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Numerical modeling of wind turbine wakes using large eddy simulation

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Large-eddy simulation (LES), coupled with a wind-turbine model, is used to investigate the characteristics of wind turbine wake turbulence in the neutrally atmospheric boundary layer flow. The recently developed tuning-free scale-dependent Lagrangian dynamic SGS model (Stoll and Porté-Agel, 2006) is applied for the SGS stresses. The turbine-induced drag force is parameterized using two methods: the actuator-disk method (ADM) and the blade-element method (BEM), which distribute the force loading of blades on a disk. Simulation results obtained with the two wind-turbine models are compared with the wind-tunnel measurements collected with hot wire anemometry in the wake of a miniature wind turbine at the St. Anthony Falls Laboratory atmospheric boundary layer wind tunnel. We find that the characteristics of the simulated turbine wake are sensitive to the wind-turbine model. In general, the BEM produces more realistic turbine wakes due to the fact that, unlike the ADM model, it is able to capture the rotation of the flow.