Are there increased observations of equatorial TC genesis in the satellite era?

Chih-Pei Chang

Naval Postgraduate School

(Current affiliation: National Taiwan University)

Laing , A. and J. L. Evans, 2016: Introduction to Tropical Meteorology

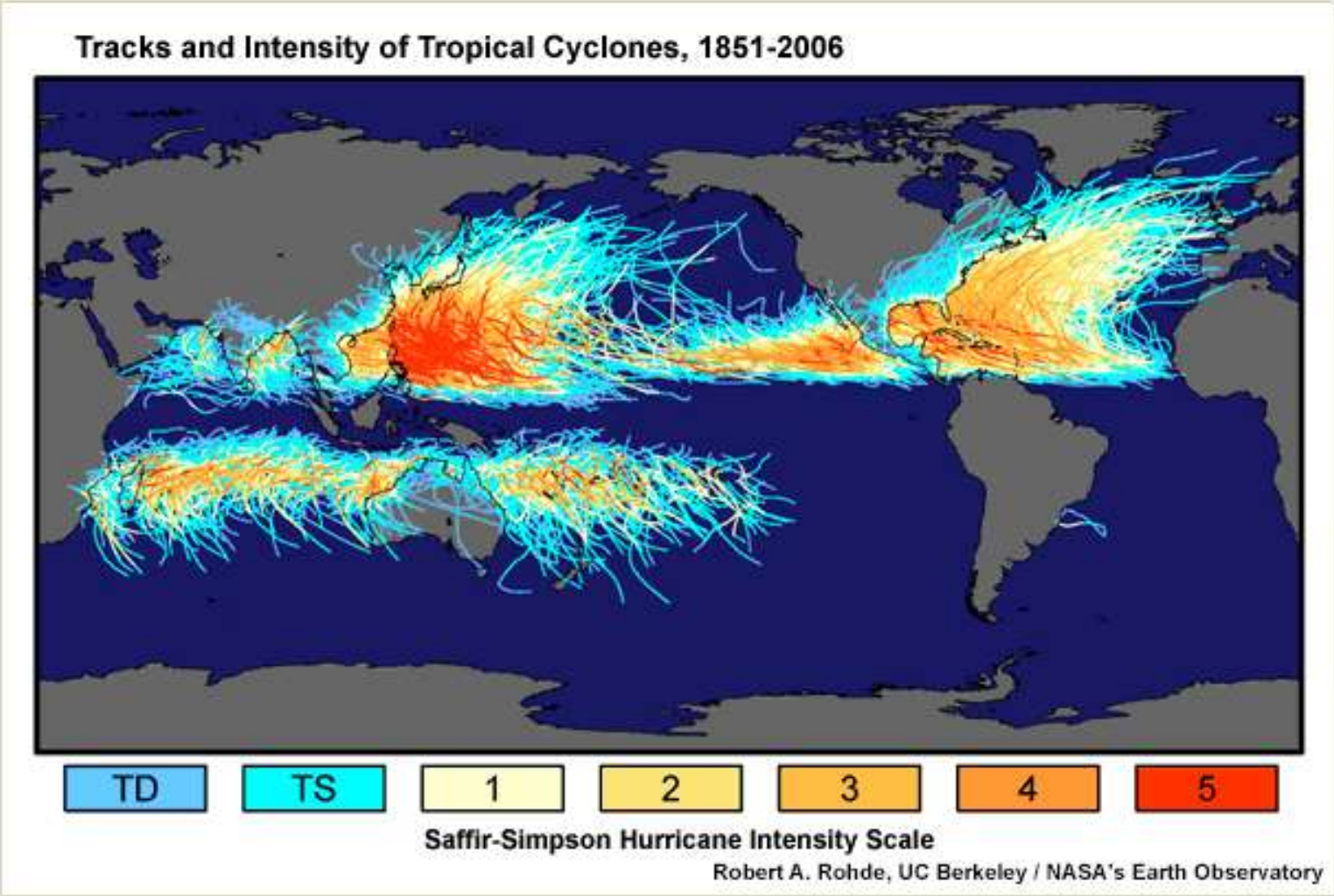


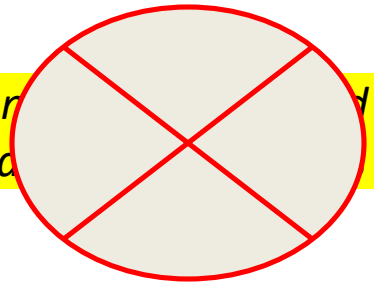
Fig. 8.1. Global distribution of observed tropical cyclone tracks from 1851-2006 (where available).

Laing , A. and J. L. Evans, 2016: Introduction to Tropical Meteorology

Six features of the large-scale tropics were identified by Gray (1968)[41] for tropical cyclogenesis:

(i) sufficient ocean thermal energy [SST > 26°C to a depth of 60 m],
(ii) enhanced mid-troposphere (700 hPa) relative humidity,
(iii) conditional instability,
(iv) enhanced lower troposphere relative vorticity,
(v) weak vertical shear of the horizontal winds at the genesis site, and
(vi) displacement by at least 5° latitude away from the equator.

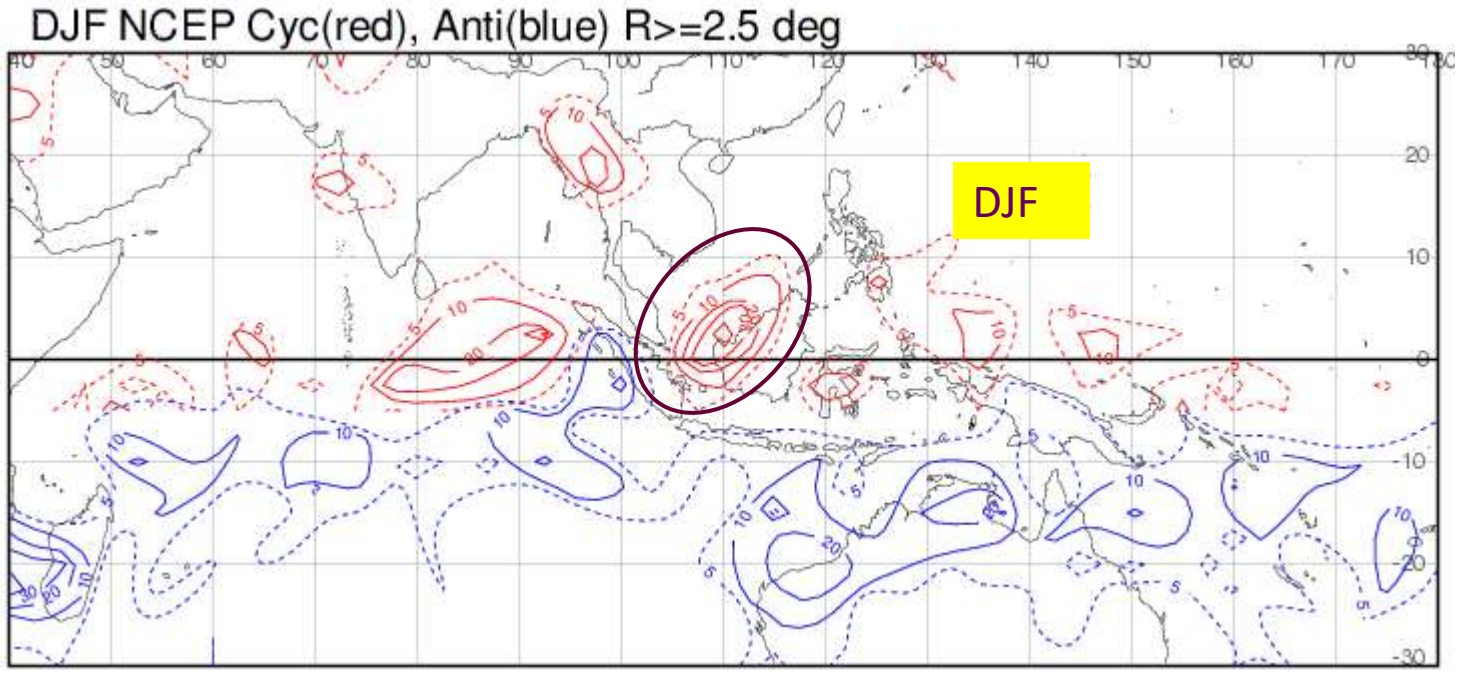
In recent years, a number of tropical cyclon[illegible]d within 5 latitude of the equator, (Chang et al. 2003)[43] suggesting c[illegible] constraint.



41. Gray, W. M., 1968: Global view of the origin of tropical disturbances and storms. Mon. Wea. Rev., 96, 669-700.

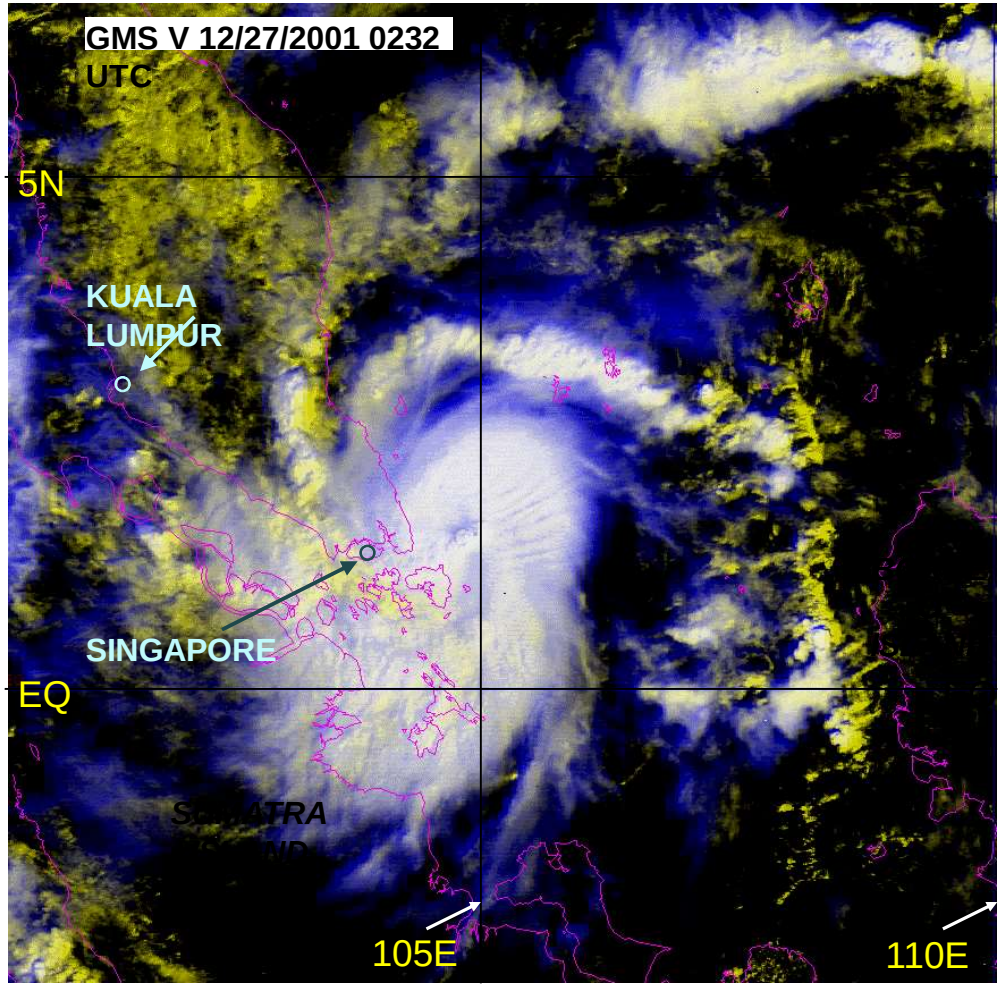
43. Chang, C. -., H. C. Kuo, and C. H. Liu, 2003: Typhoon Vamei: An equatorial tropical cyclone formation. Geophys. Res. Lett., 50, 1–4.

Seasonal-Mean Vortex Centers



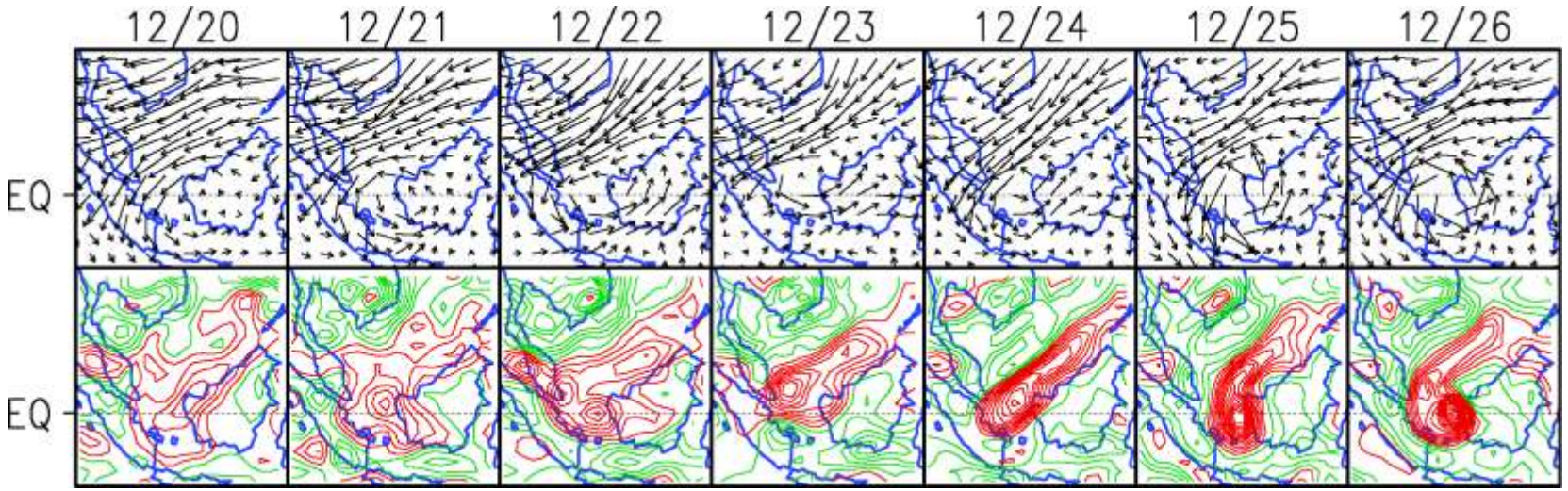
Graph by CH Liu

Typhoon Vamei



- Chang, C.-P. and T. S. Wong (2008) Rare typhoon development near the equator. *Recent Advances in Atmospheric Sciences in Asia-Pacific*. World Scientific, 172-181.

NOGAPS 850hPa Wind and Vorticity



(red +, green -)

- Chang, C.-P., C. H. Liu, and H. C. Kuo (2003) Typhoon Vamei: An equatorial tropical cyclone formation. *Geophys. Res. Let.*, **30**, 50 1-4.

Linear shallow water model on an equatorial beta plane

The linearized shallow-water equations with a motionless basic state on a β plane are

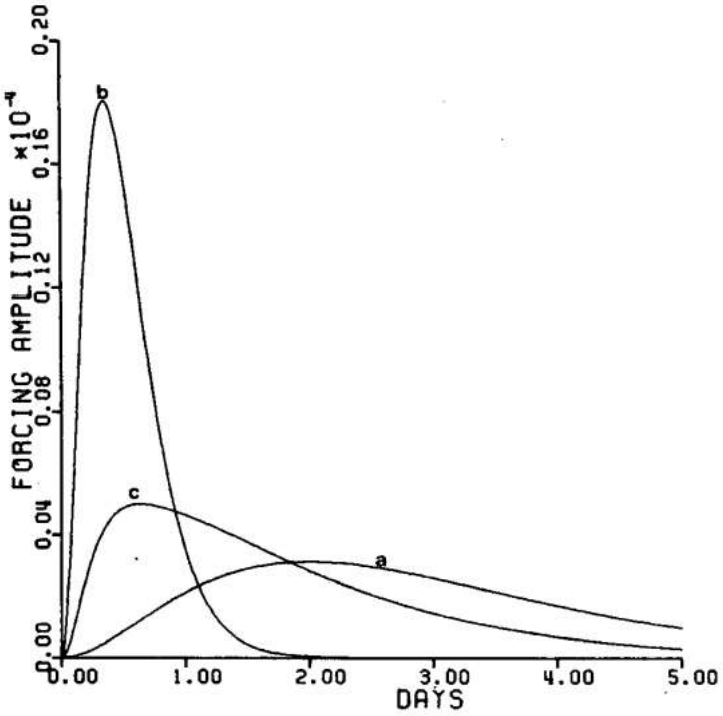
$$\left.\begin{aligned} &\frac{\partial u'}{\partial t} + g\frac{\partial h'}{\partial x} - \beta y v' = 0 \\ &\frac{\partial v'}{\partial t} + g\frac{\partial h'}{\partial y} + \beta y u' = 0 \\ &\frac{\partial h'}{\partial t} + H\left(\frac{\partial u'}{\partial x} + \frac{\partial v'}{\partial y}\right) = \Phi' \end{aligned}\right\} . \qquad (1)$$

$$\Phi' = \exp\left\{-\frac{1}{2}\left[\left(\frac{\zeta - a}{\sigma}\right)^2 + \left(\frac{x}{\lambda}\right)^2\right]\right\} \times \left(\frac{t^2}{2\tau^3} e^{-t/\tau}\right) . \qquad (10)$$

Here the ζ profile is expanded in terms of the Hermite solutions $D_n(\zeta)$,

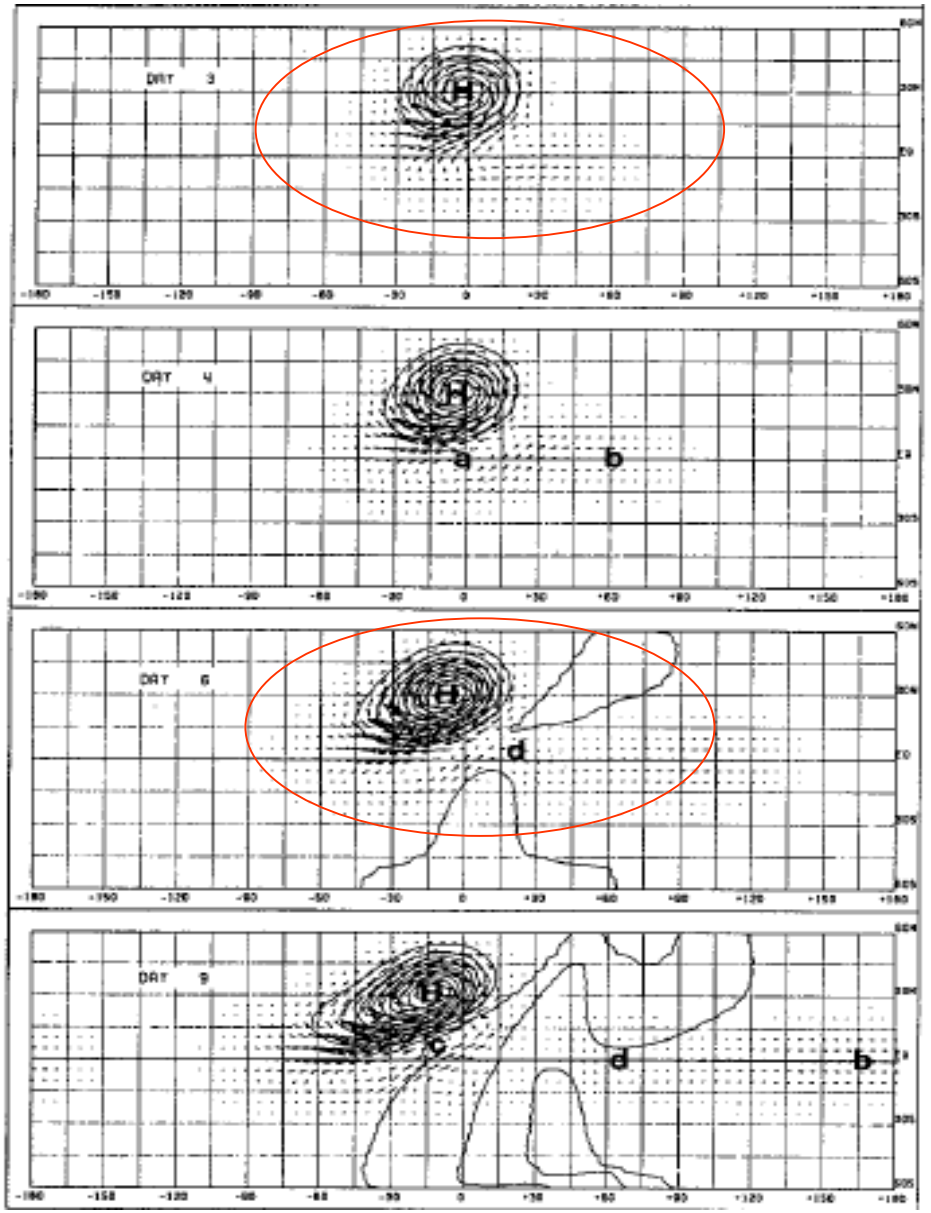
$$\exp\left[-\frac{1}{2}\left(\frac{\zeta - a}{\sigma}\right)^2\right] = \sum_{n=0}^{\infty} p_n D_n(\zeta), \qquad (11)$$

where the expansion coefficients p_n may be readily



- Lim, H. and C.-P. Chang (1981) A Theory for Mid-Latitude Forcing of Tropical Motions during Winter Monsoons. *J. Atmos. Sci.*, **38**, 2377-2392.

Wind and geopotential response to p(t) forcing 30N



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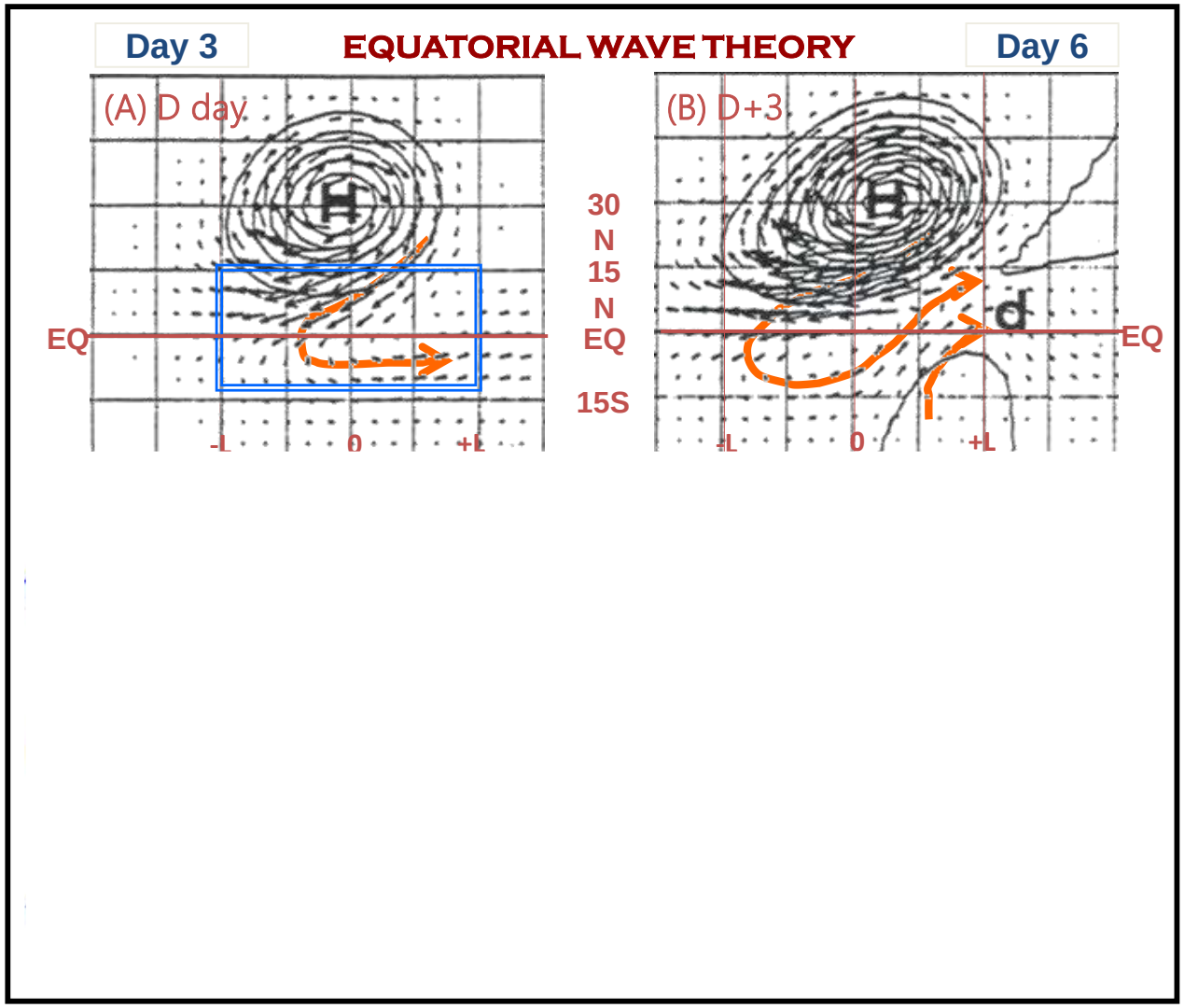
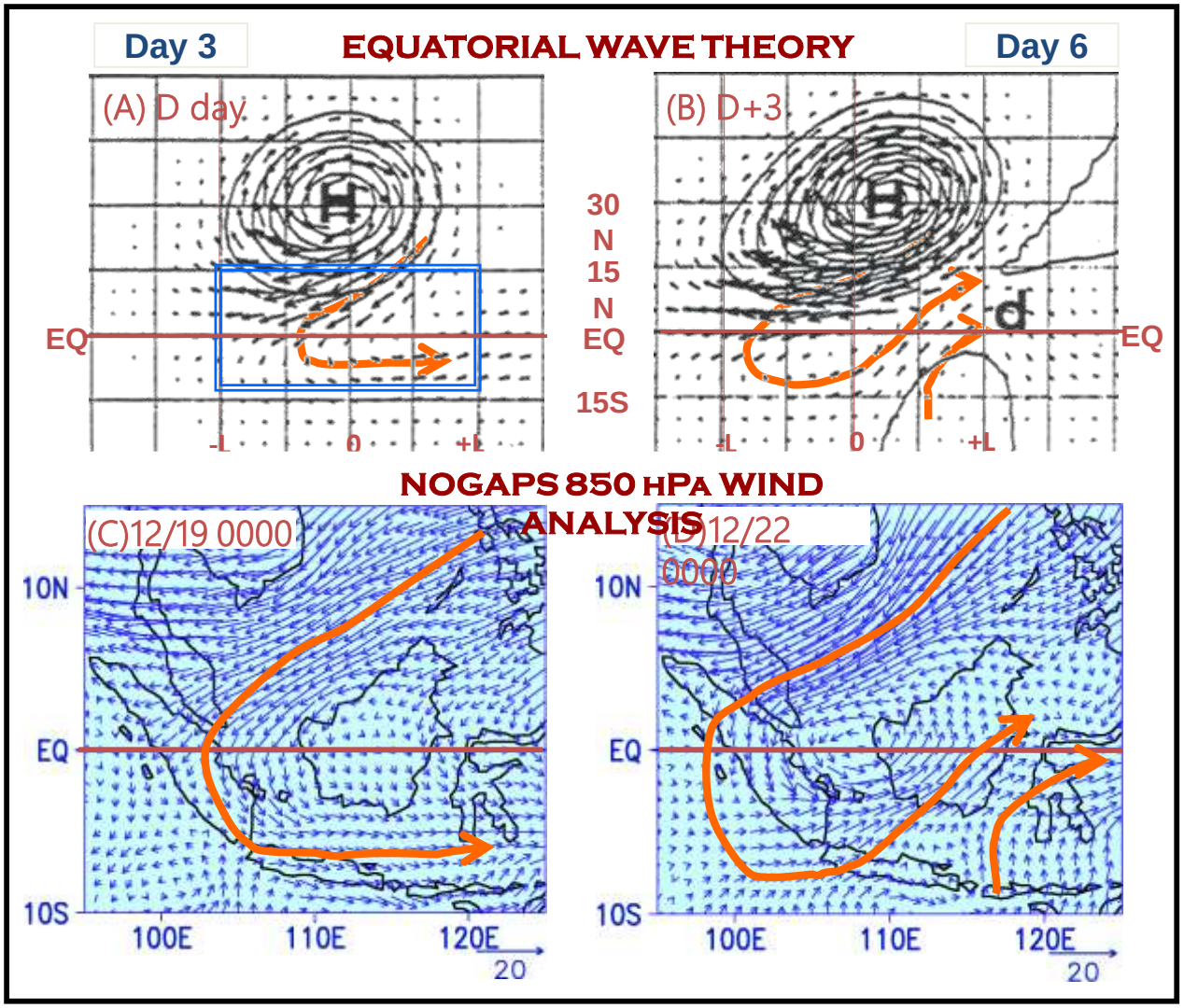


Chang, C. P., M. M. Lu, and H. Lim, 2016: Monsoon Convection in Maritime Continent: Interaction of Large-Scale Motion and Complex Terrain, *in Multiscale Convection-Coupled Systems in the Tropics*, R. Fovell, and W. Tung, Eds., *Meteoro. Monogr.*, **56**, American Meteorological Society, doi:10.1175/AMSMONOGRAPHS-D-15-0011.1



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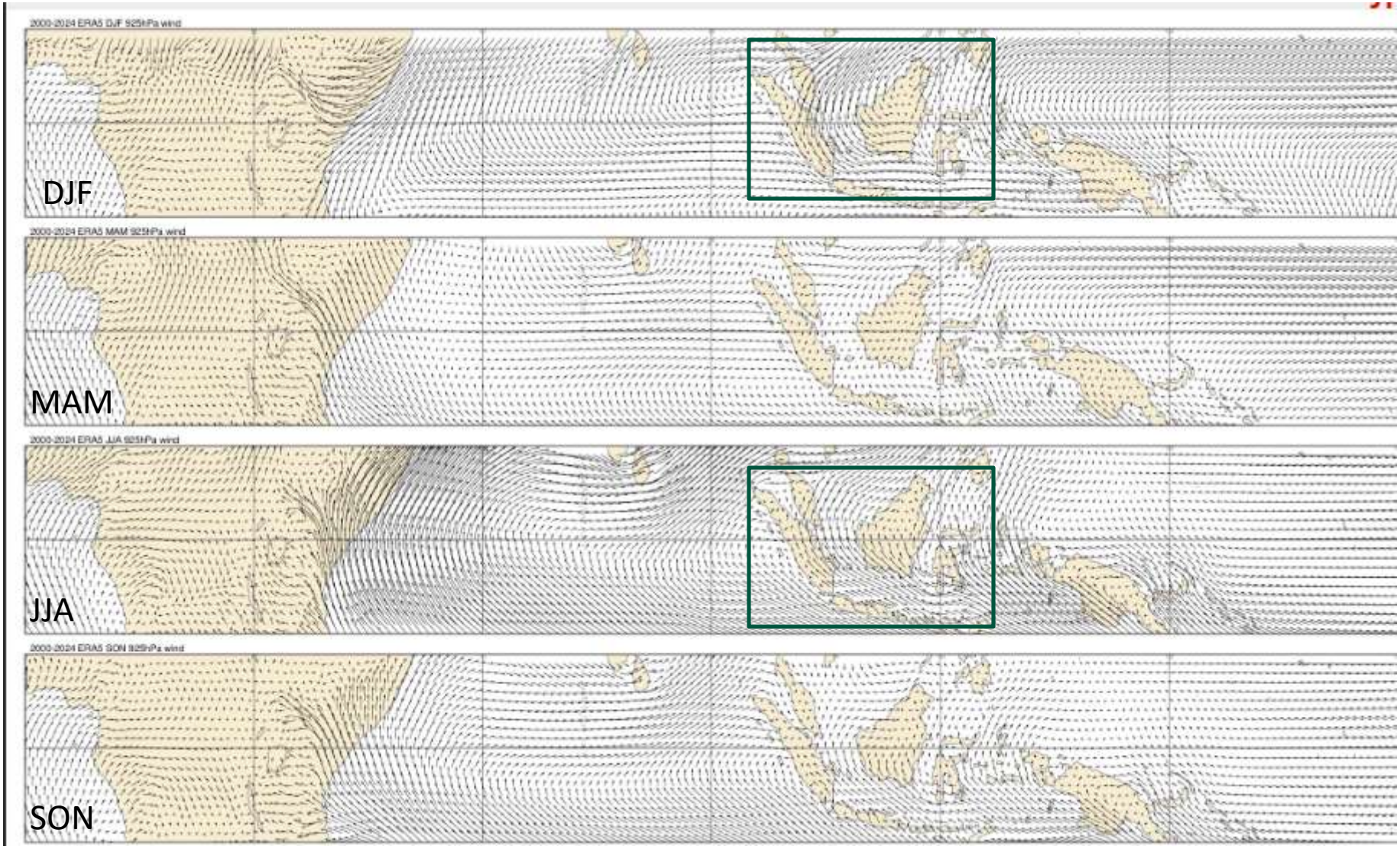
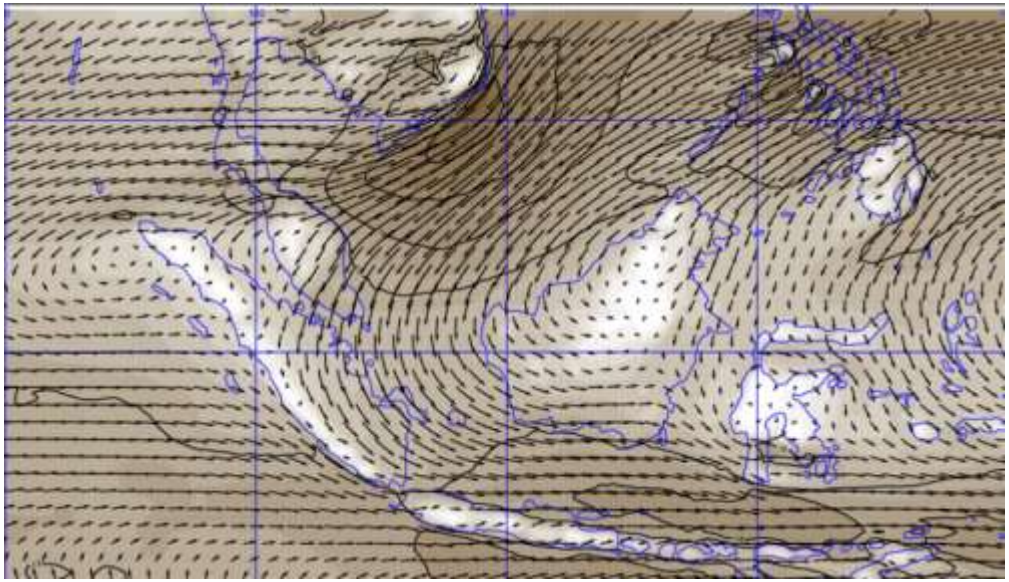
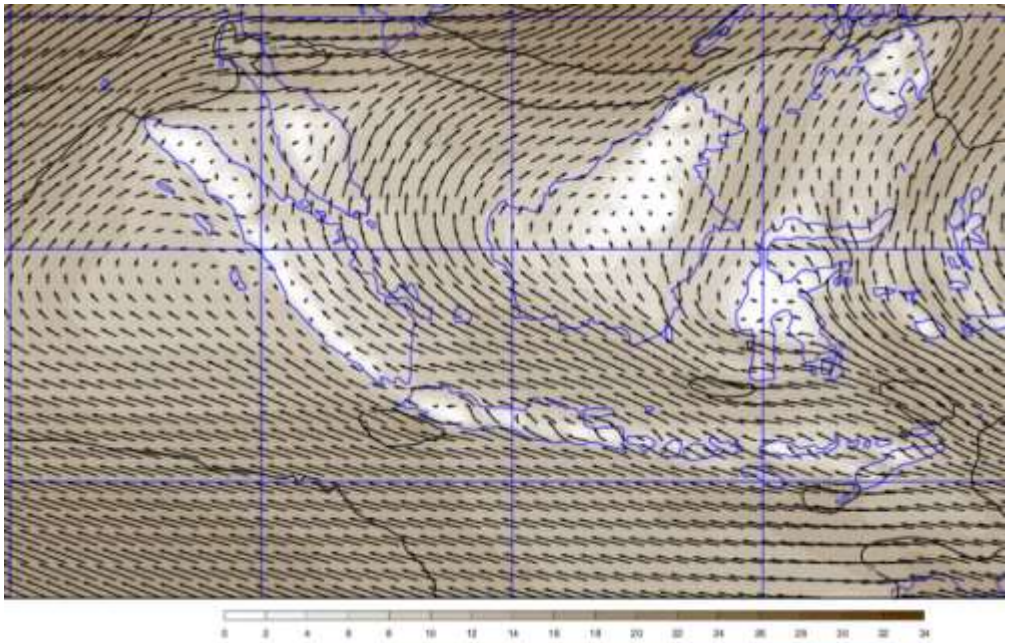
ERA5 925 hPa 2020-2024



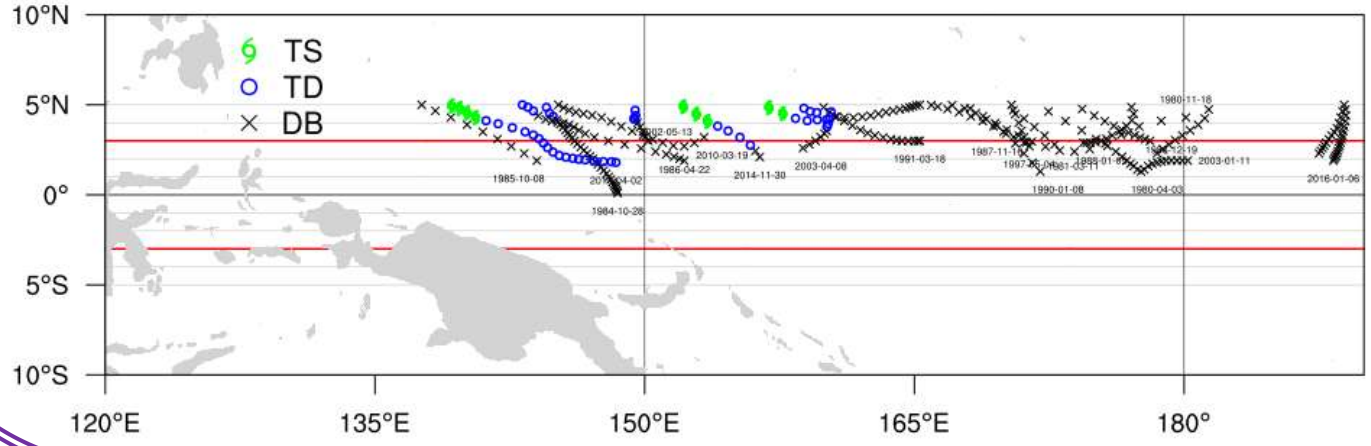
DJF 925 hPa

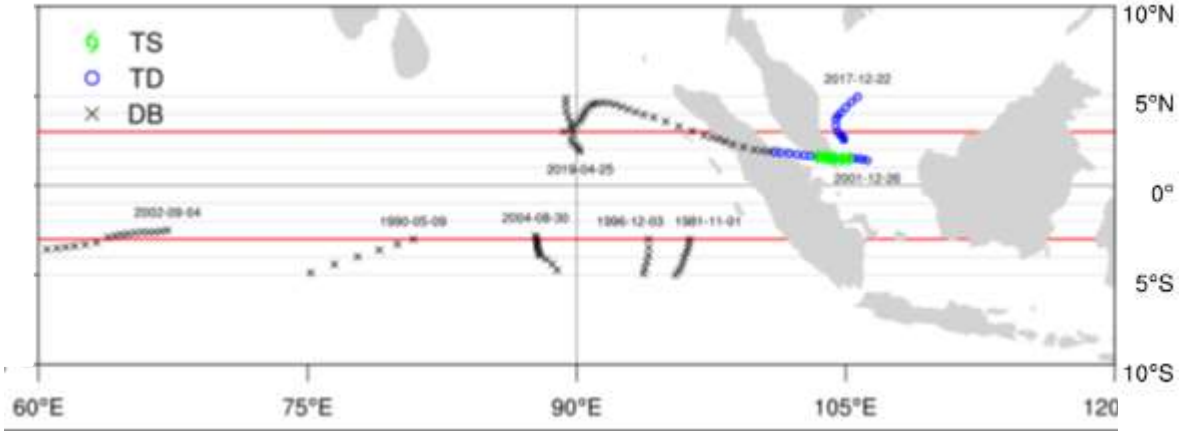


JJA 925 hPa



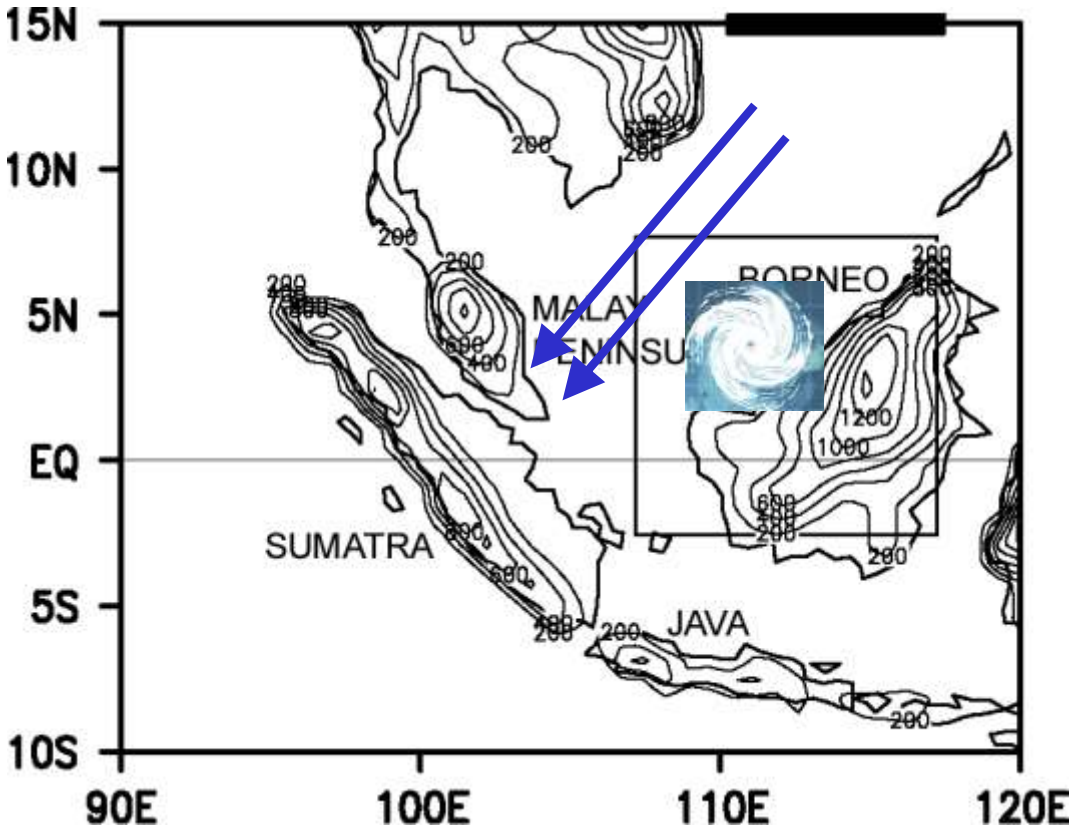
Named TCs with history between 3S-3N





Data source: JMA

South China Sea Topography



- Terrain helps: Strong and persist cold surge – strengthened by the narrowing SCS
- Terrain hurts: Borneo vortex pushed over land

Equatorial Cyclogenesis Probability

Chang et al. 2003

61 strong surges lasting >1 week. Total 582 days. Assuming vortex needs 3-day overlap with the surge, sustained “spinning top effect” presents at the equator for 460 days/(51X90+13=4603) ~ 10% of winter days. If minimum persistent surge duration required reduced from 7 to 5 days, the available time of spinning top effect increases to 14%. During the 51 winters, the frequency of a pre-existing Borneo vortex staying over the equatorial water continuously for ≥ 4 days or more is 6, or a probability of 6/51=12% in a given year.

Whether a pre-existing disturbance develops depends on du/dz, ζ, upper div, etc. In the more favored W Pacific and N Atlantic, 10-30% pre-existing disturbances develops into TC. So probability for development in Eq-SCS=.10(-.14)x.12X.10(-.3) = 0.12%-0.49% a year, once every 300-400 years.

This probability may be increased to about once every 100 years, the required persistence period of Borneo vortex center reduced to 72 h (21 times vs 6 times). Since cold surges strongest and penetrate deepest in the SCS, it is unlikely that such a formation scenario can take place elsewhere along the equator.

Numerical Modeling

- At least seven research teams reported simulation of the development of Typhoon Vamei, using regional models.
- All are “successful”, with large-scale flow, latent heat, and boundary layer identified as important processes. One even said “needing some *f* ”.
- But none answered the real question!

Thank You!