Potential impact of land use change over northern Japan in a changing climate

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Dynamical downscaling using monthly mean GCM was performed with a support of Environment Research and Technology Development Fund (s-8-1(2)3) by Ministry of Environment. Land cover change experiment was carried out with a support of RECCA (Research Program on Climate Change Adaptation) program by MEXT, Japan.

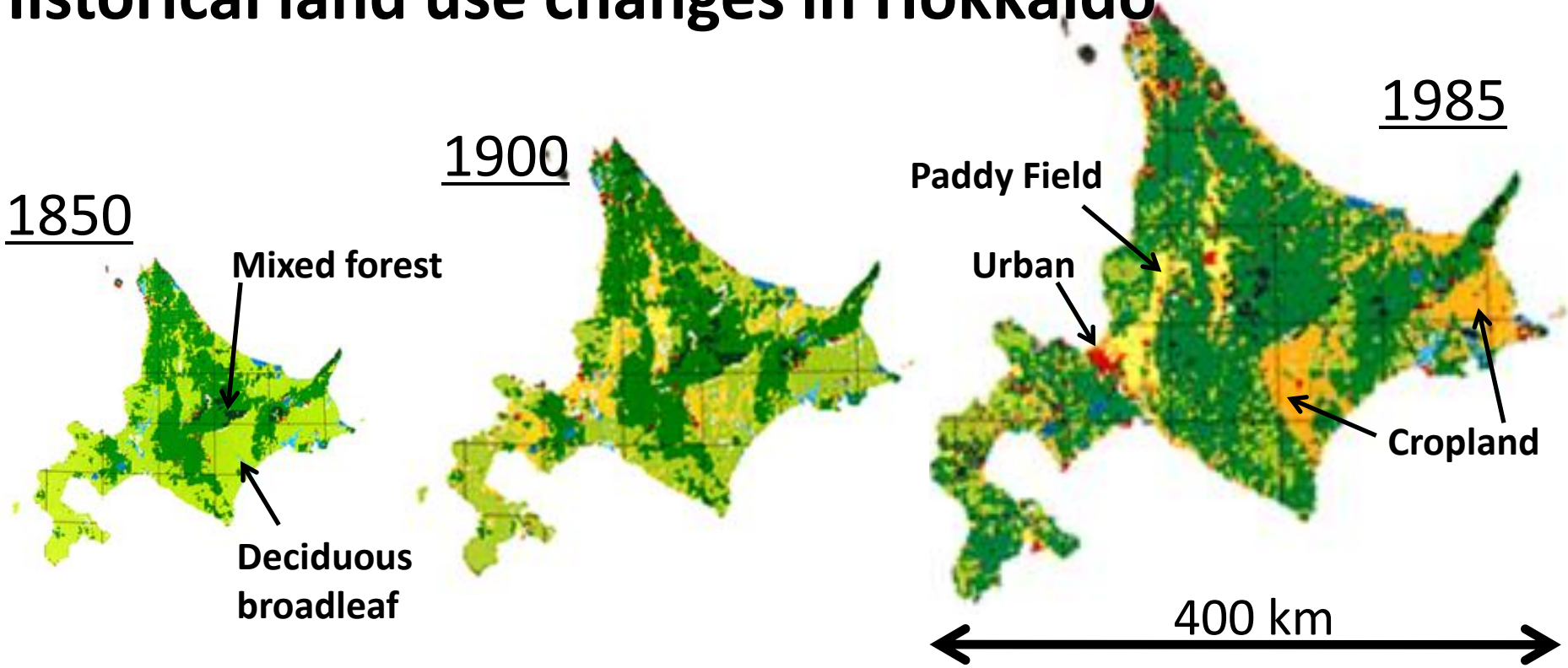
Two topics

(1) Historical land use change impact to regional climate

(2) Global warming influence to regional climate in North Japan, especially to snow regime.

➔ Discuss combined effect (A hypothesis)

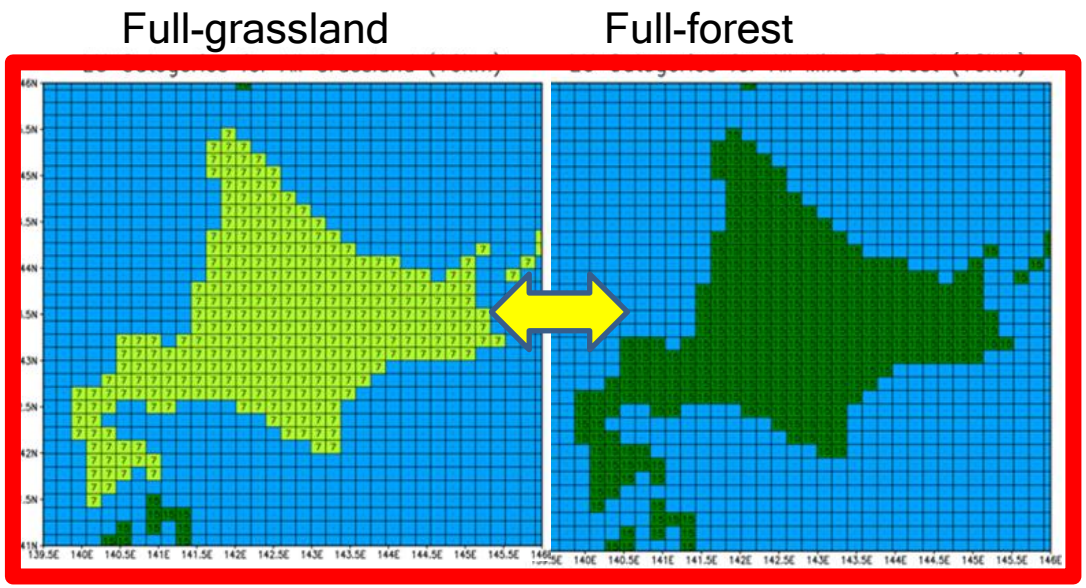
Historical land use changes in Hokkaido

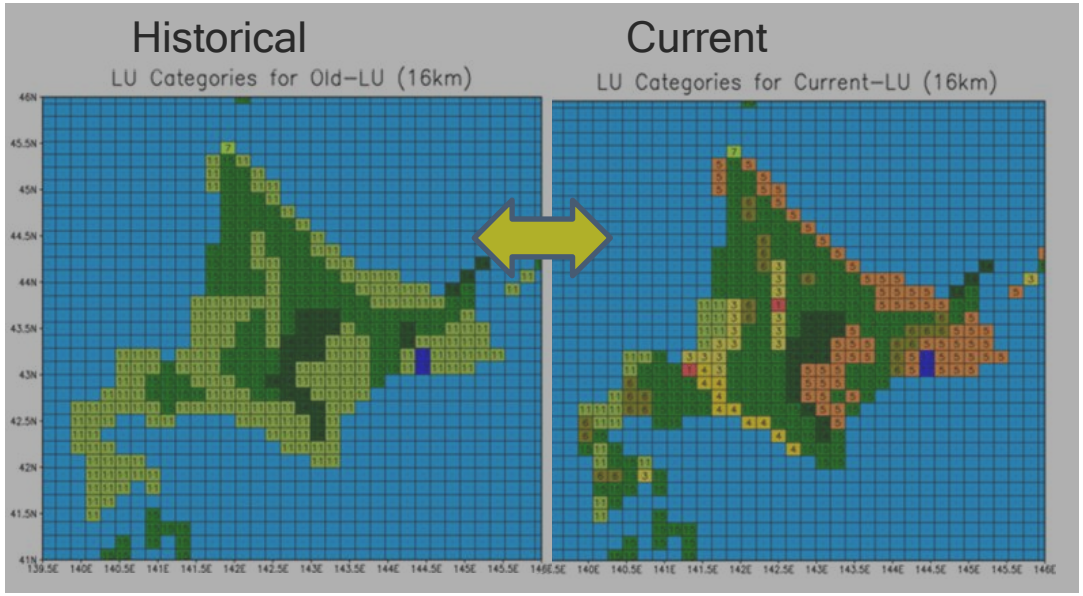


Why interesting and important ?

- Evidence of whole-island-scale land cover change
- Snow cover makes dynamic seasonal variation in land cover
- Drastic change is expected in snow regime due to global warming

Land use data and run settings





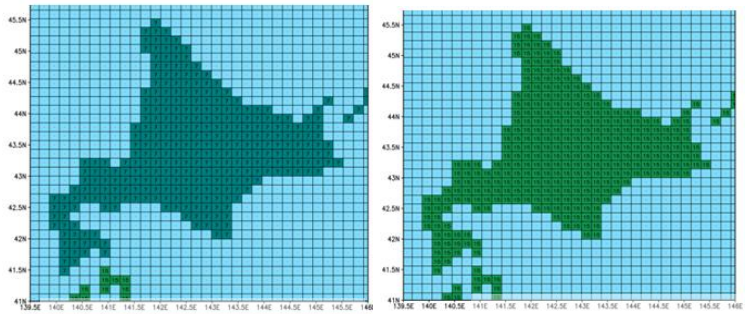
- ARW/WRF Ver3.2.1
  -Cumulus : KF
  -Microphysics: WSM-6
  -Land surface: NOAH-LSM

- Grid size: 16 km (100 x 100)
  -Without nesting
-

- Dec. 2003 – 1 Dec. 2004
  (run from 15 Oct 2003)

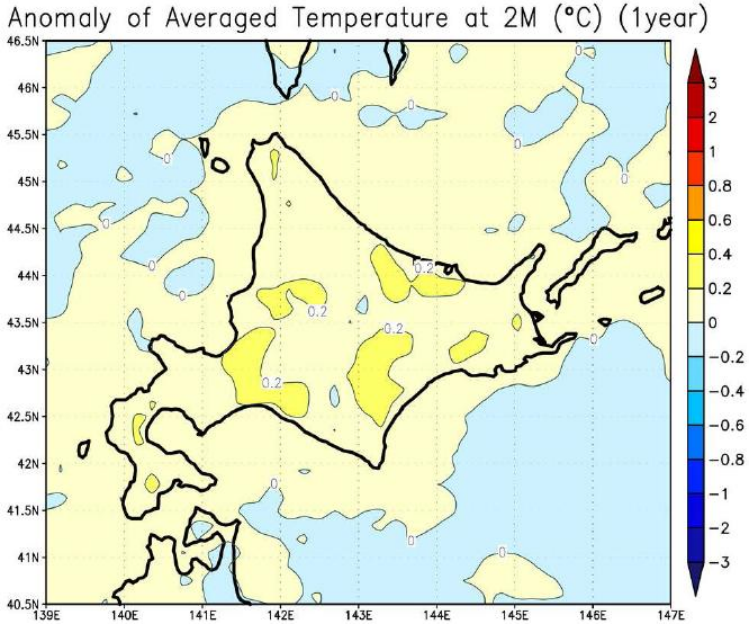
- Driven by JRA25, OISST

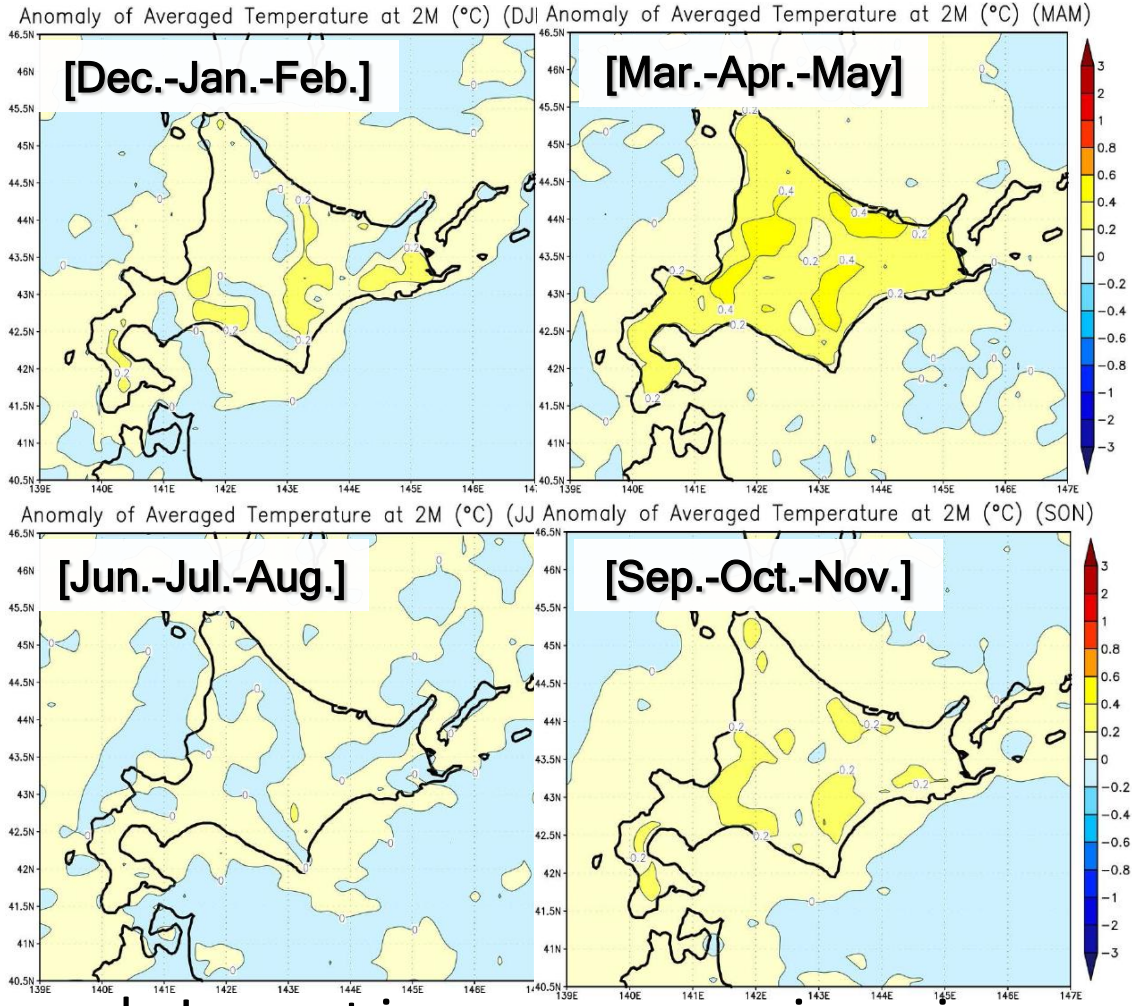
Idealized land cover change experiment (Difference in temperature; Grassland minus Forest)



Full-grassland Full-forest

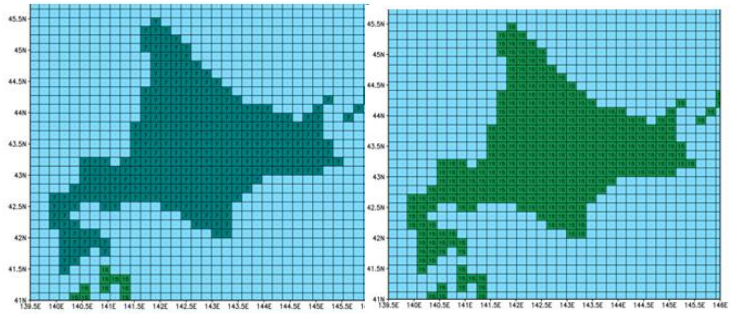
Annual mean





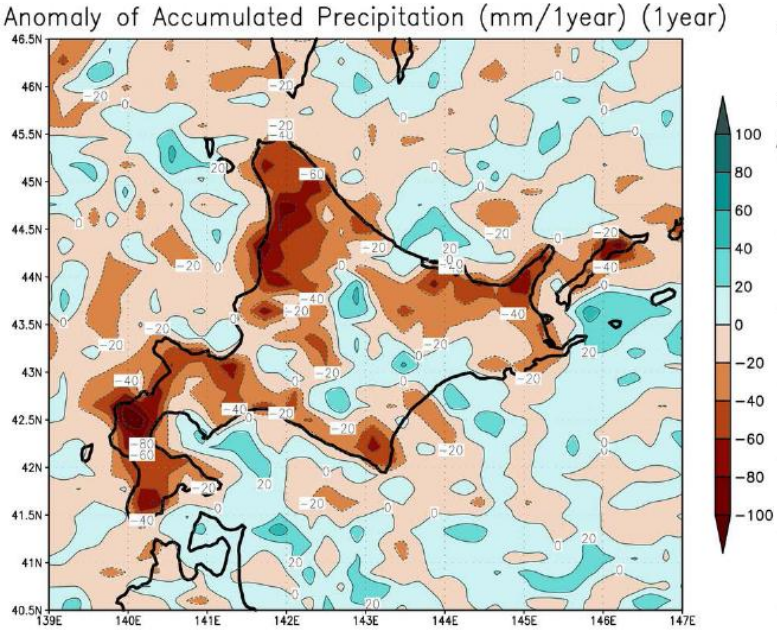
Temperature increase is very weak. Largest increase occurs in spring while summer temperature is not sensitive.

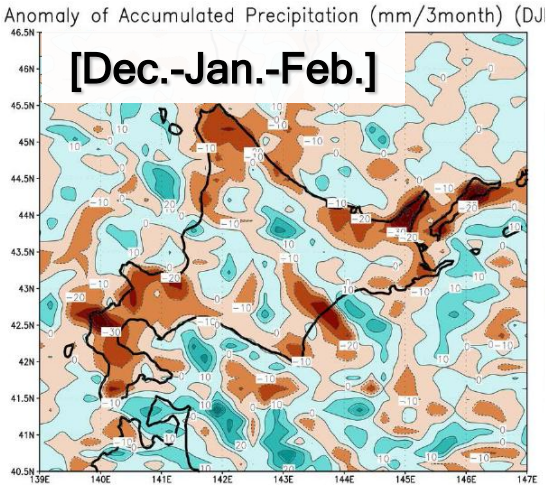
Idealized land cover change experiment (Difference in Precipitation; Grassland minus Forest)

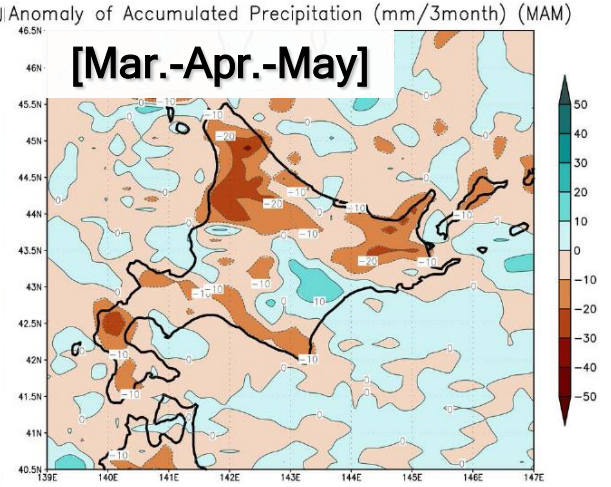


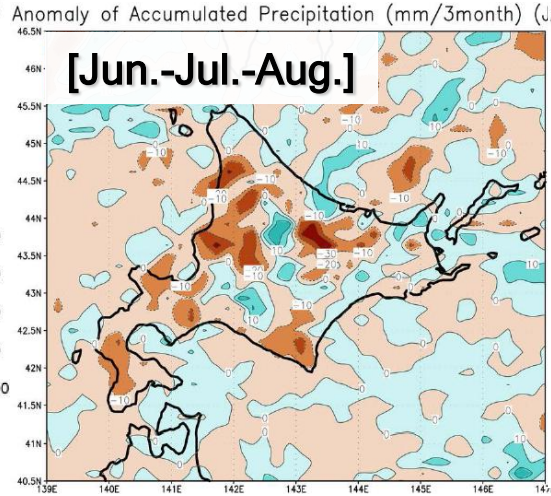
Full-grassland Full-forest

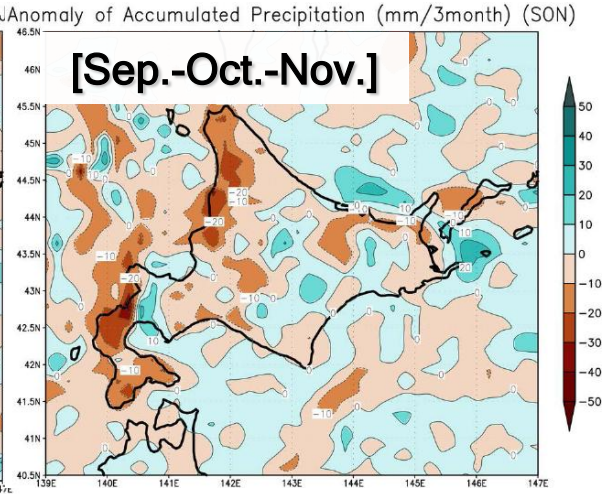
Annual mean





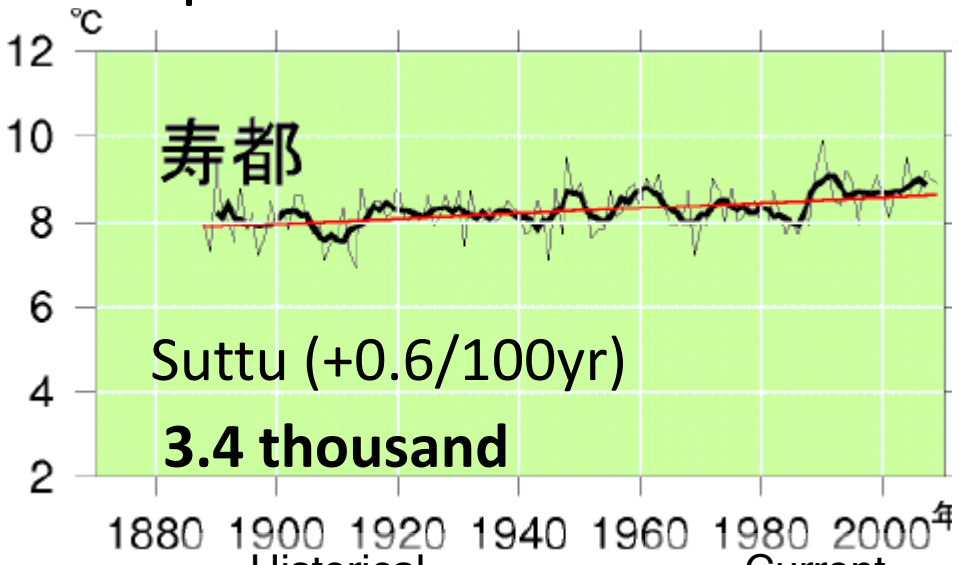


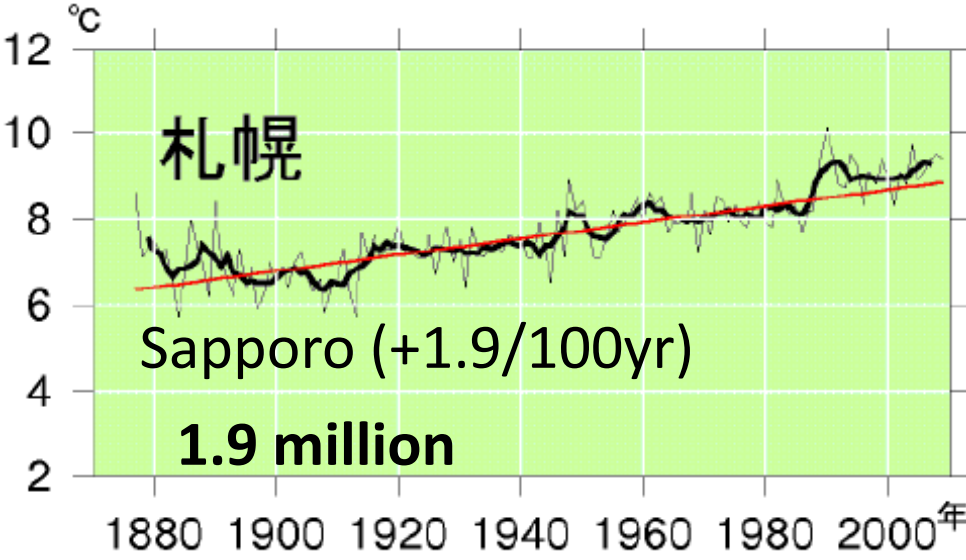




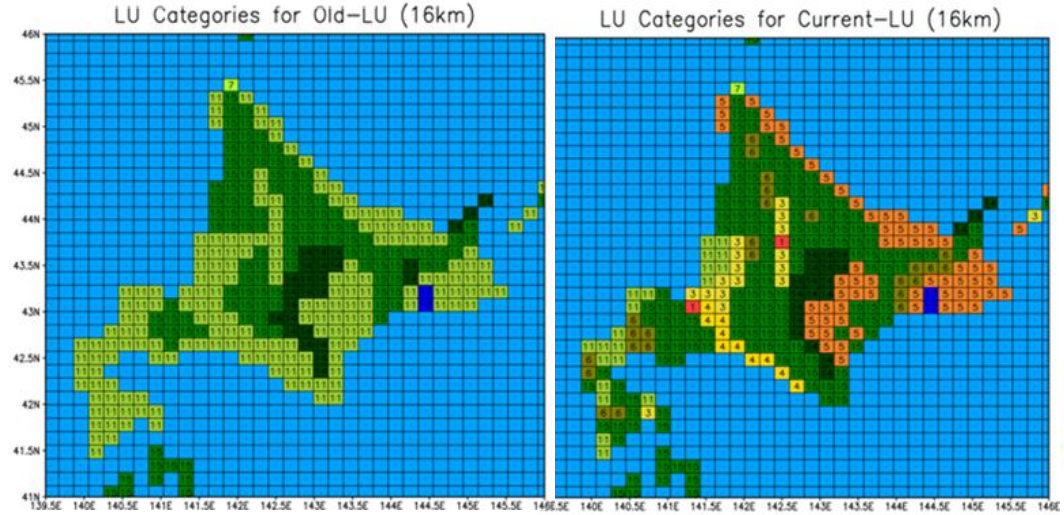
Local circulation change is excited by energy budget and roughness changes which eventually reduce precipitation, especially in coastal area.

Comparison between rural and urban

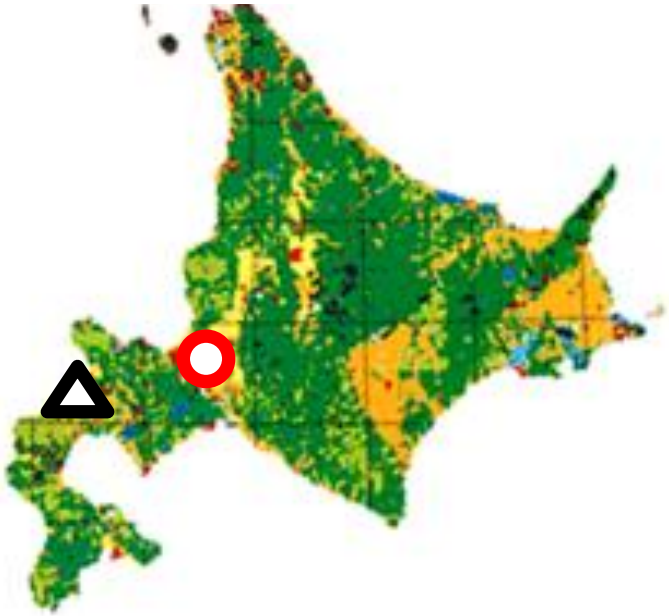




Historical



Current

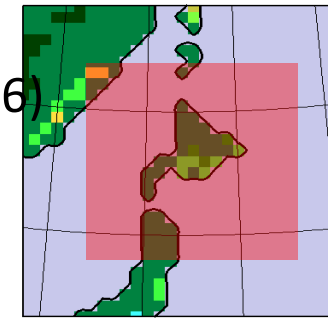


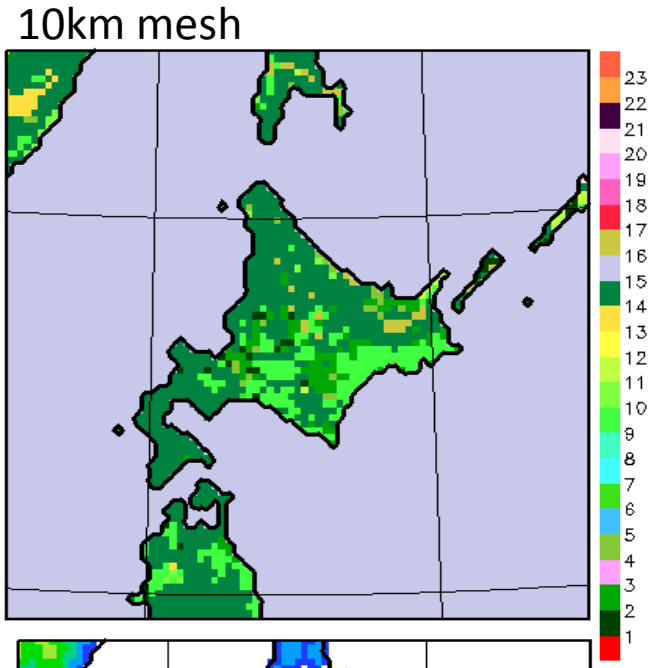
Land use change effect for All Hokkaido island seems small while urbanization effect would be very large for Sapporo city.

Experimental design for global warming simulation

Model

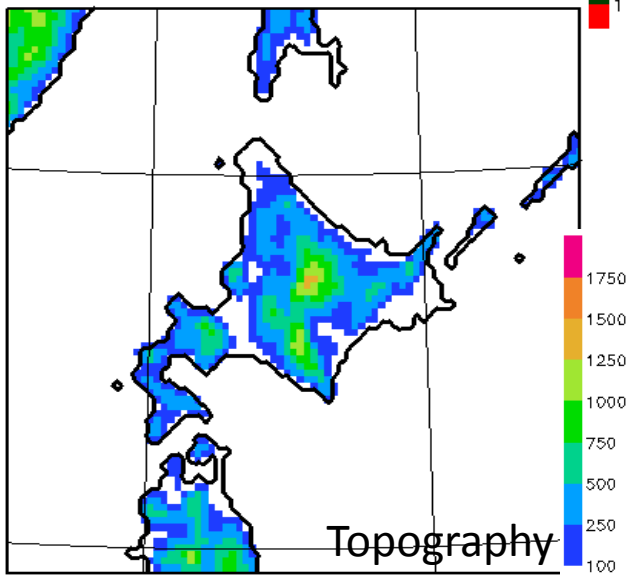
-ARW/WRF Ver3.2.1
-Grid size: 50 km (30 x 30), 10 km (86 x 86)
-Cumulus : KF
-Microphysics: WSM-6
-Land surface: NOAH-LSM





Boundary forcing and initial condition

-Atmosphere:
NCEP-NCAR reanalysis **with GW anomaly equivalent to 2060-2089 (T, U, V, Z)**
-SST:
OISST **with GW anomaly equivalent to 2060-2089**
-Land use : USGS



Period

00Z 21 Nov. 2005 – 31 Dec. 2005

Making future weather pattern for downscaling

(2) (2060~2090) − (1980~2000)

3-dim Monthly Mean diffs

***N** GCM ***N**

\+

Reanalysis (Present climate)

Day-by-day variation

(1)

Present climate (control)

Downscale (perfect boundary run)

(4)

Comparison for regional climate change

(3)

Future climate

Future weather ***N**

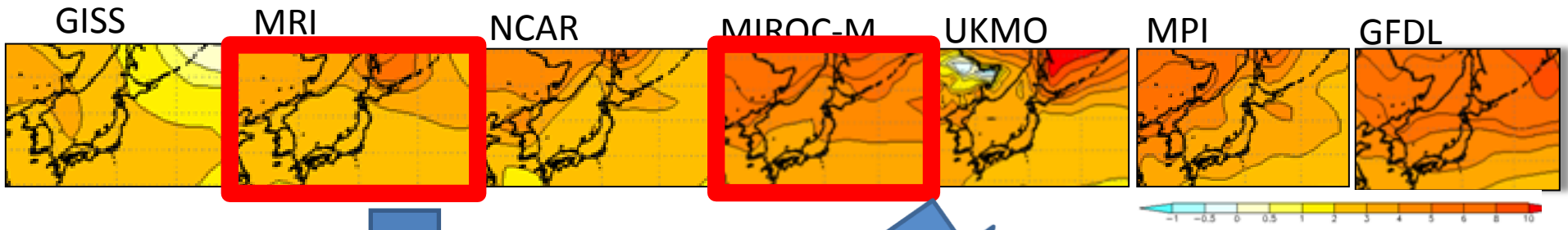
Downscale

***N**

-Do not consider future weather variability
+Easy to know sensitivity of mean component

Sato et al (2007) for detailed method

Dynamical downscale using anomalies from multi-GCM



Winter temperature change (2080~2099)

DDS-MRI

?

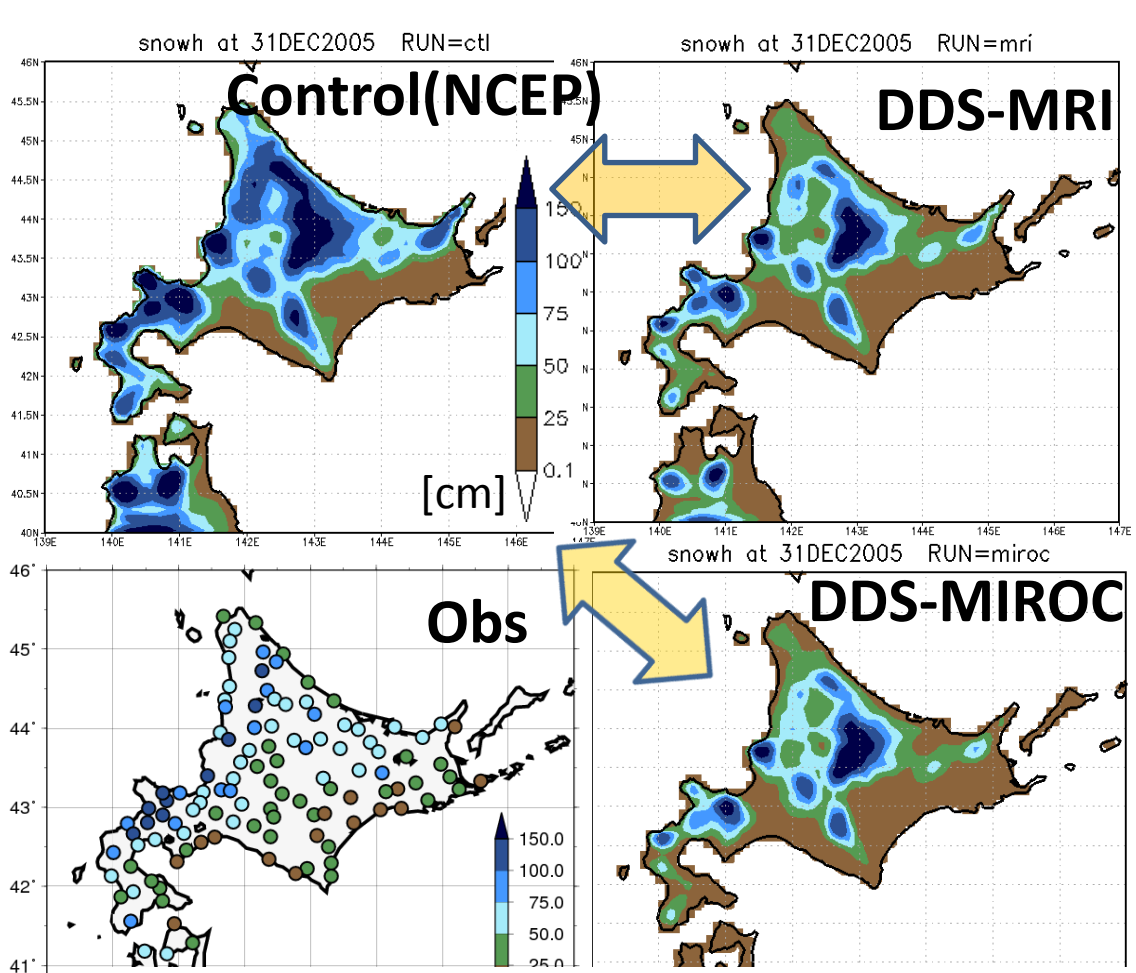
DDS-MIROC

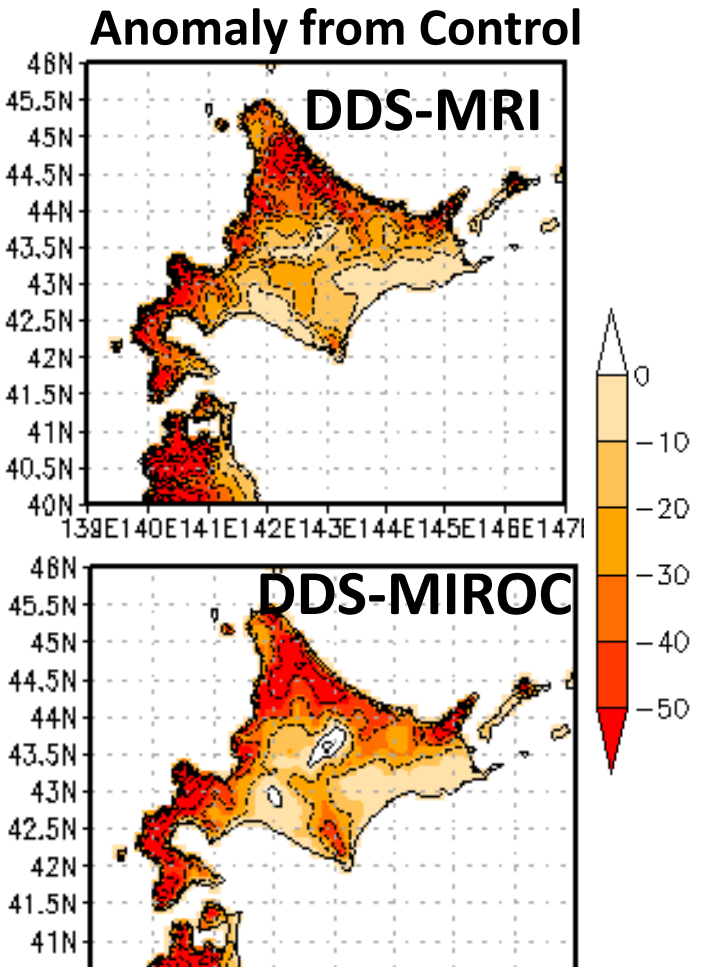
?

Courtesy of JAMSTEC group for technical support

Changes in snow regime due to global warming

In case of Snow depth in 31 Dec 2005





For both DDS, snow depth is drastically decreased along eastern side as a result of increasing environment temperature. This also means snow-covered duration tends to be shorten.

Sensitivity experiment for land use change

Warm season
(without snow cover)

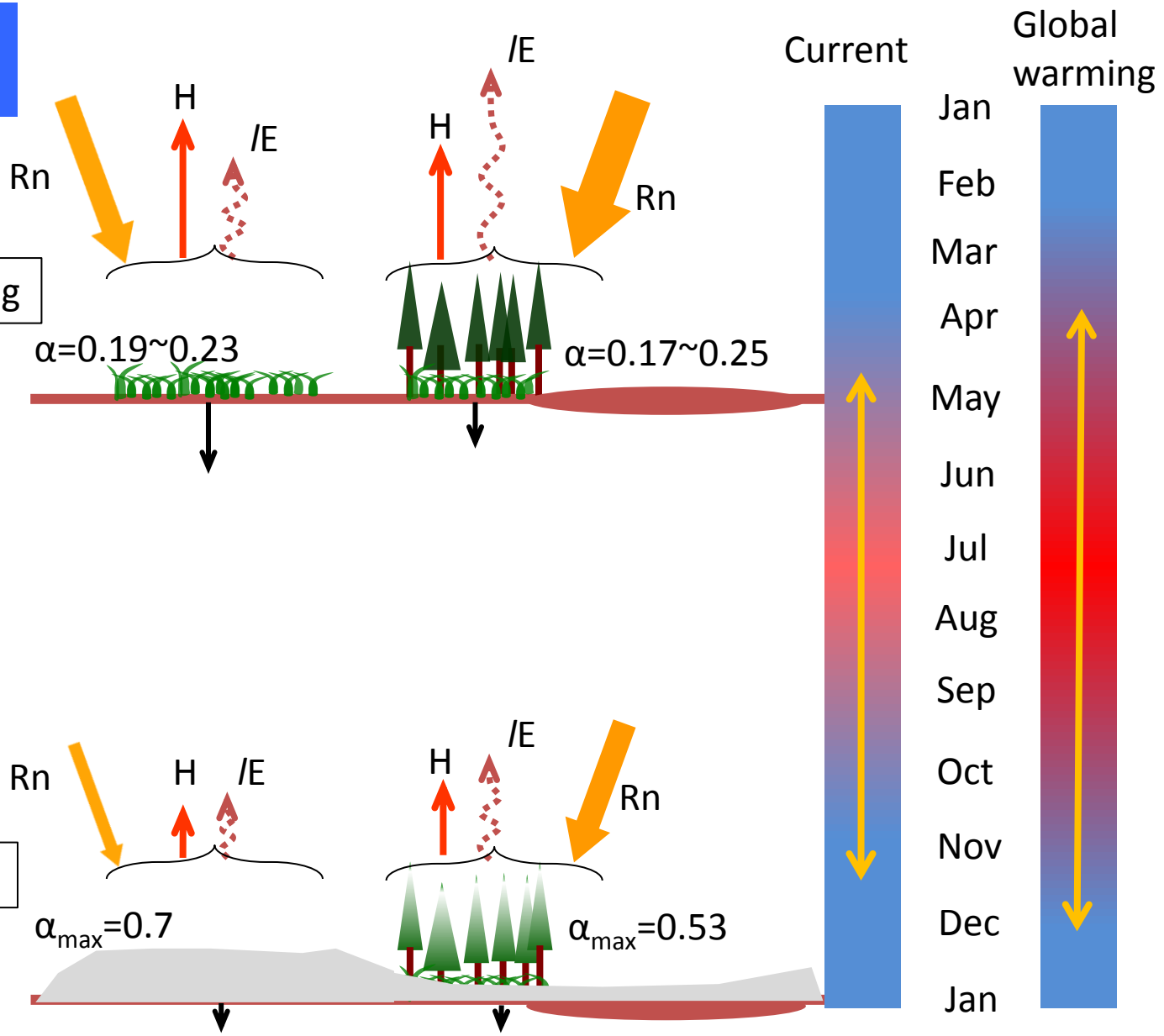
(May to November)

Lengthen after warming

Cold season
(with snow cover)

(December to April)

Shorten after warming

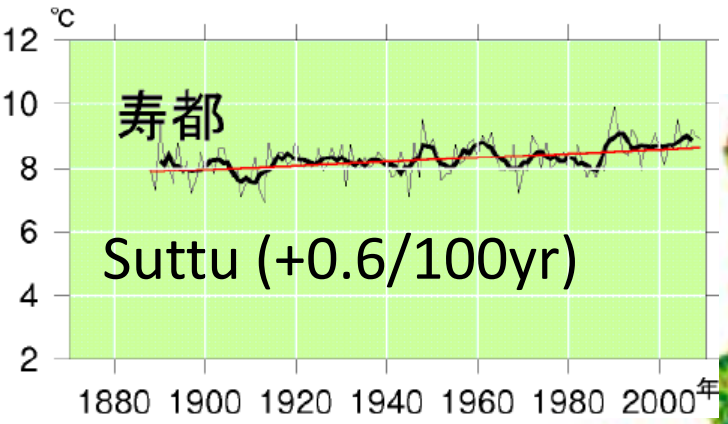


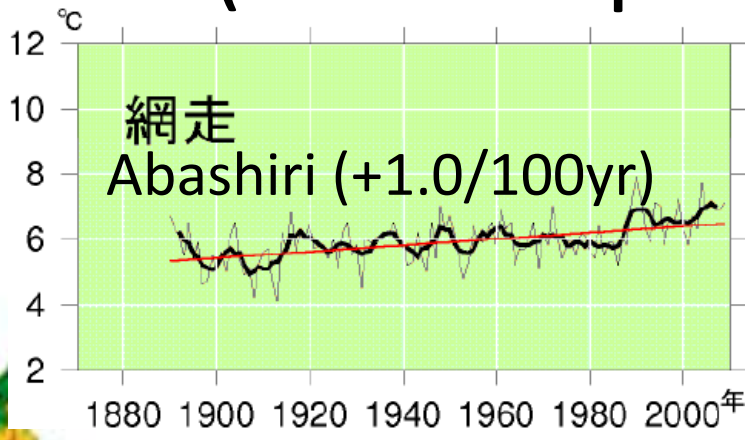
Conclusion

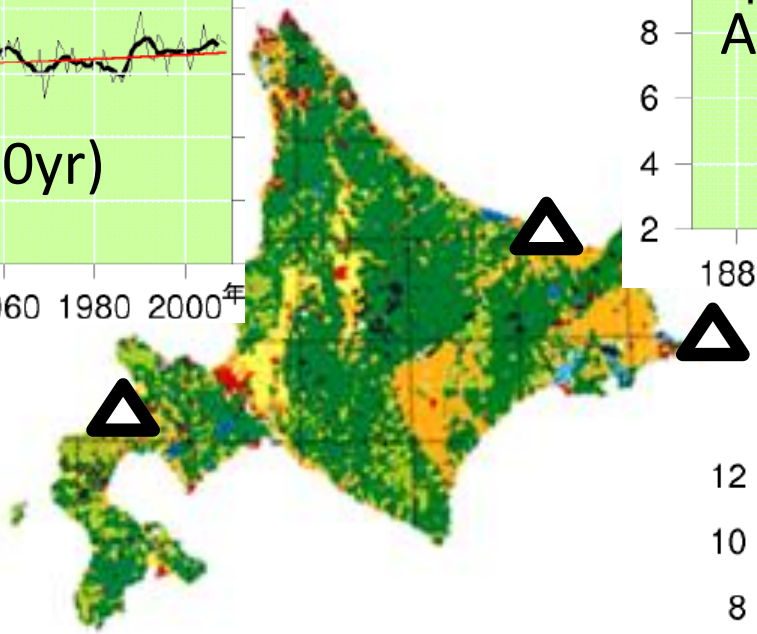
- Forest to grassland conversion does not cause large temperature change as it was observed. Further experiments with different parameters or different LSM are necessary.
- Urbanization effect seems to be a primary factor for causing warming trend in Sapporo. Additional experiment with realistic land use change is just started.
- Simplified global warming run is a good method to study sensitivity of snow in Japan to the mean temperature change. Multi-GCM and Multi-year run will be useful to produce uncertainty information.
- Further studies are necessary for future regional climate with possible land use change taken into account.

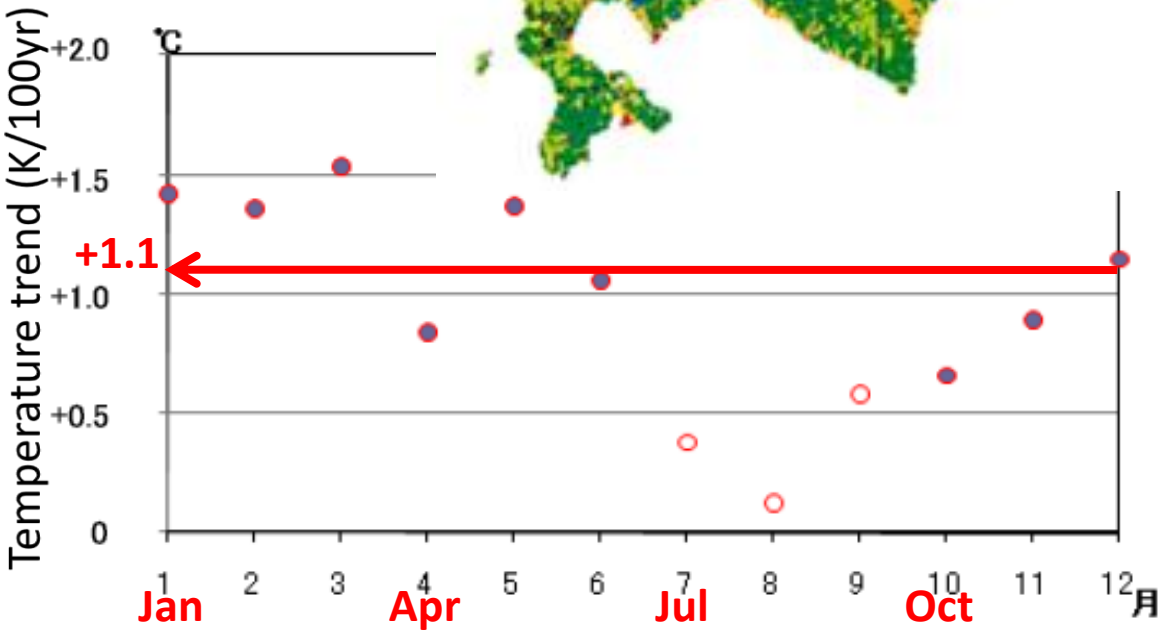
Either of global warming run and land use change run in this talk is underway. I suggest you to carefully refer these results.

Long-term trend in Hokkaido (North Japan)

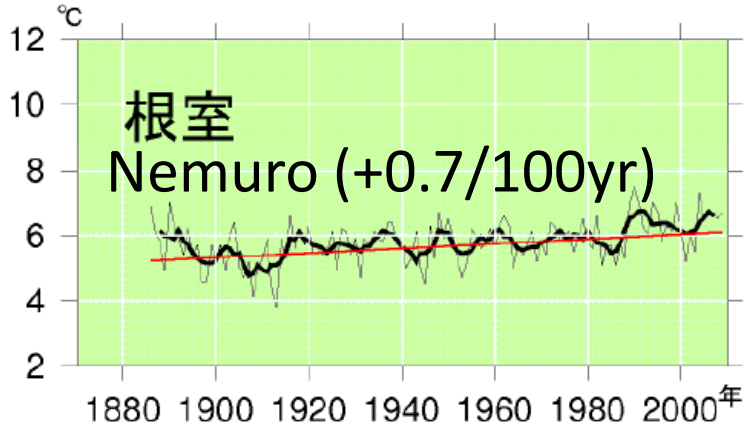






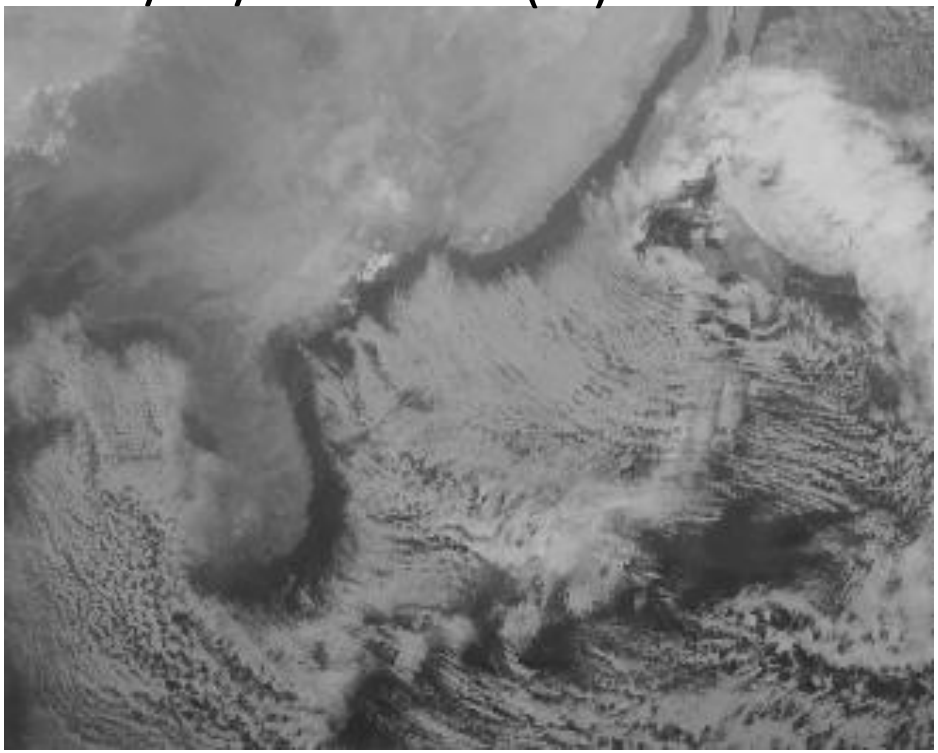


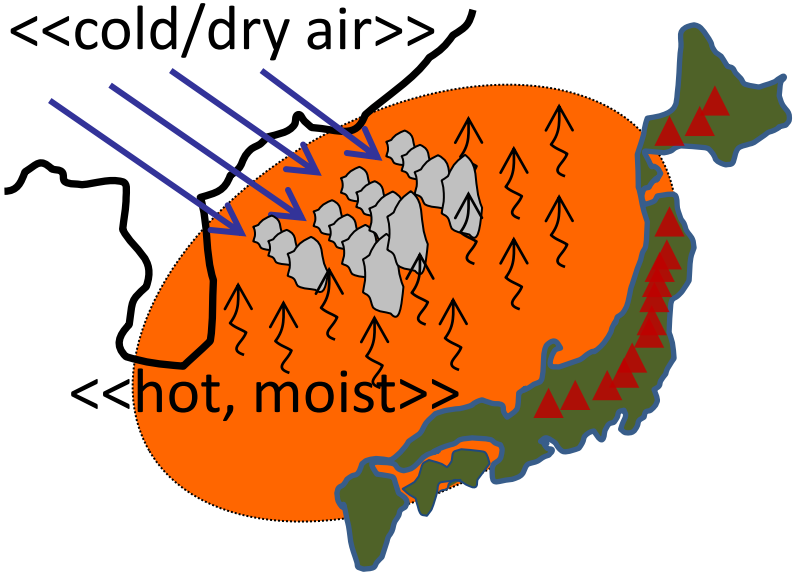
Seasonal variation of recent temperature trend



Sapporo District Meteorological Observatory, JMA (2010)

2005/12/13 12UTC (IR)

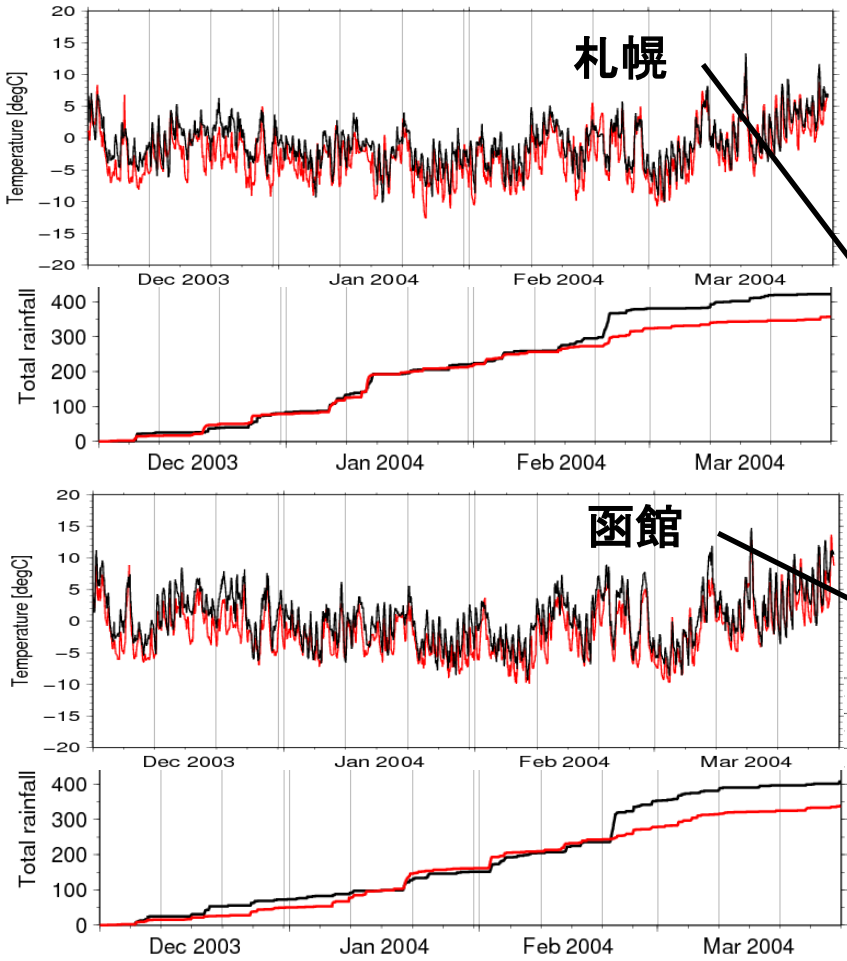


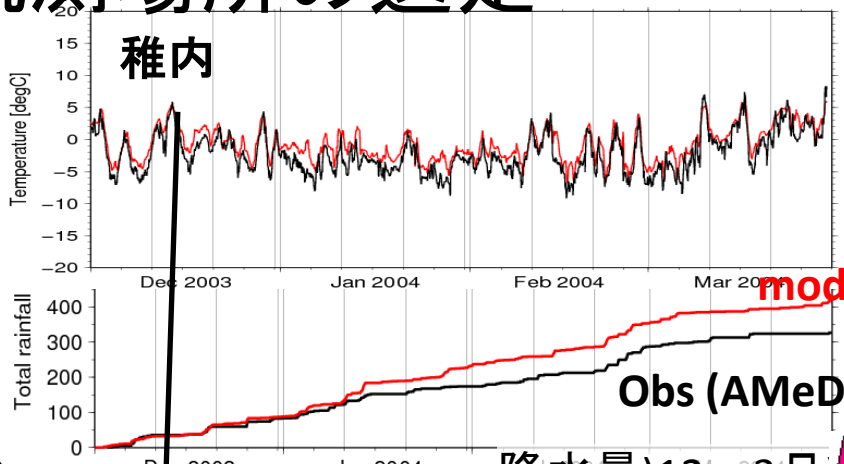


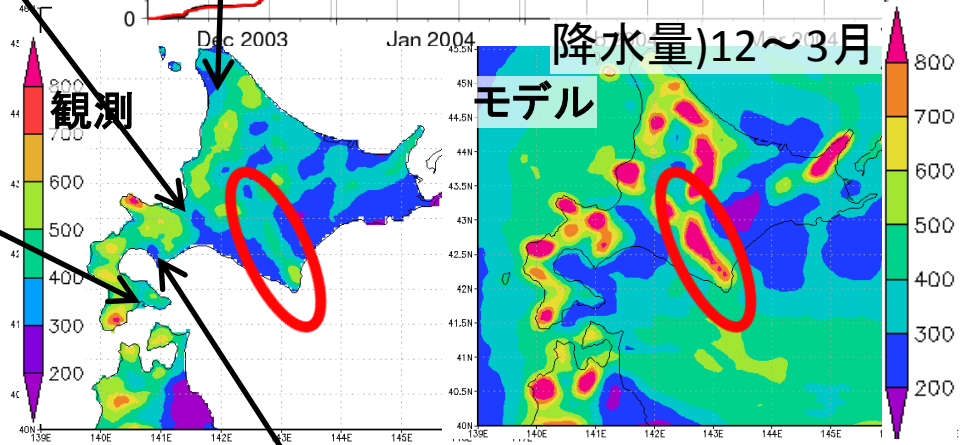
Cold and dry air from Eurasian continent was modified with moisture supply from warm ocean, which makes very heavy snowfall along the western side of central mountain in Japan.

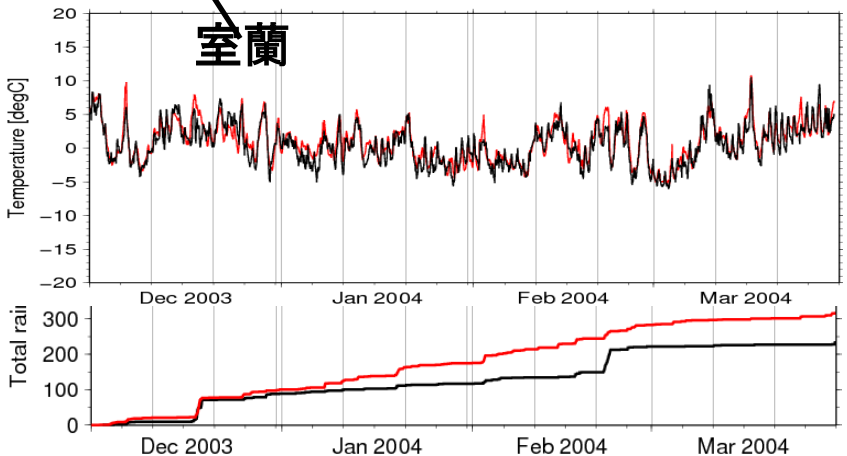
Snowfall in Japan occurs with relatively high temperature. Therefore, it would be very sensitive to the temperature

冬季降水量の検証と観測場所の選定



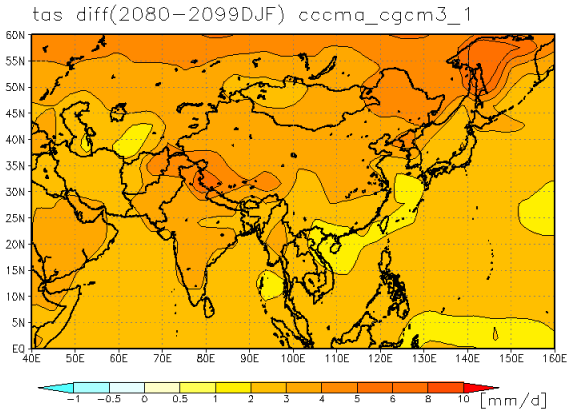


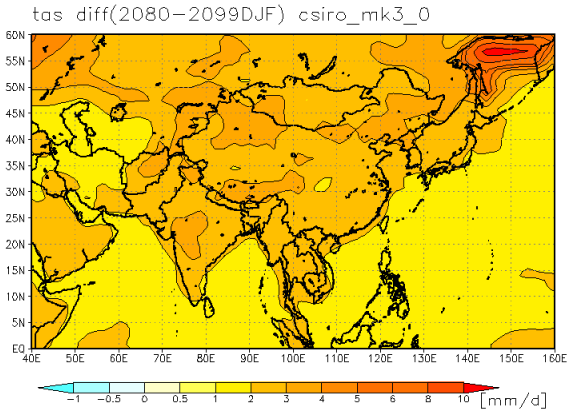


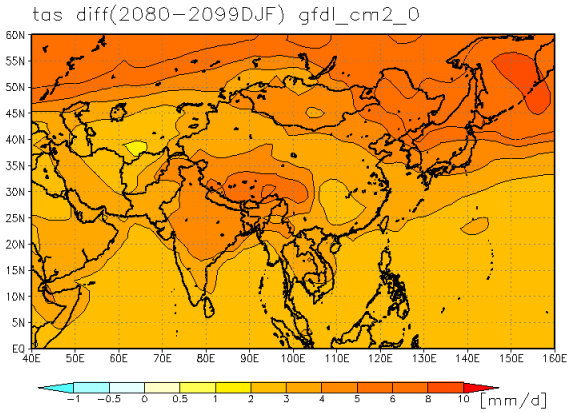


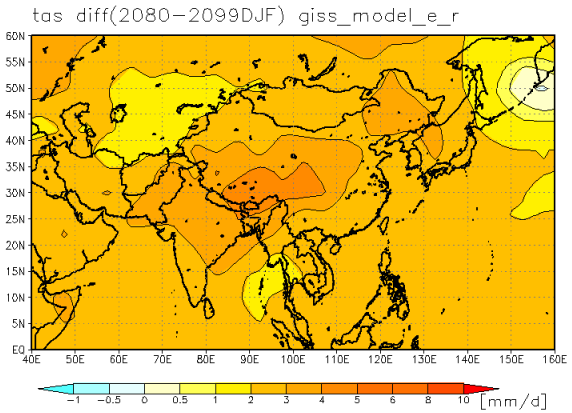
- 水資源として重要な冬季降水に着目してモデルの調整を行っている
- 観測の空白域である山岳で追加観測を実施する

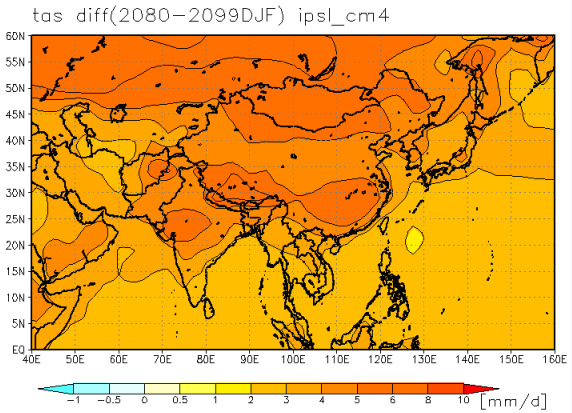
Temperature change (2080-2099; December-January-February)

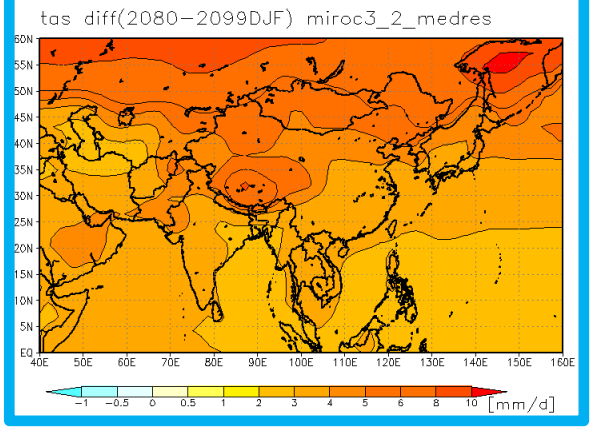


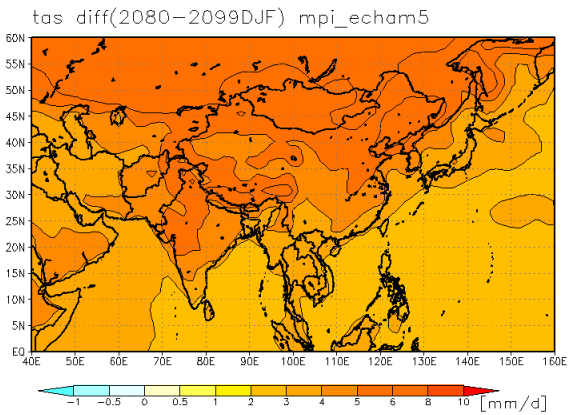


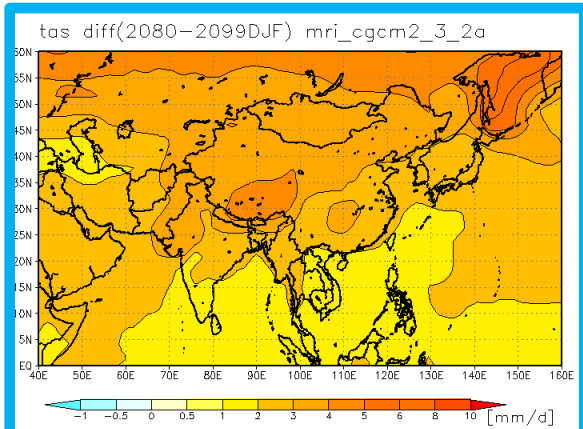


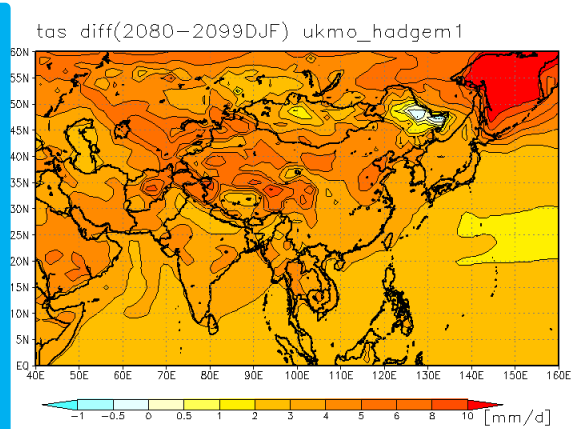






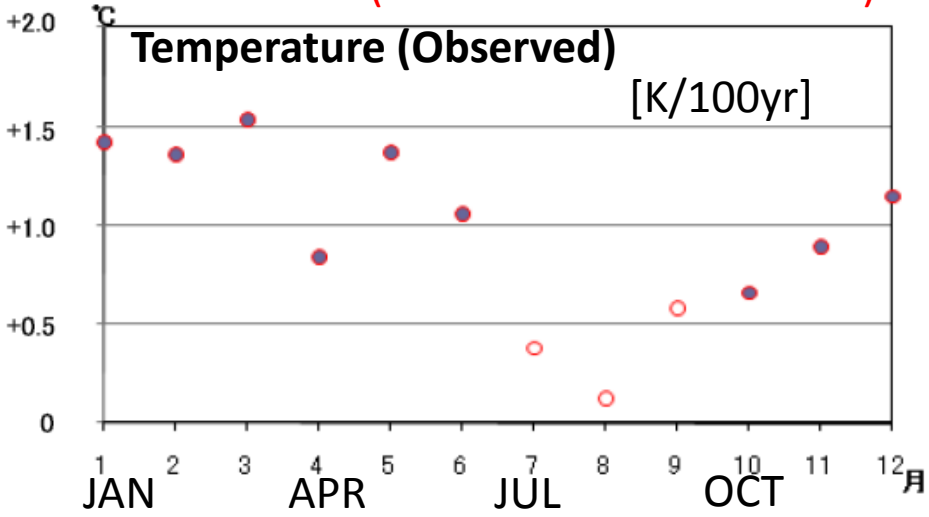






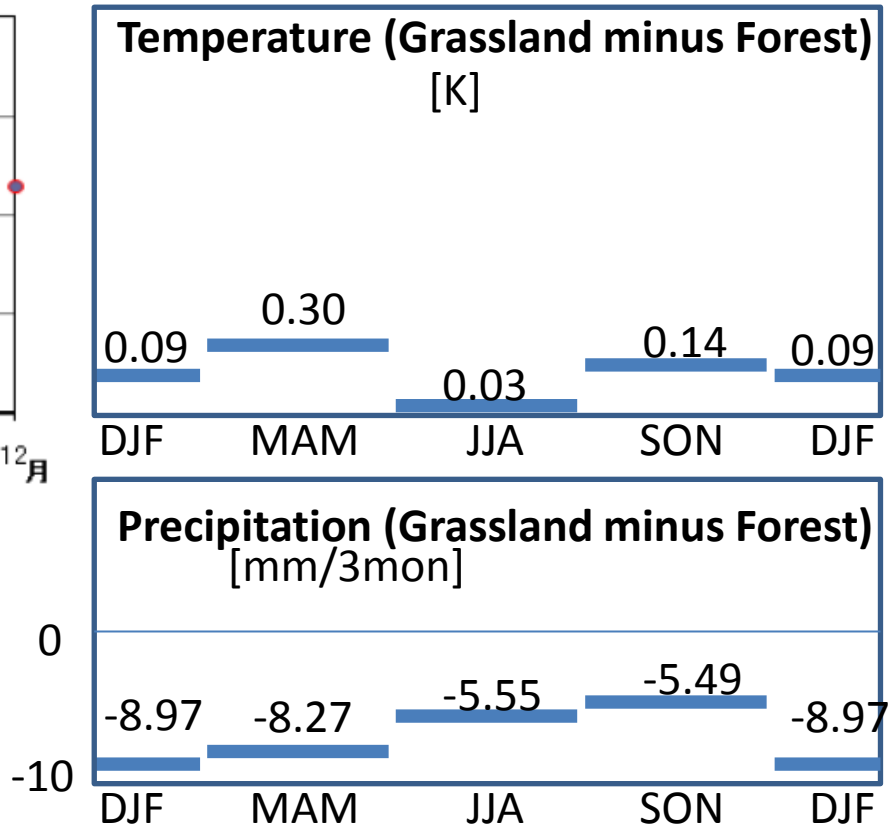
Observed Temperature difference

All Hokkaido (3 stations without urban)



Idealized LU change

All Hokkaido (Grassland minus Forest)



- Temperature change that is expected by idealized LU change is rather small compared to the observed temperature change if we consider All Hokkaido area.
- Cold season tends to have larger temperature change due to deforestation.
- Multi-year run is required.