Challenges in recording high quality wake flow measurements of a wind turbine in field experiments

M. Bromm*, A. Rott*, H. Beck*, L. Vollmer, G. Steinfeld* and M. Kühn***
*ForWind – Carl von Ossietzky University of Oldenburg, Institute of Physics, Oldenburg, Germany
** Fraunhofer Institute for Wind Energy and Energy System Technology IWES, Oldenburg, Germany
marc.bromm@uni-oldenburg.de

Abstract

Field measurements are frequently demanded as a reference for a qualitative and quantitative validation of simulation models. To ensure the quality of the data a comprehensive and comprehensible documentation of the experimental setup and the applied post-processing methods is required. A lack of common measurement guidelines within the wind energy research community may affect the comparability of field measurements and renders the validation of simulation results and wake models difficult. We would like to share our observations from a recent field campaign at a 3.5MW wind turbine in which we used state-of-the-art sensors to demonstrate the applicability of wake deflection through yaw misalignment. The main focus of the current work is not primarily going to be on the scientific results but rather on the methodological and technical challenges which are encountered when performing such complex campaigns.

Keywords: *lidar, field campaign, validation, wake deflection*

For analysing the wake flow of a wind turbine in regular operation and for assessing the applicability of wake deflection [1, 2] through turbine yaw misalignment, we carried out a measurement campaign at a 3.5MW eno114 wind turbine in northeastern Germany [3]. A state-of-the-art measurement setup was employed to capture the key parameters needed for improving our understanding of the interaction of wind turbine and flow and for recording high quality measurements which can be used for further validation purposes. The setup we used consisted of a nacelle based long-range lidar for capturing the wake flow, a lidar profiler and a spinner lidar for characterising the inflow, eddy-covariance-stations for obtaining the atmospheric stability and GPS for identifying the yaw orientation of the wind turbine. Additional redundancy was generated through the availability of met mast measurements and SCADA data.

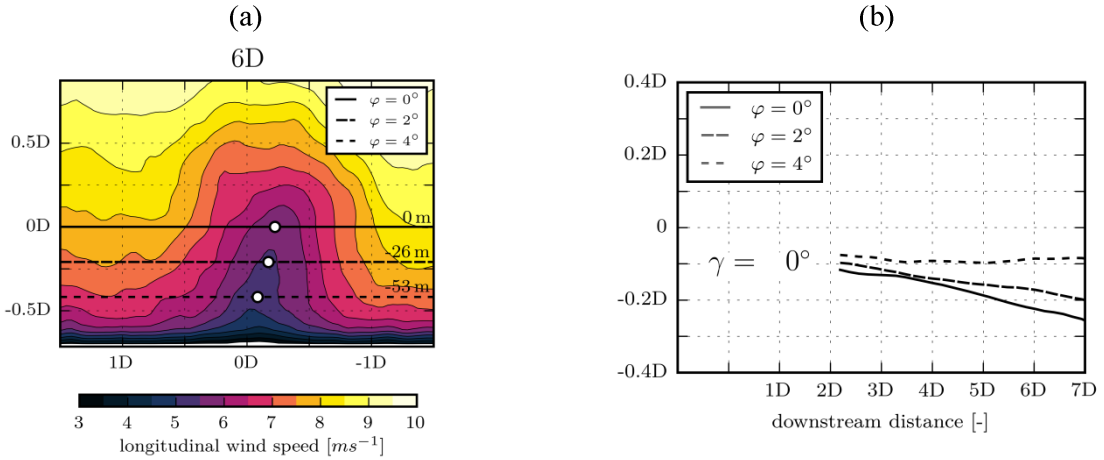

Figure 1: (a) Impact of inclined plane position indicator measurements of a nacelle lidar illustrated with the mean 600s averaged longitudinal flow 6D downstream of a NREL 5MW wind turbine in a neutrally stratified boundary layer. The wake sections measured for inclinations angles φ of 0°, 2° , 4° of the measurement plane are indicated by black horizontal lines of different styles. The corresponding wake centres which were determined by a Gaussian fitting approach are marked by white dots. (b) Full wake trajectories until 7D downstream for the three inclined measurements described in (a)

In preparation of the campaign large-eddy simulations were performed to adjust the experimental setup according to the expected measurements. Furthermore we used the simulations results to analyse the effect of potential uncertainties in the measurement setup. One example being how the nacelle movement influences the intended measurement position of a nacelle mounted long-range lidar (Figure 1).

The given approach allowed us to successfully demonstrate wake deflection through turbine yaw misalignment in the field. However, despite extensive experiences based on previous onshore and offshore field experiments, a thoughtful planning of this campaign and the use of state-of-the-art sensors, we identified several aspects throughout the campaign which we believe need further thought and must be critically assessed. Those include, among others, the general alignment of lidar devices (ground-based and nacelle-based), the identification of the inflow direction (Figure 2) and the turbine orientation.

A lack of common guidelines or recommendations within the wind energy research community for measurement procedures and post-processing methods may affect the comparability of field measurements and renders the validation of simulation results and wake models difficult, thus limiting the overall value of the measurement data.

Particularly based on our experiences from the recent comprehensive field campaign we would like to share our observations, highlight challenges, point out possible solutions and thereby initiating a discussion about future strategies and developments.

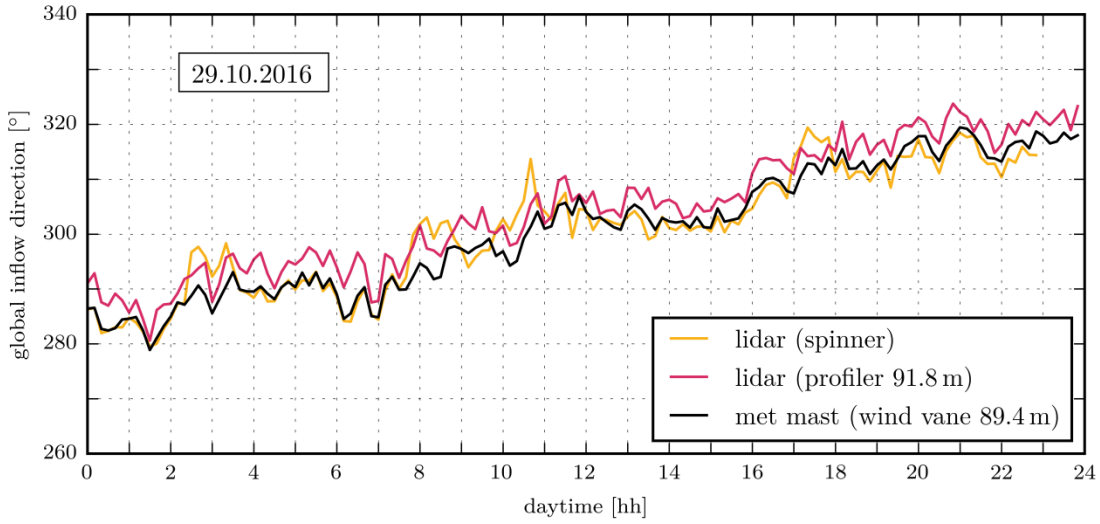

Figure 2: Time series of the 10 min averaged inflow direction determined by a short-range spinner lidar, the lidar profiler in 91.8 m height and the met mast wind vane in 89.4 m height for the 29th of October, 2016.

References

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