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A classical model wind turbine wake "blind test" revisited by remote sensing lidars

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One of the classical model wind turbine wake "blind test" experiments[1] conducted in the boundary-layer wind tunnel at NTNU in Trondheim and used for benchmarking of numerical flow models has been revisited by remote sensing lidars in a joint experiment called "Lidars For Wind Tunnels" (L4WT) under the auspices of the IRPWind initiative within the community of the European Energy Research Alliance (EERA) Joint Programme on Wind Energy.

The wind tunnel has a test section that is 11 m long and a cross-section of 2 by 3 m with windows along one side of the tunnel allowing for optical access from outside of the tunnel. Two continuous-wave lidars developed at DTU Wind Energy, short-range WindScanners[2], with a minimum focus distance of about 8 m were placed outside the tunnel with the optical heads at the turbine hub height. The short-range WindScanners can address the measurement location by synchronized steering of two wedge-shaped prisms and a translational motor stage for the focusing of the light. In addition, a small telescope (Lidic) was placed inside the wind tunnel and connected to the WindScanner steering system allowing for synchronized measurements.

The diameter of the model turbine studied was D=0.894 m and it was designed for a tip speed ratio (TSR) of 6. However, the TSRs used were 3, 6, and 10 at a free-stream velocity of 10 m/s. Due to geometrical constraints imposed by for instance the locations of the wind tunnel windows, all measurements were performed in the very same vertical cross-section of the tunnel and the various down-stream distances of the wake, i.e. 1D, 3D, and 5D were achieved by re-positioning the turbine.

The approach used allows for unique studies of the influence of the inherent lidar spatial filtering on previously both experimentally and numerically well characterized flow fields with various spatial flow gradients which is difficult to achieve in full-scale field experiments. As a consequence of the quadratic range dependence on the averaging length of a continuous-wave lidar, the results are of relevance also for full-scale wind turbine lidar measurement scenarios in terms of the averaging length relative to the wind turbine rotor size.

Figure 1: (**Left**) The model wind turbine and the Lidic lidar telescope on a traversing system in the background. (**Right**) One of the short-range WindScanners surrounded by some of the authors.

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[1] Krogstad and Eriksen, *Renewable Energy* **50**, 325 (2013).
[2] www.windscanner.eu