Terrain-influences on the regionality of future increases in Japan's summertime extreme high temperatures and the projection uncertainty

Publishments

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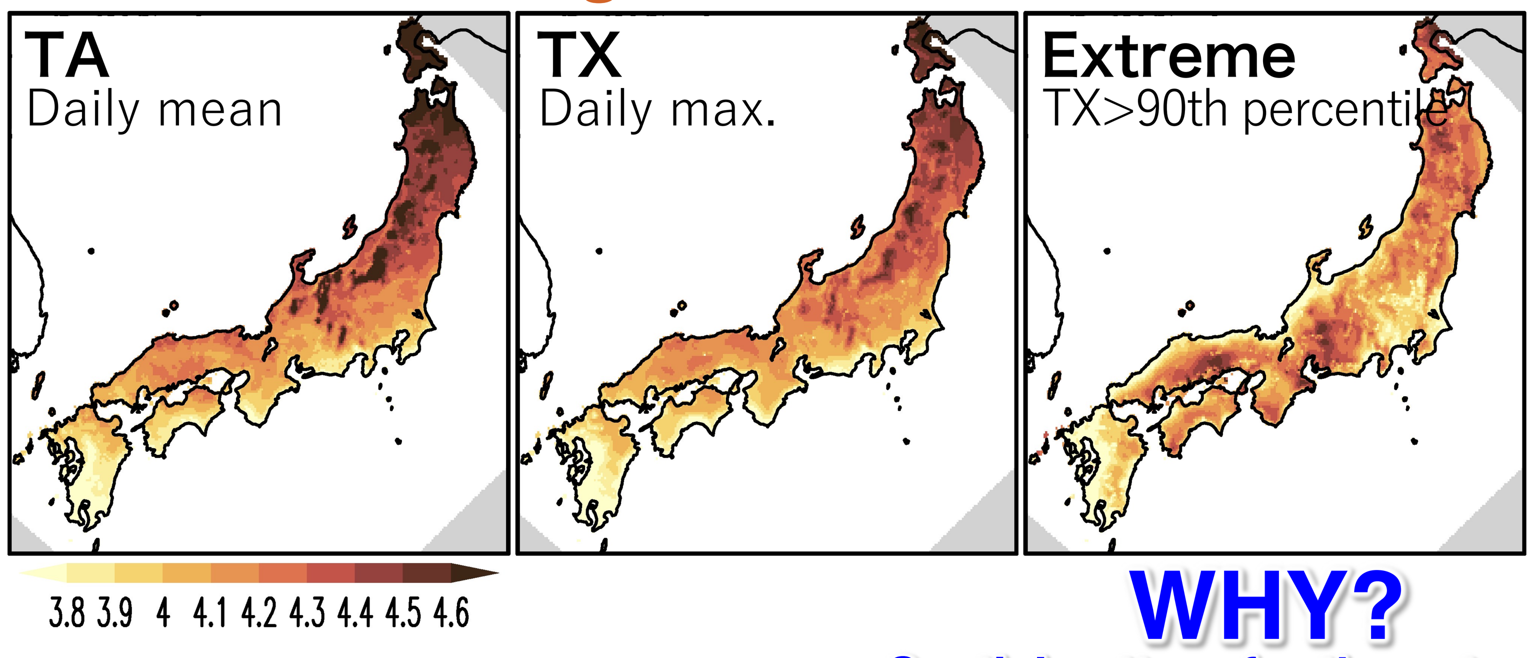
Abstract. *Our large-ensemble climate simulations by GCM & RCM indicates that future rise of extreme high temperature (> 90th percentile) in Japan has a different spatial distribution from that of mean temperature. On the extreme events, the SLP pattern reflects the local topography and favors the foehn-type wind. The dynamical impact of climate change on the foehn-inducing SLP pattern varies with site, leading to regional differences in high-temperature changes.*

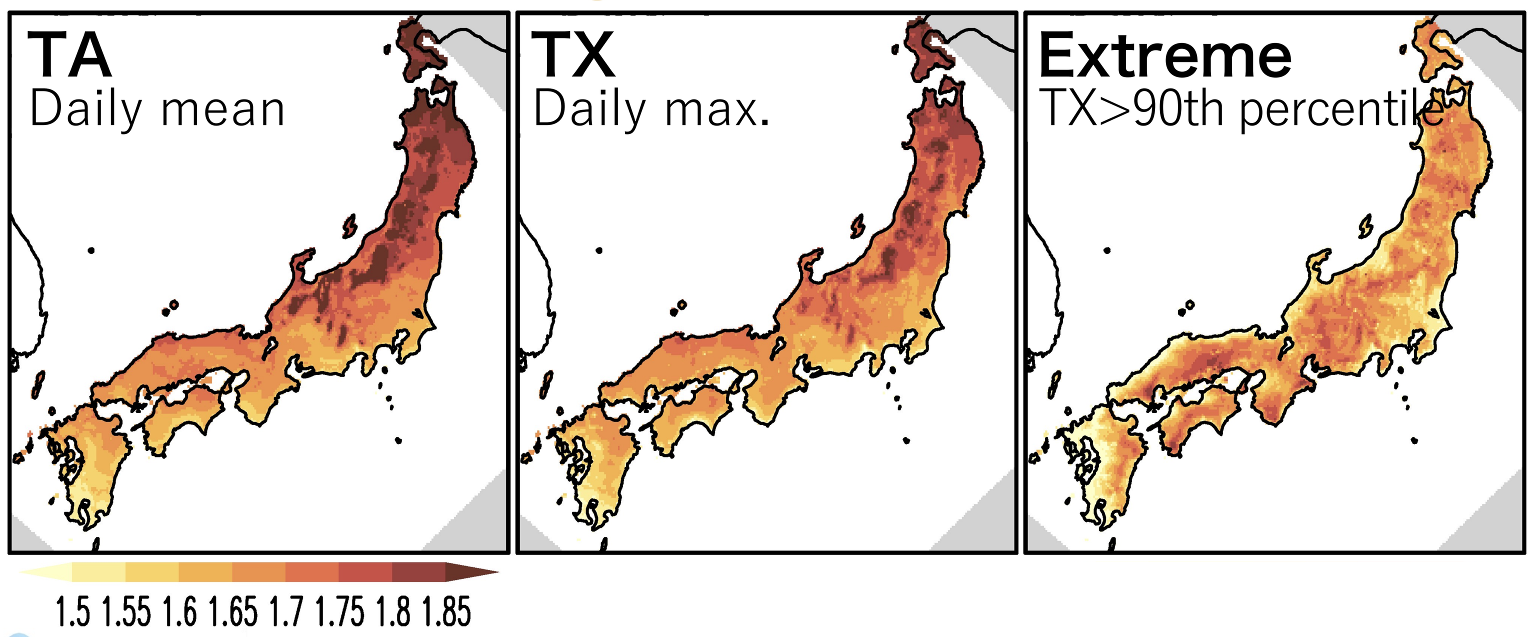
Increasing surface air temperature under global warming

Global 4°C warming

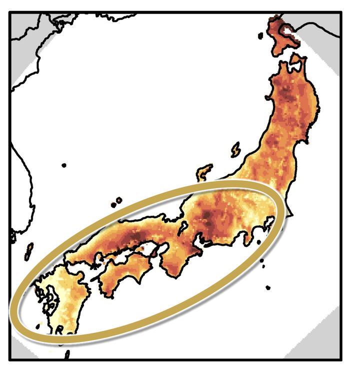


WHY?
Spatial pattern for the extreme is different from that for TA.

Global 2°C warming

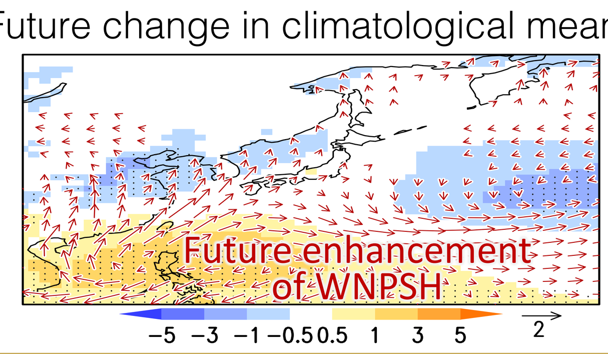


Large increase on the Pacific side

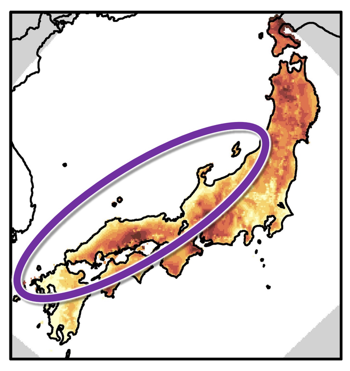


Future enhanced climatological mean of SLP in the south of Japan due to global warming.
→ **Promote the SLP pattern inducing the foehn**
→ **Acceleration** of the rises in extreme high Tair

Small uncertainty from comparison with the CMIPs (check below)

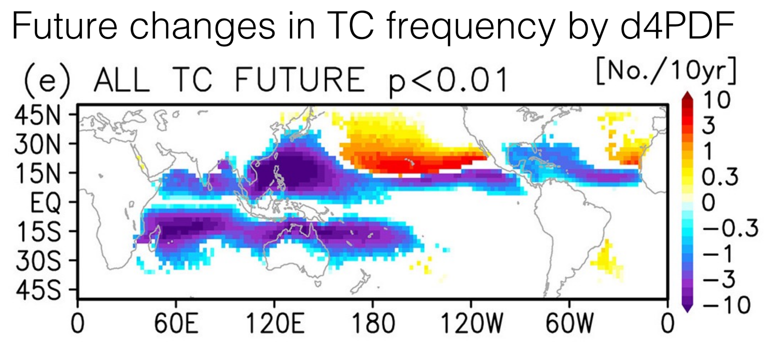


Small increase on the Sea of Japan side



Related to the typhoon-induced foehn.
→ **Future low frequency of TCs** around Japan
→ **Suppression** of the rises in extreme high Tair

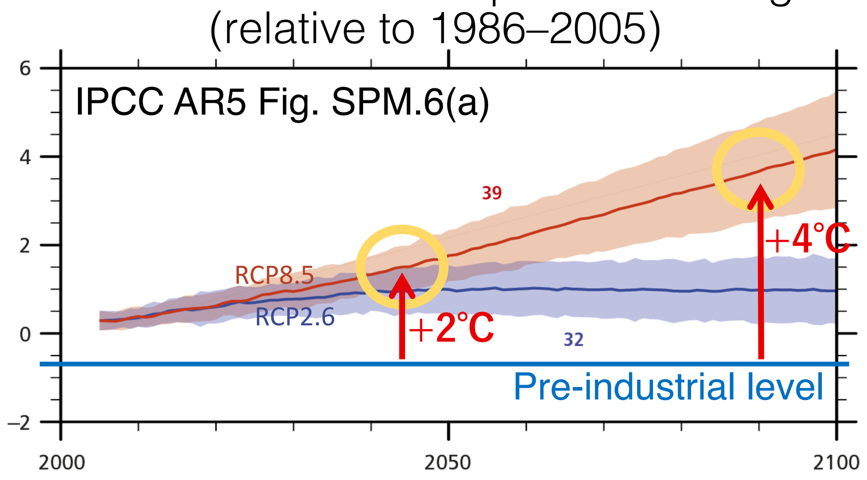
Sufficient uncertainty because future change in TCs varies depending on the dataset



Large ensemble climate dataset

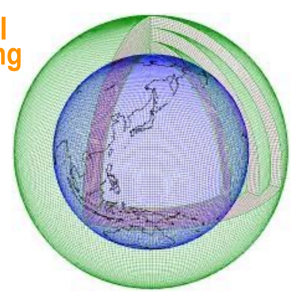
Database for Policy Decision-Making for Future Climate Change

Global surface air temperature change (relative to 1986–2005)



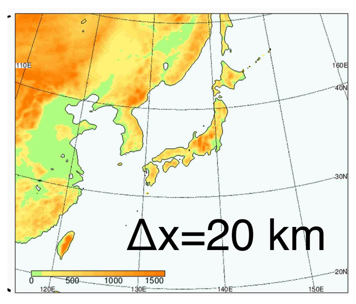
Global model (MRI-AGCM3.2, JMA)

Dynamical Downscaling

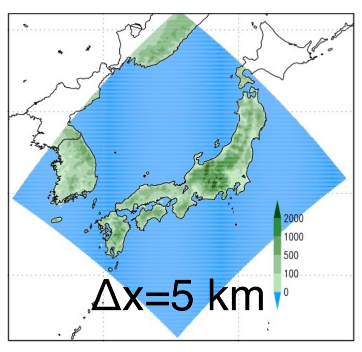


- Historical 6000 year (1951–2010 × 100mem.)
- 2°C Warming 3240 year (2031–2090 × 54mem.)
- 4°C Warming 5400 year (2051–2110 × 90mem.)

Regional model (NHRCM, JMA)



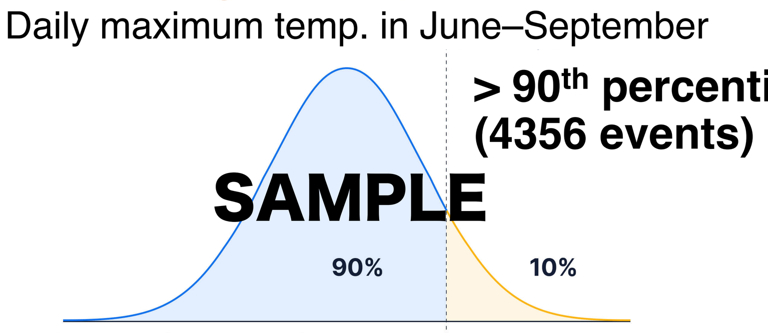
- Historical 6000 year
- 2°C Warming 3240 year
- 4°C Warming 5400 year



- Historical 360 year (1981–2010 × 12mem.)
- 2°C Warming 360 year (2061–2090 × 12mem.)
- 4°C Warming 360 year (2081–2110 × 12mem.)

Definition of Extreme high temperature events

Daily maximum temp. in June–September



Anomaly from the 30-year average of the first, middle and last 10-days of each month

Background

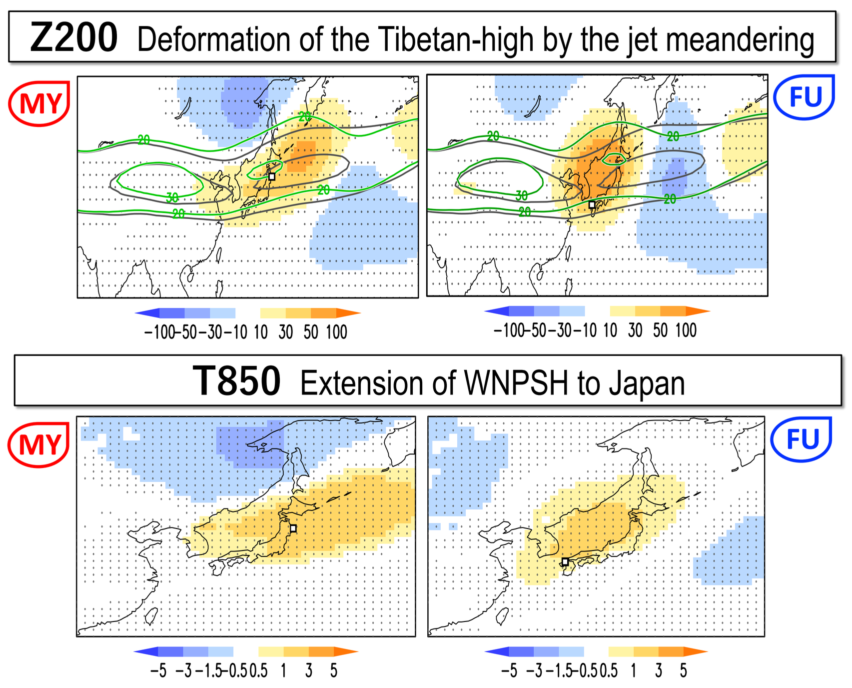
Japan's climate research group created a large ensemble climate dataset (d4PDF: database for Policy Decision-Making for Future Climate Change) in 2015 to investigate future projection of various extreme events around Japan. This study is one of them which focuses on future change in extreme high temperatures during summertime.

Results

Two-tiered anticyclone system

occurs on the hot days in Japan

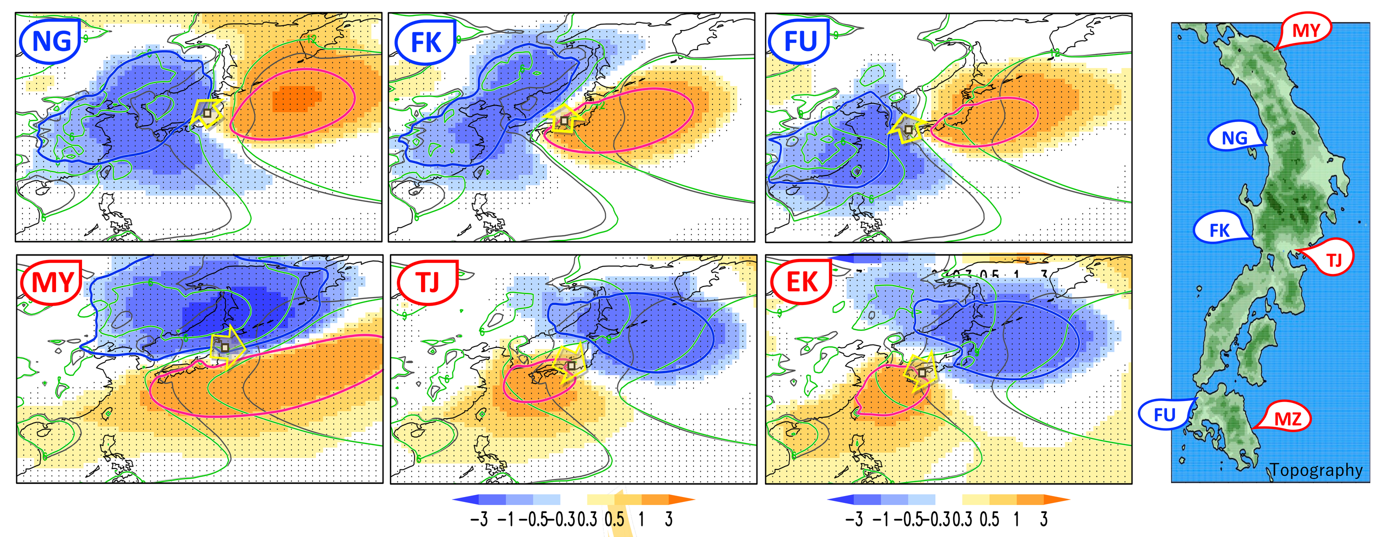
Similar pattern on the events among sites



Site variation of the SLP anomaly pattern

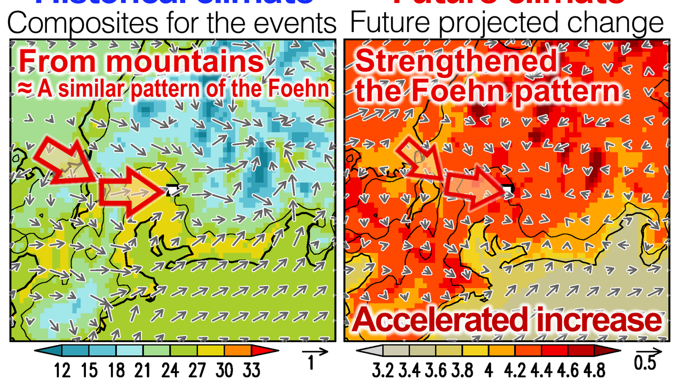
on extreme high temperature events in the present climate

Each pattern reflects the local topography and induces the foehn wind



Shaded: SLP anomaly (hPa) Dotted: 99% confidence level
Red & blue line: Correlation >0.1 (<−0.1) between TX & SLP
Open square: Site location for the extreme events

TJ Surface wind on the events



Uncertainty in future SLP pattern around Japan

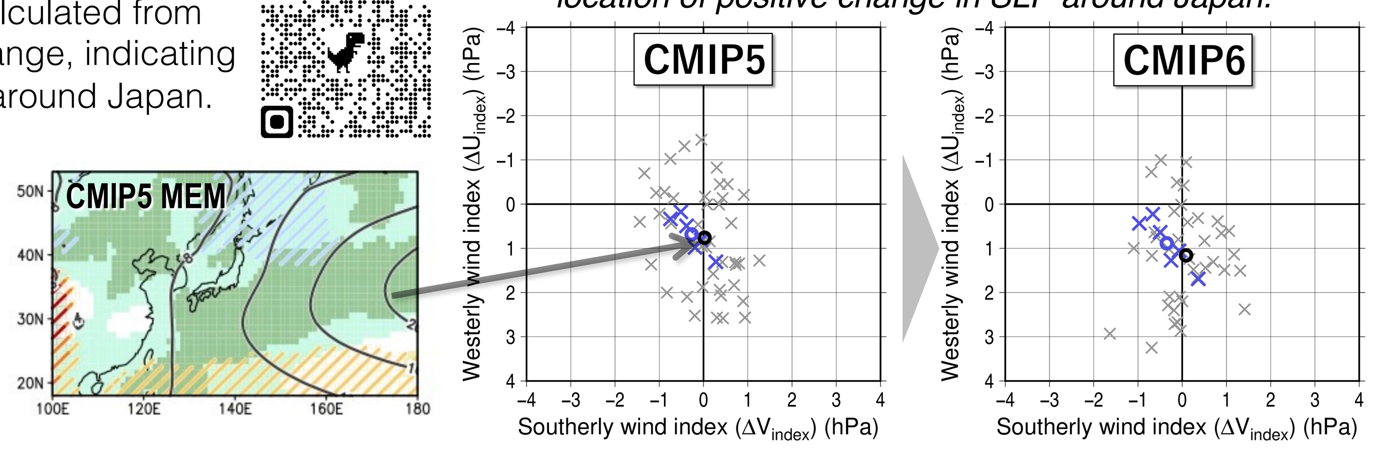
estimated from the GCM of d4PDF and CMIPs

CMIP5➡CMIP6 ***Reduction of uncertainty & Close to our GCM projection***

ΔU_{index}, ΔV_{index}
Indices are calculated from future SLP change, indicating wind change around Japan.

Detailed method

The relative position from the origin represents the location of positive change in SLP around Japan.



× CMIP Each model
○ CMIP Model mean
× d4PDF Each mem.
○ d4PDF Ens. mean

CMIP5→CMIP6
- Reduce the projection spread
- CMIPs gathering at d4PDF

Conclusion

Future increase in extreme high temperature has a different spatial distribution from that in mean temperature. This is because:

1) The SLP pattern on the extreme events reflects the local topography, inducing foehn-like wind for each site.
2) The impact of future SLP change on the foehn-inducing pattern varies with site, leading to regional variation.
3) Whereas the distribution for the mean-temperature change generally shows the thermodynamic response, that for the high-temperature change is affected by the dynamic response of SLP to global warming.

References
– (d4PDF) Mizuta, R., and coauthors (2017, BAMS) doi:10.1175/BAMS-D-16-0099.1
– (d4PDF 5kmDS dataset) Sasai, T., and Coauthors (2019, JGR Atmos.) doi:10.1029/2019JD030781

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MEXT-Program for The Advanced Studies of Climate Change Projection (SENTAN)
DIAS Data Integration & Analysis System
d4PDF
DS2022