# Simulations of Present-day Tropical Cyclone Climatology and Their Temporal Variability Associated with ENSO with a 20km-mesh High-Resolution AGCM

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## 1. INTRODUCTION

Tropical cyclones (TCs) are among the most harmful weather phenomena. Recently, a number of studies have been conducted using global circulation models (GCMs) to explore the influence on TC activity of global warming. For example, Oouchi et al. (2006, JMSJ) evaluated TC changes in a warm-climate environment using a 20-km-mesh, high resolution Atmospheric GCM (AGCM). However, it is uncertain weather the GCM can reproduce the real TC climatology given the observational sea-surface temperature (SST) and sea-ice concentration (SIC).

The goal of this study is to evaluate the TC simulation of seasonal variability of genesis position, interannual variability, and trend with the AGCM. The AGCM performance of the dependence of TC activity on the El Niño-Southern Oscillation (ENSO) in the Western North Pacific (WNP) basin is also evaluated in terms of position of TC genesis and difference of accumulated cyclone energy (ACE).

## 2. MODEL AND EXPERIMENTAL DESIGN

### ·JMA/MRI 20km-mesh AGCM

| | 20 km mesh global climate model |
|---|---|
| Horizontal Grids | 1920x 960 |
| Vertical Layers | 60 |
| Truncation Wave | TL959 |
| Grid Spacing | 20km |
| Top Layer Pressure | 0.4hPa |
| Dynamical frame | Semi-Lagrangian scheme |
| Radiation Process | Shibata et al. (1999)<br>Solar (every hour)<br>Infrared (3 hourly) |
| Precipitation Process | Prognostic Arakawa-schubert<br>Large-scale condentation<br>Prognostic cloud water |
| Gravity wave drug | Iwasaki et al (1989) |
| Land surface | Simple Biosphere(SiB) model |
| PBL and surface fluxes | Mellor-Yamada level 2<br>Moni-Obukhov similarity |

### ·Integration Period

1979 ～2003 (25 years)

### ·Lower Boundary Condition

The Hadley Centre Sea-Ice and Sea-Surface Temperature data set version 1 (HadISST1) (Rayner et al., 2003)

### ·Observation Data

A global TC best-track data provided by Unisys Corporation Website (http://weather.unisys.com/hurricane/)

### ·Detection Method of Simulated Tropical Cyclones

The method of TC identification involves the six sets of criteria described in Oouchi et al.(2006). The criteria as follow,

1. The minimum surface pressure is at least 2 hPa lower than the surrounding 7 degree x 7 degree grid box.
2. The magnitude of the maximum relative vorticity at 850hPa exceeds 3.5 x 10**(-5) /s
3. The maximum wind speed at 850 hPa is larger than 15m/s,
4. The sum of the temperature deviations at 300, 500 and 700hPa exceeds 2 K for warm core.
5. The maximum wind speed at 850hPa is larger than that at 300 hPa in order to exclude extra-tropical cyclone
6. The duration is not shorter than 36 hours.

## 3. SAMPLE OF A SIMULATED TROPICAL CYCLONE

Observation AGCM

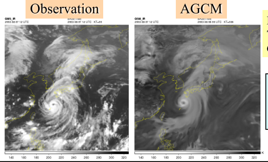


Fig. 1
The comparison of satellite infrared image by the GOES-9 and that by the AGCM simulation.

The tropical cyclone structure by the AGCM is very fine. The eye, eye wall, and cloud bands are very realistic.

## 4. SIMULATED TROPICL CYCLONE CLIMATOLOGY

### ·Tracks

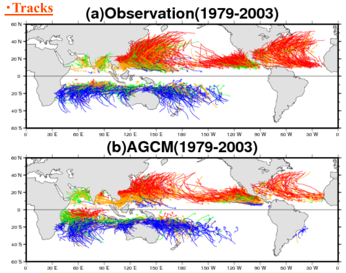
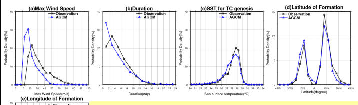



Fig. 2 TC genesis location and track.
Blue: JFM, Green: AMJ, Red: JAS, Orange: OND.

The AGCM captures very well observational features of the latitudinal and longitudinal distribution of genesis position and the seasonal variability for each basin.

### ·Intensity, duration, SST of formation



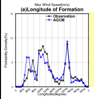




Fig. 3 Probability density of (a) maximum wind speed , (b) duration in which maximum wind velocity records more than 17m/s, (c) local sea surface temperature when TC formed, (d) and (e) latitude and longitude when TC formed.

The maximum wind speed and duration are underestimated. The local SST, when TCs are formed, id well simulated. As for location of TC genesis, the AGCM tends to generate too much TCs at the lower latitudes. The longitudinal distribution is different from the observation. This is caused by few TCs over Western North Pacific Ocean, and too much TCs over Indian Ocean basin.

## 5. INTERANNUAL VALIABILITY OF TC FORMATION

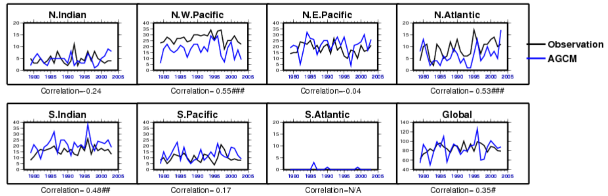



Fig. 4 Interannual variability of TC genesis for each basin. Correlation between observation and the AGCM is noted below the panels. The triple, double, and single sharp sign mean that the correlation is statistically significant at 99%, 95%, and 90% confidence level, respectively.

Although the interannual variability of TC formation is not highly correlated with observation for some of basins, the western North Pacific and the north Atlantic shows relatively highly correlated. The number of TC formation is not so much highly correlated with the local SST (figure not shown). This result indicates that the large scale forcing (e.g., relative vorticity, vertical shear of horizontal wind) was simulated well with the AGCM.

## 6. ENSO INFLUENCE ON TROPICAL CYCLONE ACTIVITY OVER WESTERN NORTH PACIFIC

### ·Genesis position difference between El Niño and La Niña years

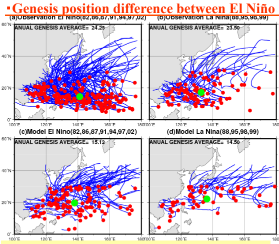



Fig. 5 TC genesis positions and tracks for each (a) observation in El Niño, (b) observation in La Niña, (c) AGCM in EL Niño, and (d) AGCM in La Niña.
Red plots show genesis positions. Blue lines show tracks. Green plots show average genesis positions.

The observation data reveal that genesis positions during the El Niño years shift southeastward, while those during the La Niña years shift northwestward, as reported by Wang and Chan (2002, J.Climate).
The AGCM reveals a subtle southeastward shift during the El Niño years though there are fewer TCs around the lower latitude and eastern area (e.g., around 140-175E, 5-15N)

**El Niño years: 1982, 1986, 1987, 1991, 1994, 1997, and 2002.**

**La Niña years: 1988, 1995, 1998, and 1999.**

### ·ACE difference between El Niño and La Niña years

Accumulated Cyclone Energy (ACE) is the sum of the squares of the estimeated 6-hourly maximum sustained surface wind velocity defined as follows, $ACE = \sum (V_{max})^2$ (When $|V_{max}| \geq 17m/s$) . When there are stronger and longer lived TCs, the ACE increases.

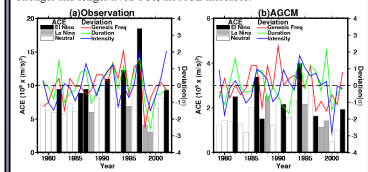



Fig. 6 Accumulated Cyclone Energy (ACE) per year between 1979-2003 for (a) observation and (b) the AGCM. Black, gray, and white bars shows El Niño, La Niña, and neutral years, respectively. The colored lines show the deviation of genesis frequency (red), duration in which maximum wind speed exceeds 17m/s(green), and averaged maximum wind speed (blue).

As Camargo and Sobel (2005,J.Climate) pointed out, the observed ACE values are larger in the El Niño years but smaller in the La Niña years (see fig 6(a)), which are related to the TC number, strength, and duration. Although the ACE itself underestimated compared with the observation, the AGCM shows the larger ACE in the El Niño years than in the other years.

## SUMMARY

We conducted a 25-year, present-day simulation with a 20-km-mesh AGCM using observational SST and SIC as lower boundary conditions in order to evaluate the model performance of interannual and seasonal variabilities of the genesis position and genesis frequency of TCs. We found the following features.

- The genesis position and its seasonal variability for each basin are quite realistic, though TCs over the western North Pacific basin are underestimated.
- The maximum wind speed and duration in which the maximum wind speed exceeds 17m/s are a little bit underestimated.
- The interannual variability of TC formation simulated by the AGCM are relatively highly correlated in the western North Pacific and the north Atlantic.
- The TC activity influenced by ENSO was investigated. Although the ACE value by the AGCM is underestimated compared with the observation, the general feature that the ACE increases in El Niño years is well simulated. The genesis position shift by the ENSO was also confirmed by the AGCM.