Vortex simulations of wind turbines operating in atmospheric conditions using a prescribed velocity‐vorticity boundary layer model

A prescribed velocity‐vorticity boundary layer model for the vorticity transport equation is proposed, which corrects the unphysical upward deflection of the wake seen in a simpler prescribed velocity shear approach. A Lagrangian implementation of the boundary layer model has been investigated using our in‐house vortex solver MIRAS. The MIRAS code contains both an aerodynamic part and a structural‐mechanical part taking into account aeroelastic phenomena. The solver is employed to simulate flows around wind turbines and uses a combination of filaments and particles in order to mimic the vorticity released by the wind turbine blades. The vorticity is interpolated onto a uniform Cartesian mesh, where the interaction is efficiently calculated by an fast Fourier transform‐based method. Simulations of wind turbines operating in an atmospheric boundary layer flow are carried out and analysed in detail for a range of scenarios. The manuscript focuses on studying the influence of wind shear and turbulence, which is varied to mimic natural atmospheric conditions. A traverse virtual probe up to 30 diameters downstream of the rotor plane is used to investigate the properties of the turbulent wake flow for the different cases. This includes mean and standard deviation of the streamwise velocity component, wake deficit, Reynolds stresses, and power spectral density of the velocity signal. The results show that combining a prescribed boundary layer approach with a vortex method gives consistent and physically correct results if properly implemented.

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