A yearlong tropical cyclone simulation with a high-resolution tropical channel regional climate model

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1. Introduction

To help predict changes in tropical cyclone (TC) activity due to global warming, we evaluated the TC applicability of a tropical channel regional climate model (WRF-ARW) to present climate.

2. Model Descriptions and Setup

A yearlong simulation was conducted for 2004. Forcing data are obtained from the ECMWF ERA-Interim (T106). The boundary conditions were updated every 6 h, and the continuous integration method was executed during the prediction period.

Table 1. Model description and calculation environments.

WRF Version	WPSV3.1.1, WRFV3.1.1
Horizontal grids	CaseA-55(361×111), CaseA-60(361×121),
	CaseB-60 and CaseC-60(1801×601)
Vertical sigma levels	35 layer (model top = 50hPa)
Time step	CaseA-55 and CaseA-60(t = 240s), CaseB-60 and CaseC-60(t = 60s)
Initial and Boundary conditions	ECMWF ERA-Interim Analysis T106(atmosphere) , N80 (surface, sst)
Cumulus parameterization scheme	Kain-Fritsch
Microphysics scheme	Morrison 2-Moment
Planetary Boundary Layer scheme	YSU
Land-Surface Model	Noah-LSM
Long Radiation scheme	RRTM
Short Radiation scheme	Dudhia

Table 2. Calculation conditions

	Horizontal Resolution	Meridional Range	Period
CaseA-55	100 km	55° S – 55° N	JAN 2004-DEC 2004
CaseA-60	100 km	60° S – 60° N	JAN 2004-DEC 2004
CaseB-60	20 km	60° S – 60° N	JAN 2004-DEC 2004
CaseC-60	20 km	60° S – 60° N	OCT 2003-DEC 2004

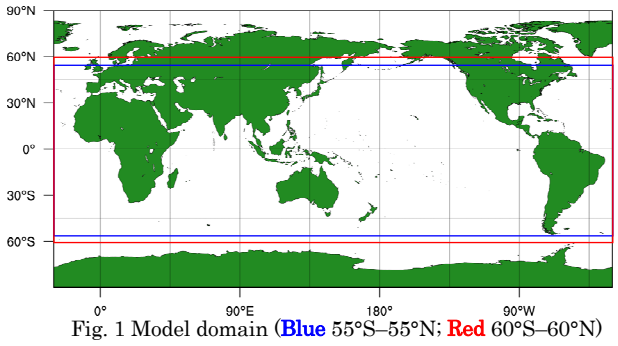


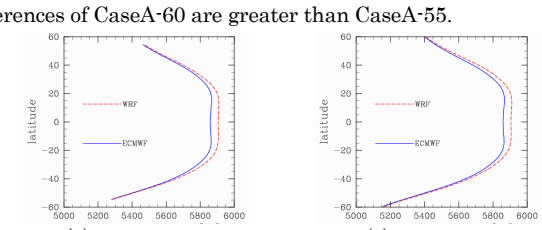
Fig. 1 Model domain (**Blue** 55°S–55°N; **Red** 60°S–60°N)

3. Model characteristics

3.1 Meridional span of domain

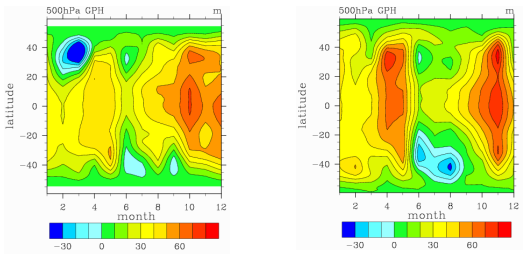
In this section, the effect of the meridional span of the domain on reproducibility of the model is evaluated.

Fig. 2 shows that CaseA-55 and CaseA-60 exhibit almost the same distribution in the meridional direction. And, CaseA-55 has the trend that the influence of the maximum value remains in the domain compared with CaseA-60, although the maximum differences of CaseA-60 are greater than CaseA-55.



(a) CaseA-55 (b) CaseA-60

Fig. 2 One-year zonal mean geopotential height at 500 hPa in 2004.



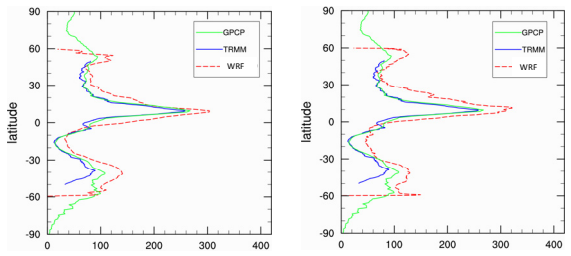
(a) CaseA-55 (b) CaseA-60

Fig. 3 Time series of the difference in monthly zonal mean geopotential height at 500 hPa from ECMWF data (January 2004–December 2004).

3.2 Precipitation

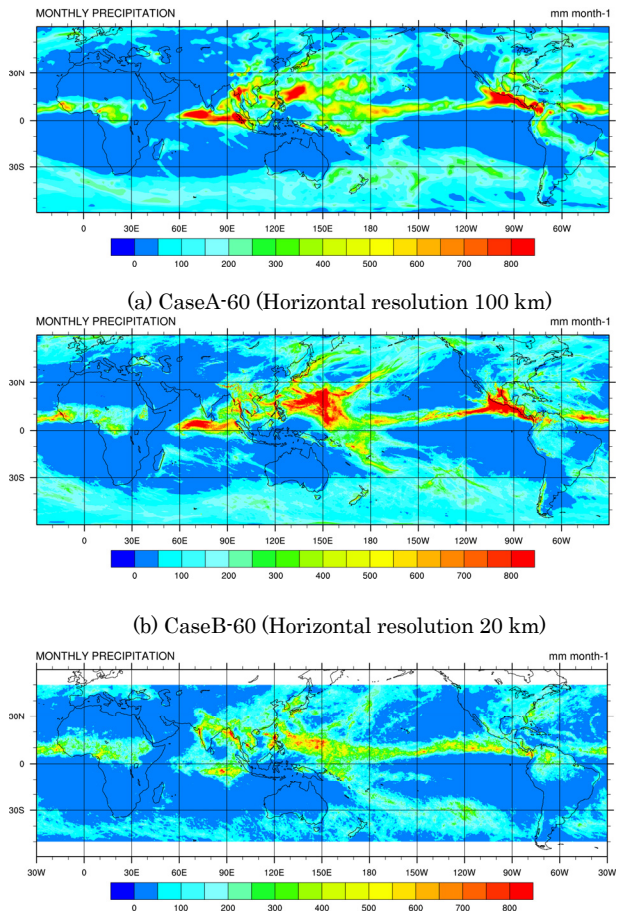
The reproductions of precipitation by the model with different horizontal resolution are compared with observations.

Fig. 4 shows that CaseA-60 and CaseB-60 exhibit almost the same precipitation distribution. And, Fig. 5 shows that CaseB-60 (high resolution 20km) is able to capture the precipitation distribution in more detail than CaseA-60 (coarse resolution 100km).



(a) CaseA-60 (b) CaseB-60

Fig. 4 Zonal mean precipitation in August 2004.

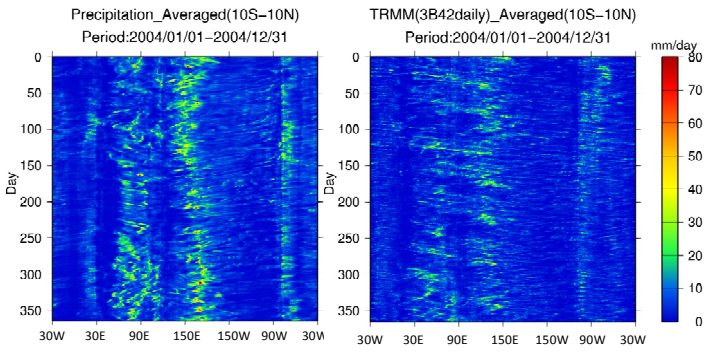


(a) CaseA-60 (Horizontal resolution 100 km)

(b) CaseB-60 (Horizontal resolution 20 km)

(c) TRMM (3B43) (Horizontal resolution 0.25°)

Fig. 5 Monthly precipitation in August 2004.



(a) CaseC-60 (b) TRMM

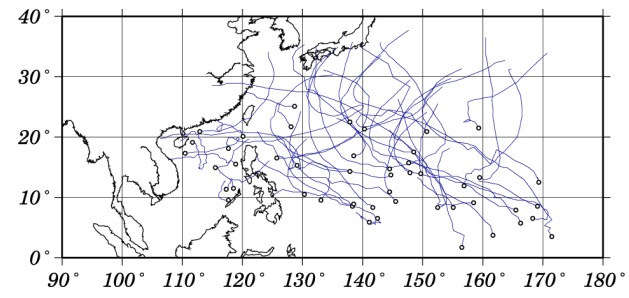
Fig. 6 Time series of daily precipitation averaged in the meridional direction between 10°S and 10°N from January 1 2004 to December 31 2004.

4. TC activity

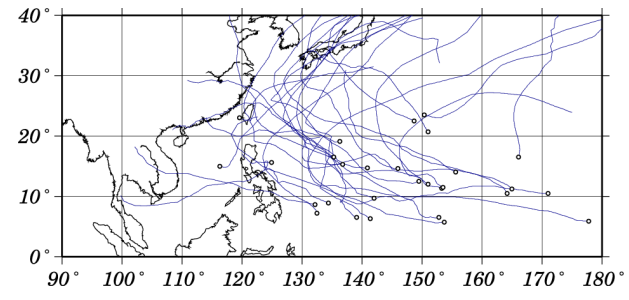
To evaluate TC activity over the northwestern Pacific Ocean using the model, we used a TC tracking method based on Suzuki [2012]. This method involves several steps or criteria.

Fig. 7 shows the model well predicted TC genesis areas and paths, although overestimated the frequency of TC genesis compared with JMA's RSMC Best Track Data (JMA Track).

Fig. 8 shows the number of typhoons generated in 2004. It is clear that many more TCs were generated by the model, particularly during January–March, than were apparent in the JMA data.



(a) CaseC-60



(b) JMA Track

Fig. 7 Storm tracks over the northwestern Pacific Ocean in 2004.
Black dots are track start points, and **blue** lines are tracks.

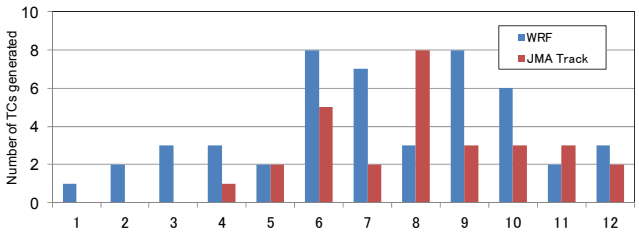


Fig. 8 Number of typhoons generated in 2004.

5. Summary

In this study, we evaluated the applicability of a tropical channel regional climate model to present climate to predict changes in tropical cyclone (TC) activity due to global warming.

To evaluate the TC activity predicted by the model, a yearlong simulation was conducted for 2004.

First, we compared the model precipitation profiles with satellite data (TRMM 3B43), and showed that the model predicted well the perturbation of precipitation over tropical regions.

Second, a TC tracking method was developed and applied to evaluate the TC activity predicted by the model over the northwestern Pacific Ocean. Our results showed that TC genesis areas and paths were predicted well, but the model overestimated the frequency of TC genesis compared with JMA's RSMC Best Track Data.

Reference:
Suzuki-Parker, A., An assessment of uncertainties and limitations in simulating tropical cyclone climatology and future changes, Springer Thesis Series, XIII (78), Springer, London, pp.91, 2012.