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Very short-term probabilistic wind speed and power forecasts based on lidar measurements at the offshore wind farm Global Tech I

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Due to the fluctuating nature of wind and its increasing integration into the grid short-term wind power fluctuations have become a challenge for transmission system operators. Very short-term forecasts of wind speed and power are therefore increasingly gaining importance as a tool to improve power system management and grid stability and to reduce curtailment costs.[1] Hereby, especially probabilistic forecasts are considered useful for decision making processes as they additionally provide uncertainty information.[2]

Current research has shown that lidar measurements can be used to forecast wind speed on very short time horizons and in a deterministic manner.[3] Further, very short-term probabilistic power forecasts based on dual-doppler radar measurements have been developed, showing more skill than commonly applied statistical methods.[4] Our research aims to extend this methodology to single-doppler lidar data.

For this analysis long range lidar measurements are used to predict wind speed and power on short time horizons up to 10 minutes. Here, we utilize plan position indicator (PPI) lidar measurements of the inflow at the offshore wind farm Global Tech I in the German North Sea. The horizontal PPI scans, measured at a platform height of 25 m, span an azimuth of $150°$ with a resolution of $2°$, have an averaging time of 2 s per measurement and are repeated roughly every 2.5 minutes. Range gates ranging from 0.5 km to 8 km with 35 m spacing are measured.

Horizontal wind speed components at each azimuth and range gate are reconstructed by applying a velocity-azimuth display (VAD) algorithm and further interpolated to a cartesian grid. Applying an advection technique, the wind vectors are then propagated downstream. Wind speed distributions at individual free stream turbines are developed by selecting those vectors falling into a defined temporal and spatial window.[4] Forecasts at hub height are determined assuming a logarithmic wind profile. To do so, atmospheric stability is estimated using on-site meteorological measurements. Applying a bootstrapping technique and a probabilistic power curve wind speed distributions are further translated into power distributions. Wind speed and power point forecasts as well as predictive densities derived from those distributions will be evaluated using high resolution operational data (SCADA data) of the wind farm. Initial results have shown that 5-minute-ahead wind power point forecasts outperform the benchmark persistence.

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