



Large-eddy simulation of an infinitely large wind farm in a stable atmospheric boundary layer

Hao Lu (1) and Fernando Porté-Agel (1,2)

(1) Saint Anthony Falls Laboratory, Department of Civil Engineering, University of Minnesota, Minneapolis, United States,

(2) School of Architecture, Civil and Environmental Engineering, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

When deployed as large arrays, wind turbines interact among themselves and with atmospheric boundary layer. To optimize their geometric arrangements, accurate knowledge of wind-turbine array boundary layer is of great importance. In this study, we integrated large eddy simulation with an actuator line technique, and used it to study the characteristics of wind-turbine wake in an idealized wind farm inside a stable atmospheric boundary layer (SBL). The wind turbines, with a rotor diameter of 112m and a tower height of 119m, were placed in a well-known SBL turbulent case that has a boundary layer height of approximately 180m. The super-geostrophic nocturnal jet near the top of the boundary layer was highly reduced due to the energy extraction and the enhanced mixing of momentum. Non-axisymmetric behavior of wake structure was observed in response to the non-uniform incoming turbulence, the Coriolis effects, and the rotational effects induced by blade motions. The turbulence intensity was persistent and reached its saturation value, and the Coriolis force caused an inclined spatial structure and drove certain amount of turbulent energy away from the center of the wake. The height of SBL was increased, while the magnitudes of the surface momentum flux and the surface buoyancy flux were reduced by approximately 30%. Evaluation of the vertical transport of momentum and heat shows enhanced mixing, especially at the top-tip level.