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The US DOE A2e Mesoscale to Microscale Coupling Project: Nonstationary Modeling Techniques and Assessment

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The purpose of the US DOE's Mesoscale-Microscale Coupling (MMC) Project is to develop, verify, and validate physical models and modeling techniques that bridge the most important atmospheric scales that determine wind plant performance and reliability. As part of DOE's Atmosphere to Electrons (A2e) program, the MMC project seeks to create a new predictive numerical simulation capability that is able to represent the full range of atmospheric flow conditions impacting wind plant performance.

The recent focus of MMC has been on nonstationary conditions over flat terrain. These nonstationary cases are critical for wind energy and represent a primary need for mesoscale meteorological forcing of the microscale models. The MMC team modeled two types of non-stationary cases: 1) diurnal cycles in which the daytime convective boundary layer collapses with the setting of the sun when the surface heat flux changes from positive to negative, passing through a brief period of neutral stability before becoming stable, with smaller scale turbulence and the potential for low level jet (LLJ) formation; and 2) frontal passage as an example of a synoptic weather event that may cause relatively rapid changes in wind speed and direction.

The team compared and contrasted two primary techniques for non-stationary forcing of the microscale by the mesoscale model. The first is to use the tendencies from the mesoscale model to directly force the microscale mode. The second method is to couple not only the microscale domain's internal forcing parameters, but also its lateral boundaries, to a mesoscale simulation. While the boundary coupled approach provides the greatest generality, since the mesoscale flow information providing the lateral boundary information for the microscale domain contains no explicit turbulence information, the approach requires methods to accelerate turbulence production at the microscale domain's inflow boundaries. Forefront assessment strategies, including comparing spectra and cospectra, were used to assess the techniques. Testing methods to initialize turbulence at the microscale was also accomplished.