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A high resolution WRF model for wind energy forecasting

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The increasing penetration of wind energy into national electricity markets has increased the demand for accurate surface layer wind forecasts. There has recently been a focus on forecasting the wind at wind farm sites using both statistical models and numerical weather prediction (NWP) models. Recent advances in computing capacity and non-hydrostatic NWP models means that it is possible to nest mesoscale models down to Large Eddy Simulation (LES) scales over the spatial area of a typical wind farm. For example, the WRF model (Skamarock 2008) has been run at a resolution of 123 m over a wind farm site in complex terrain in Colorado (Liu et al. 2009). Although these modelling attempts indicate a great hope for applying such models for detailed wind forecasts over wind farms, one of the obvious challenges of running the model at this resolution is that while some boundary layer structures are expected to be modelled explicitly, boundary layer eddies into the inertial sub-range can only be partly captured. Therefore, the amount and nature of sub-grid-scale mixing that is required is uncertain.

Analysis of Liu et al. (2009) modelling results in comparison to wind farm observations indicates that unrealistic wind speed fluctuations with a period of around 1 hour occasionally occurred during the two day modelling period. The problem was addressed by re-running the same modelling system with a) a modified diffusion constant and b) two-way nesting between the high resolution model and its parent domain. The model, which was run with horizontal grid spacing of 370 m, had dimensions of 505 grid points in the east-west direction and 490 points in the north-south direction. It received boundary conditions from a mesoscale model of resolution 1111 m. Both models had 37 levels in the vertical. The mesoscale model was run with a non-local-mixing planetary boundary layer scheme, while the 370 m model was run with no planetary boundary layer scheme. It was found that increasing the diffusion constant caused damping of the unrealistic fluctuations, but did not completely solve the problem. Using two-way nesting also mitigated the unrealistic fluctuations significantly. It can be concluded that for real case LES modelling of wind farm circulations, care should be taken to ensure the consistency between the mesoscale weather forcing and LES models to avoid exciting spurious noise along the forcing boundary. The development of algorithms that adequately model the sub-grid-scale mixing that cannot be resolved by LES models is an important area for further research.

References
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