Generic Methodology for Field Calibration of Nacelle-Based Wind Lidars

Nacelle-based Doppler wind lidars have shown promising capabilities to assess power performance, detect yaw misalignment or perform feed-forward control. The power curve application requires uncertainty assessment. Traceable measurements and uncertainties of nacelle-based wind lidars can be obtained through a methodology applicable to any type of existing and upcoming nacelle lidar technology. The generic methodology consists in calibrating all the inputs of the wind field reconstruction algorithms of a lidar. These inputs are the line-of-sight velocity and the beam position, provided by the geometry of the scanning trajectory and the lidar inclination. The line-of-sight velocity is calibrated in atmospheric conditions by comparing it to a reference quantity based on classic instrumentation such as cup anemometers and wind vanes. The generic methodology was tested on two commercially developed lidars, one continuous wave and one pulsed systems, and provides consistent calibration results: linear regressions show a difference of ~0.5% between the lidar-measured and reference line-of-sight velocities. A comprehensive uncertainty procedure propagates the reference uncertainty to the lidar measurements. At a coverage factor of two, the estimated line-of-sight velocity uncertainty ranges from 3.2% at 3 m·s⁻¹ to 1.9% at 16 m·s⁻¹. Most of the line-of-sight velocity uncertainty originates from the reference: the cup anemometer uncertainty accounts for 90% of the total uncertainty. The propagation of uncertainties to lidar-reconstructed wind characteristics can use analytical methods in simple cases, which we demonstrate through the example of a two-beam system. The newly developed calibration methodology allows robust evaluation of a nacelle lidar’s performance and uncertainties to be established. Calibrated nacelle lidars may consequently be further used for various wind turbine applications in confidence.

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