Asymmetrically Intensifying Processes of a Category 4 Super Typhoon Lan (2017) during High Vertical Wind Shear

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On 21 October 2017, Typhoon Lan developed to a Category 4 super typhoon with the minimum central pressure (MCP) of 915 hPa at 25.6 degrees north latitude and maintained the peak intensity until the storm arrived at 29.9˚N under a strong environmental vertical wind shear (VWS) of 14 m s^{-1}. To understand the intensification processes of an intense typhoon with such high VWS, numerical simulations on Typhoon Lan were conducted using a high-resolution three-dimensional atmosphere regional model, the Cloud Resolving Storm Simulator (CReSS; Tsuboki and Sakakibara, 2002). Two sensitivity experiments, 1dO and FO, were conducted with different SST representations. In the 1dO experiment, a simple thermal diffusion model was used to express temperature changes due to ocean vertical mixing. The FO experiment with a time-fixed SST did not consider the evolution of SST. Both experiments used the same initial and boundary conditions and model specifications for the atmosphere, started at 0000 UTC 18 October 2017, and had an integration time of 5 days. The computational domain was 2˚N–37.8˚N and 115˚E–145˚E. The number of horizontal grids in the computational domain was 752×896 with the horizontal grid size of 0.04 longitude by 0.04 latitude.

The typhoon simulated in the 1dO experiment successfully achieved the MCP of 910 hPa at 29.5˚N, exhibiting strong asymmetric precipitation pattern as observed by the satellites. The intensification processes were accompanied by rapid developments of the strong winds and warm core in the low-levels. The strong northeast VWS forced to tilt the storm axis to downshear side (northeast) and, in the downshear quadrants, tall, intense and upstanding eyewall updrafts (CBs) formed from the low-level convergence of the storm travelling northeastward with a relatively fast translation speed of 10 m s^{-1}. Meanwhile, dry subsidence from the upper-levels intensified the low-level warm core in the upshear side of the eye. Despite the inner-core convection and precipitation exhibited strong asymmetric structures, the axisymmetricity of the storm circulation was maintained in the mid-to-low levels and abundant water vapor enclosed in the eye allowed to develop CBs around the radius of the maximum wind speeds. Although the FO storm overestimated the MCP of 879hPa, the similar asymmetric patterns in precipitation and convection were also found in the FO storm. The results indicated that the storm structures of typhoon Lan would be less sensitive to the SST-cooling effect.

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