A large-eddy simulation framework for wind energy studies

Yu-Ting Wu and Fernando Porte-Agel

Wind Engineering and Renewable Energy laboratory (WIRE)
School of Architecture, Civil and Environmental Engineering (ENAC)
École Polytechnique Fédérale de Lausanne (EPFL)
1015 Lausanne, Switzerland

Email: fernando.porte-agel@epfl.ch

Abstract

The goal of this research is to develop a numerical modeling framework for aerodynamic simulations of wind turbines operating in the atmospheric boundary layer (ABL). In this framework, two major numerical techniques are adopted and combined: (a) a large-eddy simulation (LES) technique used to simulate ABL flows, and (b) a wind-turbine model used to parameterize the effects of wind turbines on the flows. In order to ensure the accuracy of this numerical modeling framework, experimental measurements collected in the wake of three-blade miniature wind turbines placed in a wind-tunnel boundary layer flow are used for model validation. Furthermore, the LES framework is also applied to two case studies of an operational wind farm in Minnesota (USA) and Horns Rev offshore wind farm. In general, the numerical models can produce reasonable results in the turbine wake. The characteristics of the simulated turbine wakes (mean velocity and turbulence intensity distributions) are similar to what we observed from the wind-tunnel measurements or the wind-farm field measurements. Recently, We also focus on further development, validation and application of this framework in a variety of cases involving different atmospheric stability conditions (neutral, stable and unstable), land-surface characteristics (land cover and topography) and wind-farm layouts (aligned and staggered).