DSWS2017, Tsukuba Oct. 2-4, 2017

Past simulation and future projection of snowfall over mountainous areas in central Japan

Outlines

1. Introduction
2. Simulation of recent mountainous snow cover
3. Future projections in snowfall in Japan
4. Next step and Summary

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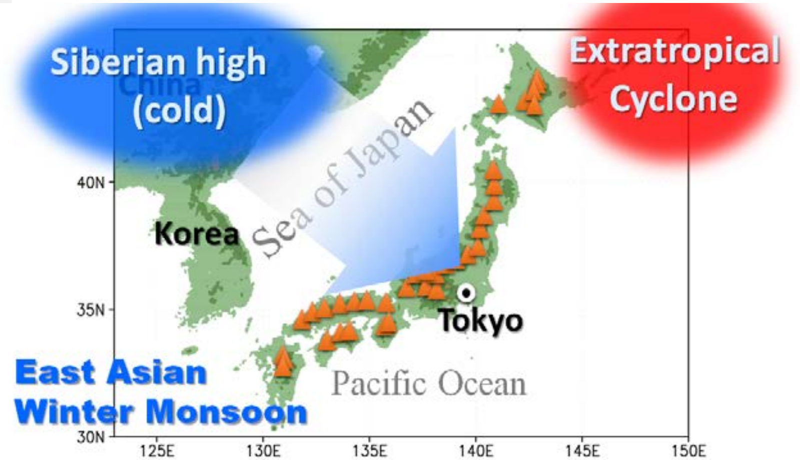
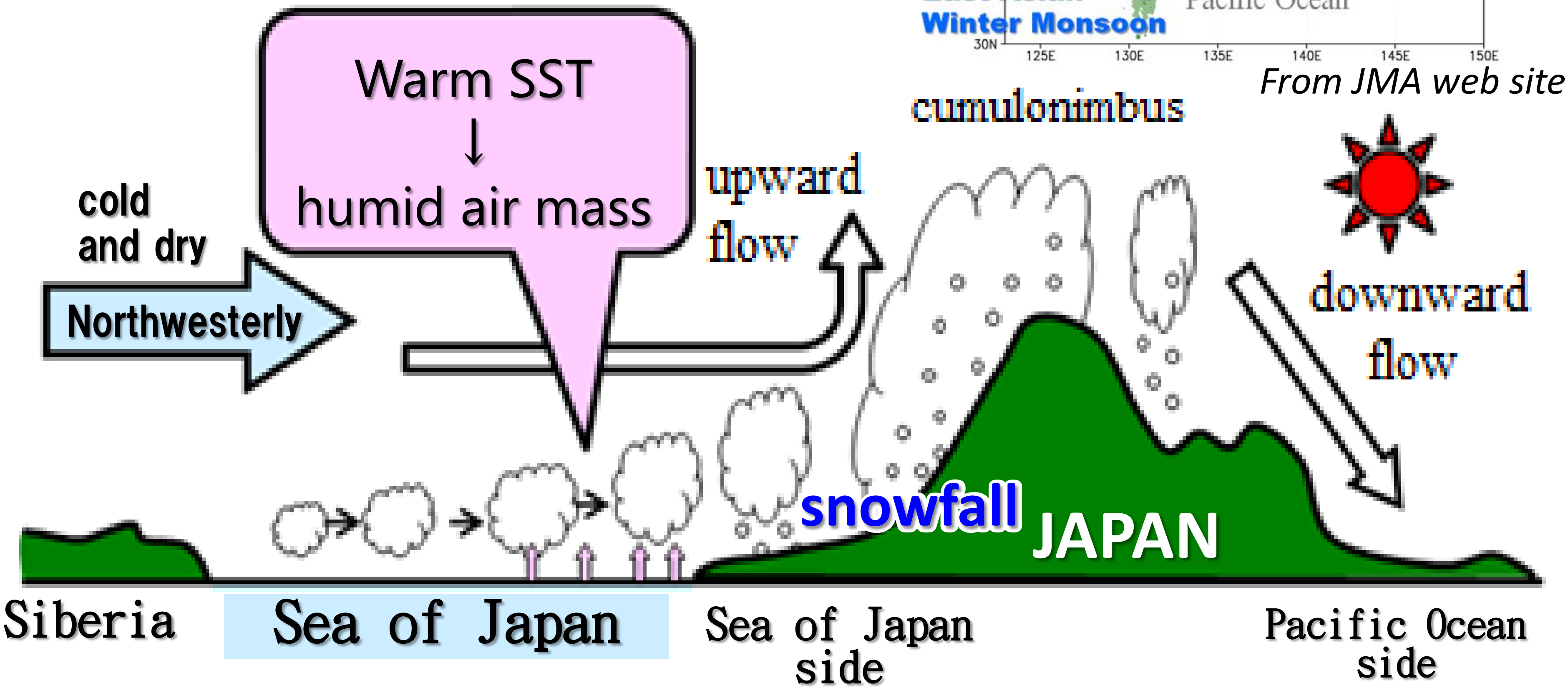
and Akira Yamazaki (JAMSTEC)

Mechanism of large snowfalls in Japan



From JMA web site



Colder air from Siberia and warmer SST result in more developed snow clouds and heavier snowfall

Niigata prefecture, Feb, 2006

Introduction

- Heavy snowfall and large amount of snow cover causes avalanches, traffic accident, and isolation of small town.
  [*Kawashima et al.*, 2015]

- Large snow cover over the mountainous areas is, on the other hand, important for water resources and winter sports.

- There is few observations over high mountainous areas. Understanding of mountainous snow cover is insufficient.

- Due to global warming, total snowfall and maximum snow depth will widely decrease in the future, while in colder regions, snow cover could increase because of moistening.
  [*Brown and Mote* 2009; *JMA* 2013; *Kawase et al.* 2015]

- It is still unclear if extremely heavy snowfall will increase or decrease due to global. [*O'Gorman* 2014; *Lute et al.* 2005]

Introduction

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Topics of my presentation are

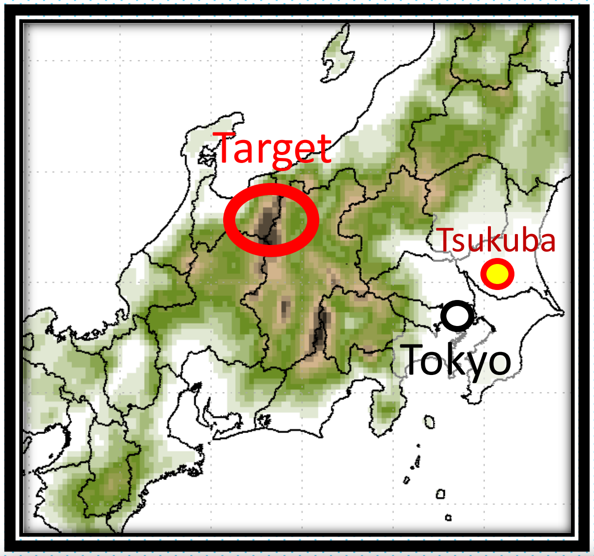
1. Snow cover simulations in recent 16 years over the Japanese Northern Alps in central Japan

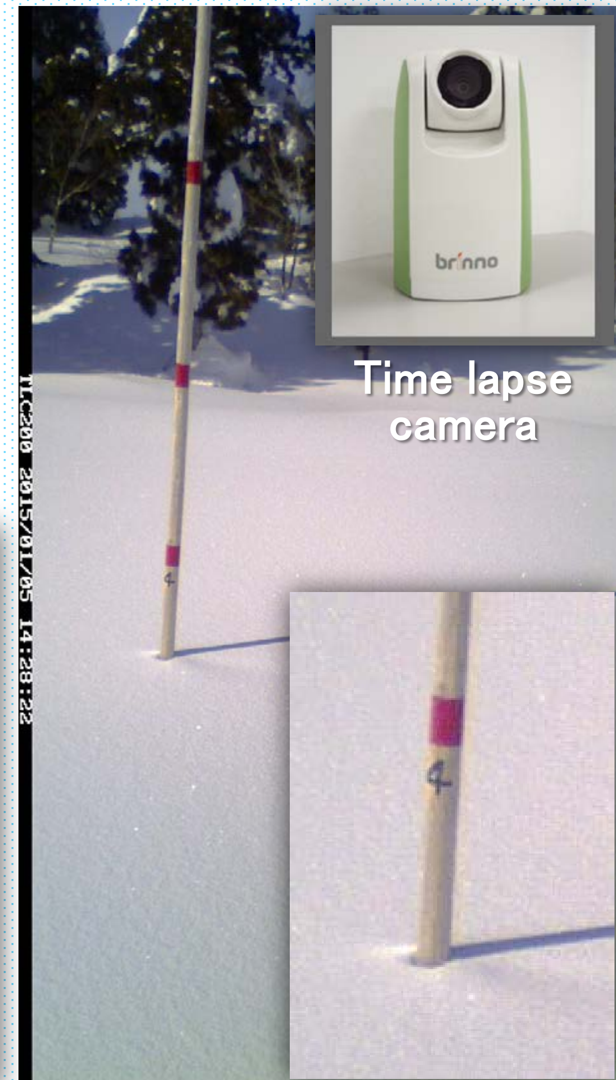
2. Future changes in heavy snowfall in Japan

Research field and observation

Japanese Northern Alps

- Tateyama Kurobe Alpine route -





Experimental design

NHRCM (Non-hydrostatic Regional Climate Model)

[*Sasaki et al.*, 2008]

Boundary Condition: JRA-55 (55 years Japan Re-Analysis data)

Grid spacing: 20km -> 5km -> 2km

Land surface: MJ-SiB

Boundary layer: Improved Mellor-Yamada Level3 (MYNN)

Microphysics: Bulk-type cloud microphysics [*Murakami et al.*, 1994]

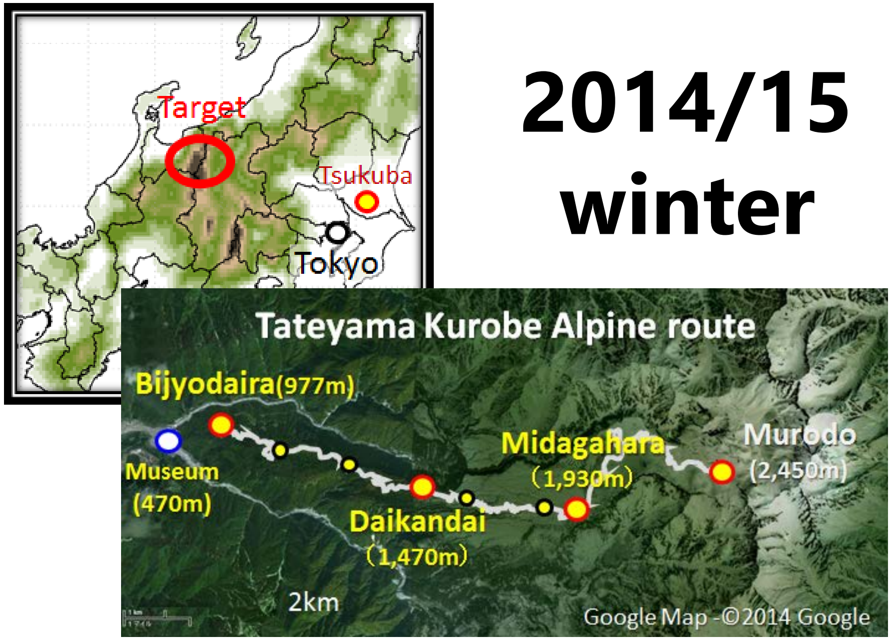
Cumulus convection: Kain-Fritsch (5km and 20km)

[*Kain and Fritsch*, 1993]

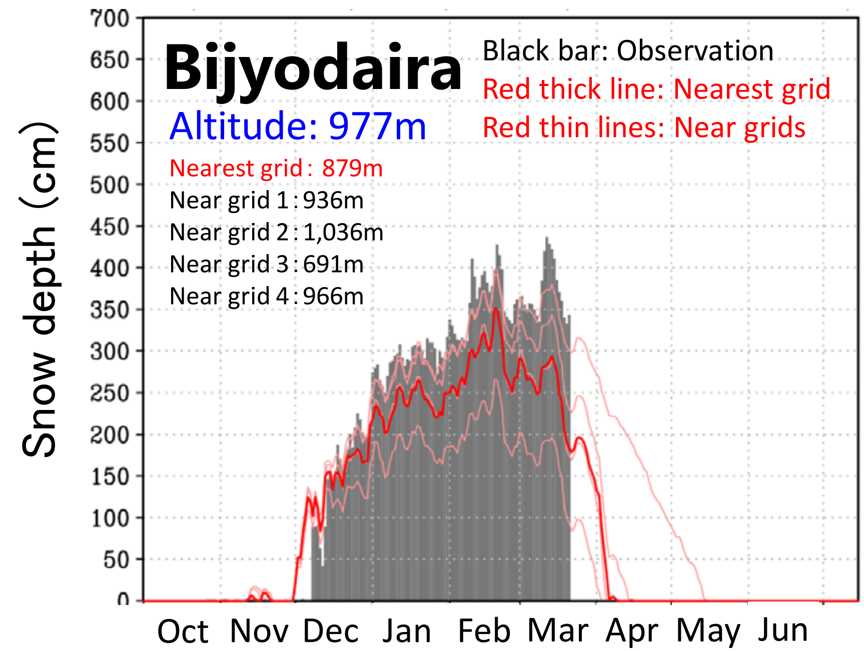
Target period: Sep. 15 – Jul 15, 2000 - 2016

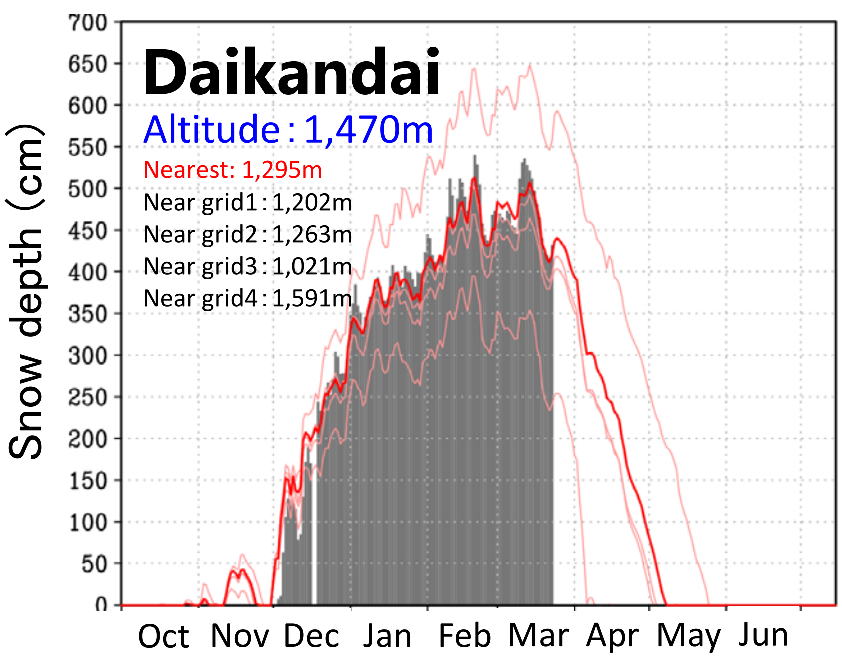
* Spin-up duration: Sep. 15 - Sep. 30

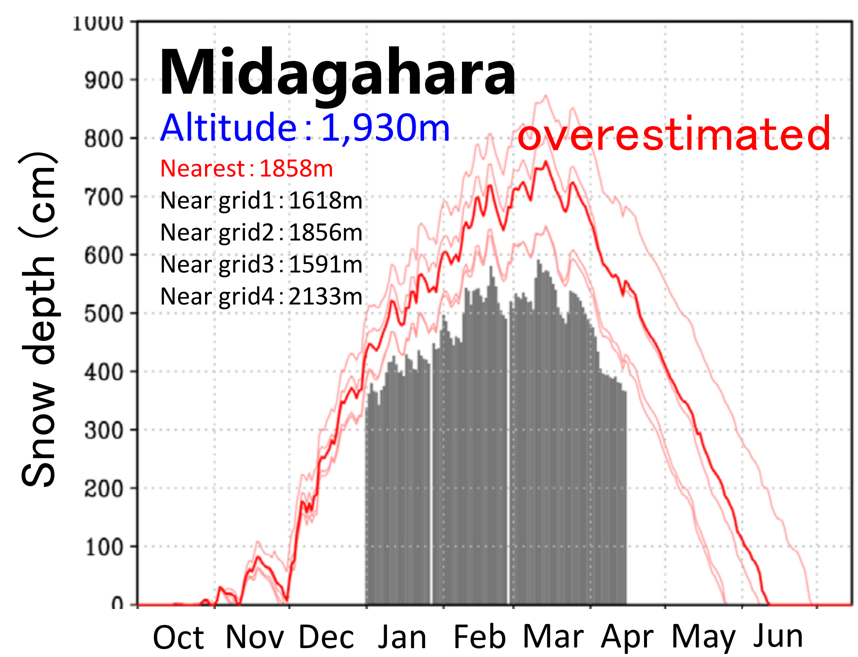
Simulation of snow depth in 2014/15



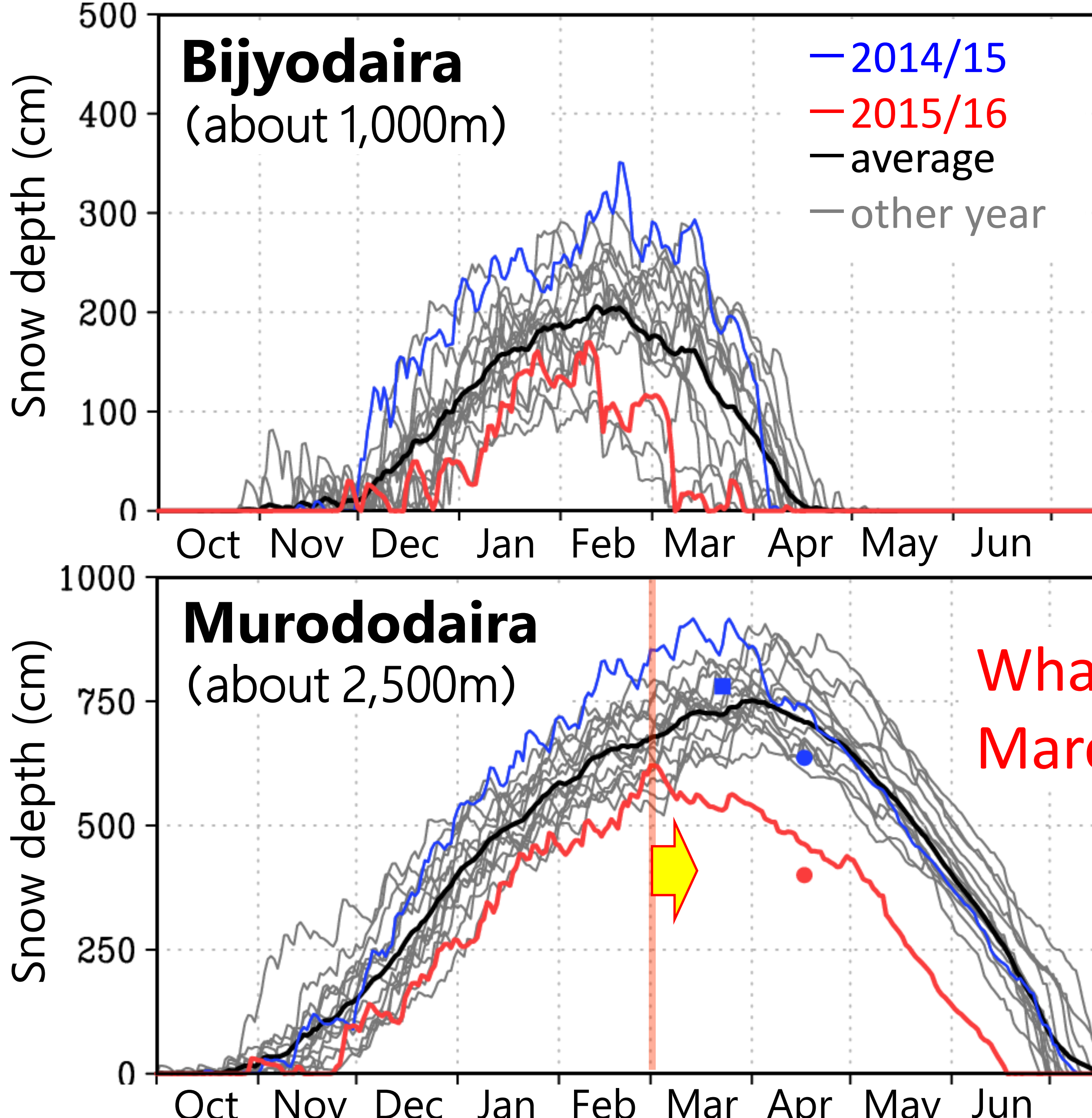
2014/15 winter





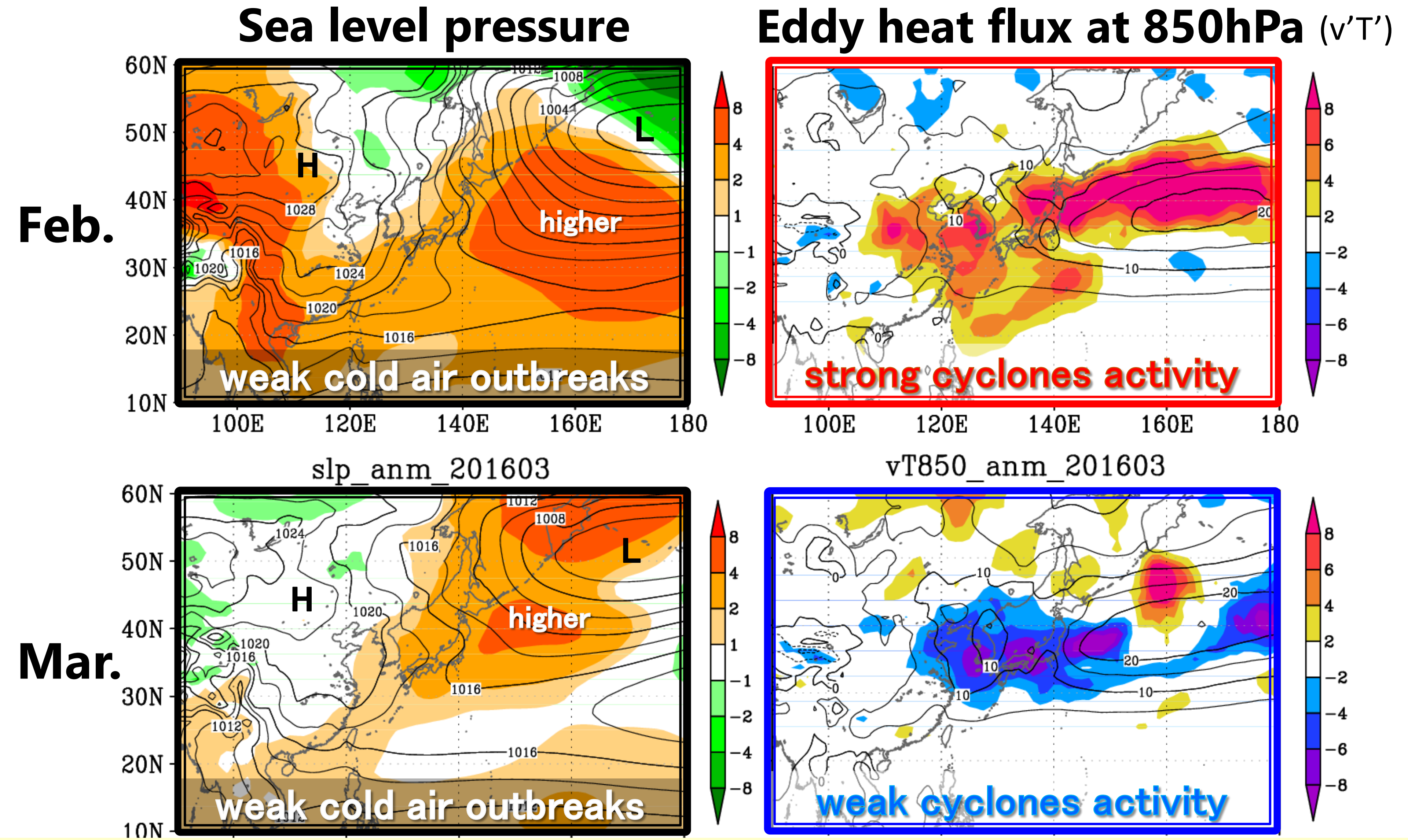


Seasonal variation of snow depth during 16 years



What happened in March, 2016?

Synoptic conditions in Feb. and Mar., 2016

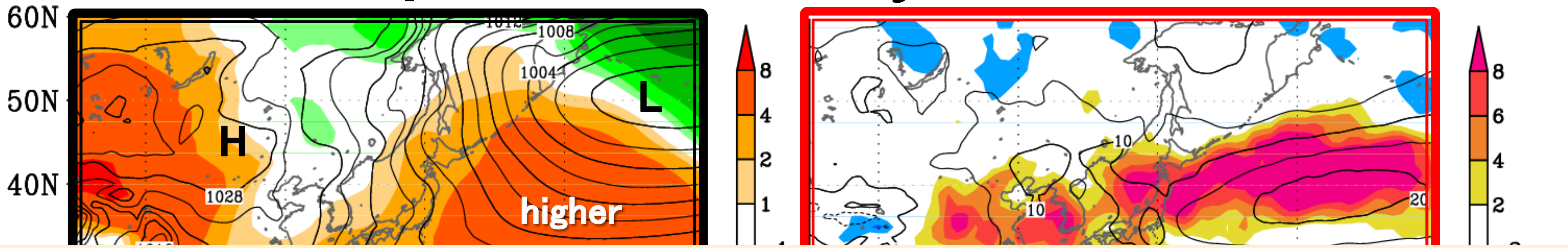


➔ Extremely small amount of March snowfall over high mountains

Synoptic conditions in Feb. and Mar., 2016

Sea level pressure **Eddy heat flux at 850hPa** (v’T’)

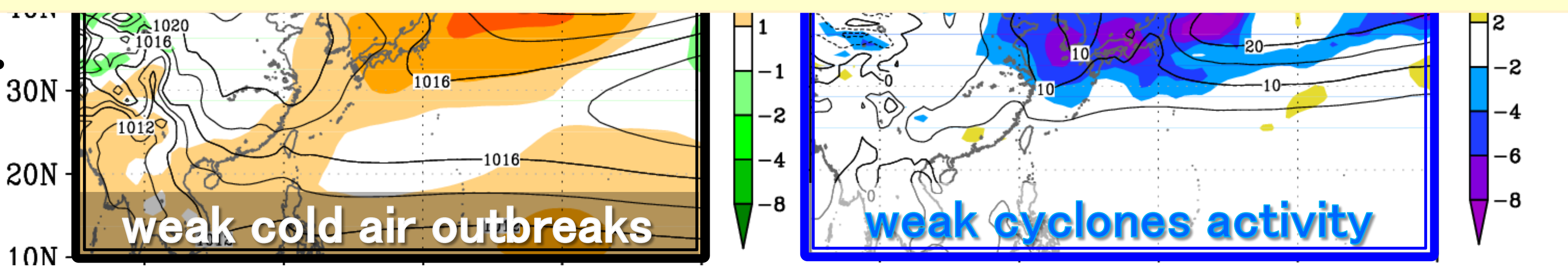
Feb.



This small amount of snow cover was caused by natural variability, not global warming.

To evaluate snow cover changes due to global warming, ensemble regional climate projections were analyzed.

Mar.



➔ Extremely small amount of March snowfall over high mountains

Large ensemble climate simulations

Database for Policy Decision making for Future climate change (d4PDF)

■ Global climate experiments（MRI-AGCM3）60km

○ **Historical experiments** (61yrs, **100 member**) [6100yrs]

SST: COBE-SST2 1950～2011 (with 100 initial perturbations)

○ **Future experiments** (61yrs, **90 member**) [5490 yrs]

SST: Historical SST plus 6 SST anomalies of CMIP5 CGCMs between past and future climate assuming 4 K warming (around 2080-2099)

■ Regional climate experiments（NHRCM）20km

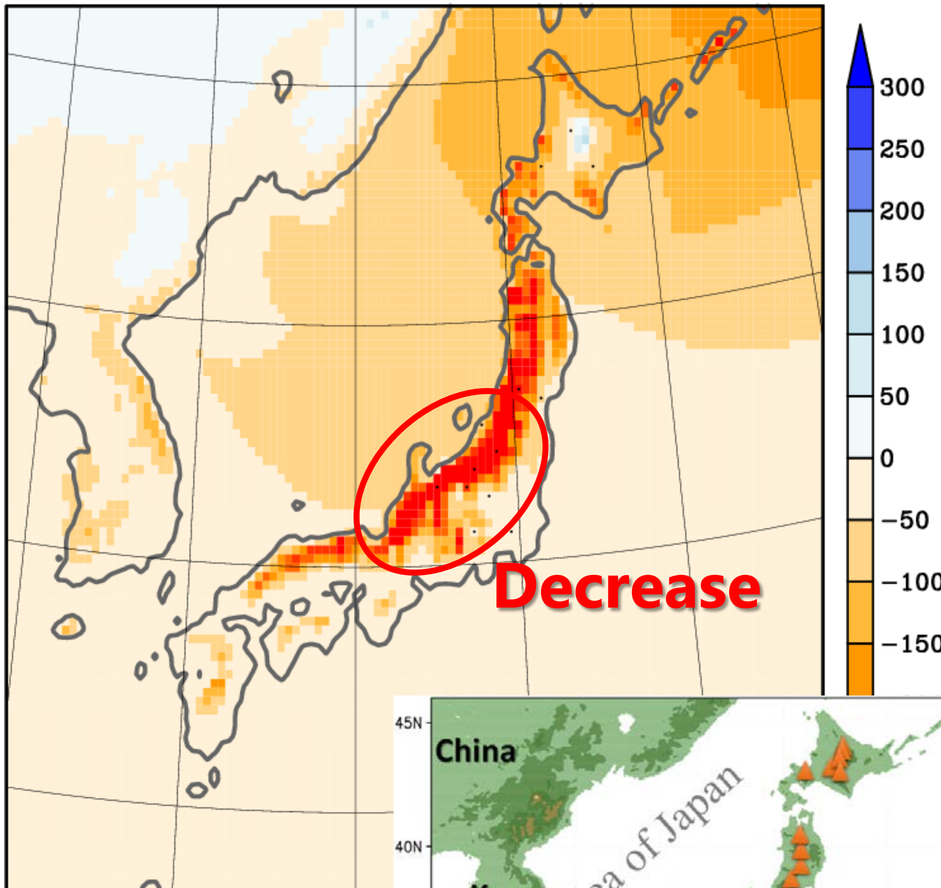
Initial and lateral boundary conditions: MRI-AGCM

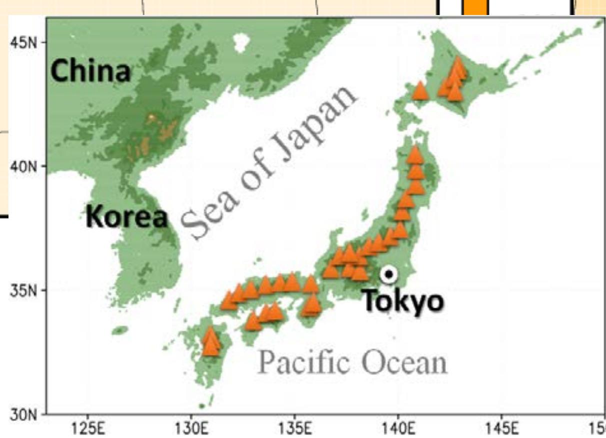
○ **Historical experiments** (61 years, 50 member)➔48 members

○ **Future experiments** (61 years, 90 member)➔48 members

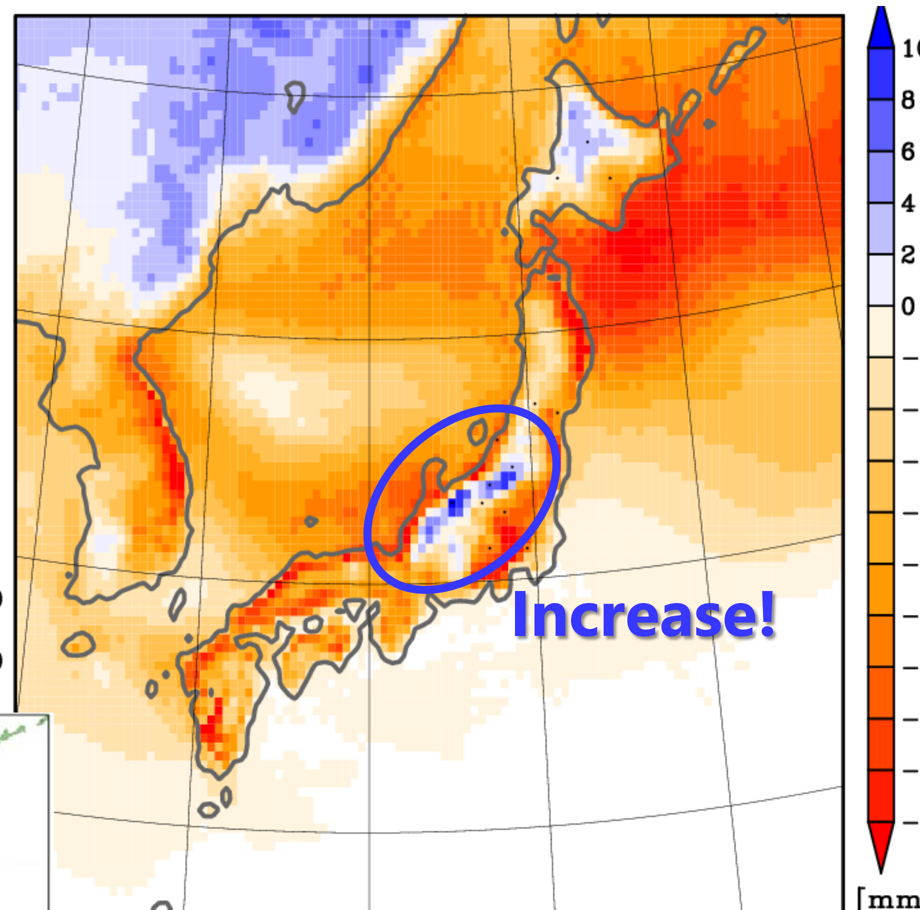
Future changes in extremely heavy daily snowfall

Total snowfall changes





Heavy daily snowfall changes
(occurring every 10 years)

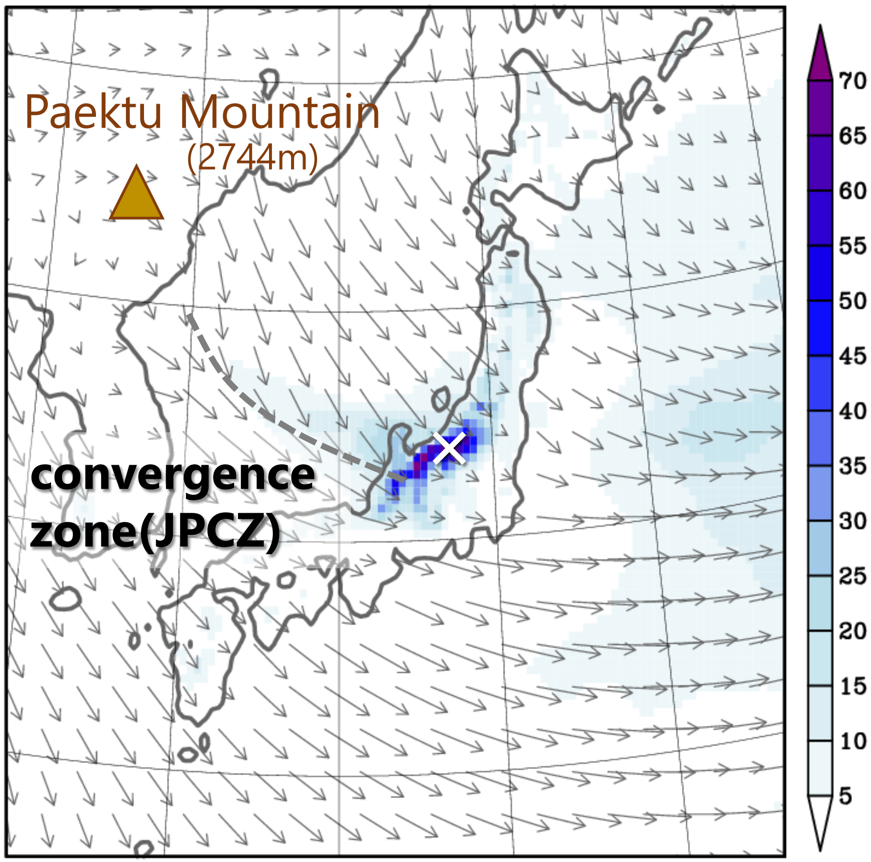


Remarkable increase in daily snowfall around Central Japan, Hokkaido, and eastern parts of Asian continent.

Why increase? Composites of top 50 heavy snowfall events

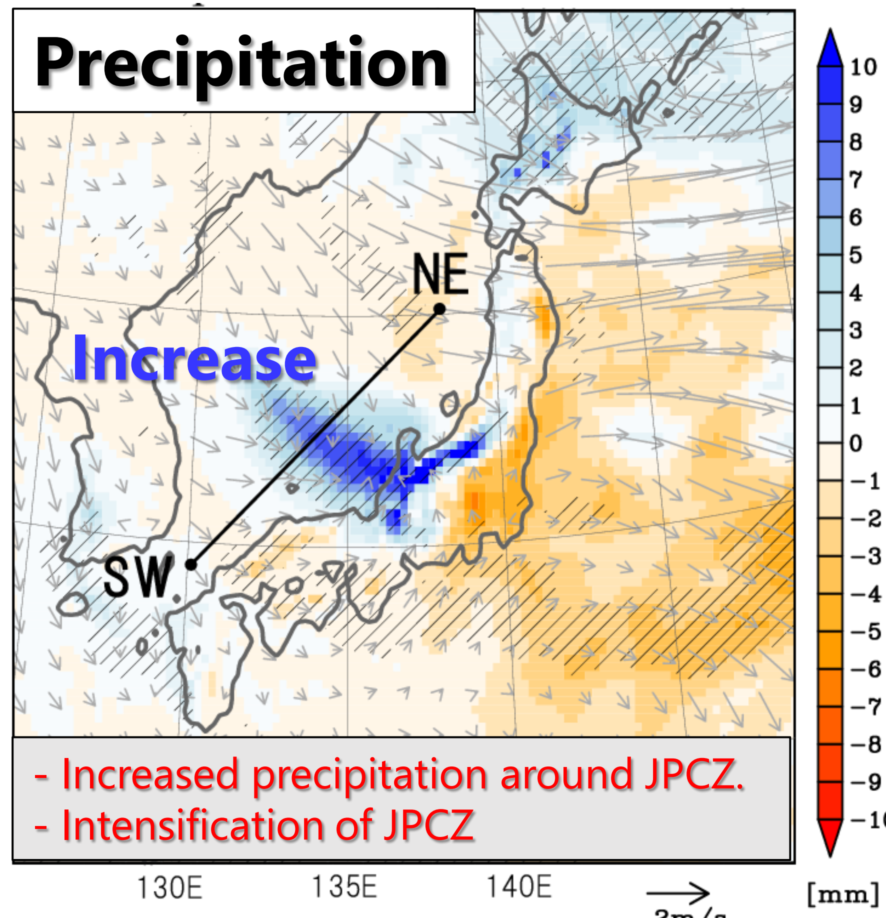
Precipitation(snowfall+rainfall) and surface wind

Historical experiments



X : Location of Tsunan station

Future exp. – Historical exp.

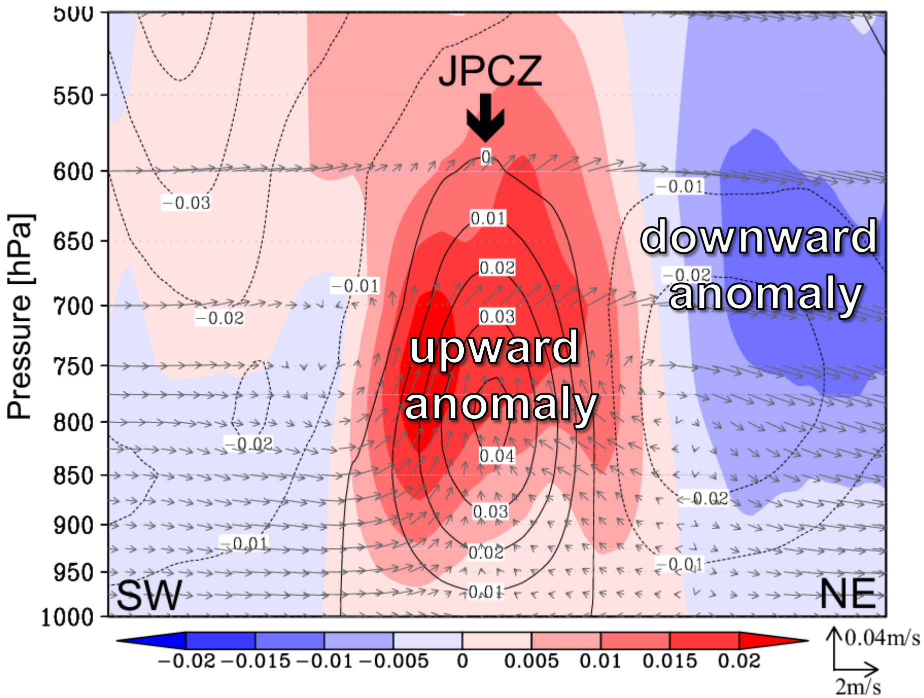


JPCZ: Japan sea Polar air mass Convergence Zone

Why increase? Composites of top 50 heavy snowfall events

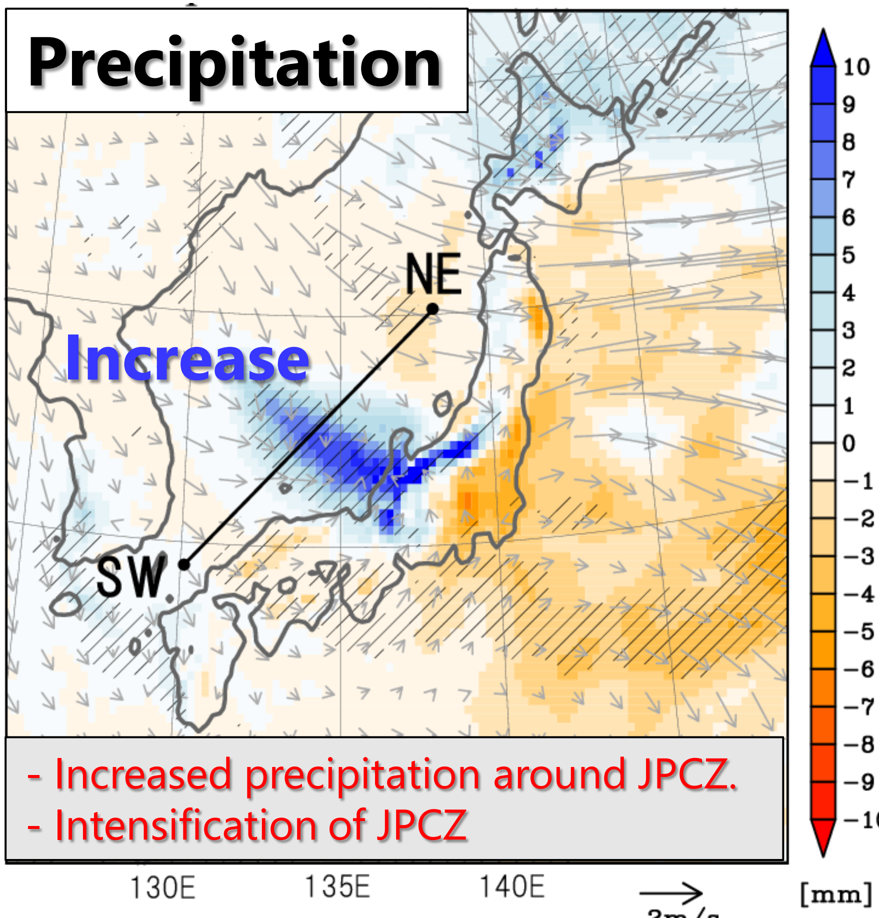
Precipitation(snowfall+rainfall) and surface wind

Mean vertical wind and differences



Enhancement of JPCZ
(convergence)

Future exp. – Historical exp.



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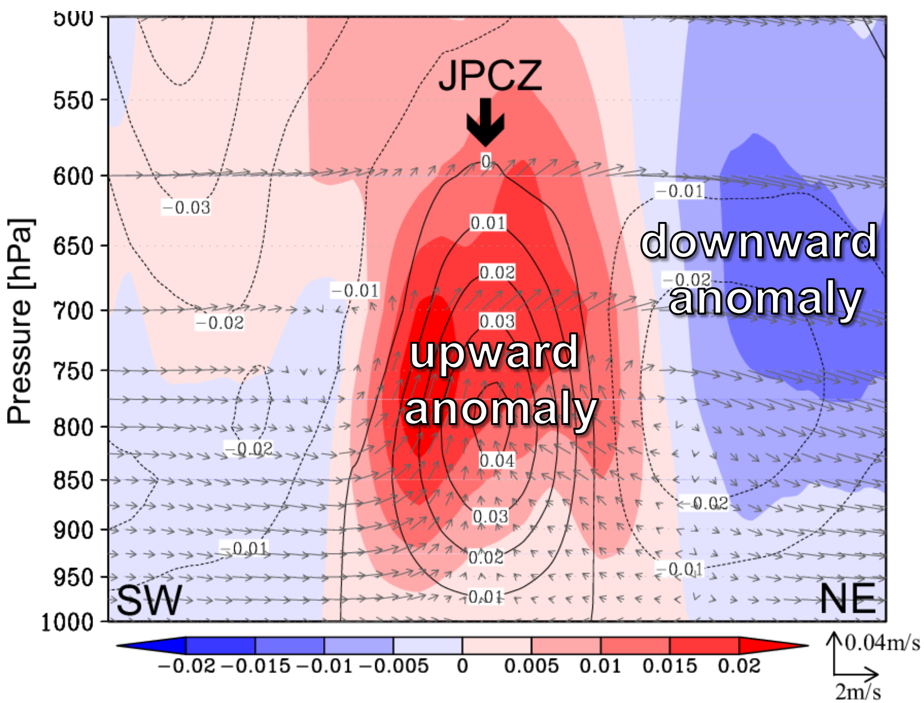

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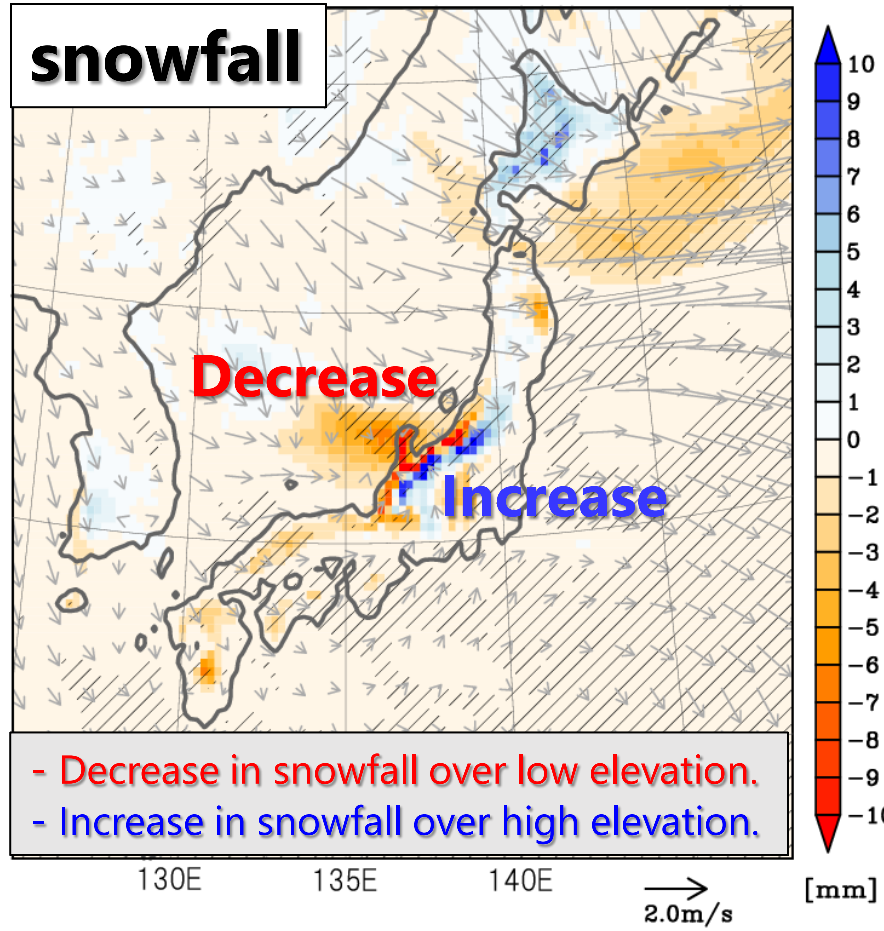
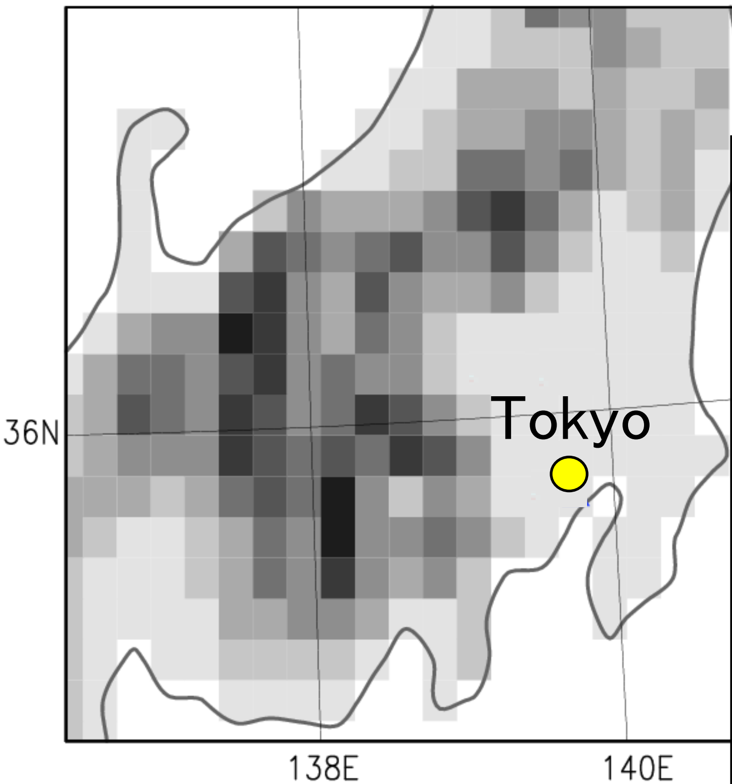
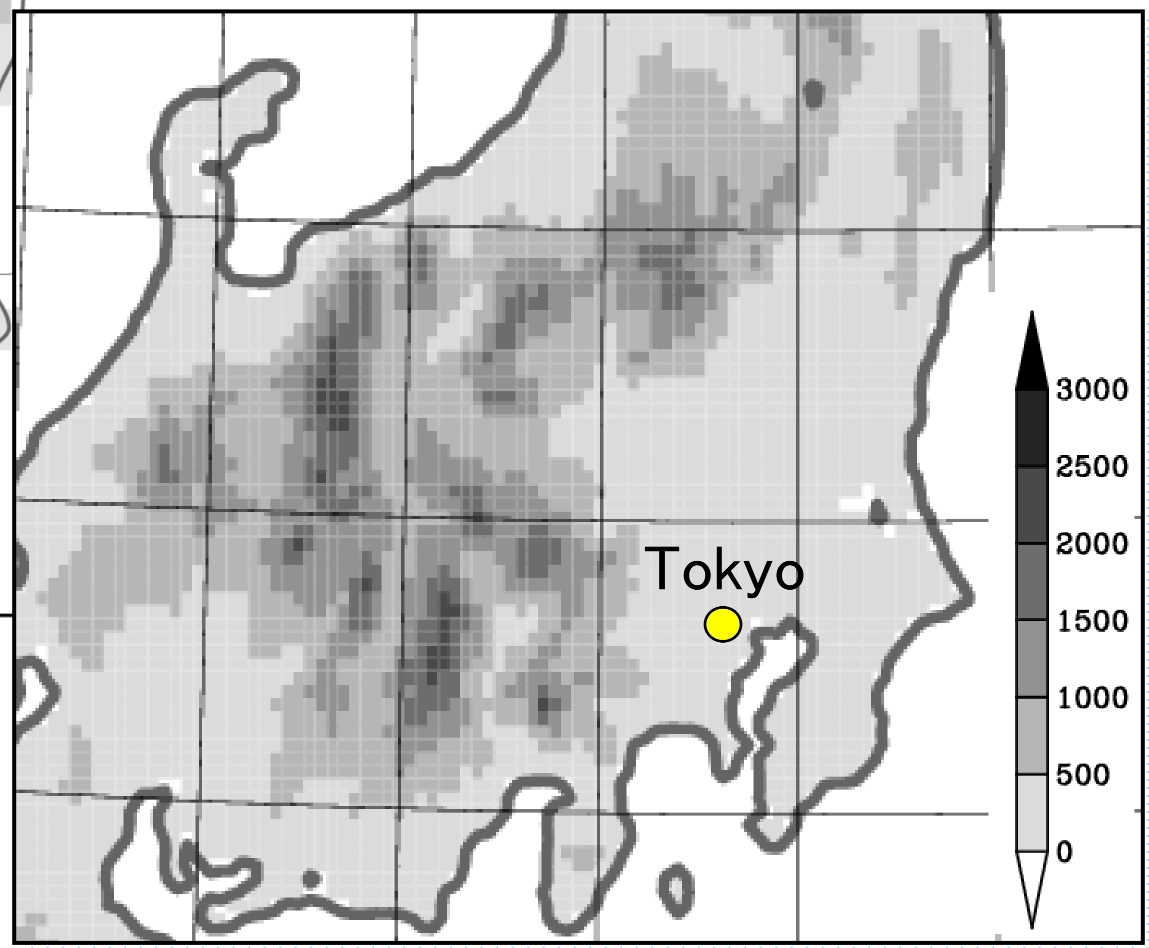


Next Step: Higher resolution ensemble simulations

20-km NHRCM (d4PDF)



5-km NHRCM



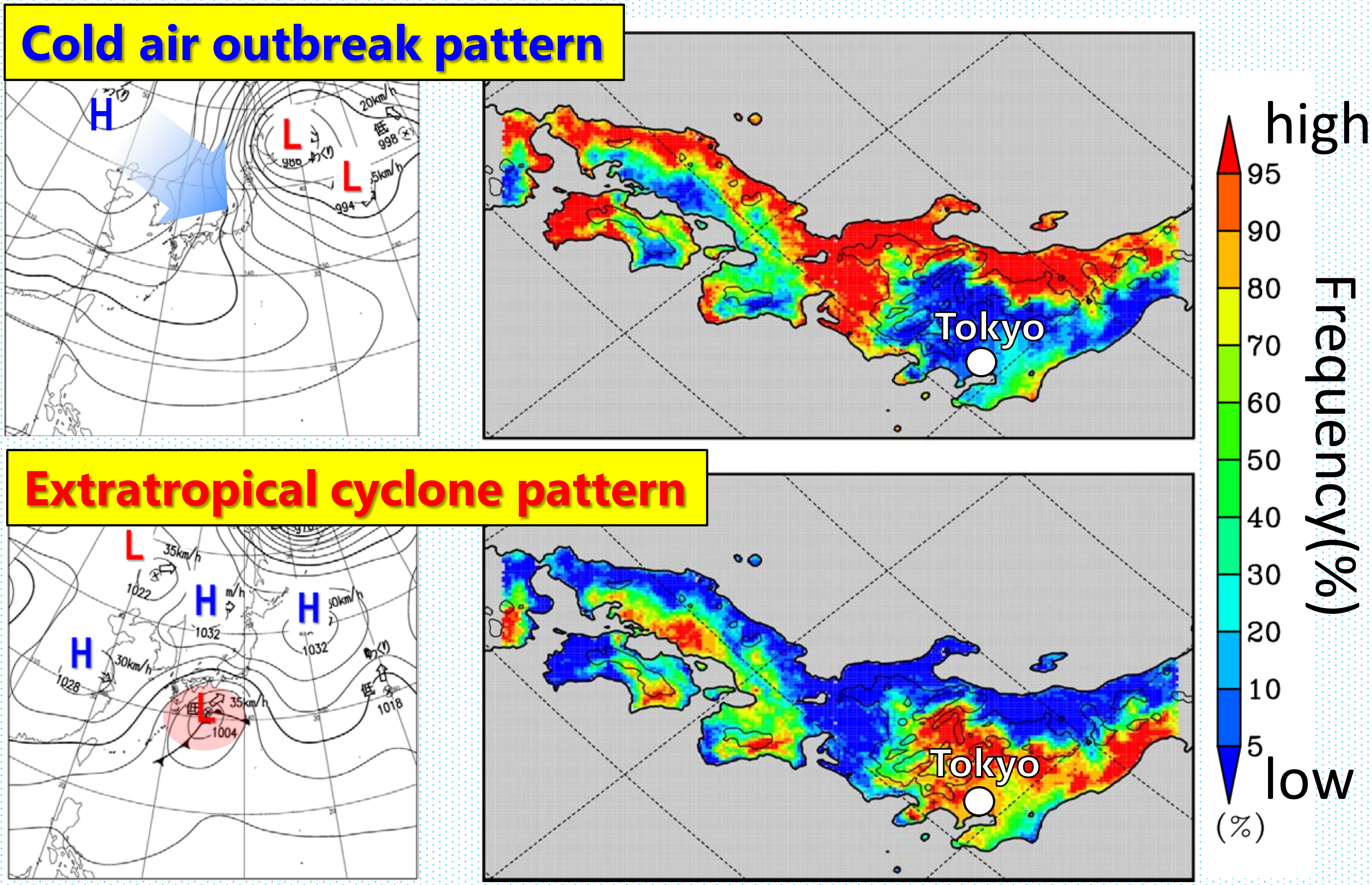
20-kmNHRCM (d4PDF)

downscaling

5-kmNHRCM (372 years)

Next Step: Higher resolution ensemble simulations

Classification of top 30 heavy daily snowfall events

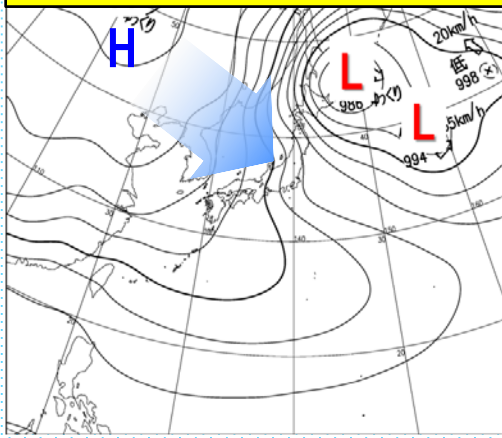


5-km NHRCM shows a clear boundary of synoptic patterns causing extremely heavy daily snowfall. (clearer than all snowfall event)

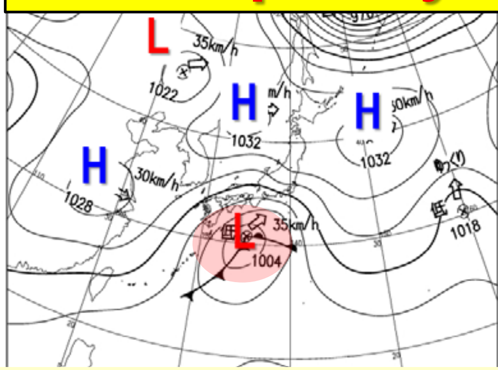
Next Step: Higher resolution ensemble simulations

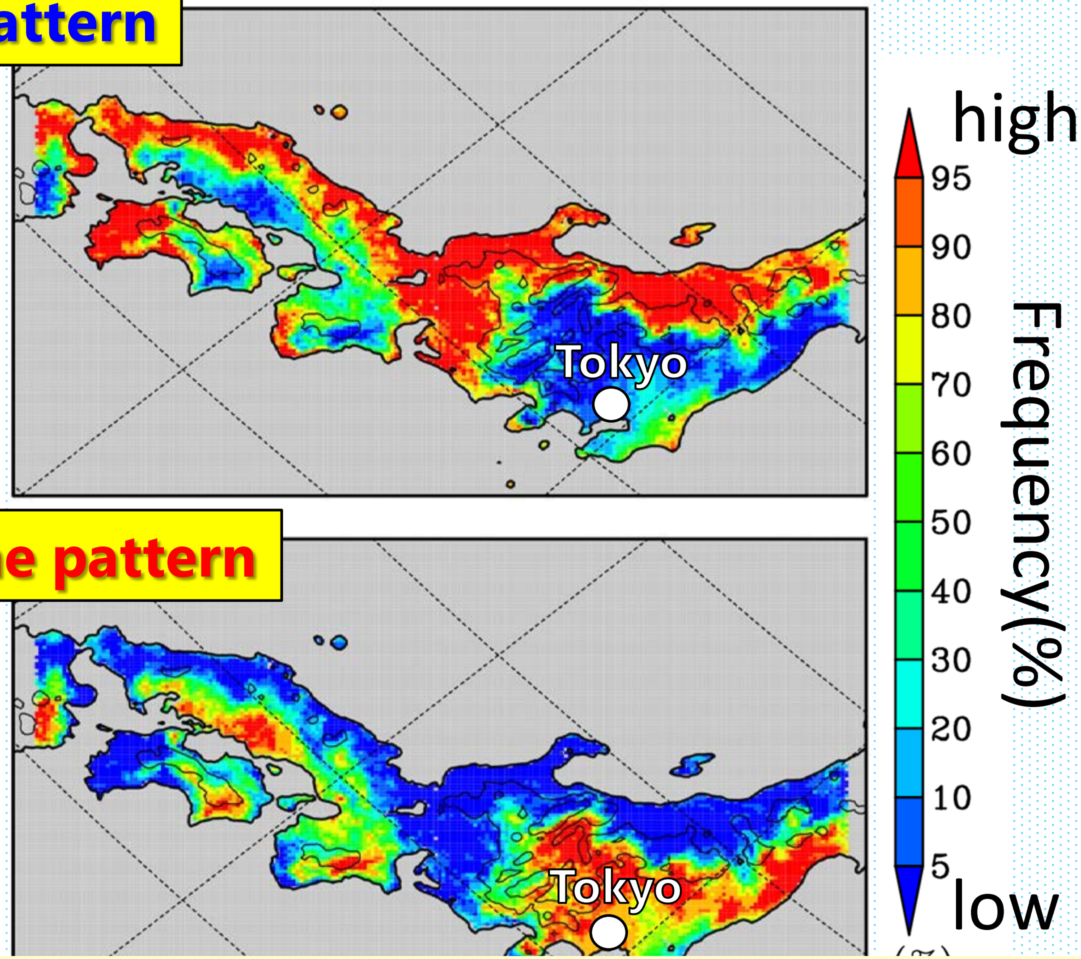
Classification of top 30 heavy daily snowfall events

Cold air outbreak pattern



Extratropical cyclone pattern





Future climate projections with 5-km NHRCM can evaluate future changes in heavy snowfall in each pressure pattern.

Summary

- Snow covers are well simulated by 2-km NHRCM around Japanese northern Alps. The extremely small amount of snow in 2016 was caused by the weak cold air outbreak and inactive extratropical cyclone in March.

- Due to global warming, total winter snowfall will decrease, while extremely heavy daily snowfall occurring once every ten years could increase on the mountainous areas in central Japan.

- The composite analysis indicates that the Japan sea Polar air mass Convergence Zone (JPCZ) could be enhanced due to global warming, bringing an increase in heavy snowfall over the mountainous areas in central Japan.

- Higher resolution simulations with 5-km grid spacing resolves Japan's complex mountains, showing a clear regional boundary of synoptic patterns causing heavy daily snowfall.


(Elevation: 2400m)
雪の大谷 19m
2017.4.23
Thank you