Wind turbine aerodynamic measurements using a scanning lidar

A method for measuring wake and aerodynamic properties of a wind turbine with reduced error based on simulated lidar measurements is proposed. A scanning lidar measures air velocity scalar projected onto its line of sight. However, line of sight is rarely parallel to the velocities of interest. The line of sight projection correction technique showed reduced axial velocity error for a simple wake model. Next, an analysis based on large-eddy simulations of a 27 m diameter wind turbine was used to more accurately assess the projection correction technique in a turbulent wake. During the simulation, flow behind the turbine is sampled with a nacelle mounted virtual lidar matching the scanning trajectory and sampling frequency of the DTU SpinnerLidar. The axial velocity, axial induction, freestream wind speed, thrust coefficient, and power coefficient are calculated from virtual lidar measurements using two different estimates of the flow: line of sight velocity without correction, and line of sight with projection correction. The flow field is assumed to be constant during one complete scan of the lidar field of view, and the average wind direction is assumed to be equal to the instantaneous wind direction at the lidar measurement location for the projection correction. Despite these assumptions, results indicate that all wake and aerodynamic quantity error is reduced significantly by using the projection correction technique; axial velocity error is reduced on average from 7.4% to 2.8%.

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