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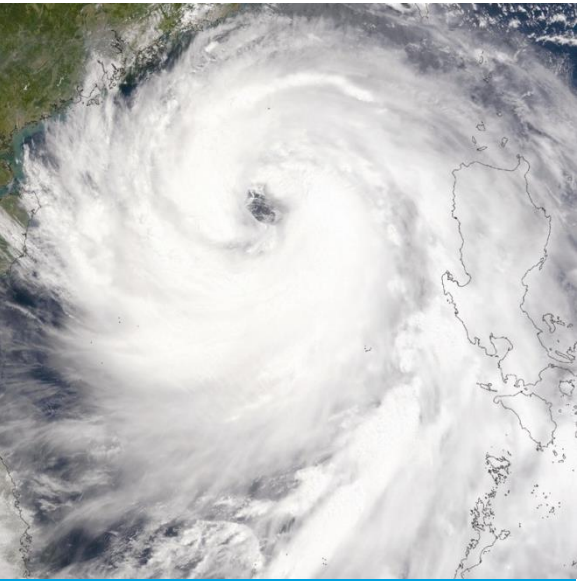

Dynamical Seasonal Prediction of Landfalling Tropical Cyclone Activity in East Asia

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Outline

- Model description
- Modeling the diurnal and semi-diurnal variations of summer rainfall over Southeast China
- Model climatology and interannual variability and hindcasts
- Forecasts and verification for 2014 and 2015
- Predicting seasonal landfall intensity
- Summary

The model

- **ICTP Regional Climate Model version 3**
  - Modified Emanuel cumulus scheme (Chow et al. 2006)
  - Vorticity & RH limitations
- Domain: 90ºE-170ºW, 14ºS-48ºN
- Resolution: 50 km
- 18 levels up to 1 hPa
- 8 ensemble members:
  initial time at 01Z00/06/12/18 and 02Z00/06/12/18 of the first month
- Integration for 7 months, with first month as spinup

The model

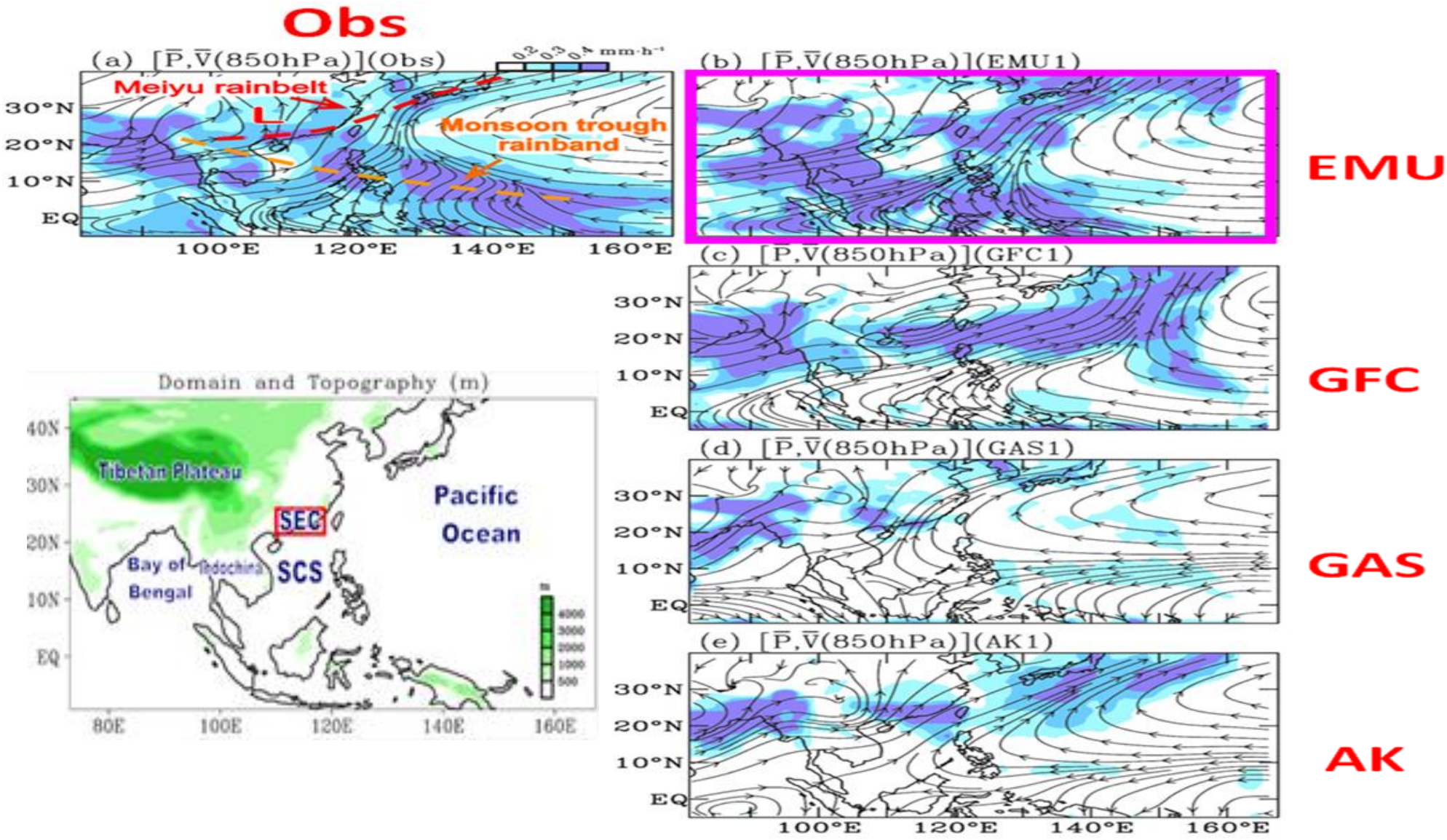
- Initial and boundary conditions:
  - NCEP CFS reanalysis (climatology study)
  - NCEP CFS hindcasts (prediction study)
  - NCEP CFS predictions (actual forecast)

Huang et al. (2013)

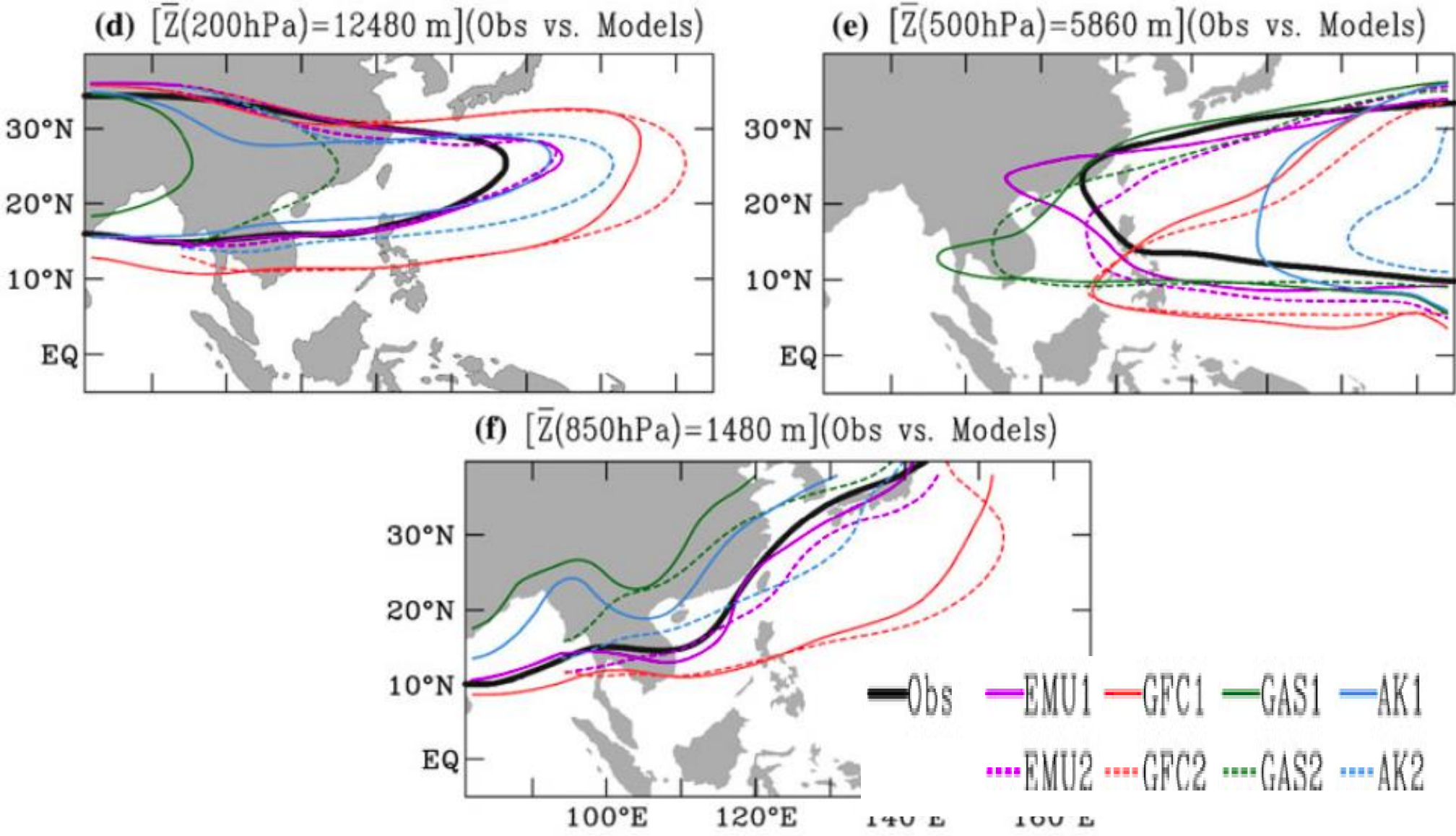
The model

Group of experiments (model domain)	Individual experiment	Convective scheme	Closure
Exp_domain1 (73 ^{o}E–167 ^{o}E, 10 ^{o}S–45 ^{o}N)	EMU1	MIT-Emanuel	–
	GFC1	Grell	Fritsch-Chappell
	GAS1	Grell	Arakawa-Schubert
	AK1	Anthes-Kuo	–
Exp_domain2 (93 ^{o}E–167 ^{o}E, 10 ^{o}S–45 ^{o}N)	EMU2	MIT-Emanuel	–
	GFC2	Grell	Fritsch-Chappell
	GAS2	Grell	Arakawa-Schubert
	AK2	Anthes-Kuo	–

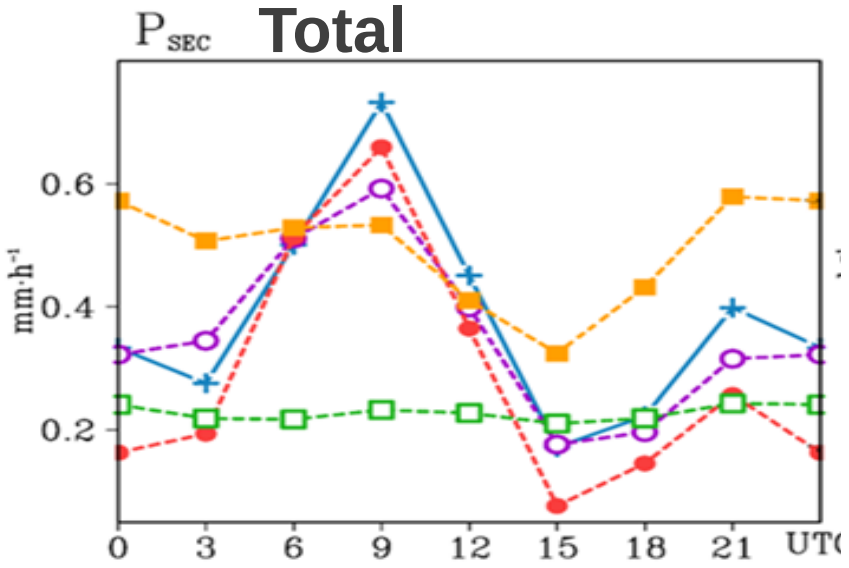
Simulations of Regional Circulation and Precipitation



Simulations of geopotential heights at various levels



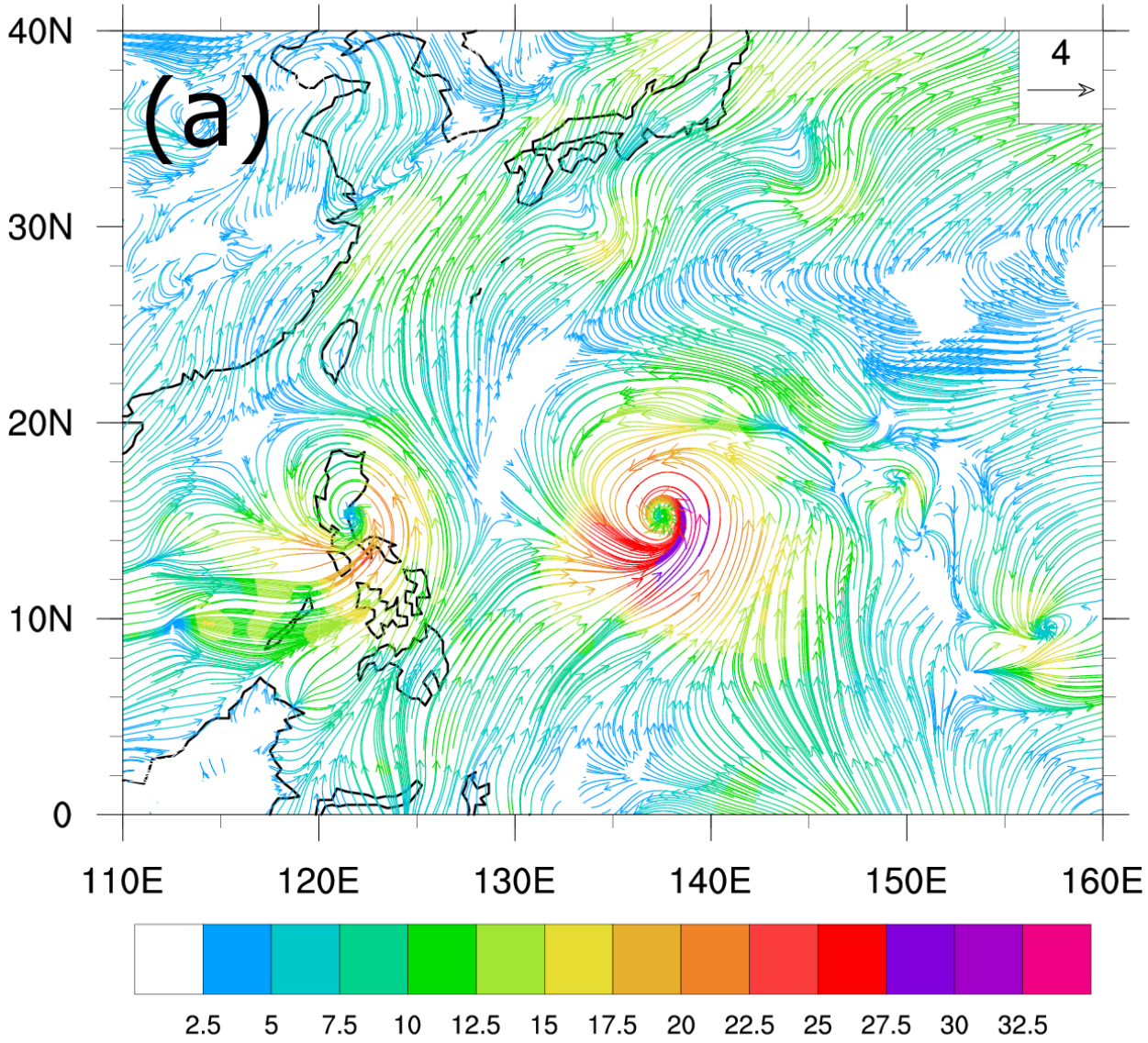
Simulations of Diurnal Rainfall



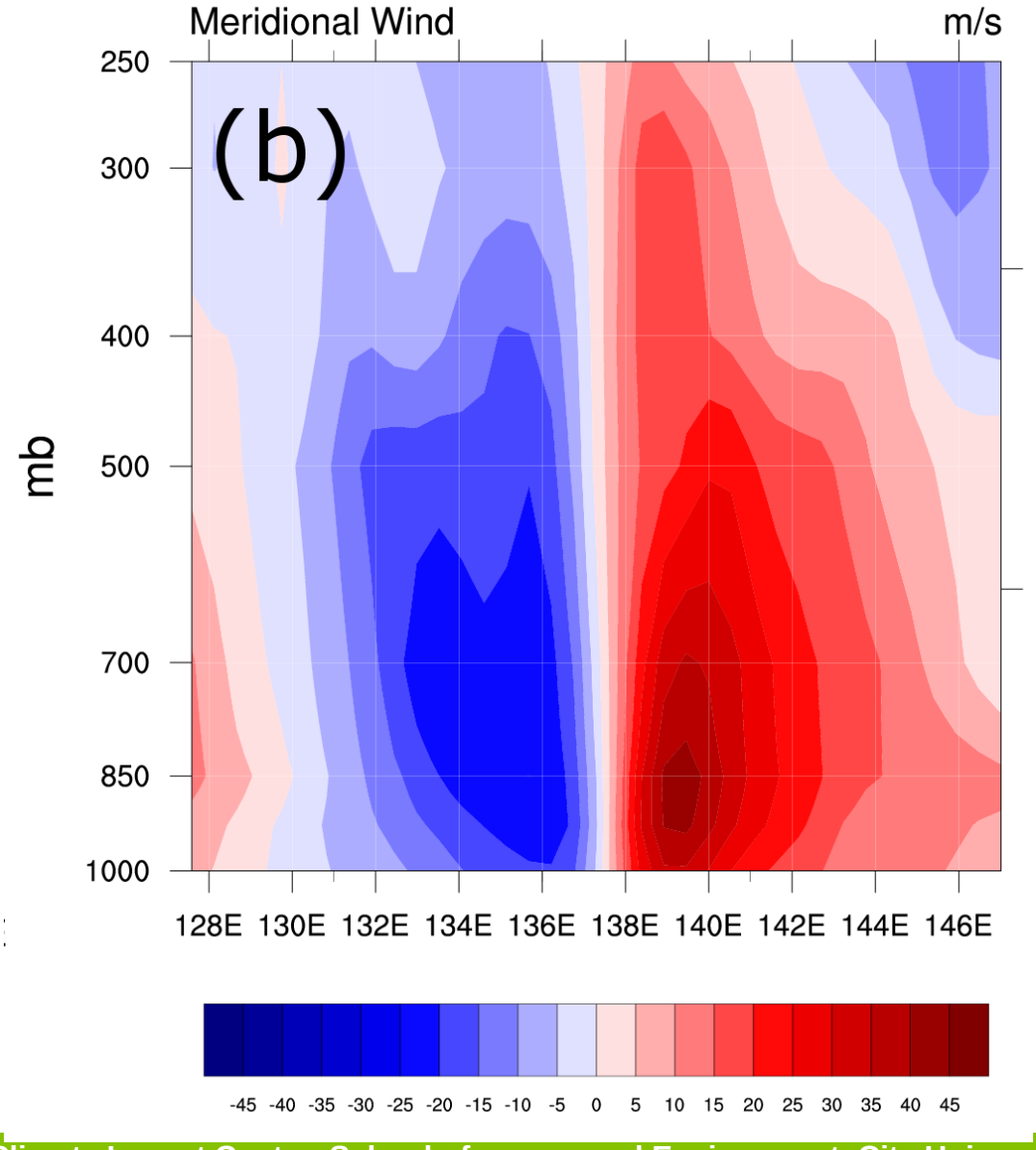
Detection of a tropical cyclone

- Local maximum $\zeta_{850hPa} \geq 1x\ 10^{-4}\ s^{-1}$)
- T_{300hPa} at centre – $T_{environment} \geq 1^{o}C$, where $T_{environment}$ is the average temperature within 15^{o} latitude radius from the TC centre
- lifetime ≥ 2 days
- Genesis over the ocean

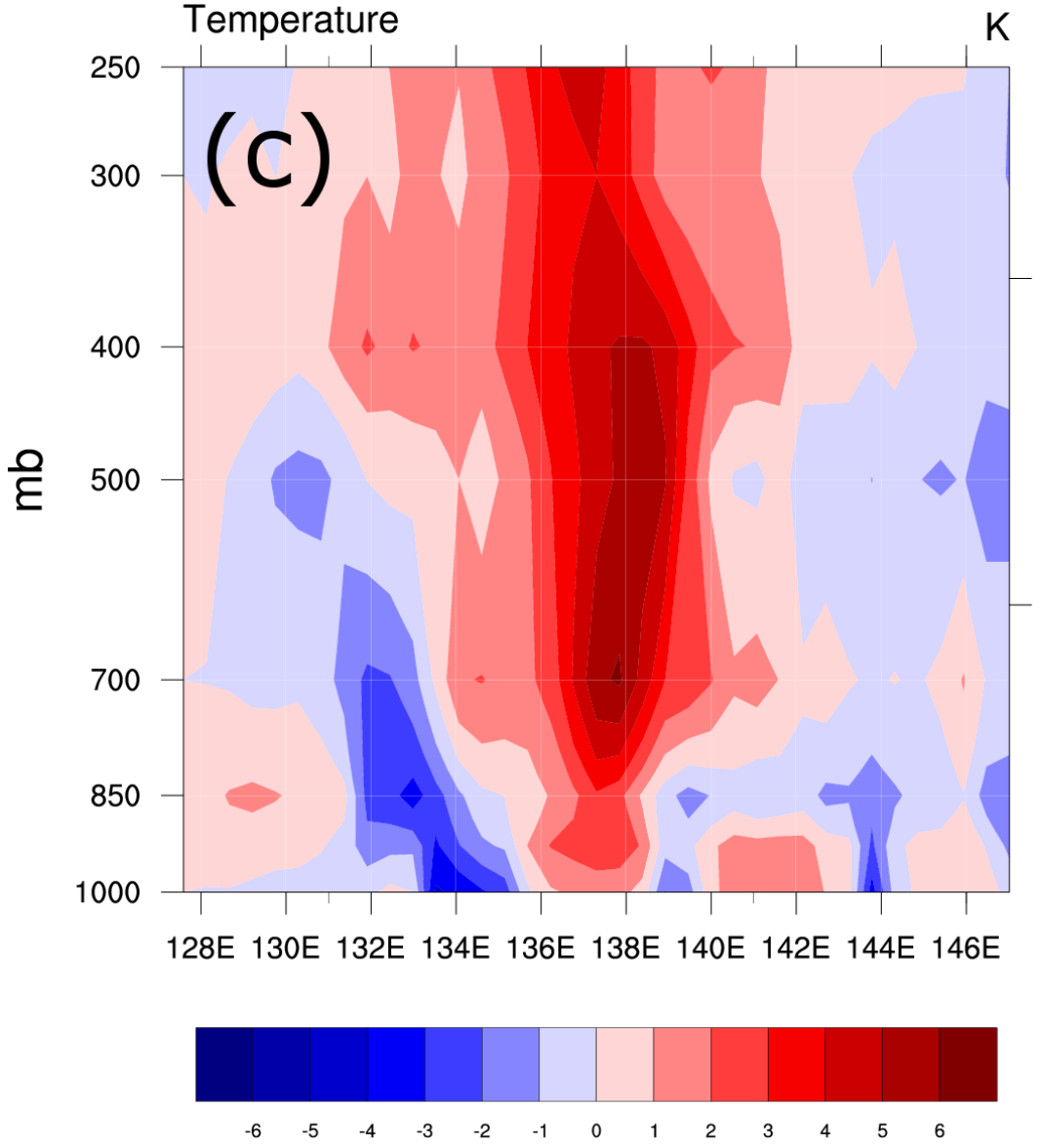
Example of a tropical cyclone in RegCM3



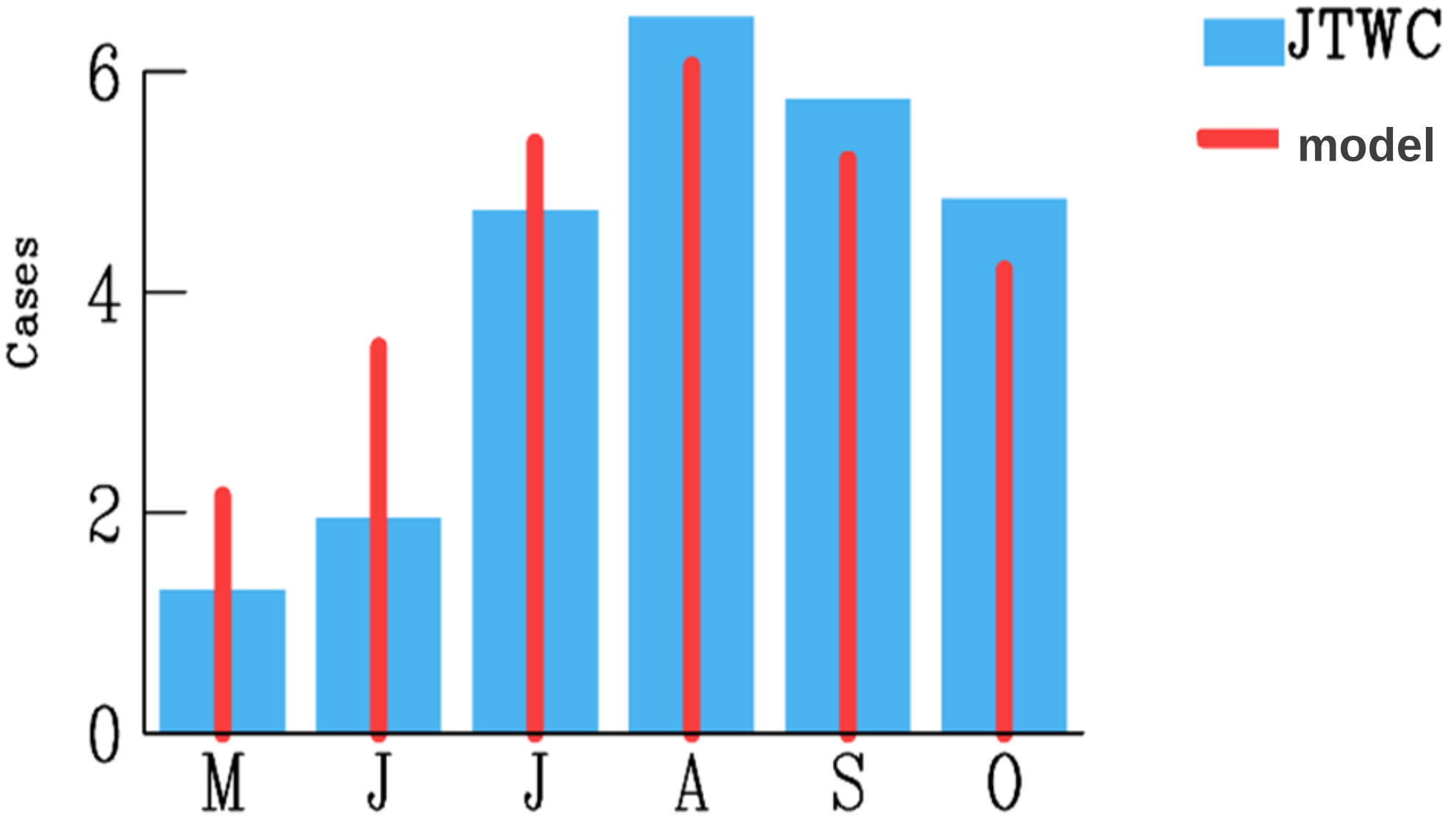
Example of a tropical cyclone in the Regional Model



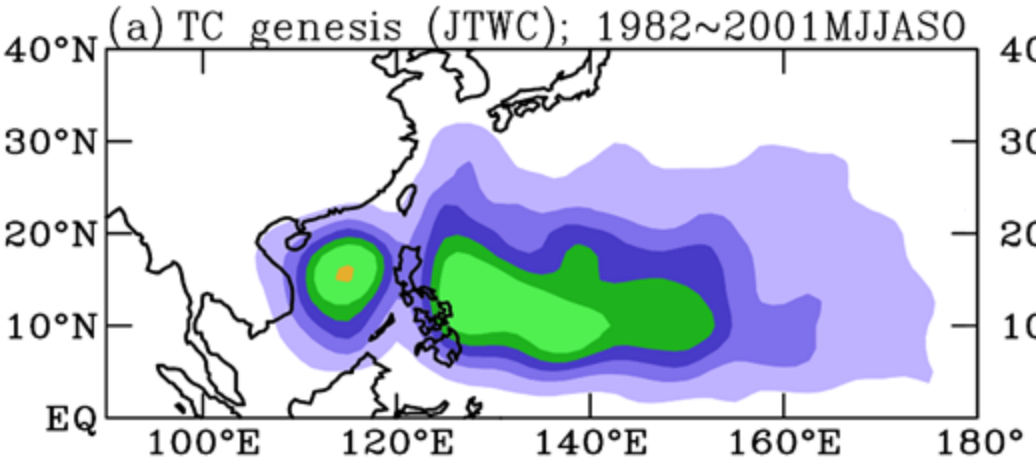
Example of a tropical cyclone in the Regional Model

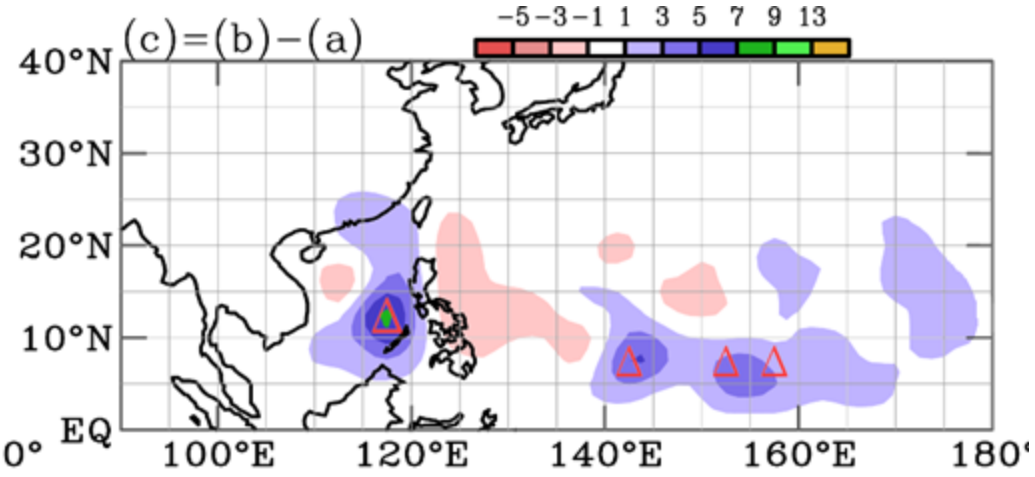


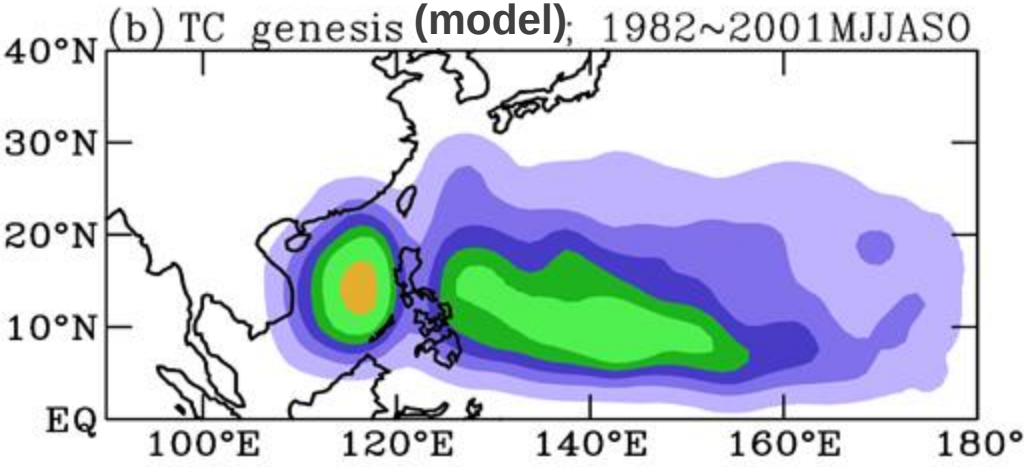
TC Numbers (1982-2001)



TC Climatology (1982-2001)



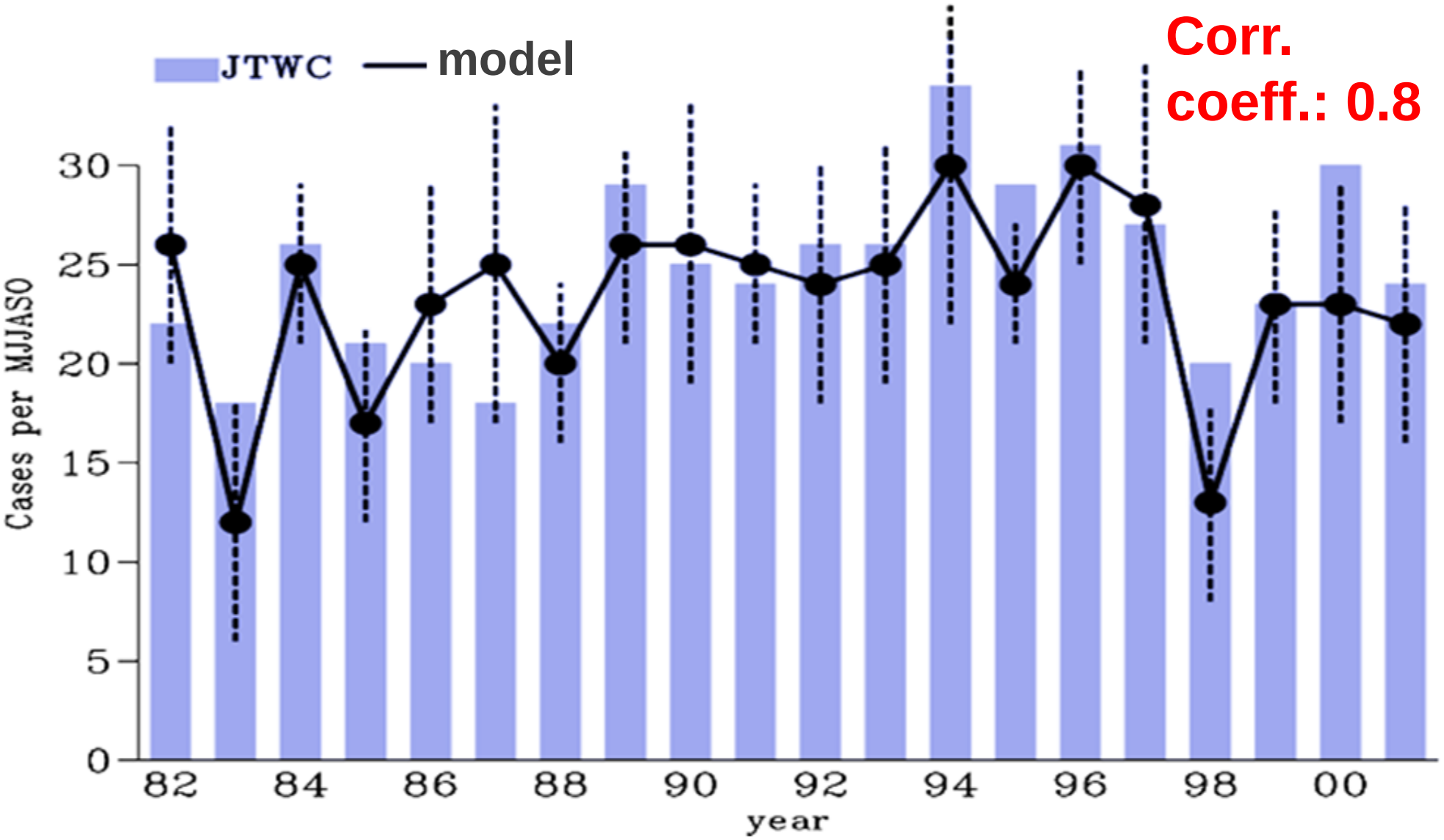




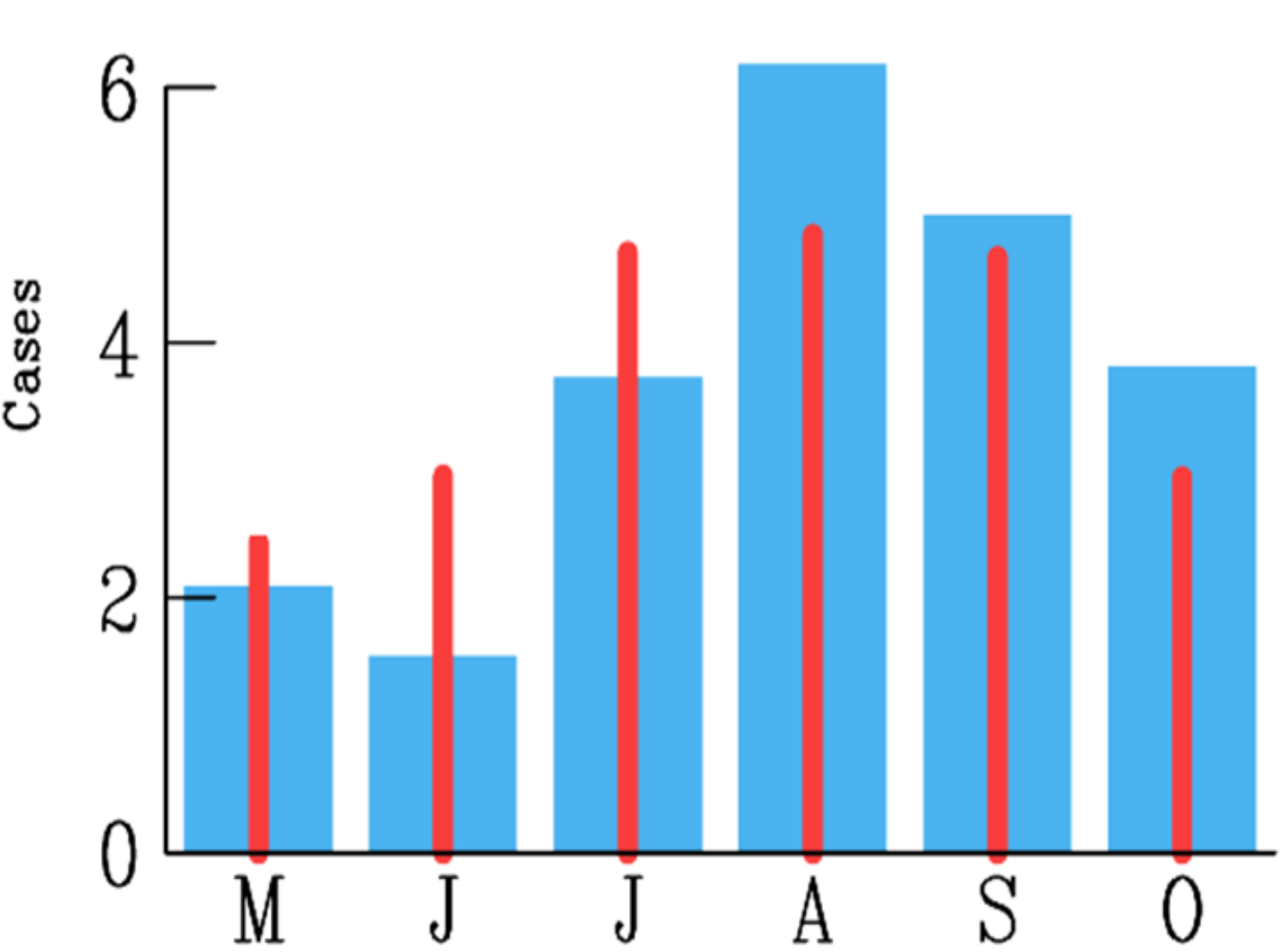
△ **significant at the 95% confidence interval**

Spatial correlation coefficient for (a) and (b) ~ 0.93; significant at the 95% confidence interval

Interannual Variability (1982-2001)

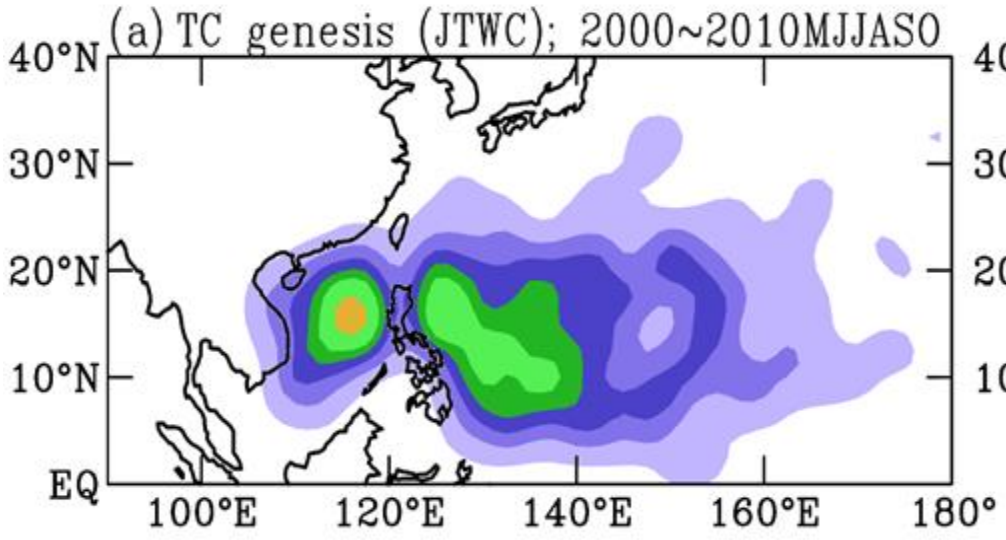


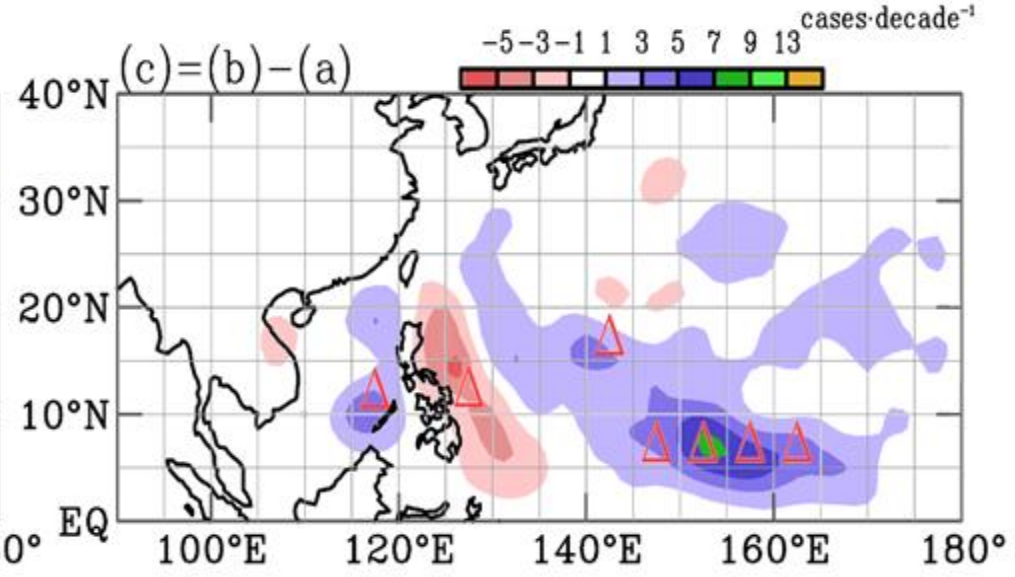
Hindcasts of TC numbers (2000-2010)

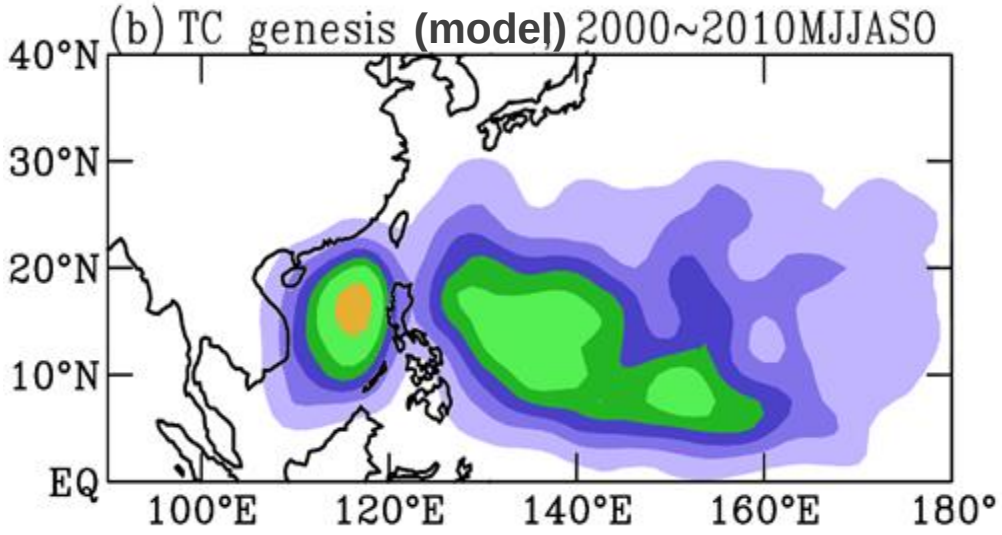


Total number per MJJASO season:
model: 22.54
obs: 22.36

Hindcasts of Spatial Distribution (2000-2010)

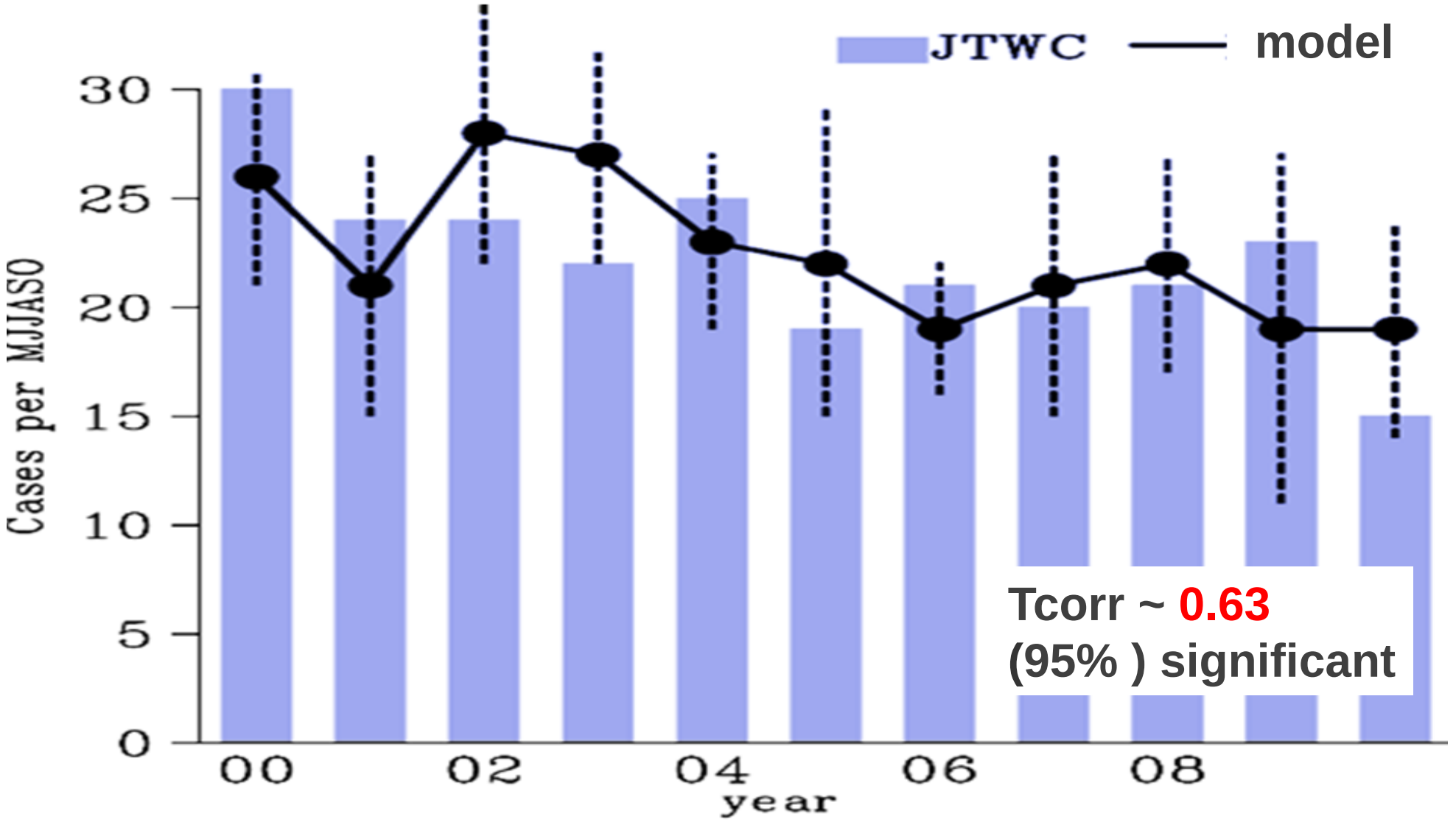




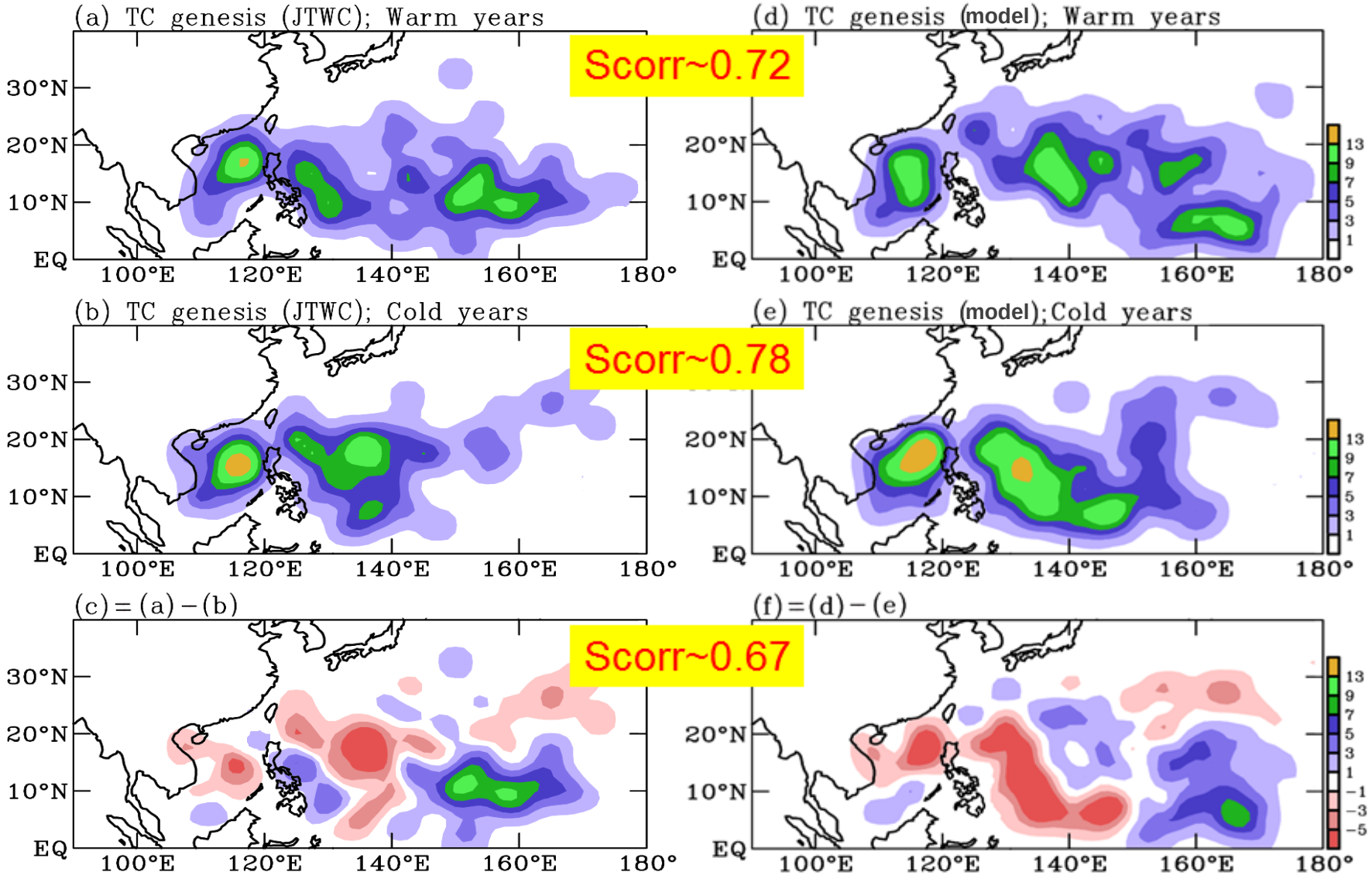


△ **significant at the 95% confidence interval**

Hindcasts - Interannual Variability (2000-2010)

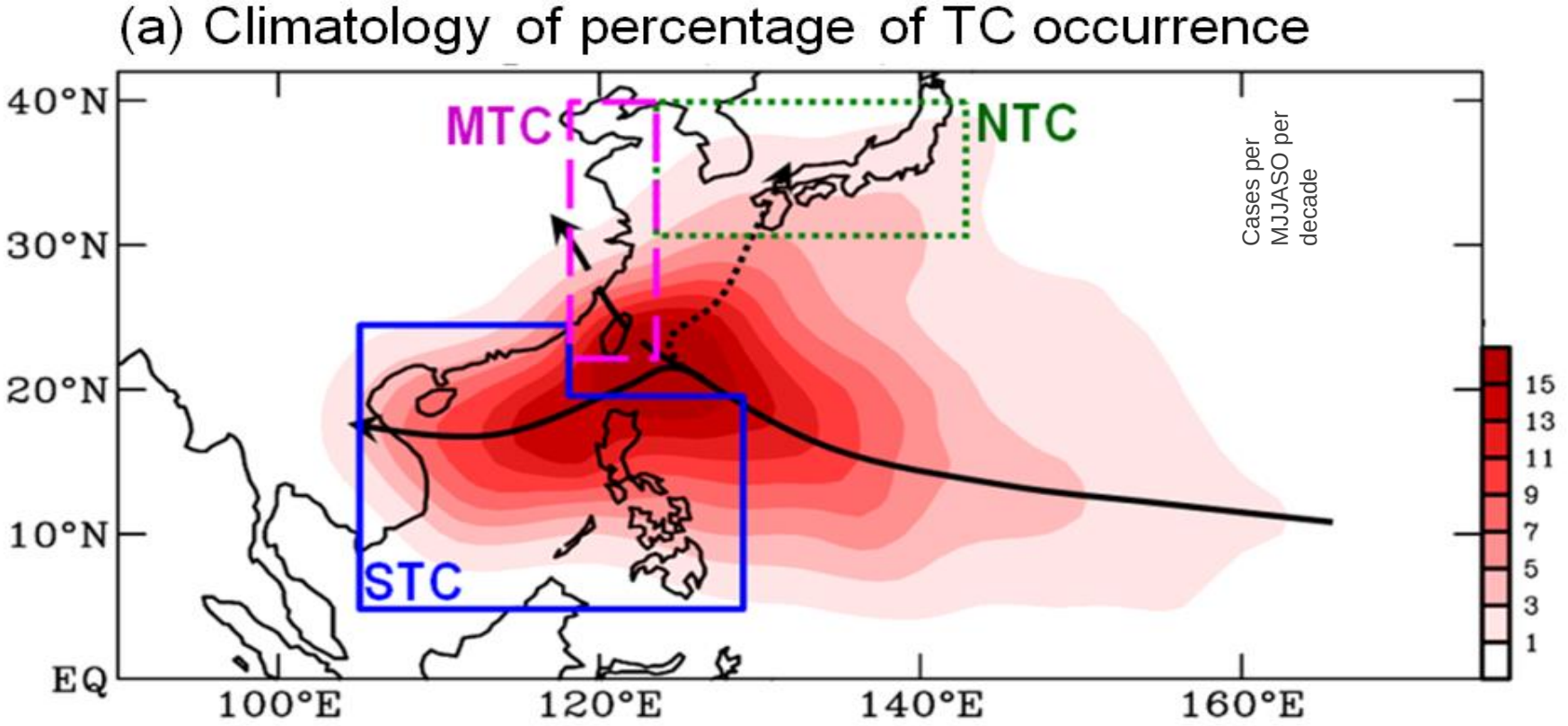


Hindcasts – Warm vs Cold Years



TC Landfall

Chan and Xu (2009)



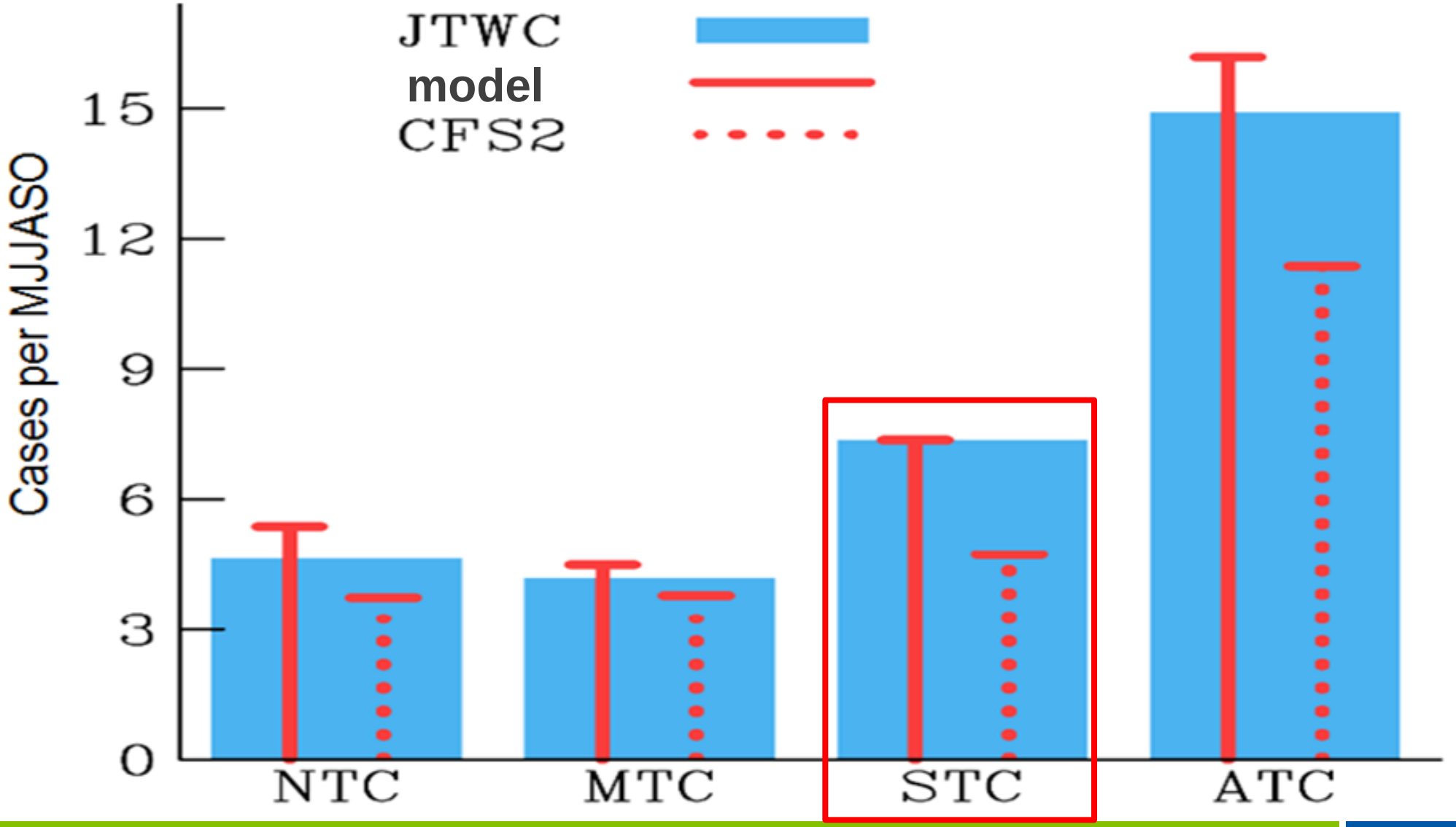
South TCs (STC) – TC landfall in South China, Vietnam and the Philippines

Middle TCs (MTC) – TC landfall in East China

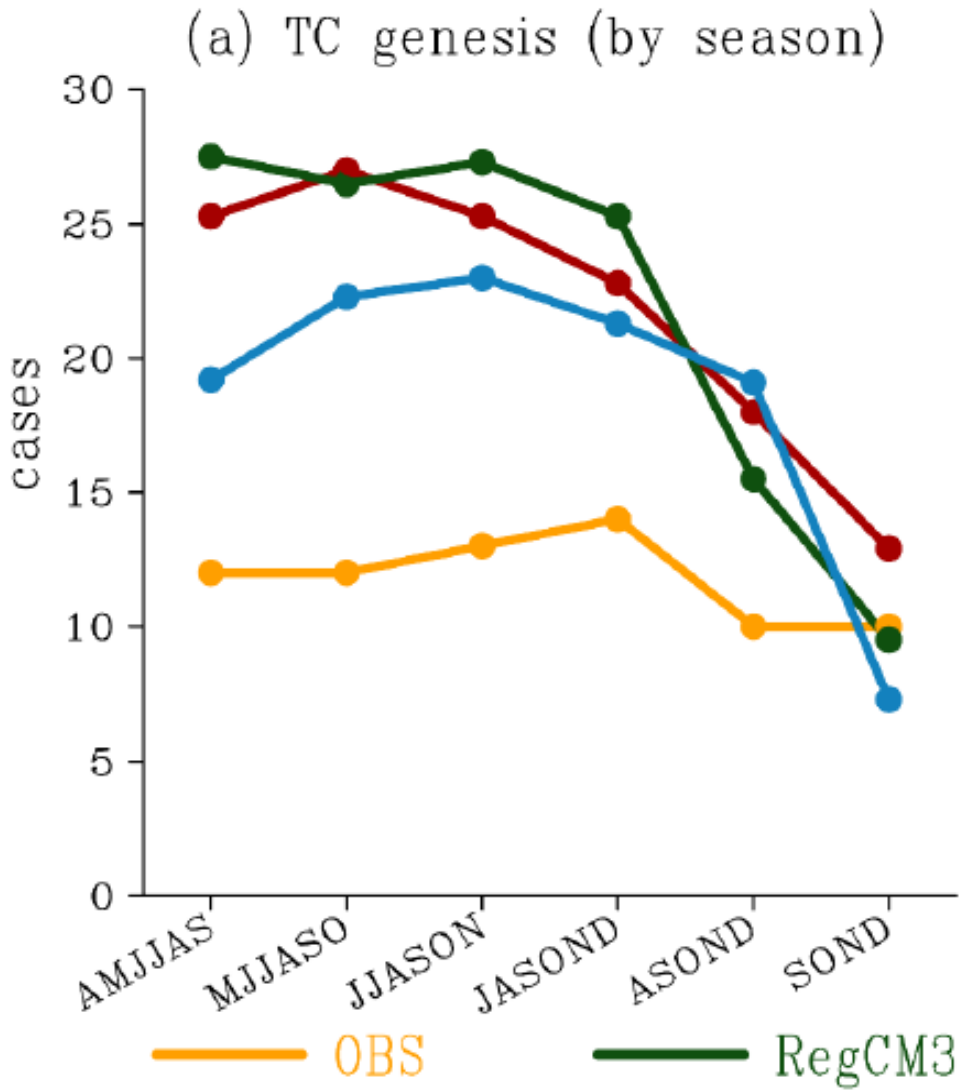
North TCs (NTC) – TC landfall in the Korean peninsula and Japan

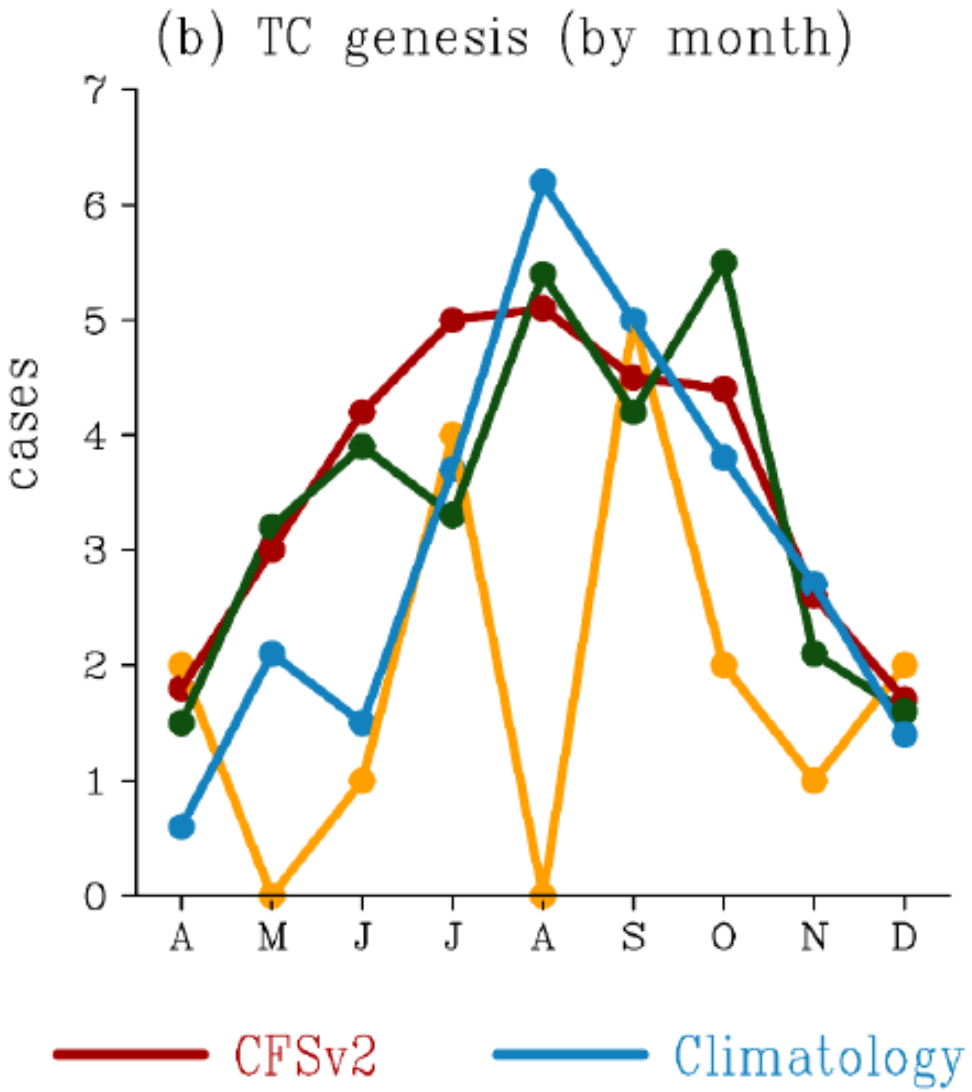
All TC (ATC) – the total number of landfalling TCs in Asia

Hindcasts of TC Landfall (2000-2010)

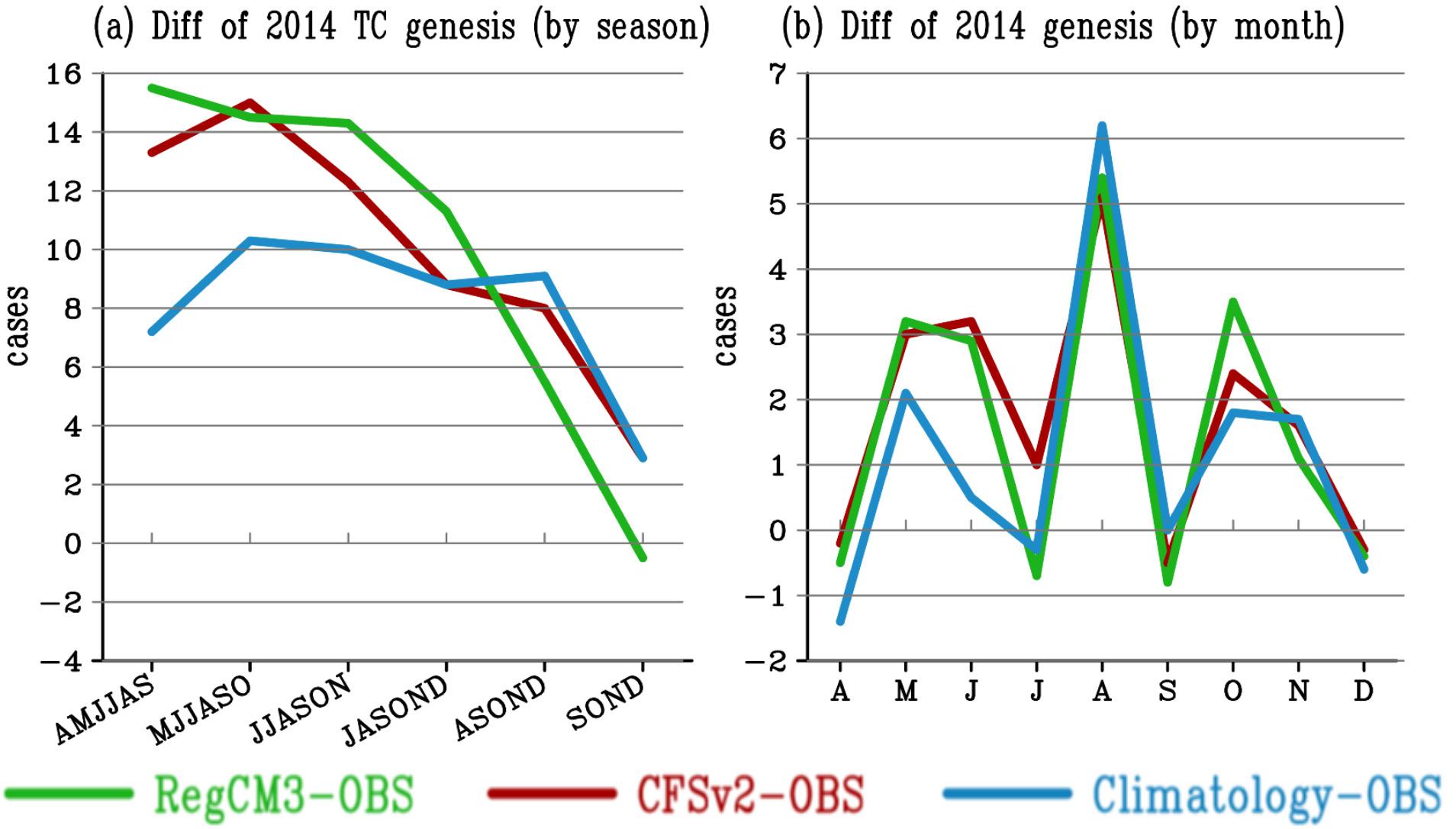


2014 Forecasts and Verification



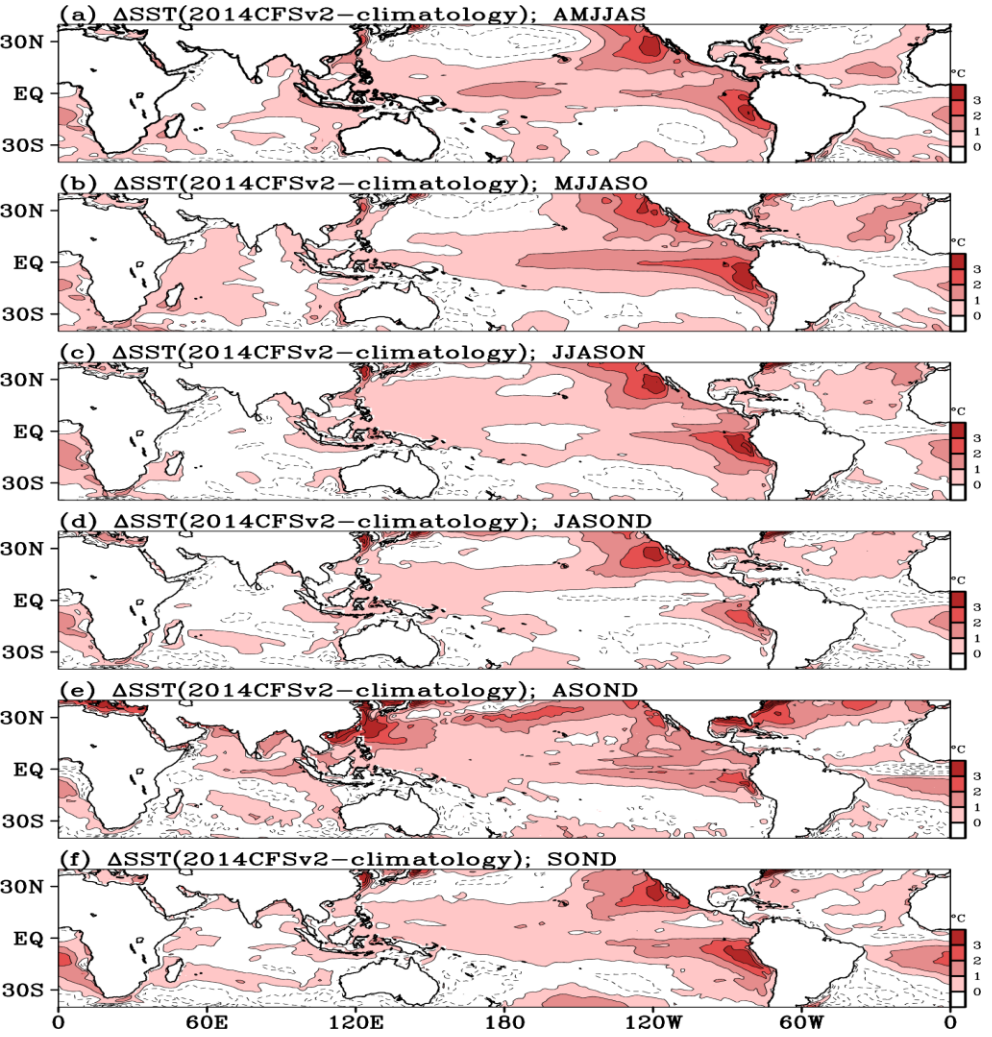


2014 Forecasts and Verification

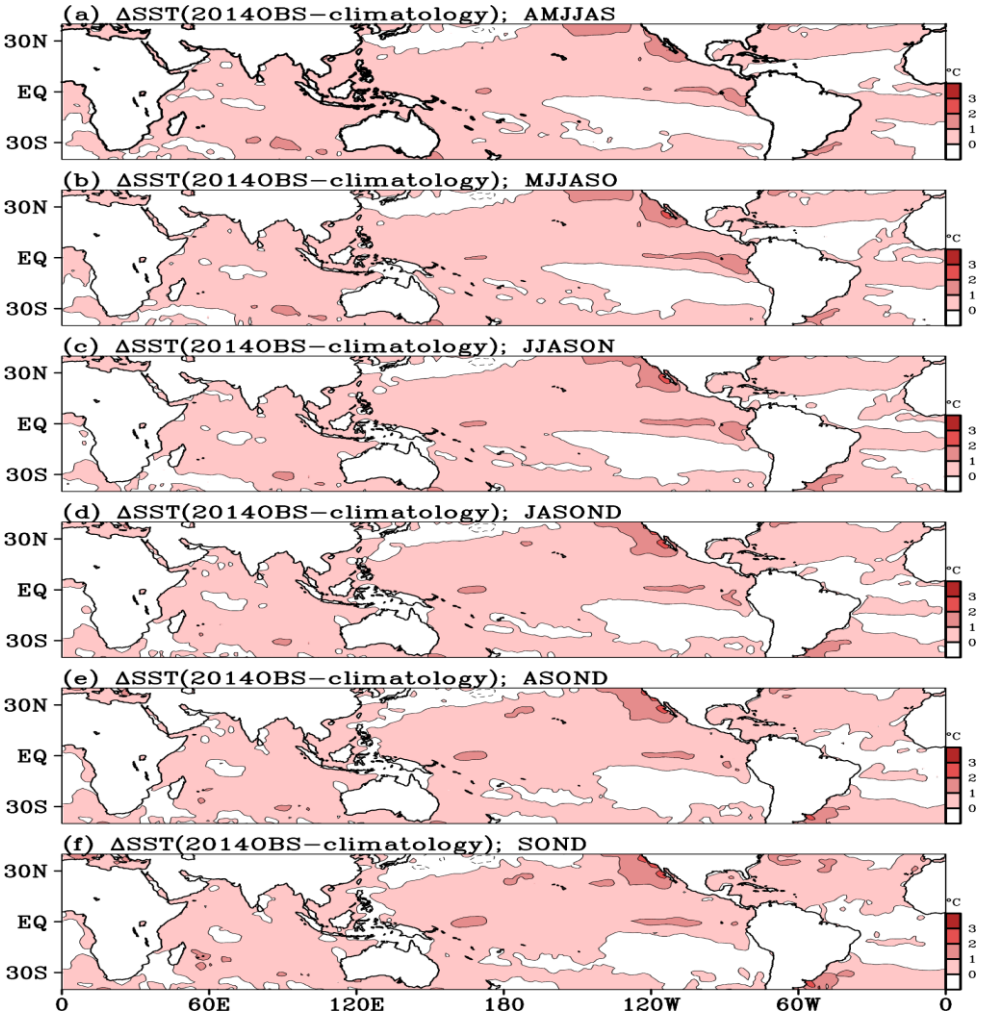


2014 Forecasts and Verification (SSTA)

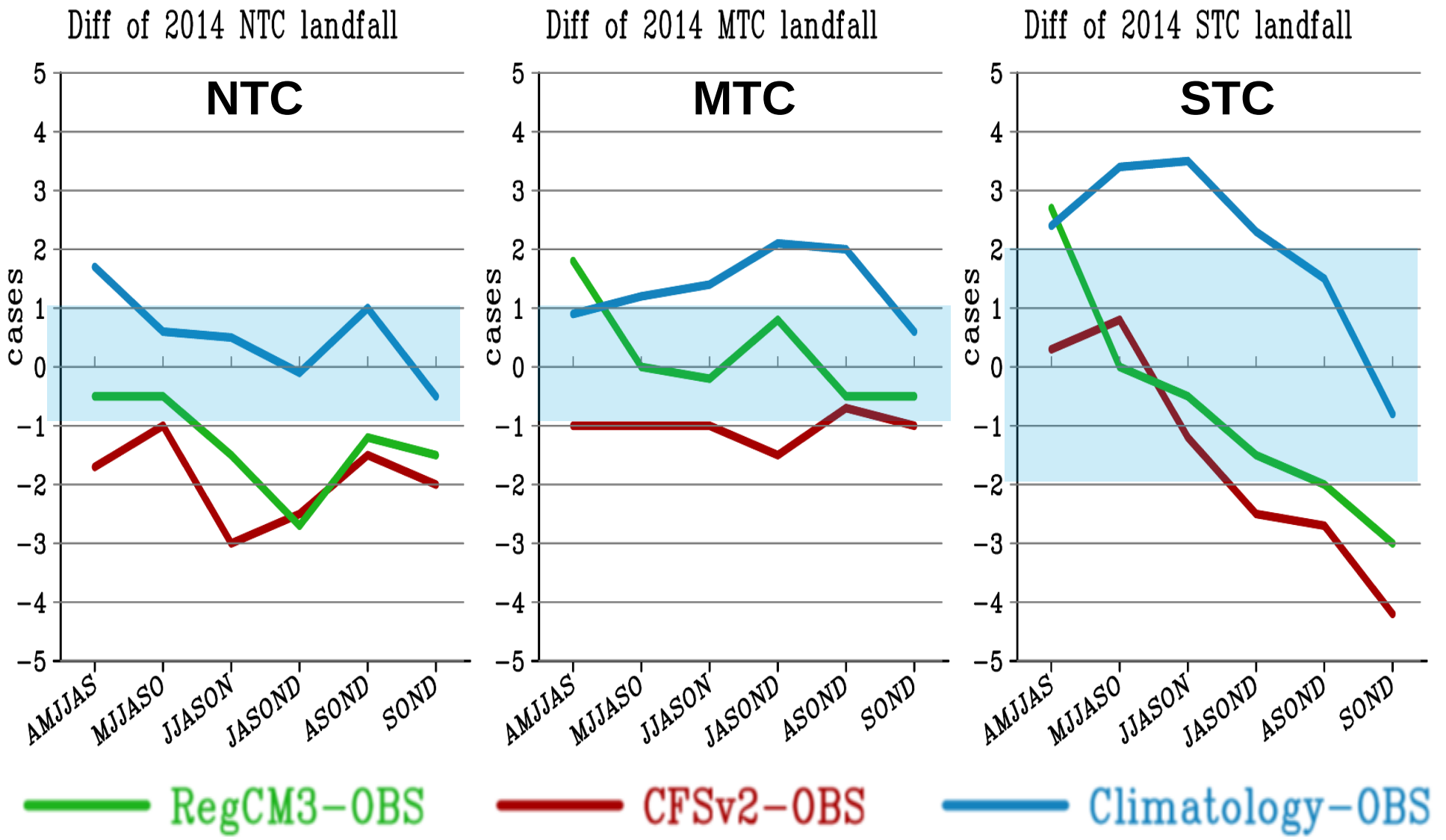
CFSv2 minus climatology



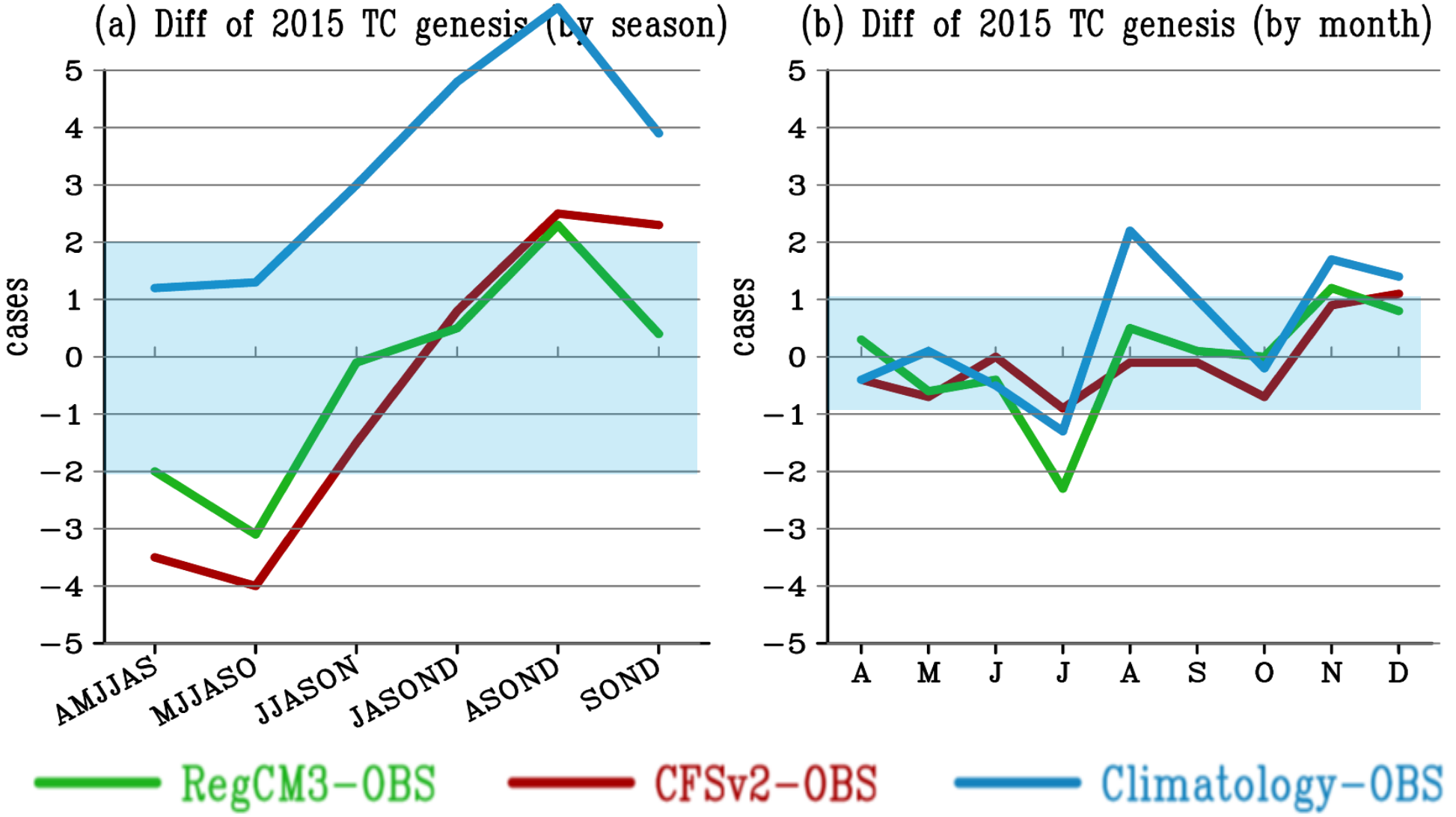
Observations minus climatology



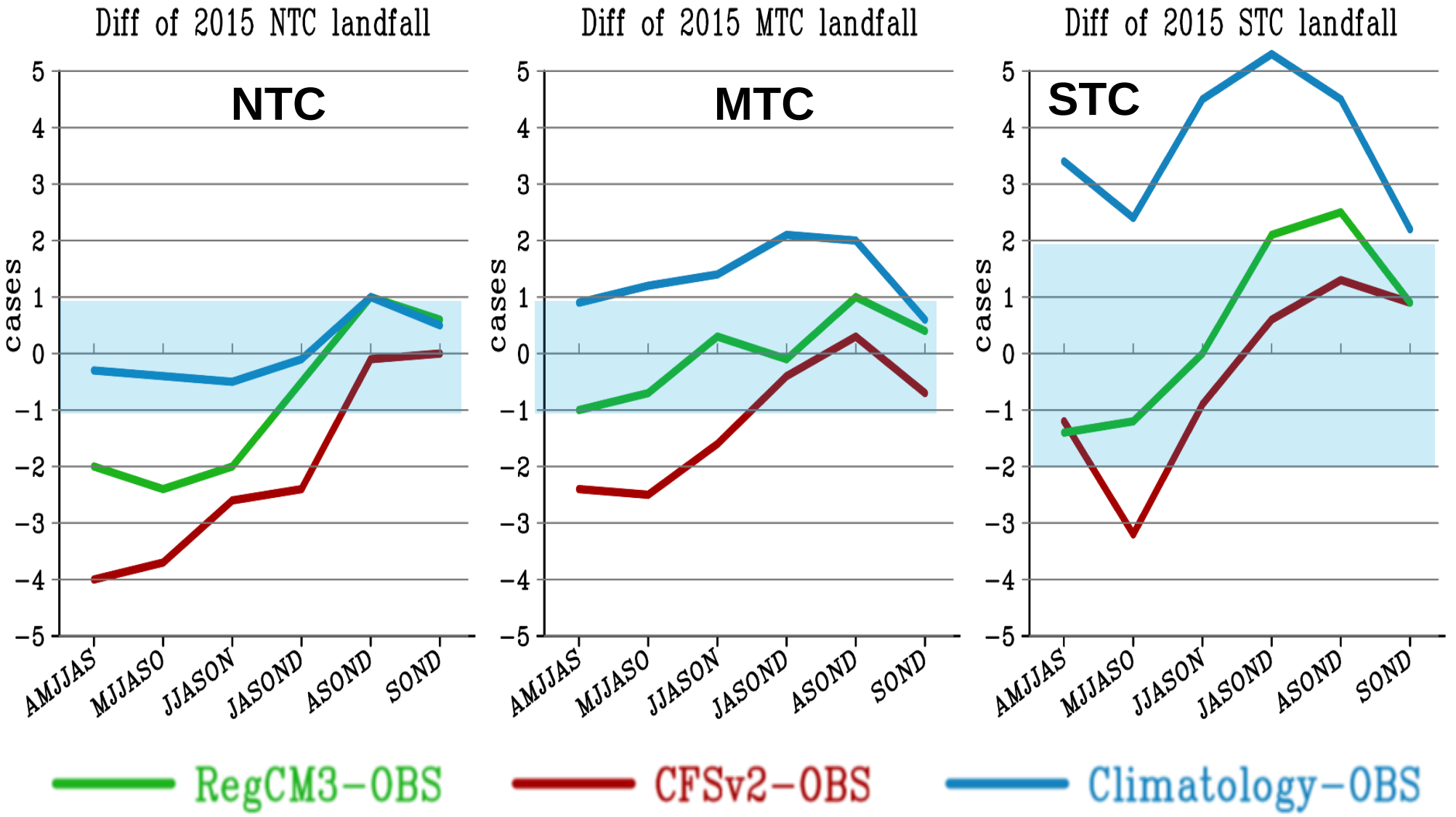
2014 Forecasts and Verification (Landfall)



2015 Forecasts and Verification



2015 Forecasts and Verification (Landfall)



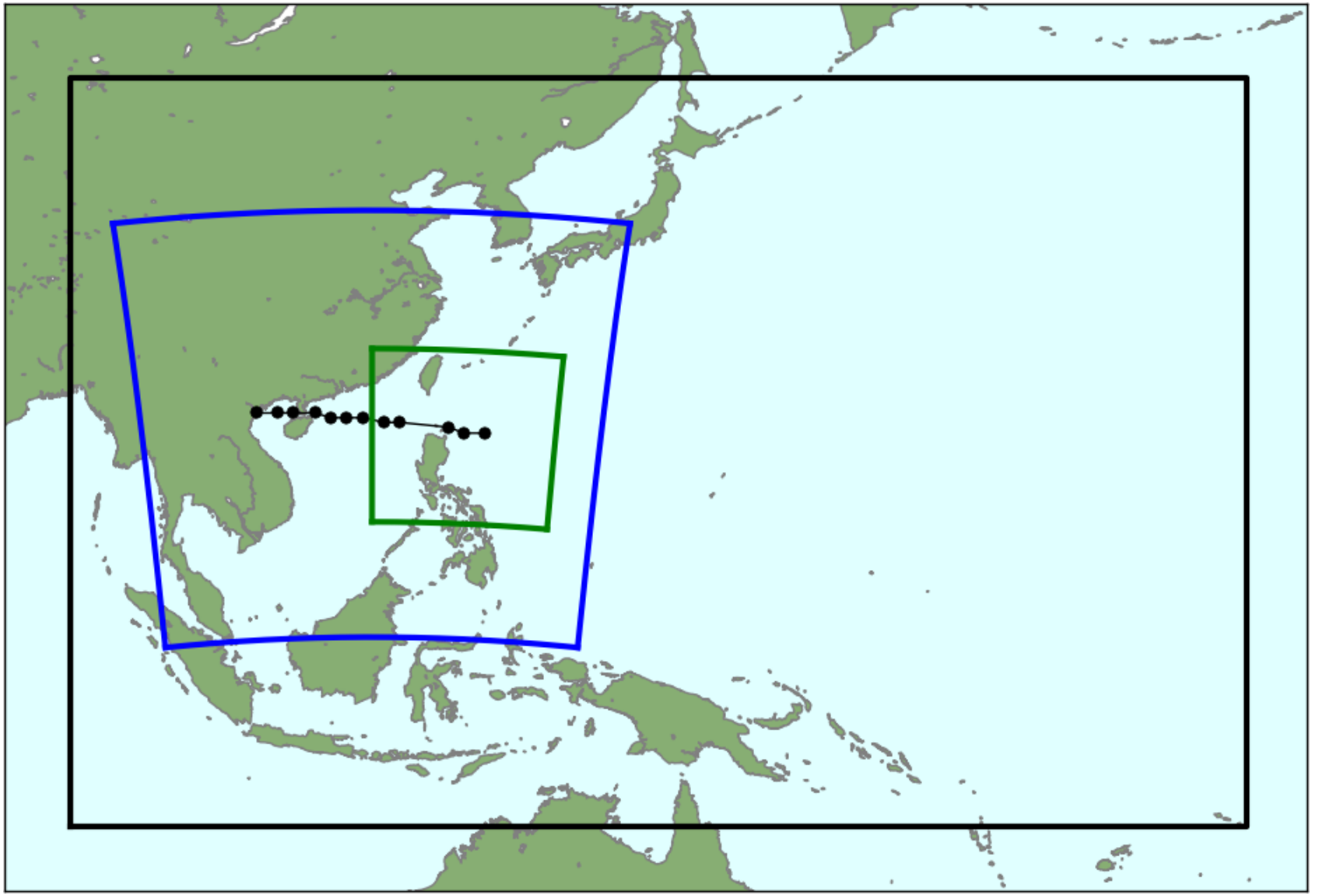
Predicting seasonal intensity

- **Weather Research and Forecasting Model V3.7**
- Resolution: double nesting 27/9km
- Time: 60 hours from RegCM3 TC landfall
- 28 levels up to 100 hPa
- Initial and boundary conditions: RegCM3
  - Microphysics: Ferrier
  - PBL: YSU
  - Cumulus: Kain-Fritsch
  - Radiation: RRTMG
  - Land Surface: 5-layer diffusion

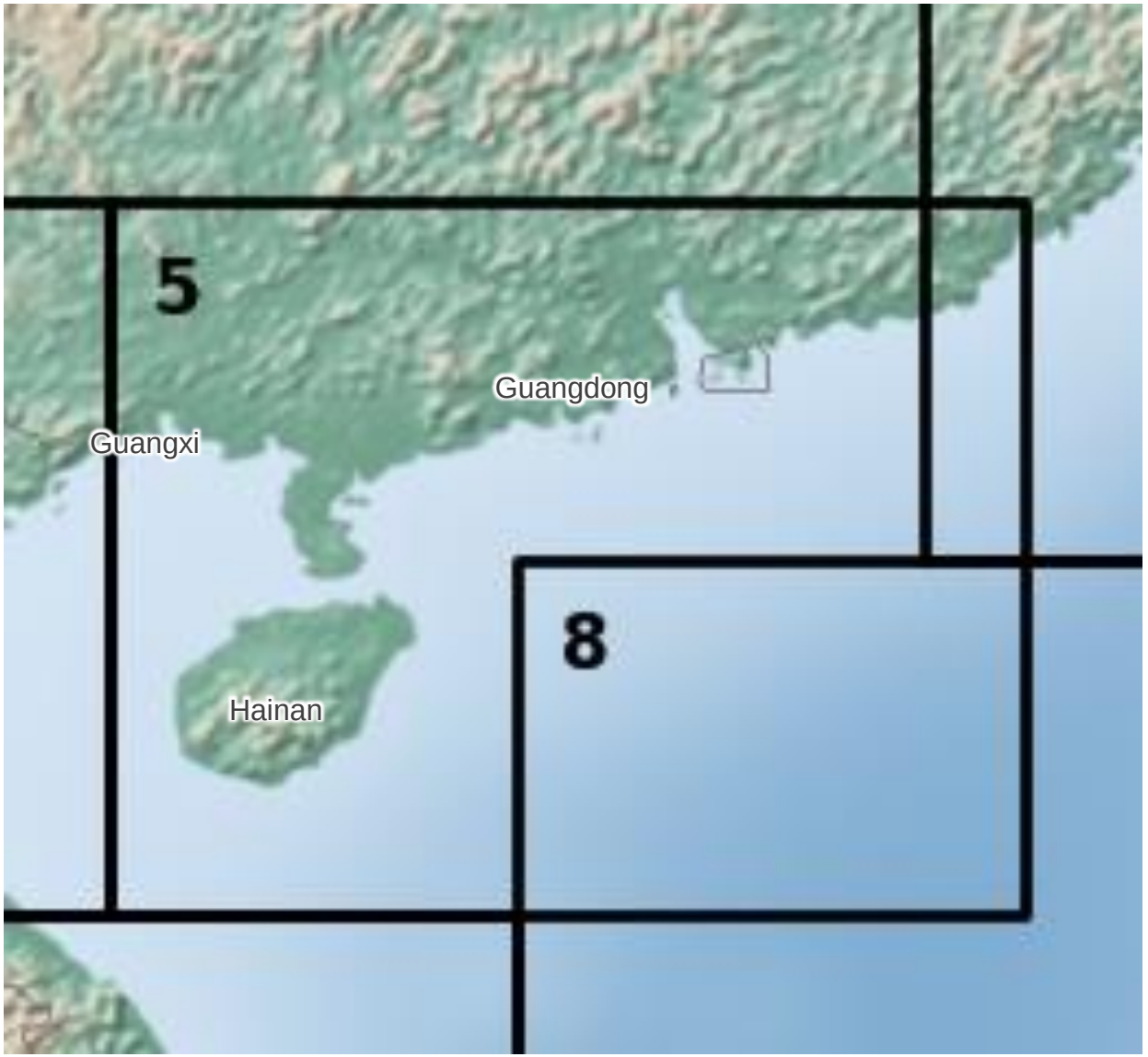
Predicting seasonal intensity

- Estimate the intensity at landfall and calculate the PDI (= V^3)
- Calculate the mean PDI for the season by summing up the PDI for each landfalling TC and dividing by the number of landfalling TCs

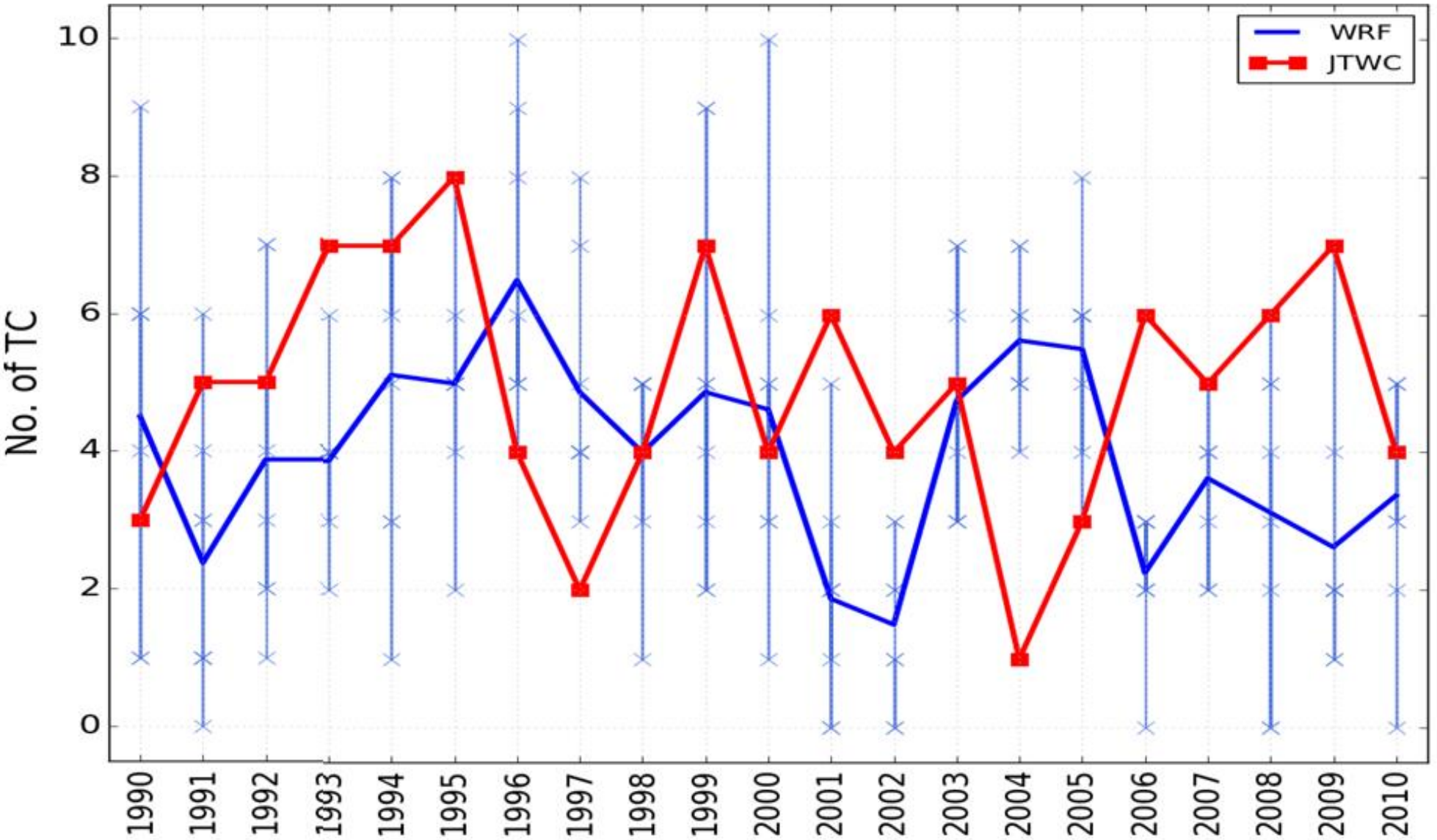
Predicting seasonal intensity



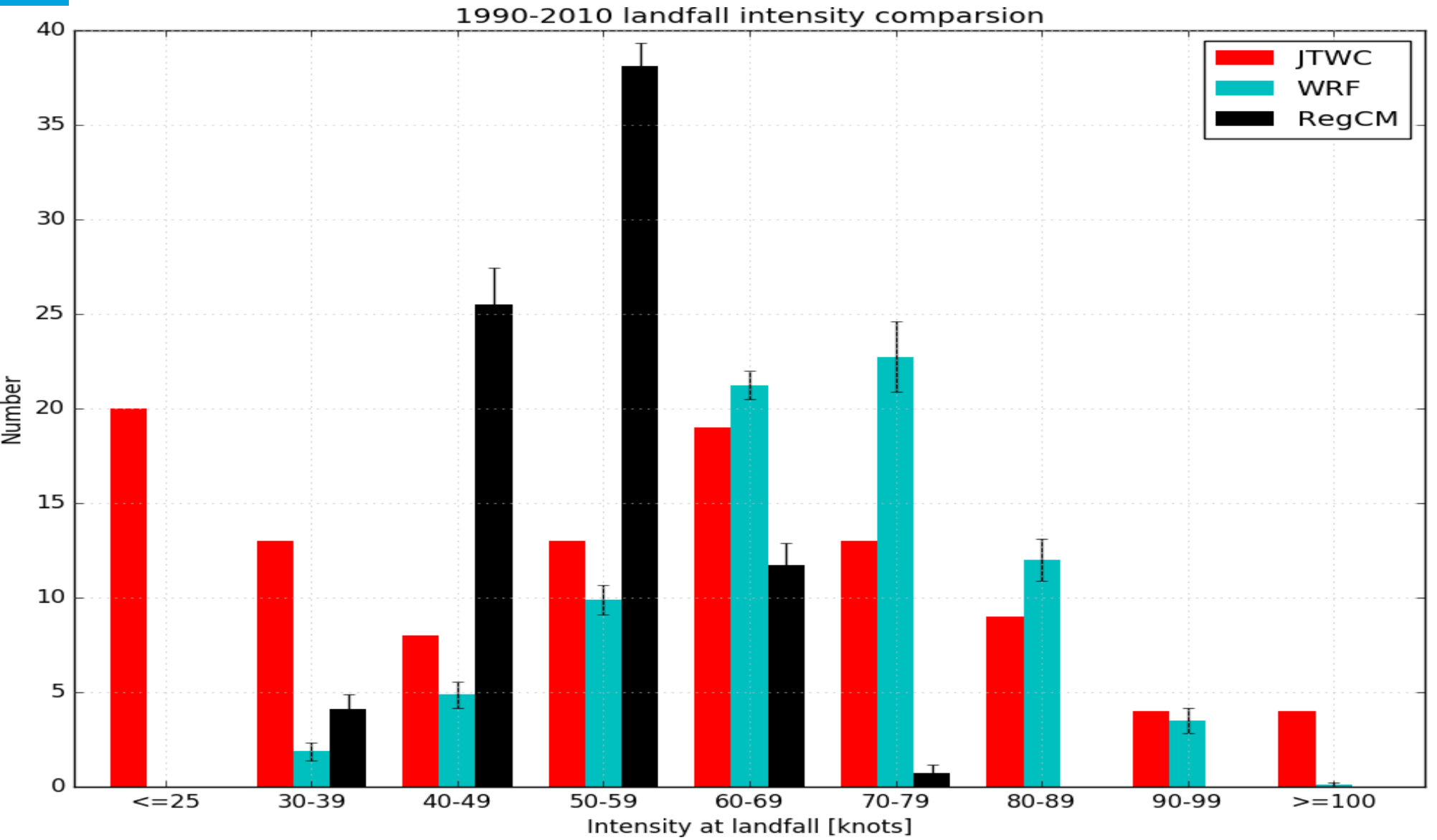
Test region: South China Coast



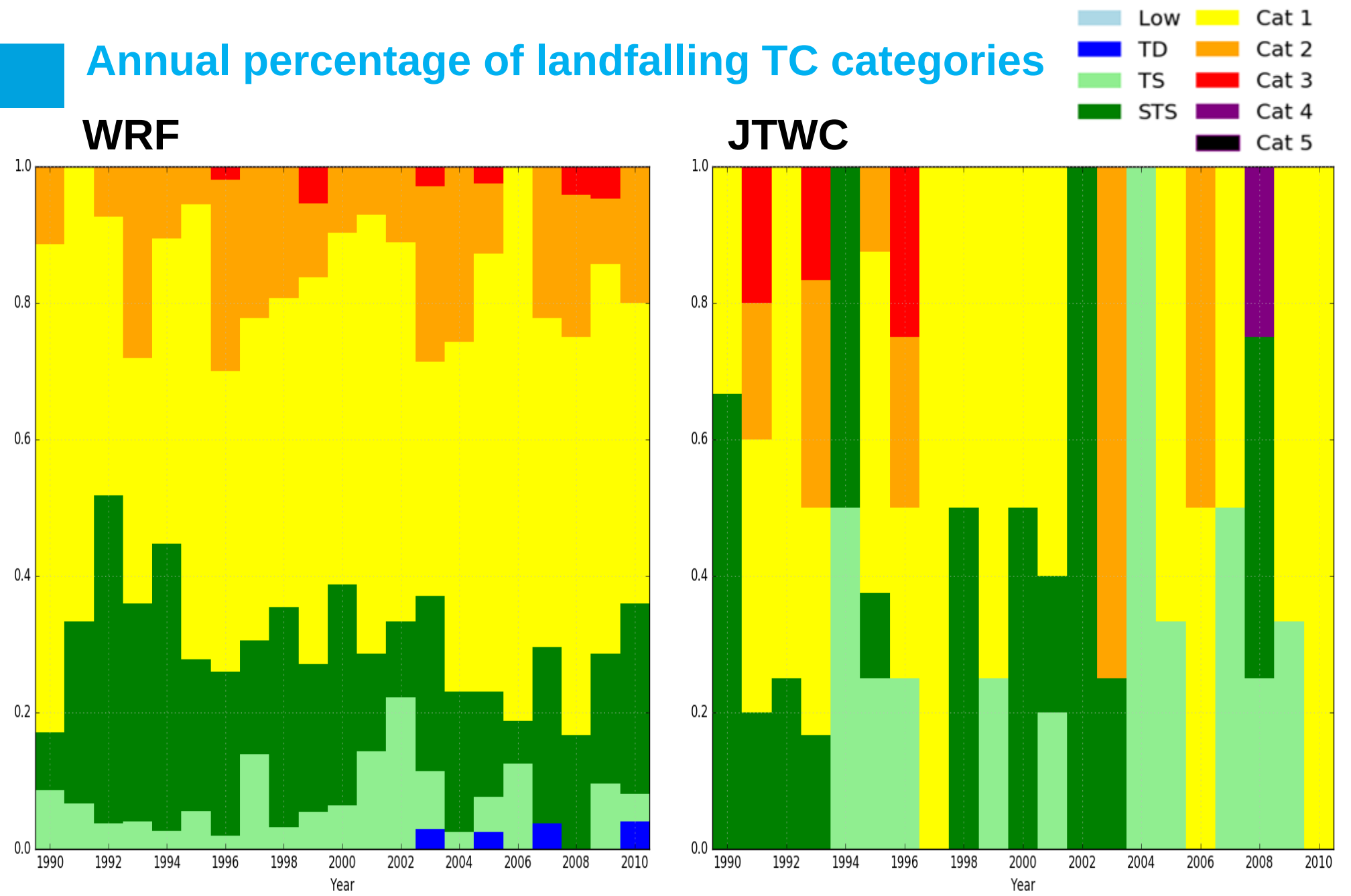
Annual number of landfalling TC along South China coast



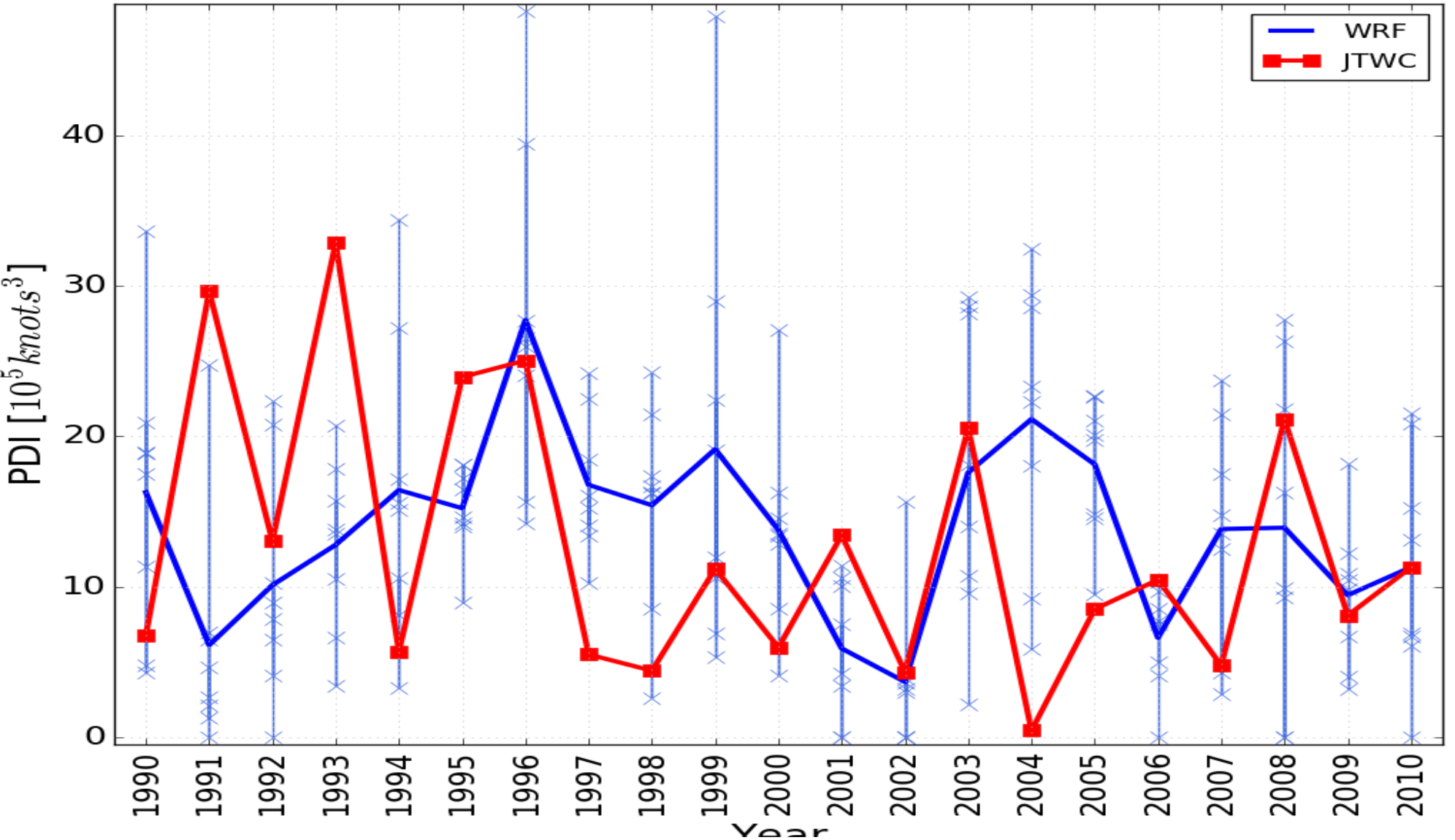
Distributions of TC intensity at landfall (1990-2010)



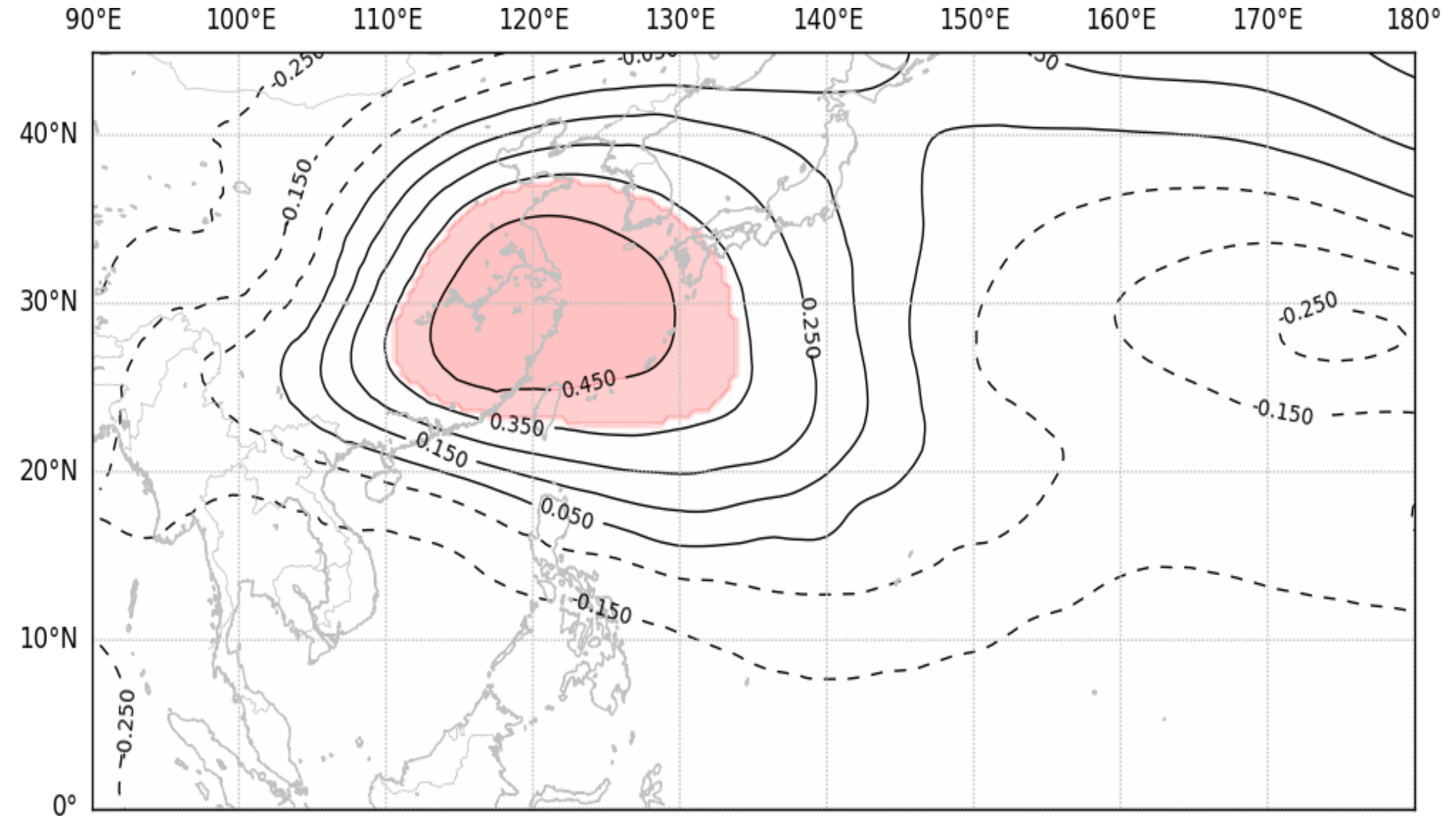
Annual percentage of landfalling TC categories



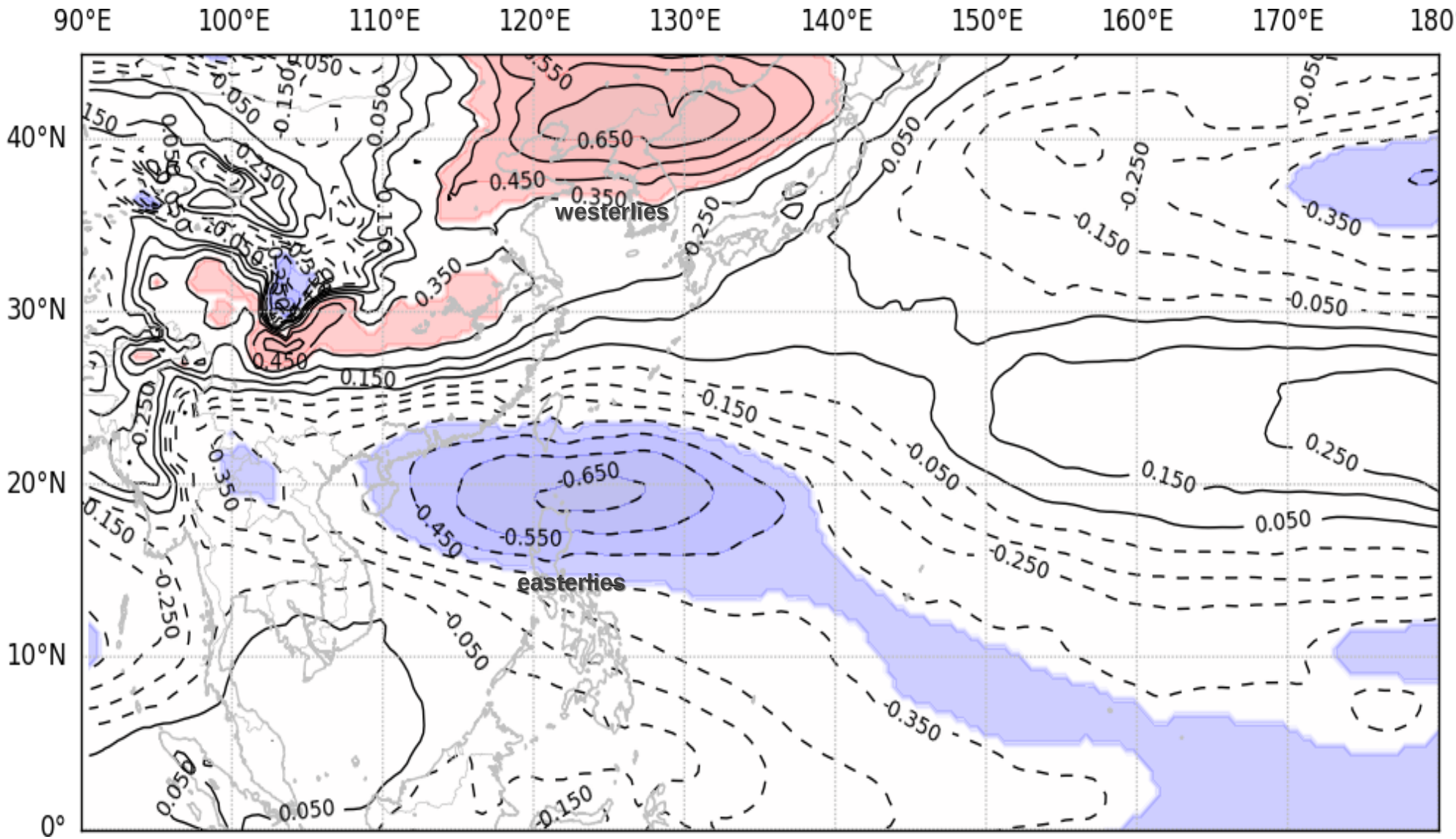
Annual PDI at TC landfall



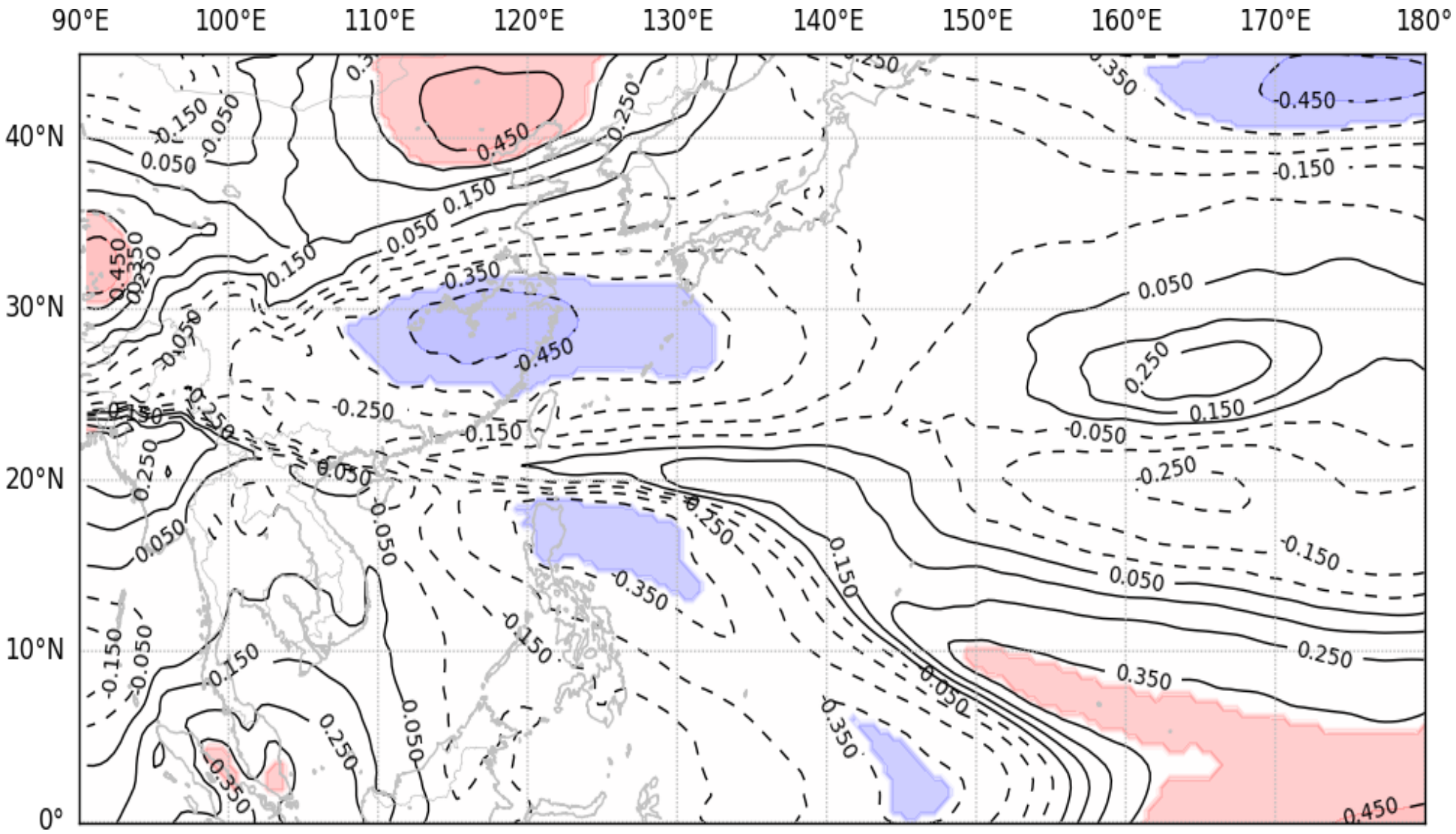
Correlation b/w RegCM hgt500 & simulated PDI at TC landfall



Correlation b/w RegCM u850 & simulated PDI at TC landfall



Correlation b/w RegCM VWS & simulated PDI at TC landfall



Summary

- Choice of cumulus scheme is important in regional climate modeling
- Even with a 60-km resolution, RegCM3 is able to generate vortices with structures that resemble those of real tropical cyclones.
- The model is capable of reproducing the basic climatology and interannual variability of tropical cyclones in the western North Pacific, and producing good hindcasts.
- Landfall hindcasts are also good especially in the South China region.

Summary

- 2014 real-time forecasts and verifications suggest that the ability of the regional model to predict seasonal activity depends strongly on the ability of the global model to predict the large-scale atmospheric and ocean conditions; 2015 gave better results because the global model performed much better in terms of predicting the occurrence of El Niño.

- Nesting WRF into the RegCM3 appears to have the potential of predicting seasonal intensity in a region, although more studies need to be carried out to ascertain this conclusion.