



ULSAN NATIONAL INSTITUTE OF
SCIENCE AND TECHNOLOGY

Impact of horizontal resolution on the tropical cyclone activity over the western North Pacific in CORDEX-East Asia phase I and II experiments

Ulsan National Institute of Science and Technology (UNIST)

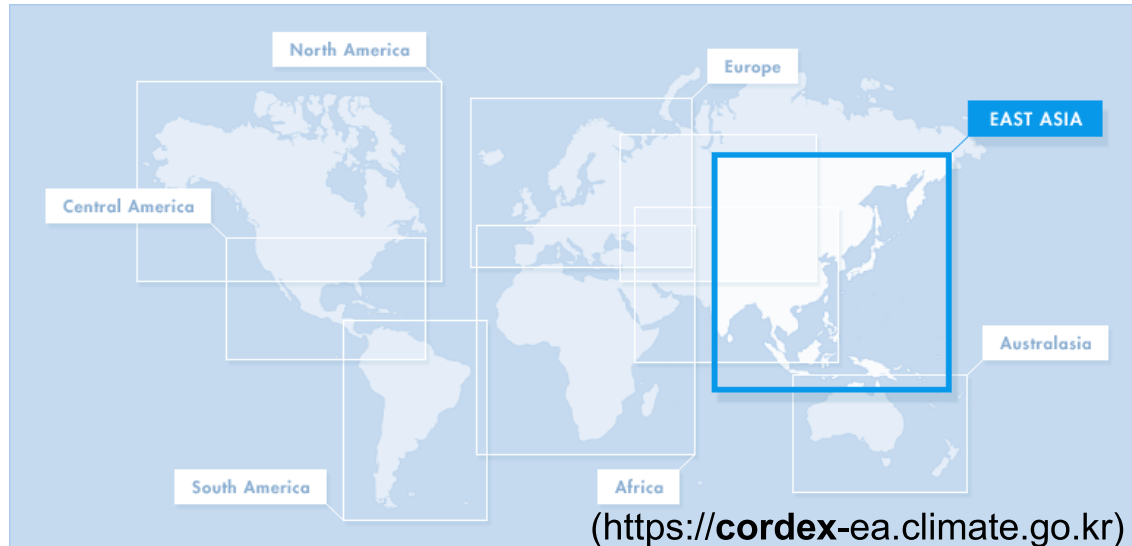
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2020.05.04

Introduction

- CORDEX (Coordinated Regional Downscaling Experiment)**



- The World Climate Research Programme (WCRP) established in 2009 the Task Force for Regional Climate Downscaling (TFRCD), which created the CORDEX initiative to generate regional climate change projections for all terrestrial regions of the global within the timeline of the Fifth Assessment Report (AR5) and beyond.
- The major aims of the CORDEX initiative are to provide a coordinated model evaluation framework, a climate projection framework, and an interface to the applicants of the climate simulations in climate change impact, adaptation, and mitigation studies.
- CORDEX-East Asia is the East-Asian branch of the CORDEX initiative and will produce ensemble climate simulations based on multiple dynamical and statistical downscaling models forced by multiple global climate models.

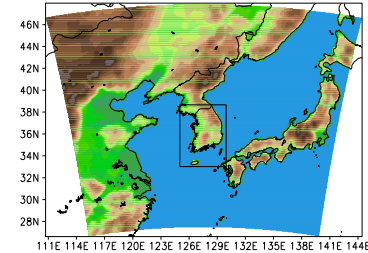
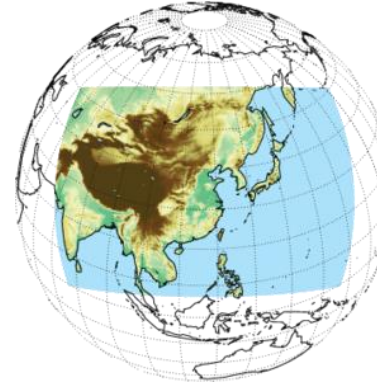
Introduction

Regional climate downscaling projects in Korea

2010-2011: CORDEX Phase I (EAS-44)

2012-2014: 12.5km Korea (KOR-11)

2015-2017: CORDEX Phase II (EAS-22)



2018-2020: New Project for CORDEX (3 million US\$ for 3yr)

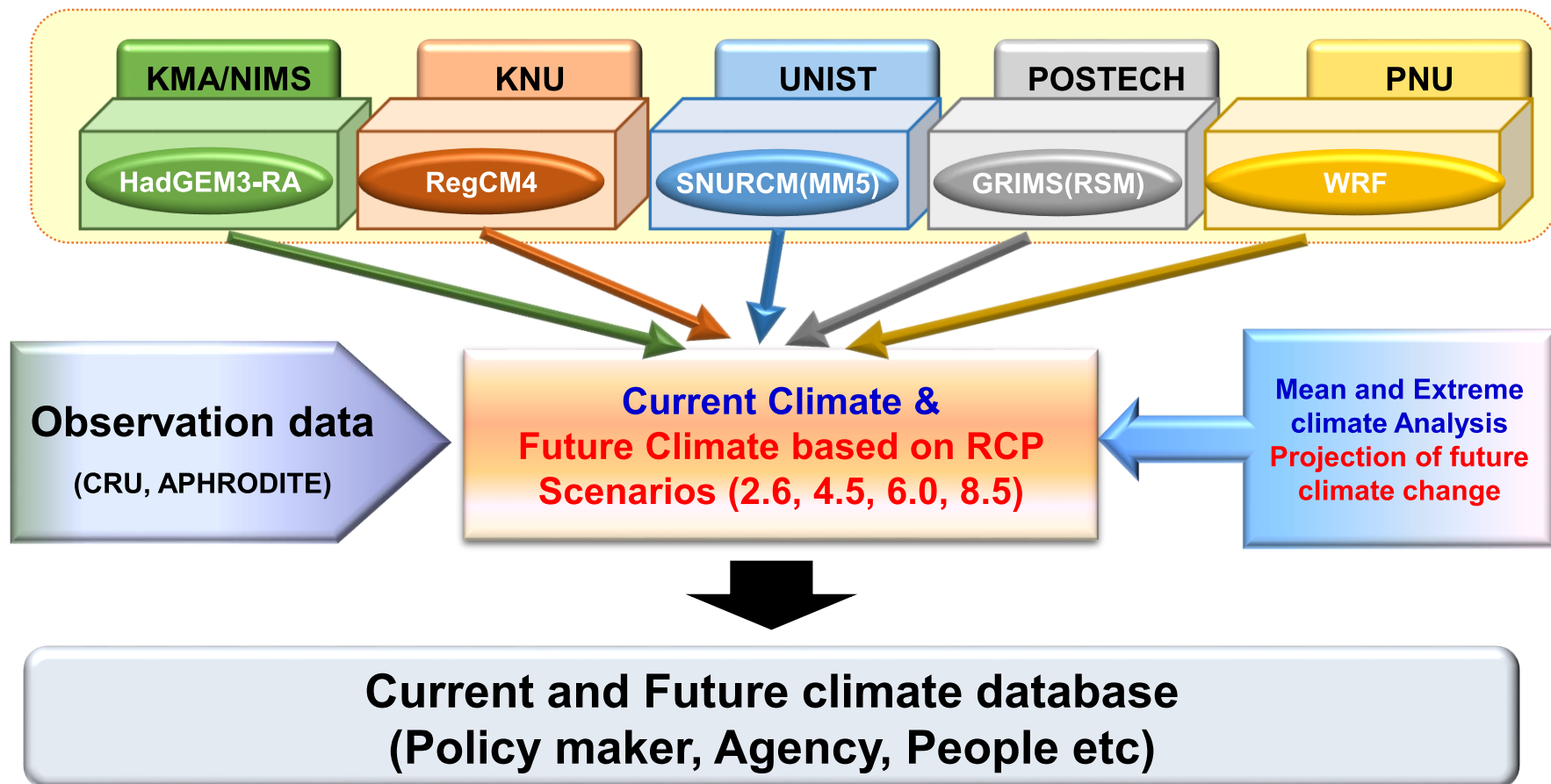
CORDEX EA
CORE
Experiments

CORDEX
FPS
Experiments
(CPM &
LULC)

Development
of Coupled
RCM

Introduction

Dynamical downscaling for CORDEX CORE

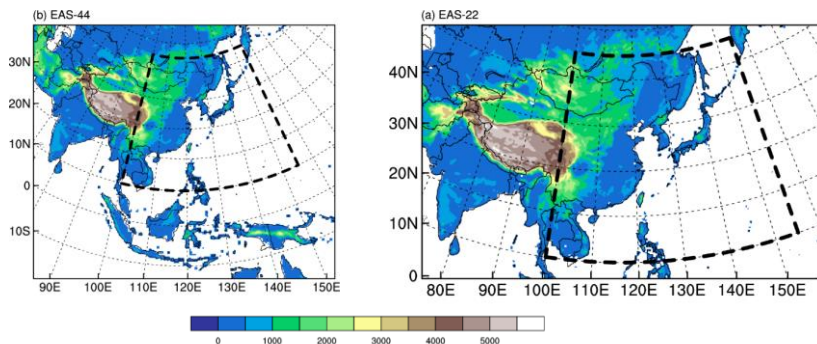


Data and methods

- Model configurations

	RegCM4		MM5	
	EAS-22	EAS-44	EAS-22	EAS-44
Dynamics framework	Hydrostatic		Non-hydrostatic	
Map projection	Lambert conformal			
Horizontal resolution and dimensions	25km (396 × 251)	50km (241 × 195)	25km (405 × 260)	50km (232 × 196)
Vertical level	23	18	24	24
convection	Emanuel (1991)		Kain (2004)	
Microphysics	Pal et al. (2000)		Reisner et al. (1998)	
PBL	Holtslag et al. (1990)		Hong et al. (2006)	
Reference	Giorgi et al. (2012)		Lee et al. (2004)	
Initial and boundary condition	ERA-Interim reanalysis			
Analysis period	1989–2008 (20 years), June to November (JJASON)			

- Domain



- TC detection

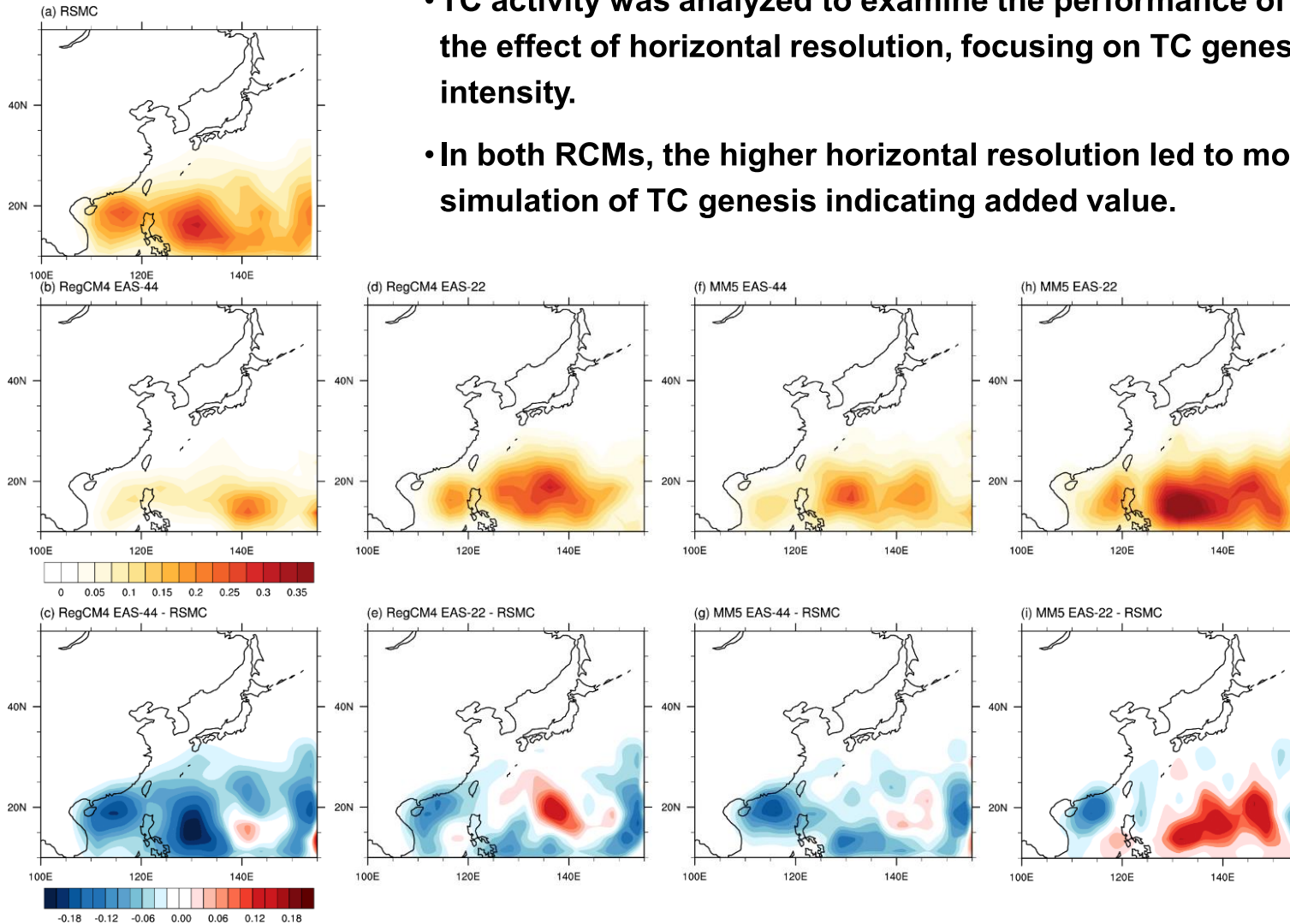
- 1) Local minimum sea level pressure
- 2) Maximum relative vorticity at 850hPa $> 10^{-5} \text{ s}^{-1}$
- 3) Maximum wind speed $> 17 \text{ m s}^{-1}$
- 4) Warm core criterion: $T_{sum} = \Delta T_{200} + \Delta T_{500} + \Delta T_{850} \geq 2 \text{ K}$
- 5) Maximum wind speed at 850hPa $>$ that at 300hPa
- 6) Duration of all above conditions > 2 days

Results

- Genesis density

- TC activity was analyzed to examine the performance of each model and the effect of horizontal resolution, focusing on TC genesis, tracks, and intensity.

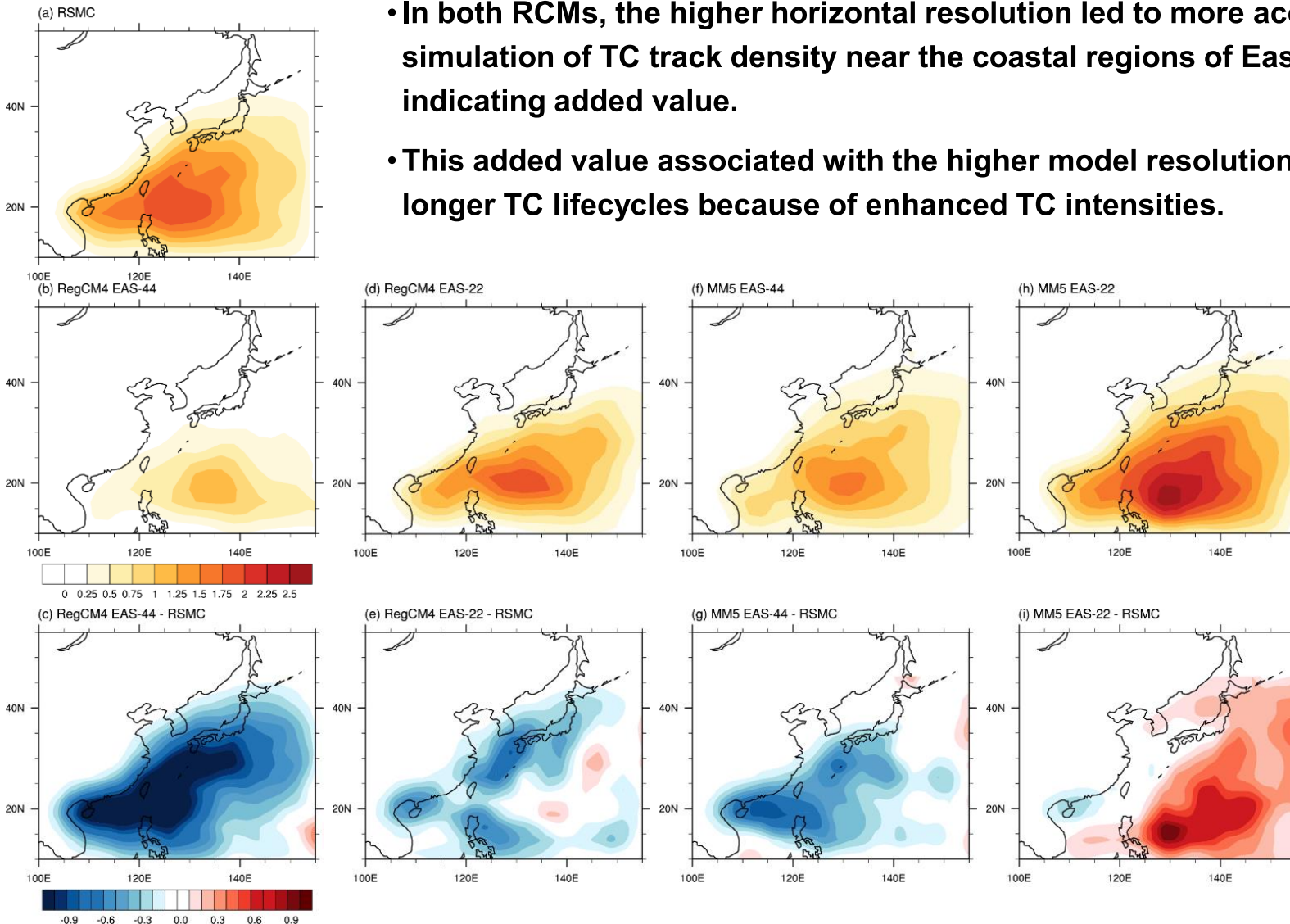
- In both RCMs, the higher horizontal resolution led to more accurate simulation of TC genesis indicating added value.



Results

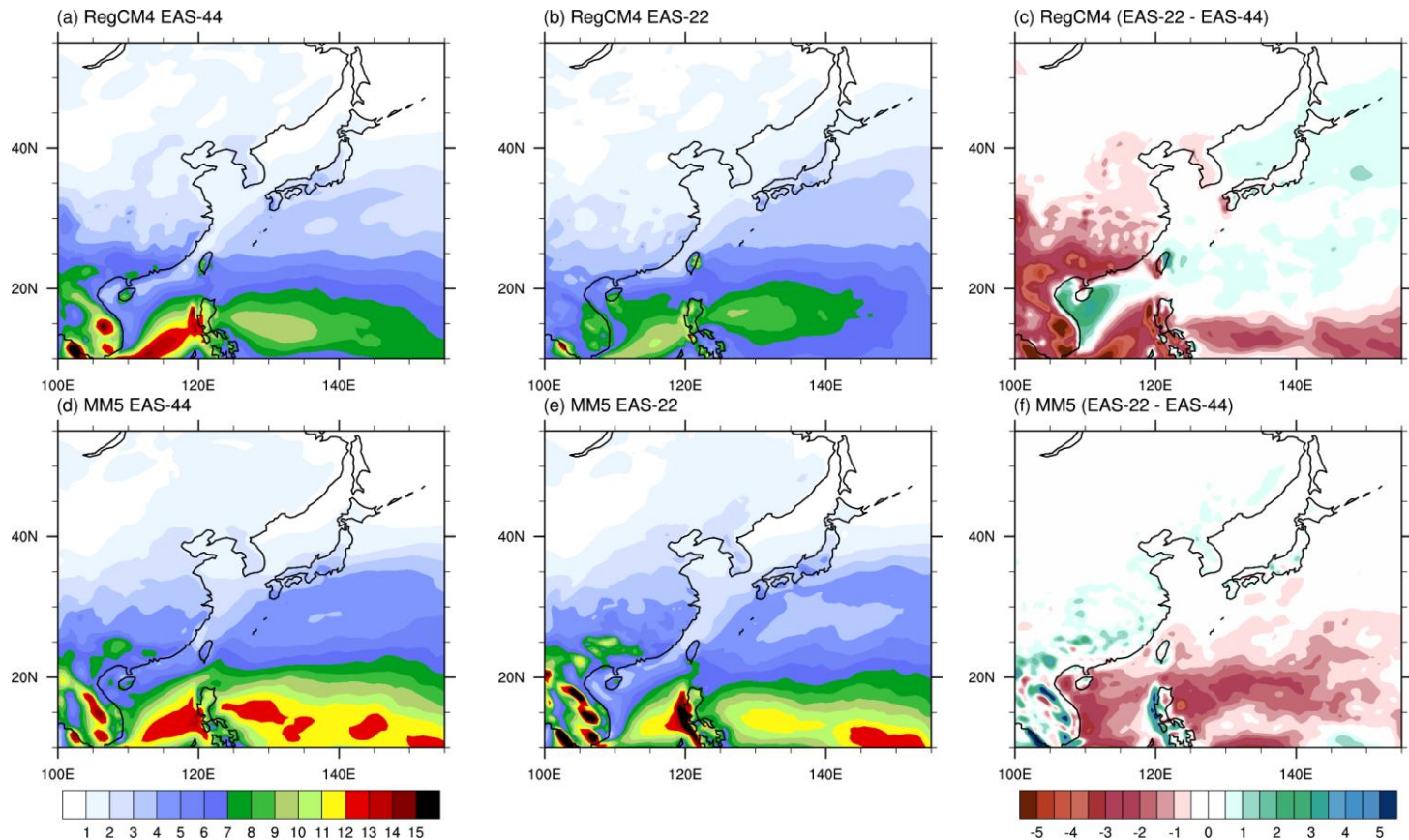
- Track density

- In both RCMs, the higher horizontal resolution led to more accurate simulation of TC track density near the coastal regions of East Asia, indicating added value.
- This added value associated with the higher model resolution resulted in longer TC lifecycles because of enhanced TC intensities.



Results

- Convective precipitation

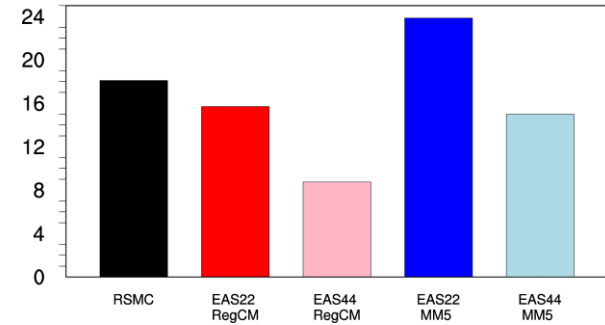


- The role of cumulus parameterization stabilizing the atmosphere decreases and relevant convective precipitation is reduced as the role of cloud microphysics increases.
- Less convective precipitation around the core regions of TC genesis in the higher-resolution experiments indicates the reduced role of the convection scheme.

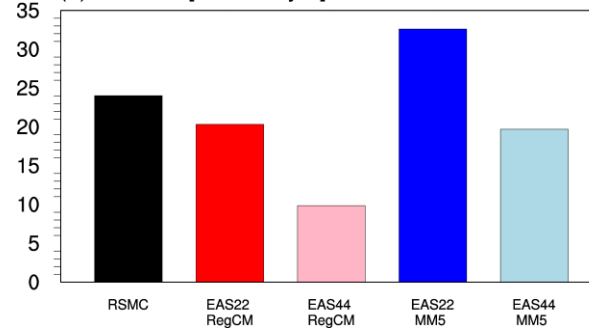
Results

- NTC, Duration, mean MWS, PDI, and Mean LMI

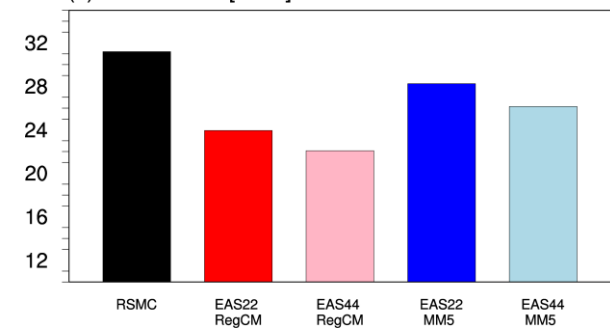
(a) NTC [yr^{-1}]



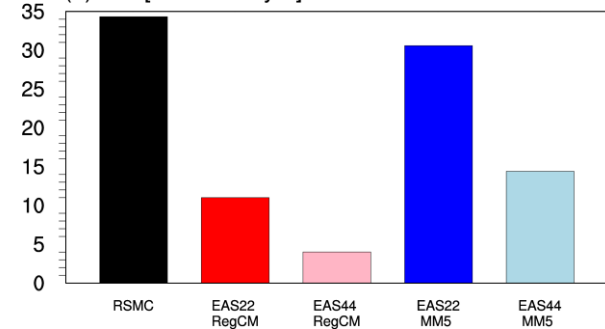
(b) Duration [$10^2 \text{ hour yr}^{-1}$]



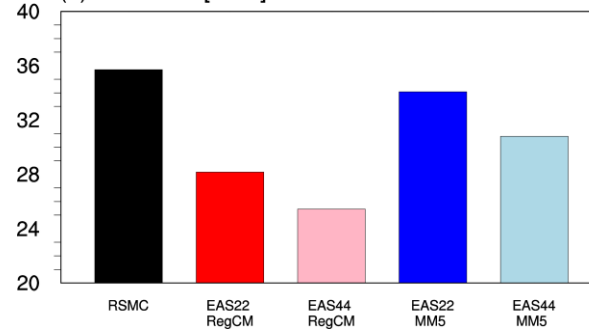
(c) Mean MWS [m s^{-1}]



(d) PDI [$10^{10} \text{ m}^3 \text{ s}^{-2} \text{ yr}^{-1}$]



(e) Mean LMI [m s^{-1}]

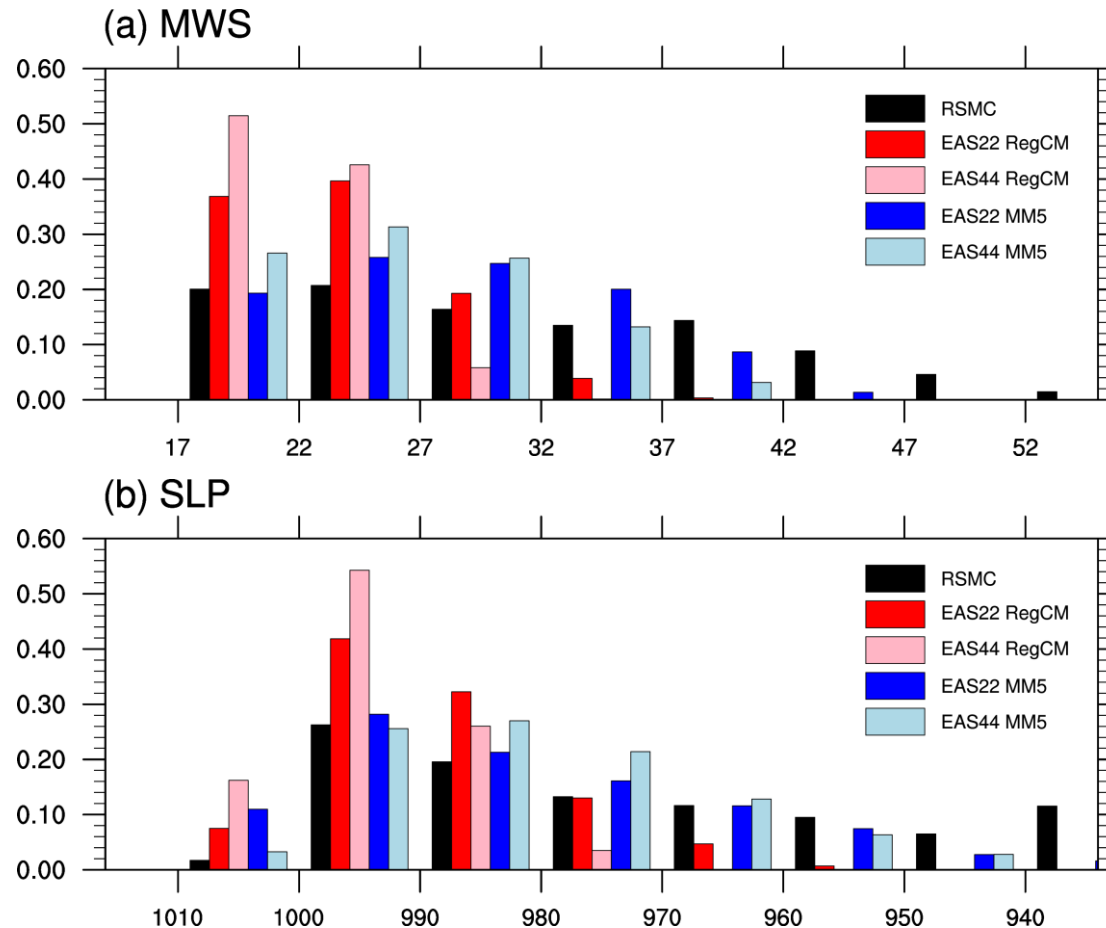


- NTC : Number of TCs
- MWS : Maximum wind speed
- PDI : Power dissipation index
- LMI : Lifetime maximum intensity

- The modeling of the frequency and duration of TCs could be improved by the RegCM4 with higher resolution, whereas those tended to be overestimated (underestimated) by the MM5 with higher (lower) resolution.
- However, both models more realistically simulated MWS, PDI, and LMI in relation to TC intensity with increased horizontal resolution.

Results

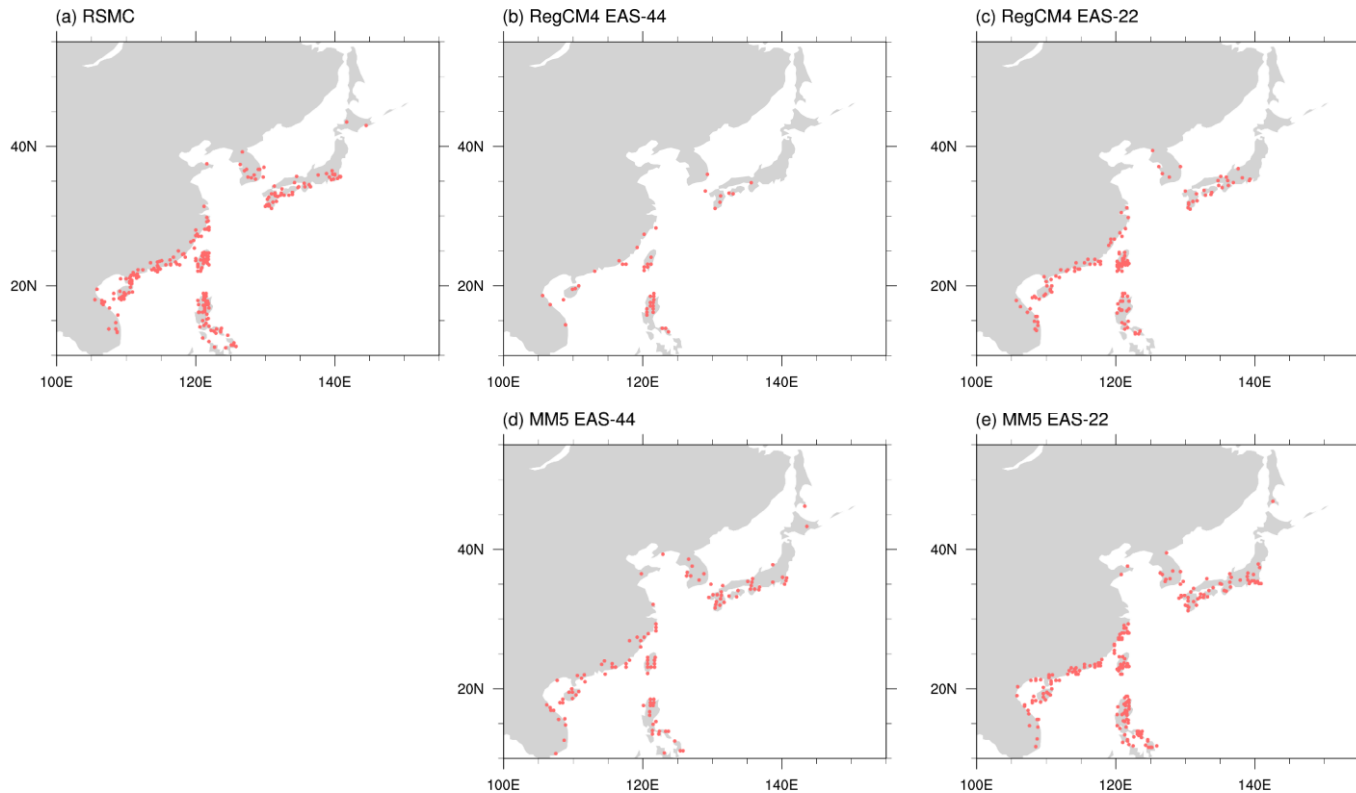
- Distribution of the maximum wind speed and minimum sea level pressure



- In both RegCM4 experiments, more than 80 percent of PDF distributions were concentrated above 980 hPa. In contrast, the MM5 produced a PDF distribution of sea level pressure comparable with that of the best track data.

Results

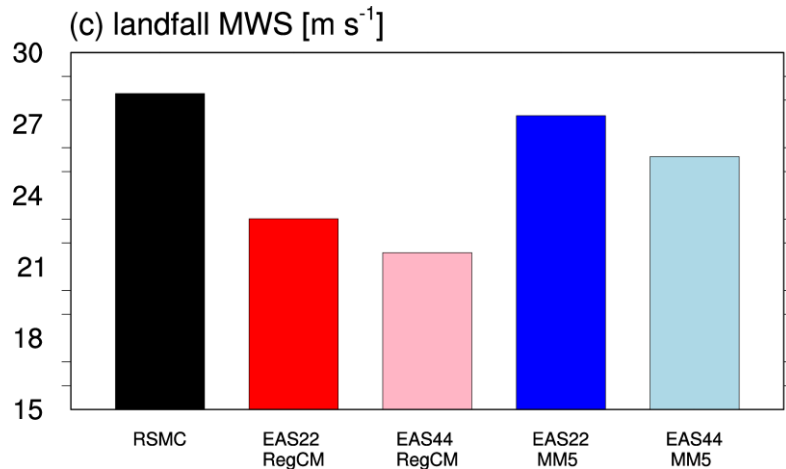
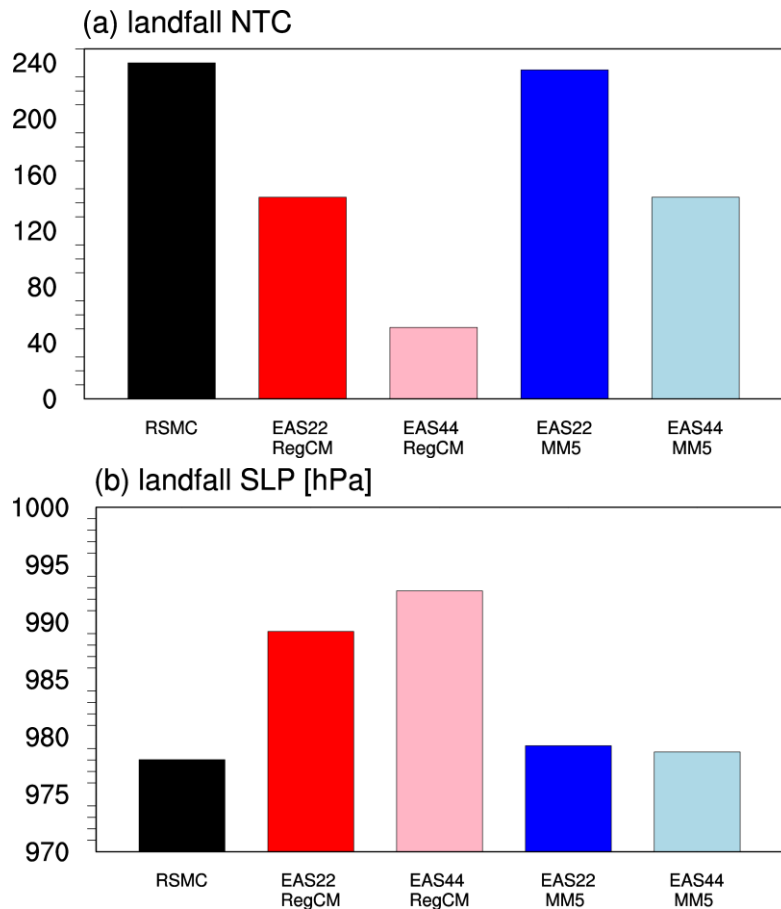
- **First-landfall points of TCs**



- Compared with the RegCM4, the MM5 realistically simulated many more TC landfalls. In particular, the MM5_EAS22 showed the best performance in terms of landfalling TCs, with results comparable with the best track data.
- both of the RCMs could improve the simulation of landfalling TCs in East Asian countries with increased horizontal resolution.

Results

- Landfall NTC, MWS, SLP

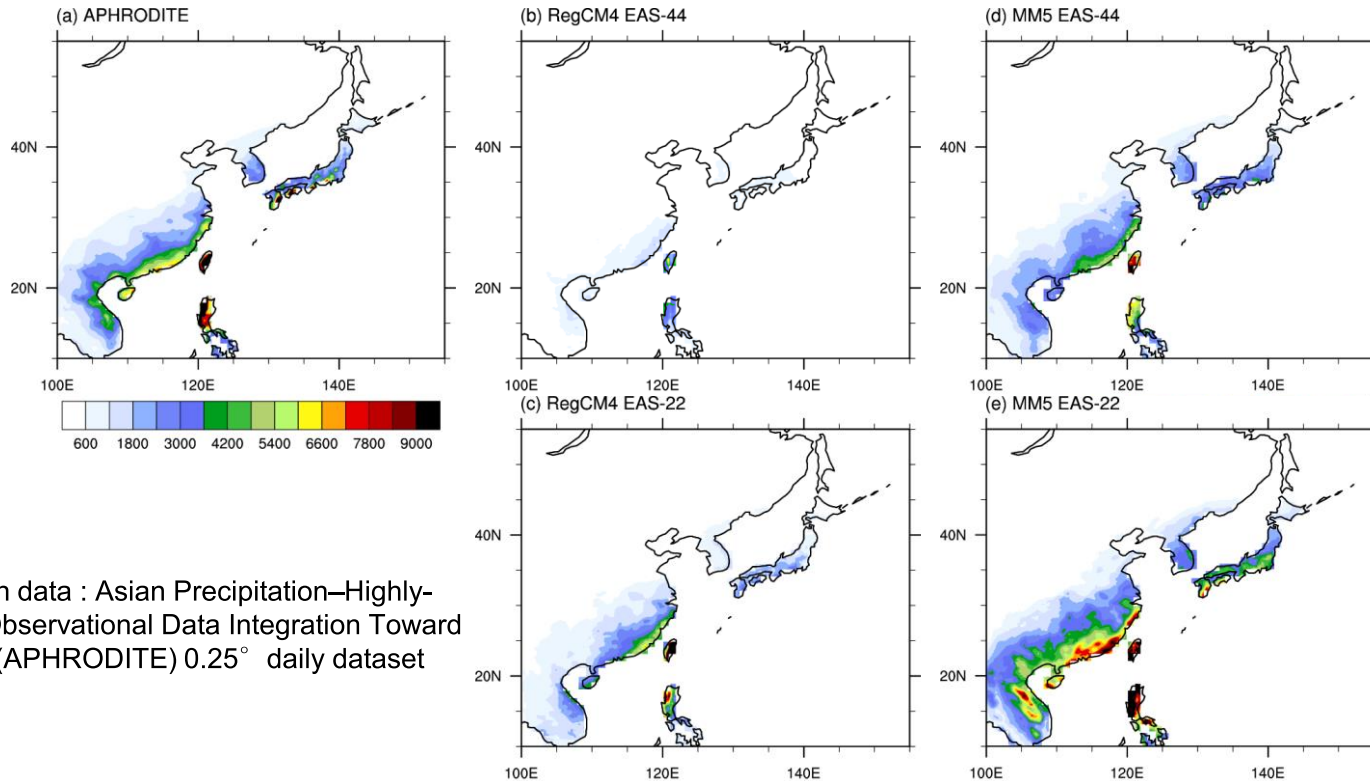


- NTC : Number of TCs
- MWS : Maximum wind speed
- SLP : Sea-level pressure

- it was apparent that the frequency and intensity of TCs landfalling in East Asia were better simulated by the MM5 than the RegCM4, and that increased model resolution led to improved simulation of these characteristics.

Results

- TC-induced accumulated precipitation (mm)

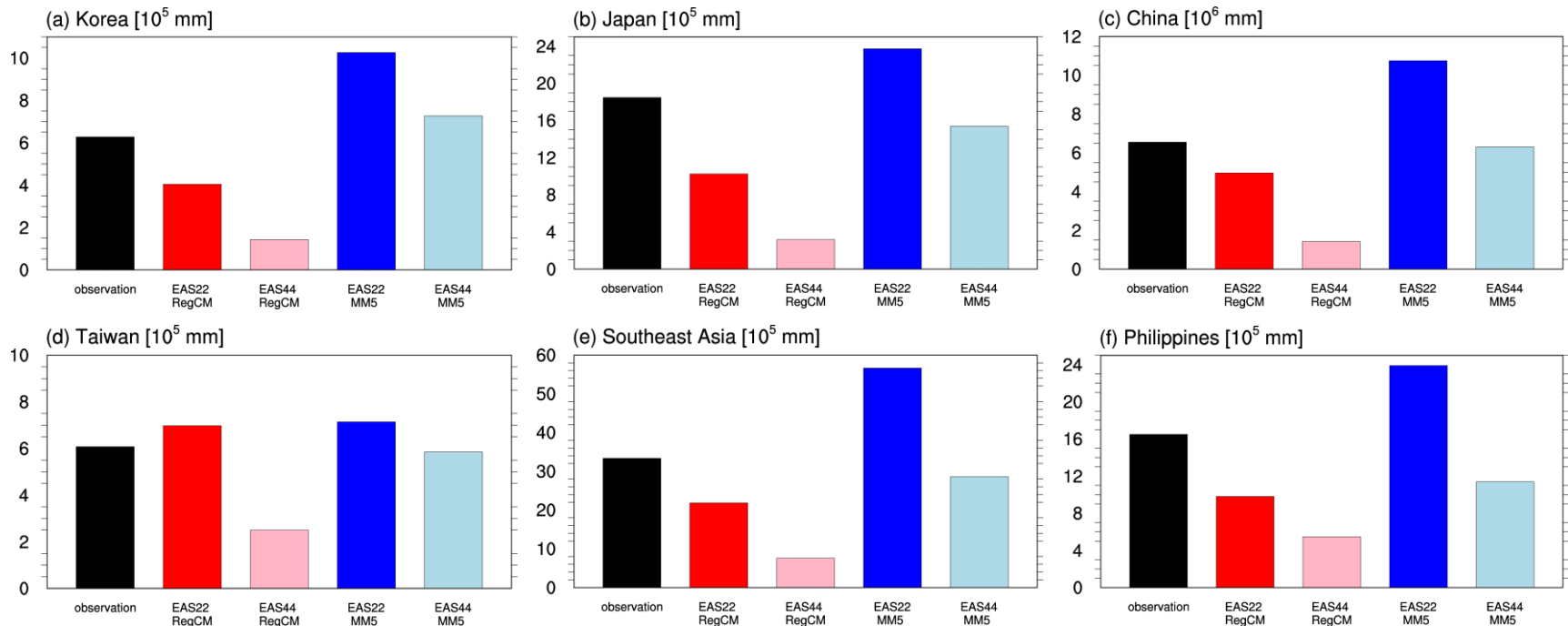


- Precipitation data : Asian Precipitation–Highly-Resolved Observational Data Integration Toward Evaluation (APHRODITE) 0.25° daily dataset

- In the RegCM4_EAS22, with the higher model resolution, TC-induced precipitation was relatively improved in the coastal regions, but it was still somewhat underestimated compared with observations.
- the MM5_EAS44 had results similar to observations to some extent, but TC-induced precipitation over the subtropics was overestimated in the case of the MM5_EAS22.

Results

- TC-induced accumulated precipitation only inland in the each country



- In particular, the increased TC-induced precipitation in the experiments with higher resolution may be more affected by the increased frequency of TC landfalls rather than enhanced intensity, because the sensitivity of frequency to horizontal resolution was prominently larger than that of TC intensity

Summary

- This study evaluated tropical cyclone (TC) activity simulated by two regional climate models (RCMs) incorporated in the Coordinated Regional Climate Downscaling Experiment (CORDEX) framework with two different horizontal resolutions.
- Evaluation experiments with two RCMs (RegCM4 and MM5) forced by reanalysis data were conducted over the CORDEX-East Asia domain for phase I and II. Main difference of phase I and II is horizontal resolution (25 and 50 km).
- The 20-year (1989–2008) mean performances of the experiments were investigated in terms of TC genesis, track, intensity, and TC-induced precipitation.
- For both models, higher horizontal resolution improved the simulation of TC tracks near the coastal regions of East Asia, whereas the coarse horizontal resolution led to underestimated TC genesis compared with the best track data because of greater convective precipitation and enhanced atmospheric stabilization.
- In addition, the increased horizontal resolution prominently improved the simulation of TCs landfalling in East Asia and associated precipitation around coastal regions.
- This finding implies that high-resolution RCMs can produce added value in improving from the finer-resolution simulation of TCs over the WNP; thus, they have an advantage in climate change assessment studies.



Thank you