



Verification of a Mesoscale Simulation of Tropical Cyclone Vamei

T.-Y. Koh (1) and H. Lim (2)

(1) Nanyang Technological University, Singapore, (2) National University of Singapore, Singapore. (kohty@ntu.edu.sg / Phone: +65-67903731 / Fax: +65-63166984)

On 27 Dec 2001, tropical cyclone Vamei landed on the southern tip of the Malayan 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 degrees north 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 and whether the model dynamics can capture such a rare case is an open question.

The atmospheric module of the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) was used to make a high-resolution simulation of the weather for the period 17 - 29 Dec 2001. Navy Operational Global Atmosphere Prediction System (NOGAPS) 1 degree x 1 degree analyses was used to initialize and to provide boundary conditions for the model run. Observational data were assimilated every 12 hours, without "bogusing" of the tropical cyclone. We used three nested grids at 54/18/6 km resolutions in Mercator projection: the outmost grid includes the whole Southeast Asia; the middle grid spans Sumatra, Malayan Peninsula and Borneo; and the innermost grid covers Singapore's vicinity, including the southern reaches of the South China Sea east of Singapore where Vamei's genesis occurred. 60 vertical levels were employed, 50 of which lie in the tropical troposphere (0-16km) and 20 of which lie below 3km. Description of the COAMPS model can be found in Hodur (1997).

A tropical cyclone was spun up in the COAMPS model simulation, despite the rela-

tively sparse observational data in the region. This is probably a testament to the fact that the conditions favouring tropical cyclone formation occur in the synoptic scale rather than in the mesoscale and/or mesoscale conditions are under synoptic control in the period under consideration. To verify the simulated track of the cyclone, we essentially followed the same methodology as Power and Davis (2002): from the region of maximum relative vorticity (which is a layer-average from the lower model levels), we look for the grid location where the magnitude of the mean wind vector normalized by the mean wind speed is minimized. Here, “mean” refers to a 9-point average over the grid location. Thus, we locate the centre of circulation of the simulated tropical cyclone. The track so derived is compared to published best-track data of Vamei. This allows us to compute the root-mean-square deviation of the simulated track.

A second part of the work that will only be briefly discussed in the proposed presentation at the EGU meeting focuses on the dynamical conditions for the formation of tropical cyclone Vamei. By means of a vorticity budget analysis, we elucidate the origin of the anomalously large absolute vorticity of Vamei at such a low latitude. The 3D velocity outputs were interpolated into pressure coordinates and an analysis of the absolute vorticity budget of an atmospheric column (defined as from the surface to 500mb) was carried out. We may conceptualize the change in vertical absolute vorticity (VAV) averaged over a vertical column as follows:

Change in VAV = 3D Convergence of VAV-flux + Generation/Destruction by Vortex Stretching/Compression + Generation/Destruction by Vortex Tilting + Destruction by Surface Turbulent Drag

Our results show that waves of absolute vorticity perturbation grow over the north side of the Vamei vortex and interact, eventually leading to the intensification of the cyclone. The convergence of VAV-flux serves mainly to redistribute VAV among the atmospheric columns, while its impact on the VAV budget is generally $\pi/2$ out-of-phase with vortex tilting. Strong vortex stretching is the primary cause of the increase in VAV. Surface turbulent drag has negligible effects on the VAV of an atmospheric column.

References

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Note: COAMPS is a registered trademark of US Naval Research Laboratory.