

Impact Assessment of Climate Change on Coastal Hazards due to Winter Cyclone around Japan using Large Ensemble Database

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TOUGOU

Integrated Research Program
for Advancing Climate Models

Conclusion and Outline of This Study

- Extratropical cyclone's track shifts northward and its intensity increases in +4K climate, and high wave event due to extratropical cyclone becomes severe.

Outline

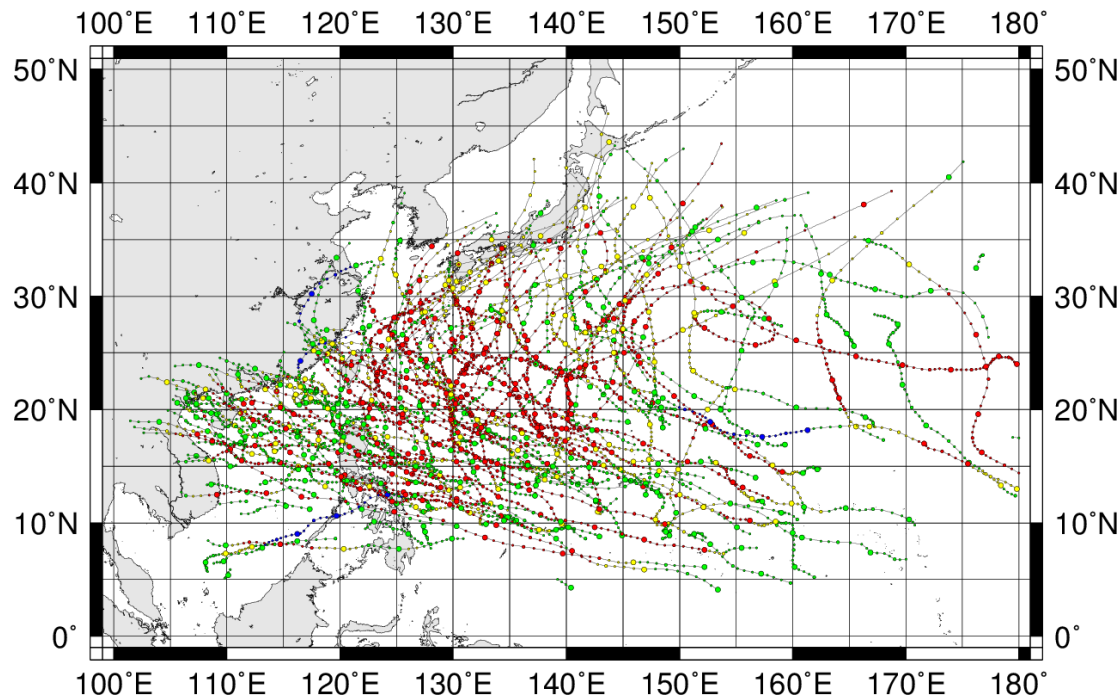
1. Introduction
2. Methodology
 1. Used dataset (d4PDF)
 2. Developed extraction algorithm
 3. Wave simulation
3. Results
 1. Future change of extratropical cyclone
 2. Future change of high wave
4. Conclusions

Future Change of Extreme Events

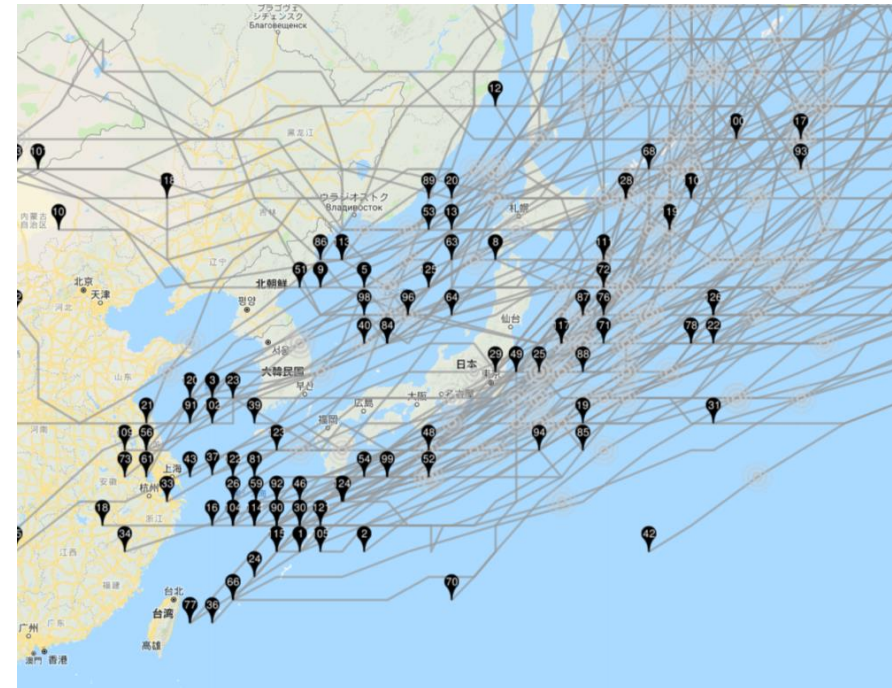
- IPCC AR5

- Likely : Increasing intensity of **Tropical Cyclones (TC)**
- Lower confidence : Change of **Extratropical Cyclones (ETC)**

TC Track 2013-2017

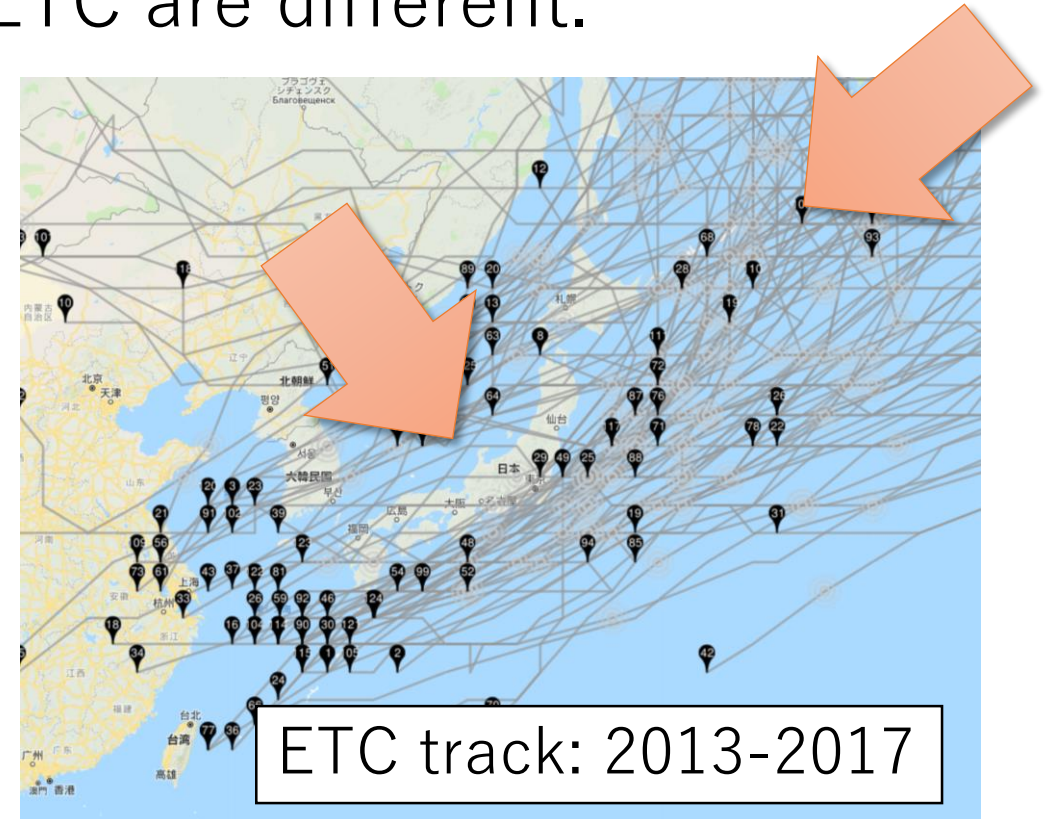
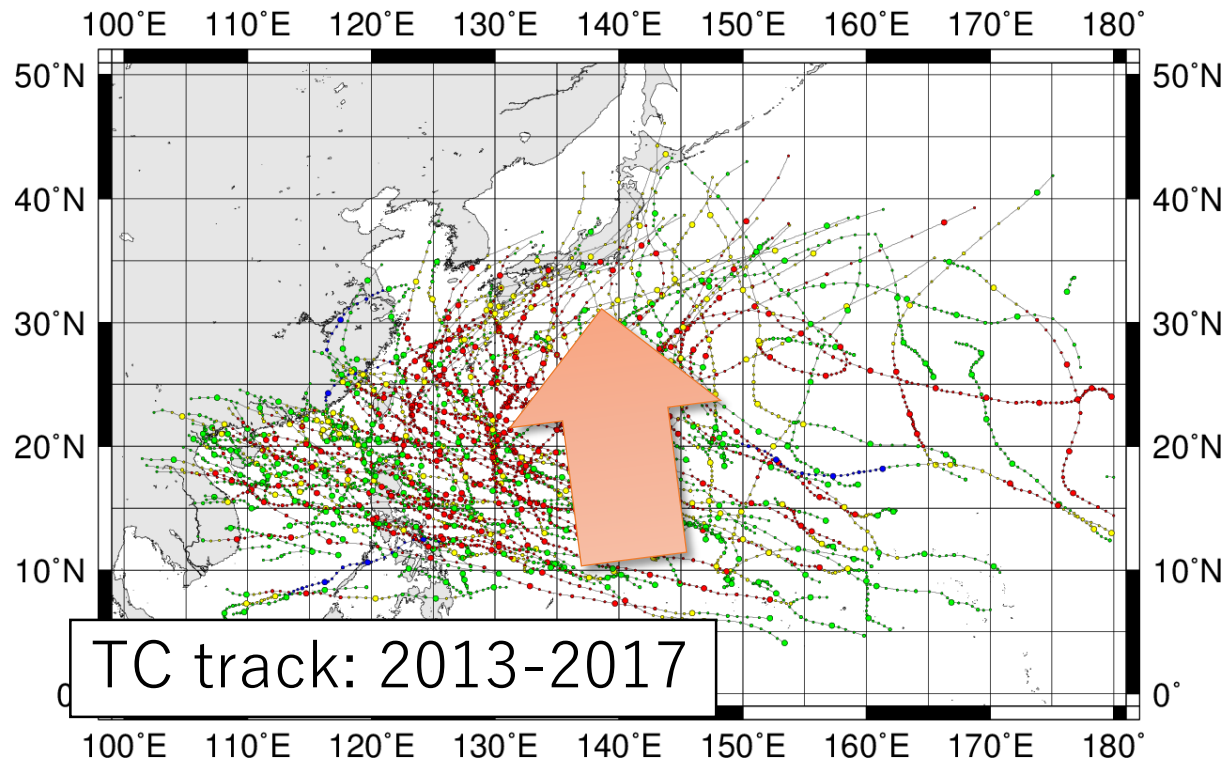


ETC Track 2013-2017

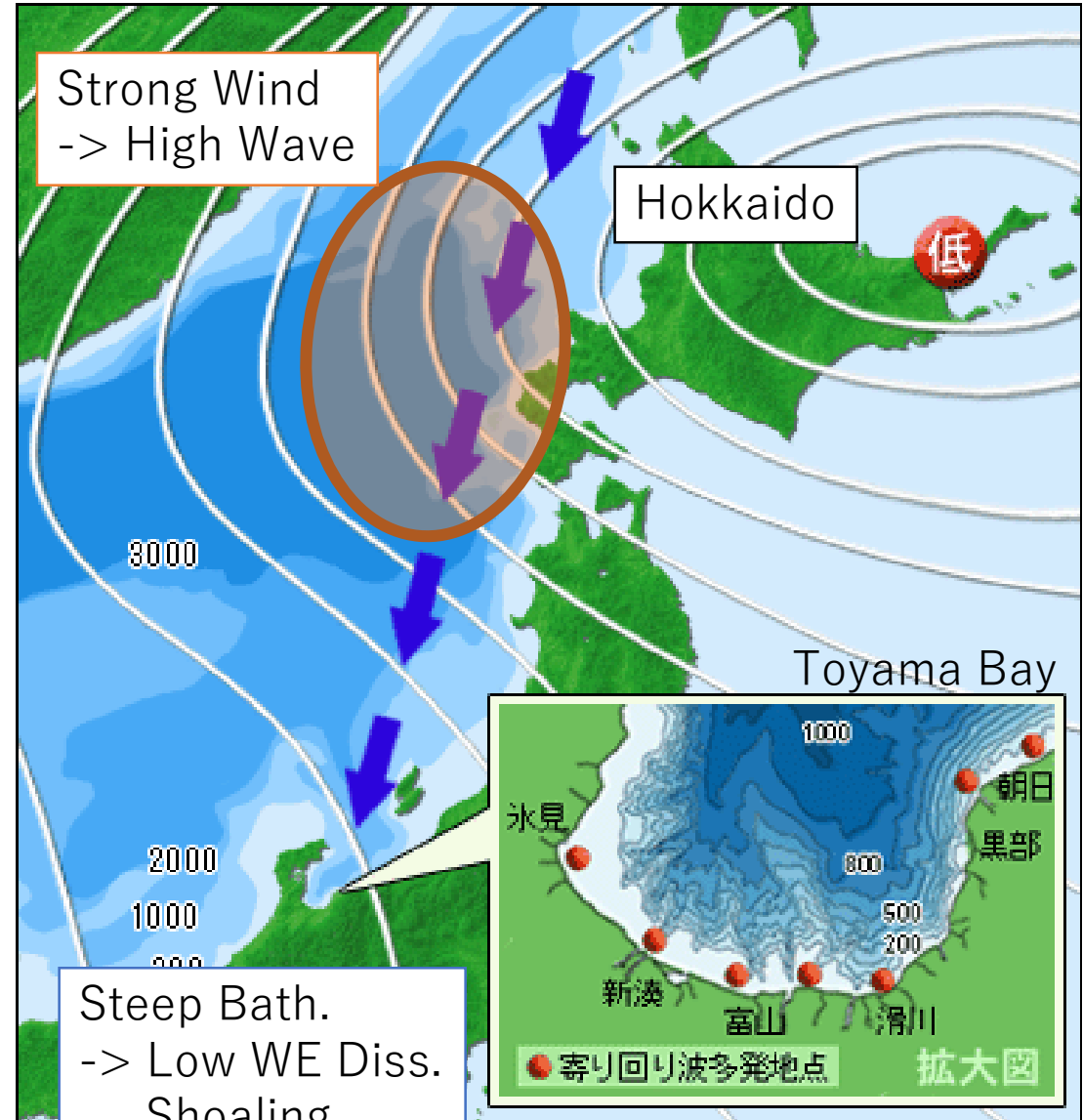
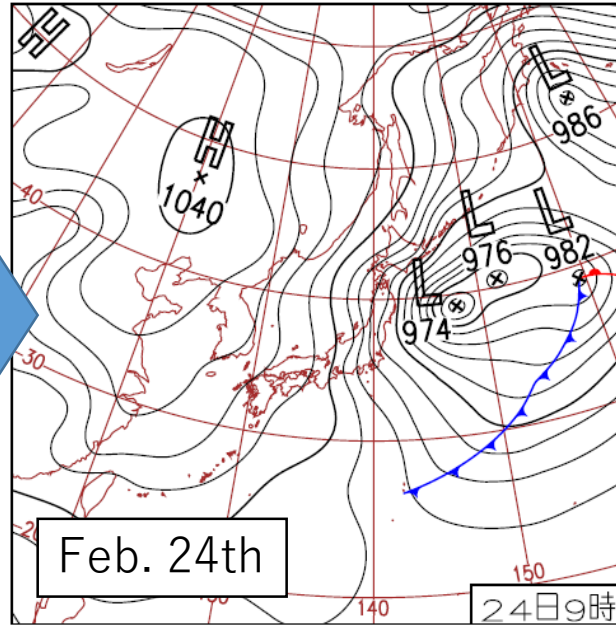
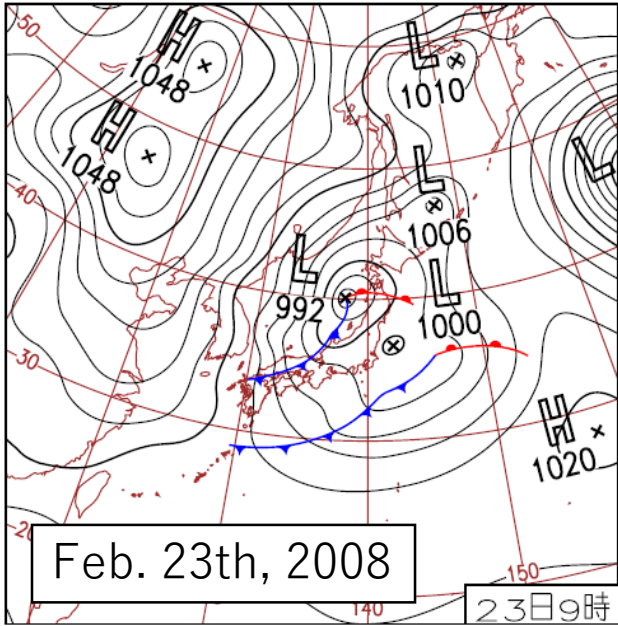


Coastal Hazards (High Wave) around Japan

- Japan has suffered from high wave due to Tropical Cyclones (TC) and Extratropical Cyclones (ETC), but wave directions due to TC and ETC are different.



High wave due to ETCs: Yorimawari Wave



4200 tons caisson

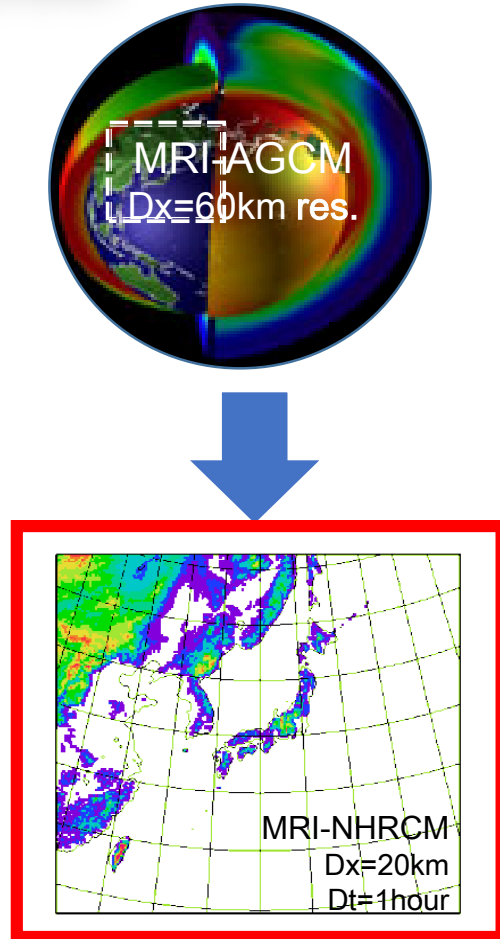


Aims of This Study

- Reveal future change of ETCs around Japan especially related high wave (Yorimawari wave) disaster.
- Evaluate future change of Yorimawari wave.

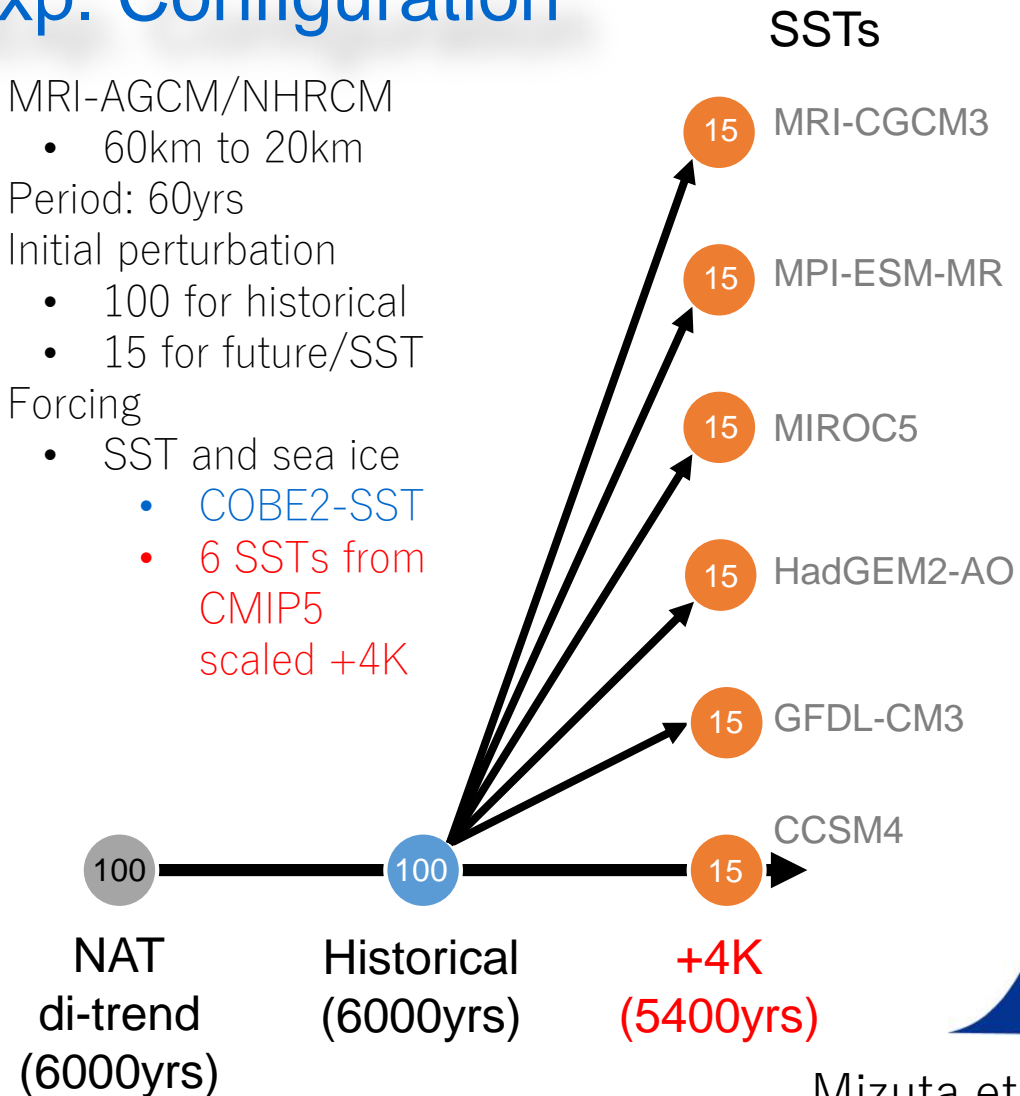
Methodology: Large Ensemble Database (d4PDF: database for Policy Decision making for Future climate change)

Model



Exp. Configuration

- MRI-AGCM/NHRCM
 - 60km to 20km
- Period: 60yrs
- Initial perturbation
 - 100 for historical
 - 15 for future/SST
- Forcing
 - SST and sea ice
 - COBE2-SST
 - 6 SSTs from CMIP5 scaled +4K



Methodology: Developed ETC Extraction Algorithm

Extracting

- Smoothing: Sea Level Pressure (SLP)
- Searching: 1hPa smaller than surrounding cells

d4PDF regional data

- 534,720 (steps per 60 year) x 100 (90) cases

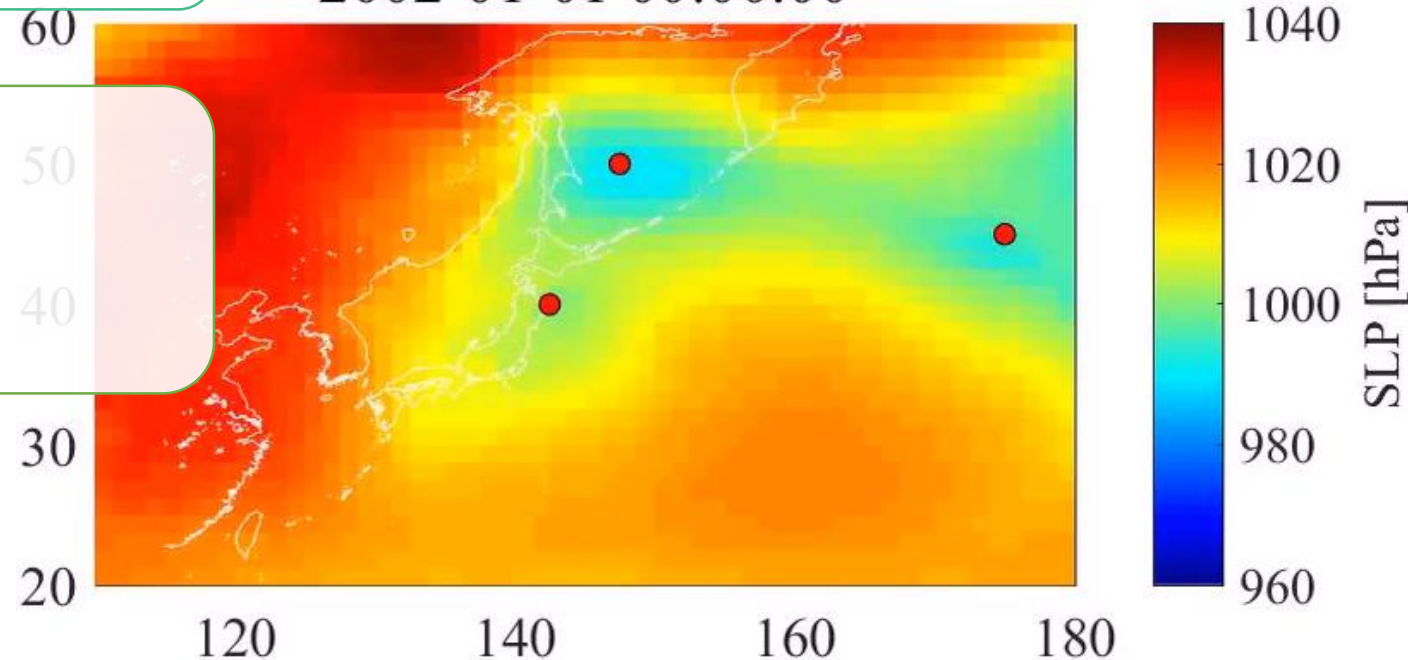
Tracking

- Moving Distance: EW $\pm 4.5^\circ$, NS $\pm 3^\circ$ / step
- Duration: longer than 24 hours

Sorting

- Season: Oct. to April
 - Maximum Development Rate: $\varepsilon > 1$
- $$\varepsilon = \frac{p(t - 12) - p(t + 12)}{24} \times \frac{\sin 60^\circ}{\sin \varphi(t)}$$

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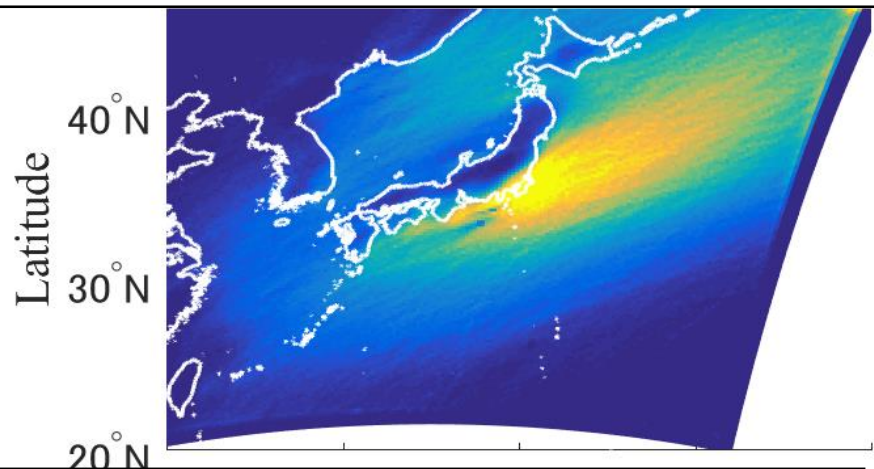


Results

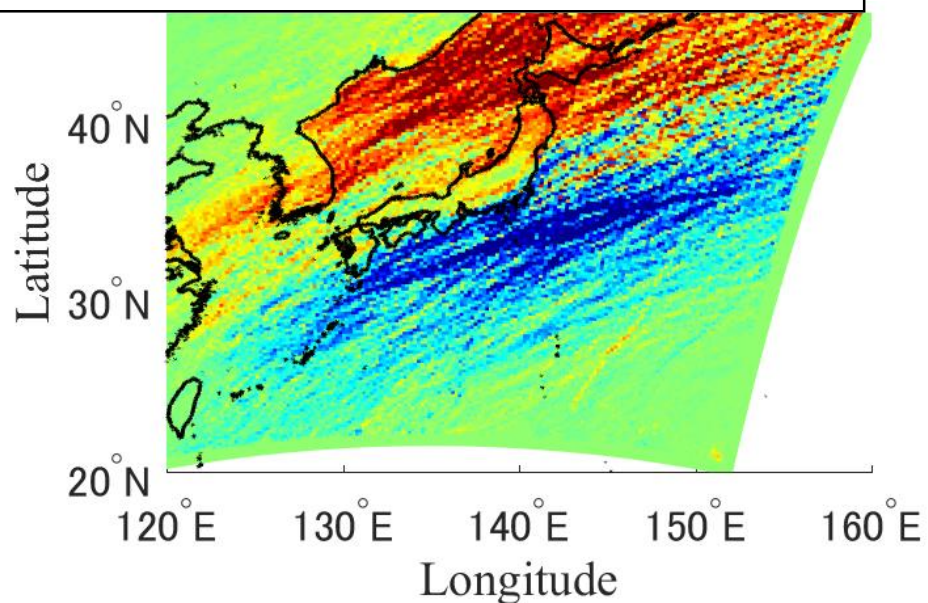
Future Change of ETC around Japan and
Yorimawari wave

Future Change of ETC Track

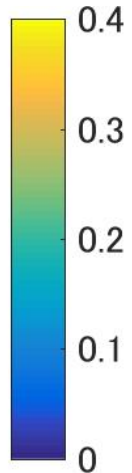
The number of ETC under present climate



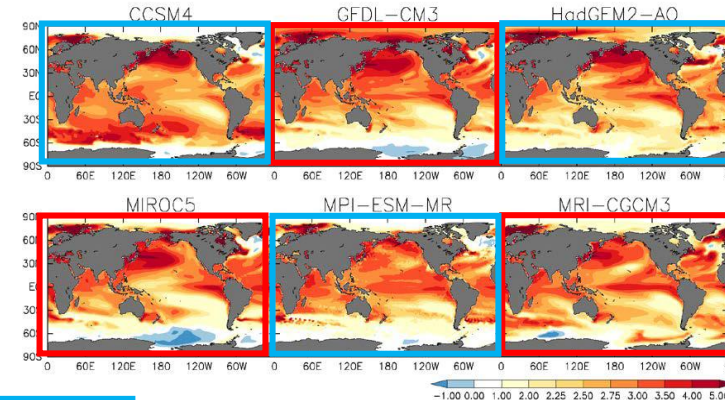
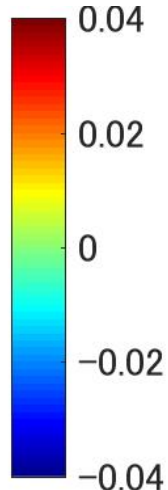
Future change of the number of ETC



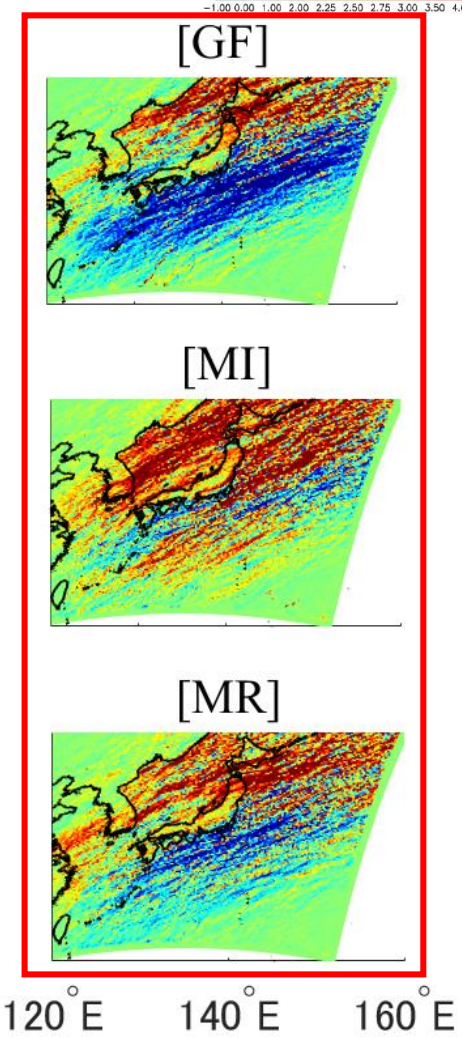
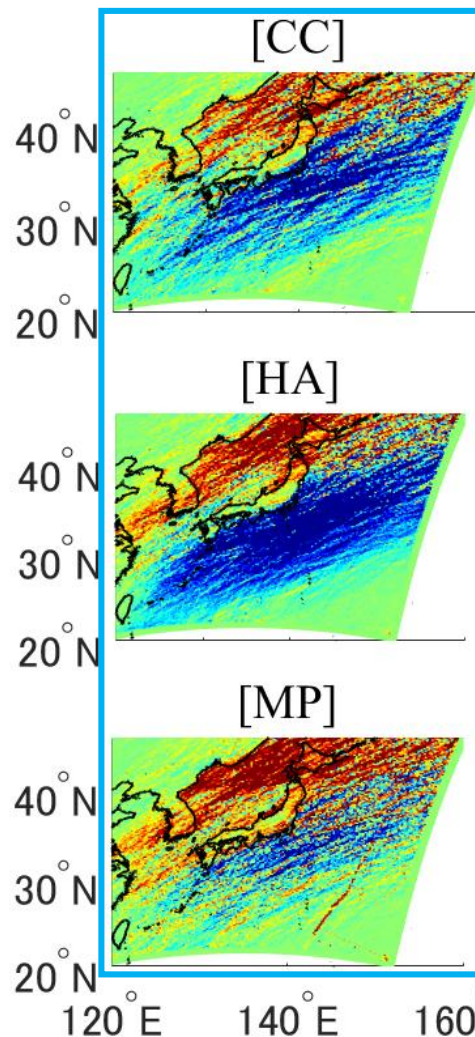
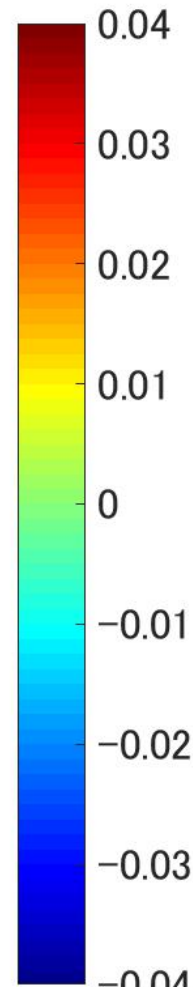
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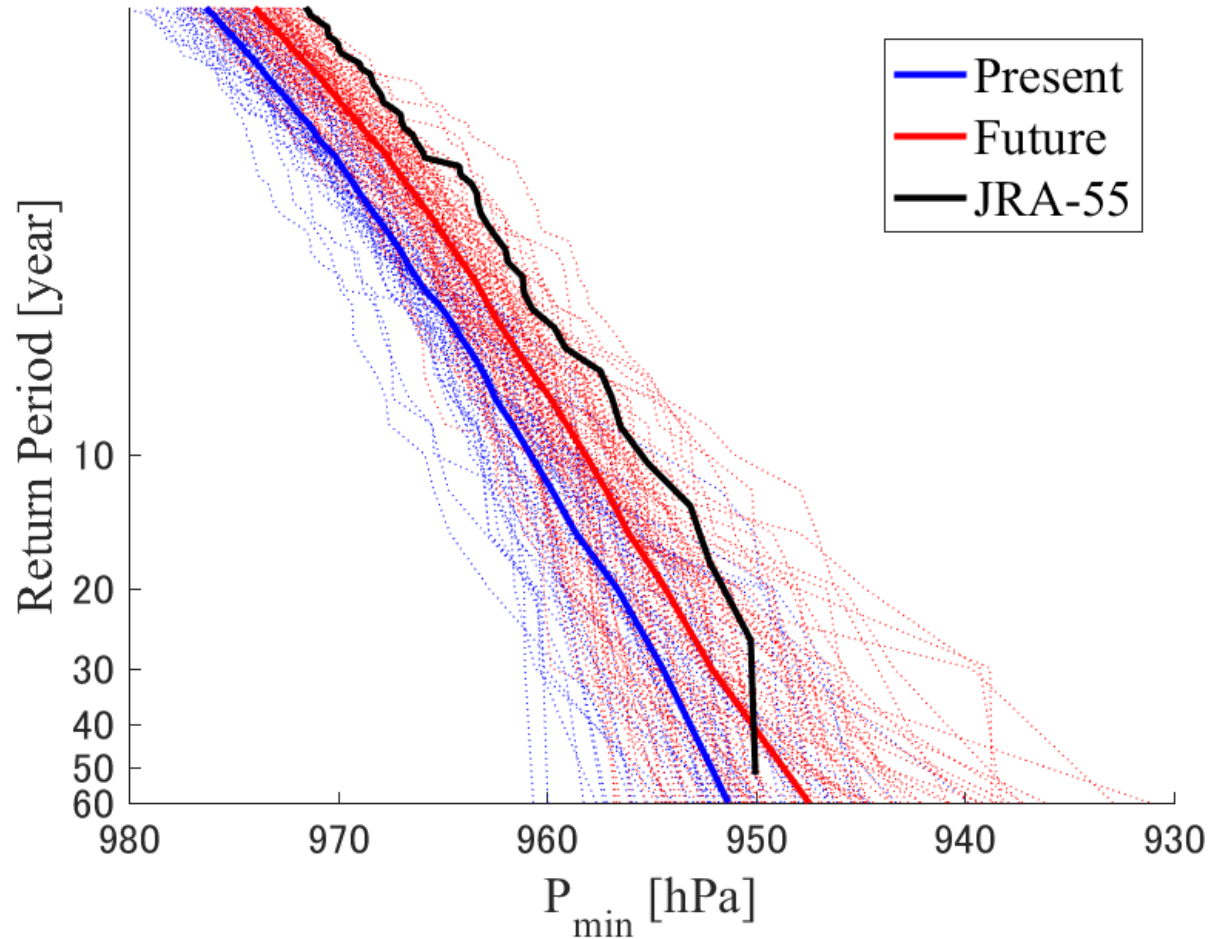


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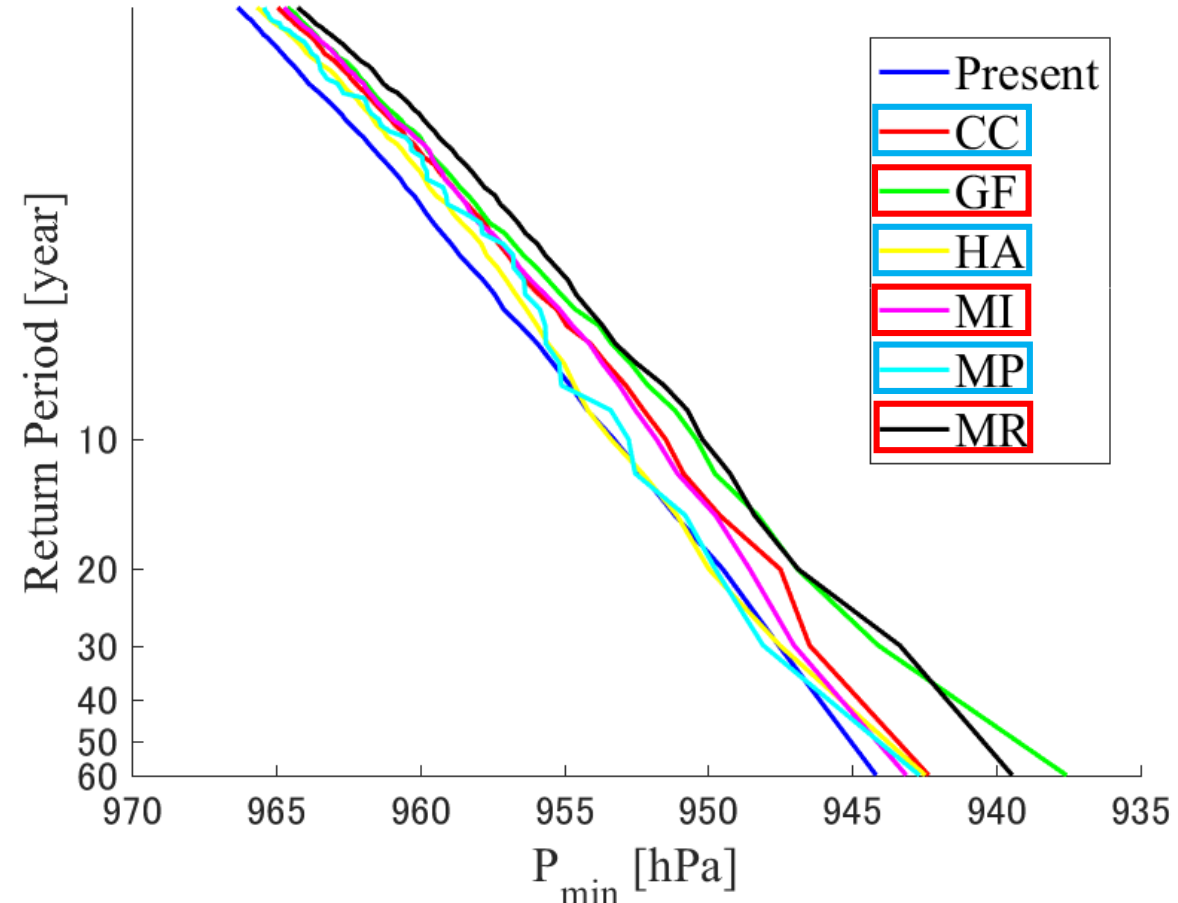
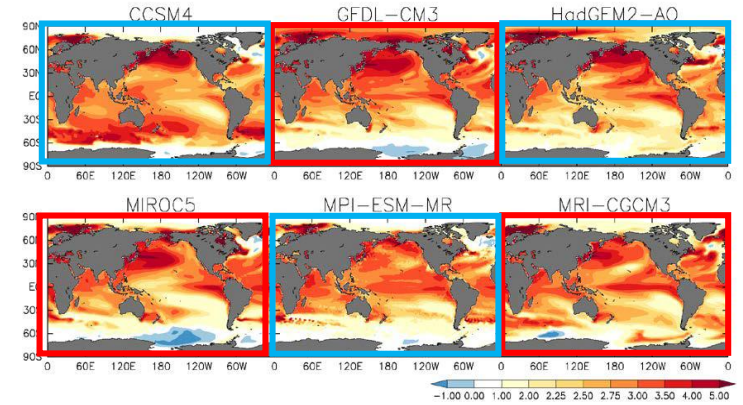


ETC Intensity around Japan

Relationship between minimum ETC pres. and return period.

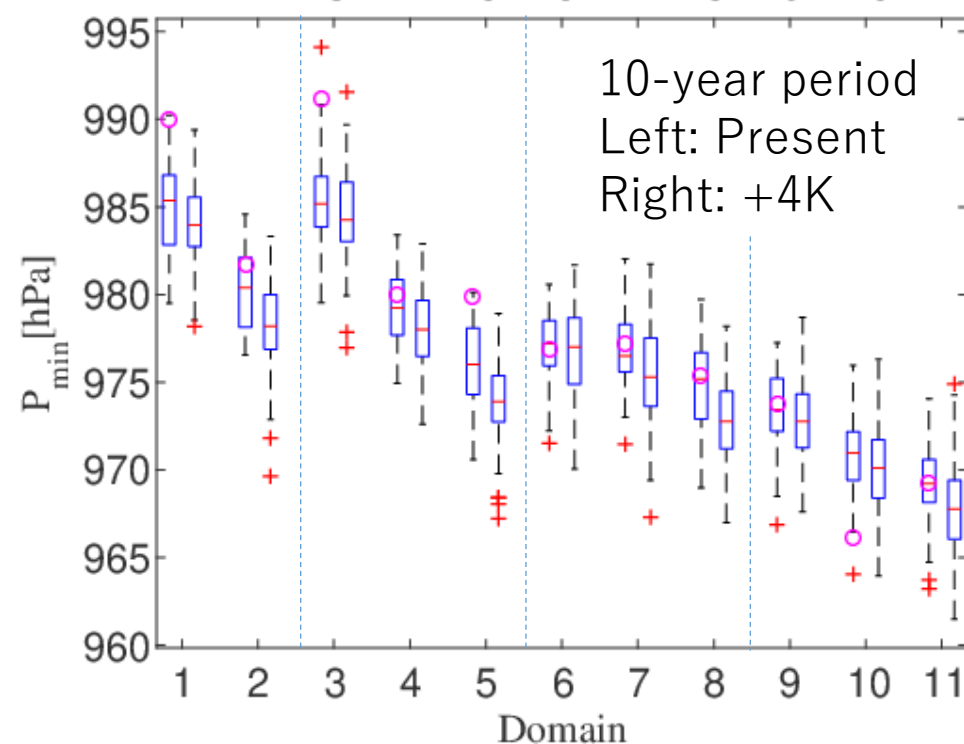
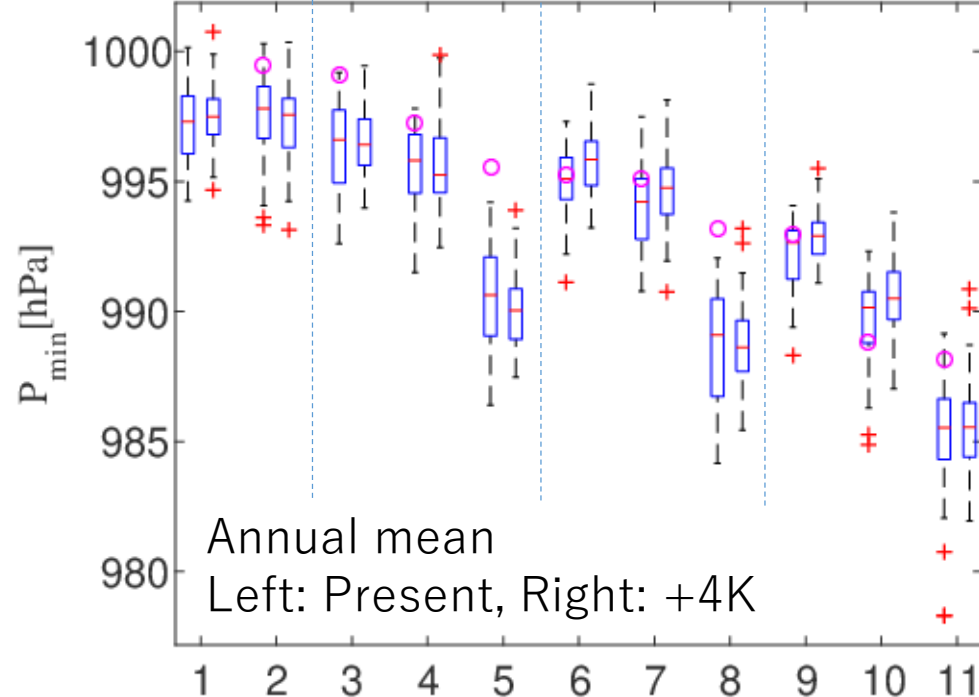
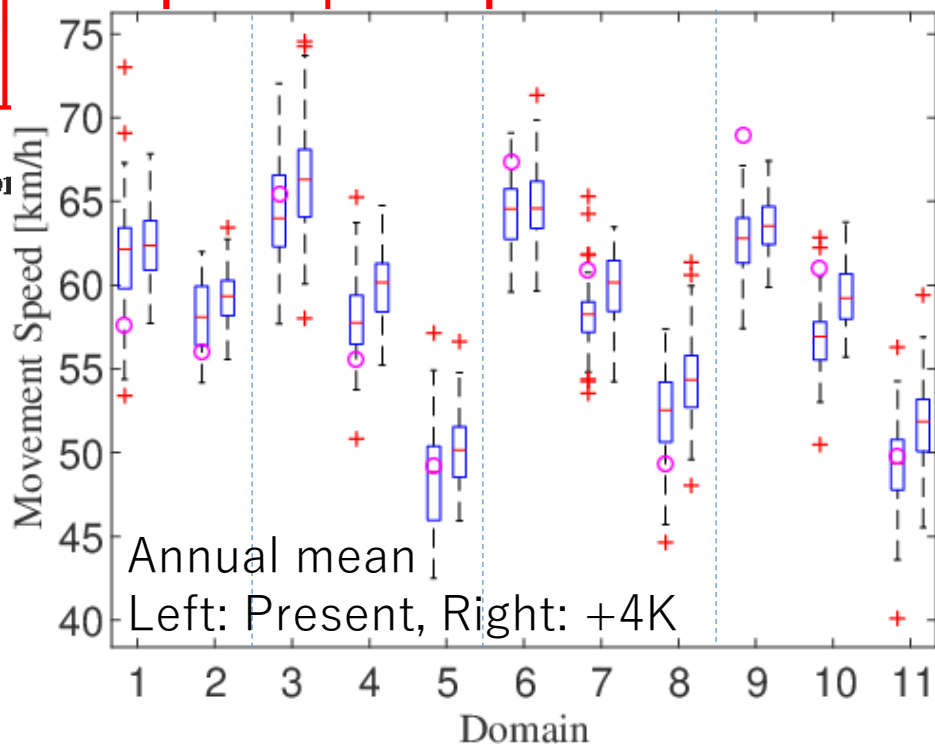
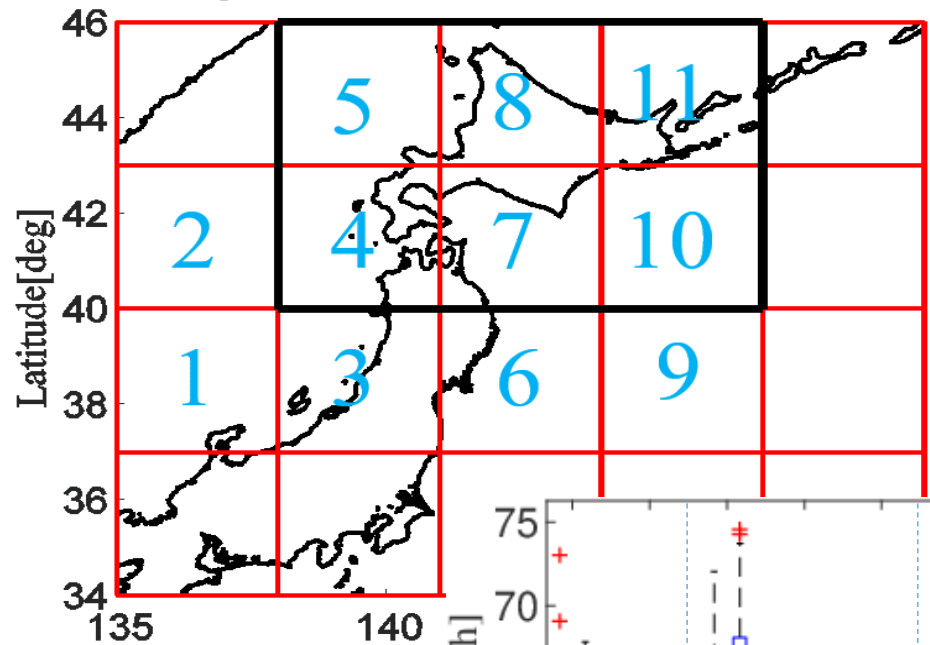


JRA-55 vs Present -> Upper limit of d4PDF.
 Present vs +4K -> Climate change makes ETC intensify.

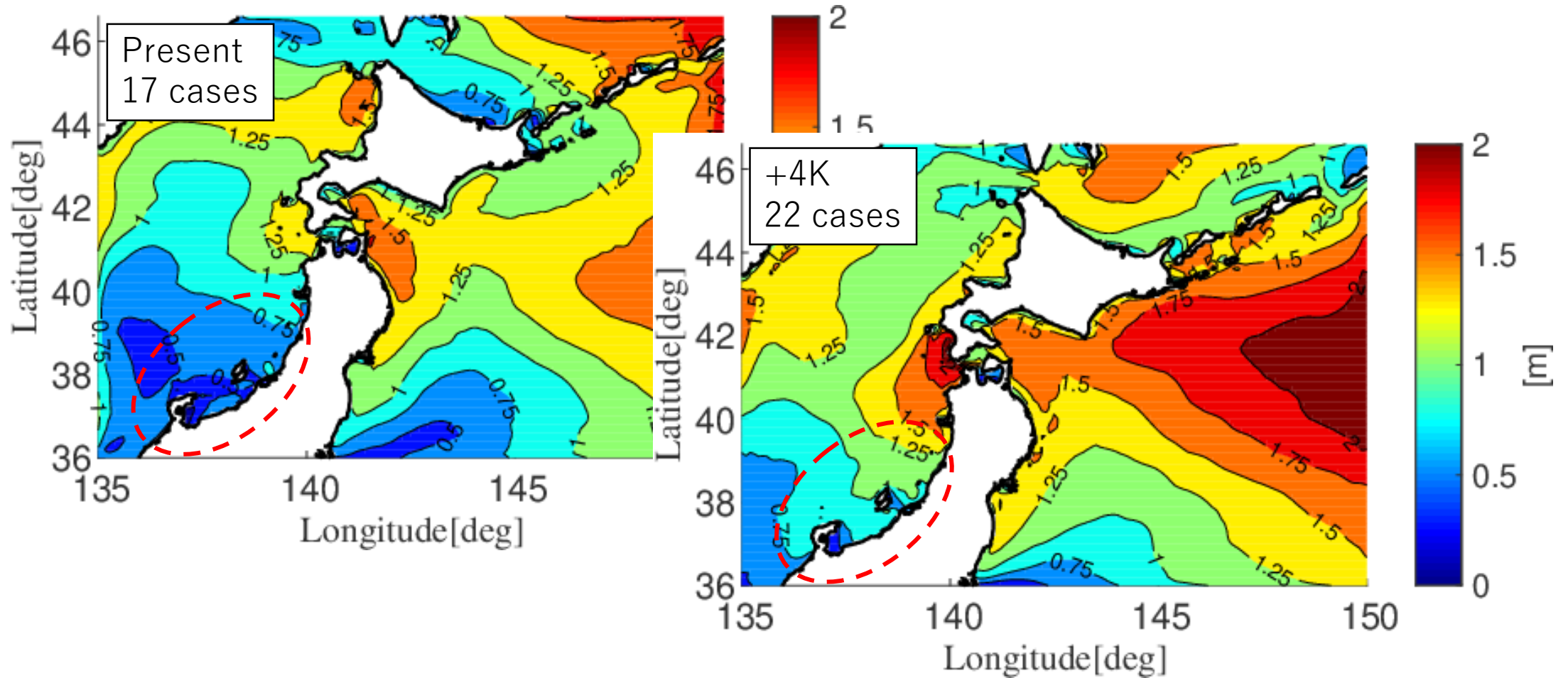


Relationship between SST and ETC intensity?

Regional ETC Intensity

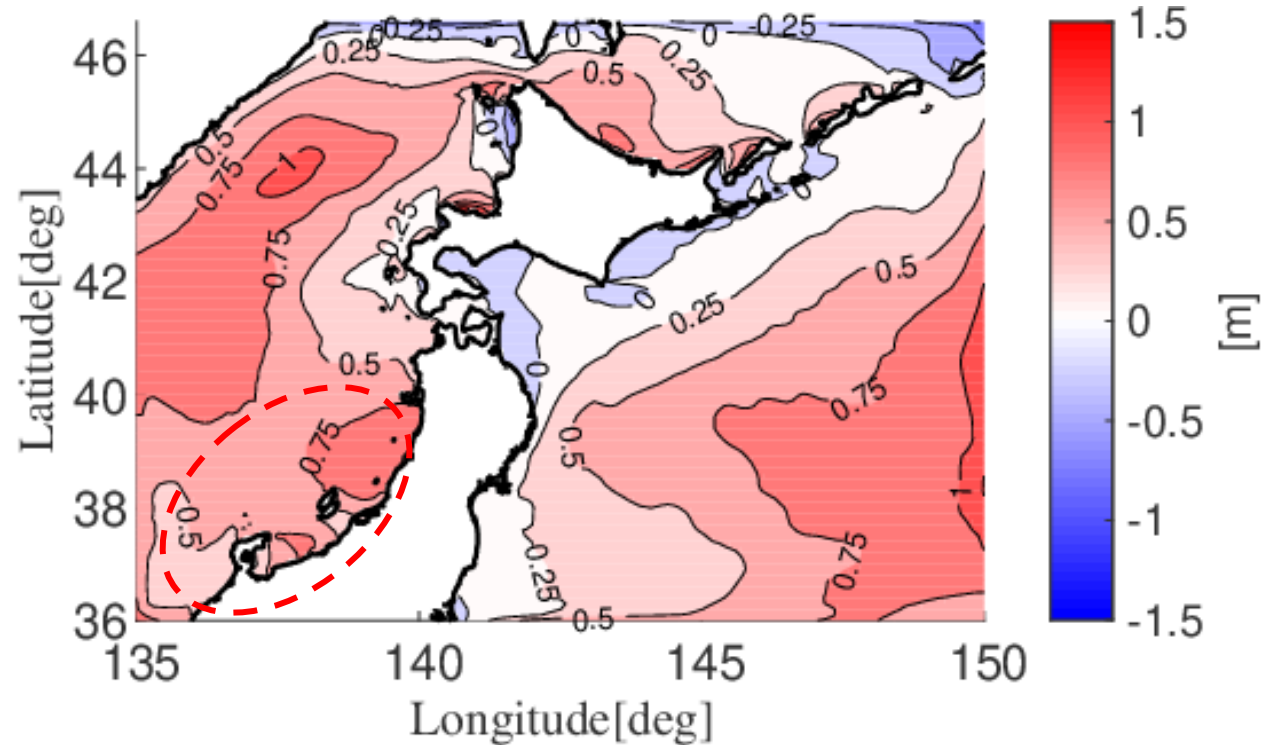


S.D. of Maximum Significant Wave Height

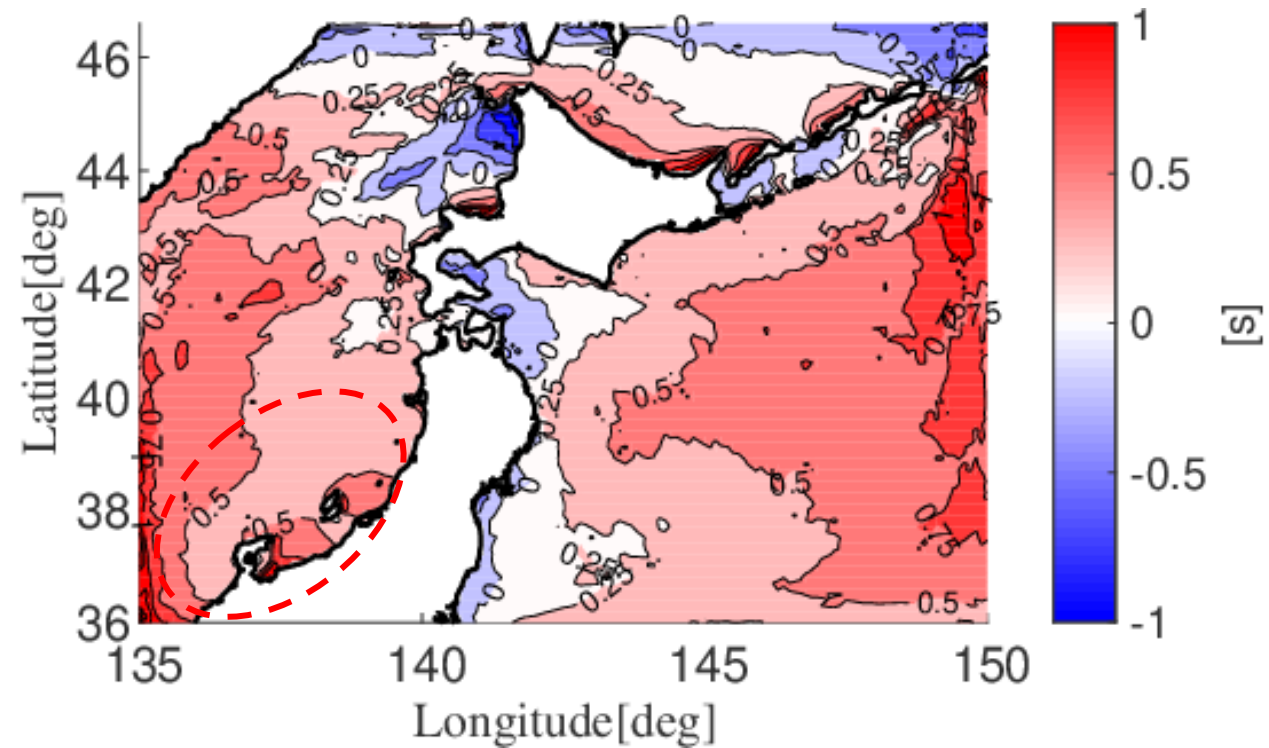


Future Change of Yorimawari Wave

Future change of ensemble mean of maximum wave height



Future change of ensemble mean wave period



Wave height increases 0.25 – 0.75 m, and wave period increases 0.25 – 0.5 s near Toyama bay. This results show that the risk of Yorimawari wave will increase.

Conclusions

- Extratropical cyclones (ETC) were extracted from large ensemble dataset (d4PDF), and analyzed.
 - ETC track shifts northward.
 - ETCs passing Pacific Ocean decrease, and ETCs passing Sea of Japan increase.
 - ETC intensity increases.
 - ETC's Return period shortens
 - SST distribution may affect ETC track and intensity, but their relationship is unclear.
- Wave simulation using d4PDF wind due to 10-year return period ETCs evaluated future change of Yorimawari wave.
 - Wave height: +0.25 – +0.75 m
 - Wave period: +0.25 – +0.5 s