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Sub-kilometer dynamical downscaling over complex terrain: does a refinement of horizontal resolution uniquely bring increased model accuracy?

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Regional/mesoscale models currently provide useful wind power density products. Besides the traditional use in numerical weather prediction, this type of model is often used for regional wind resource estimates, owing to the low spatial and temporal representativeness of routine measurements. 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.

In this study, we examined the effect of horizontal grid resolution on the prediction accuracy of winds and turbulence at the standard as well as hub heights (80 m AGL) using two models, Mesoscale Model 5 (MM5) and 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. Five meteorological towers in central western Nevada, equipped with conventional and sonic anemometers at several heights up to 80 m AGL for a 5-year period, provided an excellent dataset for evaluation of the simulated low-level wind and turbulence properties. Classical verification scores indicated mixed results concerning improvement of model accuracy with respect to refinement of horizontal grid resolution, while spectral analysis was found to be useful for a better understanding of the model performance at finer grid resolutions. The analysis of the major impacts pointed to the appropriateness of the physical parameterizations on variety of scales, representation and transfer of the synoptic information through the grid interaction and treatment of topography.