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Reynolds Number dependence of flow characteristics of wind turbine wakes

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Obtaining high quality data for turbulent flow around a full scale wind turbine is a quite complex and expensive task. The unsteady nature of atmospheric flow conditions further exacerbate the quality of the measurements that can be obtained. Wind tunnel experiments can provide very important information about the turbine wakes under controlled conditions. Since these measurements are obtained at lower than full scale values this could, in principle, preclude extrapolating some quantitative conclusions to full size wind turbines.
In this study, we study the wake of a model wind turbine under different Reynolds numbers (5 in total, ranging from 1.5×10^{5} to 1.3×10^{6}). Flow statistics, such as mean velocity, turbulence intensity and kinematic shear stress were compared at different locations behind the turbine (2, 4, 6, 8, 10 and 12 rotor diameters). Our results suggest that, in general, turbulent statistics will collapse at roughly a Reynolds number (Re_{δ}) of 3.6×105, that is significantly less than full scale Reynolds number In the far wake, where the flow starts to be modulated by the boundary layer flow, turbulence statistics become nearly independent of the Reynolds number. This is an important finding. Even though the structure of the turbulence cannot be replicated in wind tunnels, our results show that it is possible to infer quantitative conclusions about some of the important properties of a full size wind turbine wake.