Simulations of the Tropical Cyclone Climatology and Interannual Variability Using a High-Resolution Tropical Channel Model

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Introduction: What is tropical channel model?

- We tailored the Weather Research and Forecast (WRF) model with tropical channel configuration (hereafter refer to as Topical Channel Model，TCM) to study tropical cyclones (TCs) climatology and variability.
- Dislike typical regional climate model (RCM) and General Circulation model (GCM), TCM is continuous zonally but bounded in meridional direction and specifically designed to study tropical climate variabilities.

Fig.1 TCM domain and an outlook of TC simulations in the model.

- TCM has a horizontal resolution of 27-km and 32 vertical terrain-following sigma layers, covering 30° S-50° N.
- Physics parameterizations are carefully tuned to achieve more realistic TC and climate mean state simulations. No nudging or other data assimilations.

Introduction: What is tropical channel model?

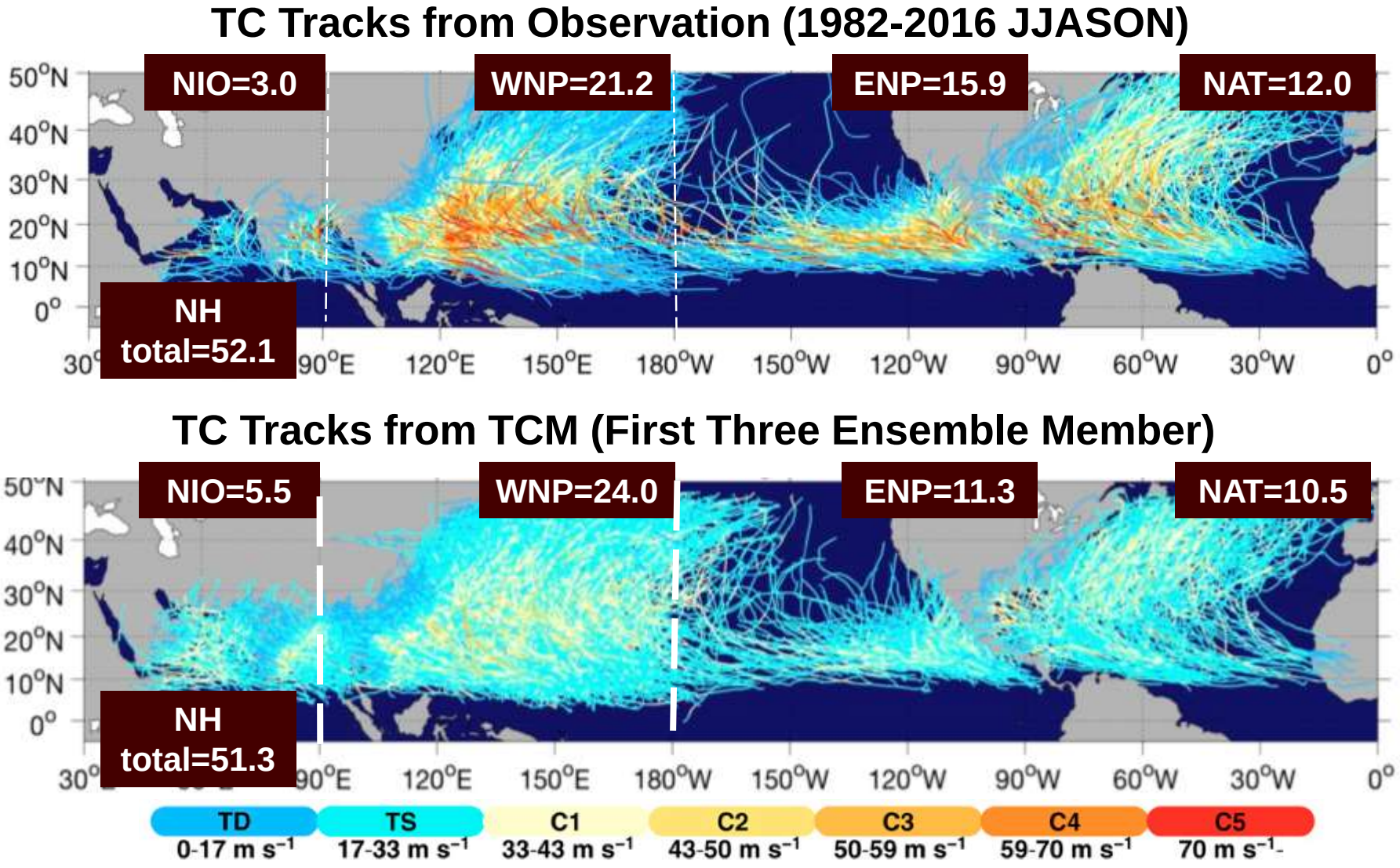
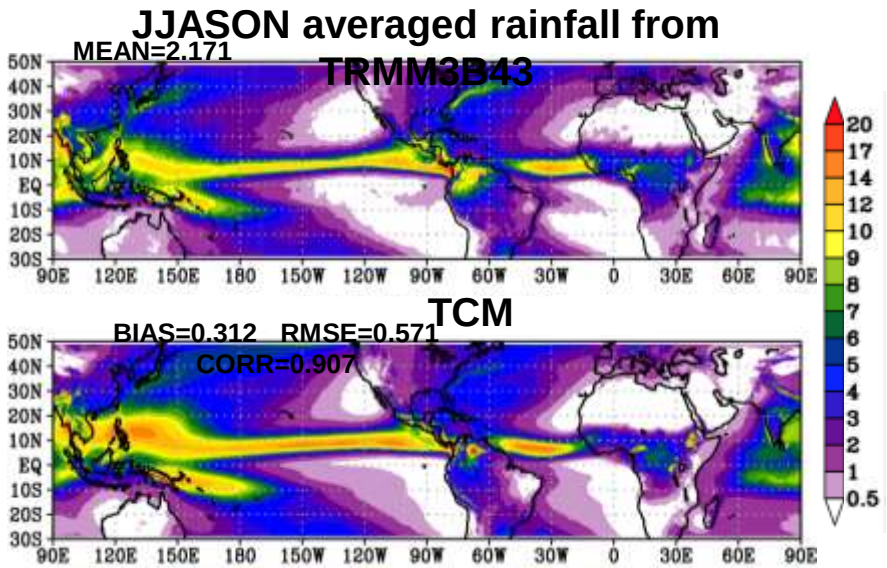


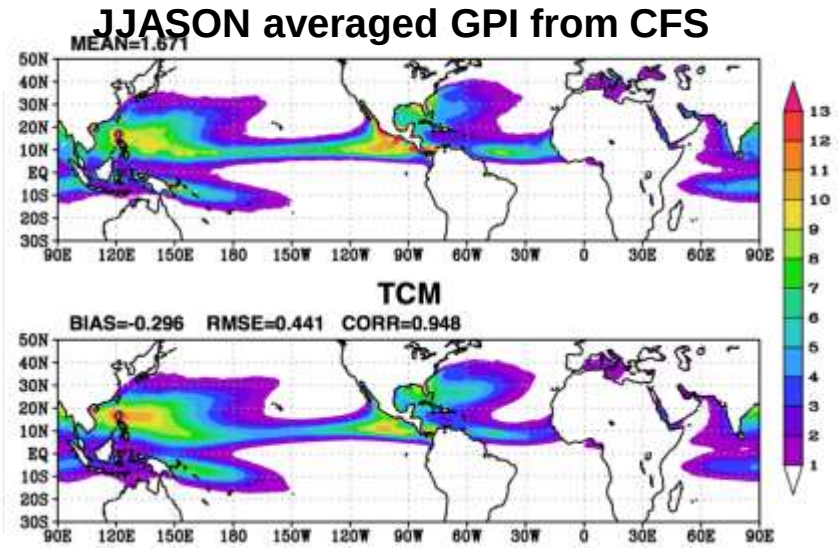
Fig.2 TC tracks from observations and TCM simulation.

We have already obtained following results:

- Large set of retrospective hurricane season simulations from 1982 to 2016 boreal summers, with 15-member ensemble for each season. SSTs and lateral boundary conditions from 6-hourly NCEP-CFSR or NCEP-CFSv2.
- Seasonal forecasts of 2017 and 2018 hurricane season with 30-member ensemble for each.

35-season retrospective simulations





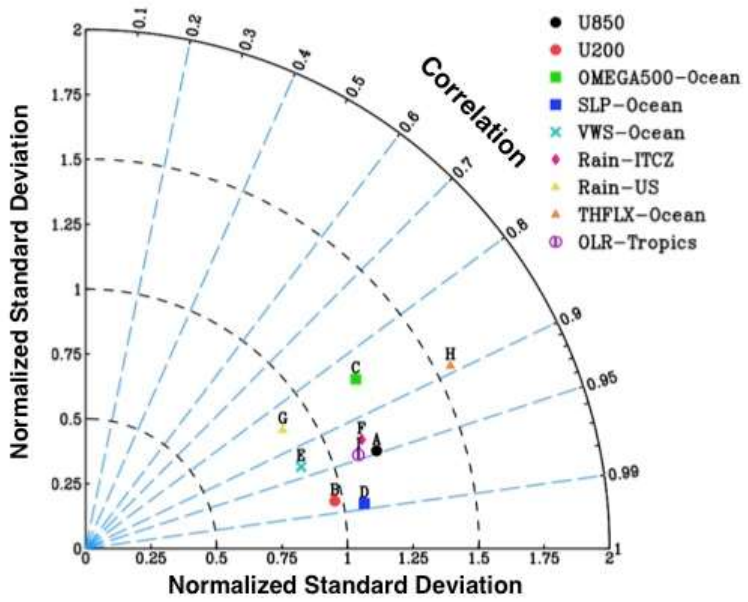


Fig.3 Comparison of rainfall, GPI (Emanuel and Nolan 2004) , and other key variables (Taylor diagram shown below) between observation and ensemble averaged TCM simulations .

	Number of Hurricanes	Number of TCs	ACE (Bell et al. 2000)
NAT	0.62**	0.63**	0.61**
WNP	0.64**	0.48**	0.80**
ENP	0.60**	0.65**	0.64**
NIO	-0.27	0.13	-0.16

**: 99% confidence level; *: 95% confidence level

Table 1 Correlations between observed and ensemble-mean simulated TC metrics.

35-season retrospective simulations

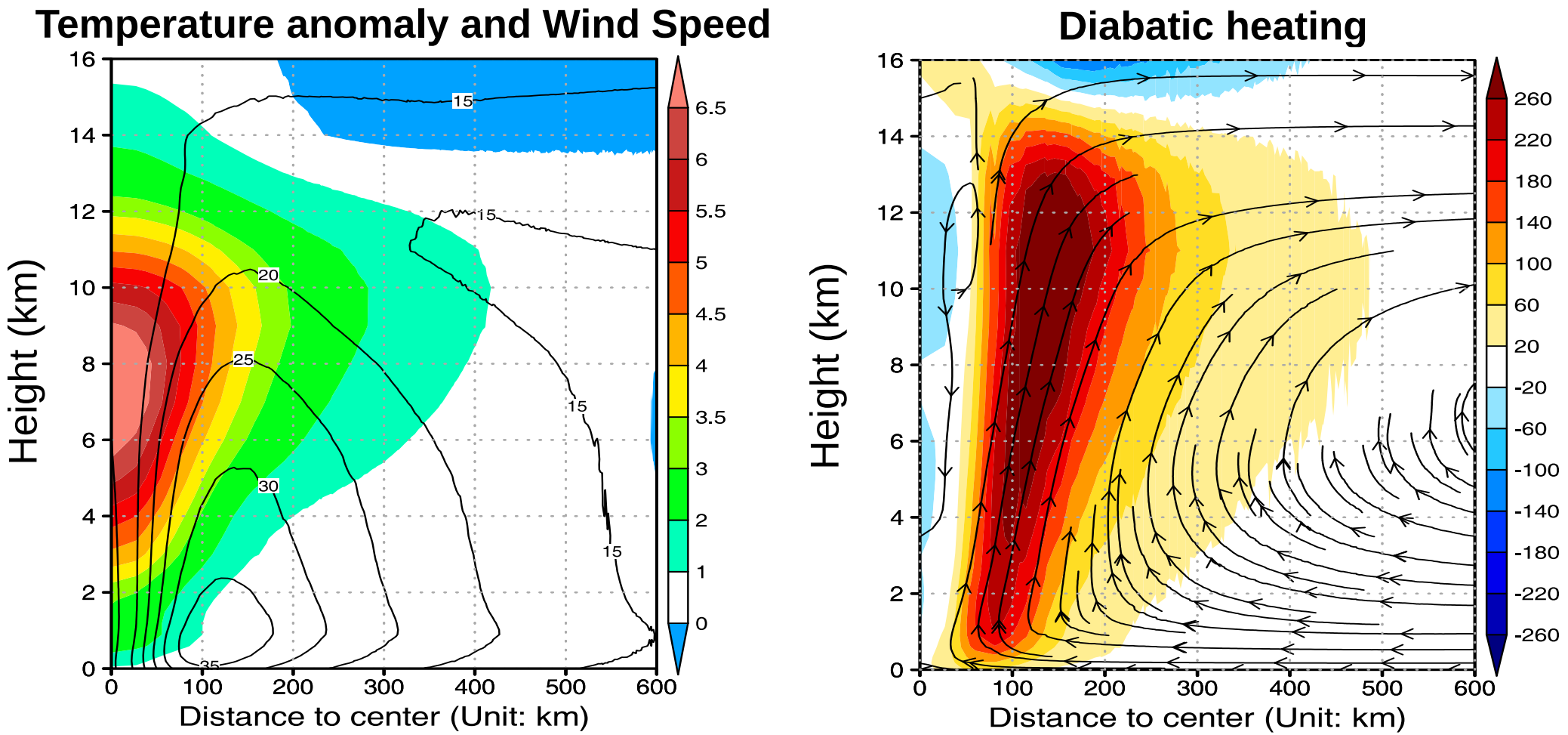


Fig.5 Composites of simulated Atlantic hurricane cross sections.

35-season retrospective simulations

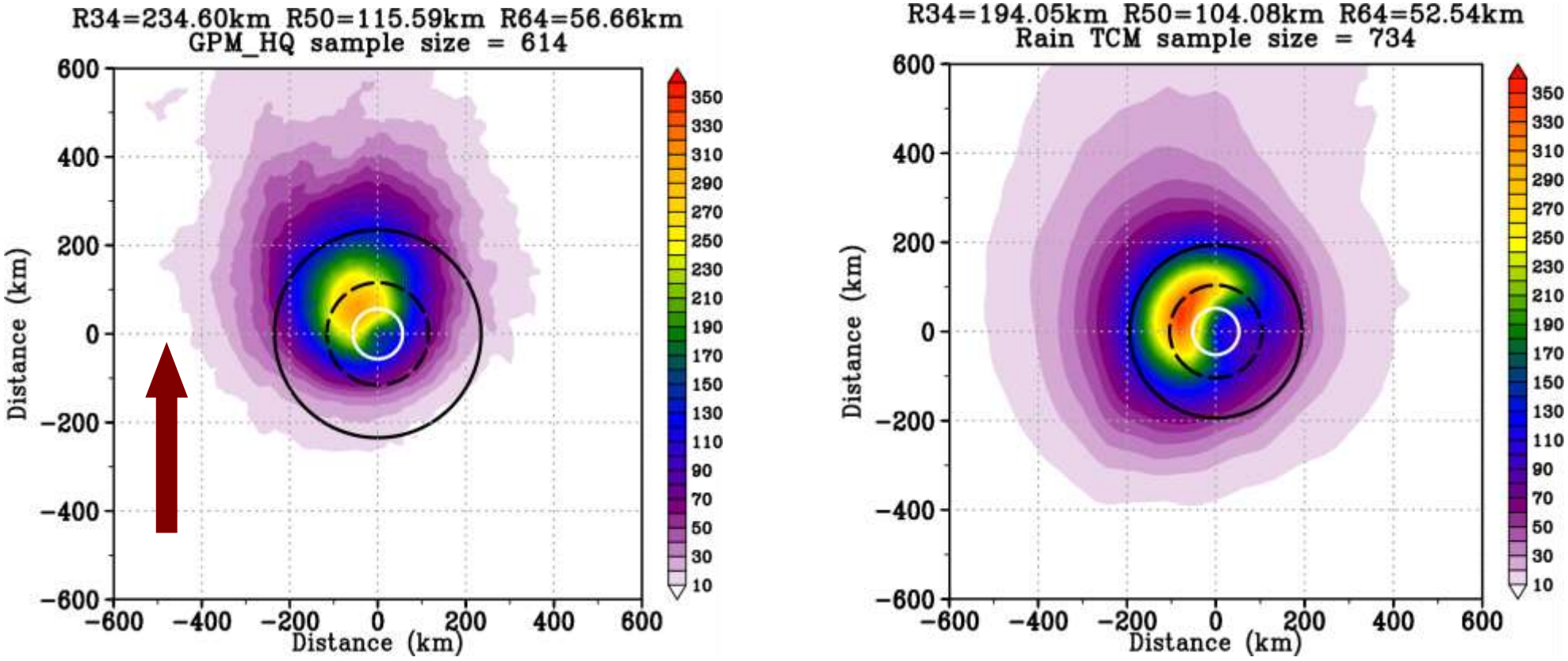


Fig.6 Composites of Atlantic hurricane rainfall and wind radii from observation and TCM simulations. The plots are rotated based on environmental shear direction.

35-season retrospective simulations

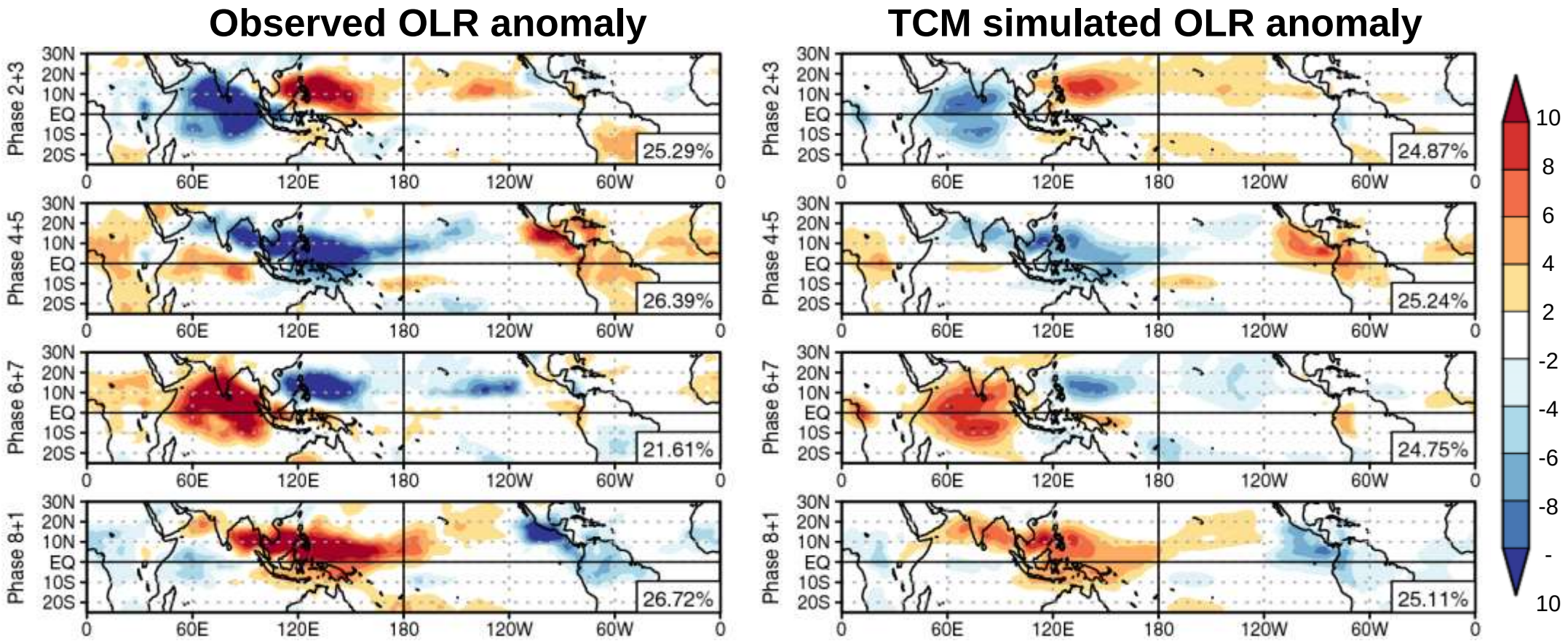


Fig.7a Composites of OLR anomaly and TC genesis density anomaly based on different MJO phases.

35-season retrospective simulations

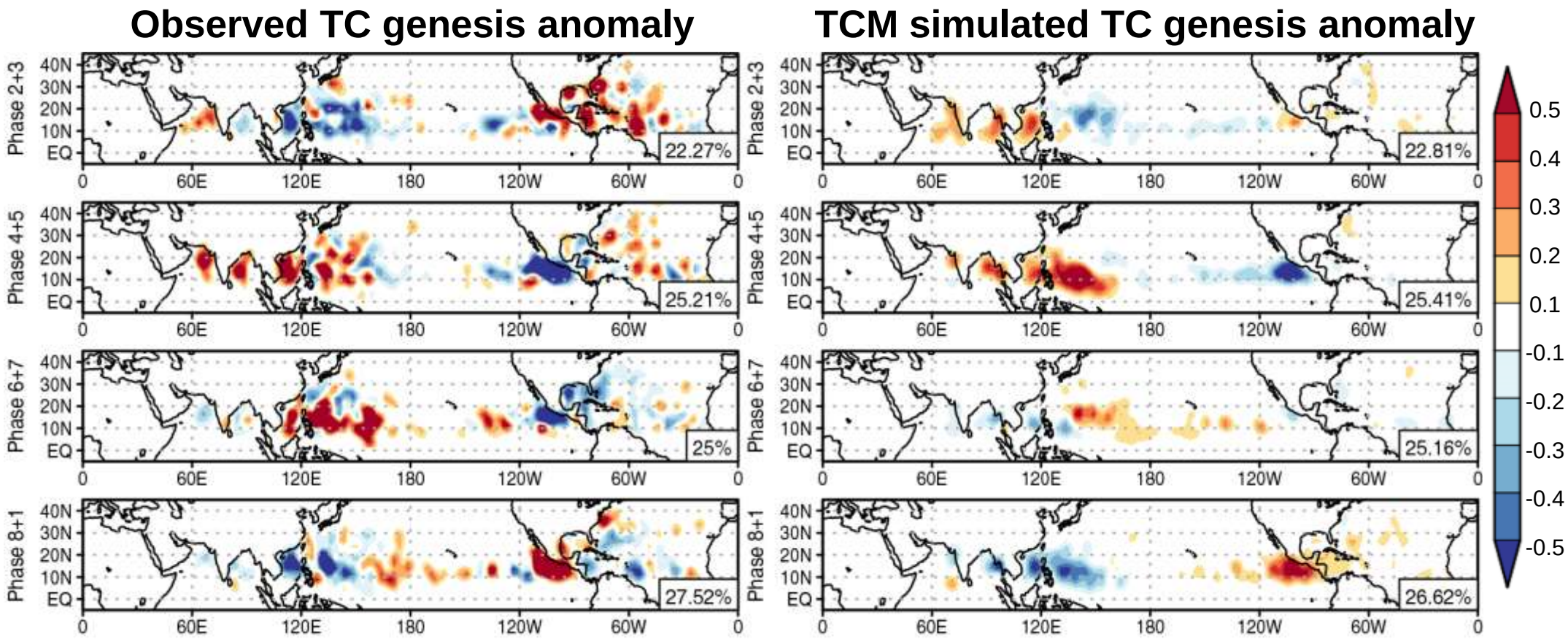


Fig.7b Composites of OLR anomaly and TC genesis density anomaly based on different MJO phases.

Forecasts of 2017 and 2018 hurricane season

- SST inputs are from bias-corrected CFSv2 operational forecast. 30-member ensemble averaged.
- Boundary conditions are fixed to the observed values of 1996. Another set of retrospective simulations with 1996 fixed boundary conditions from 1990-2016 are made to generate climatology.

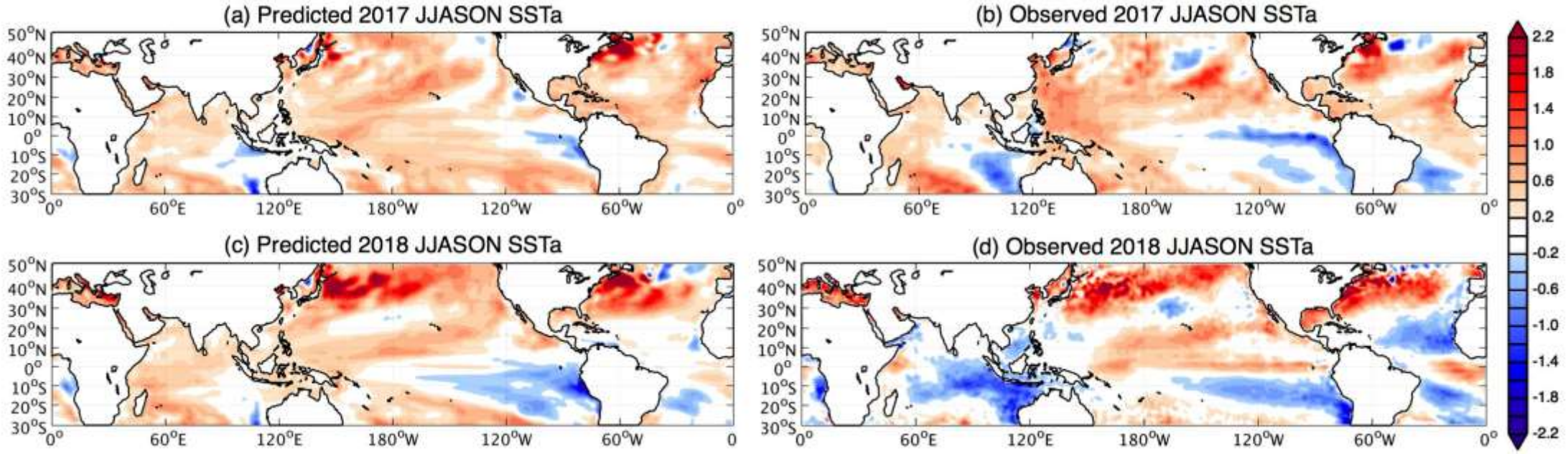
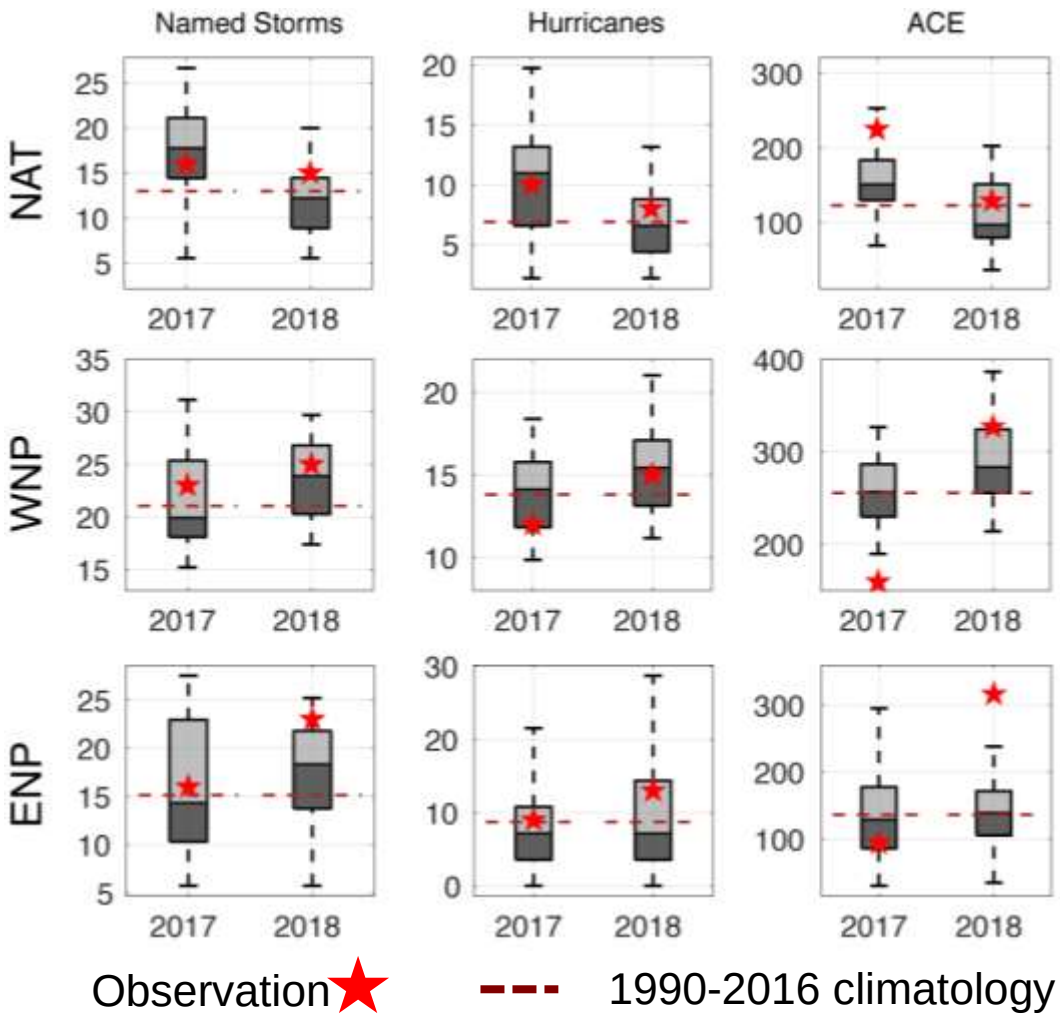


Fig.8 Predicted and observed 2017 and 2018 JJASON SST anomaly (relative to 1982-2010). The SST seasonal predictions are made in Mays, from CFS operational forecast.

Forecasts of 2017 and 2018 hurricane season



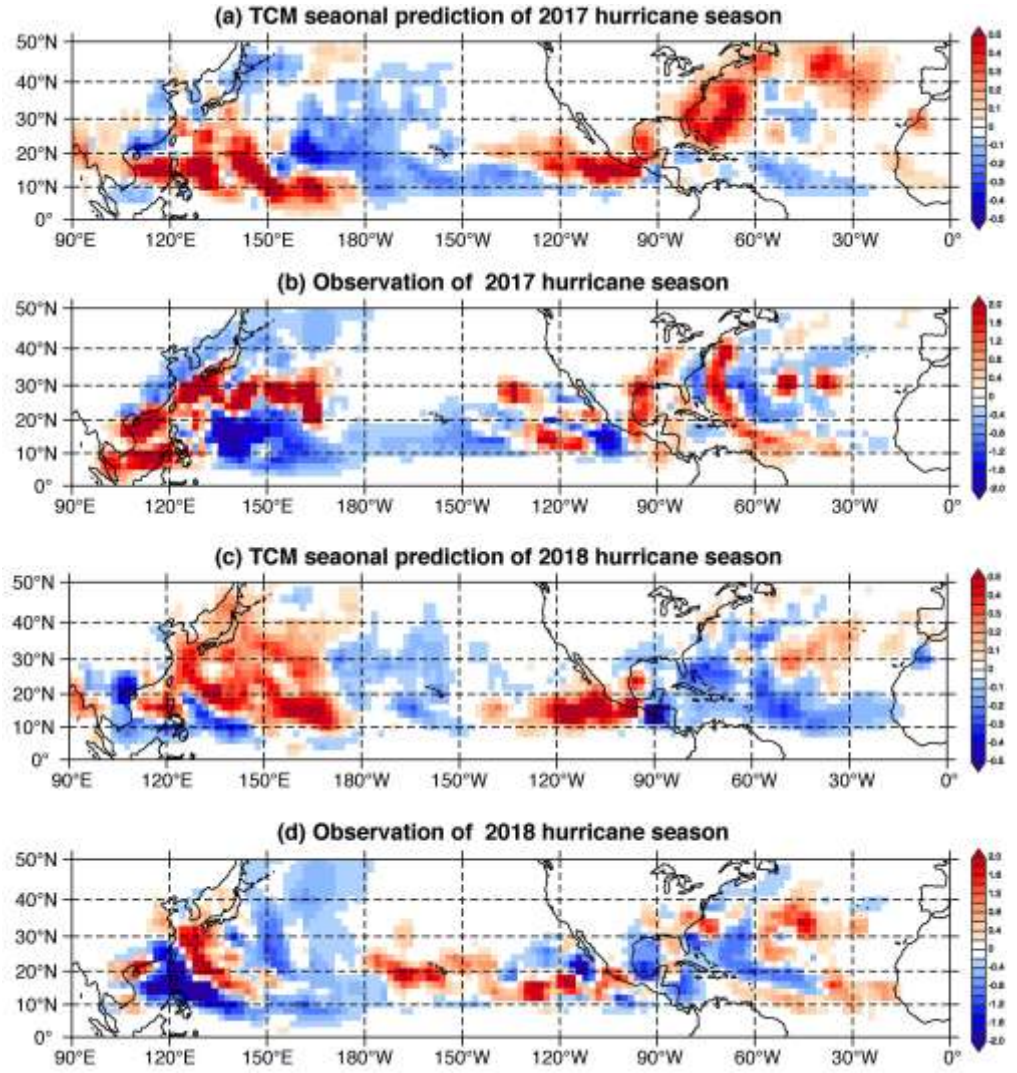


Fig.9 Boxplots of 2017 and 2018 seasonal TC forecast results.

Conclusions

- TCM yields great skills in simulating TCs, including climatology and subseasonal to seasonal variations.
- Simulated TCs characterize with realistic structures.
- TCM successfully predicts the hyperactive 2017 Atlantic hurricane season. For 2018 season, record-breaking ENP TC season is not well predicted due to the flaws in SSTa.
- Manuscript has been submitted to *Journal of Climate*.