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Evaluation of sub-kilometer dynamical downscaling with MM5 and WRF mesoscale models

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Regional/mesoscale models are often utilized for wind resource estimates, owing to the low spatial and temporal representativeness of routine measurements and global reanalysis. In many applied scientific disciplines including wind engineering, it is often considered that the higher resolution the better, i.e. that increased horizontal resolution of the model yields more accurate results. However, the gain in forecast accuracy with increased horizontal resolution is not always straightforward. The principal question addressed in this study is whether a refinement of horizontal resolution uniquely produces more accurate wind and turbulence estimates and to what extent this result is dependent on the predominant seasonal low-level circulation patterns.

In this study, we examined the effect of horizontal grid resolution on the prediction accuracy of wind speed, turbulence and wind power at the standard and hub height using two mesoscale models, Mesoscale Model 5 (MM5) and the Weather Research and Forecasting Model (WRF). The models are configured with nine domains, with the first four having grid resolutions 27, 9, 3 and 1 km, respectively, as well as five innermost domains at 333 m horizontal grid resolutions centered on the locations of the meteorological towers. The period of dynamical downscaling included a summer (July) and a winter (December) month, that crucially differ by the existence or absence of diurnal circulations. The meteorological towers were operational in central western Nevada, equipped with conventional and sonic anemometers at several heights up to 80 m AGL for about a 5-year period, providing an excellent dataset for the models' evaluation. Statistical verification scores indicated mixed results concerning improvement of model accuracy with respect to refinement of horizontal grid resolution, as well as a considerable seasonal variability. The main undesired feature of MM5 is underestimation of stronger wind speeds almost regardless of the season, while the main drawback of WRF is overestimation of nocturnal flows during the summer. Complementary spectral analysis suggested that while the MM5 model lacks energy on both synoptic and diurnal scales, WRF yields much more realistic power spectrum estimates, but overestimates the power of the motions within sub-diurnal periods. The analysis of the major impacts provided insight into the representation and transfer of the synoptic information through the grid interaction, treatment of topography, representation of the surface energy balance, and appropriateness of the physical parameterizations on variety of scales.