Future Change Storm Surge based on Multi-Scenario and Multi-Regional Climate Model Ensemble Experiments

Kanazawa Univ. Junichi Ninomiya

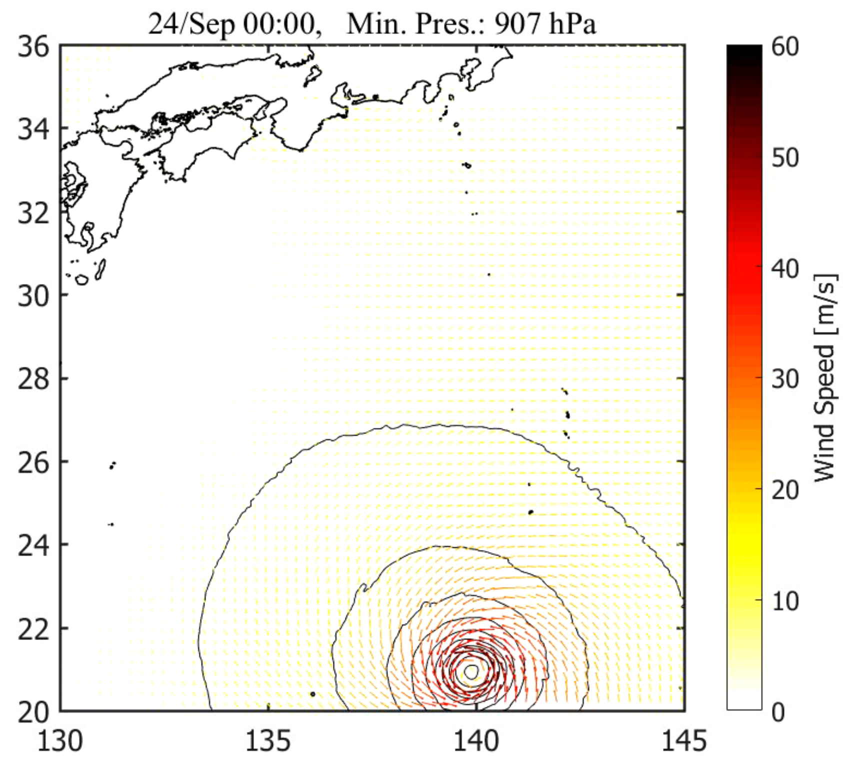
Kyoto Univ. Nobuhito Mori

Tetsuya Takemi

Tsukuba Univ. Osamu Arakawa

Nagoya Univ. Sachie Kaneda

Masaya Kato



Outline

- Motivation
- Summary
- Methodology
  - SST ensemble experiment using MRI-AGCM
  - RCM and Storm surge model and setting
- Results
  - Sensitivity of future change parameter for TC simulation
  - Future change of TC
  - Storm surge simulation using RCM outputs and the other method
- Summary

Motivation

- Subjects
  - Uncertainty for future change estimation
  - Extreme event assessment based on coarse-resolution GCM
- Aims
  - To decrease uncertainty for GCM and RCM bias, and estimate probable extreme event by careful simulations.
  - To evaluate future change of largest storm surge.
    -> To make management plan for coastal structures

- This research is case study of pseudo global warming (PGW) experiment with historical typhoon Vera (1959).

Summary

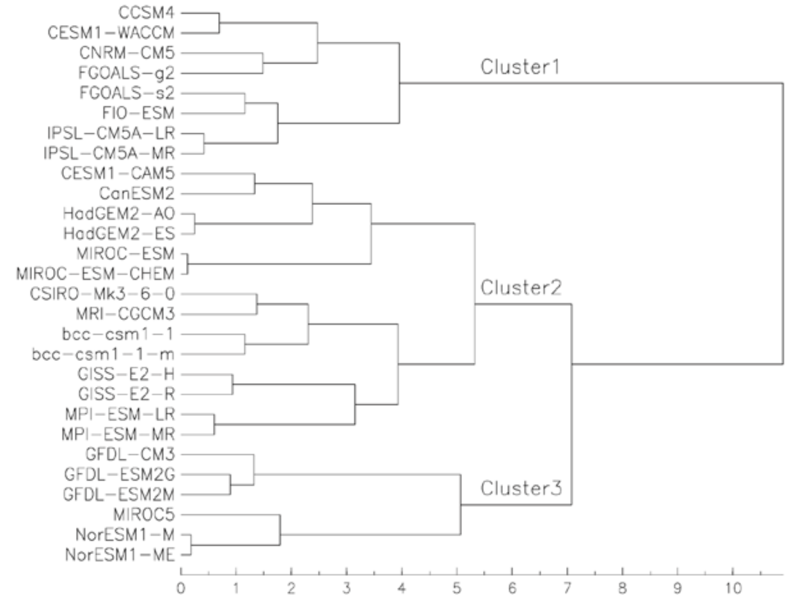
- A series of delicate RCM simulations
  - RCM hindcast gave reasonable result.
  - Partial future change parameter for RCM simulation estimated excessively strong TC.
  - All future TCs intensity were stronger than present TC and their tracks change to west. (WRF: 9.3 hPa, JMA-NHM: 29.7 hPa)
- Future change of storm surge
  - Storm surge simulations using empirical TC model based on fine RCM output were carried out.
  - Estimated storm surge future changes by forcing from WRF, JMA-NHM and ensemble mean were 26 cm.

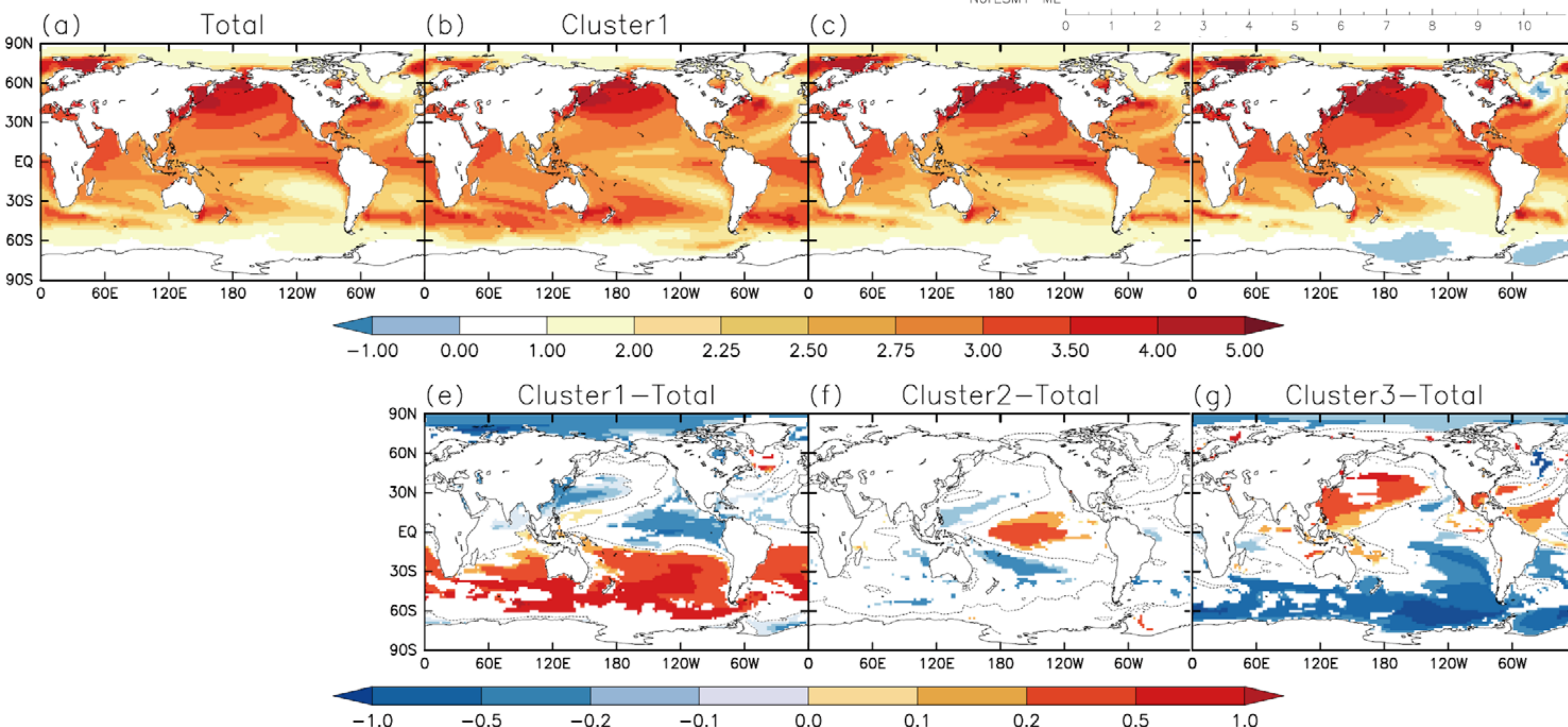
Methodology

1. Estimate future change of atmospheric parameters based on SST ensemble experiments using MRI-AGCM (RCP 8.5, 20 km-resolution, Mizuta et al., 2014)
   -> 4 kinds of future change distribution
   1. Ensemble average of CMIP5 (C0)
   2. 3 kinds of SST distribution calculated by cluster analysis (C1 – 3)
2. Present- and Future-RCM simulation of TY Vera using 2 RCMs
   1. Present-experiments (Pre) using JRA-55
   2. Future-experiments (PGW; Pseudo Global Warming, C0 – 3)
3. Storm surge simulation using RCM outputs

SST Ensemble Exp.

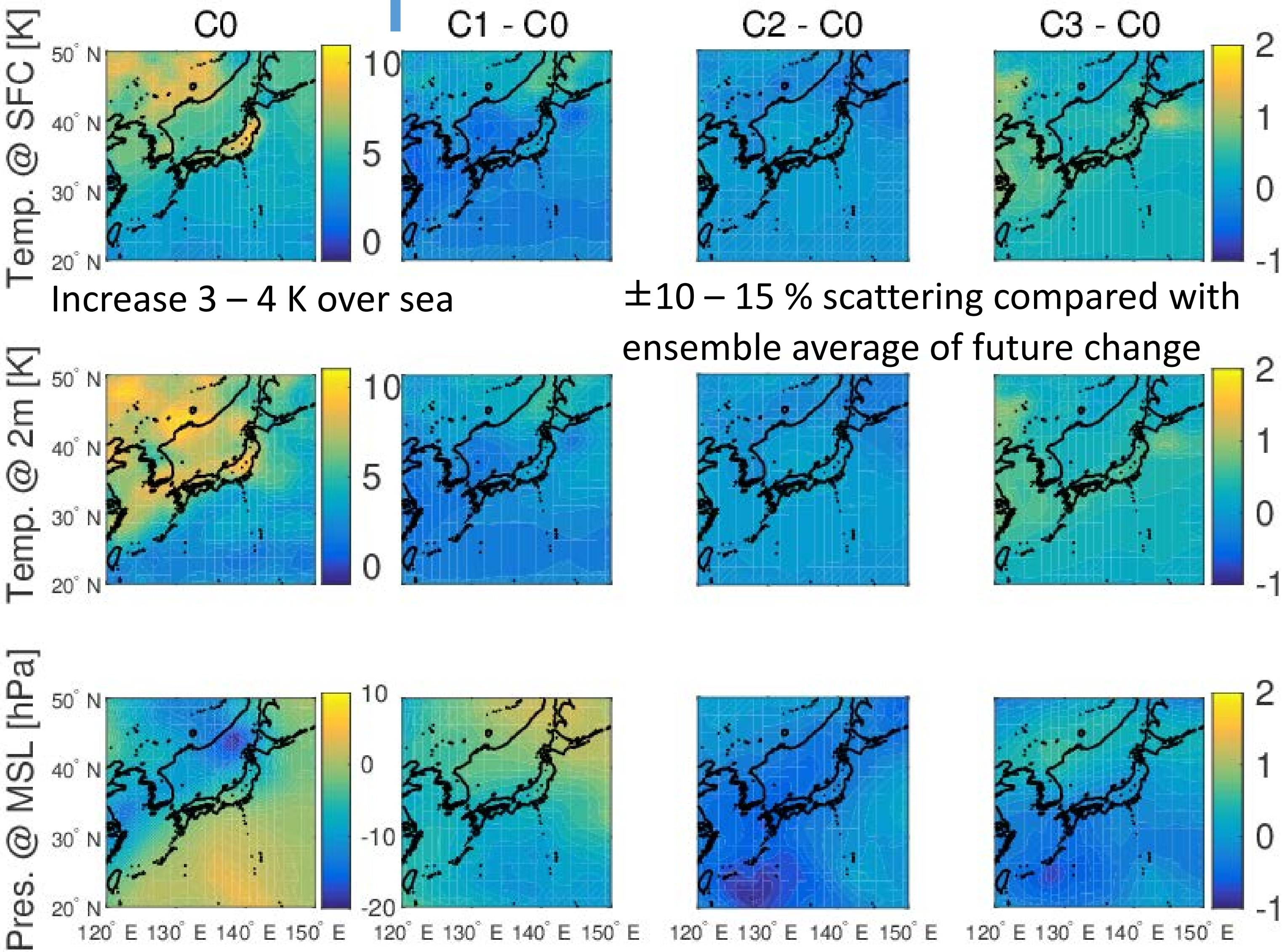
- Mizuta et al. calculated using MRI-AGCM with 4 SST distributions.





Future Change Distribution from MRI-AGCM

Ensemble average → Difference between each cluster and ensemble avg.



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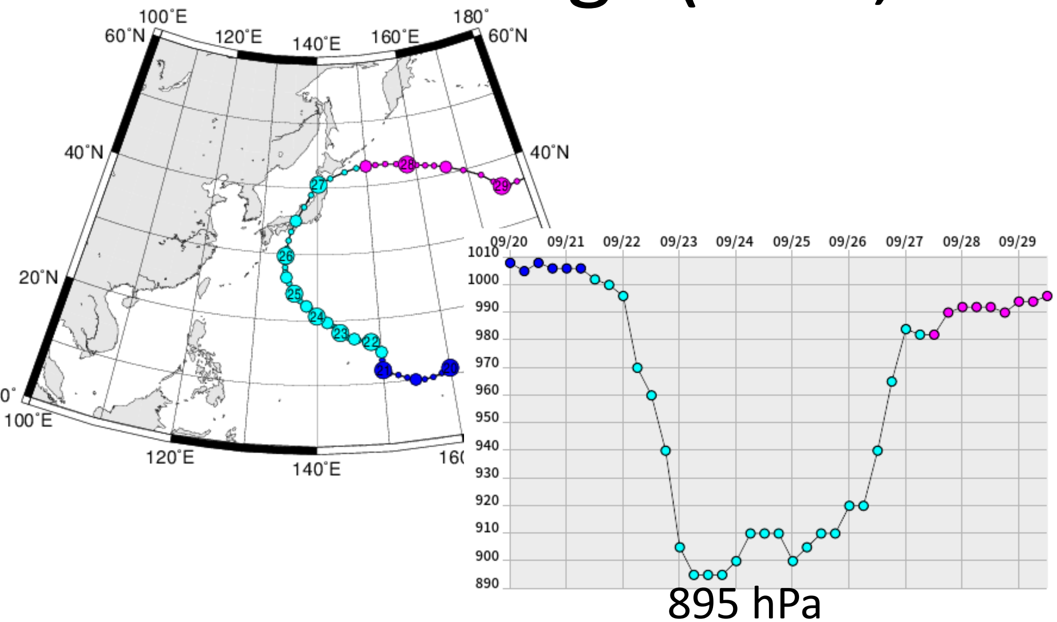
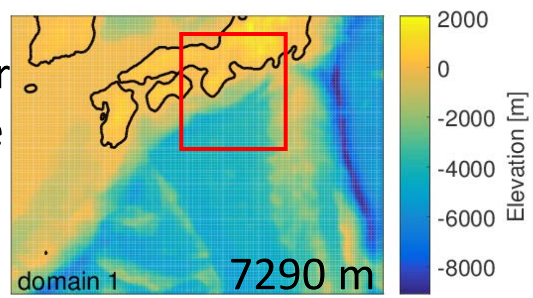
Models

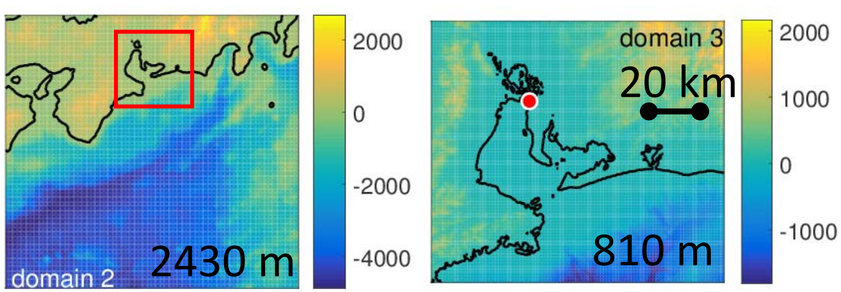
- RCM
  - WRF v3.3.1
  - JMA-NHM
    - Japan meteorological agency, non-hydrological model
    - Work for weather forecast in Japan
- Storm Surge model
  - SuWAT
    - Coupled model of Surge, Wave and Tide
    - Developed by S. Y. Kim (3rd presenter in this session)

Model settings (WRF, JMA-NHM & SuWAT)



Domains for storm surge model





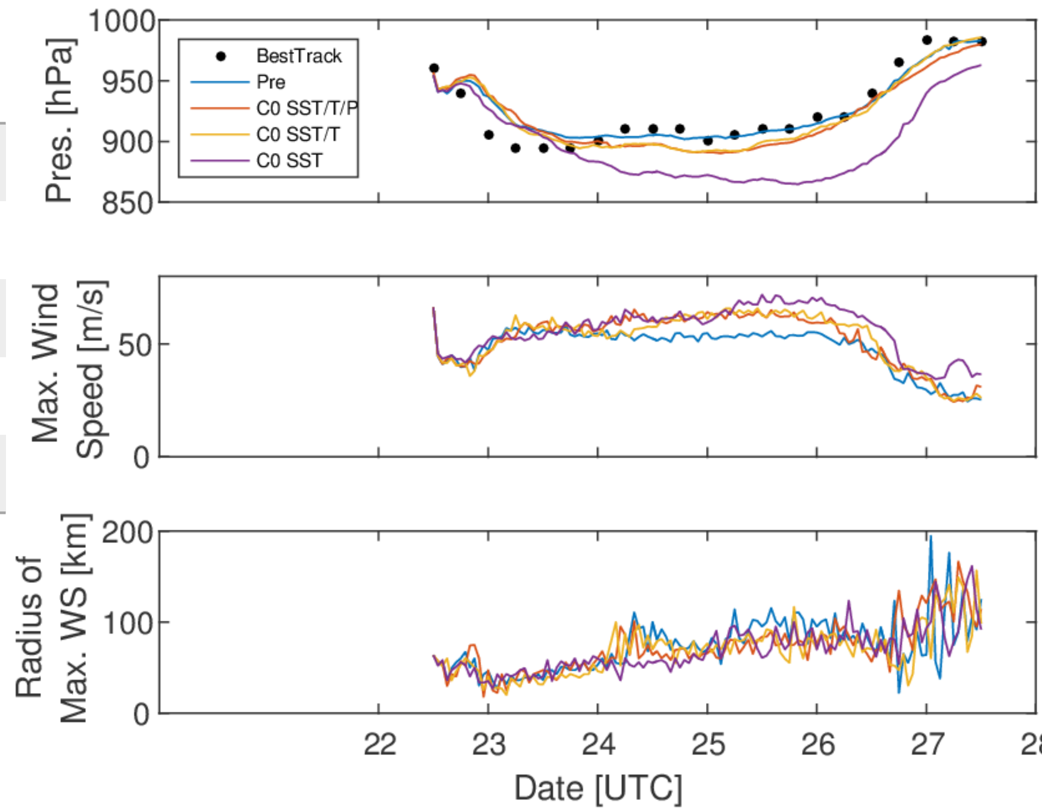
Item	WRF settings
Duration	1959/9/22 12:00 – 9/27 0:00
Spatial Res.	5 km
Grids	976 x 831
Vert. Lay.	56
Dt	20 s
Micro.	WSM 6-class
Shortwave	RRTMG
Longwave	RRTMG
Surface Bound.	Revised MM5 Monin-Obukhov
Planet. Bound.	YSU
Land Surf.	5-layer Thermal diffusion
Cumulus	Kain-Fritsch
Urban	w/o
Topo. & Landuse	USGS GTOPO30
Nudging	Spectral Nudging（Wave Num. 2， Upper layer of 700hPa）
Bogus	Initial

Sensitivity of Future Change Parameter

Case Name	future change Param.	Min. Cen. Pres. [hPa]
BestTrack	w/o	895
Pre	w/o	901.8
C0 SST	SST	859.7
C0 SST/T	SST, T	889.4
C0 SST/T/P	SST, T, P	893.0

T: Temp., P: 3D Pres.

n/a
 Humidity: Future change is small.
 Wind: It will change TY track.

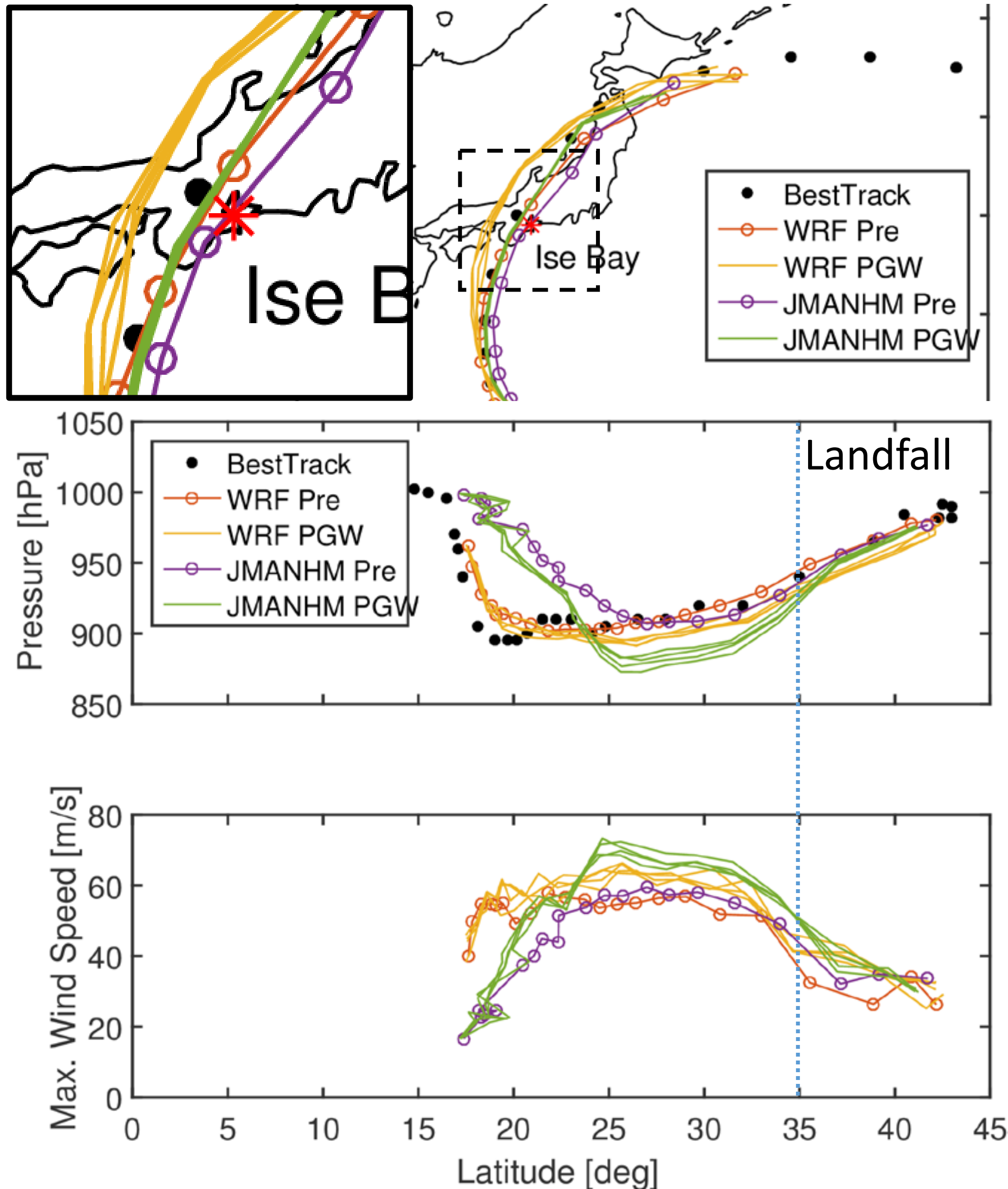


Case C0 SST estimated very strong typhoon due to intensification of atmospheric instability.

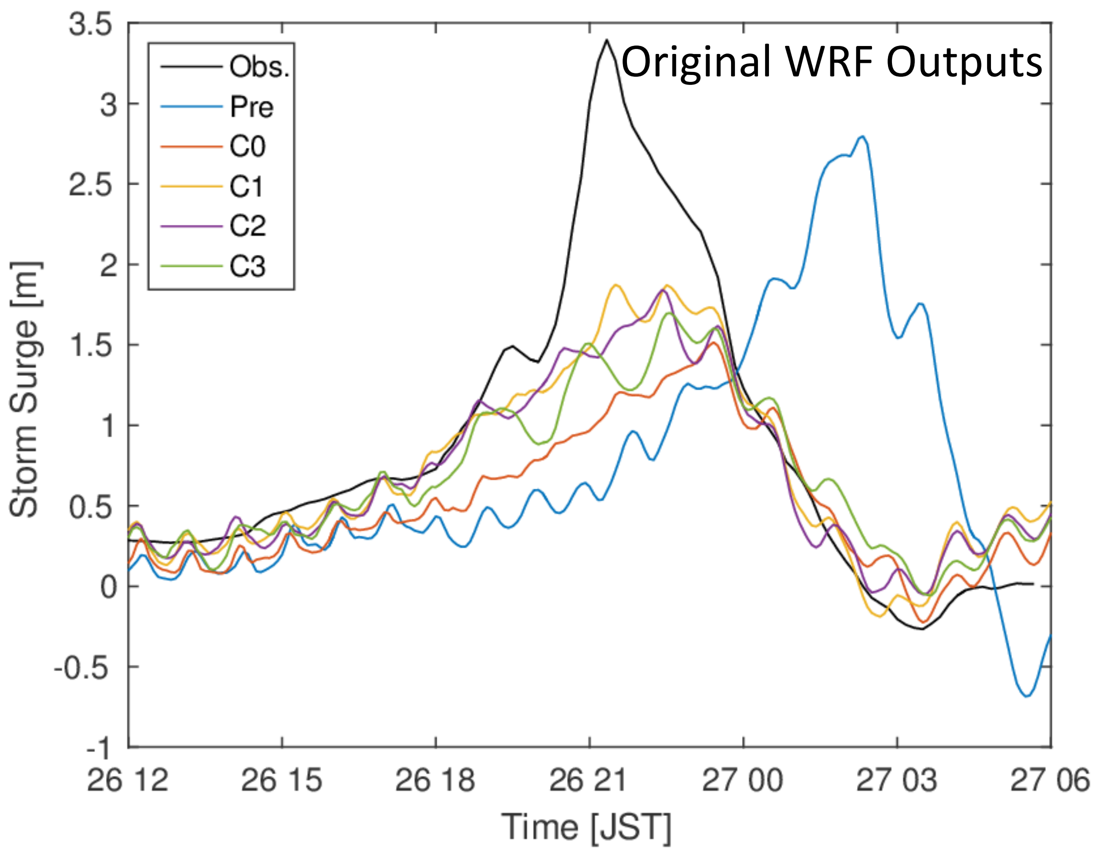
Pre & PGW experiments using RCM

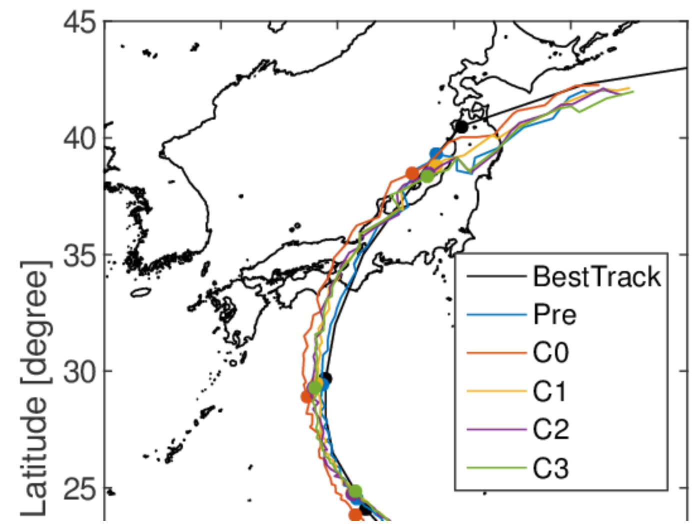
Case Name	Param. future change	Min. Cen. Pres. [hPa]
BestTrack	w/o	895
WRF Pre	w/o	901.8
WRF PGW	SST, T, P	892.6
JMA-NHM Pre	w/o	907.0
JMA-NHM PGW	SST, T, P	877.3

T: Temp., P: 3D Pres.



Storm Surge using WRF Pre & PGW

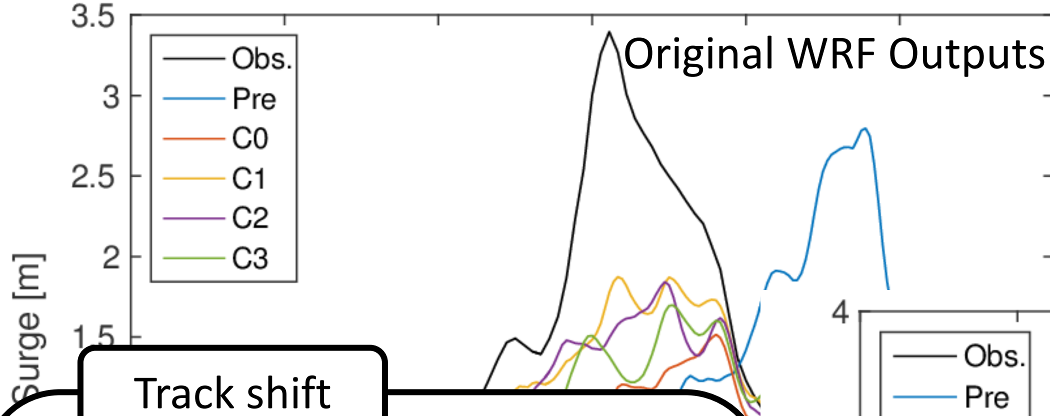


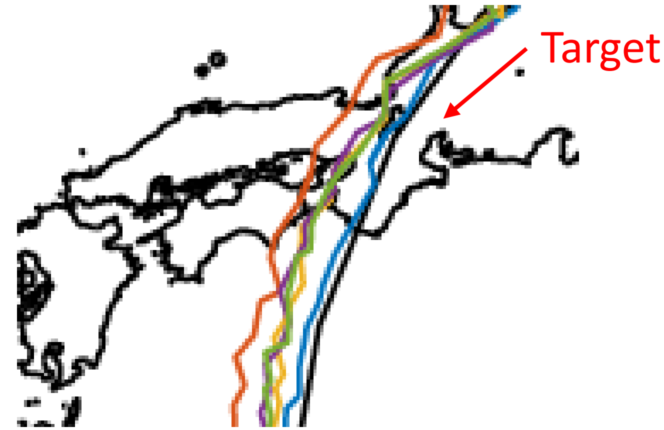


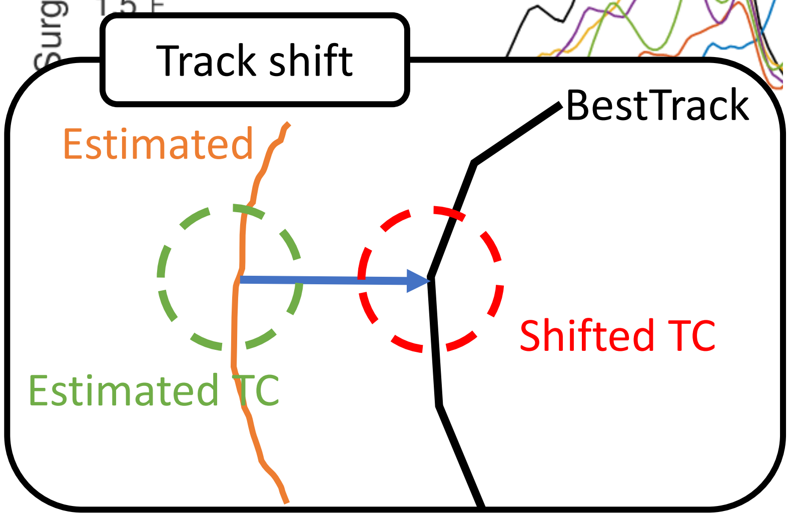
Pre experiment
・Slow TY moving
・Large TY eye
-> Late and small peak surge

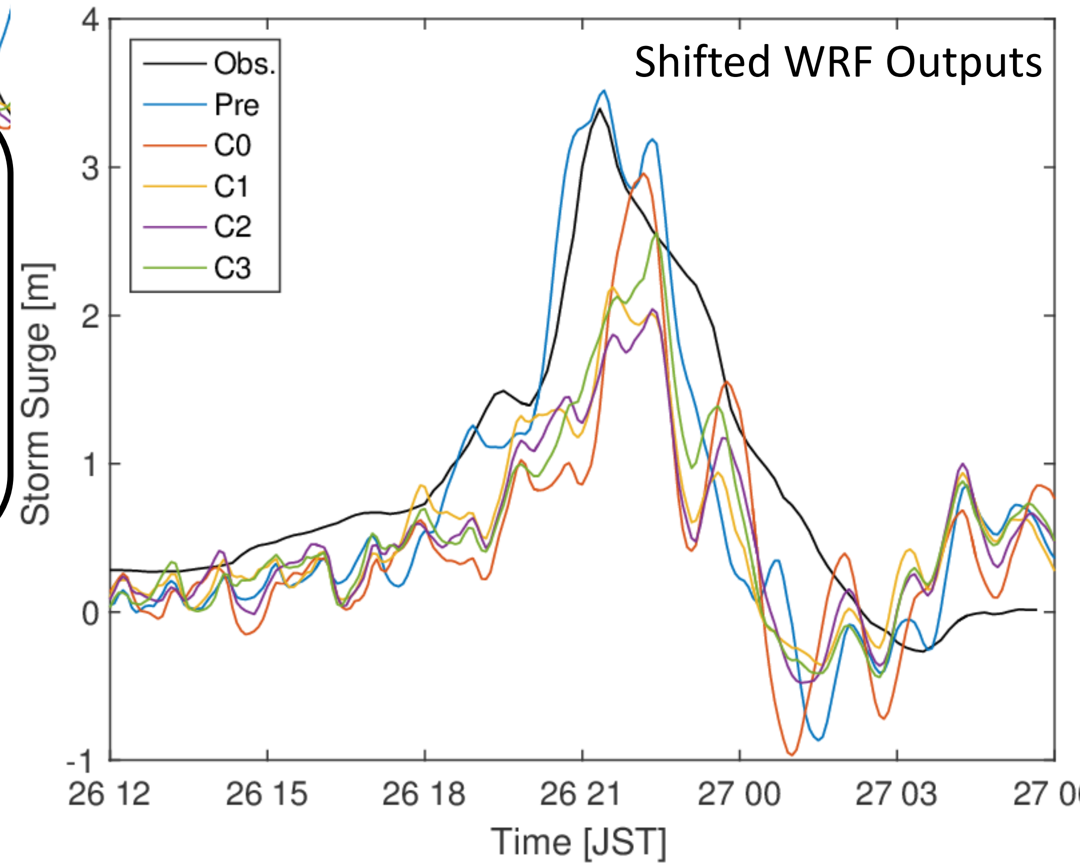
PGW experiments
・Westward track drift
-> Small peak

Storm Surge Sim. under Pre & PGW using WRF outputs



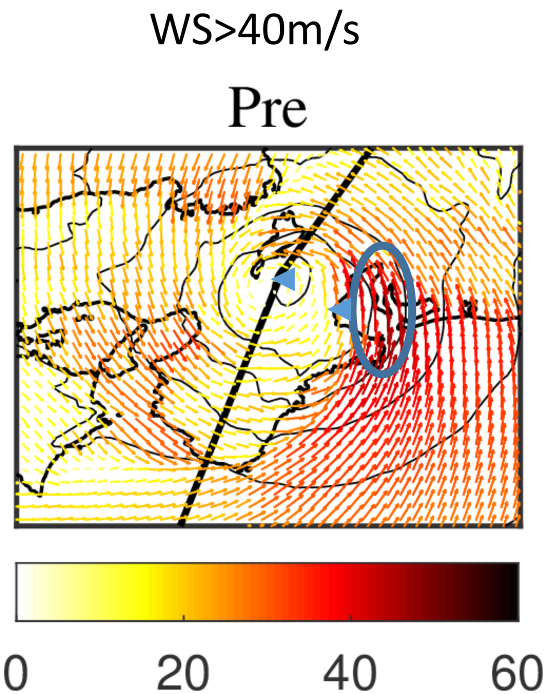


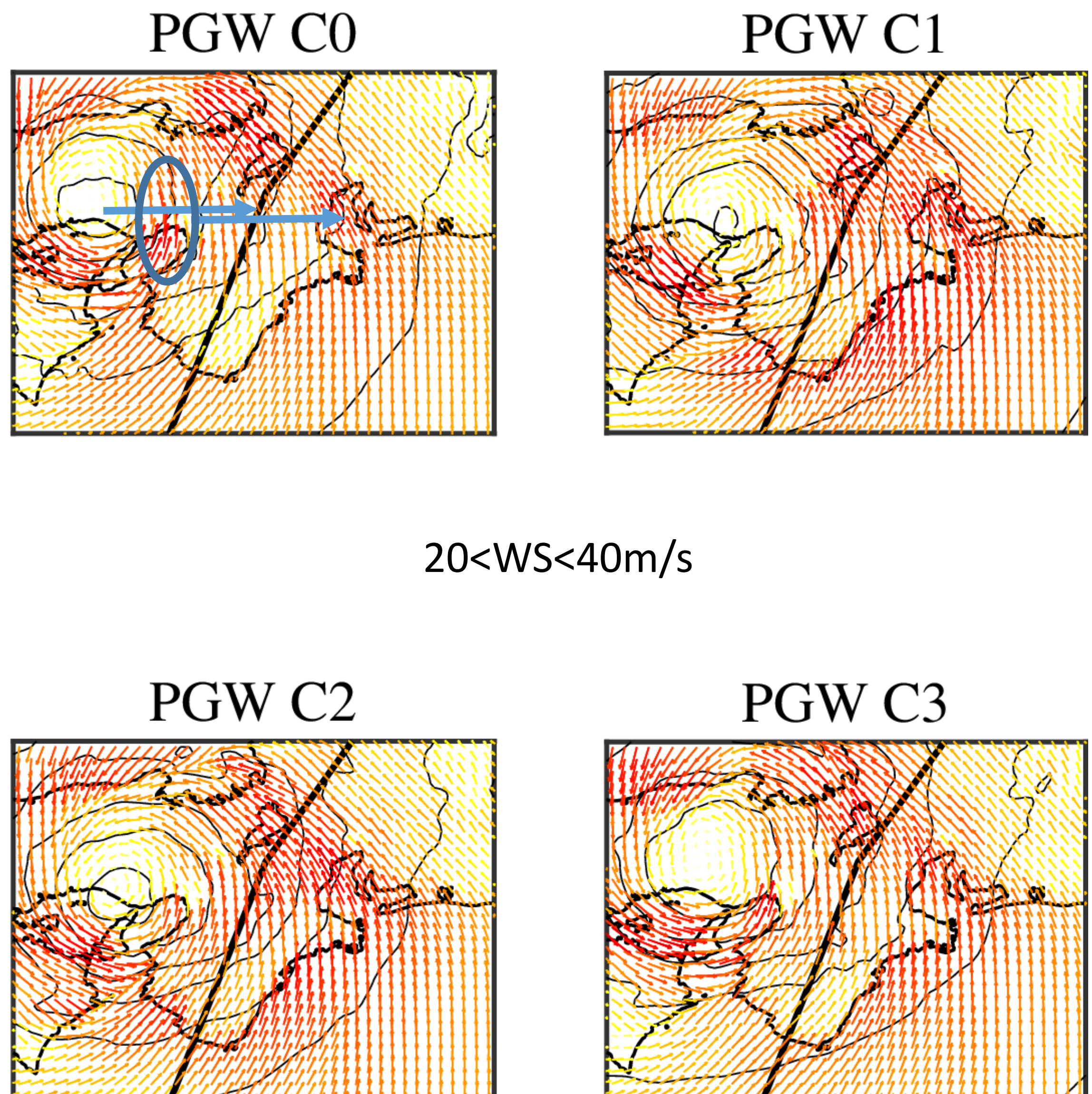




Pre using shifted WRF output
・Good agreement
PGW using shifted WRF output
・Small peak <- influenced surface roughness on land

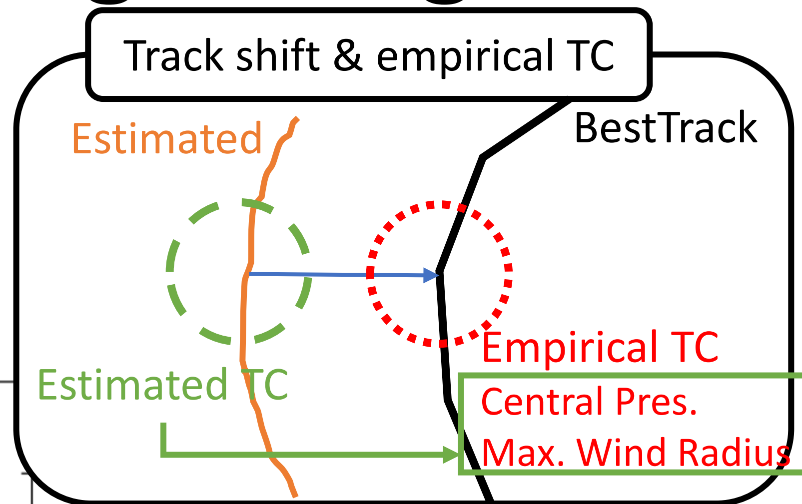
Storm Surge Sim. under Pre & PGW using WRF outputs

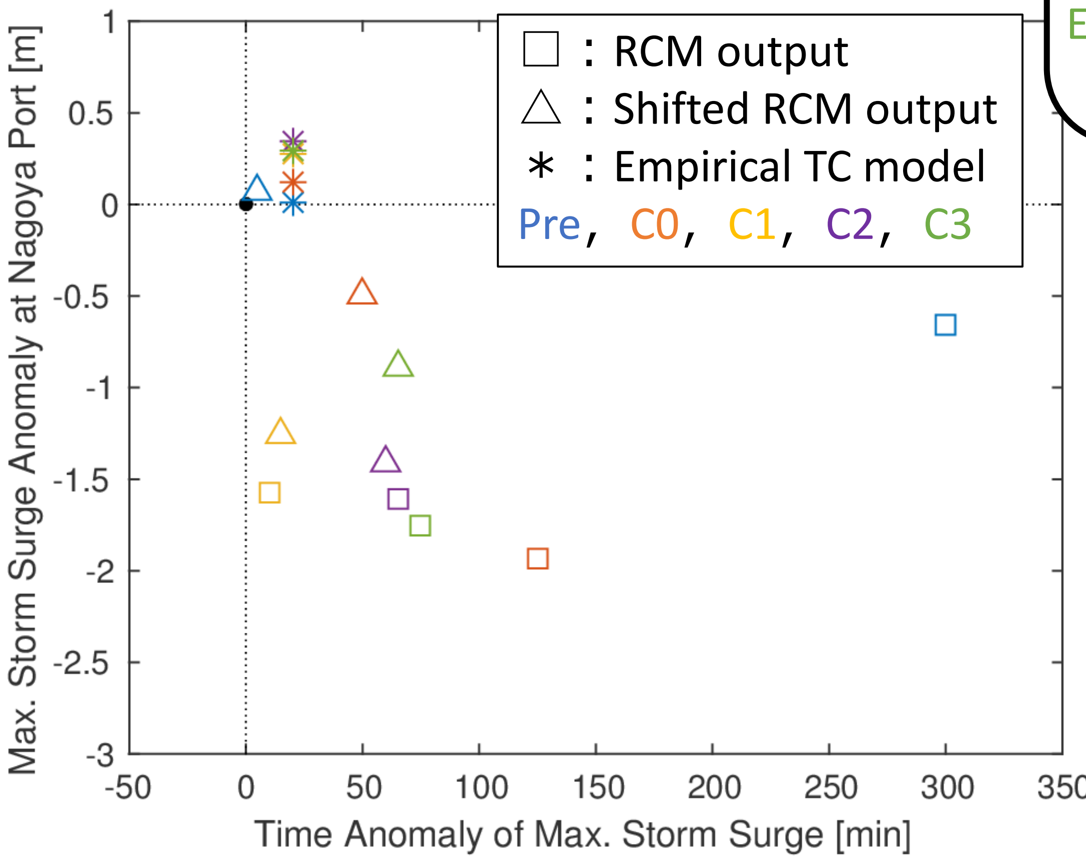




Due to difference of surface roughness between over land and over sea.

Summary of Storm Surge using WRF Forcing





It is difficult to compare with surge results using RCM output each other because of track mismatch and difference of moving speed.

Experiments using empirical TC model are effective to investigate TY intensification.

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- Future change of storm surge
  - Storm surge simulations using empirical TC model based on dynamical DS were carried out.
  - Estimated storm surge future changes by forcing from WRF, JMA-NHM and ensemble mean were 26 cm, 26 cm and 26 cm, respectively.

Thank you for your attention.

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