Examining the Sensitivity of Horizontal and Vertical Grid Spacing on Simulations of Cool Season Severe Thunderstorms in the Southeast United States

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High-Shear, Low CAPE Environments
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Weak CAPE, strong shear environments are prevalent during Southeast cool season severe outbreaks (Guyer et al. 2006) and can prime local environments for tornadic activity. Due to these atypical conditions and their tendency to form overnight, storms in these environments pose an enhanced societal threat and forecasting challenge (Guyer et al. 2006, 2010; Evans et al. 2006). This was the case on March 25, 2009, when a supercell spawned an EF3 tornado that ripped through central Mississippi around 1:30 a.m. local time.

This study examines simulations of this event at varying horizontal (4, 2, and 1 km) and vertical (30, 40, and 50 levels) grid spacings. Recent studies have shown the influence of different grid spacings on simulated convective development, but limited emphasis has been placed on high-resolution modeling of storms forming in weak CAPE, strong shear environments.

By examining the effects of varying grid spacings on simulated storms in these environments, our results expand our understanding and predictive ability of cool season severe weather in the southeast United States.

Simulation Sensitivity to Horizontal Resolution
Low-level Reflectivity and Updraft Rotation

1 km
- Meridional, along-flow rain bands ahead of line
- Strengthening updraft rotation within two of the bands (circled in purple)

2 km
- Relatively weak, along-flow rain bands
- No strong updraft rotation in the loading bands
- Strong updraft rotation in the main line near Magee

4 km
- No rain bands or strong updraft rotation ahead of the line
- Weak, localized updraft rotation in the main line

Decreasing horizontal grid spacing ultimately yields localized reflectivity and updraft rotation maxima ahead of the line. While both the 4 km and 2 km runs failed to reproduce the supercell, the 1 km simulation showed the development of a supercellular feature with strong, low-level updraft rotation indicative of the potential for tornadogenesis. These experiments show that the operational use of storm-scale models with 1 km horizontal grid spacing would be extremely beneficial in distinguishing between potentially tornadic and non-tornadic storms in low CAPE, high shear environments.

Simulation Sensitivity to Vertical Resolution
Low-level Reflectivity and Updraft Rotation

2 km
- More organized, large reflectivity maxima ahead of the line associated with convective roll development

30 Vertical Levels
- Horizontal convective rolls and unorganized convection ahead

40 Vertical Levels
- More organized, large reflectivity maxima ahead of the line

50 Vertical Levels
- More organized, large reflectivity maxima ahead of the line associated with convective roll development

Decreasing vertical grid spacing yields slightly more organized reflectivity and updraft rotation maxima ahead of the line. While the run with 30 vertical levels only reproduced horizontal convective rolls, the simulations with 40 and 50 vertical levels both showed strong, discrete cells developing from the rolls. None of these runs were able to reproduce a reflectivity and updraft rotation signature characteristic of a tornadic supercell, but the simulation with 40 vertical levels did resolve a particularly strong, rotating storm two counties north of the actual supercell at that time. This suggests that, while decreasing vertical grid spacing may not be as critical for resolving discrete supercells as decreasing horizontal grid spacing, increasing the number of vertical levels in storm-scale models results in more accurate simulations of wintertime thunderstorms. This is currently being investigated by examining simulations of other tornadic events associated with low CAPE, high shear environments in the southeast U.S.

Methods:
- Three simulations at varying horizontal resolutions (1, 2, 4 km)
- Three simulations at varying vertical resolutions (30, 40, 50 levels)

References

Evans, J. S., and J. L. Guyer, 2006: The Relationship of Cool Season Significant Tornado Events and Buoy Data in the Western Gulf of Mexico. Preprints, 23rd Conf. Severe Local Storms, St. Louis MO.

Guyer, J. L., D. A. Imy, A. Kus, and K. Vendelle, 2006: Cool season significant (EF3-5) tornadoes in the Gulf Coast states. Preprints, 23rd Conf. Severe Local Storms, St. Louis MO.