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Regional Meteorological Simulations of Typhoons for Impact Assessment Applications

Tetsuya Takemi

Disaster Prevention Research Institute (DPRI)
Kyoto University

SOUSEI Program for Risk Information on Climate Change
気候変動リスク情報創生プログラム

DPRI-KU

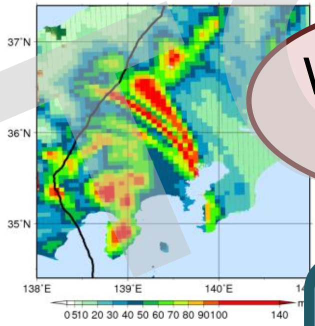
京都大学 KYOTO UNIVERSITY

Risk assessment of meteorological disasters under SOUSEI-D program

Climate model output (GCM, RCM) (CMIP5, Kakushin, Sousei)

Extreme events (Typhoon, rain, wind)

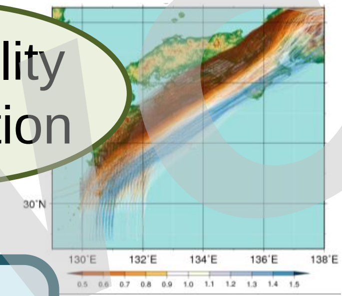
Dynamical downscaling



Worst-case scenario

Statistical downscaling

Probability information



Downscaling to regional-scales (river basin, coastal area)

- Sufficient resolution for engineering assessment
- Probability information based on ensemble simulations
- Meteorological disaster risk in worst-case scenarios

Socio-economic impact assessment

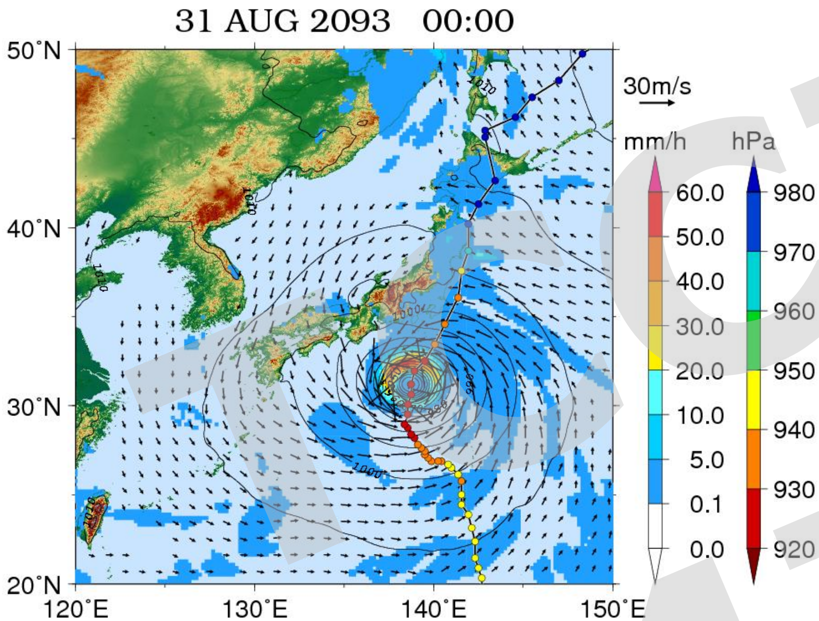
Motivation

- Heavy rainfall and high winds under typhoon conditions strongly depends on the track and intensity of typhoons.
- Owing to the limited number of the actual severe typhoons, the assessment of the typhoon hazards with various tracks and intensities of typhoons is difficult.
- Therefore, numerically generating severe cases by controlling typhoon tracks is a viable alternative in increasing the number of extreme cases.
- Furthermore, quantitative estimates of typhoon hazards are important for impact assessment applications.

Purpose

- Proposes an approach to increase the extreme typhoon ensembles with regional meteorological model for use in assessing the impacts of typhoon hazards.
- Simulate quantitatively typhoon hazards for impact assessment studies.
  - Case study of Typhoon Haiyan (2013)

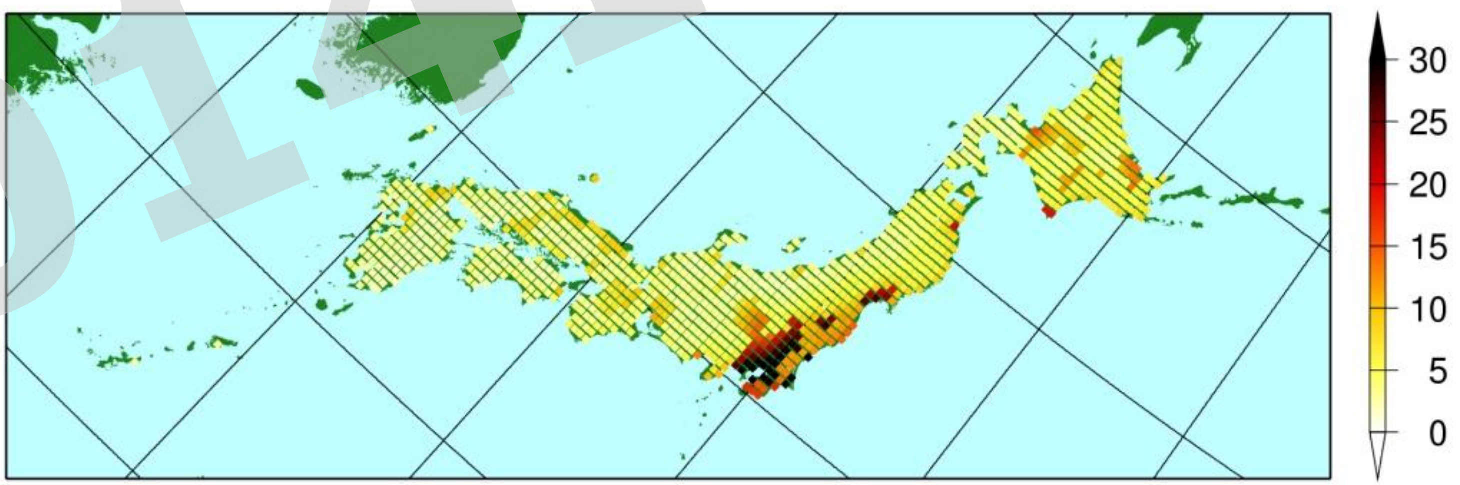
Future severe typhoon in GCM projection



Result from the 20-km GCM climate simulation in a future warming climate

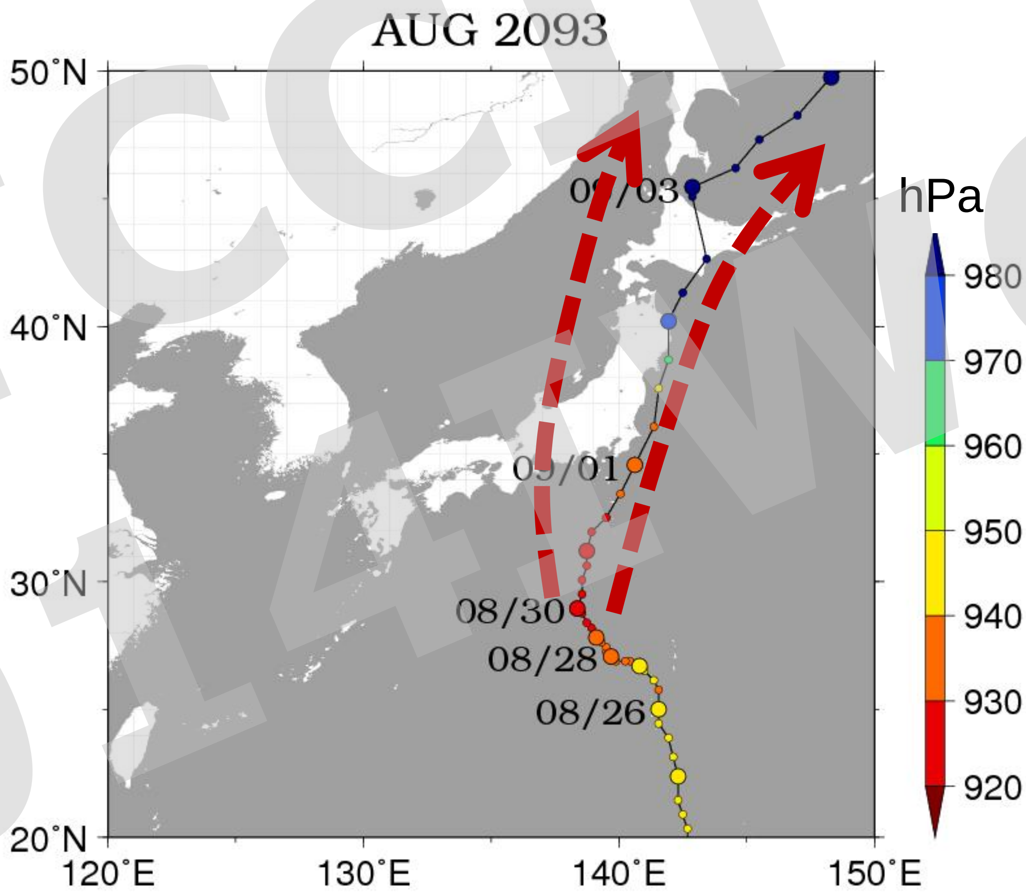
One possible realization in GCM projection under GW.

Maximum Wind Distribution



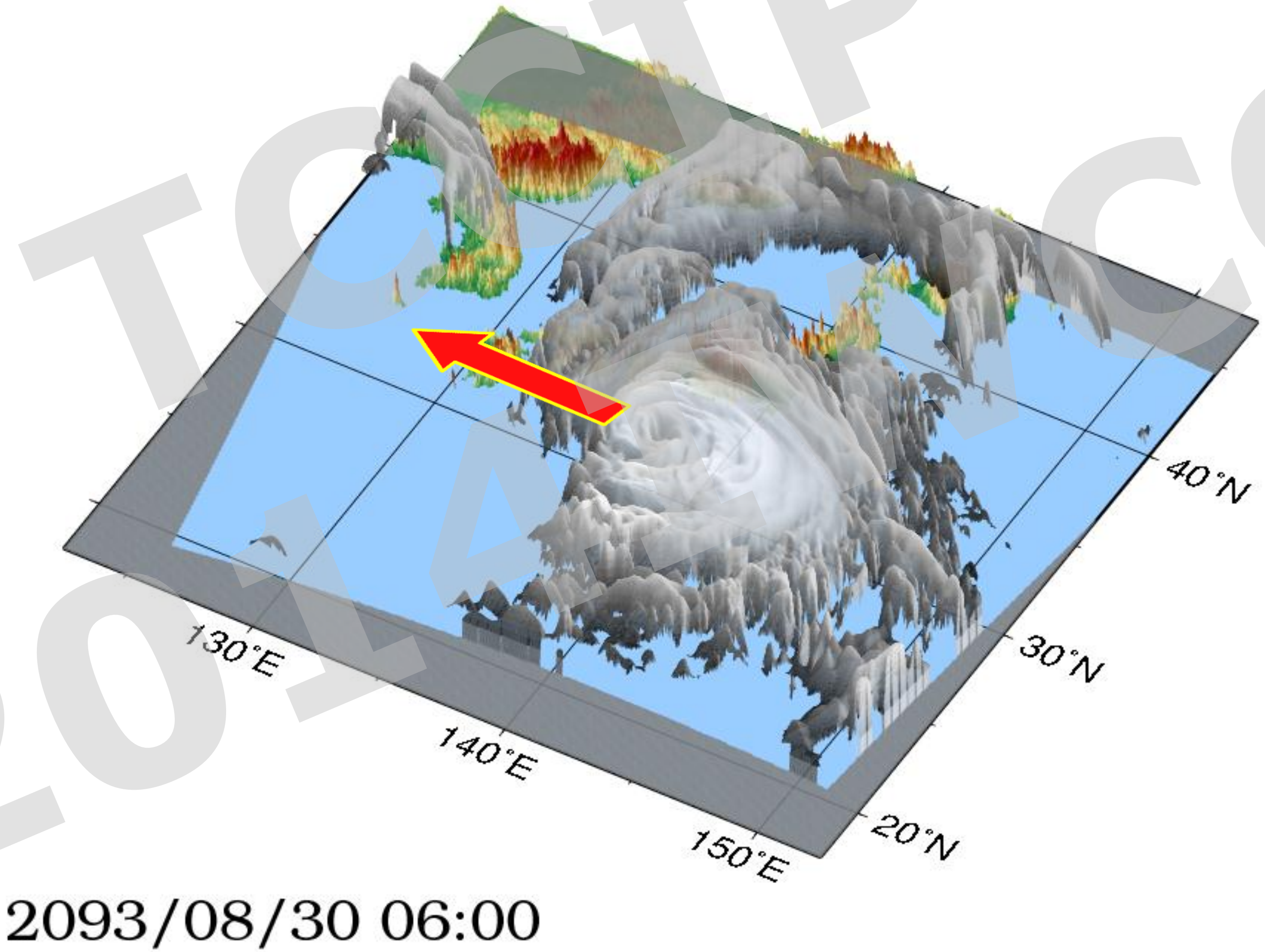
Assessment of hazards w/different tracks

How met disasters will change if the track changes?



(Ishikawa et al. 2013)

Relocate the initial position of typhoon



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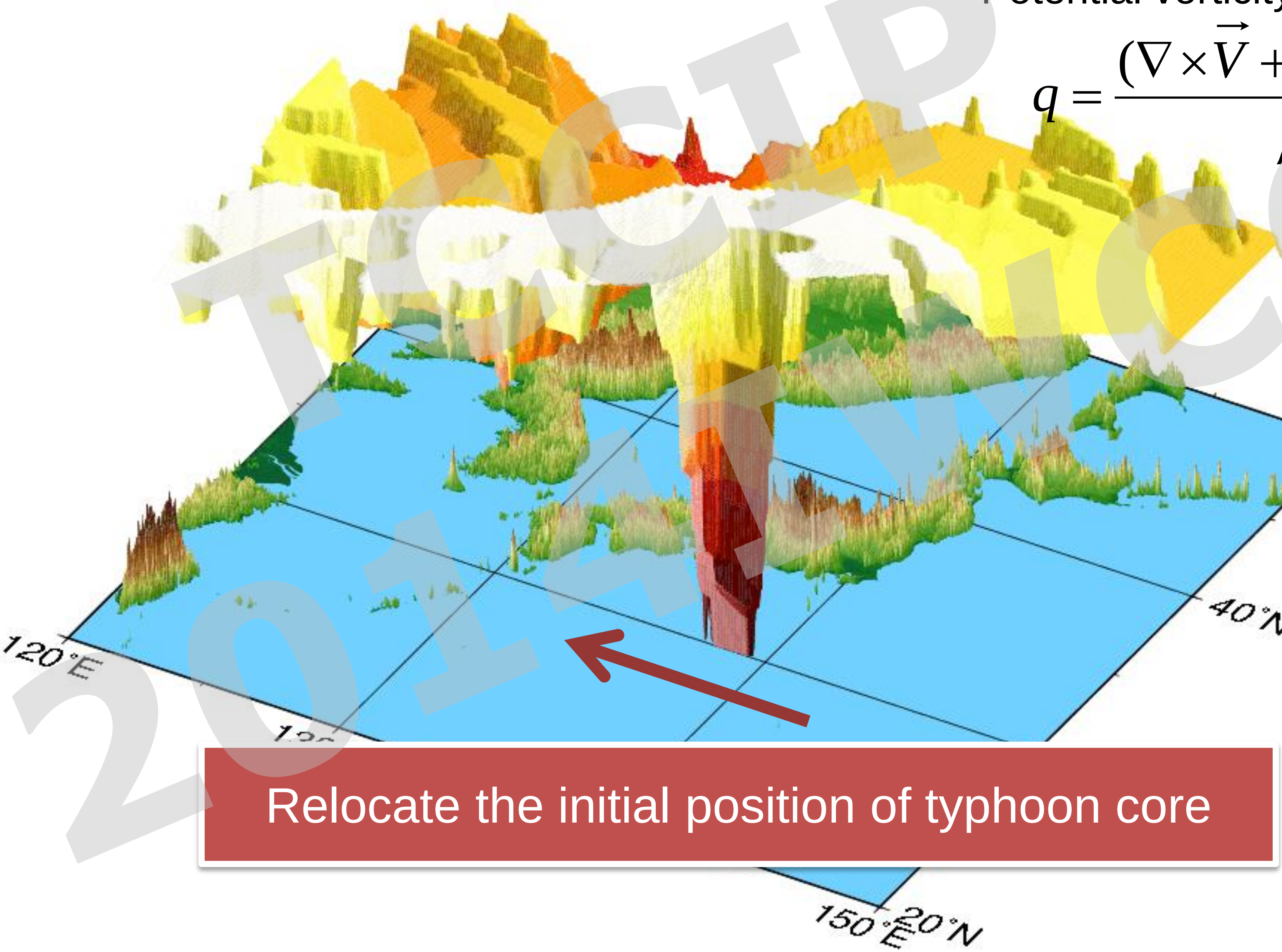
Typhoon bogus relocation by PV

Potential vorticity (PV)

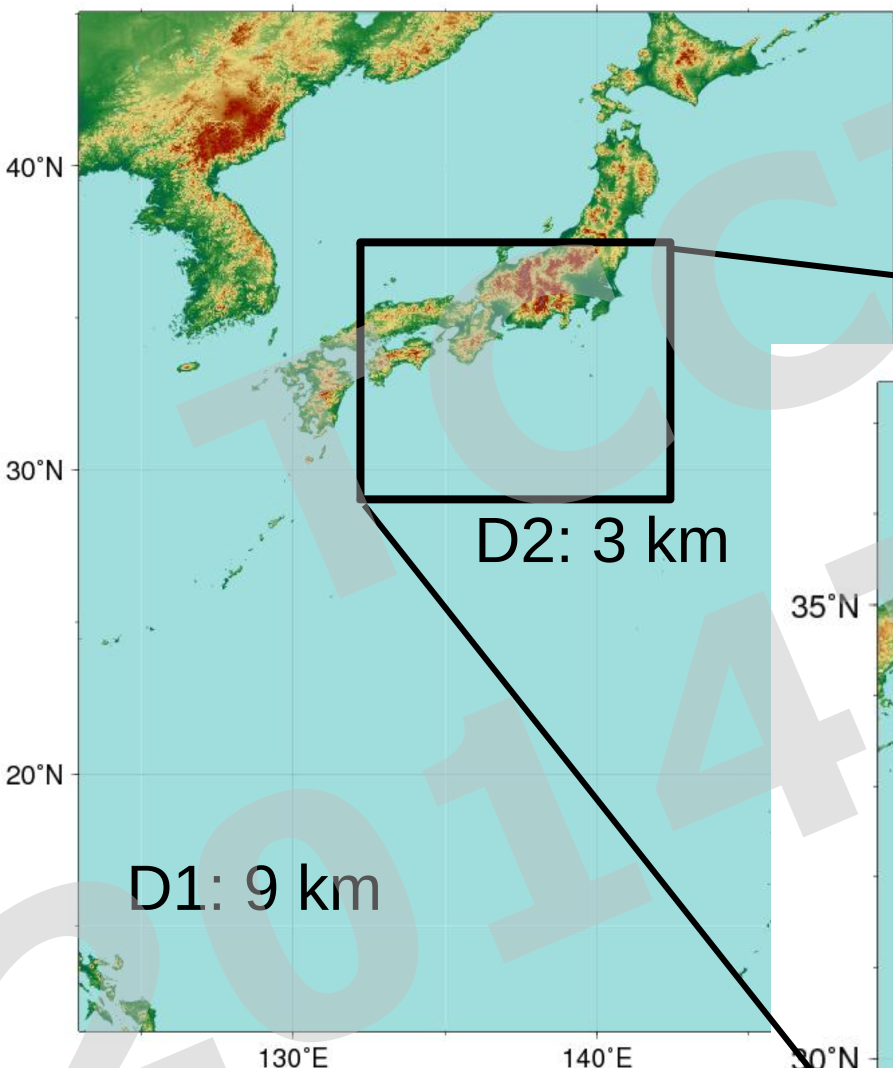
$$q = \frac{(\nabla \times \vec{V} + \Omega) \bullet \nabla \theta}{\rho}$$

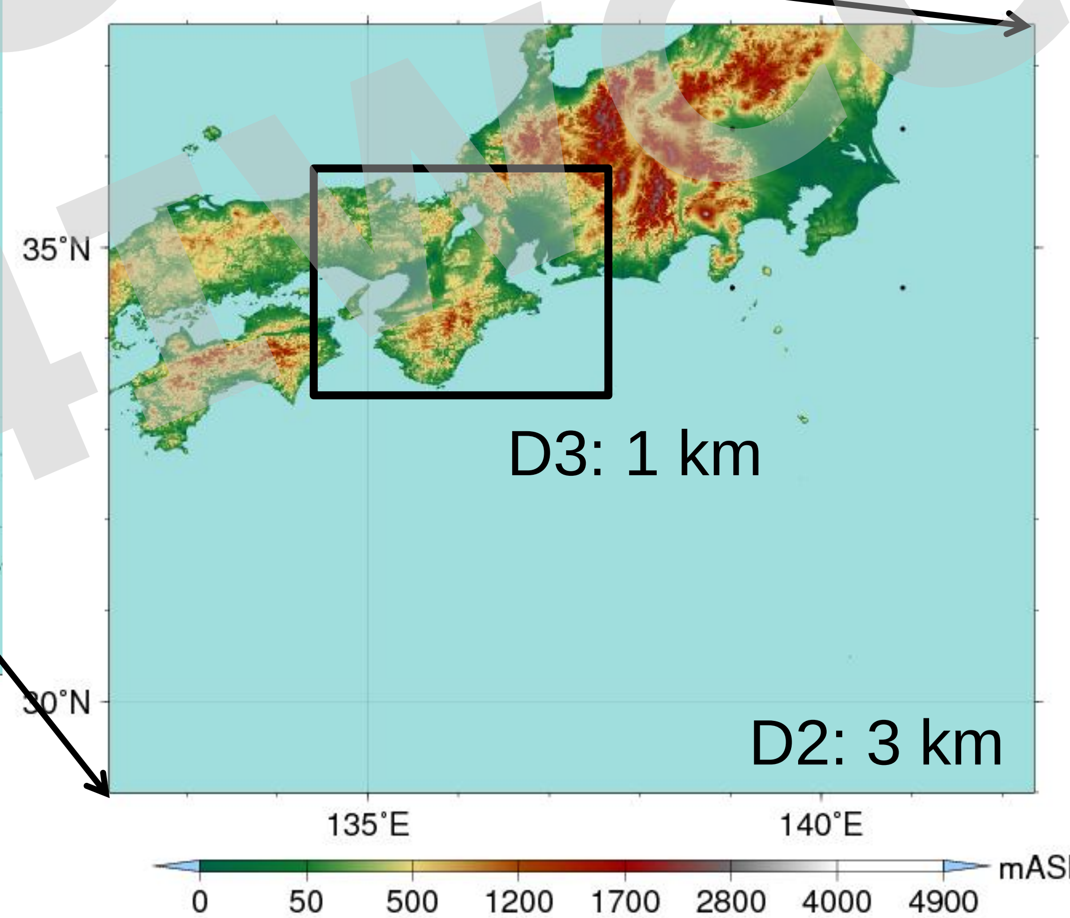


Relocate the initial position of typhoon core

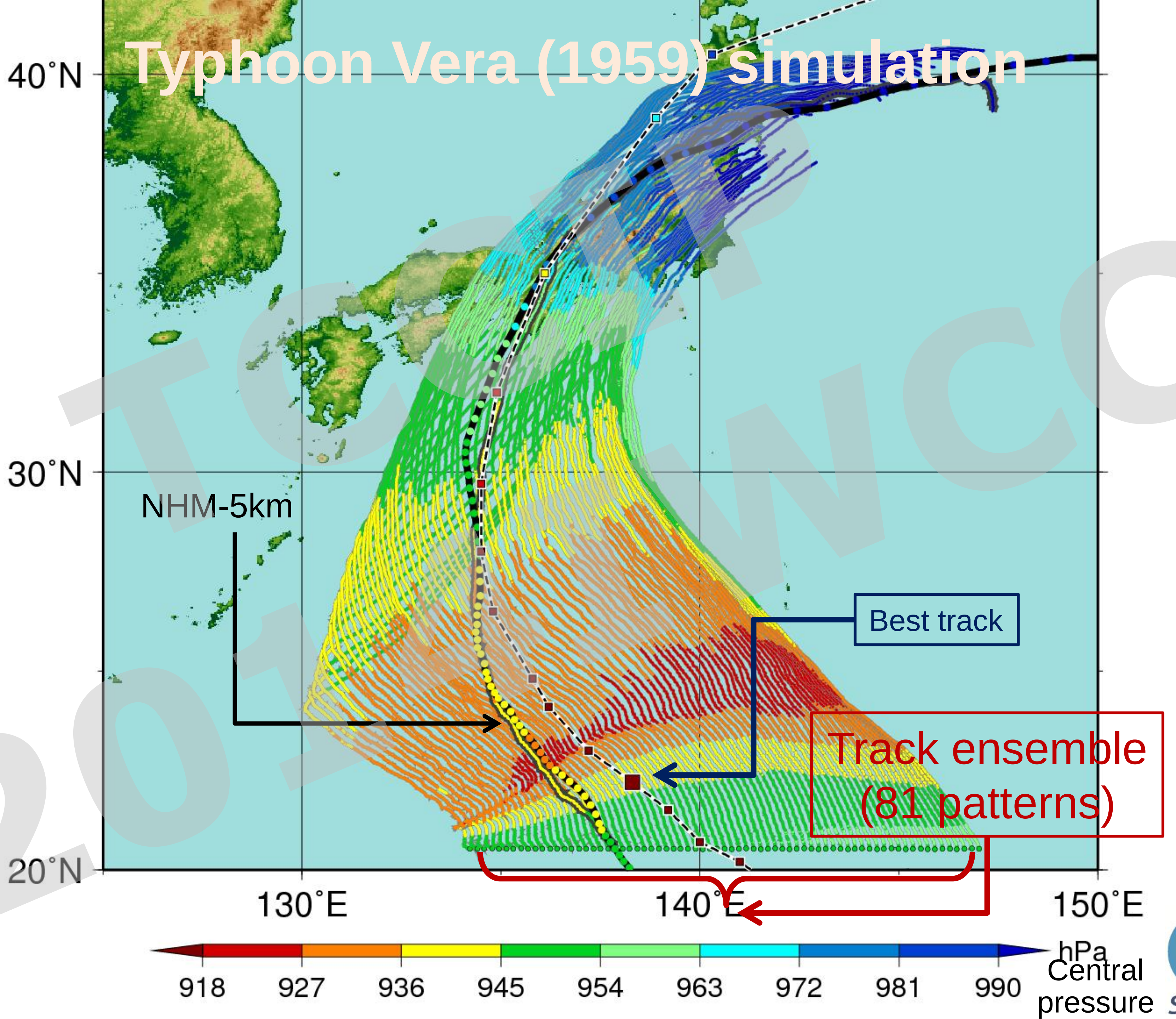
Typhoon Vera (1959)

- Model: WRF/ARW
- IC and BCs: MRI-NHM 5-km simulation downscaled from reanalysis

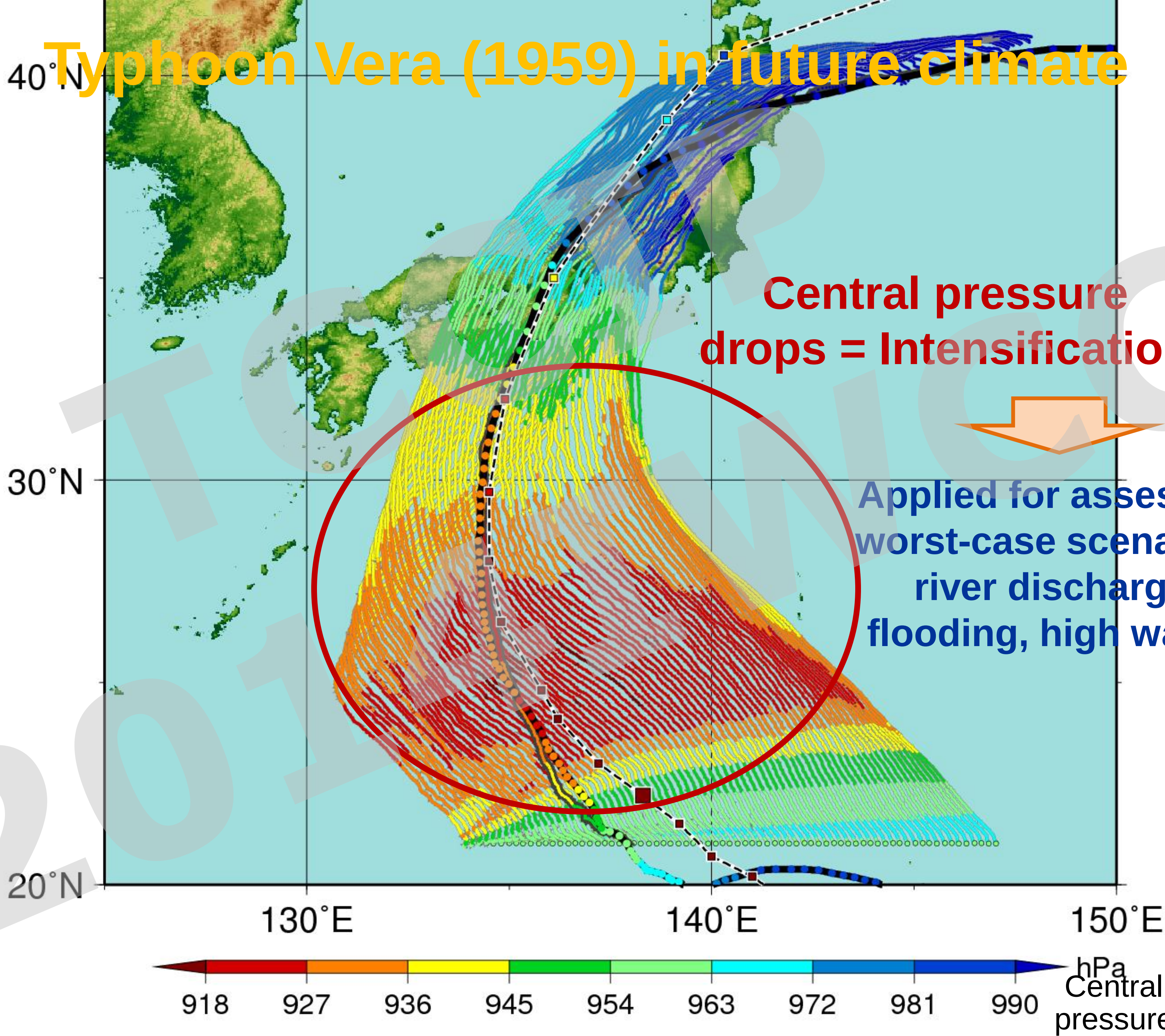




Typhoon Vera (1959) simulation



Typhoon Vera (1959) in future climate



Central pressure drops = Intensification

Applied for assessing worst-case scenarios: river discharge, flooding, high waves

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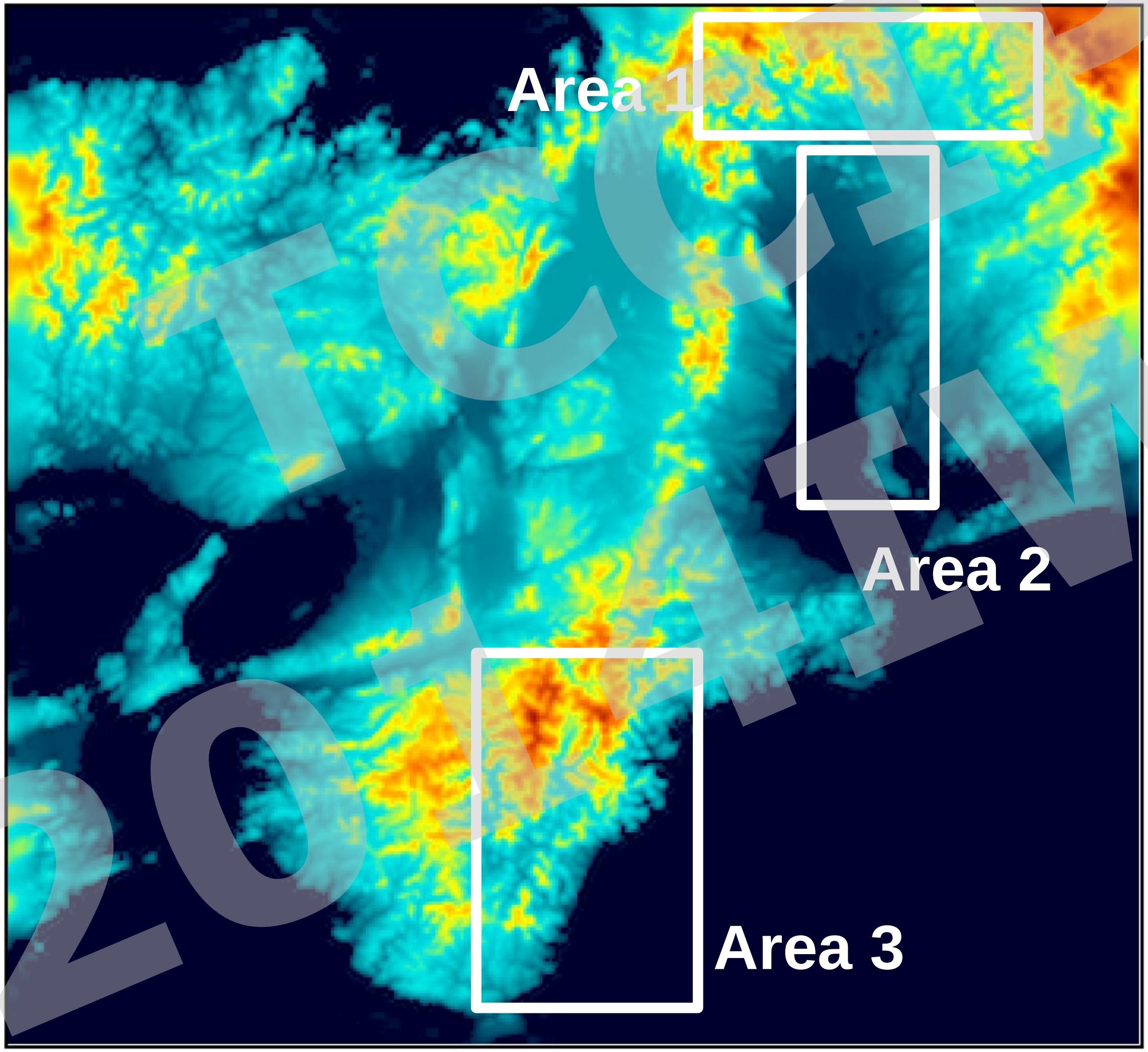
Assessment of precip & wind extremes

Precipitation and wind in specified areas are examined.



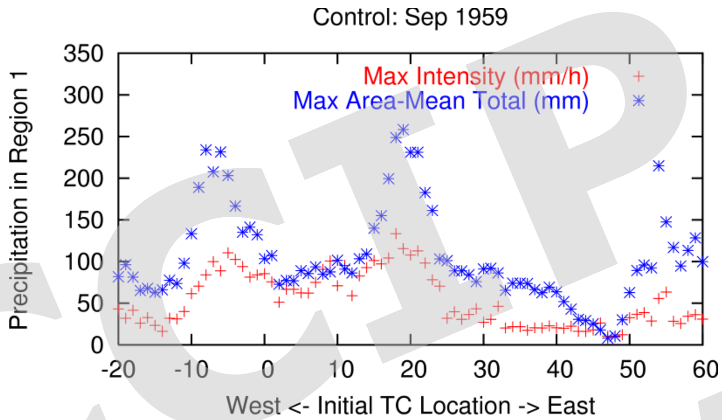
Area 1: Mountainous area north of the Nobi Plain, the Nagoya metro area

Area 2: The Nobi Plain and the Isewan Bay

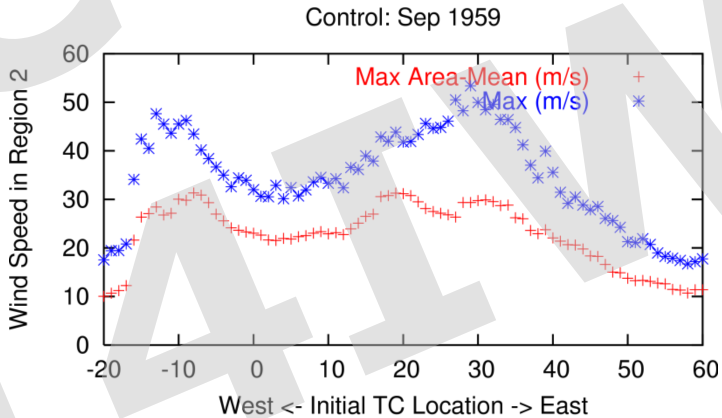
Area 3: Mountainous area in the Kii Peninsula

Precip & wind extremes wrt TC track

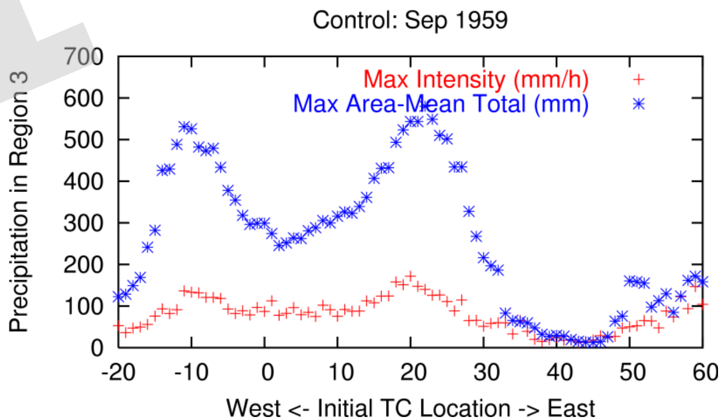
Precip in Area 1



Wind in Area 2



Precip in Area 3

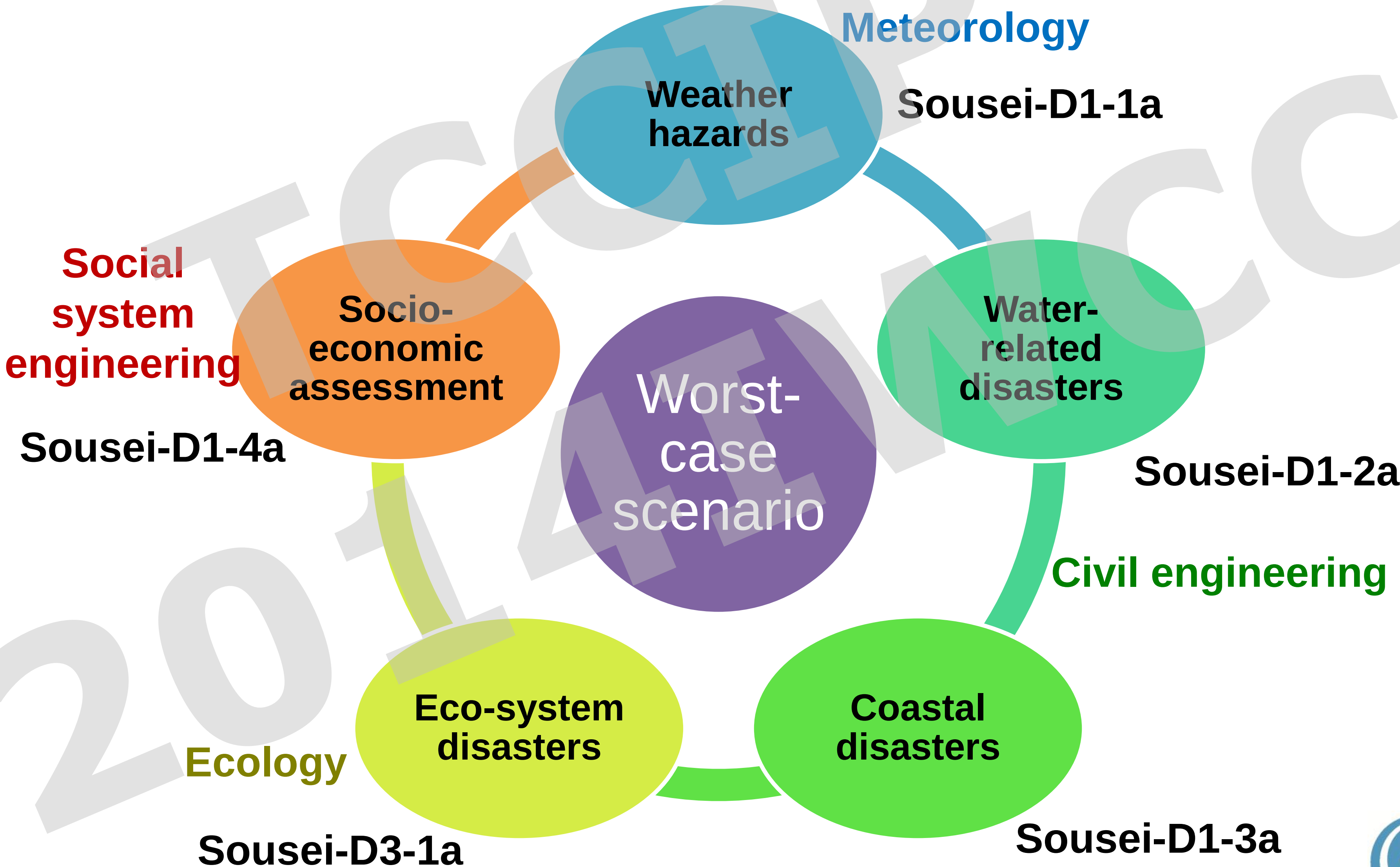


Worst-case scenarios

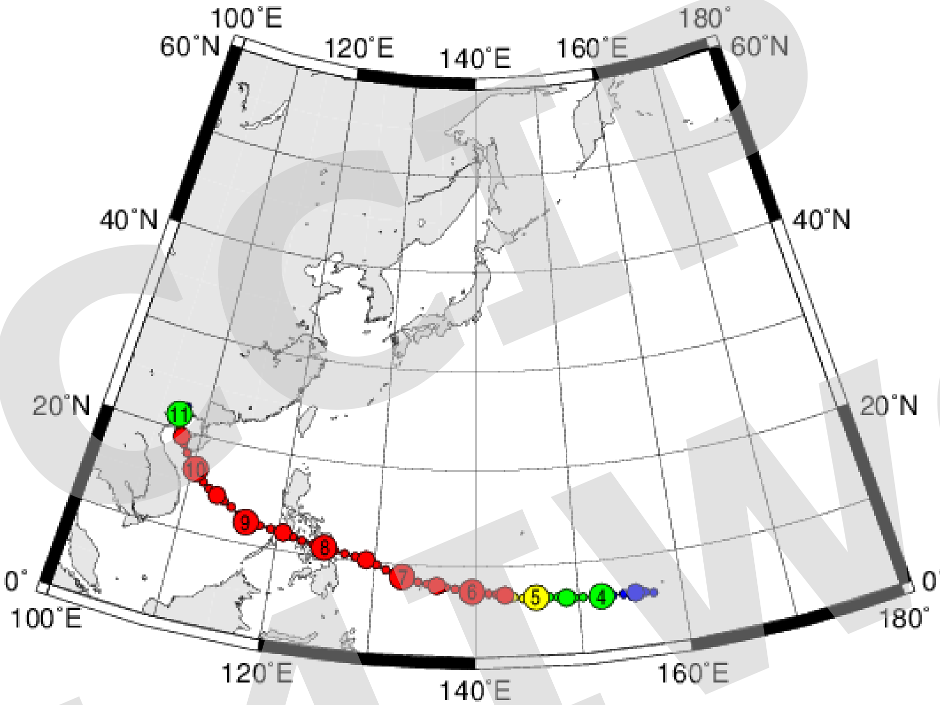
- Worst-case scenarios for natural disaster assessments:
  - water-related disasters, coastal disasters, wind disasters, eco-system disasters
- Not *the* sole worst case, but multiple worst *scenarios*
  - Normally typhoons become a meteorological hazard in a certain aspect: heavy rainfalls or high winds
  - However typhoons cause multiple hazards simultaneously
    - † Eg. flooding + high winds + high waves
- Worst-case disasters can be assessed as a scenario basis

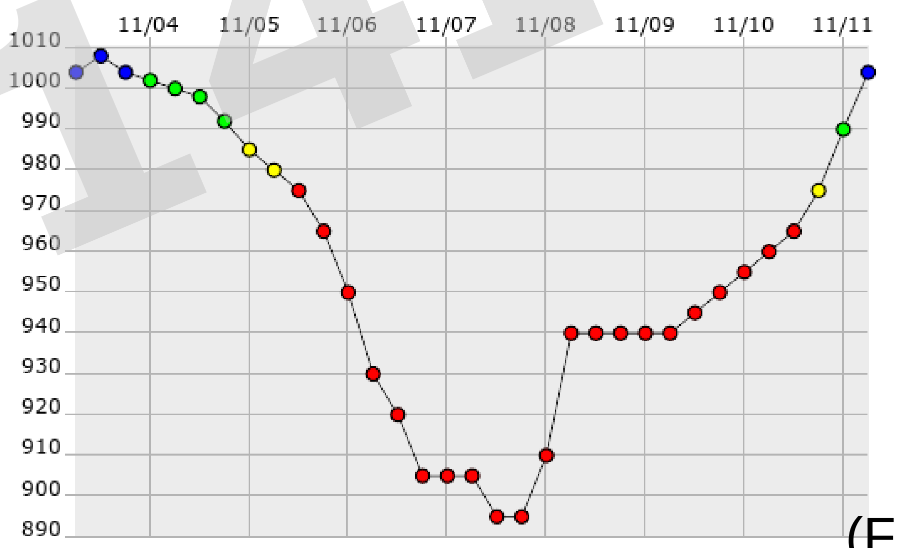
Disaster impact from worst-case scenarios

Interdisciplinary collaboration



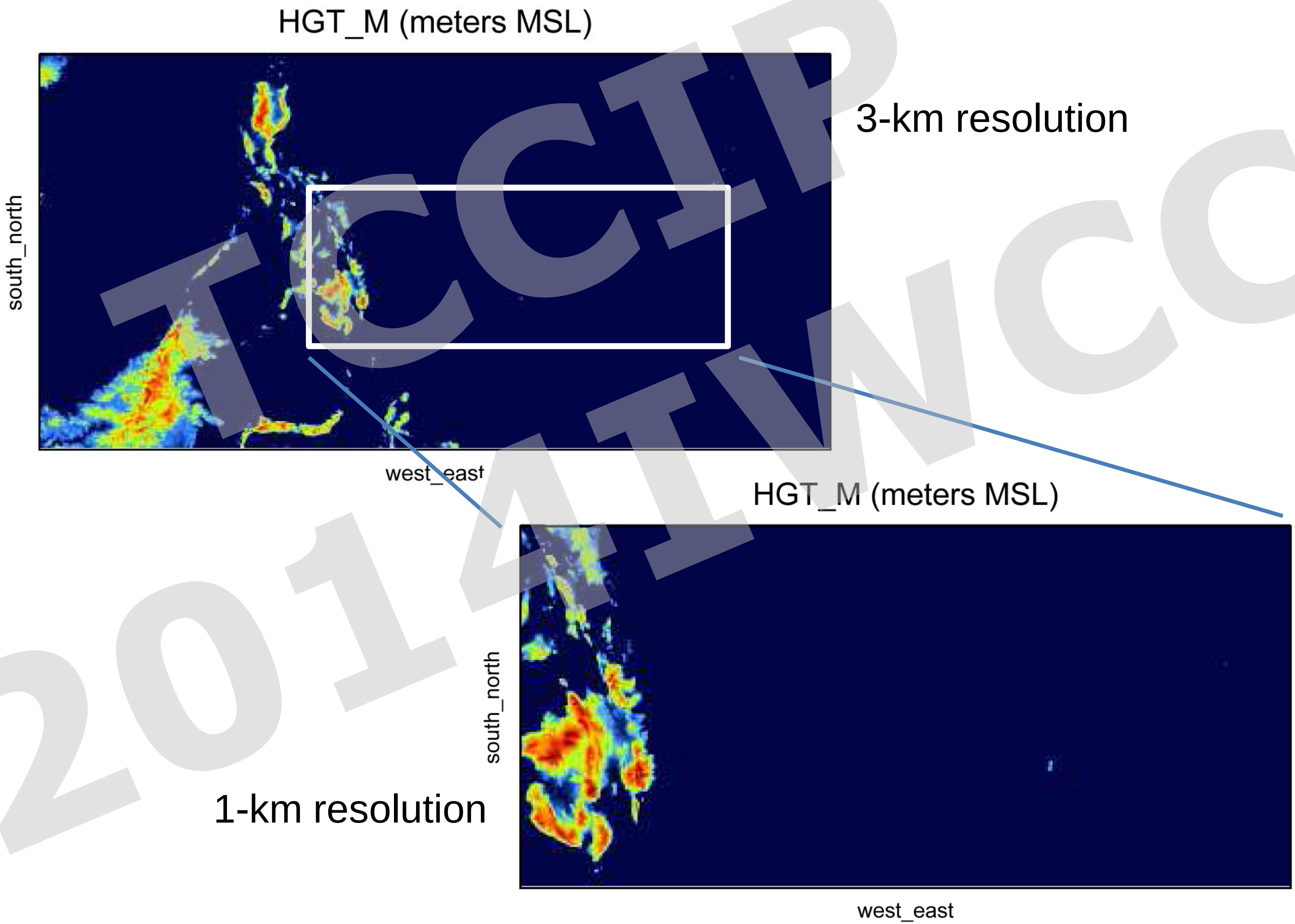
Typhoon Haiyan (2013)





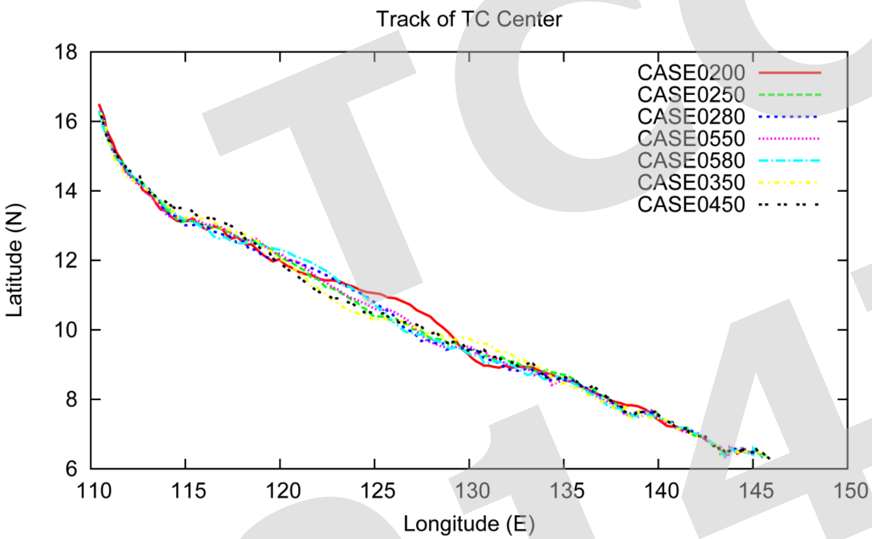
(From Digital Typhoon)

Regional simulation domains

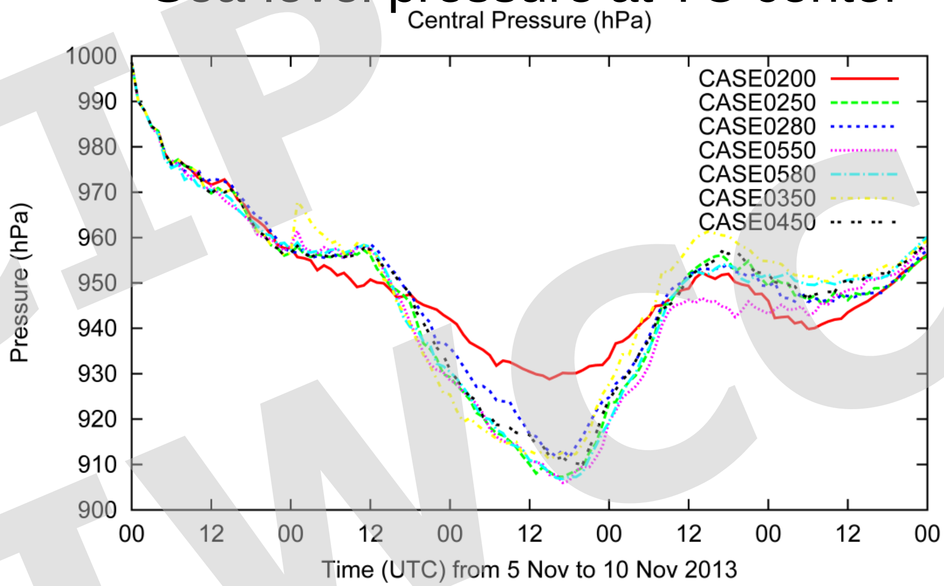


TC intensity and evolution

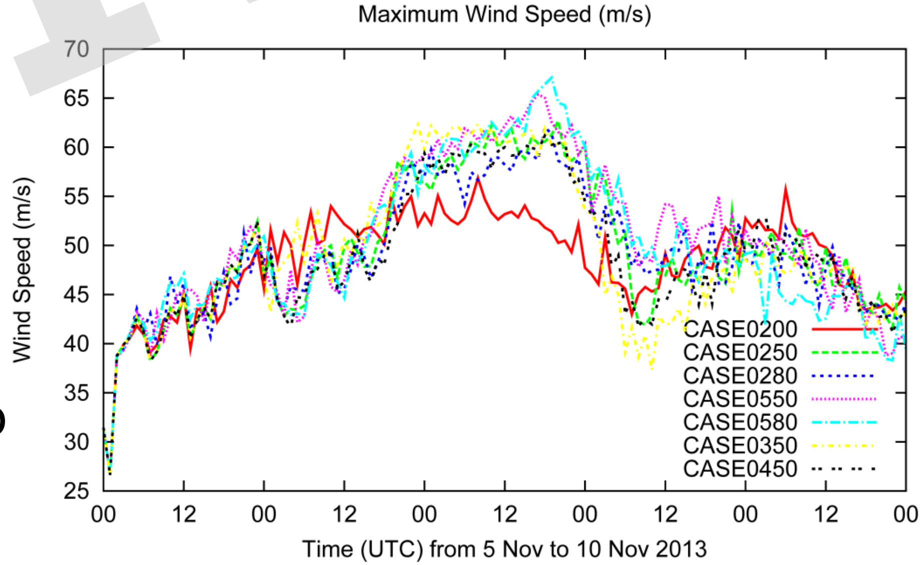
Track



Sea-level pressure at TC center



Maximum surface wind



To Prof. Mori's coastal disaster group

Model uncertainties: physics schemes

- Numerical simulations of typhoons are quite sensitive to physics parameterizations.
- For demonstrating sensitivity to physics parameterizations, sensitivity of TC intensification to turbulent mixing parameterization is examined
- Conduct 3D numerical experiments by changing the coefficient in the eddy viscosity formulation of Smagorinky.

$$K_m = (C_s l)^2 |S|$$

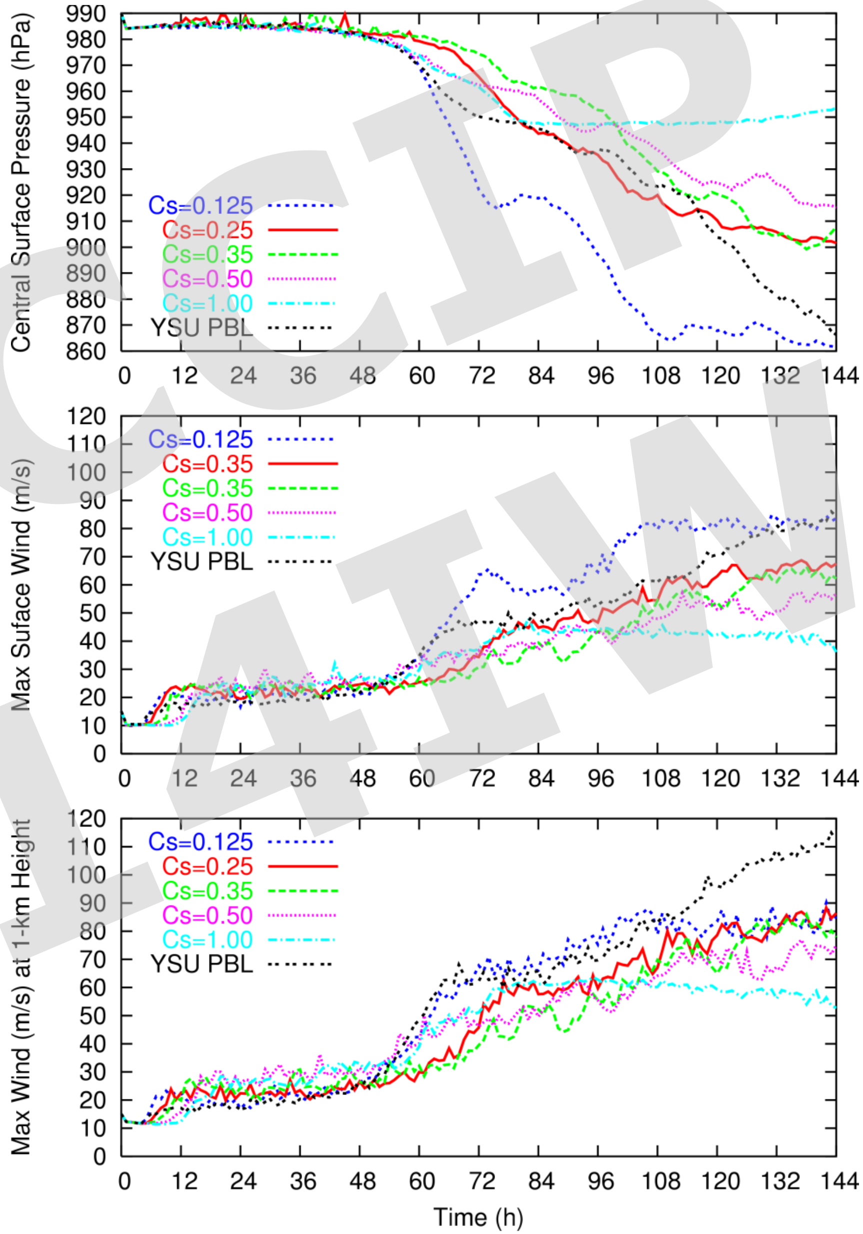
  - Smagorinsky constant: C_s=0.125, 0.25, 0.35, 0.50, 1.00
  - Non-local PBL scheme (Hong et al. 2006)

Temporal evolution of TC intensity

Central pressure

Maximum wind speed (at the surface)

Maximum wind speed (at the 1-km level)



Cs=0.125

Cs=0.25

Cs=0.35

Cs=0.50

Cs=1.00

YSU PBL

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Summary

- Due to the limitation of the TC number of GCM climate simulations, generating a large number of ensembles by changing TC tracks is an alternative approach to obtain worst-case scenarios.
- Interdisciplinary efforts are being made under the SOUSEI program to assess disaster impacts by worst-case scenarios.
- Quantitative simulations of meteorological hazards due to typhoons are important for quantitatively assessing disaster impacts; Typhoon Haiyan (2013) is a challenging topic.
- The examination of the sensitivity of the simulated TCs to the turbulence parameterization implies the importance of physics parameterizations to improve the quantitative modeling of TC intensities.