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Effect of atmospheric turbulence on wind turbine wakes: An LES study

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A comprehensive numerical study of atmospheric turbulence effect on wind-turbine wakes is presented. Large-eddy simulations of neutrally-stratified boundary layers developed over different flat surfaces (forest, farmland, grass, and snow) are performed to investigate the structure of turbine wakes in cases where the incident flows to the wind turbine have the same mean velocity at the hub height but different mean wind shears and turbulence intensity levels. The simulation results show that the different wind shears and turbulence intensity levels of the incoming flow lead to considerable influence on the spatial distribution of the mean velocity deficit, turbulence intensity, and turbulent shear stress in the wake region downstream of the turbine. In general, the recovery of the turbine-induced wake (velocity deficit) is faster and the turbulence intensity level is higher and has its maximum closer to the turbine for wakes of turbines over rougher terrain. In order to isolate the effect of turbulence intensity from that of wind shear, simulations have also been performed with synthetic inflow velocity fields that have the same mean wind shear but different turbulence intensity levels. We find that the effect of the inflow turbulence intensity on the wake recovery and turbulence levels is stronger than that of the mean shear.