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Turbulence estimation from a continuous-wave scanning lidar (SpinnerLidar)

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One of the current challenges using lidars for wind energy measurements is the inability of lidars to accurately measure turbulence. Two important factors affecting lidar measurements of turbulence are:

- 1) the spatial averaging by the lidars sounding volume leading to smaller eddies being filtered out, and
- 2) the mixing of velocity covariances from other components into the line-of-sight variance measurements.

However, turbulence measurements based on upwind horizontal rotor plane scanning of the line-of-sight variance measurements combined with ensemble-averaged Doppler spectra width measurements has earlier been shown to provide unfiltered, un-truncated line-of-sight turbulence measurements [1], [2].

Turbulence measurements from a continuous-wave scanning lidar, i.e. the DTU SpinnerLidar, mounted on the nacelle of the CART3 turbine at the National Renewable Energy Laboratory (NREL) wind site in Colorado, USA are presented. The standard deviation of the turbulence component $\langle u' \rangle$ in the mean wind direction has been compared to turbulence measurements from a cup anemometer installed at hub height in an upwind reference met tower, cf. fig. 1. Lidar and cup anemometer measured standard deviations averaged over 10-min sampling periods are compared. Lidar variances are inherently more prone to noise which always yields a positive bias. The 5.3 % higher turbulence level measured by the SpinnerLidar relative to the cup anemometer may equally well be attributed to truncation of turbulent structures smaller than the cup anemometers length scale.

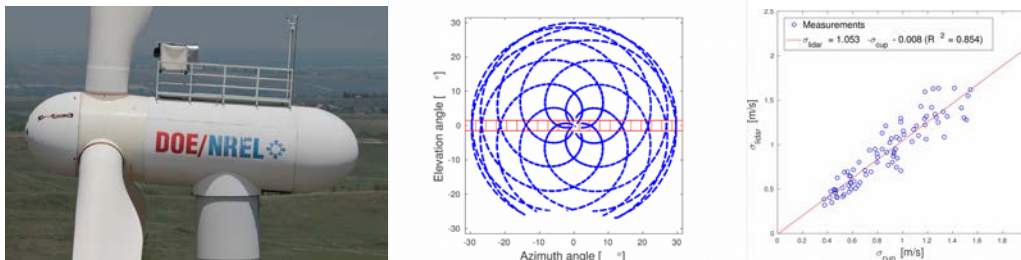


Fig.1. [Left]: NREL CART 3 test turbine with forward looking DTU SpinnerLidar installed on the Nacelle; [Middle]: Upwind 2D scan pattern. The red horizontal lines shows the area where horizontal scanned line-of-sight measurements were extracted; [Right]: Lidar measured along wind standard deviation compared to the corresponding turbulence measured by a cup anemometer.

The investigation has shown that it seems possible to overcome the truncations associated with probe volume filtering and component mixing by horizontal upwind scanning combined with spectral width information contained in the ensemble averaged Doppler spectra probability distributions.

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