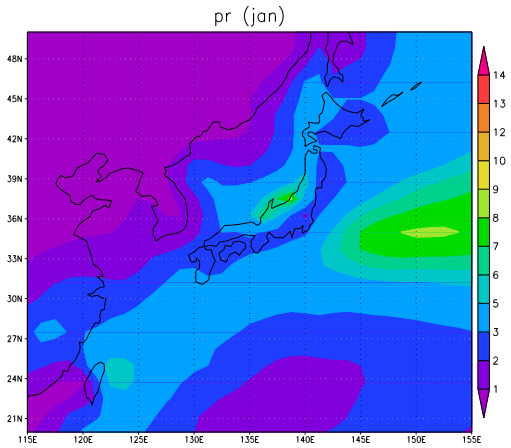
Global warming projection for Japan

- Element and period
  - Temperature in January
    … risk of avalanche
  - Precipitation in January
    … risk of snow depth change
  - Temperature in June
    … risk of heat stroke
  - Precipitation in June
    … risk of flood and drought

AGCM monthly mean climatology bias (January)

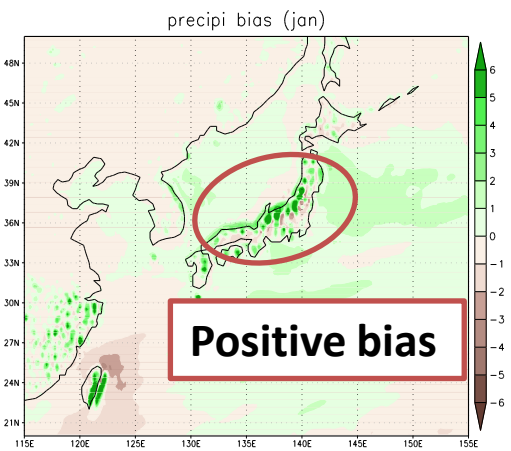
JRA-55

Precipitation (mm/day)



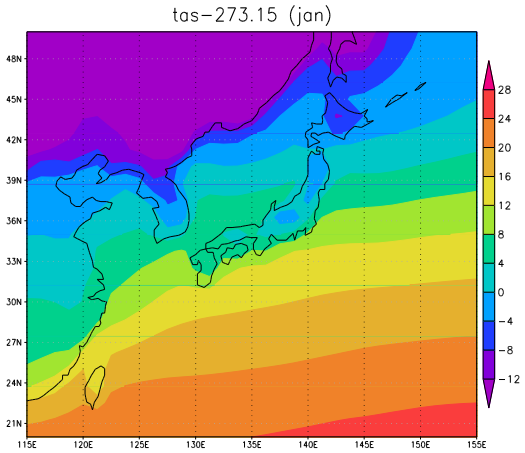
MRI-AGCM3.2S - JRA-55

Precipitation (mm/day)

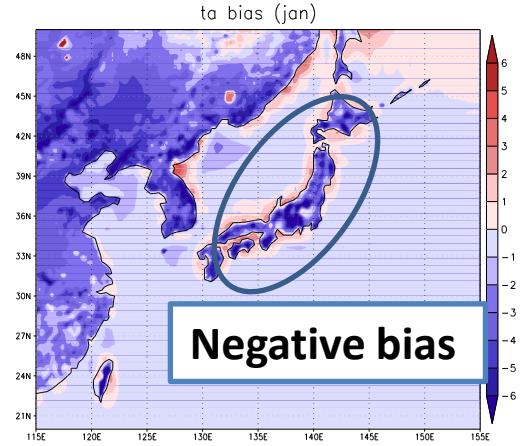


More precipitation in AGCM.

2m Temperature (℃)



2m Temperature (℃)

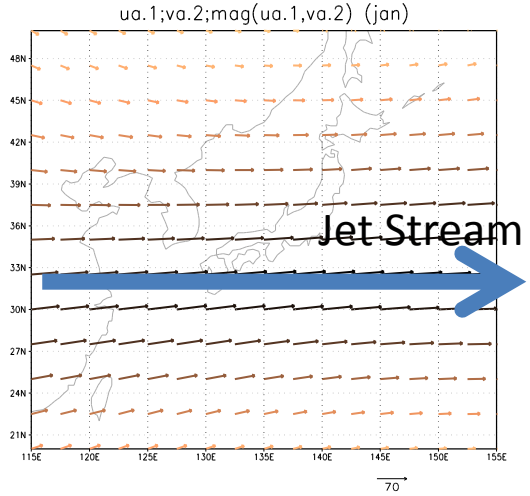


The result of AGCM is very colder than that of JRA55.

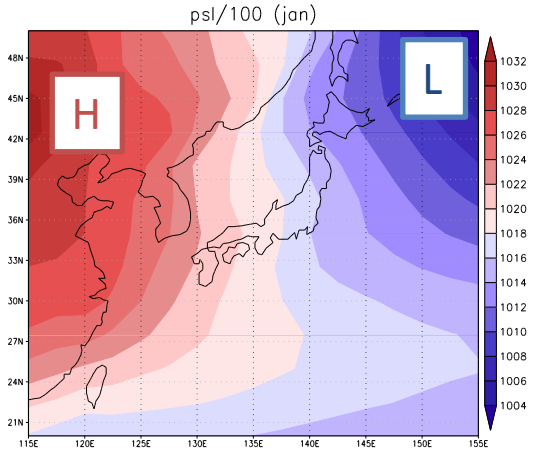
AGCM monthly mean climatology bias (January)

JRA-55

200hPa Wind (m/s)

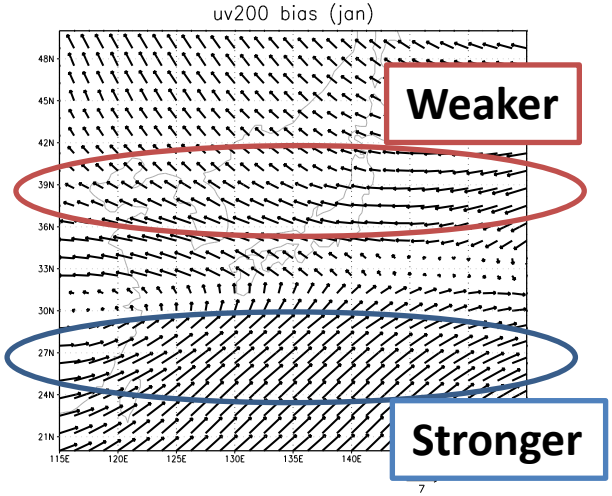


Sea Level Pressure (hPa)



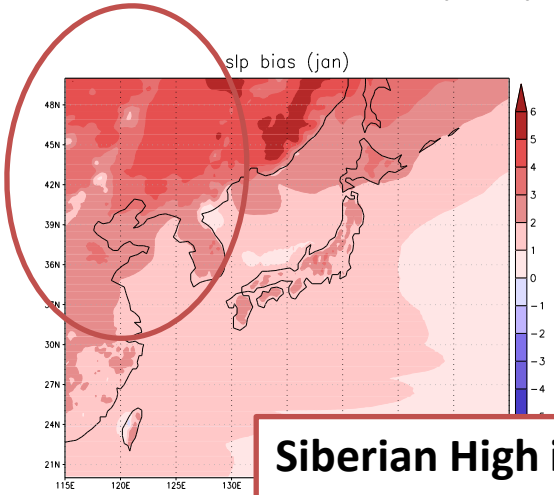
MRI-AGCM3.2S - JRA-55

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)



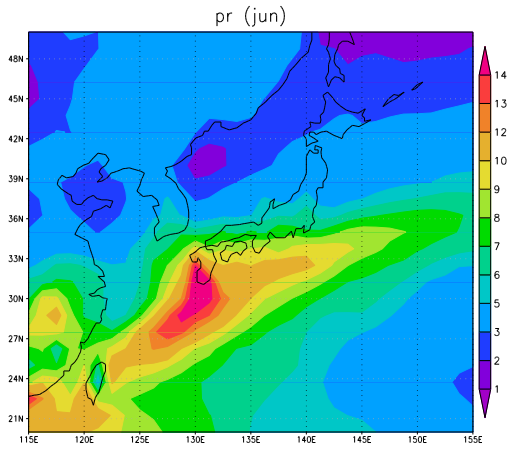
Siberian High is stronger

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

AGCM monthly mean climatology bias (June)

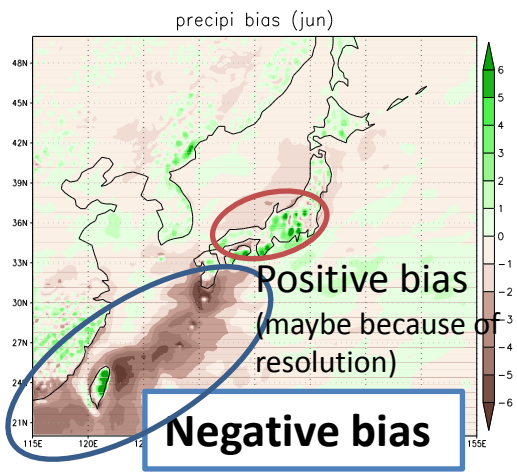
JRA-55

Precipitation (mm/day)



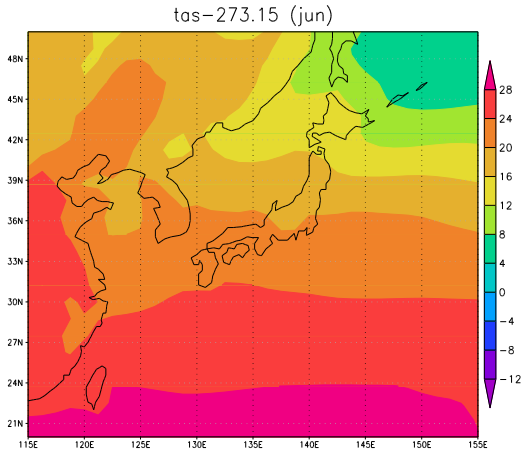
MRI-AGCM3.2S - JRA-55

Precipitation (mm/day)

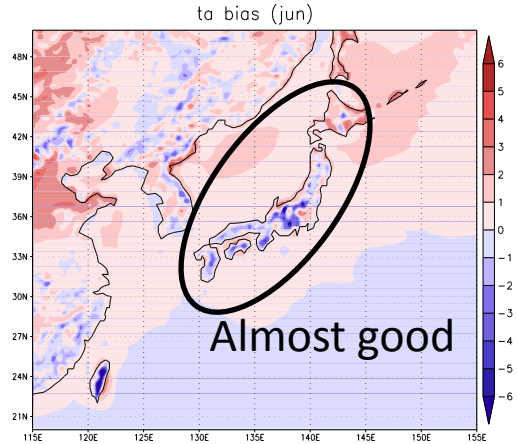


Precipitation in southeastern Japan is weaker in the result of AGCM.

2m Temperature (℃)



2m Temperature (℃)

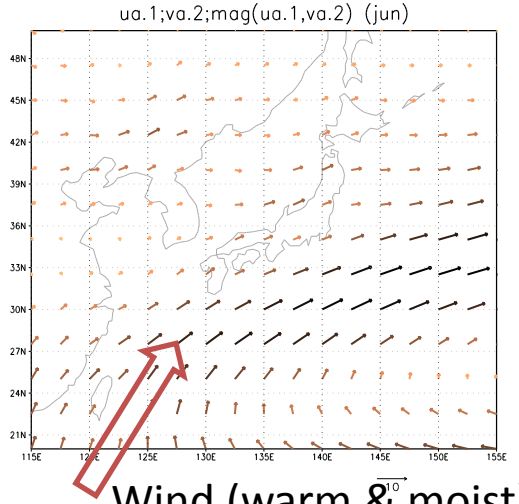


The difference is acceptable.
We can use it straightforward.

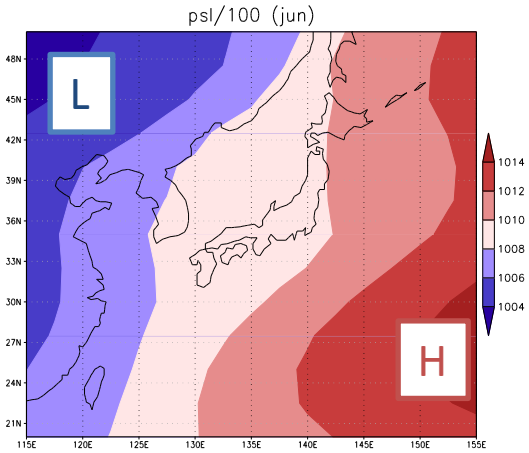
AGCM monthly mean climatology bias (June)

JRA-55

850hPa Wind (m/s)

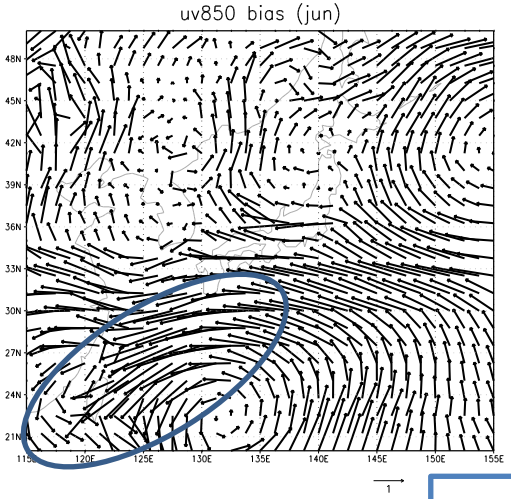


Sea Level Pressure (hPa)



MRI-AGCM3.2S - JRA-55

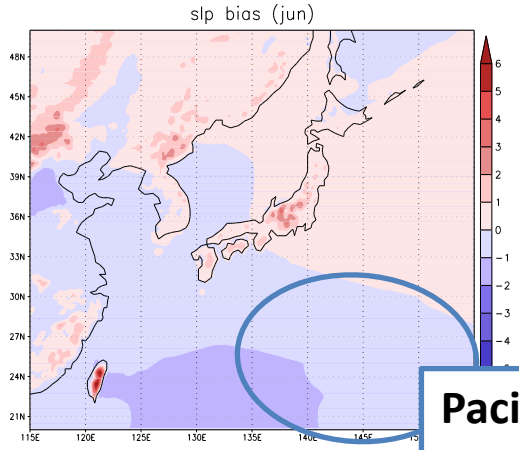
850hPa Wind (m/s)



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

Weaker Wind

Sea Level Pressure (hPa)

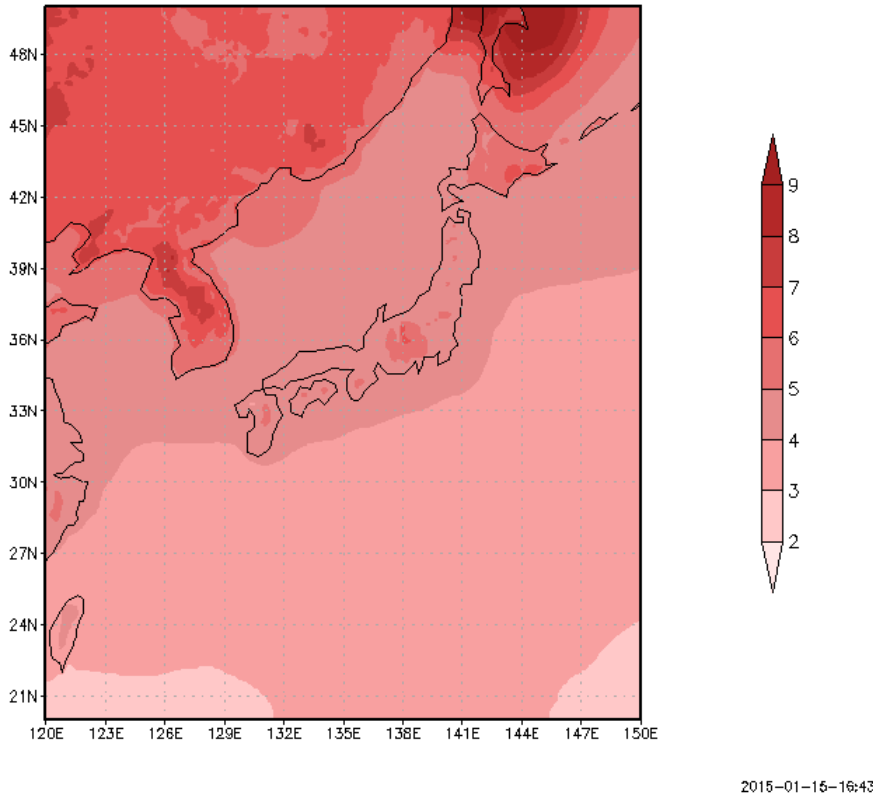


Pacific High is weaker so the position of south wind is more eastward.

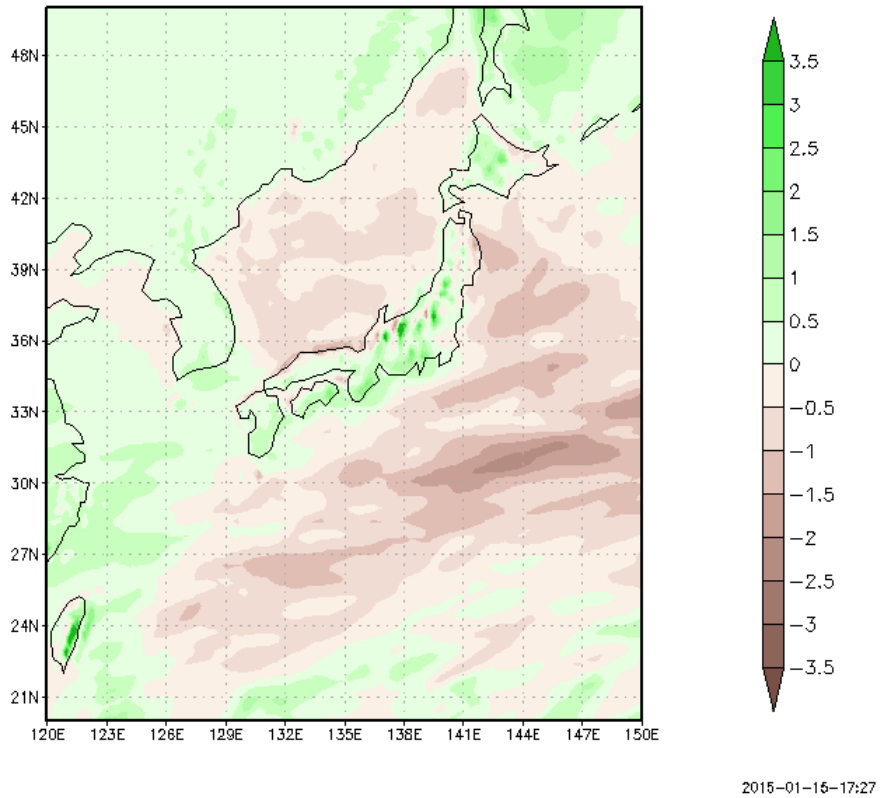
Pacific High is Weaker

Future climate change (January)

change in surface air temperature



change in precipitation

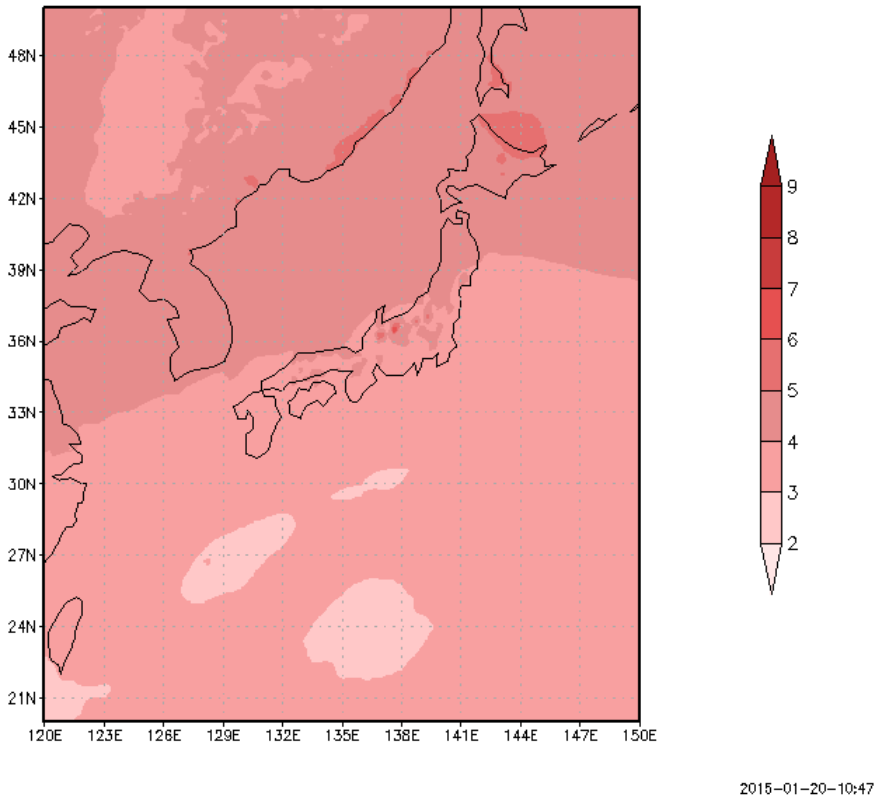


- ✓ Temperature around Japan is projected to increase between 3 to 5 deg C.
- ✓ The region at high latitude will warm more rapidly.

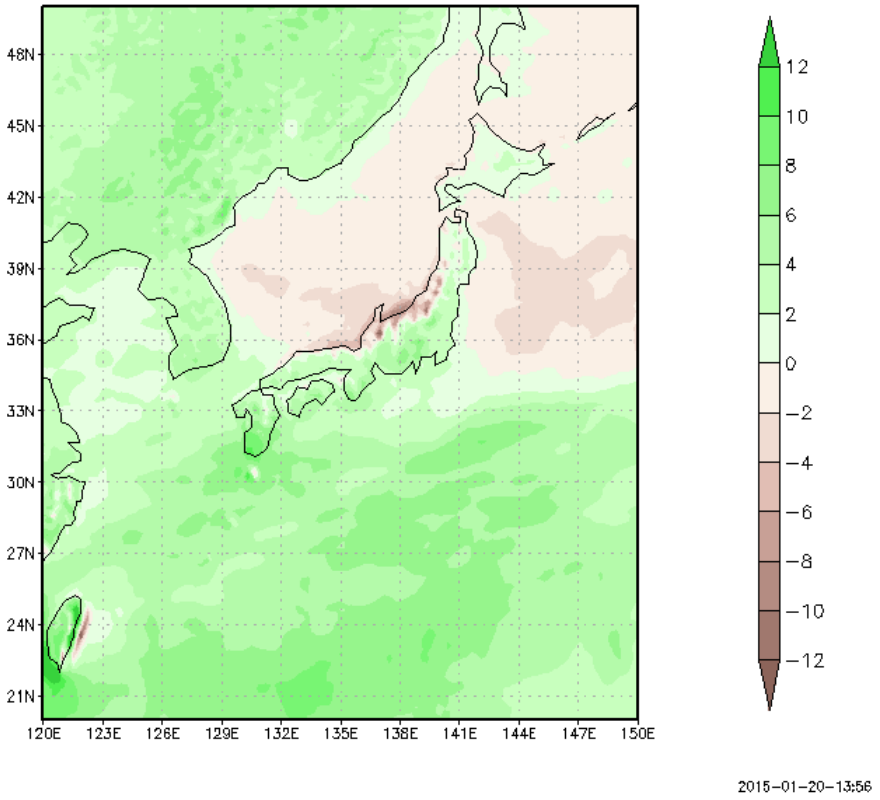
- ✓ Precipitation on land of Japan is projected to increase in the future.

Future climate change (June)

change in surface air temperature



change in precipitation

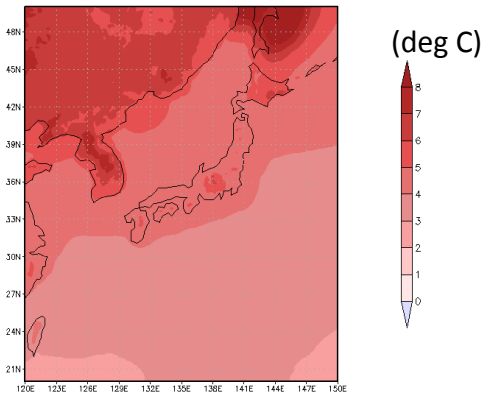


- ✓ Temperature around Japan is projected to increase between 2 to 4 deg C.
- ✓ Warming in June will be smaller than in January.

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

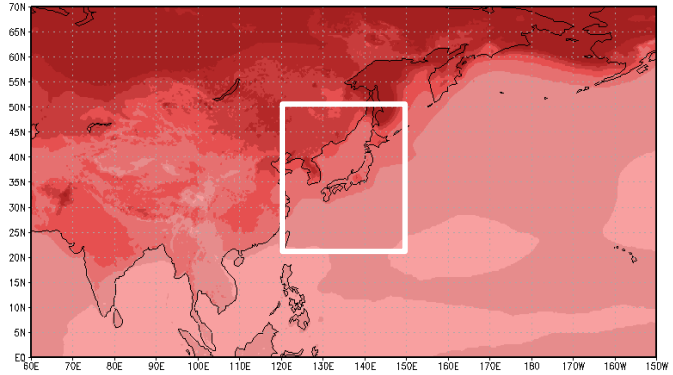
Check of uncertainty（Temperature in January）

Temperature(Future-Present) (Jan)

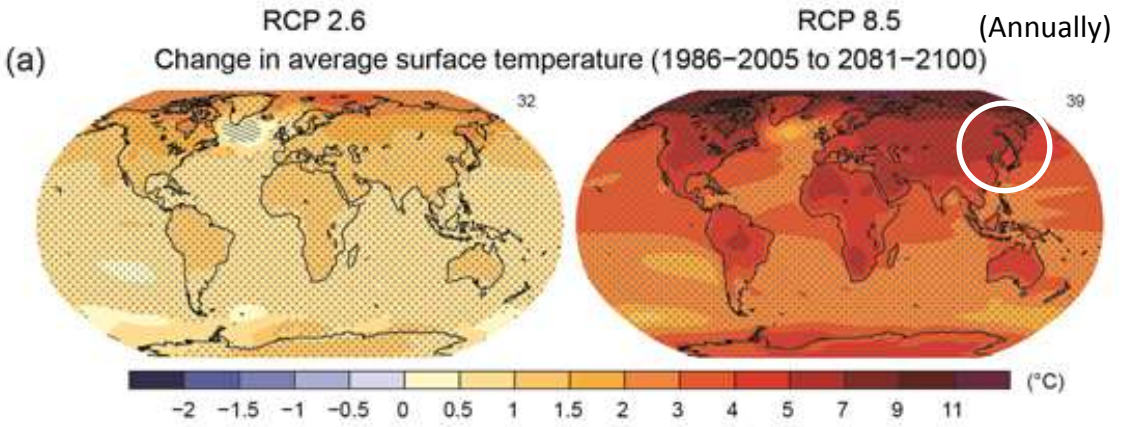


- ✓ Temperature around Japan is projected to increase between 3 to 5 deg C.
- ✓ The region at high latitude will warm more rapidly.

Temperature(Future-Present) (Jan)

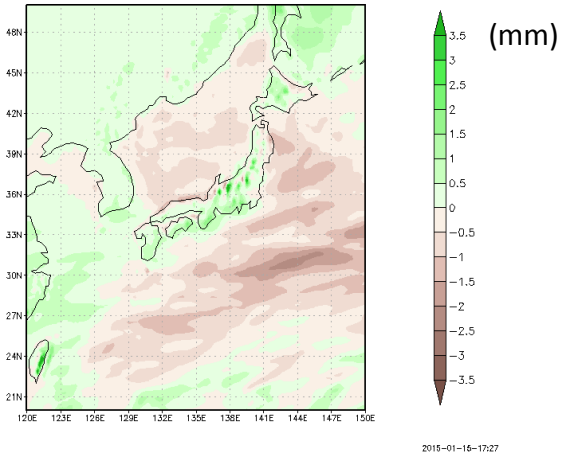


- Wide area change (right top)
  - These two features are similar.
  - In addition, land area will warm more than ocean.
  - Therefor, uncertainty of area is small.
- AR5 by multi model (right bottom)
  - These features are consistent.
  - So, uncertainty of single model is small.
- Model bias
  - Pressure gradient of winter is reproduced.
  - Negative bias is offset.
- Therefore, it is considered that the two features show future climate change.



Check of uncertainty（Precipitation in January）

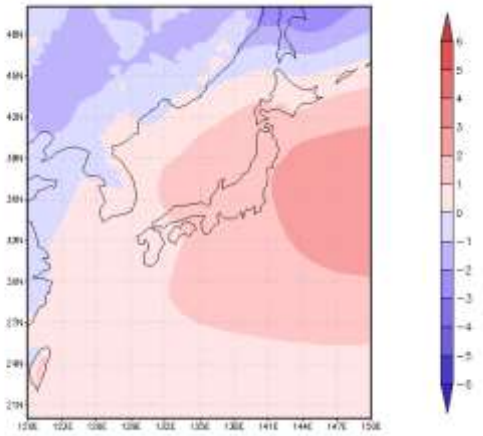
Precipitation (Future-Present) (January)



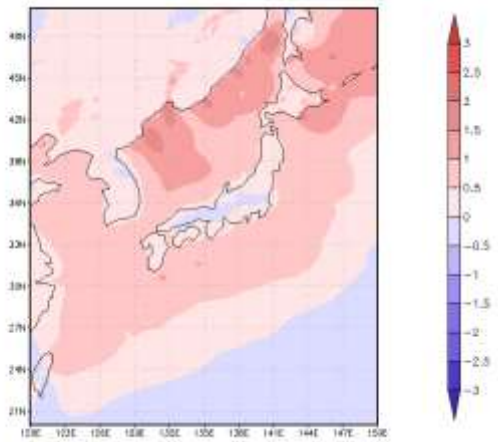
- Synoptic scale
- Sea level pressure gradient weakens in future (right top), and surface meridian velocity strengthens in future (right bottom).
- These indicate that moisture supply decrease to atmosphere at Sea of Japan (A). This is different from the prediction results (left top).
- Surface temperature
- On the other hand, increasing surface temperature suggest that precipitation increases since saturated vapor pressure increases (B). This is consistent with the prediction results.
- Model bias
- Jet stream is located more equatorward ,which means cold air from Siberia is stronger.
- This strengthen effect of (B) than (A), and might increase precipitation.
- Therefore, it is difficult to consider that the feature show future climate change.

✓ Precipitation on land of Japan is projected to increase in the future.

Sea Level Pressure (F-P) (hPa)

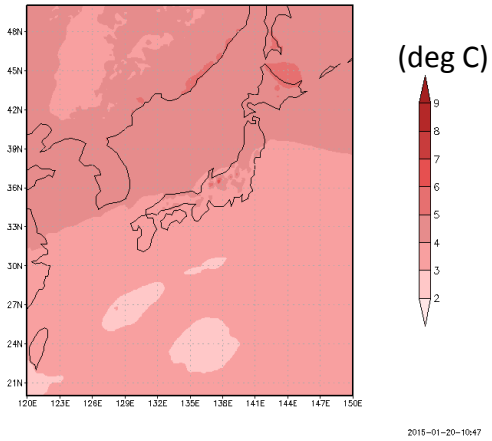


Surface Meridian Velocity (F-P) (m/s)



Check of uncertainty（Temperature in June）

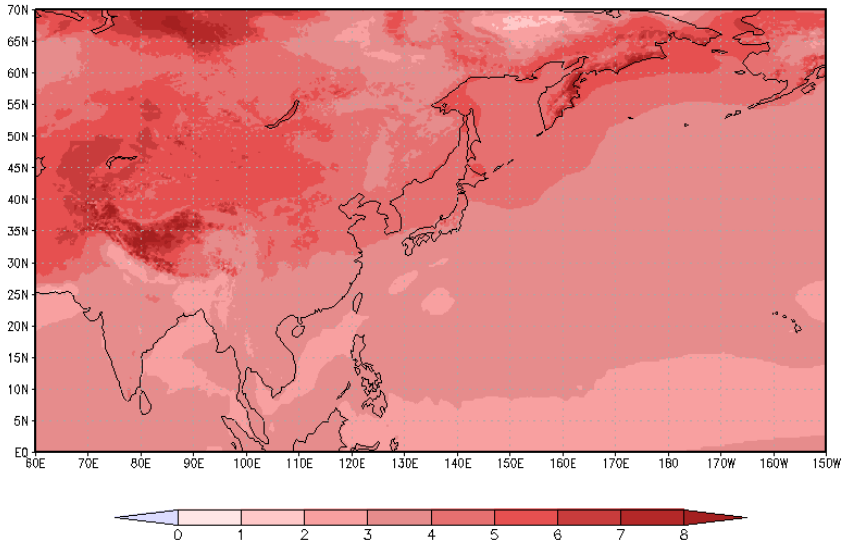
Temperature(Future-Present) (June)



- ✓ Temperature around Japan is projected to increase between 2 to 4 deg C.
- ✓ Warming in June will be smaller than in January.

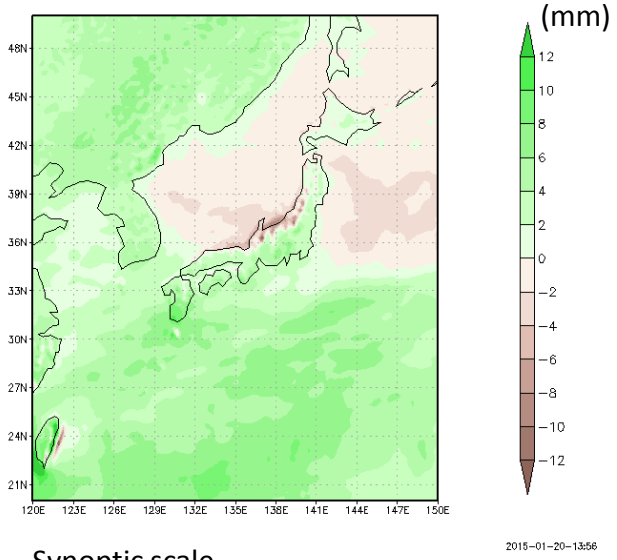
- Wide area change (right top)
  - Two features are similar.
  - In addition, land area will warm more than ocean.
  - Therefor, uncertainty of area is small.
- AR5 by multi model (no figure)
  - These features are consistent.
  - So, uncertainty of single model is small.
- Model bias
  - The difference is acceptable.
- Therefore, it is considered that the two features show future climate change.

Temperature(Future-Present) (June)



Check of uncertainty（Precipitation in June）

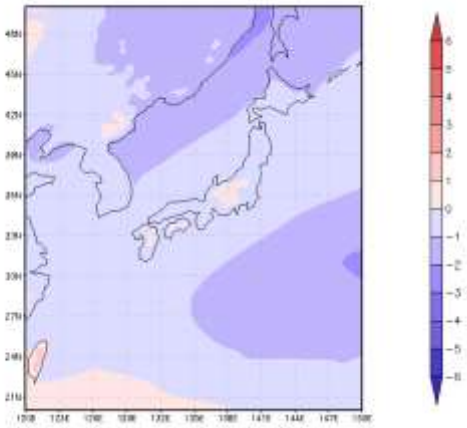
Precipitation (Future-Present) (June)



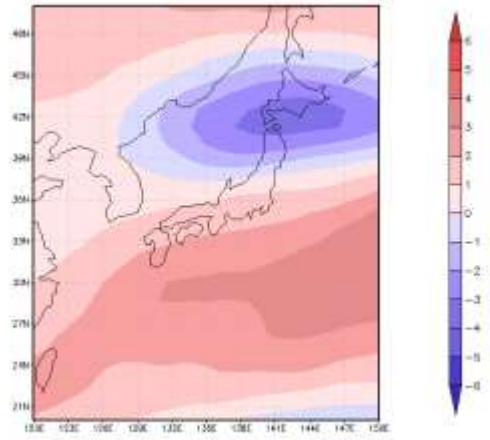
- Synoptic scale
- Change of sea level pressure means weakening of sub tropical high (right top), and 200hPa upper zonal velocity weakens in northern Japan and strengthens in southern Japan (right bottom).
- These indicate that baiu front will be delayed moving to north. This is consistent with the prediction result.
- Model bias
- Precipitation in southeastern Japan is weaker due to weakening of sub tropical high.
- These biases are offset by comparing future and present climate, so effect of synoptic scale change is small.
- Therefore, it is considered that the two features show future climate change.

✓ Precipitation is projected to increase on the pacific. On the other hand, precipitation is projected to decrease on the Sea of Japan side of northern Japan.

Sea Level Pressure (F-P) (hPa)



Upper Zonal Velocity 200hPa (F-P) (m/s)



Summary

[Reproducibility]

- Although there are little biases, these are acceptable.

[Future climate change and Reliability]

- Temperature in January … risk of avalanche
  - Temperature around Japan is projected to increase between 3 to 5 deg C.
  - The region at high latitude will warm more rapidly.
  - [OK] It is considered that the two features show future climate change.
- Precipitation in January … risk of snow depth change
  - [NG] It is difficult to consider that the feature show future climate change.
- Temperature in June … risk of heat stroke
  - Temperature around Japan is projected to increase between 2 to 4 deg C.
  - [OK] It is considered that the feature show future climate change.
- Precipitation in June … risk of flood and drought
  - Precipitation is projected to increase on the pacific. On the other hand, precipitation is projected to decrease on the Sea of Japan side of northern Japan.
  - [OK] It is considered that the two features show future climate change.