***Title:* Large eddy simulations of atmospheric turbulence and complex wind turbine wakes**

Abstract: In this work, wind characteristics in different regimes occurring throughout the idealized diurnal cycle are investigated systematically by means of large-eddy simulation (LES). Through a precursor simulation of the atmospheric boundary layer (ABL) over a homogenous surface throughout a day, it is found that the resulting shapes of wind profiles (including wind speed, wind direction and turbulence level) vary significantly at different time periods, induced by distinct stabilities of the atmosphere. Besides, wind profiles obtained using currently available engineering models are also included for comparison. Results illustrate that the standard engineering models cannot well capture the wind characteristics driven by the varying atmospheric stability solely, and further improvement is highly needed.

The simulated wind field data are then applied to wind turbine wake predictions, with the actuator line model implemented for the rotor effects. The results show that atmospheric stability has a significant effect on the spatial distribution of the wake speed and wake-added turbulence intensities as well as the wake meandering characteristics downwind of the turbine. In general, a faster wake recovery is observed under the convective condition than for the stable and neutral ones. This is mainly related to different turbulence levels of the incoming wind. Besides, detailed analysis of the resolved turbulent kinetic energy budget in the wake clearly reveals the considerable effect of thermal stratification on wake development. Based on these numerical investigations, a three-dimensional analytical wake model is developed for wake prediction. The results of both numerical simulation and model prediction are applied for validations through several cases, and proved to be of good accuracy.