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Simulation and Diagnostics of a Near-Equator Tropical Cyclone

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On 27 Dec 2001, tropical cyclone Vamei landed on the southern tip of the Malay Peninsula, bringing heavy rain and widespread flooding in the southern Malaysian state of Johor and nearby Singapore. While tropical cyclones are no strangers in some countries in Southeast Asia, e.g. the Philippines, the occurrence of Vamei at the very low latitude of 1.5°N is virtually unheard of before (Chang et al. 2003). We are interested in this rare case of extreme weather for two reasons: (i) numerical forecast of extreme weather is difficult in most circumstances, but in data-sparse Southeast Asia, it is particularly challenging; (ii) tropical cyclogenesis near the equator where the Coriolis force is almost absent is itself a meteorological puzzle.

We first evaluate numerical forecasts made by the atmospheric module of the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS^{TM})[1]. Four simulations were performed using two different initial conditions, vis-à-vis analyses from either COAMPS or NOGAPS (Navy Operational Global Atmospheric Prediction System), and either assimilating or not assimilating observational data at subsequent times. We found that the simulation starting from NOGAPS analyses followed by 12 hourly data assimilation locates Vamei's eye closest to what is seen by Doppler radar at 00 UTC 27 Dec 2001. This gives us confidence in the ability of COAMPS to simulate tropical cyclones even in data-sparse Southeast Asia, if the initial conditions are well set up. COAMPS data analyses are probably not suitable for forecast initialization in this case study, because mesoscale vorticity features in COAMPS first-guess fields are not well constrained by sparse observations.

The second part of the work focuses on the scientific question: why does the tropical depression, which is often seen in the Borneo region, intensify to form the tropical cyclone Vamei? The horizontal convergence associated with the strong winter monsoon surge preceding Vamei's genesis plays a likely role. But another possibility is the conversion of vertical shear to cyclonic vorticity by the tilting of vortex tubes. We hope to clarify the answer through a vorticity budget diagnostic.

[1] *COAMPS is a registered trademark of US Naval Research Laboratory.*

Keywords: tropical cyclone; numerical weather prediction; extreme weather.

References

[1] C.-P. Chang, C. H. Liu and H. C. Kuo, *Geophy. Res. Lett.* **30(3)**, 1150 (2003).