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Predictability and Mechanism of an Extreme-Rainfall-Producing Mesoscale Convective System along a Mei-Yu Front in East China

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Forecast uncertainties of a quasi-linear extreme-rain-producing mesoscale convective system (MCS) along a mei-yu front in east China during the midnight-to-morning hours of 8 July 2007 are studied using several 24-h convection-permitting ensembles of simulation with the nested grid spacing of 1.11 km. There is considerable spread in the ensembles' precipitation forecast despite of the synoptic environment known conducive to heavy local rainfall.

Forty simulations with perturbed initial condition reveal a very strong sensitivity to uncertainties in the initial fields. A robust feature of the best-performing members that reasonably simulated the MCS and associated heavy rainfall was the presence of a cold dome before the mei-yu front, which was generated by previous convection. The cold dome helped the nocturnal convective initiation (CI) by lifting the moist air in the low-level southwesterly flow to its level of free convection. In contrast, the bad members that missed the MCS' development could not simulate the previous convection or produced a cold dome that was not deep enough to initiate the MCS. At the initial time, the bad members had less atmospheric moisture over and upstream of the CI region than the good members. This resulted in the frontal-lifting-induced CI being delayed by about 4 hours and too weak convection to form the MCS in the bad members. Extra experiments were performed to test the sensitivity of precipitation simulation to the initial condition differences between a good and a bad member. Linear changing of the bad member's initial condition toward the good member's led to monotonic improvement of the precipitation simulation, with the most significant contribution from the moisture field.

Sensitivity of the precipitation forecast to the model physical process parameterization schemes is examined by conducting three groups of experiment, each consisting of 9 members using different physics schemes and using the same initial condition as two bad members and one good member, respectively. The two groups that used the same initial condition as the bad members could not improve the precipitation forecast. The group that used the same initial condition as the good member was able to qualitatively produce the MCS' development and attendant precipitation; however, large spread in the location and amount of maximum accumulative rainfall in the 9 simulations was observed, suggesting some scope to further improve the physics schemes for both deterministic and probabilistic precipitation forecast.