On Improving 4-km Model Simulations

Aijun Deng and David R. Stauffer
Penn State University

In a recent study funded by the Coordinating Research Council (CRC), it was shown that use of four dimensional data assimilation (FDDA) and improved physics in the MM5 produced the best overall performance on the 12-km domain. However, further reduction of the grid length from 12 km to 4 km in the simulation of the 18-19 September 1983 CAPTEX case had a detrimental effect on the meteorological solutions. The primary cause of the poor mesoscale model performance was traced to the explicit representation of convection accompanying a cold front advancing across the lower Great Lakes and into New England. Because no convective parameterization was used on the 4-km grid, the convective updrafts were forced on coarser-than-realistic scales (normal updraft diameter for most storms in the eastern United States is ~ 2 km), and the rainfall and the atmospheric response to the convection were too strong. The evaporative cooling and the associated downdrafts were too vigorous causing widespread disruption of the low-level winds and spurious advection of the simulated tracer. Penn State has completed the first year of a new project funded by CRC to improve the MM5 model simulations on the 4-km grid with special attention given to quantitative precipitation forecasts (QPF) and meteorological accuracy.

A series of experiments was designed to address model sensitivities to mixed-phase microphysics, planetary boundary layer (PBL) physics, convective parameterization, enhanced horizontal diffusion, and use of analysis nudging versus observation nudging FDDA on the 4-km domain. Some of the conclusions from this study include 1) enhanced vertical mixing in the Gayno-Seaman Turbulent Kinetic Energy (TKE) PBL scheme has shown marked improvements in the simulated fields, 2) use of the new Kain-Fritsch convection scheme on the 4-km domain, with its simple treatment of shallow convection, tended to reduce the tendency for the 4-km explicit convection to produce grid point storms, 3) use of the MRF PBL scheme generally showed larger model errors within the PBL and a clear tendency to overestimate the PBL height, 4) use of weak analysis nudging FDDA on the 4-km domain as used on the 12-km domain improved the results, and 5) the best results were obtained by modifying the model physics and applying observation nudging to the 4-km domain. In year 2 of the project, we will repeat many of these experiments in WRF to further study this problem of 4-km QPF and compare the WRF results with the MM5 results.