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Simultaneous Nested Modeling from the Synoptic Scale to the LES Scale

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Many applications require accurate weather information over broad temporal and spatial scales. For example, wind energy prediction requires regional weather forecasting to cope with intra-hour, multi-hour and day ahead decision-making. In addition, microscale modeling is needed to support wind turbine sitting decisions and turbine operations. In the last 10 years, the National Center for Atmospheric Research, US, has developed a Real-Time Four-Dimensional Data Assimilation (RTFDDA) and forecasting system to support diverse weather-critical applications such as wind energy forecasting. RTFDDA, built upon the Weather Research and Forecasting (WRF) model, is a rapid-cycling, multi-scale weather system with a capability for effectively combining all available weather observations with the full-physics WRF model to produce high-accuracy multi-scale 4D weather information from synoptic scales (~2000 km), to mesoscales (2 – 2000 km), and to microscales (< 2 km). RTFDDA performs successive downscaling from synoptic numerical weather predictions (based on global models), to regional weather predictions (mesoscale weather processes), and to small and microscale weather modeling with Large Eddy Simulation (LES). Two real weather cases with typical strong local forcing phenomena, one with an isolated elongated bell-shaped mountain in central Utah and the other with complex coastlines along the Chesapeake Bay, Maryland, were simulated using the WRF-RTFDDA-LES system with six nested domains having grid sizes of 30, 10, 3.333, 1.111, 0.369 and 0.123 km. The NASA SRTM (Shuttle Radar-sensing Topography Mission) 30-m resolution terrain heights were used to specify the fine mesh model terrain and to adjust fine-scale coastlines. Both cases were run for 24+ hours to span the diurnal evolution of local weather. Analysis of the model results indicates an encouraging downscaling capability of the modeling system in simulating the high-resolution underlying forcing and interaction with large-scale processes. It is also suggested that further understanding the transition from full parameterization of large eddies in ~1km grid model to explicit modeling of the large eddies in domains with ~100m grids is needed.