Wind Turbine Wake Experiment Wieringermeer

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An increase in nacelle height and rotor diameter of wind turbines in recent years have made measurements of wind profiles via meteorological masts difficult. In response LiDAR remote sensing has become increasingly important. With this technique, wind information at different heights is easily accessible and enables an analysis of boundary layer processes.

WindCube v1
The WindCube v1 (figure 2) is a pulsed LiDAR system using the Doppler Beam Swing (DBS) technique to retrieve prevailing wind profiles. With 10 user defined altitudes the device can measure simultaneously up to a height of 200 m with a data accumulation time of 4 seconds.

WindCube 100S
The WindCube 100S (figure 3) is a scanning pulsed LiDAR system using Plan Position Indicator (PPI), Range Height Indicator (RHI) and DBS scanning techniques to picture 2D wind profiles. With 10 user defined altitudes the device can measure to a distance of 3 km from the instrument.

First Results
First results show that the wake of the research turbine nr. 6 moves out of the assumed area of interest (2x10 D), which illustrates that the Windcube 100S is able to capture snapshots of yaw induced wake meandering. Wake meandering can also be confirmed by vertical cross-section through the central wake line, as wake deficits leave and enter the vertical plane. As illustrated in figure 6b, the Windcube 100S could also capture a snapshot of downward propagating tip vortices over a distance of at least 7.5 D.

A first analysis of the v1 profiles show that turbulence intensities are on average highest and most variable during stable weather conditions, whereas in unstable conditions turbulent structures seem to be more redistributed than intensified (figure 7).

Southwesterly winds and unstable weather conditions dominate the analyzed period (December 2013 – May 2014).

In order to capture wake characteristics under different weather conditions we scanned a 60° sector at three different elevations and two vertical cross-sections every minute. Additional Windcubes v1 measured wind profiles every second at 2 and 5 rotor diameter downstream distances. Another static Windcube, a forward-looking nacelle LiDAR and three Sonics are placed upstream to measure the undisturbed approaching flow field.

Aim
The aim of the campaign is a qualitative and quantitative description of single wind turbine wake propagation and persistency, as well as to improve CFD wake models by delivering a detailed data set of several real atmospheric conditions.

Methods
Further test/develop wake characterization criteria
EOF analysis of radial velocity fields
Definition of an area mean wake index for correlations to v1 and met mast and turbine data
Correlations between wake intensity, stability and power production of the wind turbine

Outlook

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