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Surface rainfall equation and cloud-resolving modeling study of surface rainfall processes associated with a landfalling typhoon

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The detailed surface rainfall processes associated with landfalling typhoon Kaemi(2006) are investigated based on hourly data from a two-dimensional cloud-resolving model simulation by using the surface rainfall equation proposed by Gao et al.(2005). The model is integrated for 6 days with imposed large-scale vertical velocity, zonal wind, horizontal temperature and vapor advection from National Center for Environmental Prediction (NCEP) / Global Data Assimilation System (GDAS) data. The simulation data are validated with observations in terms of surface rain rate. The Root-Mean-Squared (RMS) difference in surface rain rate between the simulation and the gauge observations is 0.660 mm/h, which is smaller than the standard deviations of both the simulated rain rate (0.753 mm/h) and the observed rain rate (0.833 mm/h).

The simulation data are then used to study the physical causes associated with the detailed surface rainfall processes during the landfall by using the surface rainfall equation. The results show that time averaged and model domain-mean Ps mainly comes from large-scale convergence (QWVF) and local vapor loss (positive QWVT). Large underestimation (about 15%) of Ps will occur if QWVT and QCM (cloud source/sink) are not considered as contributors to Ps. QWVF accounts for the variation of Ps during most of the integration time, while it is not always contributor to Ps. Sometimes surface rainfall could occur when divergence is dominant with local vapor loss to be a contributor to Ps. Surface rainfall is a result of multi-timescale interactions. QWVE possesses the longest time scale and the lowest frequency of variation with time and may exert impact on Ps in longer time scale. QWVF possesses the second longest time scale and lowest frequency and can explain most of the variation of Ps. While QWVT and QCM possess shorter time scales and higher frequencies which can explain more detailed variations in Ps.

Partitioning analysis shows that stratiform rainfall is dominant from the morning of 26 July till the late night of 27 July. After that, convective rainfall dominates till about 1000 LST 28 July. Before 28 July, the variations of QWVT in rainfall-free regions contribute less to that of the domain-mean QWVT while after that they contribute much, which is consistent to the corresponding variations in their fractional coverage. The variations of QWVF in rainfall regions are the main contributors to that of the domain-mean QWVF, then the main contributors to the surface rain rate before the afternoon of 28 July.