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Real time turbulence and wind gust estimation from wind lidar observations using the turbulence reconstruction method

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A major issue in the wind energy field is the loads on wind turbine due to atmospheric turbulence and wind gusts. The turbulence is usually quantified by two parameters : the turbulent kinetic energy (TKE), and the turbulent intensity (TI). By definition, the TI is computed using observations of the horizontal wind over 10 minutes. The reference instrument for TI estimation is the cup anemometer. The same time period is often used for the TKE. However, a recent turbulence reconstruction method has been developed to estimate this parameter in real time from 3D wind lidar observations. The method retrieves TKE estimation at the observation frequency -at 0,25Hz in the presented case. The reconstruction method is a Monte-Carlo method which uses a particle system to estimate the 3D wind and its spatial variability. In addition of estimating TKE in real time, the method also improves the TI estimation. Comparisons between TI computed from different instruments will be presented : cup anemometers, sonic anemometers, WindCube V2 lidars, and the reconstruction method have been used. The differences between the instruments will be discussed. Among them, one point has to be emphasized : the comparisons show that the WindCube lidars overestimate the TI whereas the reconstruction method retrieves TI closer to the cup anemometer TI. Concerning the gust, traditionally, the wind gust measurements have been limited to the heights reached by weather mast. Wind lidars can potentially provide information from higher levels, but significant differences between wind speed maxima measured by lidars and by sonic anemometer have been shown. The reconstruction method takes advantage of the WindCube range to provide wind gust measurements at several heights. These measurements are in good agreement with sonic anemometer measurements when a low-pass filter with a cut-off frequency similar to lidar measurement frequency is applied to the sonic data. As the reconstruction method also describes the wind probability density function at the observation frequency of the lidar, a novel approach using that information to estimate the maximum wind measured by sonic anemometer will be presented.