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Sensitivity of idealized supercell simulations to horizontal grid spacing: Implications for Warn-on-Forecast

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The Warn-on-Forecast (WoF) program aims to deploy real-time, convection-allowing, ensemble data assimilation and prediction systems to improve short-term forecasts of tornadoes, flooding, lightning, damaging wind, and large hail. Until convection-resolving (horizontal grid spacing $\Delta x < 100$ m) systems become available, however, resolution errors will limit the accuracy of ensemble model output. Improved understanding of grid spacing dependence of simulated convection is therefore needed to properly calibrate and interpret ensemble output, and to optimize tradeoffs between model resolution and other computationally constrained parameters like ensemble size and forecast lead time.

Toward this end, we examine grid spacing sensitivities of simulated supercells over Δx of 333 m - 4 km. Storm environment and physics parameterization are varied among the simulations. The results suggest that 4-km grid spacing is too coarse to reliably simulate supercells, occasionally leading to premature storm demise, whereas 3-km simulations more often capture operationally important features, including low-level rotation tracks. Further decreasing Δx to 1 km enables useful forecasts of rapid changes in low-level rotation intensity, though significant errors remain (e.g., in timing).

Grid spacing dependencies vary substantially among our experiments, suggesting that accurate calibration of ensemble output requires better understanding of how storm characteristics, environment, and parameterization schemes modulate grid spacing sensitivity. Much of the sensitivity arises from poorly resolving small-scale processes that impact larger (well-resolved) scales. Repeating some of the 333-m simulations with coarsened initial conditions reveals that supercell forecasts can substantially benefit from reduced grid spacing even when limited observational density precludes fine-scale initialization.