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Interactions between wind farms and the atmospheric boundary layer

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Accurate prediction of atmospheric boundary layer flow and its interactions with wind turbines is of great importance for optimizing the design (layout) and efficiency of wind farms. This presentation focuses on recent efforts to develop and validate a large-eddy simulation (LES) framework for wind-energy applications. The subgrid-scale turbulent fluxes of momentum and heat are parameterized using tuning-free Lagrangian scale-dependent dynamic models. The turbine-induced forces are parameterized using two types of models: an actuator disk model that allows for non-uniform force distribution and includes rotational effects, and an actuator line model. The LES code is validated against wind-tunnel measurements collected inside and above a large model wind farm. Overall, the characteristics of the wind-farm wakes simulated with the proposed LES framework are in good agreement with the measurements. Moreover, LES is also found to provide reasonable predictions of turbine power output in simulations of flow through an operational wind farm.