A Numerical Simulation of Warm Core in Typhoon Lan (2017)

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Tropical cyclones (TCs) have positive anomaly of temperature at the storm center (i.e., eye), which is known as warm core. The warm anomaly is related to low pressure at the storm center via the hydrostatic balance, and strong cyclonic circulation in the outside of the storm eye in the lower troposphere via the thermal wind relationship. This means that the warm core can control the storm intensity. Thus, full understanding of time evolution of the warm core can be helpful for more accurate numerical prediction of intensity change of TCs including rapid intensification, which is one of the most challenges in the numerical prediction of the storm intensity. Typhoon Lan (2017) underwent a rapid intensification over the western North Pacific. The minimum central pressure was 915 hPa. The mean 50-kt radius of the typhoon in the intensification and mature stages was 160-220 km. In this study, a numerical simulation of the typhoon is performed to investigate the evolution of the typhoon warm core during the rapid intensification using a cloud-resolving model. The simulation is started from 4 days prior to the intensification stage, and has an integration period of 6 days. The simulation reasonably reproduces track and time variation of the central pressure of the observed typhoon. Root-mean-square errors of the track and central pressure are about 127 km and 6 hPa during the whole simulation period, respectively. Radius of the simulated eyewall and horizontal distribution of surface wind around the simulated typhoon qualitatively agree with those observed by satellites. At that time, an observation campaign using a Japanese aircraft, which is referred to as Tropical cyclones-Pacific Asian Research Campaign for Improvement of Intensity estimations/forecasts (T-PARCII), were conducted in the mature stage of the typhoon. The simulated warm-core structure is verified using the dropsonde profile closest to the typhoon center. Both typhoon centers in the simulation and observation have a deep structure of clearly positive anomaly of air temperature in 3 to 16-km heights.

In the early stage of the intensification, the simulated warm core is confined to a higher layer of 8 to 12 km in the troposphere. Coincided with the intensification, the bottom height of the warm core rapidly decreases to 3 km in height. The rapid descent brings warming at almost all levels in the typhoon center. As a consequence of the warming, the typhoon central pressure rapidly decreases, and the typhoon undergoes the rapid intensification.

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