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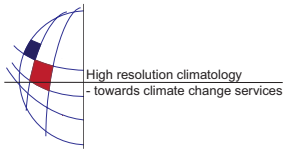

Large-eddy simulation of an infinitely large wind farm in a stable atmospheric boundary layer

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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 stably stratified 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 eliminated 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 in the simulated turbine wakes was found to reach a maximum at the top-tip level and a downwind distance of approximately 3-5 rotor diameters from the turbines. The Coriolis effects caused a skewed spatial structure and drove certain amount of turbulent energy away from the center of the wake. The SBL height was increased, while the magnitudes of the surface momentum flux and the surface buoyancy flux were reduced by approximately 30%. The wind farm was also found to have a strong effect on area-averaged vertical turbulent fluxes of momentum and heat, which highlights the potential impact of wind farms on local meteorology.