctl
set gxout shaded
set grads off

set lon 115 155
set lat 20 50

set clevs -12 -8 -4 0 4 8 12 16 20 24 28

set t 6

d tas-273.15
cbarn

printim tas-jun.png white
```

JRA-55 monthly mean climatology of Japan (June)

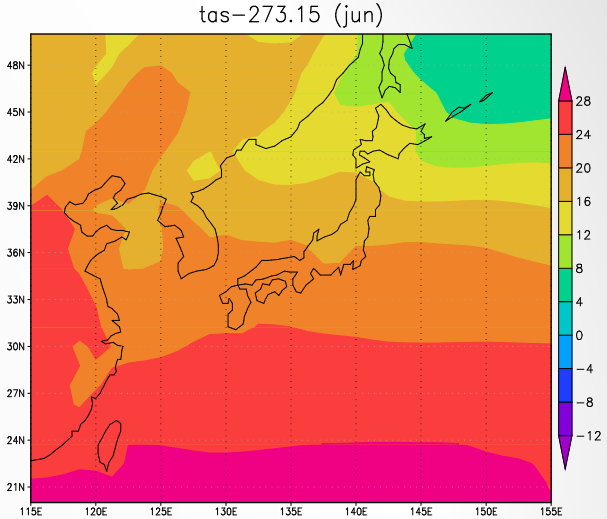
Precipitation (mm/day)



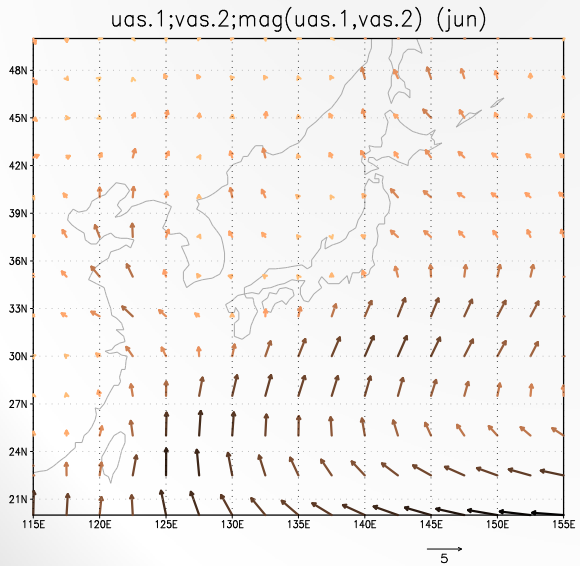
Sea Level Pressure (hPa)



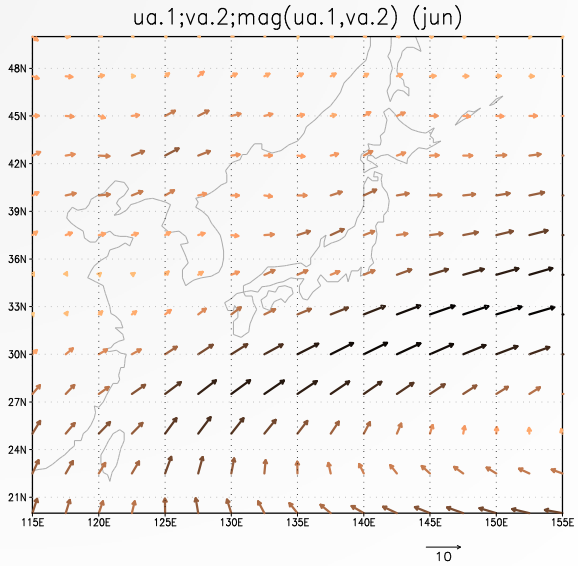
2m Temperature (°C)



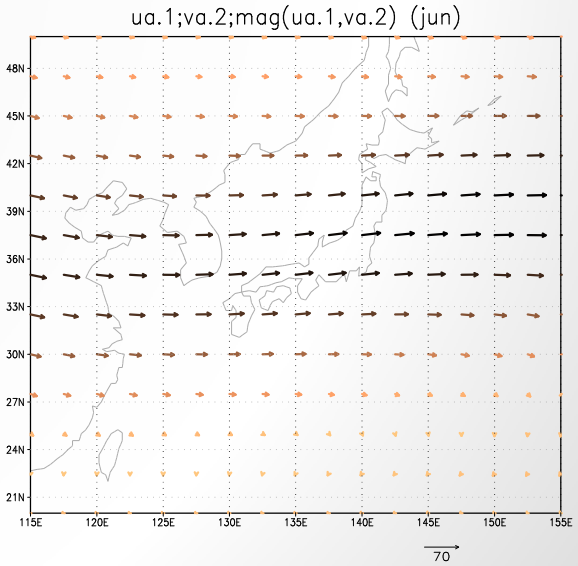
Near-Surface Wind (m/s)



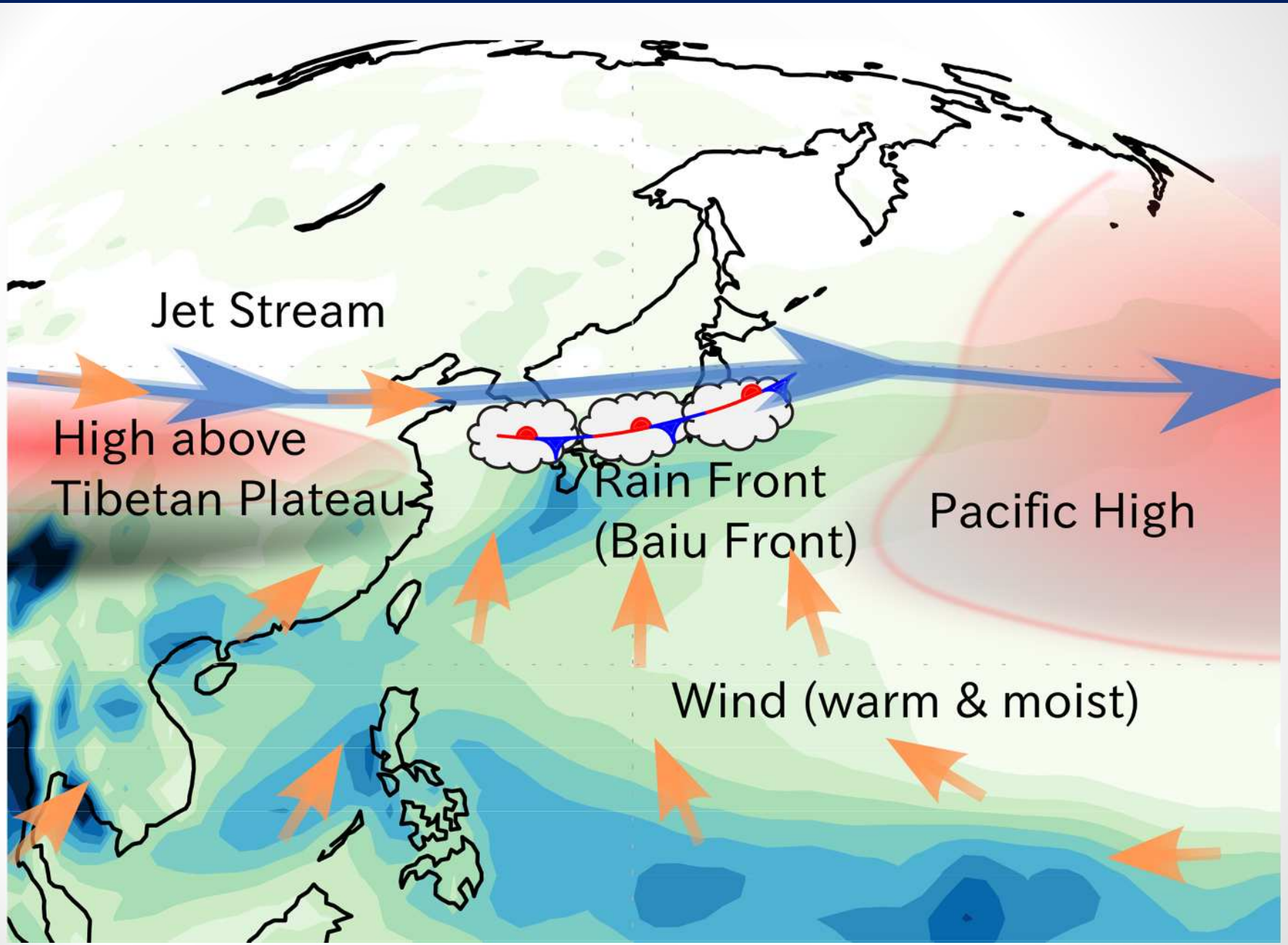
Wind (m/s) at 850 hPa



Wind (m/s) at 200 hPa



Schematic climatology of Japan (June)

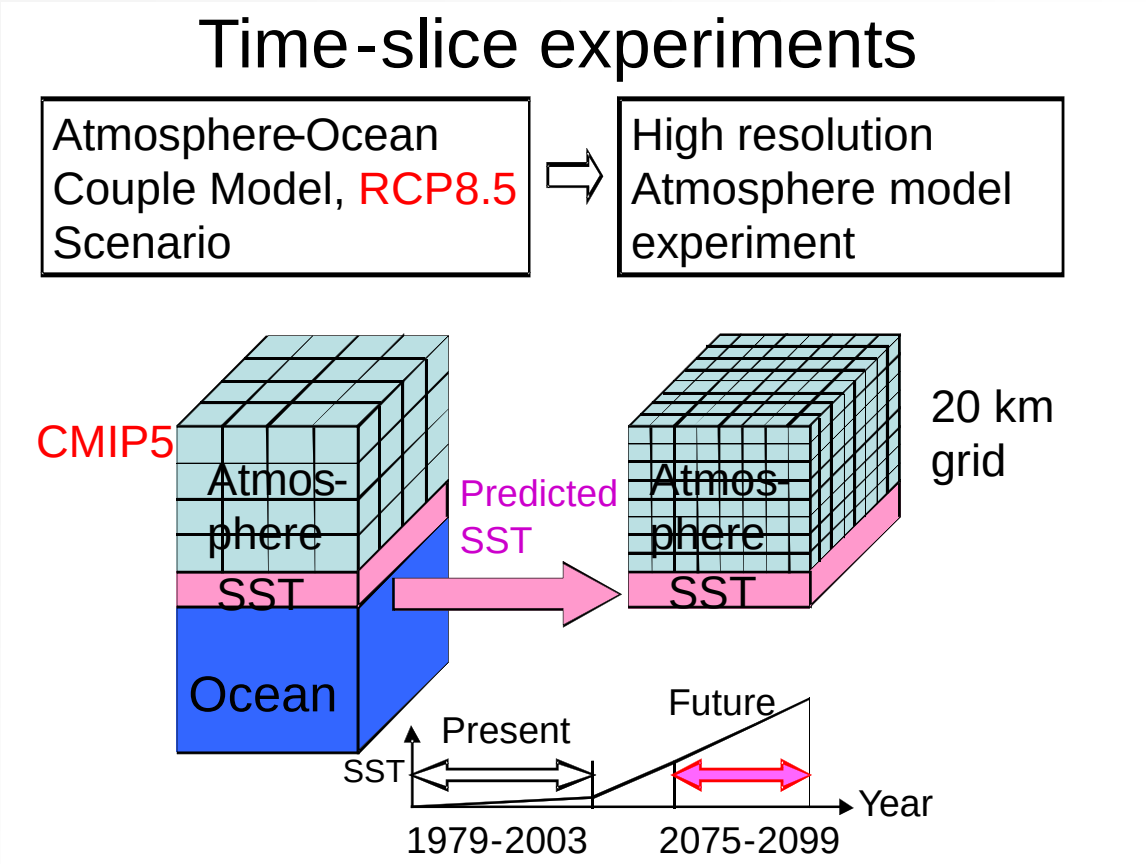


FROM MRI-AGCM3.2S - JRA-55

CHECK OF REPRODUCIBILITY

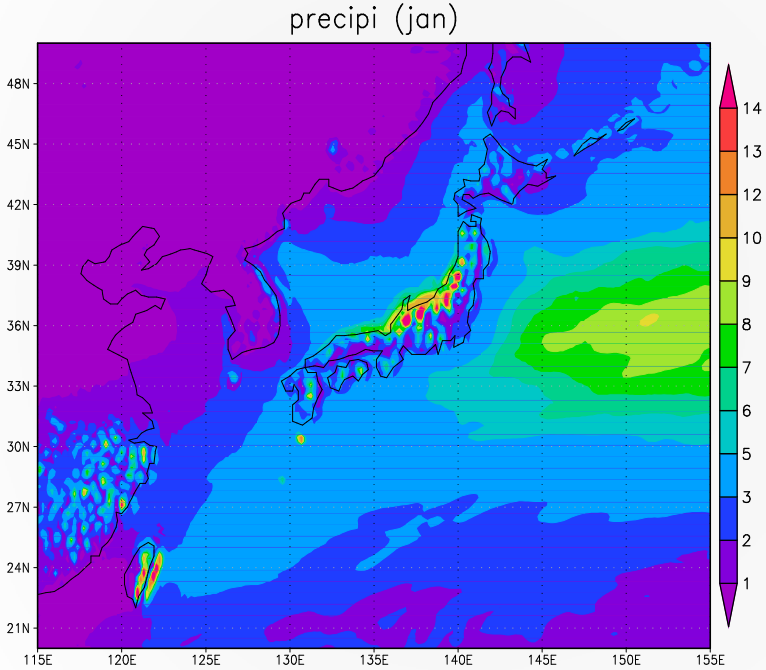
AGCM present-day simulation data

- **We have conducted global warming projections using an Atmospheric General Circulation model (AGCM) with 20-km mesh (MRI-AGCM3.2).**
- **Present-day simulation was conducted between 1979-2003.**



AGCM monthly mean precipitation (mm/day) (January)

MRI-AGCM3.2S

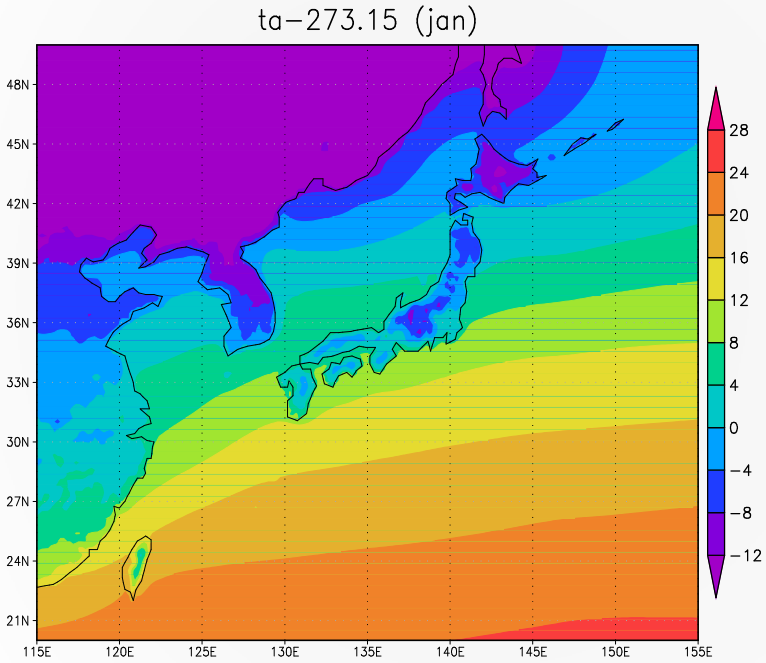



```
reinit
open AGCM/precipi-P.ctl
set gxout shaded
set grads off

set lon 115 155
set lat 20 50

set clevs 1 2 3 4 5 6 7 8 9 10 11 12 13 14

set t 1

d precipi
cbarn

printim precipi-P-jan.png white
```

January

AGCM monthly mean 2m temperature (℃) (January)

MRI-AGCM3.2S

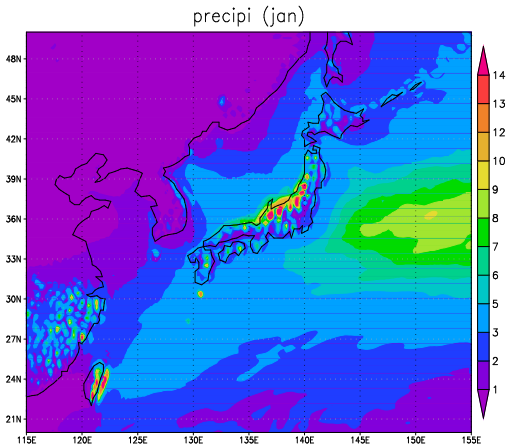



```
reinit
open AGCM/ta-P.ctl
set gxout shaded
set grads off

set lon 115 155
set lat 20 50

set clevs -12 -8 -4 0 4 8 12 16 20 24 28

set t 1

d ta-273.15
cbarn

printim ta-P-jan.png white
```

AGCM monthly mean climatology of Japan (January)

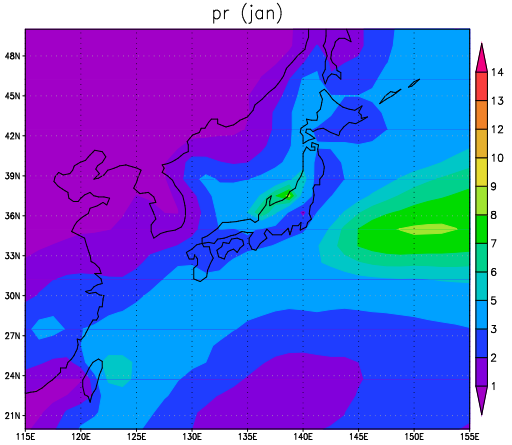
Precipitation (mm/day)

MRI-AGCM3.2S



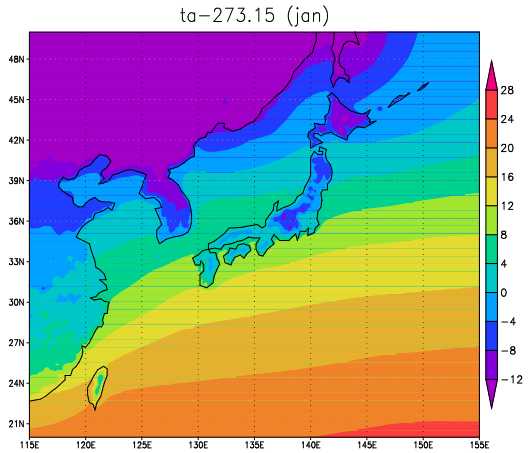
JRA-55

Precipitation (mm/day)

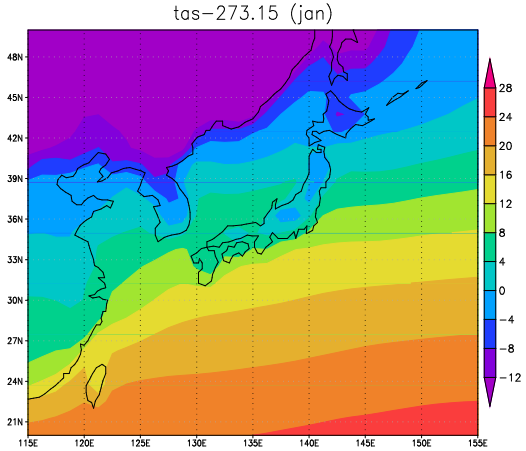


AGCM simulates JRA-55 climatology very well!
We can use AGCM data without bias correction.

2m Temperature (℃)



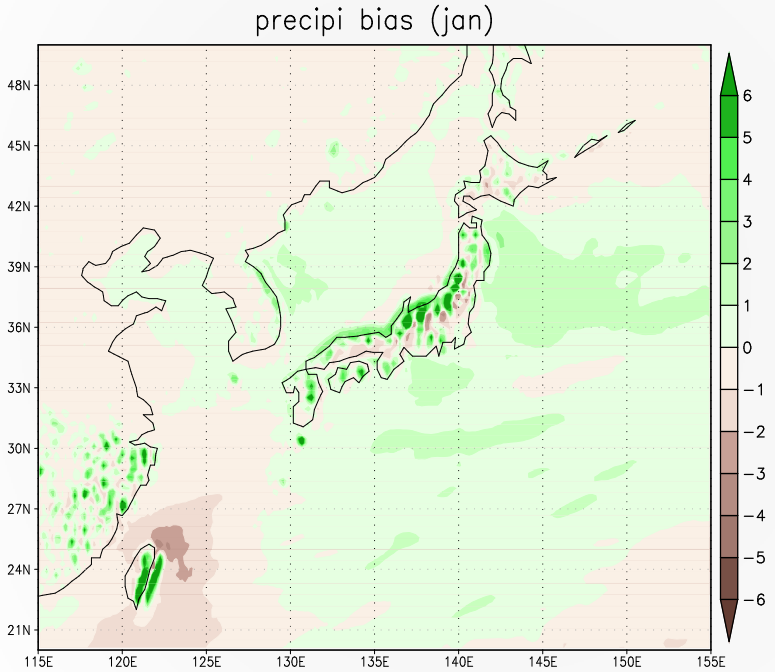
2m Temperature (℃)



For confirmation, we check the bias in the following slides.

AGCM monthly mean precipitation bias (mm/day) (January)

MRI-AGCM3.2S - JRA-55




```
reinit
open JRA55/pr.clim.ctl
open AGCM/precipi-P.ctl
set grads off
set gxout shaded

set lon 115 155
set lat 20 50

set clevs -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
define_colors
set rbcols 79 78 77 76 75 74 73 72 71 31
32 33 34 35 36 37 38 39

d precipi.2(t=1)-lterp(pr.1(t=1),precipi.2(t=1))
cbarn

printim precipi-bias-jan.png white
```

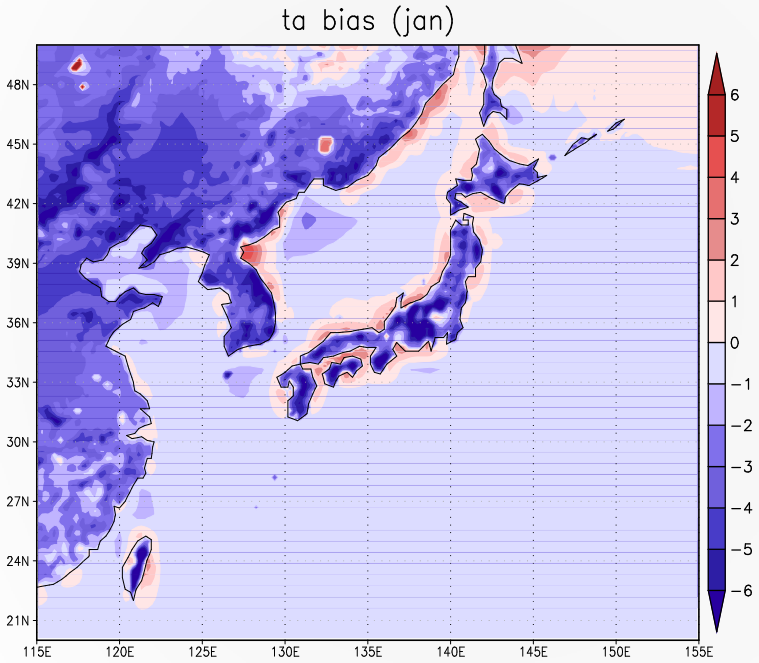
Set colors manually

January

lterp performs interpolation which is needed to compare between different resolution results.

AGCM monthly mean 2m temperature bias (℃) (January)

MRI-AGCM3.2S - JRA-55

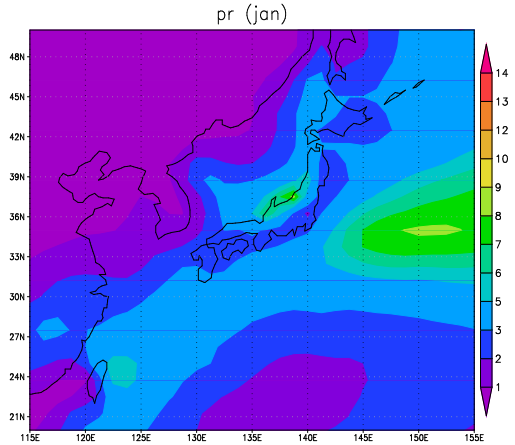



```
reinit
open JRA55/tas.clim.ctl
open AGCM/ta-P.ctl
set grads off
set gxout shaded

set lon 115 155
set lat 20 50

set clevs -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
define_colors
set rbcols 59 58 57 56 55 54 53 52 51 61
62 63 64 65 66 67 68 69

d ta.2(t=1)-lterp(tas.1(t=1),ta.2(t=1))
cbarn

printim ta-bias-jan.png white
```

AGCM monthly mean climatology bias (January)

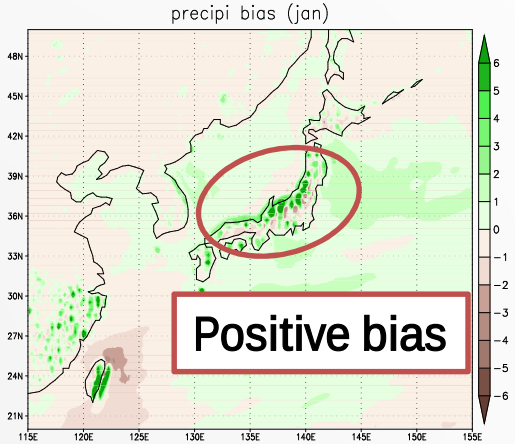
JRA-55

Precipitation (mm/day)



MRI-AGCM3.2S - JRA-55

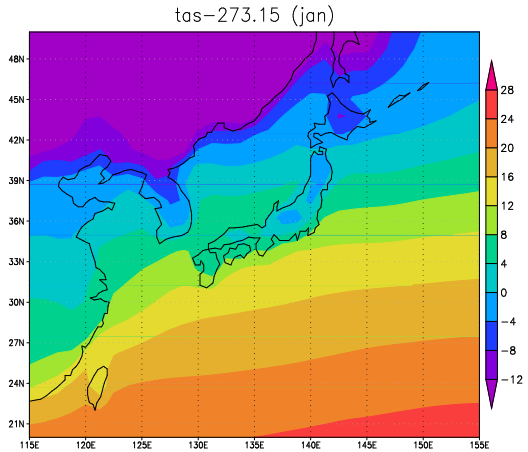
Precipitation (mm/day)



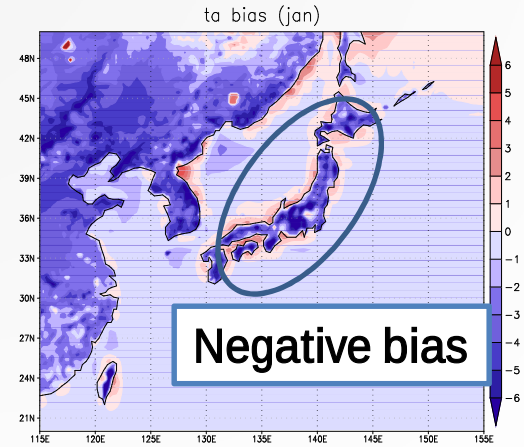
More precipitation in AGCM.

Why?

2m Temperature (℃)



2m Temperature (℃)



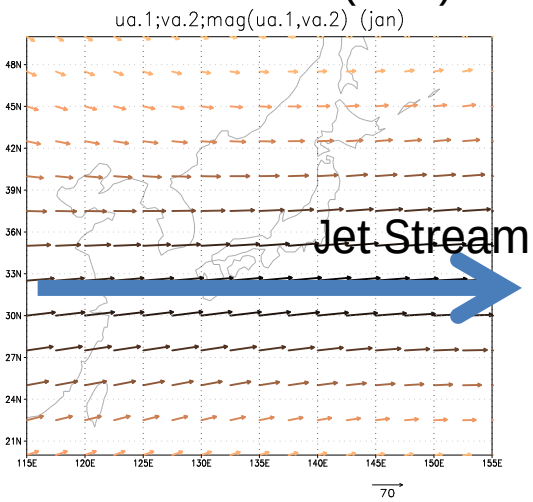
The result of AGCM is very colder than that of JRA55.

Why?

AGCM monthly mean climatology bias (January)

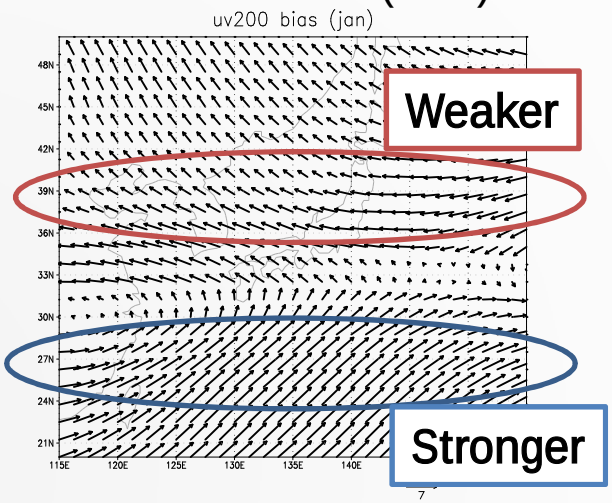
JRA-55

200hPa Wind (m/s)



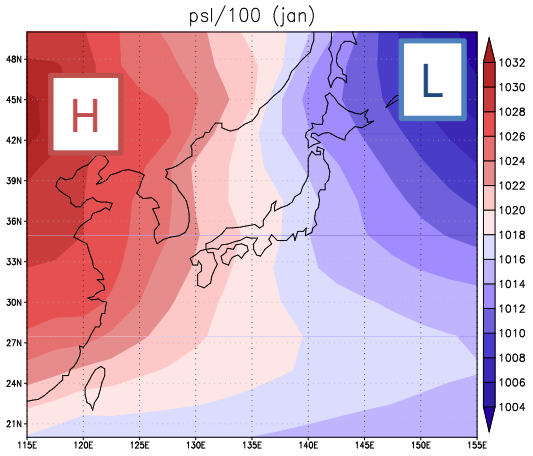
MRI-AGCM3.2S - JRA-55

200hPa Wind (m/s)

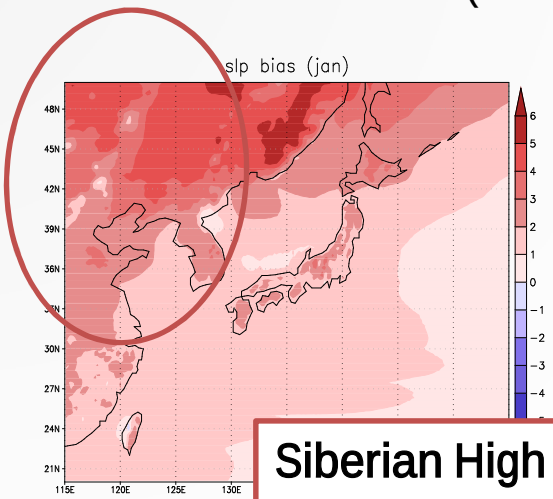


Jet stream is located more equatorward ,which means cold air from Siberia is stronger.
It is the cause of the colder temperature and more precipitation.

Sea Level Pressure (hPa)



Sea Level Pressure (hPa)

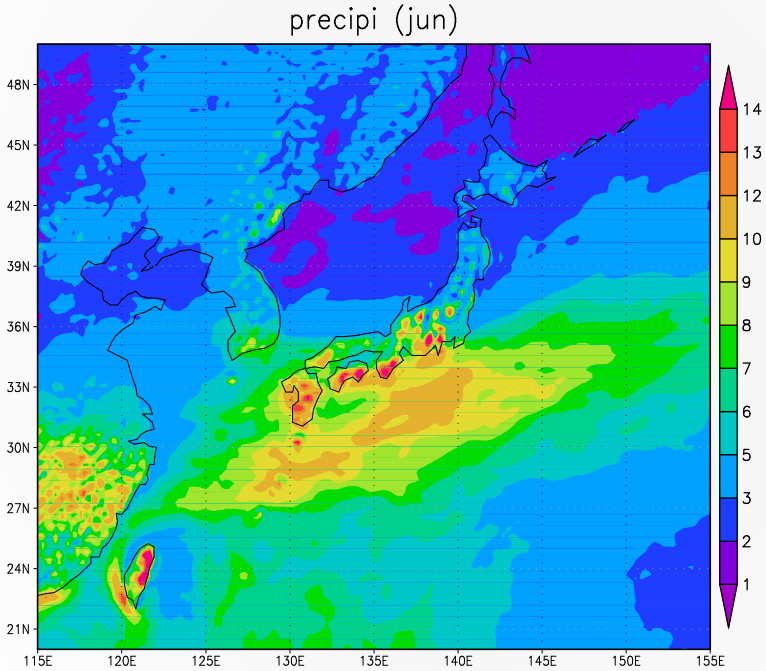


Siberian High is stronger

Larger pressure gradient of winter.
This gives Japan colder and windy season experience.

AGCM monthly mean precipitation (mm/day) (June)

MRI-AGCM3.2S

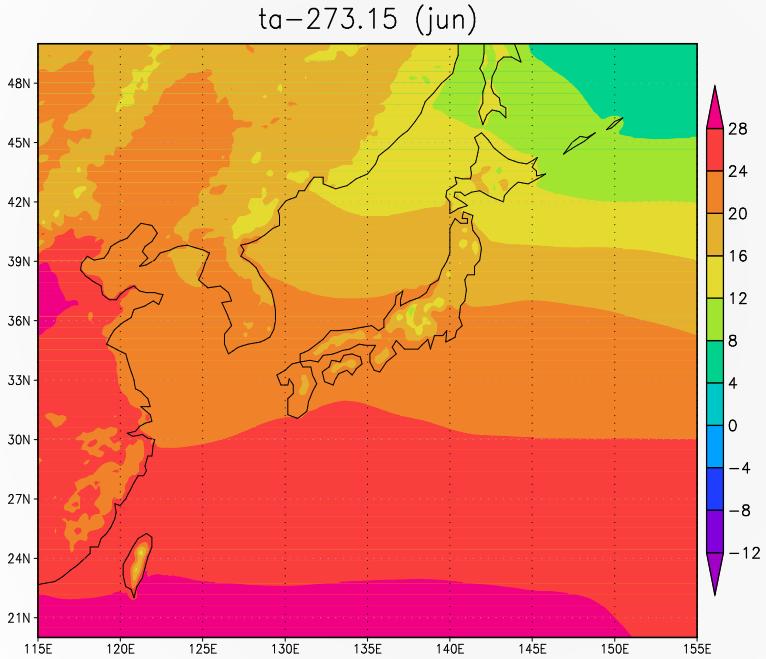



```
reinit
open AGCM/precipi-P.ctl
set gxout shaded
set grads off

set lon 115 155
set lat 20 50

set clevs 1 2 3 4 5 6 7 8 9 10 11 12 13 14

set t 6

d precipi
cbarn

printim precipi-P-jun.png white
```

June

AGCM monthly mean 2m temperature (℃) (June)

MRI-AGCM3.2S

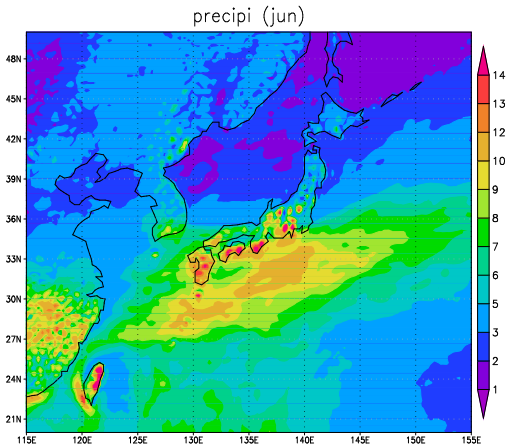



```
reinit
open AGCM/ta-P.ctl
set gxout shaded
set grads off

set lon 115 155
set lat 20 50

set clevs -12 -8 -4 0 4 8 12 16 20 24 28

set t 6

d ta-273.15
cbarn

printim ta-P-jun.png white
```

AGCM monthly mean climatology of Japan (June)

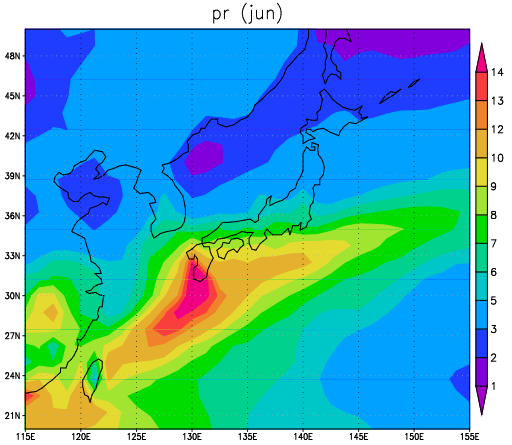
Precipitation (mm/day)

MRI-AGCM3.2S



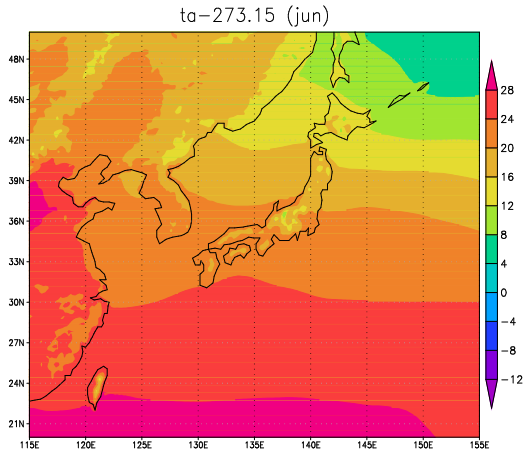
JRA-55

Precipitation (mm/day)

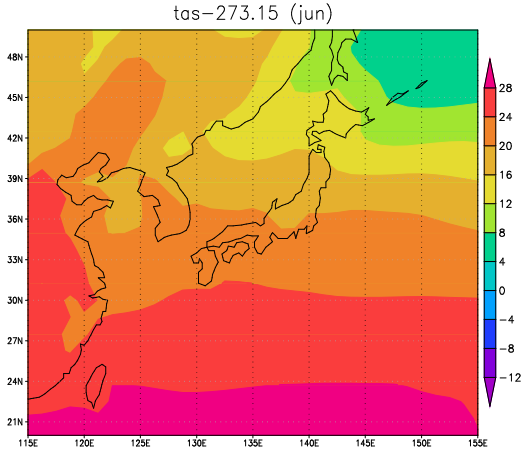


AGCM simulates JRA-55 climatology very well!
We can use AGCM data without bias correction.

2m Temperature (℃)

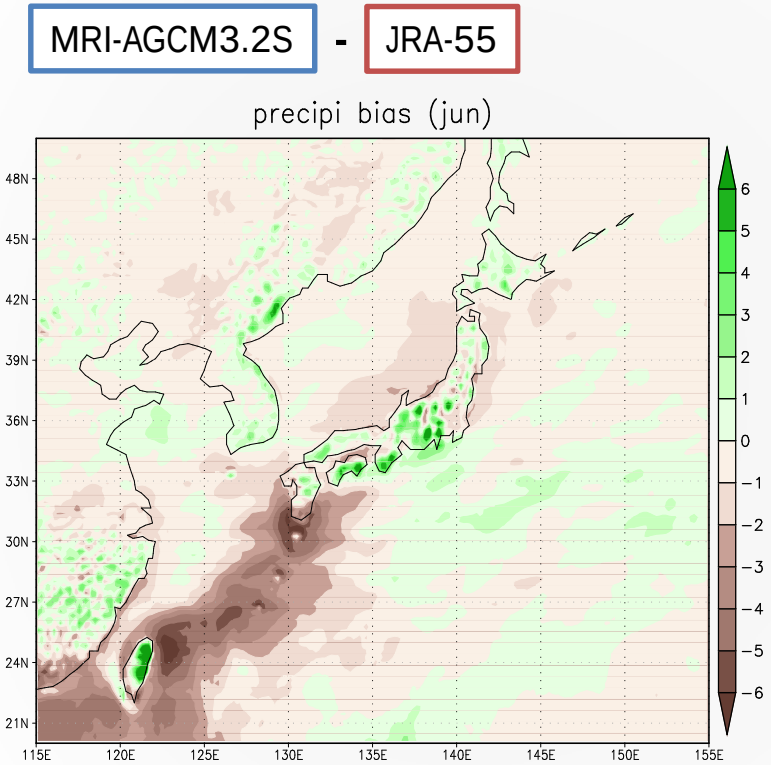


2m Temperature (℃)



For confirmation, we check the bias in the following slides.

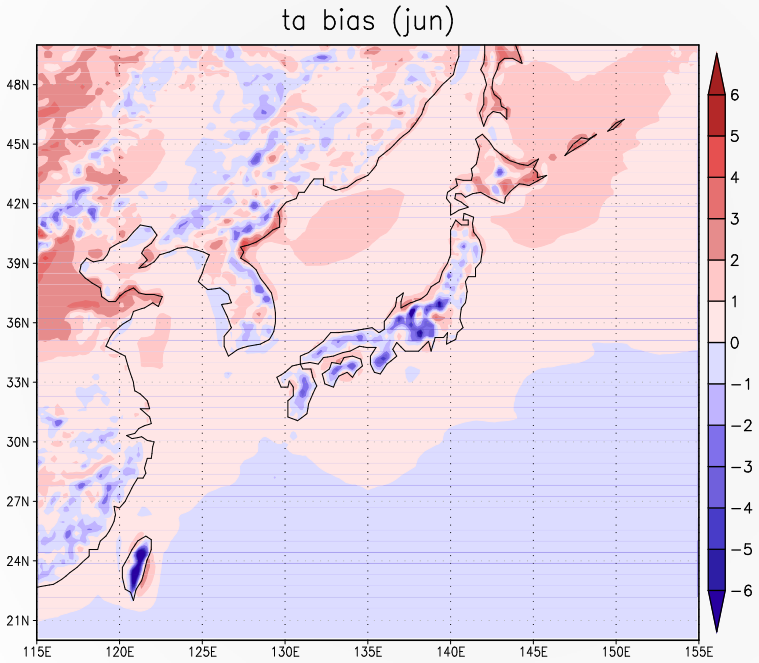
AGCM monthly mean precipitation bias (mm/day) (June)




```
reinit
open JRA55/pr.clim.ctl
open AGCM/precipi-P.ctl
set grads off
set gxout shaded

set lon 115 155
set lat 20 50

set clevs -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
define_colors
set rbcols 79 78 77 76 75 74 73 72 71 31
32 33 34 35 36 37 38 39

d precipi.2(t=6)-lterp(pr.1(t=6),precipi.2(t=6))
cbarn

printim precipi-bias-jun.png white
```

AGCM monthly mean 2m temperature bias (℃) (June)

MRI-AGCM3.2S - JRA-55

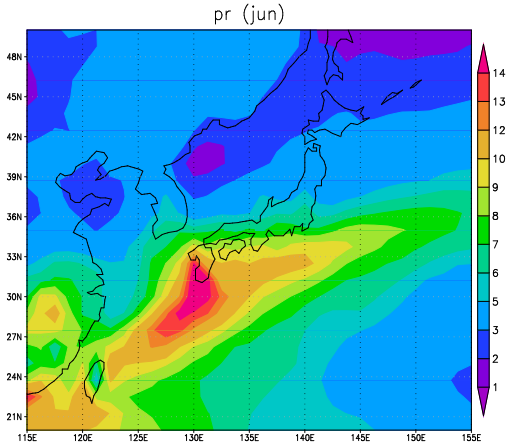



```
reinit
open JRA55/tas.clim.ctl
open AGCM/ta-P.ctl
set grads off
set gxout shaded

set lon 115 155
set lat 20 50

set clevs -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
define_colors
set rbcols 59 58 57 56 55 54 53 52 51 61
62 63 64 65 66 67 68 69

d ta.2(t=6)-lterp(tas.1(t=6),ta.2(t=6))
cbarn

printim ta-bias-jun.png white
```

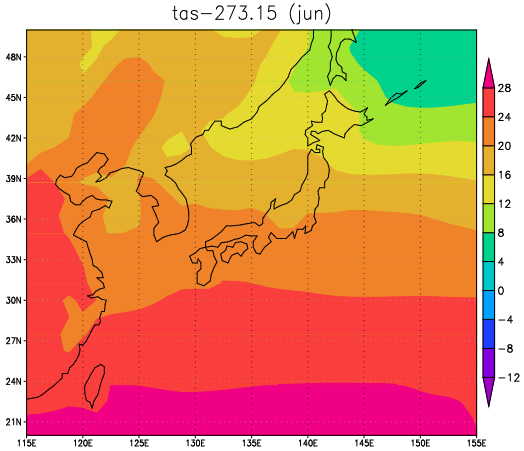
AGCM monthly mean climatology bias (June)

JRA-55

Precipitation (mm/day)

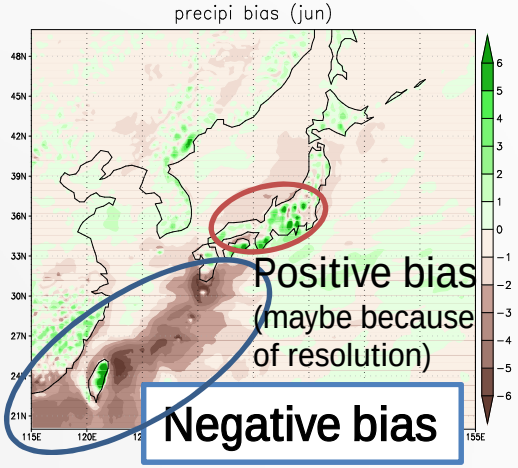


2m Temperature (℃)

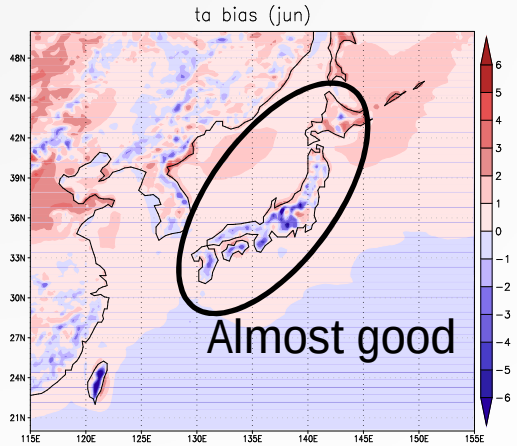


MRI-AGCM3.2S - JRA-55

Precipitation (mm/day)



2m Temperature (℃)



Precipitation in southeastern Japan is weaker in the result of AGCM.

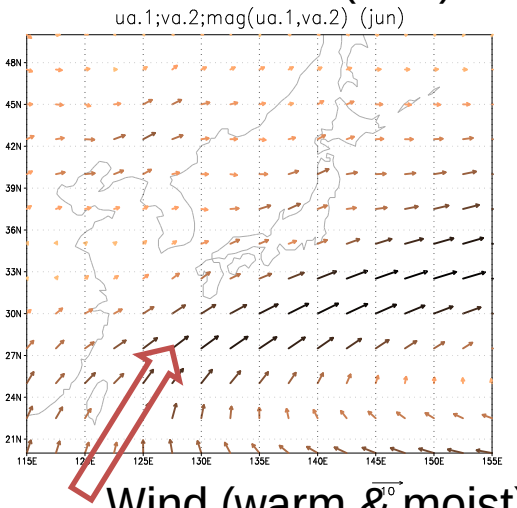
Why?

The difference is acceptable. We can use it straightforward.

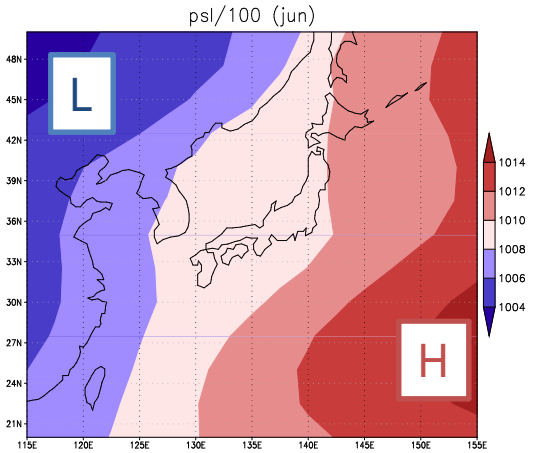
AGCM monthly mean climatology bias (June)

JRA-55

850hPa Wind (m/s)

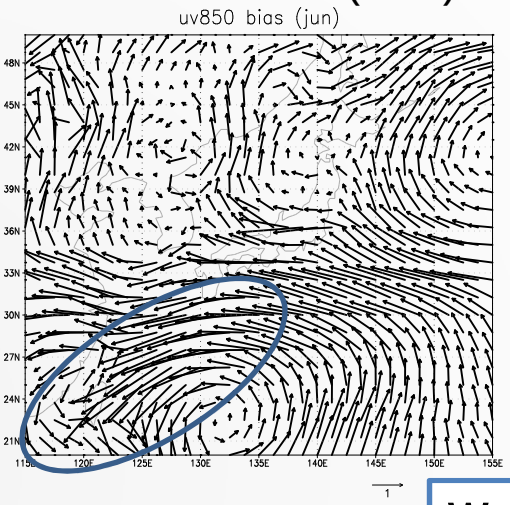


Sea Level Pressure (hPa)



MRI-AGCM3.2S - JRA-55

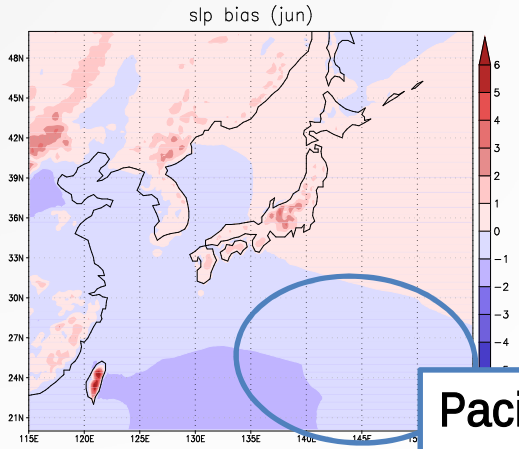
850hPa Wind (m/s)



South wind (warm & moist) is weaker in AGCM. This makes rain front weaker at the region.

Weaker Wind

Sea Level Pressure (hPa)

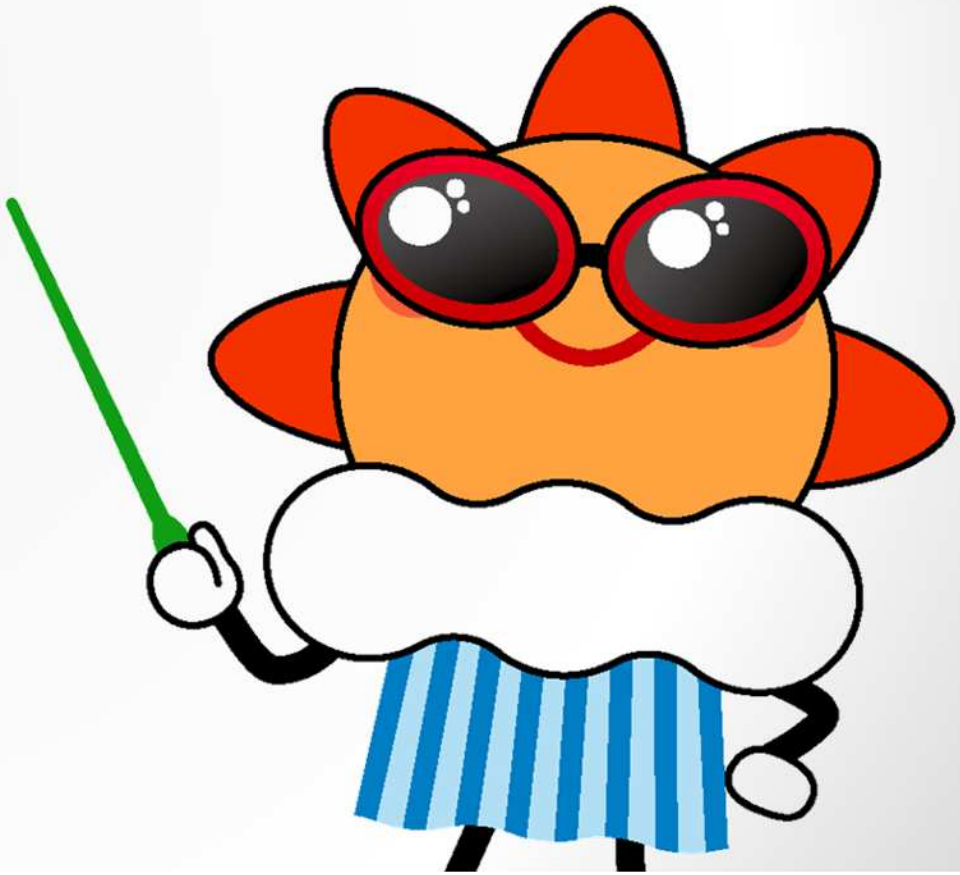


Pacific High is weaker so the position of south wind is more eastward.

Pacific High is Weaker

And it's your turn!

- **Follow today's procedure and check the AGCM's reproducibility for your country.**



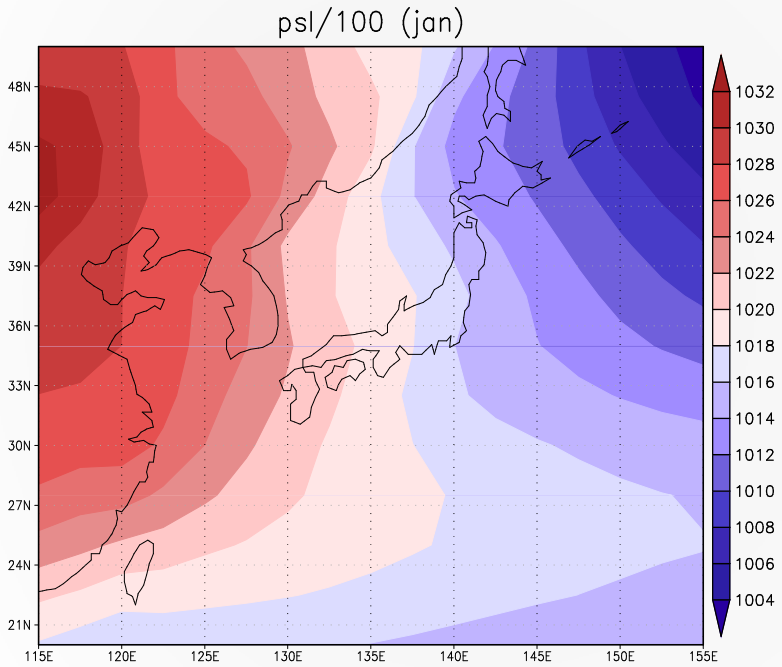
End

FROM JRA-55

FURTHER READING: OTHER ELEMENTS

Sea Level Pressure (hPa) (January)

JRA-55



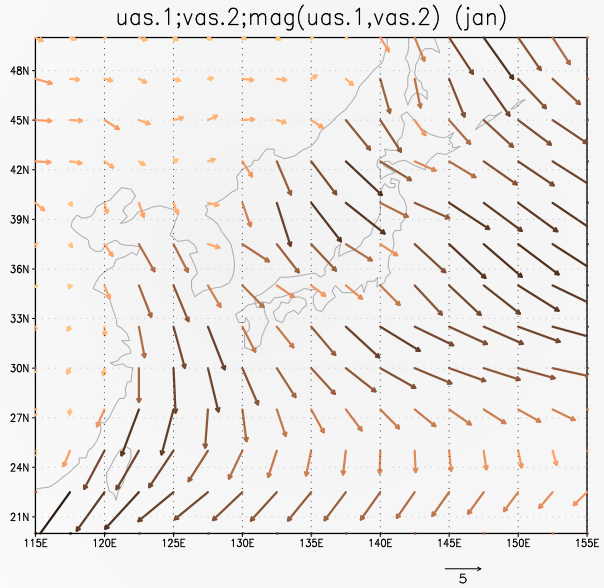

```
reinit
open JRA55/psl.clim.ctl
set gxout shaded
set grads off

set lon 115 155
set lat 20 50

define_colors
set rbcols 59 58 57 56 55 54 53 52 51 61
62 63 64 65 66 67 68 69
set cint 2

set t 1

d psl/100
cbarn

printim psl-jan.png white
```

Set contour interval manually

Pa → hPa

Near-Surface Wind (m/s) (January)

JRA-55

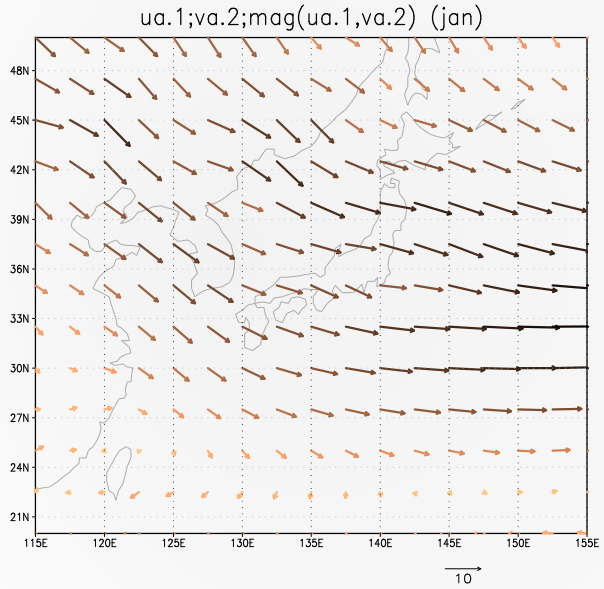



```
reinit
open JRA55/uas.clim.ctl
open JRA55/vas.clim.ctl
set grads off

set lon 115 155
set lat 20 50

set t 1

d uas.1;vas.2

printim uvas-jan.png white
```

Display as vectors

Wind (m/s) at 850 hPa (January)

JRA-55

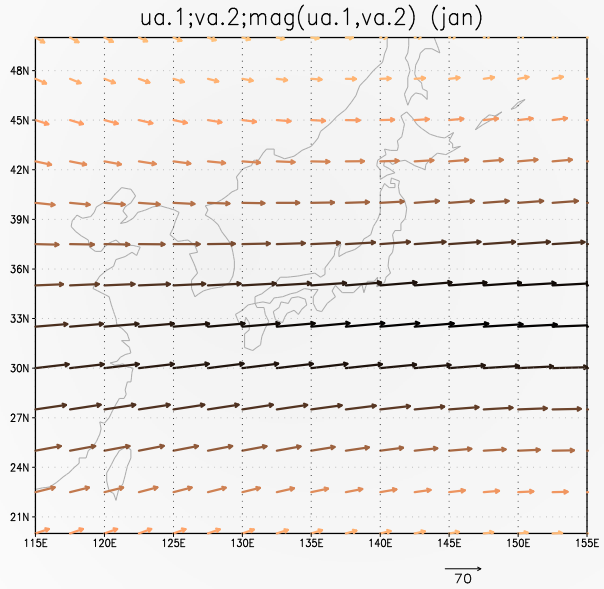



```
reinit
open JRA55/ua.clim.ctl
open JRA55/va.clim.ctl
set grads off

set lon 115 155
set lat 20 50

set lev 850
set t 1

d ua.1;va.2

printim uva850-jan.png white
```

at 850 hPa

Wind (m/s) at 200 hPa (January)

JRA-55

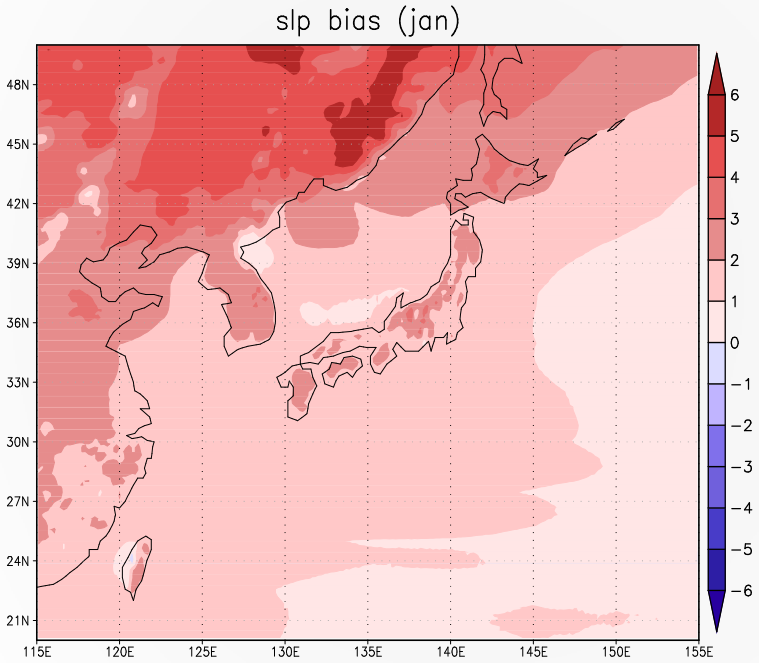



```
reinit
open JRA55/ua.clim.ctl
open JRA55/va.clim.ctl
set grads off

set lon 115 155
set lat 20 50

set lev 200
set t 1

d ua.1;va.2

printim uva200-jan.png white
```

at 200 hPa

AGCM monthly mean sea level pressure bias (hPa) (January)

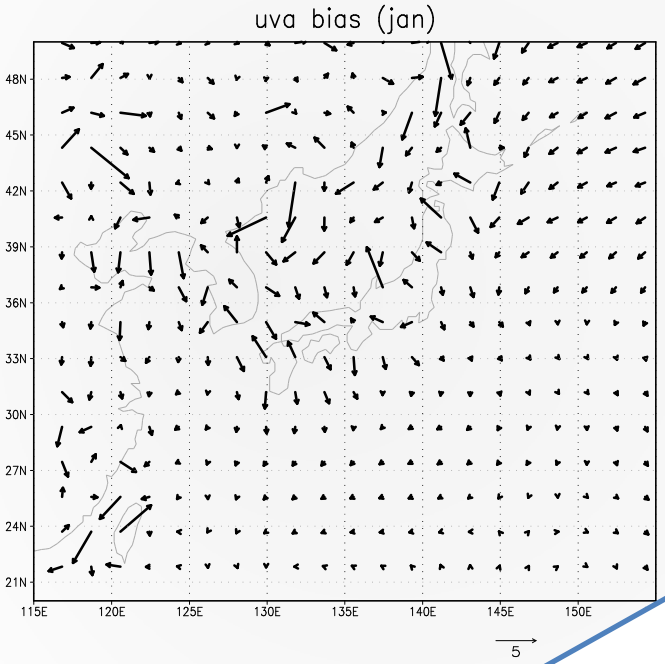
MRI-AGCM3.2S - JRA-55




```
reinit
open JRA55/psl.clim.ctl
open AGCM/slp-P.ctl
set grads off
set gxout shaded

set lon 115 155
set lat 20 50

set clevs -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
define_colors
set rbcols 59 58 57 56 55 54 53 52 51 61
62 63 64 65 66 67 68 69

d (slp.2(t=1)-lterp(psl.1(t=1),slp.2(t=1)))/100
cbarn

printim slp-bias-jan.png white
```

AGCM monthly mean near-surface wind bias (m/s) (January)

MRI-AGCM3.2S - JRA-55




```
reinit
open JRA55/uas.clim.ctl
open JRA55/vas.clim.ctl
open AGCM/ua-P.ctl
open AGCM/va-P.ctl
set grads off

set lon 115 155
set lat 20 50

d ua.3(t=1)-lterp(uas.1(t=1),ua.3(t=1));va.4(t=1)-
lterp(vas.2(t=1),va.4(t=1))

printim uva-bias-jan.png white
```

If there are too many vectors, try:
d skip(ua.3(t=1)-lterp(uas.1(t=1),ua.3(t=1)),10,10);va.4(t=1)-lterp(vas.2(t=1),va.4(t=1))