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The influence of a very large wind farm on turbulent transport in the atmospheric boundary layer

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Predicting wind and turbulent transport of heat, water vapor and pollutants through wind farms is of great importance for wind engineering, wind energy and environmental applications. It requires detailed knowledge of atmospheric boundary-layer (ABL) over a wide range of spatial and temporal scales. The complexity of such flows makes it difficult to obtain all the needed information through field experiments alone, and often necessitates high-resolution eddy-resolving numerical tools such as large-eddy simulation (LES).
In this study, Large-eddy simulation is used to simulate atmospheric boundary-layer flow through a very large wind farm. To do this, tuning-free Lagrangian scale-dependent dynamic models (Stoll and Porte-Agel 2006) are used to model the subgrid-scale fluxes and the turbine-induced forces are parameterized using the actuator disk model (Wu and Porte-Agel 2011). The effect of large arrays of wind turbines on local/regional fluxes of momentum and scalar quantities under different stability conditions is assessed. Also, it will be shown how wind farms can change the vertical distribution of momentum and scalar fluxes inside the ABL. Particular attention is placed on the growth of the boundary layer height due to the presence of the wind turbines.