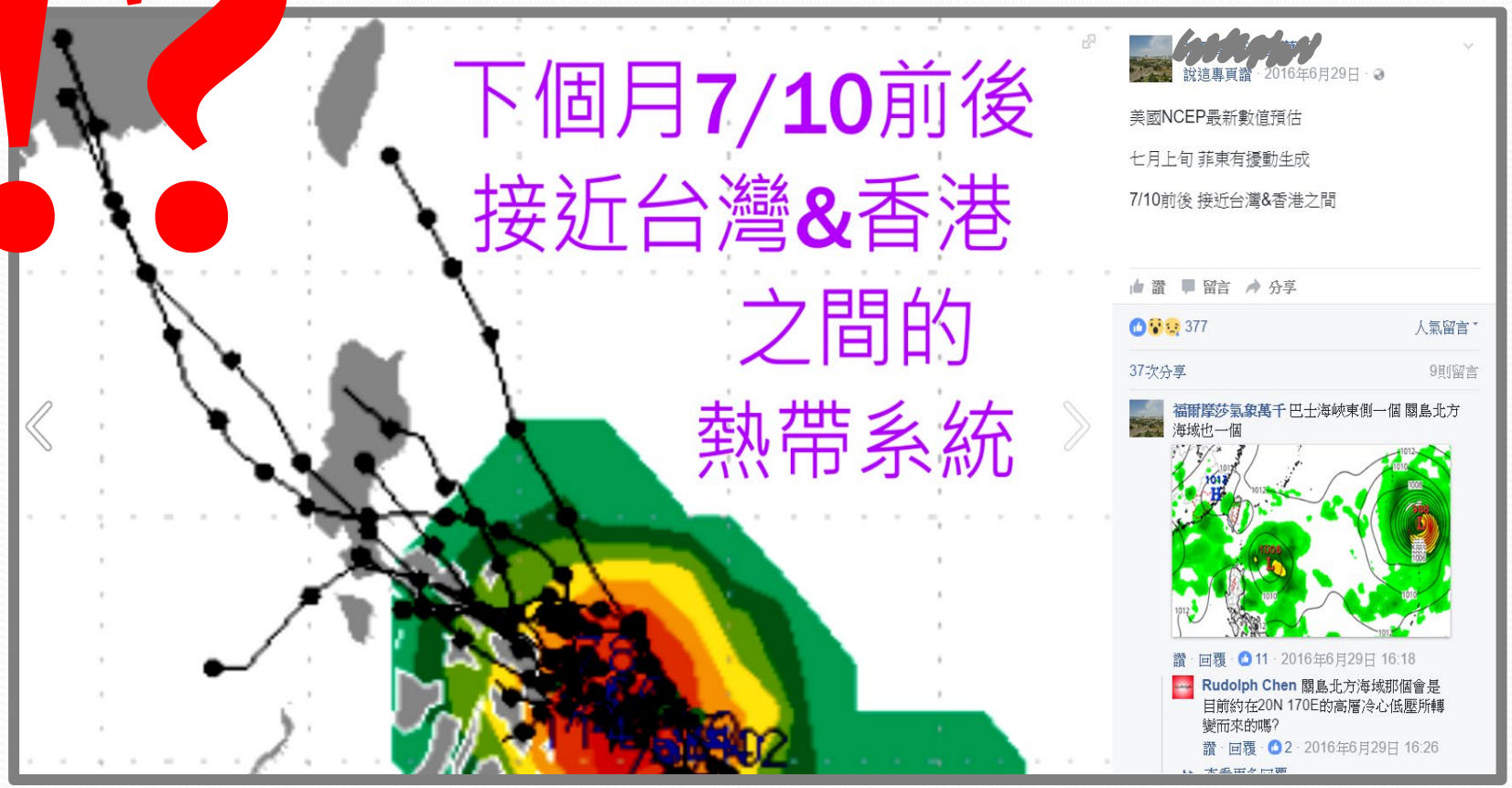
The Characteristics of Tropical Cyclone Formation in an Environment with Strong Low Frequency Vorticity in the Western North Pacific



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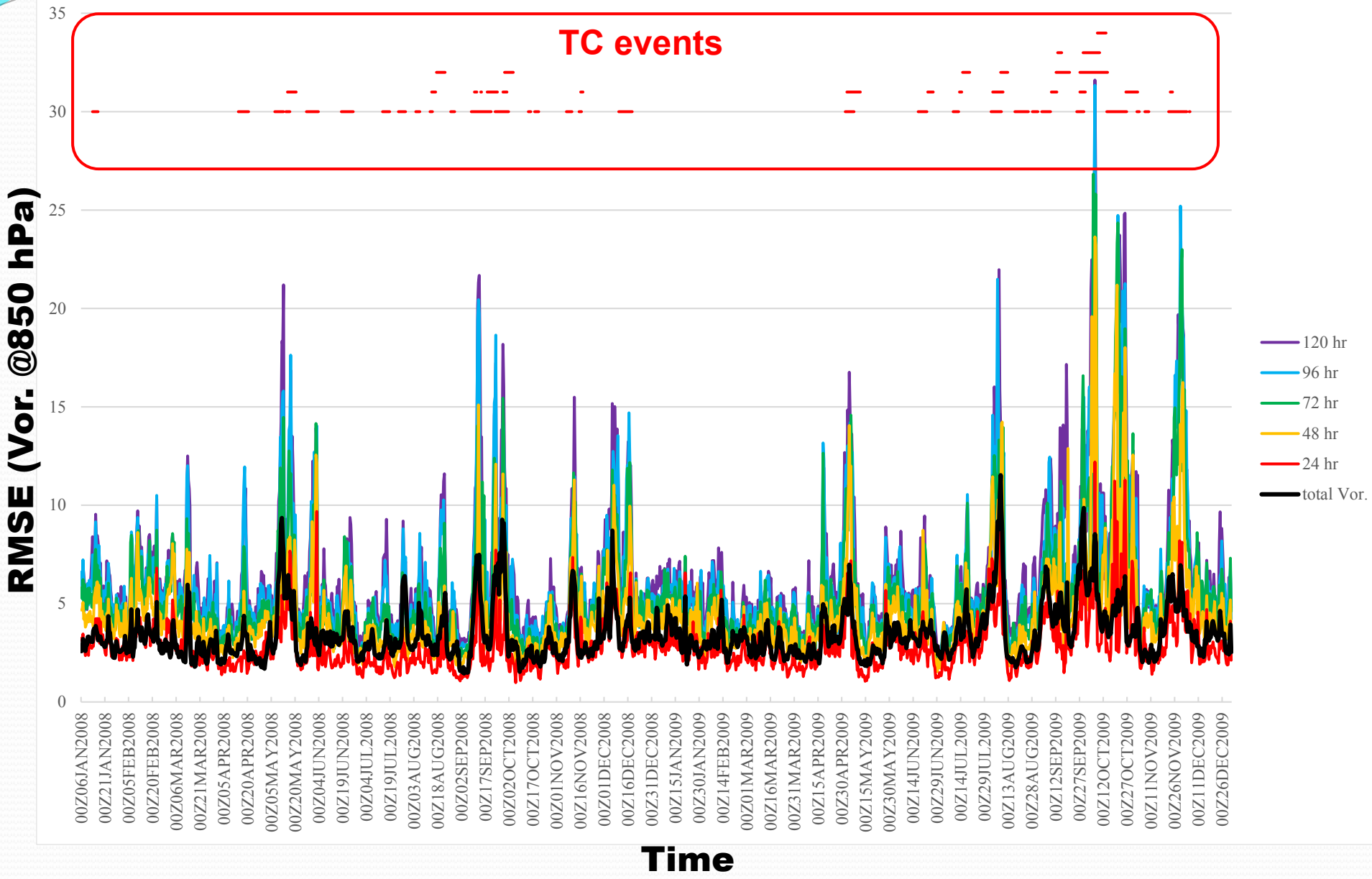
ECMWF Model errors (RMSE) in WNP (0-30 ˚N, 100-180 ˚E) during 2008-2009

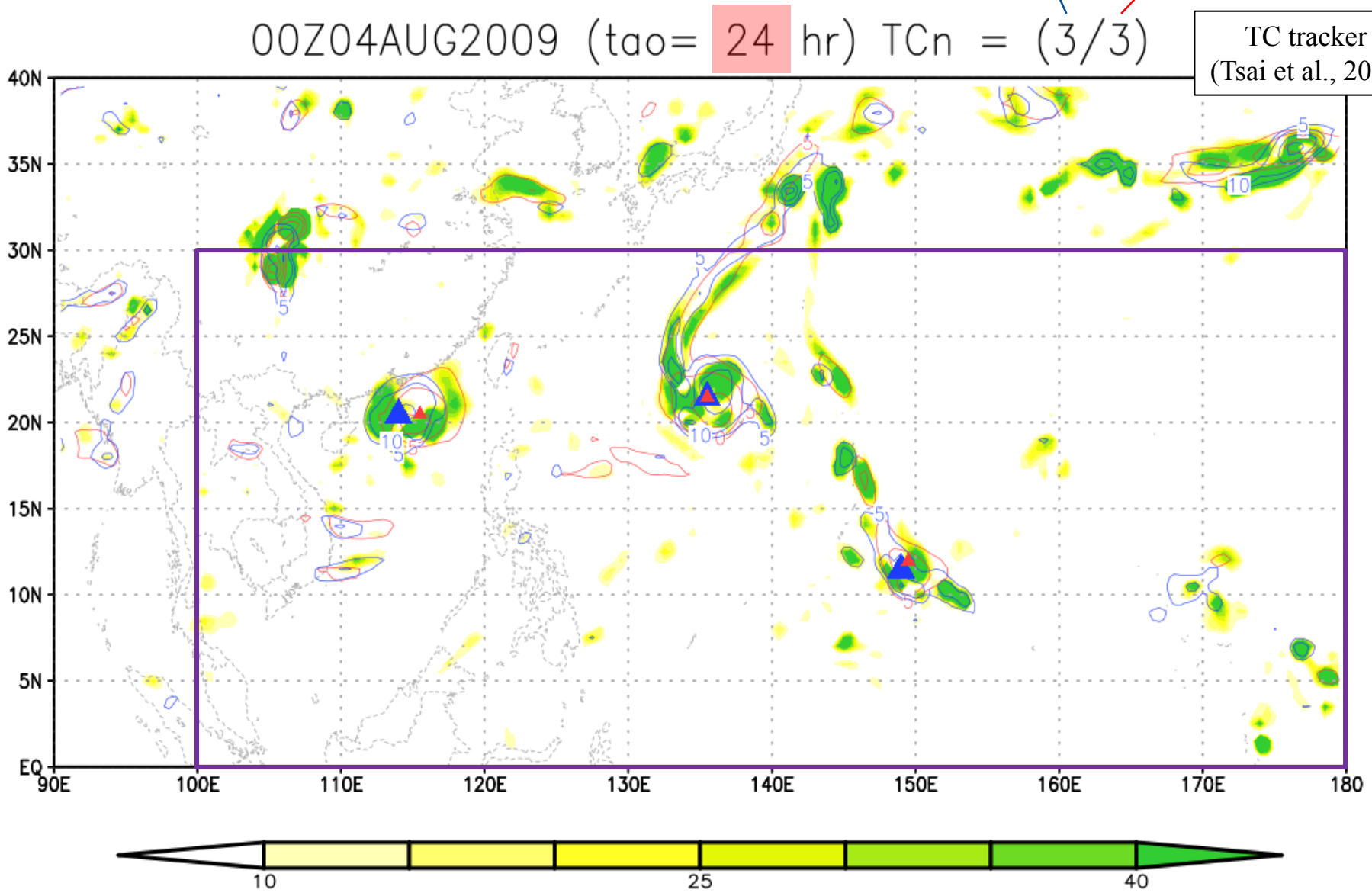


— vorticity @ 850 hPa (analysis)

— vorticity @ 850 hPa (forecast)

TC #

in analysis/ in forecast



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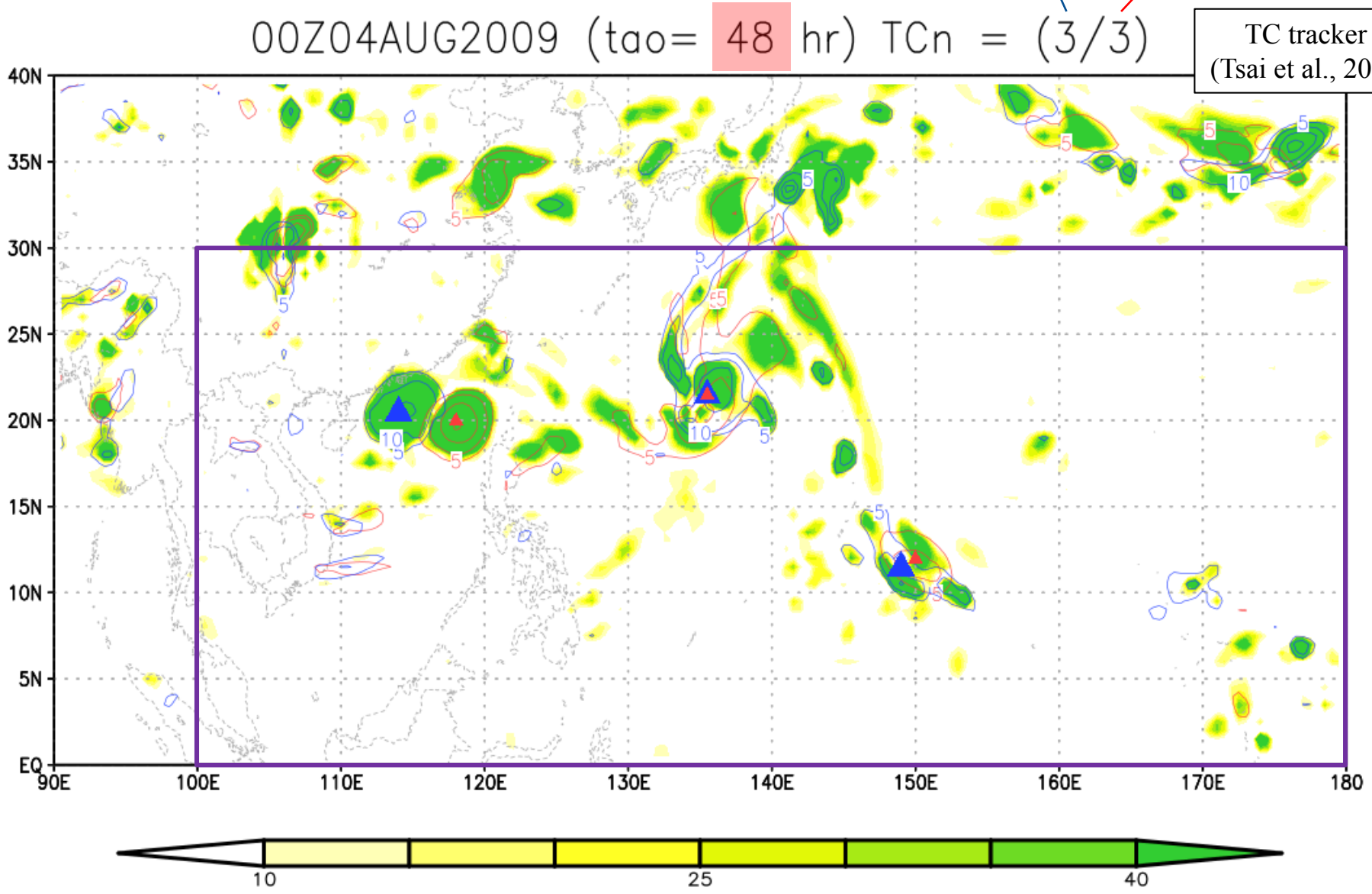

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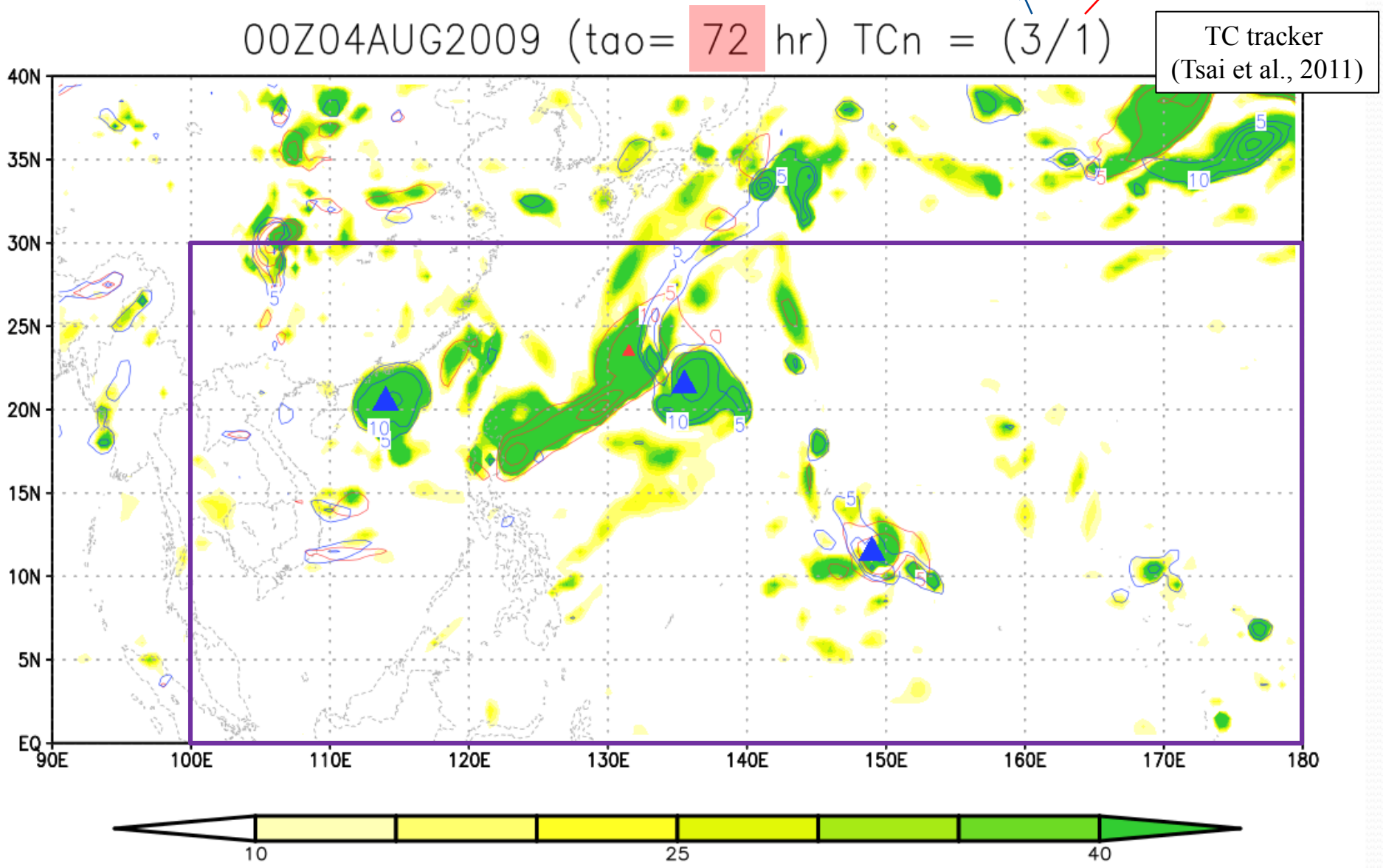

— vorticity @ 850 hPa (analysis)

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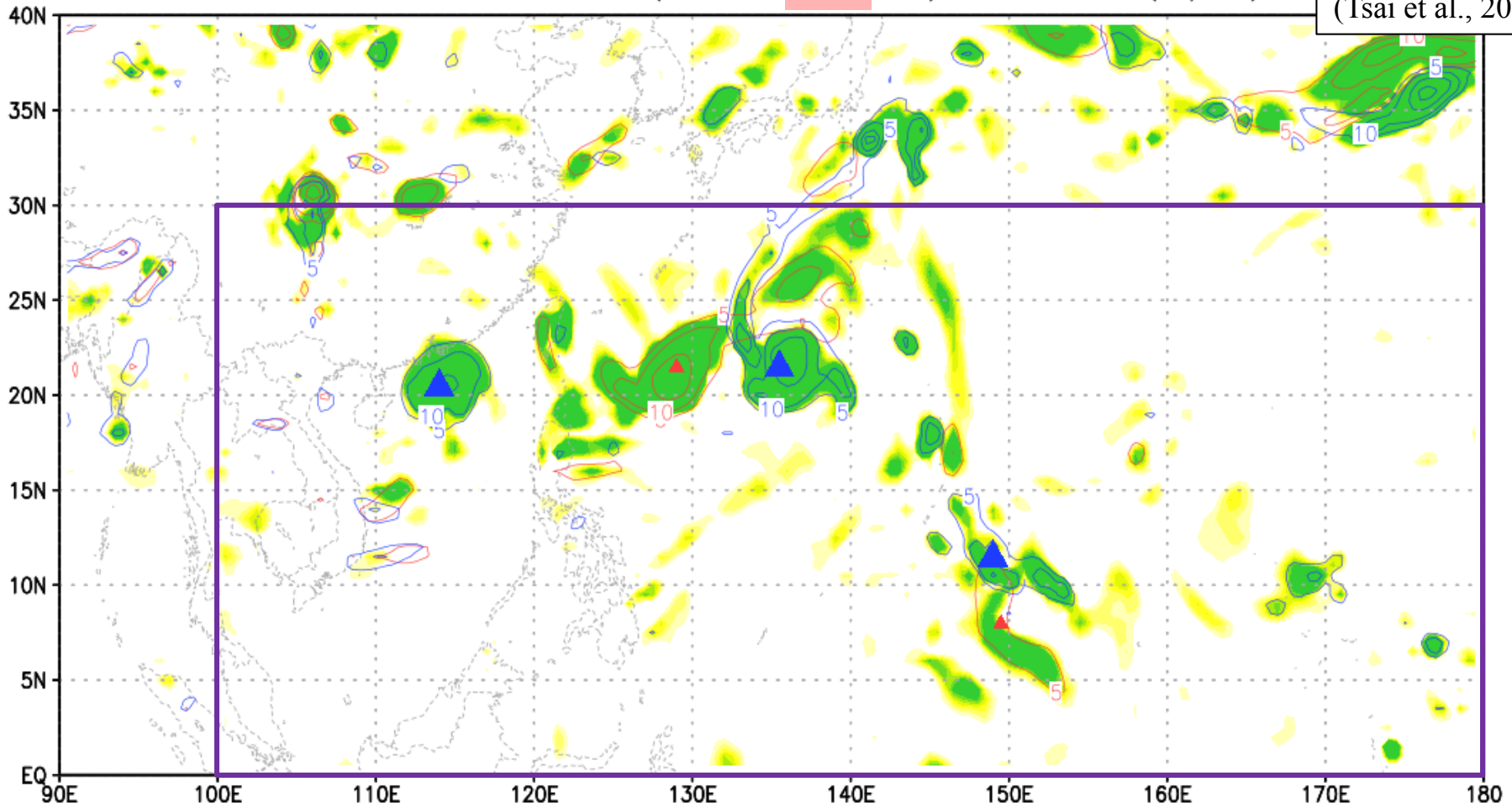
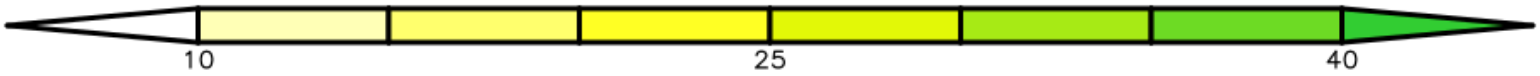
TC #

in analysis/ in forecast

00Z04AUG2009 (tao= 96 hr) TCn = (3/2)

TC tracker (Tsai et al., 2011)





RMSE (Vor. @850 hPa, $\times 10^{-5}$ s^{-1})

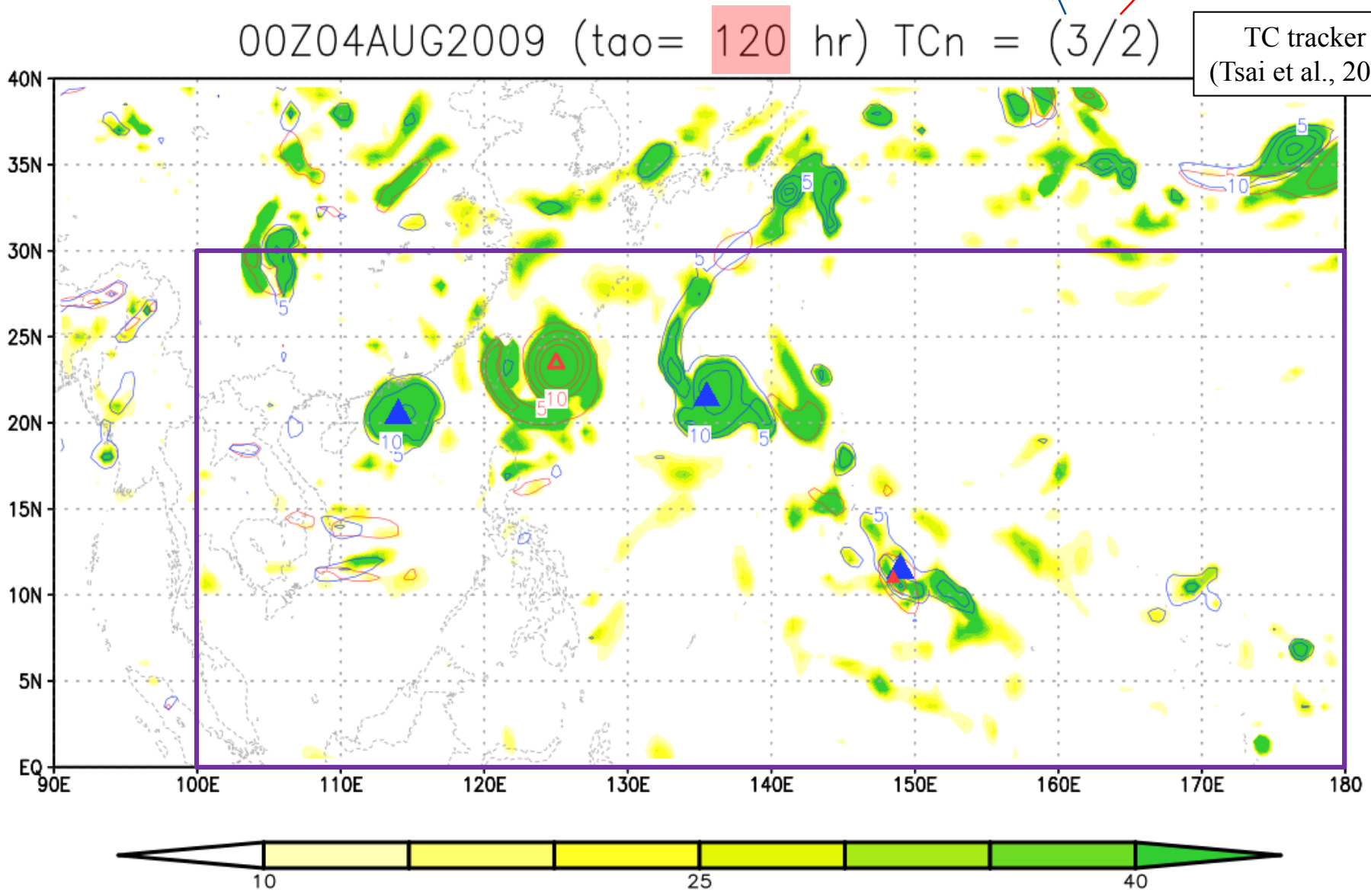
GrADS: IGES/COLA

— vorticity @ 850 hPa (analysis)

— vorticity @ 850 hPa (forecast)

TC #

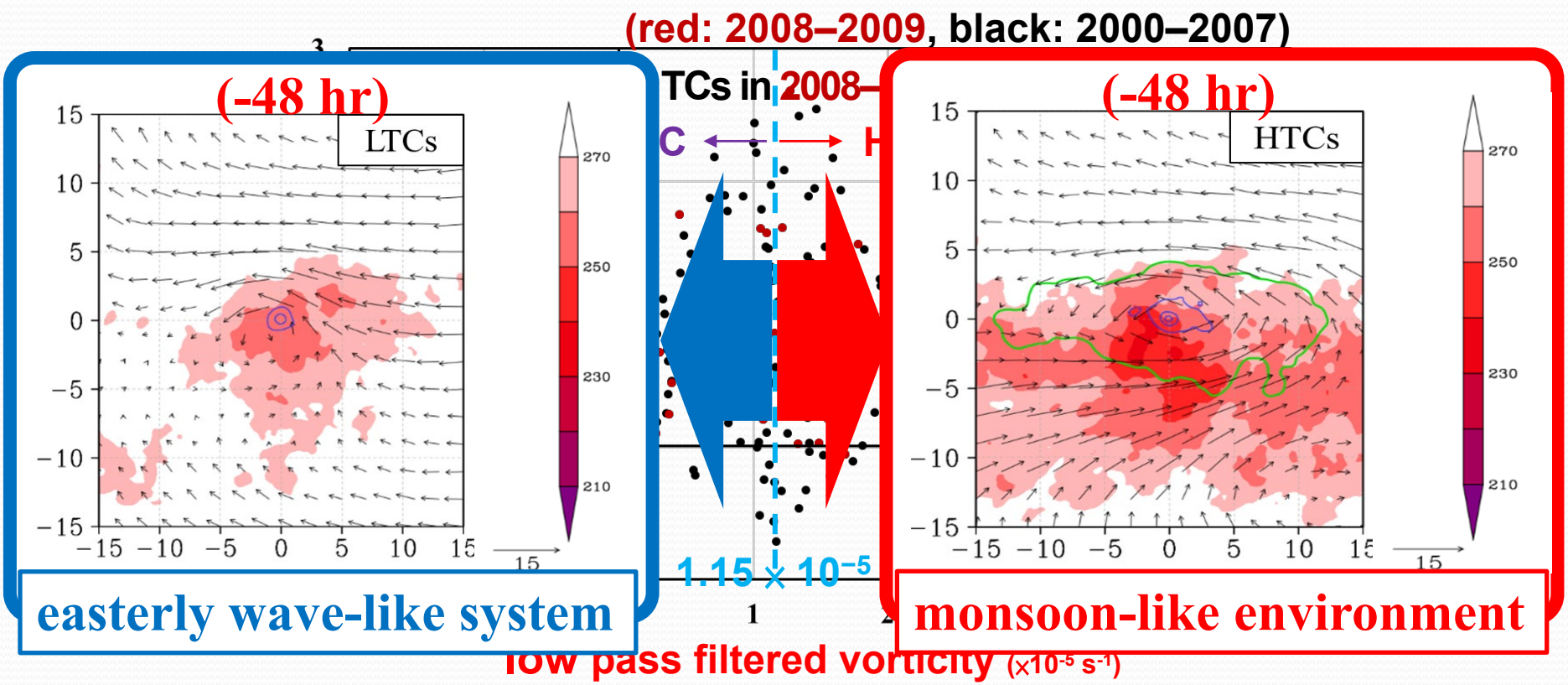
in analysis/ in forecast



Background 850-hPa vorticity of pre-TC disturbances

The 10-day* low pass and high pass filters are applied to NCEP_FNL (2000-2009) data to obtained low/high pass filtered winds. - (* Wu et al., 2013)

Use filtered winds to compute 850-hPa mean vorticity within 5° radius of the pre-TC disturbance in the WNP at 24-48h before the formation of TC (Vmax ~ 25kt).

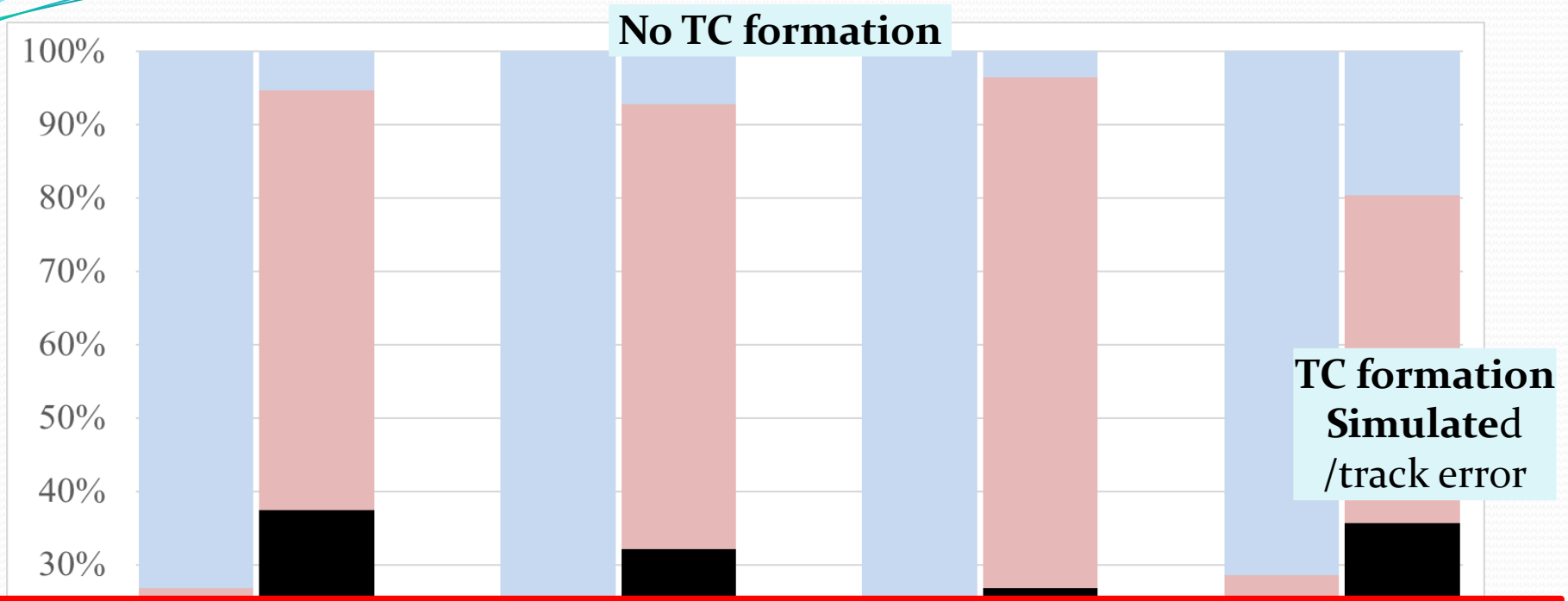


TCs with Higher low-frequency vorticity, 26 HTCs - HTCs
TCs with Lower low-frequency vorticity, 26 LTCs - LTCs

Cumulus experiment

CU_EXP

- 48h - 72h - 96h - 120h



The **convection process** (cumulus scheme) is not the dominant factor for TC formation in an environment with large low-frequency vorticity (**HTC**, e.g. DUJUAN), but very important if the environmental low-frequency vorticity is small (**LTC**, e.g. NURI).

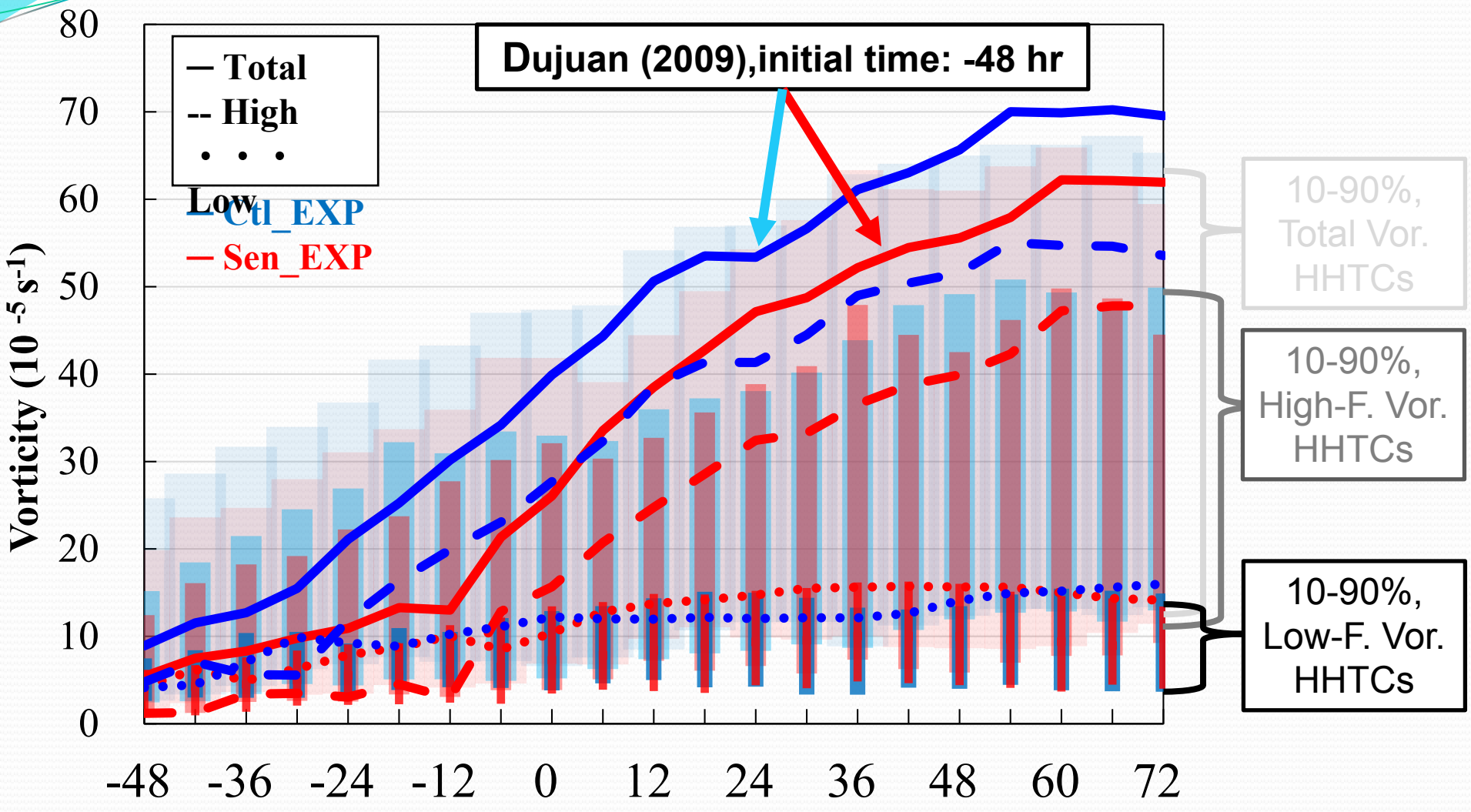
-Hsieh et al., 2017, MWR

Experiments	HHTC-formation rate (%) in all simulations/forecasts	LLTC-formation rate (%) in all simulations/forecasts	Average Track error at T_0 (km)
Ctl_Exp	100 %	75 %	196, 327, 501, 620 (-48, -72,-96, -120 hr)
Sen_Exp	100 %	35.7 %	330, 478, 671, 1013 (-48, -72,-96, -120 hr)
TIGGE	89.2%	38.1%	288, 436, 522, 695 (-48, -72,-96, -120 hr)

→ **~~Model dependent~~**

Results show that all simulations can reproduce the TC formation process in an environment with large 850-hPa low-frequency vorticity, even with the high-frequency parts being removed in initial conditions.

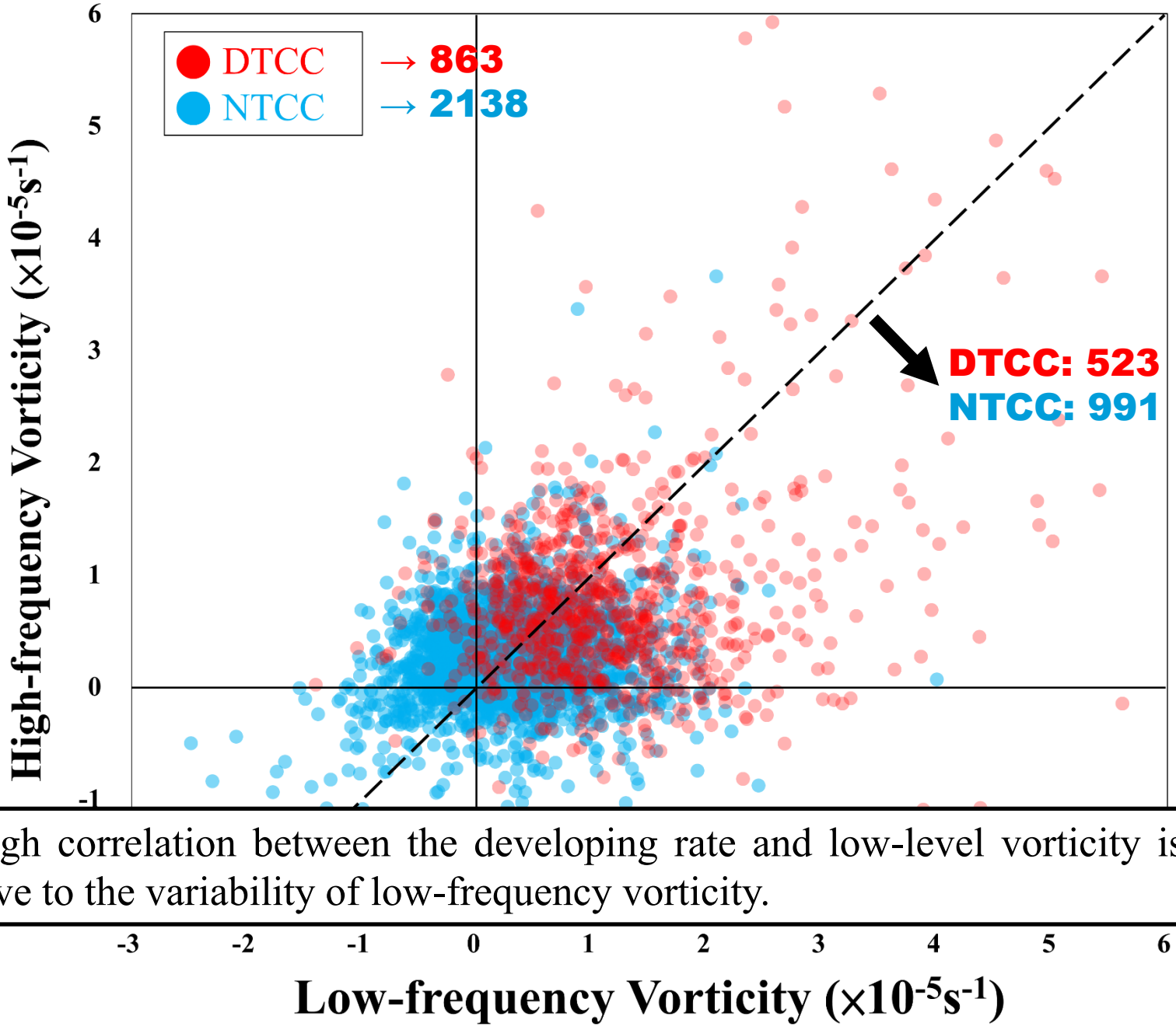
Time-series of simulated vorticity (1.5°)



High-freq. part of vorticity increases quickly around the center

Obs.

3,001 TCCs in 1981-2009 (Teng et al., 2014, GRL)



The high correlation between the developing rate and low-level vorticity is very sensitive to the variability of low-frequency vorticity.

- **The numerical model is more capable of simulating the TC formation process for TCs formed in monsoon-related environments**

-Hsieh et al., 2017, MWR

In our EXPs (Ctl_Exp, Sen_Exp)

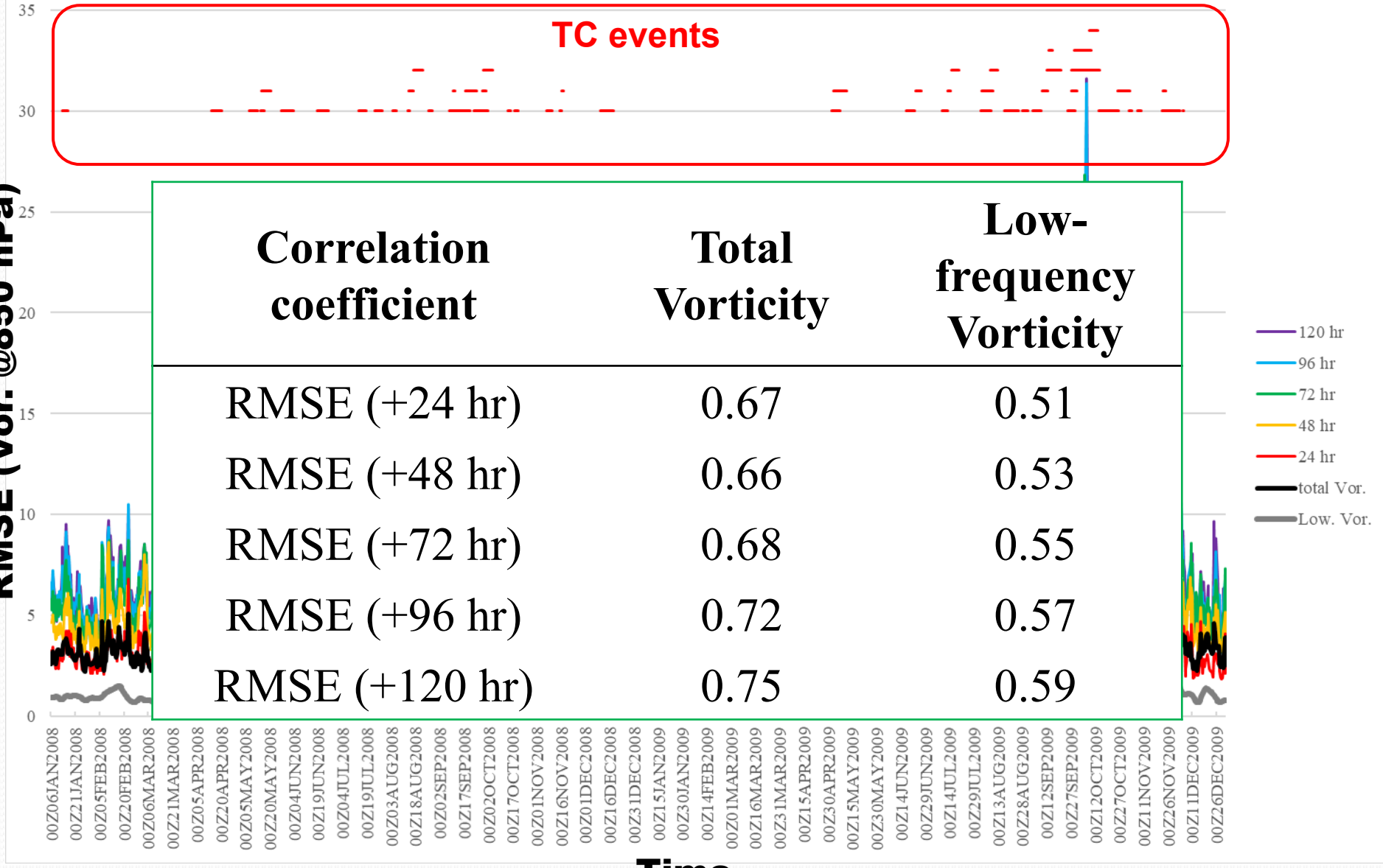
- The capability of the WRF model to simulate **HHTC** formation **is not sensitive** to the choice of cumulus scheme, and also **not sensitive** to the **high-frequency environment** in initial conditions.
- The **high-frequency systems** could determine the **position** of an initial vortex, which decide the value of vorticity tendency and affect the **strength** of **HHTC** in simulations.

- **TC formation can be expected (~5 days before formation) under specific environments (monsoon-related).**

→ Importance of environment > disturbance

- Hsieh et al., submitted to GRL

ECMWF Model errors (RMSE) in WNP (0-30 ˚N, 100-180 ˚E) during 2008-2009



Correlation coefficient	Total Vorticity	Low-frequency Vorticity
RMSE (+24 hr)	0.67	0.51
RMSE (+48 hr)	0.66	0.53
RMSE (+72 hr)	0.68	0.55
RMSE (+96 hr)	0.72	0.57
RMSE (+120 hr)	0.75	0.59

Thanks for your attention

- Hsieh, Y.-H, C.-S. Lee, and C.-H. Sui, 2017: A Study on the Influences of Low-Frequency Vorticity on Tropical Cyclone Formation in the Western North Pacific. *Mon. Wea. Rev.*, **145**, 4151–4169
- Hsieh, Y.-H, C.-S. Lee, and H.-F. Teng, 2019: The Characteristics of Tropical Cyclone Formation in an Environment with Large Low-Level Low-Frequency Vorticity in the Western North Pacific. *(Submitted to GRL)*

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