Climate sensitivity with uniformly increased SST

Ping-Gin Chiu, Chia-Ying Tu, and Huang-Hsiung Hsu
Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan

Abstract

In this study, the GFDL HiRAM model is used to examine the regional climate sensitivity to the increased global mean SST. Observed monthly HadISST with globally uniform 2°C increase is applied in the sensitivity experiment. Results indicate that the hydrologic cycle is strengthened as expected. Precipitation change in the Pacific exhibits strong regional dependence. Precipitation during the boreal summer strengthens in the ITCZ and SPCZ but significantly weakens in the tropical western North Pacific. The tropical upper troposphere is the warmest region due to strong moist convection. This response stabilizes the tropical and subtropical troposphere and has strong effect on tropical cyclone activity. Changes in the structure of large-scale circulation, tropical cyclone activity, and the related dynamical and thermodynamic mechanisms will be discussed.

Model Simulations and Tracking Method

- HiRAM C192 cube sphere model with 32 hybrid sigma level and about 1.875° resolution. (Zhao et al., 2009)
- The model data used here include monthly(average) and 6hr(instant) time resolution.
- Lower boundary is driven by HadISST and +2°C(p2d) experiment with 10 years simulation.
- RCP8.5 simulation is driven by CMIP5 ensemble SST combined by MRI with 26 years simulation.
- Tracking method is base on 6 hourly sea level pressure(closed contour), 850hPa vorticity, warm core and surface wind.

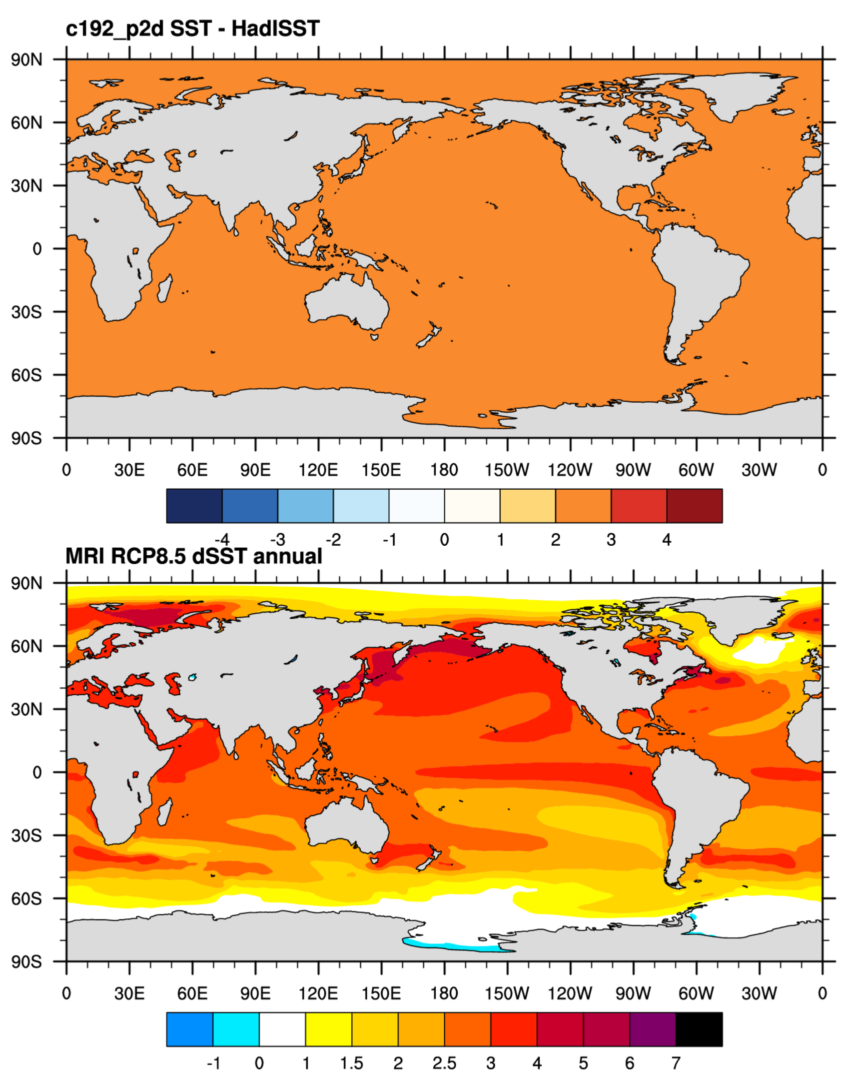

Figure 1: SST difference in (A) p2d (B) RCP8.5 experiment.

HiRAM Summer Environment Difference

- Uniform increased SST induce warmer climate. The land responds more than ocean forcing.
- North of Canada and East of Russia shows slightly cooling, and the temperature change is not significant in north Europe.
- Most warmer located mid-high level over tropical.

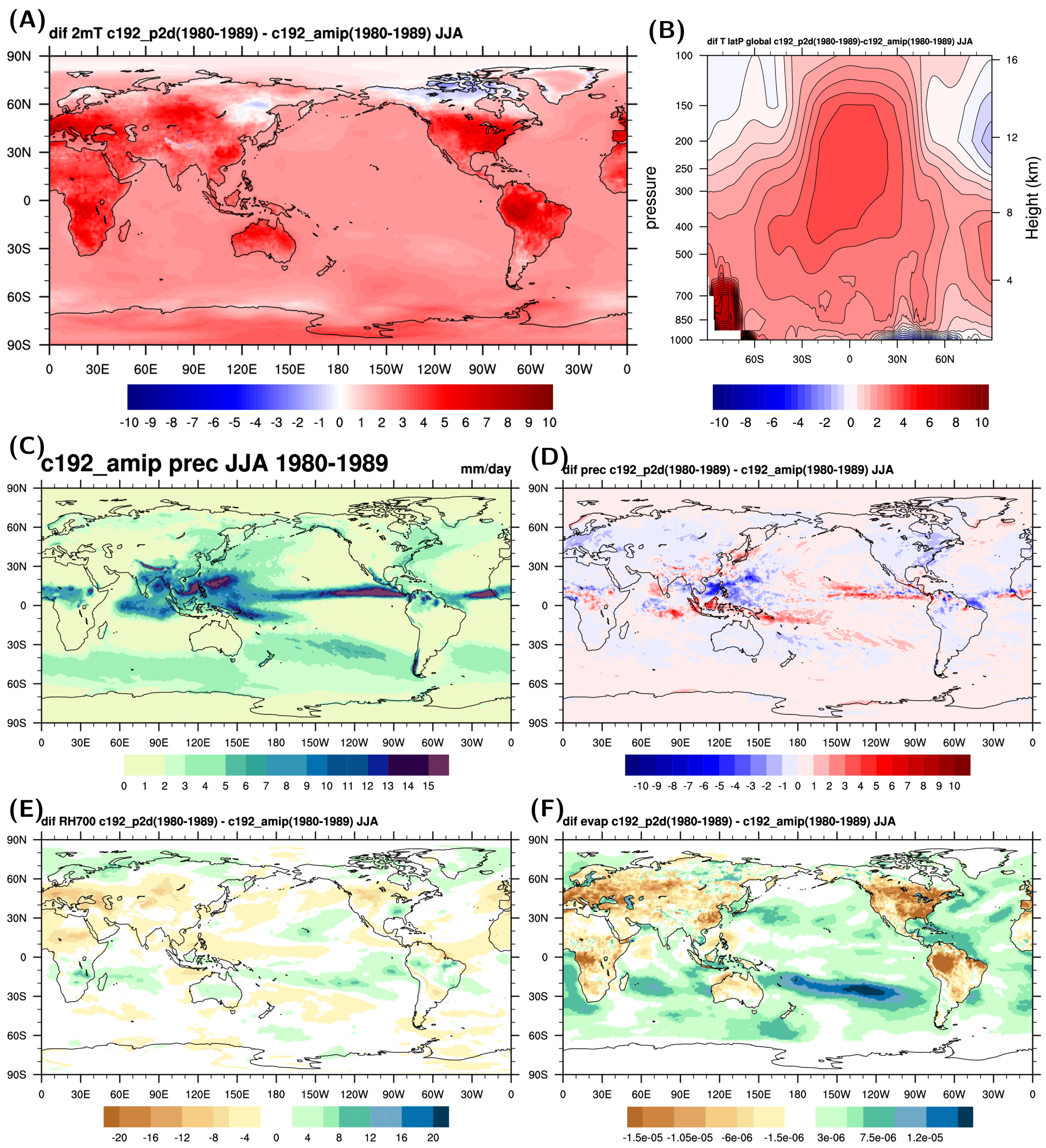

Figure 2: (A) 2 meter T change. (B) lat-P temperature change profile. (C) Precipitation in control run. (D) Precipitation change (E) 700hPa relative humidity change. (F) Evaporation change in +2° simulation.

References

Bolton, D., 1980: The computation of equivalent potential temperature. *Monthly Weather Review*, 108, 1046–1053.

Zhao, M., I. M. Held, S.-J. Lin, and G. A. Vecchi, 2009: Simulations of global hurricane climatology, interannual variability, and response to global warming using a 50-km resolution gcm. *Journal of Climate*, 22, 6653–6678, doi:10.1175/2009JCLI3049.1.

Contact: Ping-Gin Chiu, pgchiu@gate.sinica.edu.tw

Mechanism for Tropical High Level Temperature responds

- The increased SST not only heating the whole atmosphere, but also alter the pseudoadiabatic lapse rate.
- Tropical temperature responds more at high level, which stabilized the atmosphere.
- Decreased pseudoadiabatic lapse rate enhance convection.
- Above 2 mechanism may balance to each other in certain evaporation and precipitation amount.

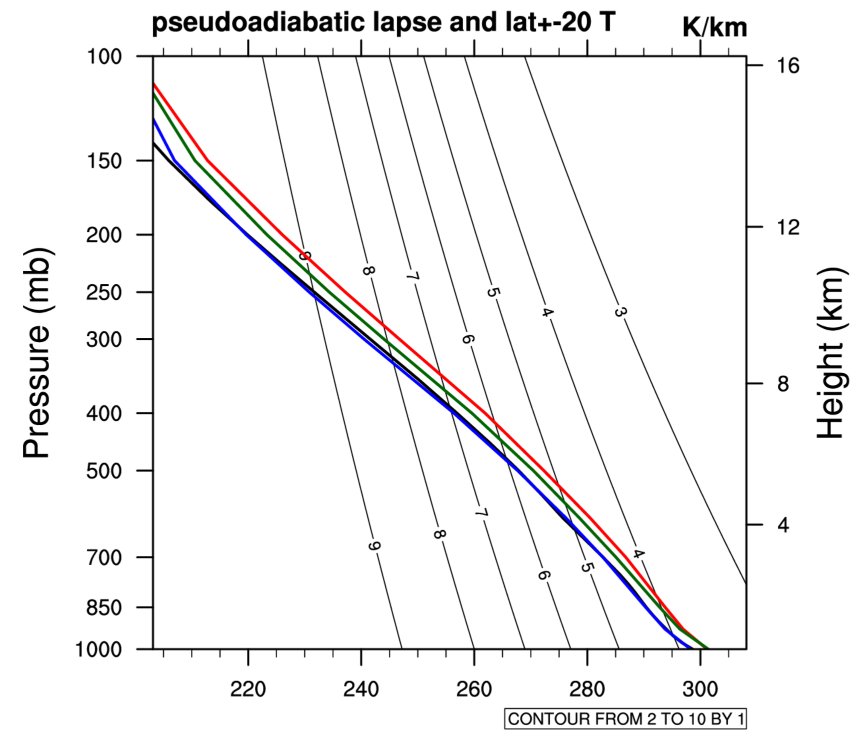

Figure 3: Pseudoadiabatic lapse rate in different temperature and pressure level(contour), Color lines indicate tropical temperature profile with different HiRAM simulation (blue: present climate, red: RCP8.5, green: p2d) and ERAIM data(black). Saturation vapor pressure estimation in Bolton (1980) is used.

Similar feature in RCP8.5 and p2d

- Consider the impact difference between mean and distribution of SST.
- Both two warming simulations shows drier in WNP, more rain in east Pacific.
- Anti-cyclonic circulation change over WNP.
- Fewer and more intense typhoon.

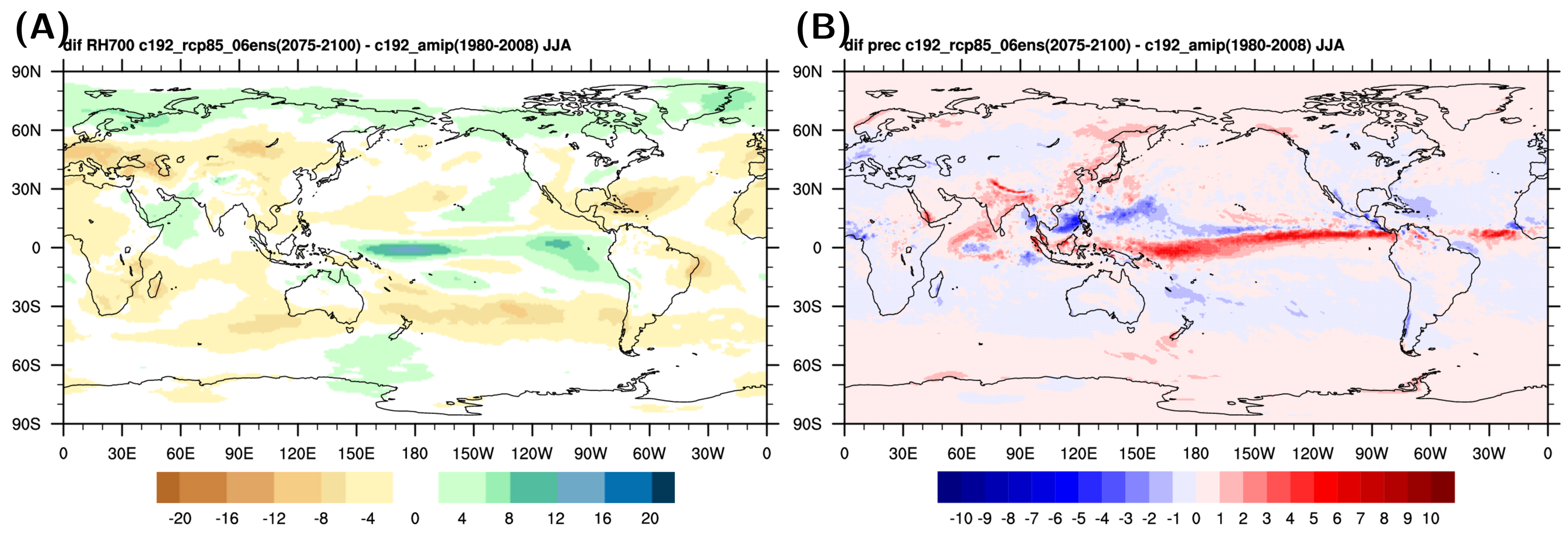

Figure 4: RCP8.5 SST driven simulated (A) 700hPa relative humidity. (B) Precipitation.

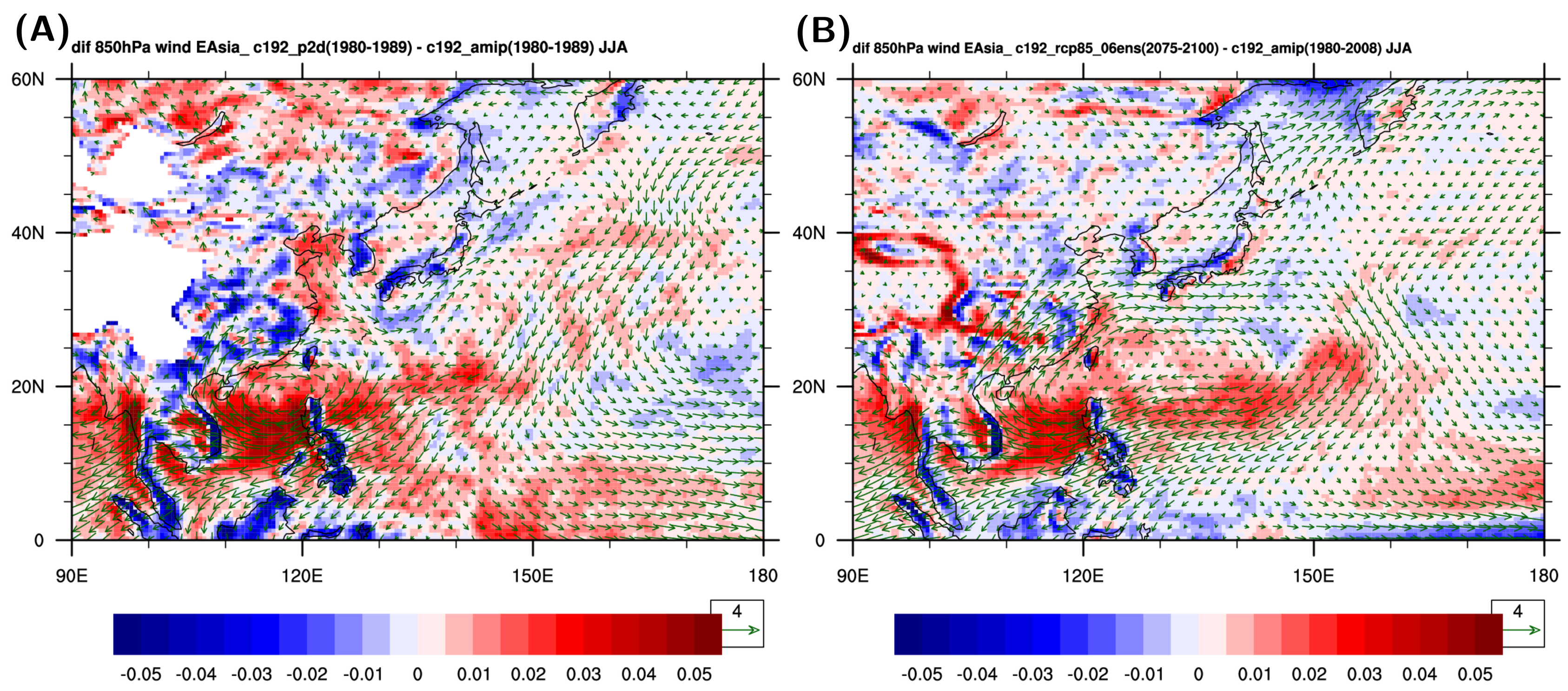

Figure 5: Western North Pacific JJA 850 hPa wind(vector) and omega(shading) in (A) p2d (B) RCP8.5 simulation.

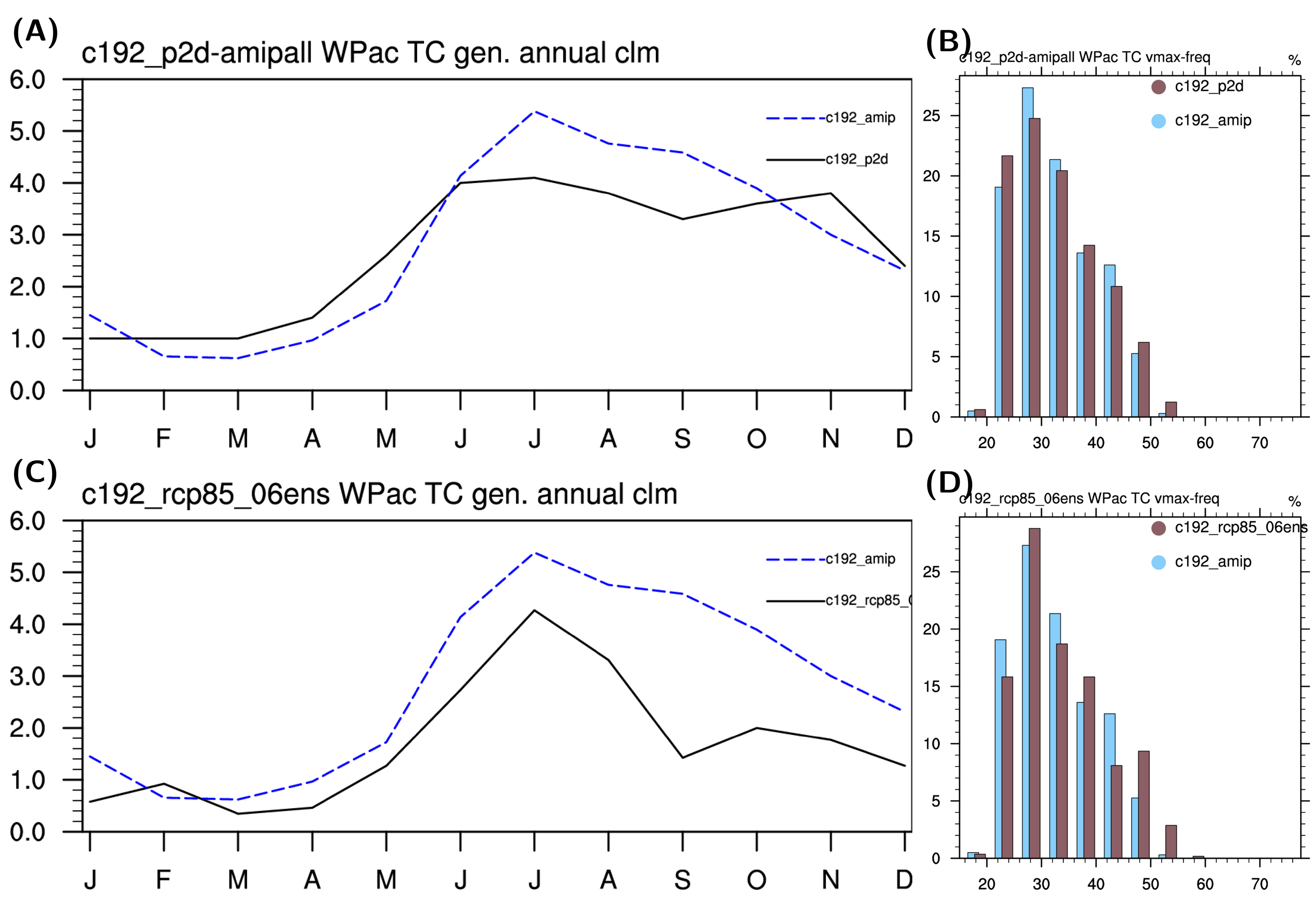

Figure 6: Western North Pacific typhoon (A) Annual genesis number. (B) Max intensity distribution in p2d and (C)(D) in RCP8.5 simulation.