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Assessment of Typhoon Disasters by Dynamical Downscaling Simulation

Tetsuya Takemi

Severe Storm Research Section
Disaster Prevention Research Institute
Kyoto University

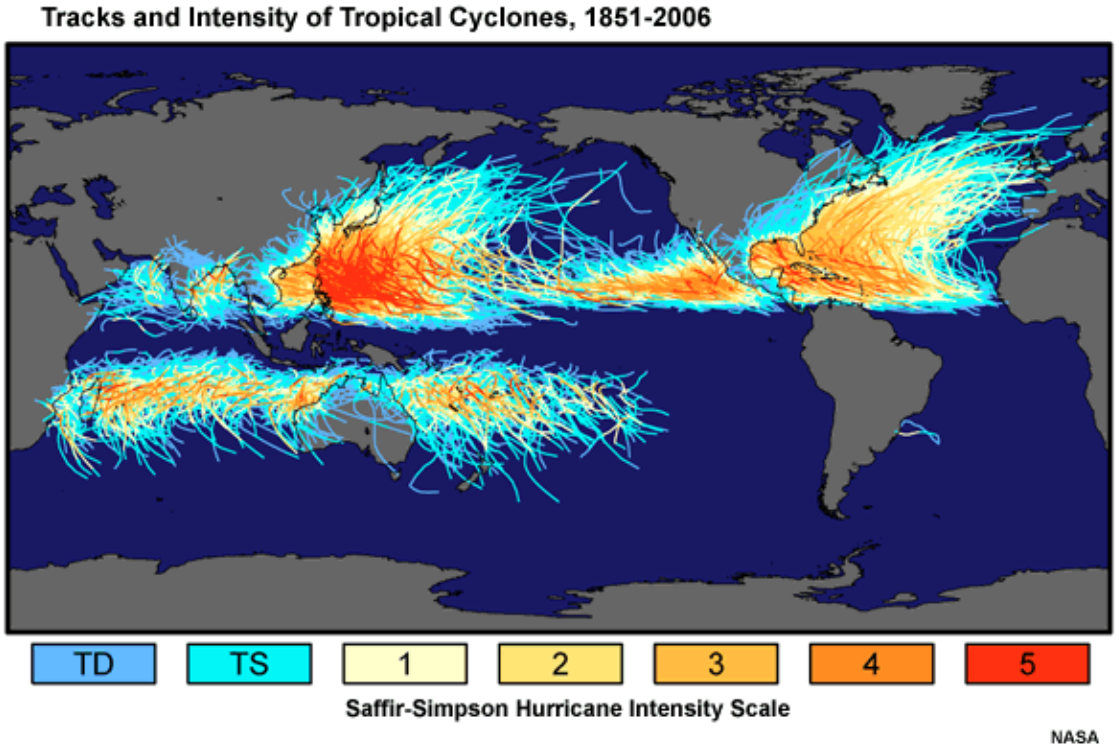
DPRI-KU

京都大学
KYOTO UNIVERSITY

Introduction

- Typhoons (tropical cyclones): tracks, frequency, and climate change impact
- Downscaling numerical simulation with the use of numerical weather prediction (NWP) model: benefit of high-resolution simulation
- Typhoon-related meteorological hazard from future projection under global warming (GW) by atmospheric general circulation model (GCM): generating ensemble information by controlling typhoon tracks

Tropical cyclone: track, intensity, frequency



Typhoon frequency in Japan (1981-2010)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
Occurred	0.3	0.1	0.3	0.6	1.1	1.7	3.6	5.9	4.8	3.6	2.3	1.2	**25.6**
Approached				0.2	0.6	0.8	2.1	3.4	2.9	1.5	0.6	0.1	**11.4**
Landed					0.0	0.2	0.5	0.9	0.8	0.2	0.0		**2.7**

TC change by GCM projection under GW

SST change

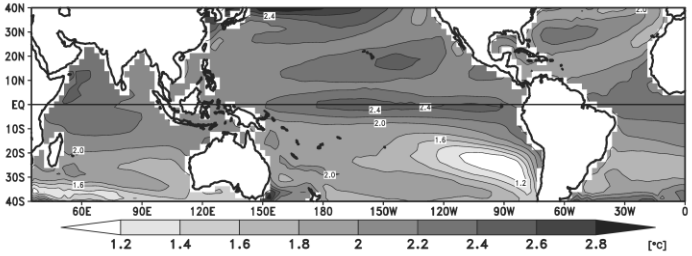
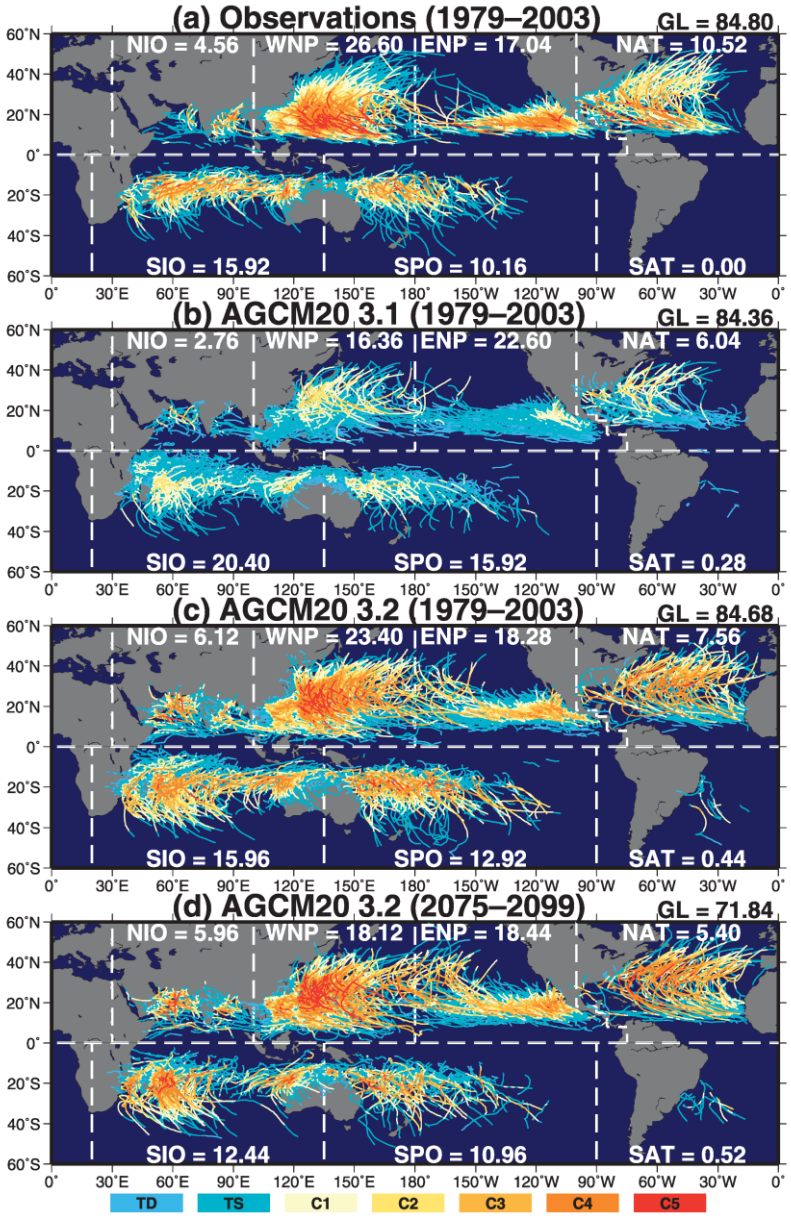


FIG. 2. Annual mean of prescribed future changes in SST (°C).

Results from KAKUSHIN program

(Murakami et al. 2012)



Observation

Present Day: Former GCM

Present Day: Latest GCM

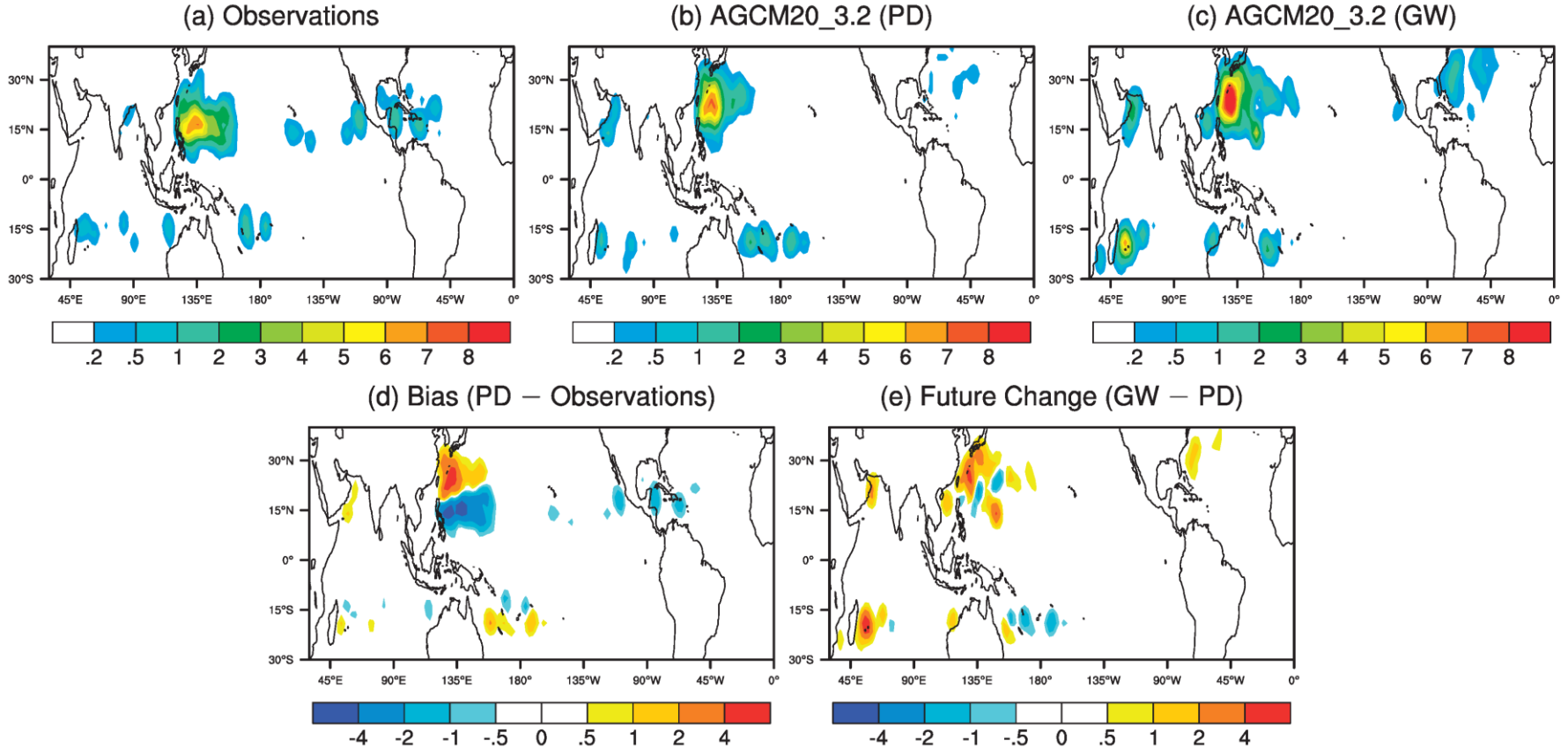
Future GW: Latest GCM

Cat-5 TC change under global warming

Observation

Present Day

Future GW

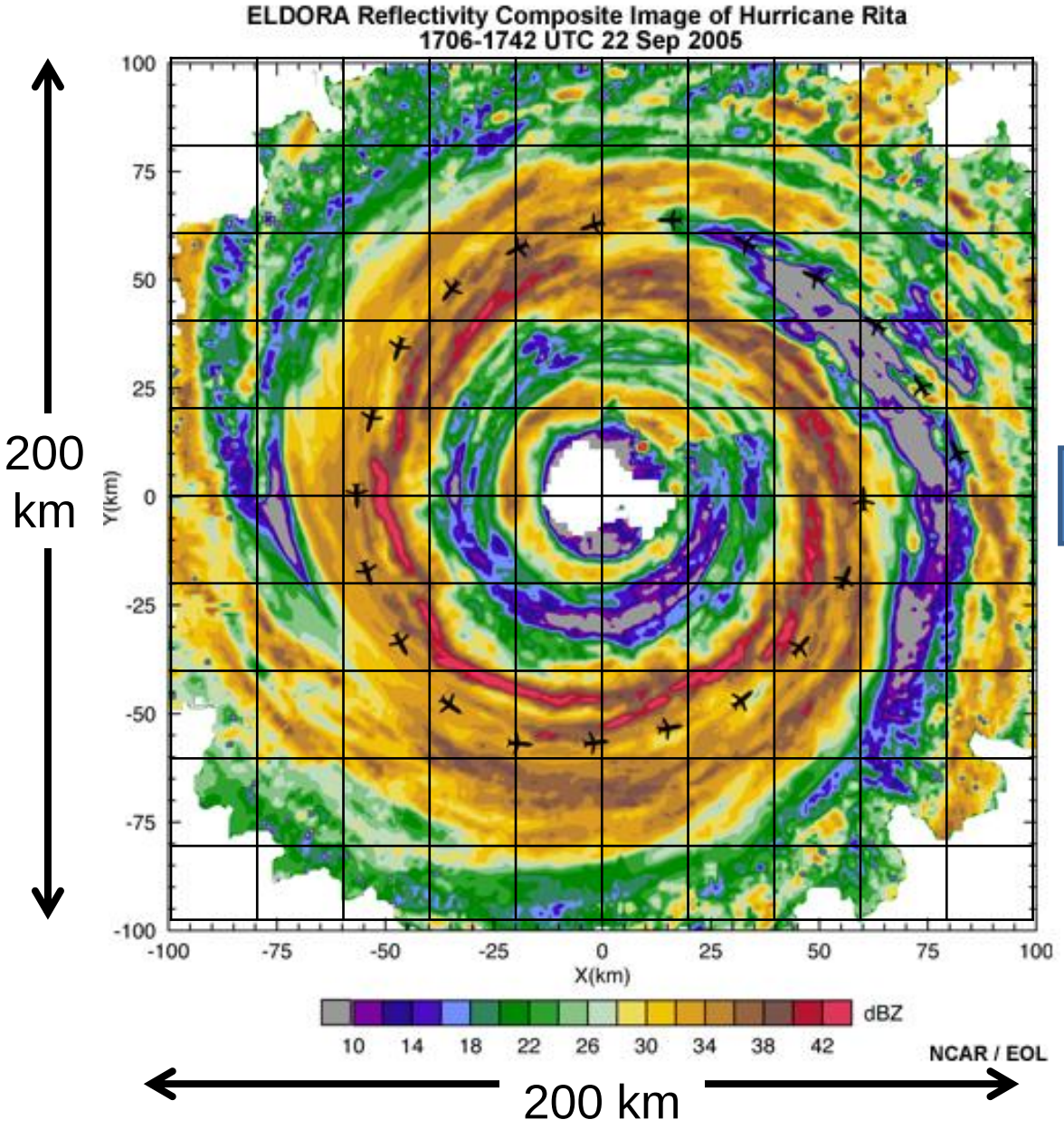


Future change

Results from KAKUSHIN program

(Murakami et al. 2012)

TCs have fine-scale structure in their core

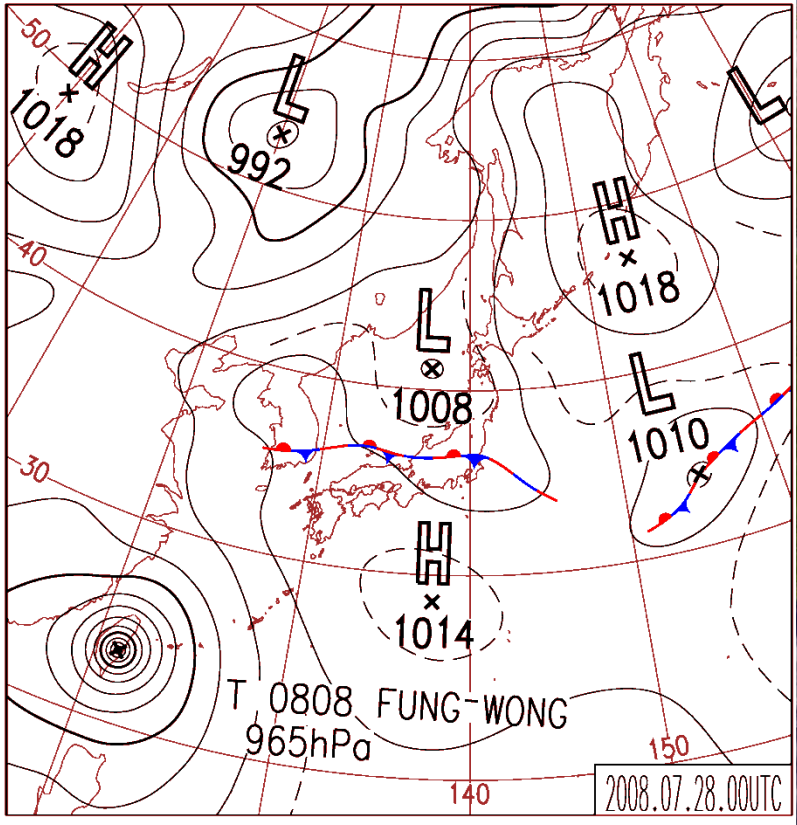


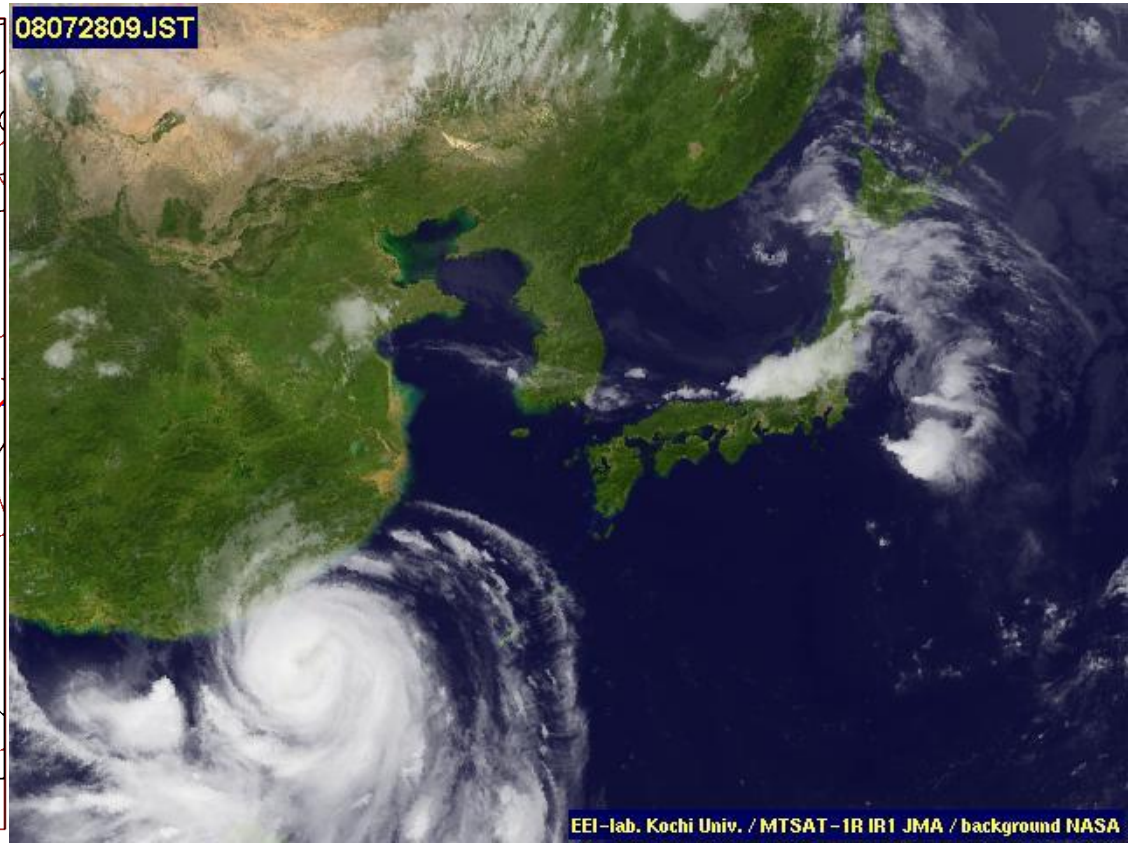
Requires downscaling model to resolve TC core at high-resolution.

Typhoons affect local-scale met disasters

- Typhoon Fung-Wong (2008) over the East China Sea
- Stationary over the Japan Sea front from Korea to Japan
- Southwesterly flow from the typhoon region to western Japan

Weather map and satellite image at 0900 JST 28 July 2008





Heavy rain on 28 July 2008 in Japan

- Gokayama, Toyama:

Flush flood in Kobe City

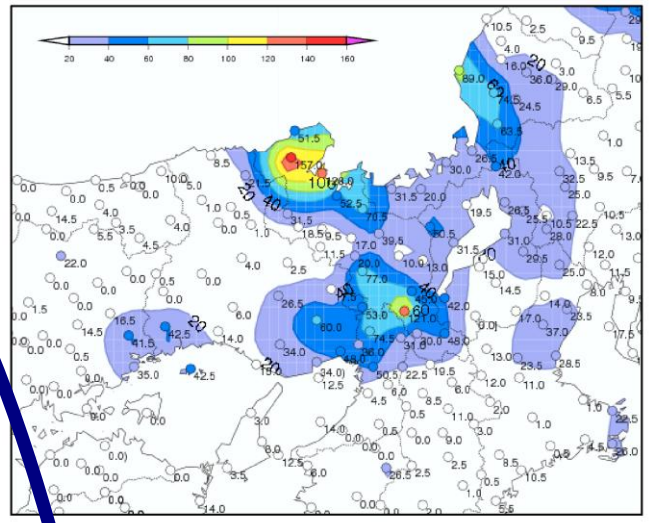
) LST)

LST)

LST)

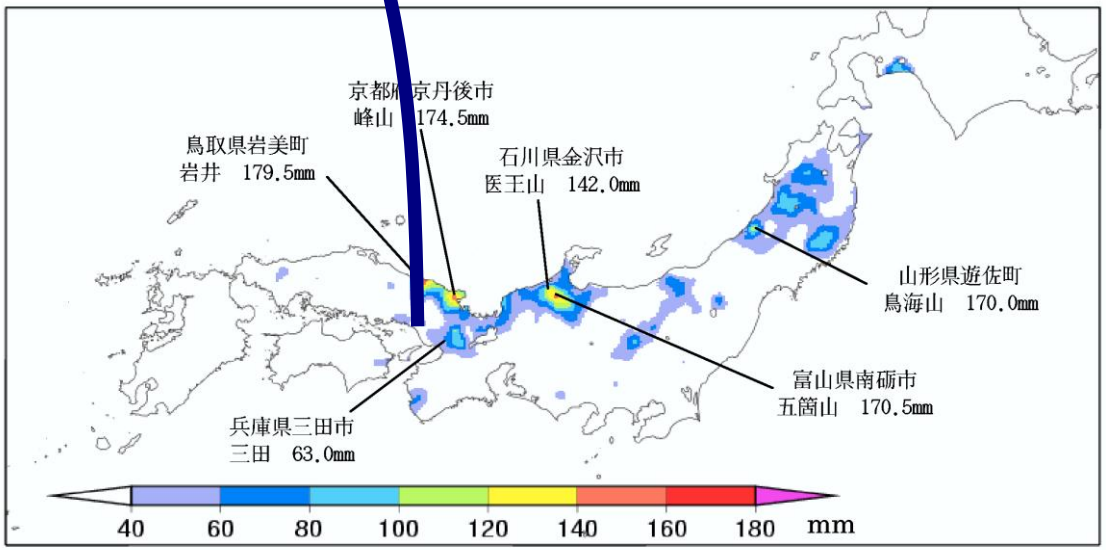
About 30 minutes later …

Total rainfall during 00-17 LST
28 July 2008 (JMA)



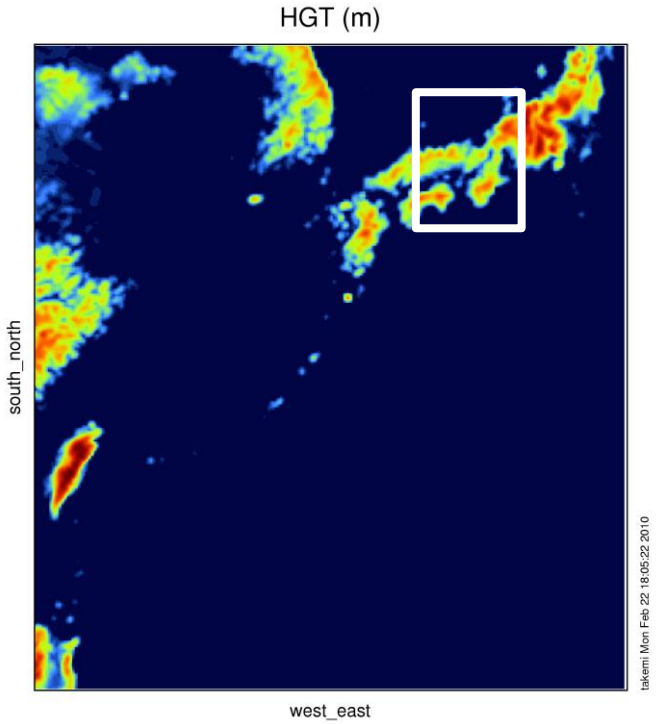
7月 28 日 00 時　17 時のアメダス降水量積算図（単位は mm）

Total rainfall during 27-29 July 2008 (JMA)

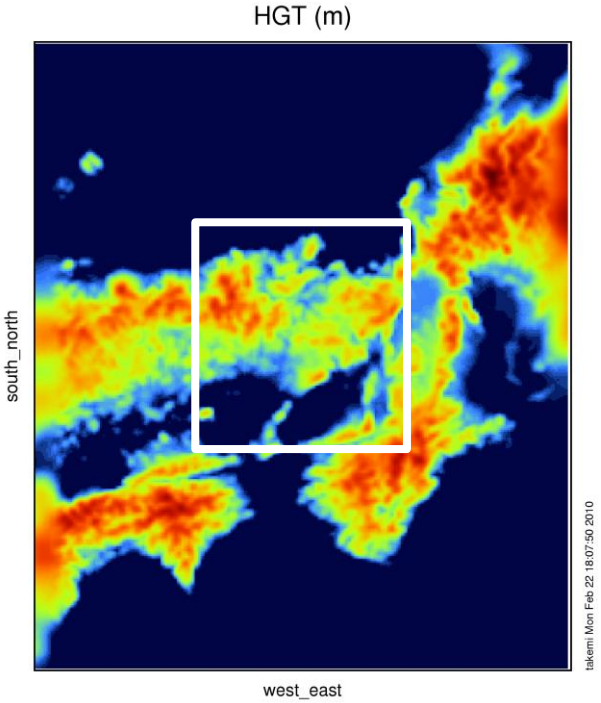


Downscaling and terrain representation

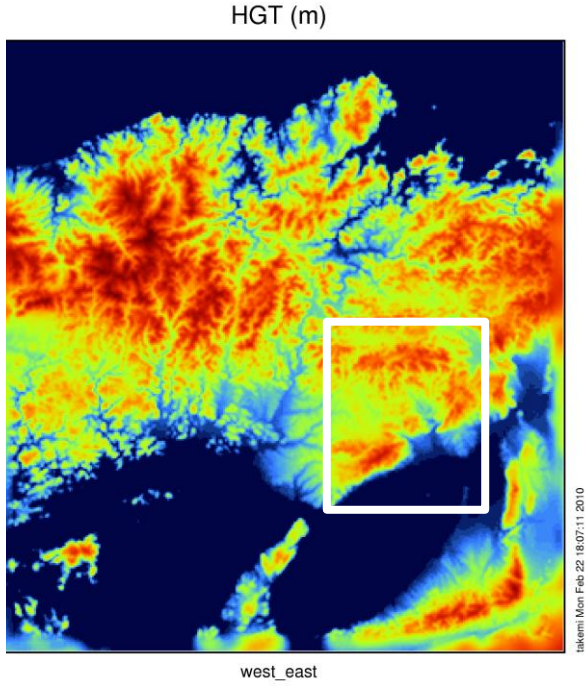
Domain 1
2200 x 2400 km
Δx=10 km



Domain 2
410 x 480 km
Δx=2.5 km



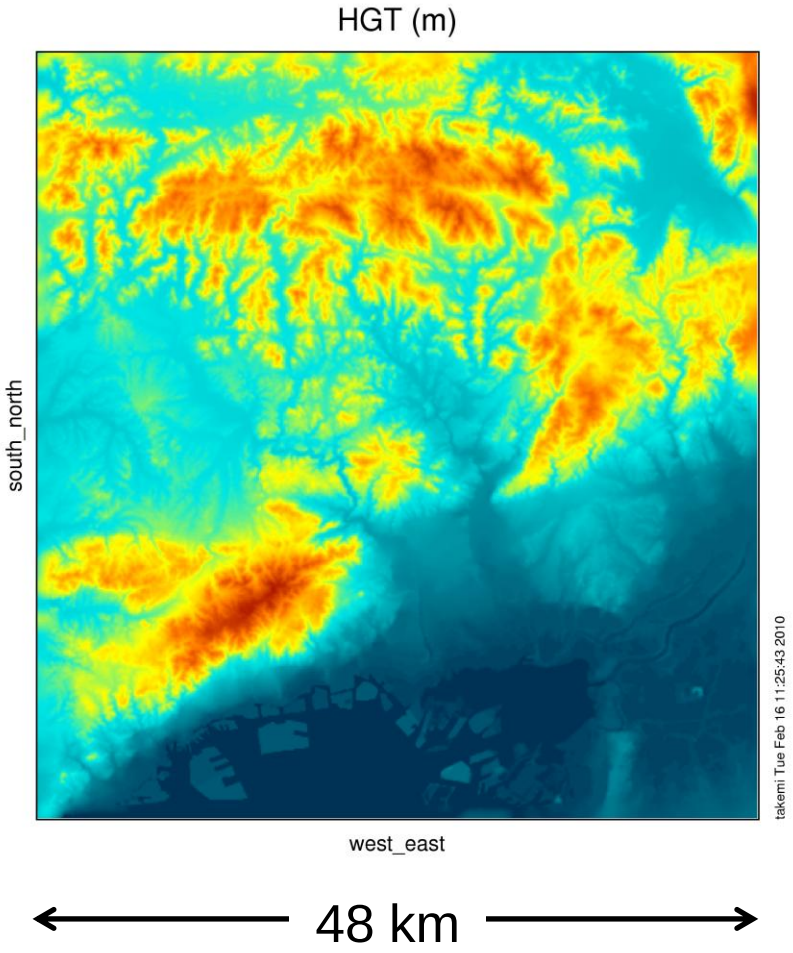
Domain 3
163 x 175 km
Δx=500 m



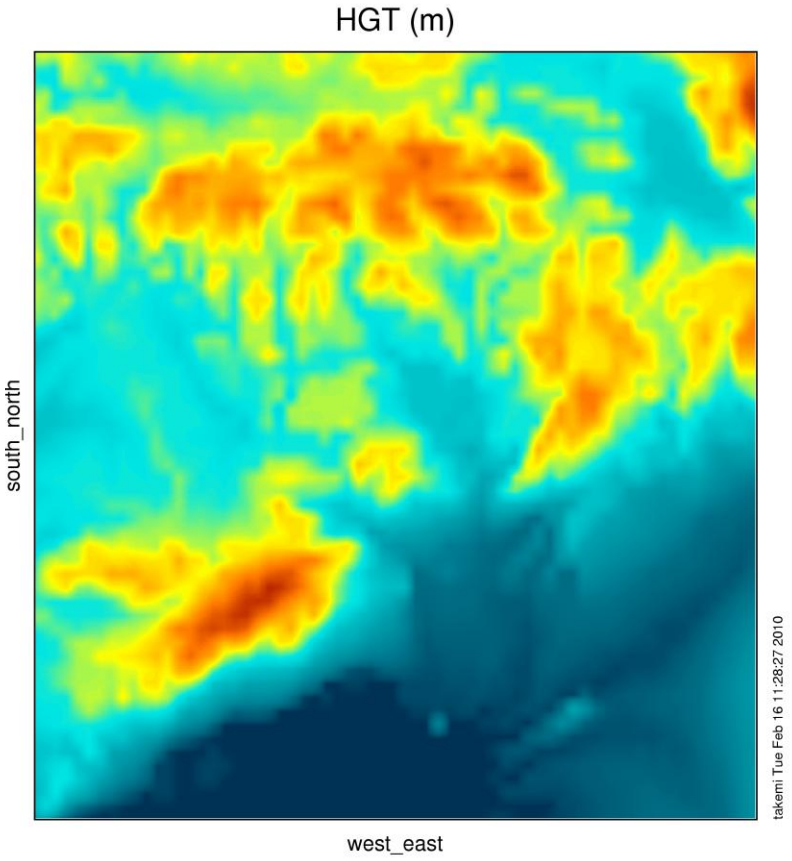
Downscaling: NWP model (WRF)

100-m resolution domain: terrain

GSI50:
50-m resolution DEM



GTOPO30:
~1 km-resolution DEM

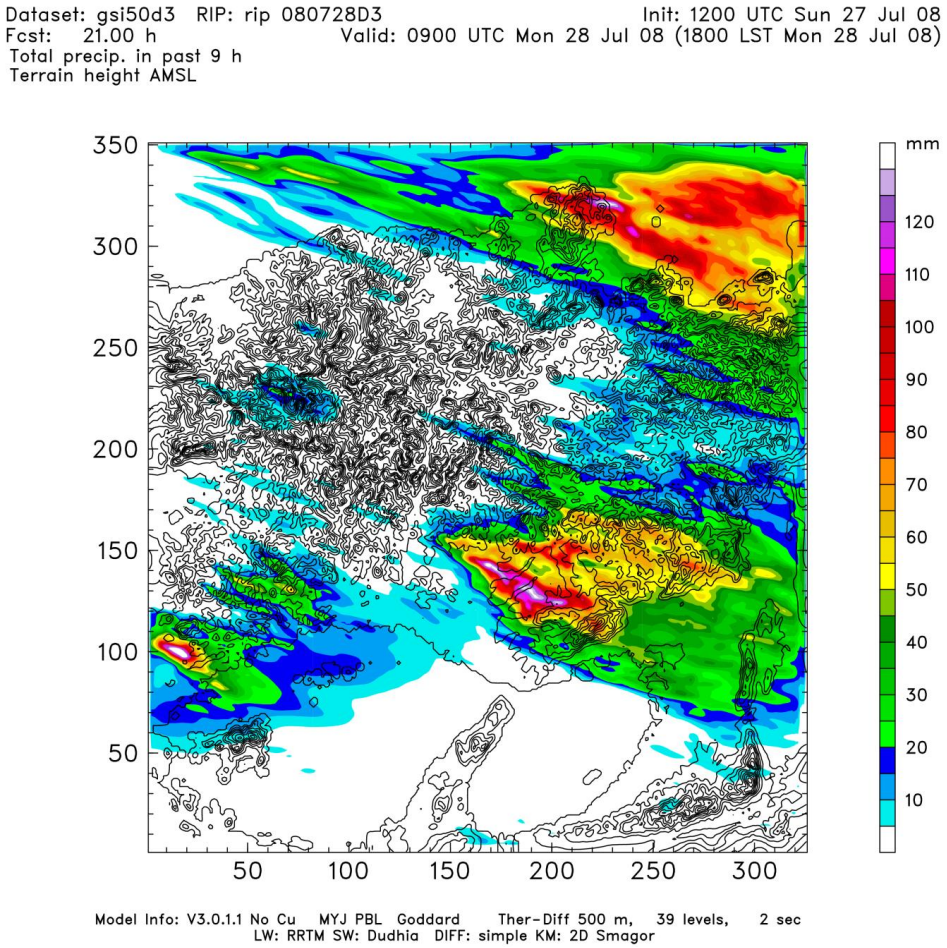


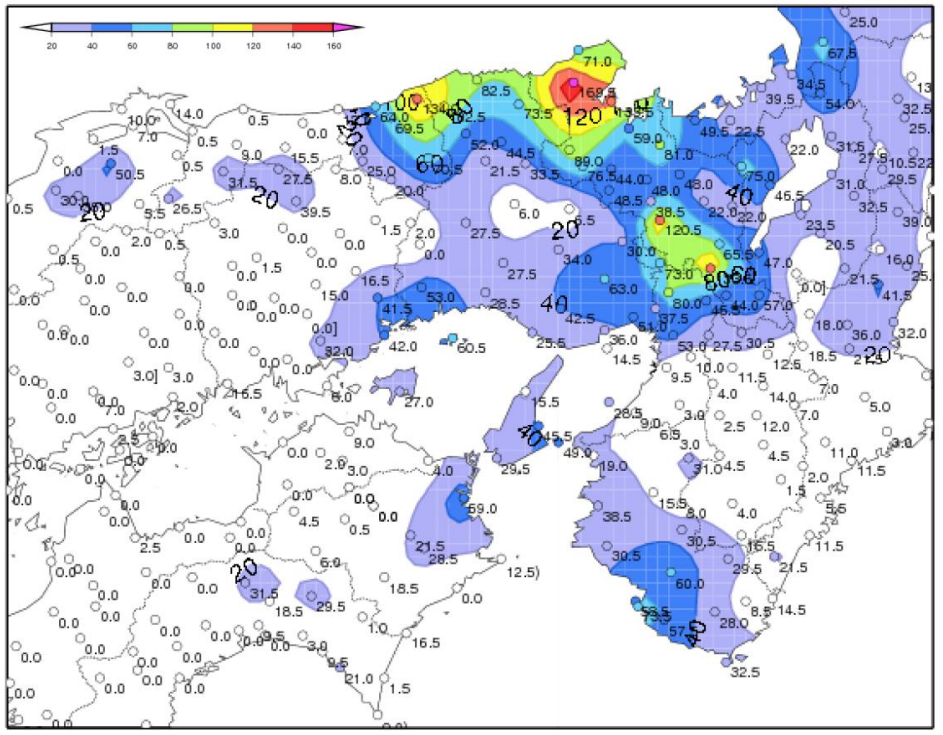
51 km

Rainfall representation

Accumulated rainfall during
0900 JST-1800 JST 28 July 2008

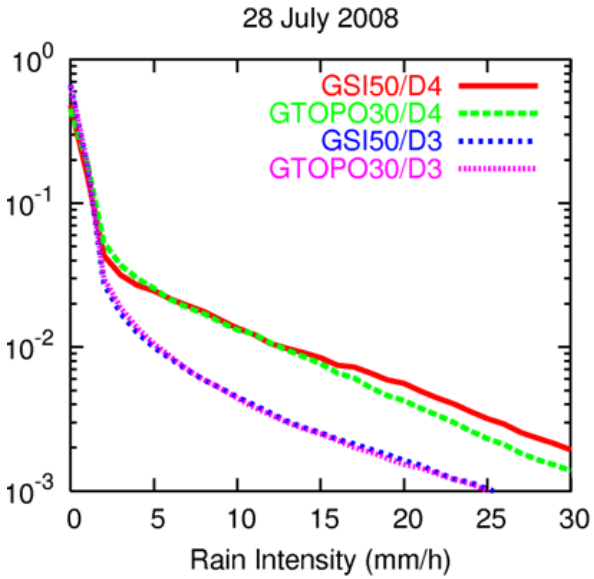
JMA observation



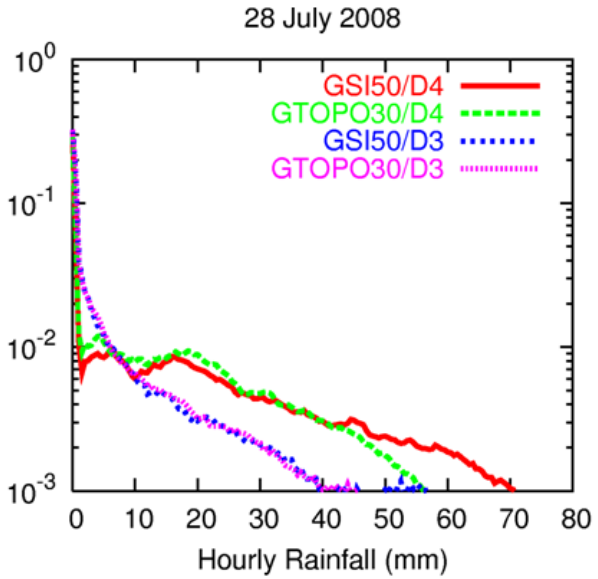


Frequency distribution of rain

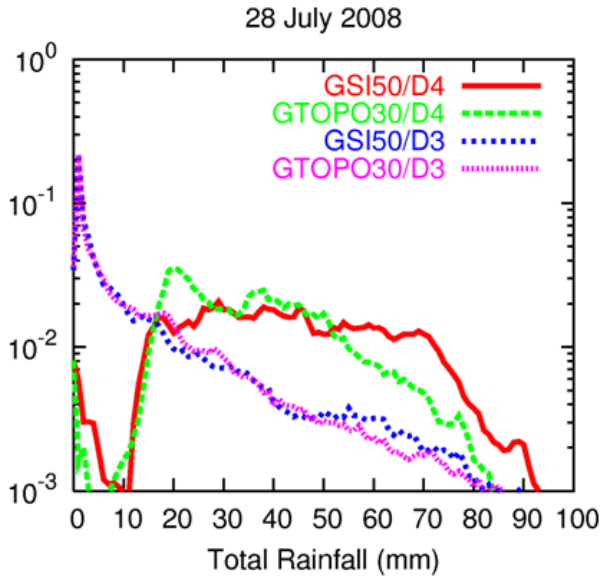
Rain Intensity,
1-min int (mm/h)



Hourly Rainfall (mm)



Total Rainfall (mm)

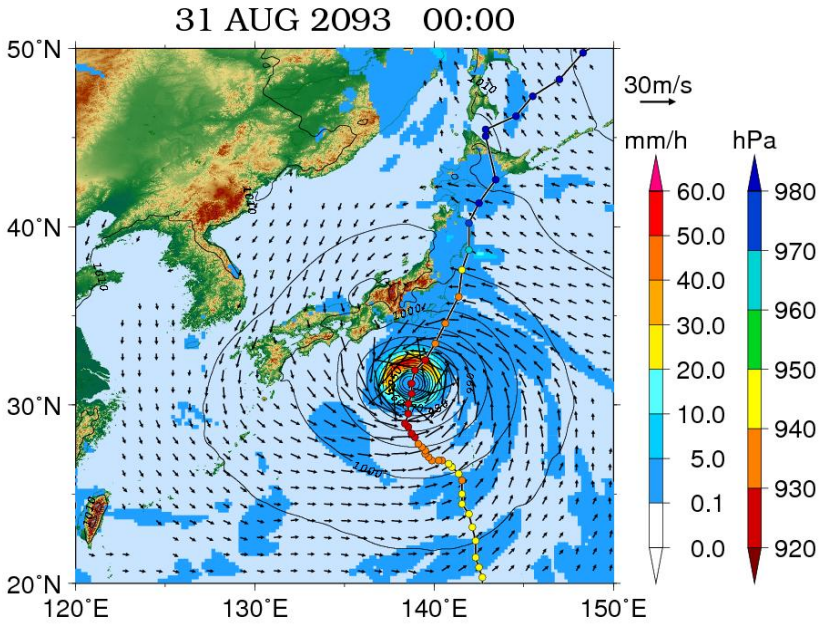


— :100-m domain, GSI50 (50-m resolution DEM)

— :100-m domain, GTOPO30 (1-km resolution DEM)

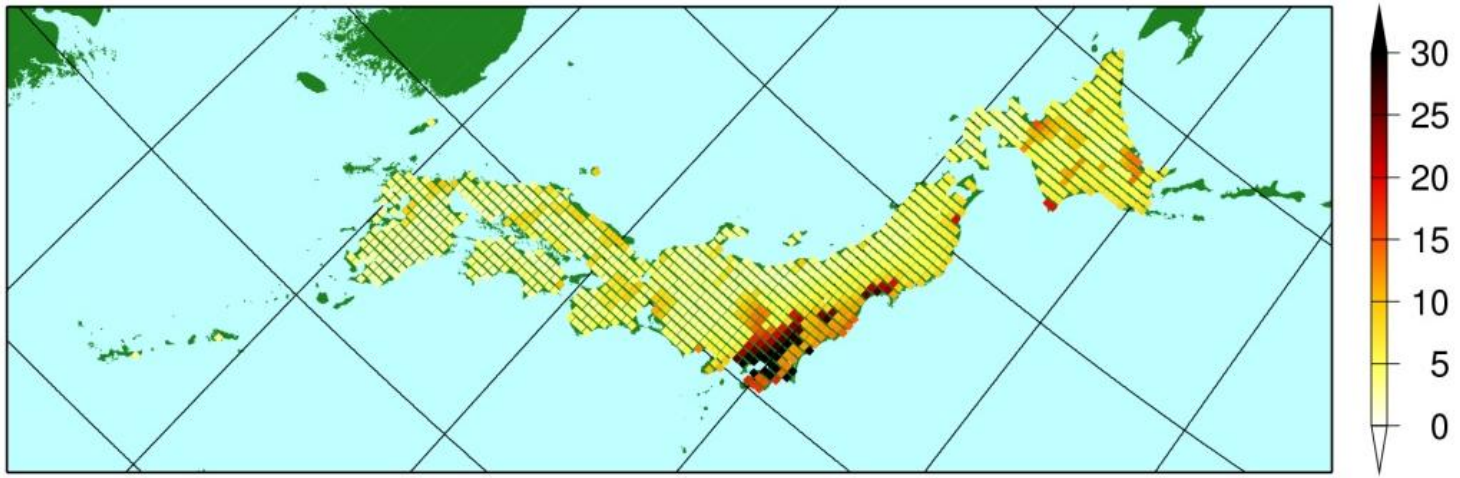
Representation of topography impacts the representation of extreme values.

Future severe typhoon in GCM projection



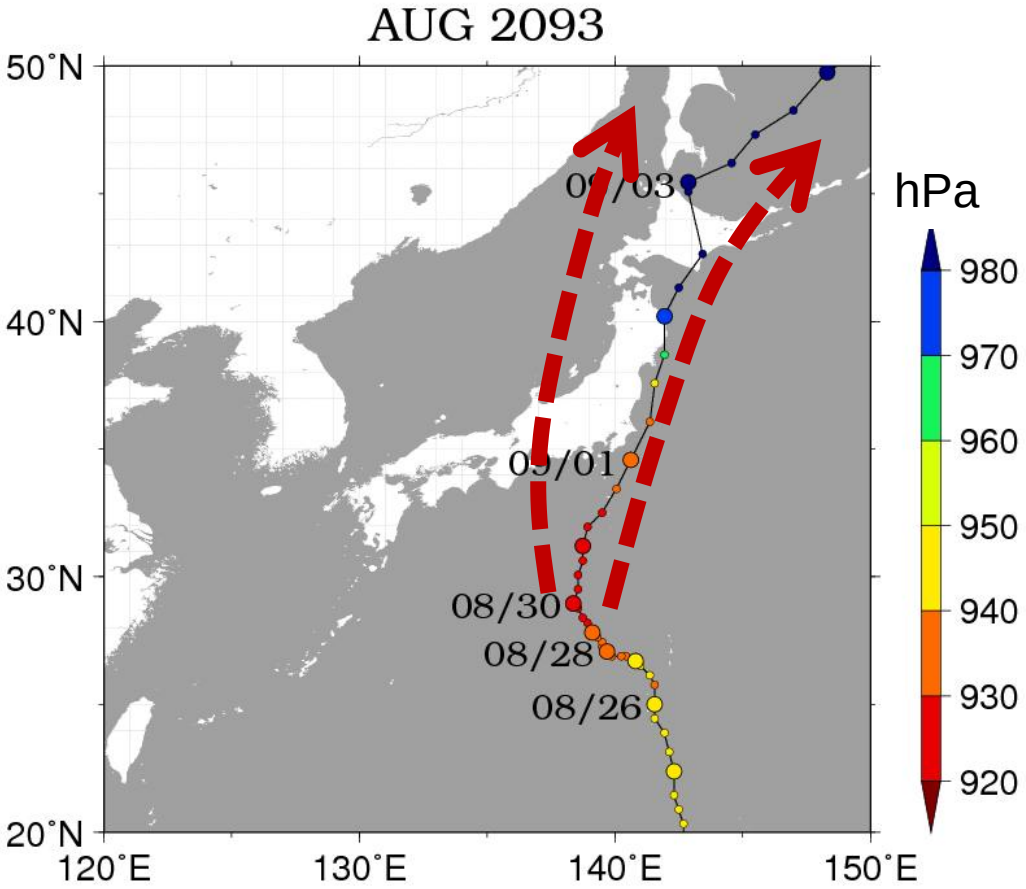
One possible realization in GCM projection under GW.
NO probabilistic information.

Maximum Wind Distribution

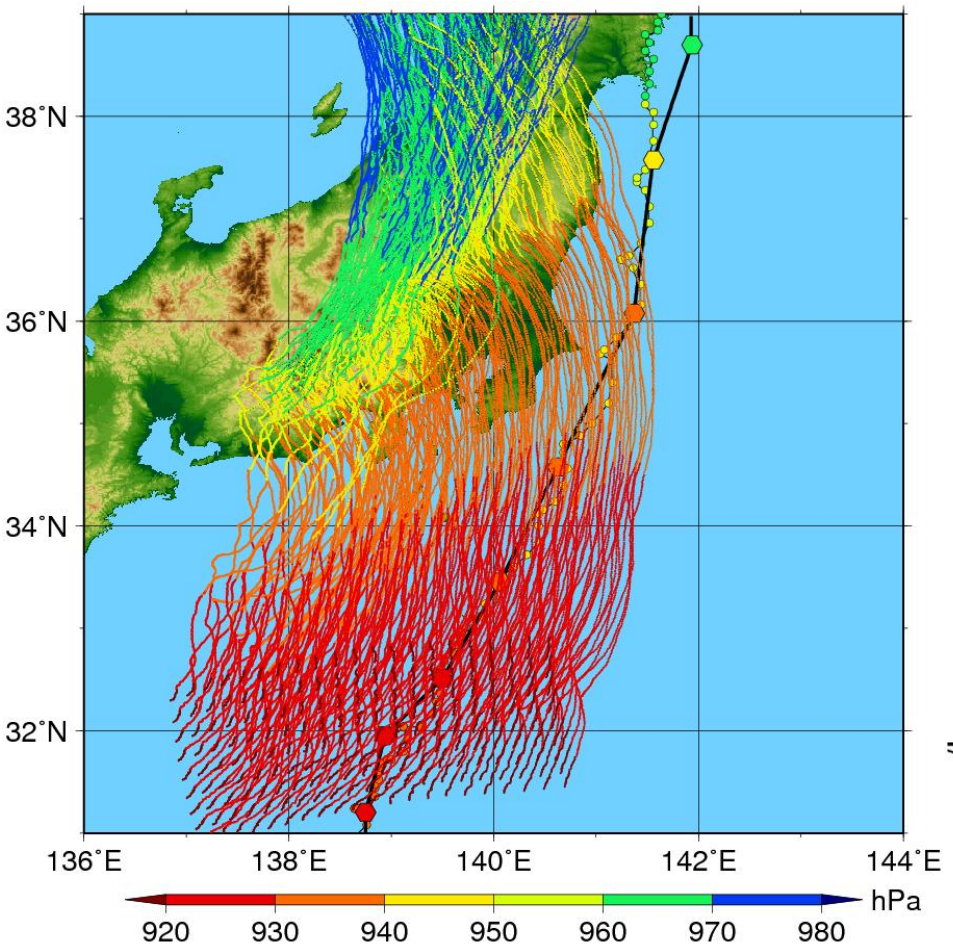


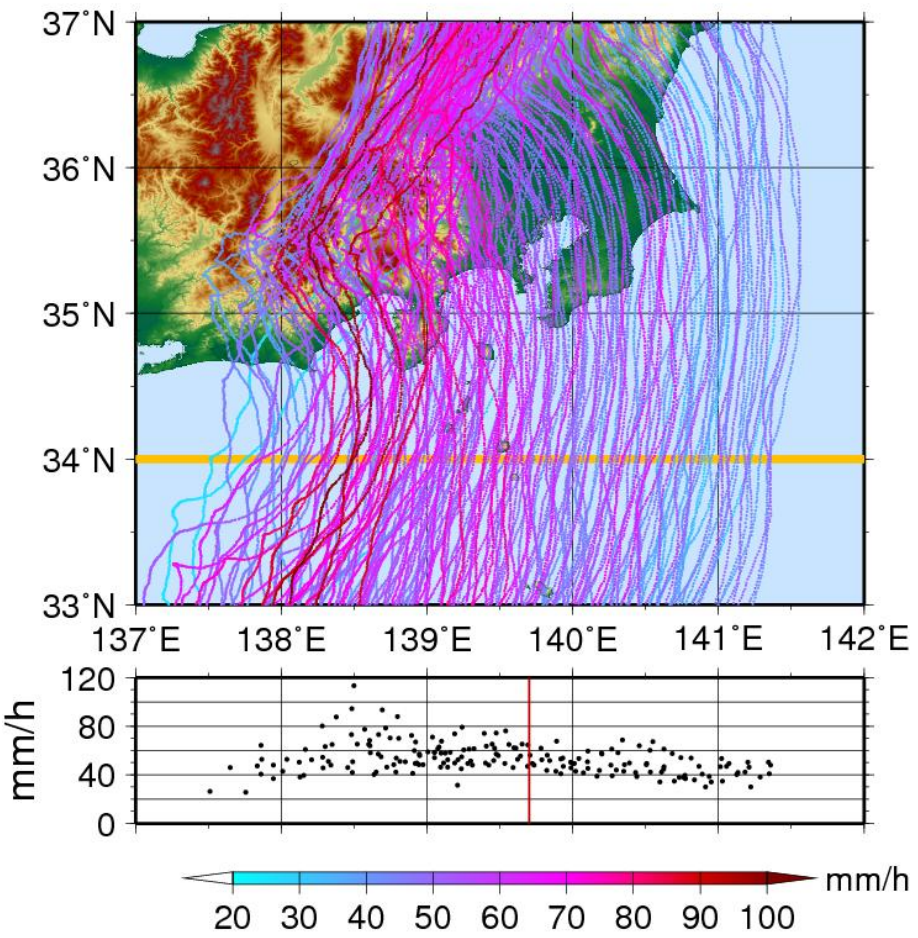
Thought experiment

How met disasters will change if the track changes?



Track ensemble for searching worst case

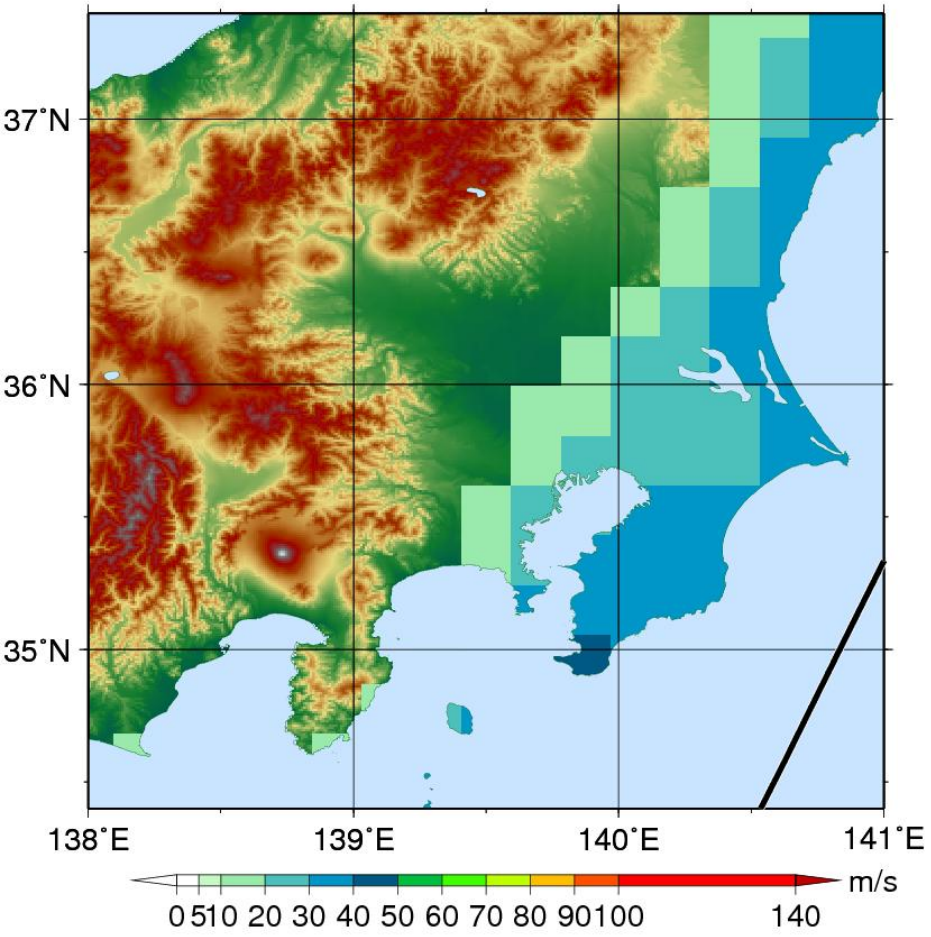




Generate ensemble information by sensitivity simulations controlling the tracks of typhoons.

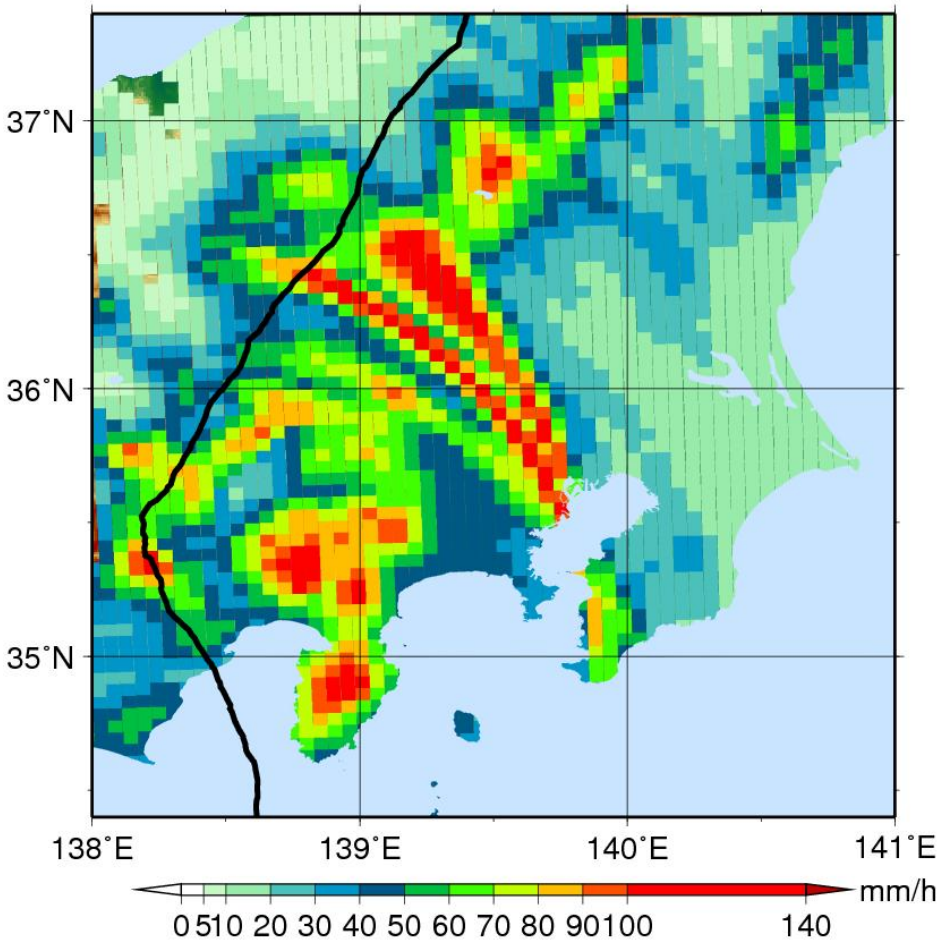
Worst scenario at local-scale

Global model (GCM)



Distribution of maximum hourly rainfall due to strongest TC simulated in GCM.

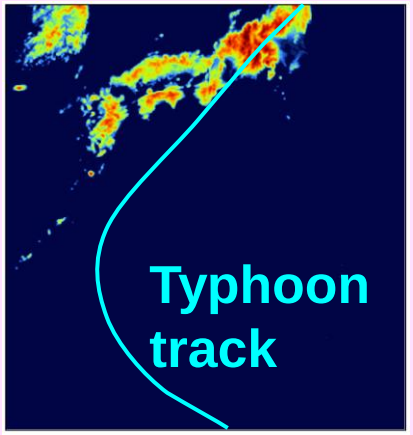
Downscaling regional model



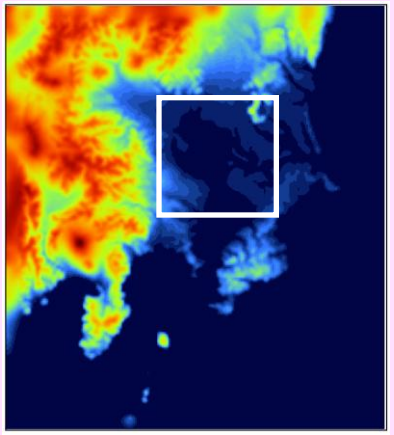
Distribution of maximum hourly rainfall due to TC whose track is the worst case in Tokyo.

Further downscaling by NWP/CFD models

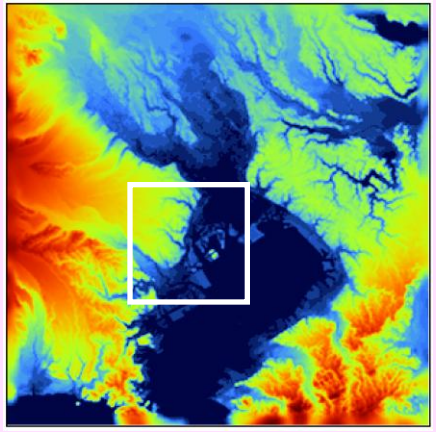
WRF domain



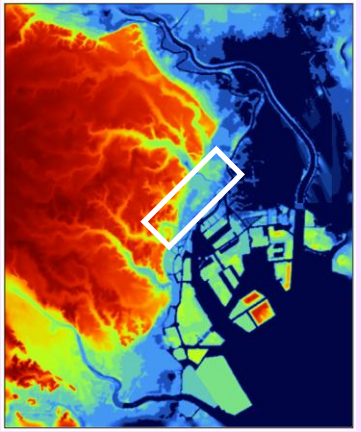
Domain1
1800 x 1900 km
dx = 4.5 km



Domain 2
270 x 300km
dx = 1.5km



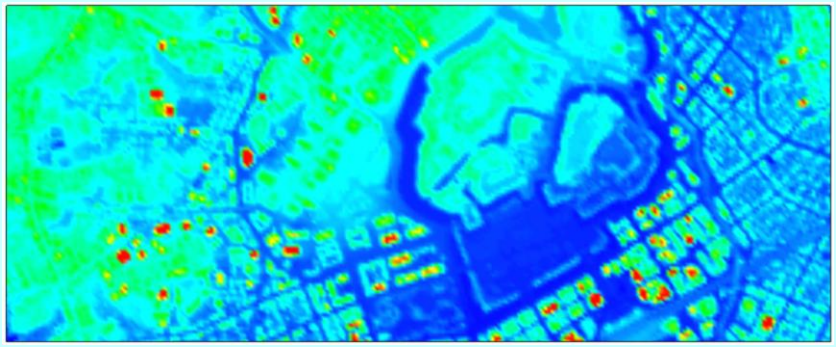
Domain 3
93 x 93 km
dx = 300m



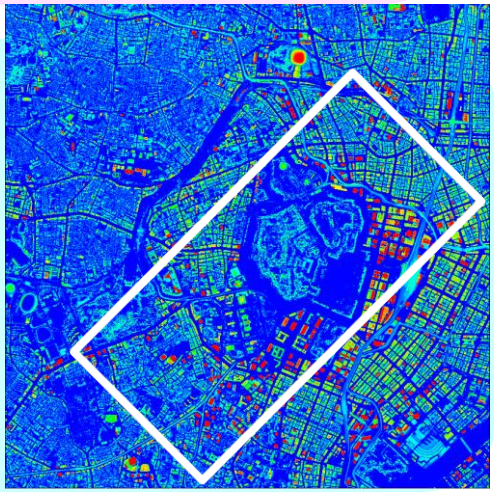
Domain 4
25 x 30 km
dx = 60 m

CFD domain

SW → NE



Domain 5
Area: 5 x 2km
dx=20m



Summary

- The intensity of typhoons increases in a projected future under global warming.
- Downscaling simulations with NWP model provide value-added information by better representing meteorological phenomena as well as topography at a high-resolution.
- Due to the limitation of the number of GCM simulations under GW, generating ensemble information by controlling tracks is an alternative approach to obtain probabilistic information for searching the worst scenario.
- Challenge: assessment of meteorological disaster from possible worst scenario; how to add probabilistic information to extreme phenomena