

# **Future Change of Western North Pacific Typhoons: Projections by a** 20-km-mesh Global Atmospheric model (J. Climate, In press) Hiroyuki Murakami (JAMSTEC/MRI), Bin Wang (University of Hawaii), and Akio Kitoh (MRI) himuraka@mri-jma.go.jp





#### 1. Motivation

IPCC-AR4 concluded in terms of future changes in tropical cyclones (TCs) that..... Genesis Frequency

Less confidence in projections of global decrease in the frequency.

It is likely that storm intensity will continue to increase.

#### **Key question:**

How do global warming affect TC tracks in the western North Pacific?

#### 2. Models and settings

Model

20-km mesh MRI/JMA Atmospheric Global Model

**Projection settings** 

resent day run (PD):

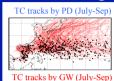
velocity at

500 hPa

1979-2003 (prescribed by the observed SST)

Global warming run (GW):

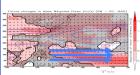
2075-2099 (prescribed by CMIP3 multi model ensemble mean SST (under A1B scenario)



TC tracks shift eastward in the WNP in the future

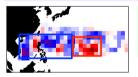
### 3.TC track changes 4. Why will the TC density change?

#### Steering flow (850-200hPa) changes



Steering flow changes (westerly flow anomaly) partly explain TC density changes by inhibiting westward TC motion.

#### TC genesis frequency changes



TC genesis location changes (eastward shift) nainly explain TC density changes.

Seasonal (July-October) mean TC genesis number decreased by 23% (from 25.0 to 19.3).

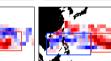
#### 5. Genesis Potential Index

To determine the factors behind such genesis changes, we used a Genesis Potential Index (GPI) by Emanuel and Nolan (2004) with some modifications.

 $GPI' = \left|10^{5} \eta\right|^{\frac{3}{2}} \left(\frac{RH}{50}\right)^{3} \left(\frac{V_{pt}}{70}\right)^{3} \left(1 + 0.1V_{s}\right)^{2} \left(\frac{-\omega + 0.1}{0.1}\right)^{\frac{1}{2}}$ 

Absolute Relative Maximum Vertical Wind Vertical Wind Vorticity Humidity Potential Shear (850- Velocity at 850hPa at 700hPa Intensity 200hPa) at 500hPa

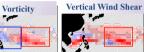
TC genesis changes GPI changes



GPI performs reasonably well in reflecting the changes in TC genesis density.

Each term contribution to the changes in GPI Relative humidity Potential Intensity





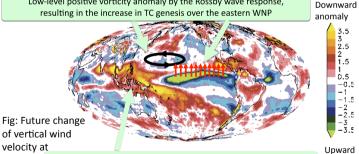
Dynamical changes have Vertical wind vel. great influences. Vorticity and vertical wind shear (vertical wind velocity and vorticity) contribute to the increase (decrease) in GPI in the

eastern (western) WNP.

## 6. Mechanisms of future changes in TC genesis in the western North Pacific

### Rossby wave response

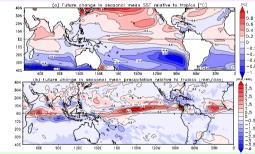
Low-level positive vorticity anomaly by the Rossby wave response,



**Future changes in overturning circulations** 

The weakening in the Walker circulation is responsible for the decrease in TC genesis over the western WNP

Relationship between changes in the prescribed SST (top) and precipitation rate (bottom)



Future change in precipitation rate relative to the global tropics (bottom) appears to be strongly related to the prescribed SST anomaly (top) relative to the global tropics, indicating that spatial distribution of tropical SST may be a key factor for TC activities.

### 7. Summary

- 1) The future (2075-99) projection indicates a significant reduction (by about 23%) in TC genesis number.
- 2) A significant **eastward shift in the TC tracks** during the peak TC season (July-October).
- 3) The changes in TC tracks are due in part to changes in large-scale steering flows, but they are due mainly to changes in the locations of TC genesis.
- 4) Analysis of the genesis potential index (GPI) reveals that the **reduced TC** genesis in the western WNP is due mainly to in situ weakening of largescale ascent.
- 5) Analysis of the GPI also indicates that enhanced TC genesis in the eastern WNP is due to increased low-level cyclonic vorticity and reduced vertical wind shear.
- 6) TC genesis changes appear to be critically dependent on the spatial pattern of future sea surface temperature; therefore, it is necessary to conduct ensemble projections with a range of SST spatial patterns to understand the degree and distribution of uncertainty in the future projections.