Effects of Microphysical Latent Heating on the Rapid Intensification of Typhoon Hato

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A 72-h cloud-resolving numerical simulation of Typhoon Hato (2017) is performed by using the Weather Research and Forecasting (WRF) model with the Advanced Research WRF (ARW) core (V3.8.1) on a horizontal resolution of 2 km. To enhance the background tropical cyclone structure and intensity, a vortex dynamic initialization scheme with a terrain-filtering algorithm is utilized. The model reproduces reasonably well the track, structure, and intensity change of Typhoon Hato. More specifically, the change trend of simulated maximum wind speed is consistent with that of best-track analysis, and the simulated maximum wind of 49 m s^{-1} is close to that (52 m s^{-1}) of the best-track analysis, indicating that the model has successfully captured the rapid intensification (RI) of Typhoon Hato (2017). Analyses of the model outputs reveal that the total microphysical latent heating of the inner-core region associated with enhanced vertical upward motion reaches its maximum at 9-km height in the upper troposphere during the RI stage. The dominant microphysical processes with positive latent heat contributions (i.e., heating effect) are water vapor condensation into cloud water (67.6%), depositional growth of ice (12.9%), and generation (nucleation) of ice from vapor (7.9%). Those with negative latent heat contributions (cooling effect) are evaporation of rain (47.6%), melting of snow (27.7%), and melting of graupel (9.8%). Sensitivity experiments further show that the intensification speed and peak intensity of this typhoon are highly correlated to the dominant heating effect. A significant increase in graupel over 5–10-km height and snow at 10–14-km height in the inner-core region of Typhoon Hato corresponds well with its RI stage, and the latent heating from nucleation and depositional growth is crucial to the RI of simulated Hato.

Keywords: microphysical latent heating, rapid intensification, budget analysis