Simulation of thunderstorms during pre-monsoon season over Indian region using WRF-3DVAR analysis system

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Abstract

This study assesses the impact of Doppler weather radar (DWR) data (reflectivity and radial wind) assimilation on the simulation of severe thunderstorms (STS) events over the Indian monsoon region. Two different events that occurred during the Severe Thunderstorms Observations and Regional Modeling (STORM) pilot phase in 2009 were simulated. Numerical experiments—3DV (assimilation of DWR observations) and CNTL (without data assimilation)—were conducted using the three-dimensional variational data assimilation technique with the Advanced Research Weather Research and Forecasting model (WRF-ARW). The results show that consistent with prior studies the 3DV experiment, initialized by assimilation of DWR observations, performed better than the CNTL experiment over the Indian region. The enhanced performance was a result of improved representation and simulation of wind and moisture fields in the boundary layer at the initial time in the model. Assimilating DWR data caused higher moisture incursion and increased instability, which led to stronger convective activity in the simulations. Overall, the dynamic and thermodynamic features of the two thunderstorms were consistently better simulated after ingesting DWR data, as compared to the CNTL simulation. In the 3DV experiment, higher instability was observed in the analyses of thermodynamic indices and equivalent potential temperature (he) fields. Maximum convergence during the mature stage was also noted, consistent with maximum vertical velocities in the assimilation experiment (3DV). In addition, simulated hydrometeor (water vapor mixing ratio, cloud water mixing ratio, and rain water mixing ratio) structures improved with the 3DV experiment, compared to that of CNTL. From the higher equitable threat scores, it is evident that the assimilation of DWR data enhanced the skill in rainfall prediction associated with the STS over the Indian monsoon region. These results add to the body of evidence now which provide consistent and notable improvements in the mesoscale model results over the Indian monsoon region after assimilating DWR fields.