Lidars and wind coheren

Jasna Bogunovic Jakobsen, Professor, University of Stavanger

Over the past two years, the University of Stavanger, the University of Bergen and Christian Michelsen Research have explored novel applications of lidars relevant to structural design. One example is the pilot measurement campaign at the Lysefjord bridge site, in which both pulsed- and continuous-wave lidars were deployed for wind characterization [1]. The continuous wave-, short range WindScanners were utilized in collaboration with the Technical University of Denmark Wind Energy Group.

The potential of lidar measurements to capture the spatio-temporal characteristics of the wind field "experienced" by a structure, demonstrated at the Lysefjord bridge, triggered a new investigation on the applicability of lidars for assessment of offshore wind coherence. The coherence function quantifies a decreasing synchronization of the wind velocity fluctuations for increasing distances in the rotor plane, and increasing frequencies.

A measurement set-up tailored for observations of the wind velocity variations in a rotor plane has been developed, and explored using lidars currently installed at the Fino1 research platform in the North Sea. The platform is located some 45 km North-West off the German cost and is utilized for the OBLEX-F1 measurement campaign. The campaign was launched by NORCOWE in May 2015 and will last to September 2016. The campaign addresses various aspects of the atmospheric and the oceanic boundary layer and their interaction across the air-sea interface, including wave effects.

One of the two pulsed Doppler lidars on the Fino1 platform, WindCube100S, is positioned at the base of the 100 m high measurement mast, in the south-west corner of the approximately 20 m x 20 m large platform deck area. The second lidar is placed on the top of a container about 3.5 m above the platform deck, at about 10 m horizontal distance from the first one. The two scanning heads are located roughly 20 and 24 m above the mean sea level.

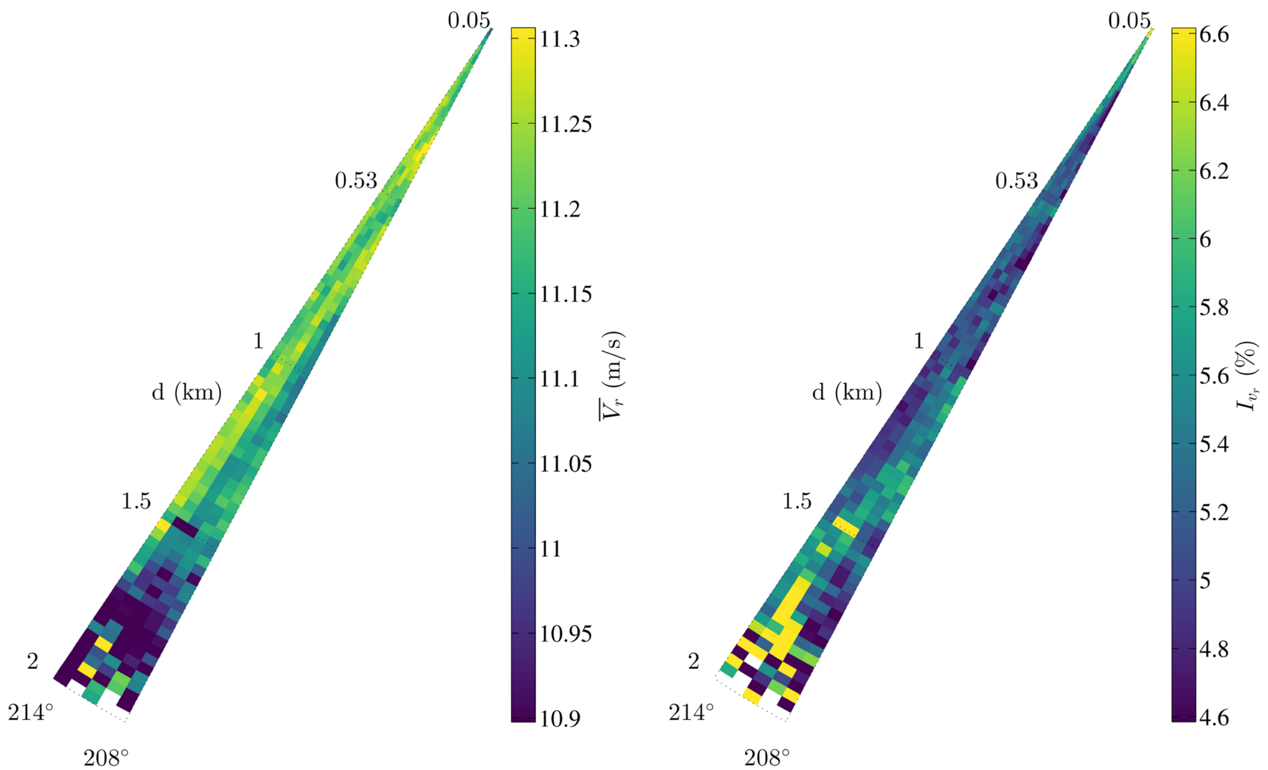

Figure 1: Mean wind velocity and turbulence intensity, PPI scan 18.12.2015 20:40 to 20:50.

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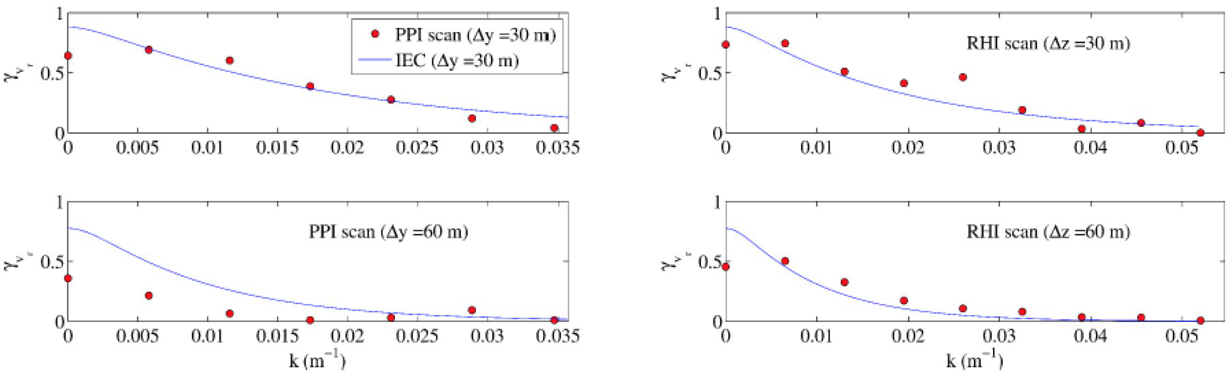

Figure 2: Coherence of the along-wind turbulence component for lateral (left) and vertical (right) separation

The key step in the coherence measurements is to orientate the lidars into the mean wind direction, similarly to the orientation of a wind turbine rotor. At present, this is done manually, utilizing the online access to the instruments and the available real-time data on the mean wind direction, from the sonic anemometers on the platform.

In order to observe the wind velocity fluctuations at various distances across the mean flow direction, the prime measurement set-up utilizes two lidars in the so-called LOS (Line Of Sight) scanning modes, with slightly diverging light beams. In another arrangement, the so-called PPI and the RHI measurement modes (see page 11) can be used by a single lidar to survey the sectors in the horizontal and the vertical plane. A 6° angle sector corresponds to the across-flow separations of 150 m at 1.5 km distance from the lidar, and is considered to be small enough to provide the measurements of nearly parallel wind velocity components. The PPI and the RHI scanning modes make it possible to acquire the data at several different across-flow separations for a given distance from the lidar, at a cost of a reduced sampling rate. The recording interval in this case varied between 2.5 to 3.5 s, for the lines in the middle of the sector, to 5 to 7 s, in the outer part of the sectors, in the RHI and the PPI modes respectively. Figures 1 and 2 show the preliminary results obtained utilizing data from a single lidar and provide the proof of concept of the measurement set-up [2]. The results suggest that the estimated coherence is in the overall agreement with the function based on the Kaimal spectra, provided in [3]. A more extensive data set is required in order to establish reliable estimates of the coherence. Further analysis is also planned to include wind velocity records acquired simultaneously by two lidars. A complementary study based on the sonic anemometer data from the Fino1 platform is investigating the along-wind turbulence coherence for vertical separations [4].

References

1. Jakobsen, J.B, Cheynet, E., Snæbjörnsson, J., Mikkelsen, T., Sjöholm, M., Angelou, N., Hansen, P., Svardal, B., Kumer, V. and Reuder, J. (2015), Assessment of wind conditions at a fjord inlet by complementary use of sonic anemometers and lidars, EERA DeepWind'2015 Deep Sea Offshore Wind R&D Conference, Trondheim, Feb 4-6, 2015. Energy Procedia, ISSN: 1876-6102.
2. Cheynet, E., Jakobsen, J.B., Svardal, B., Reuder, J. and Kumer, V. (2016), Wind coherence measurement by a single pulsed Doppler lidar, EERA DeepWind'2016 Deep Sea Offshore Wind R&D Conference, Trondheim, Jan 20-22, 2016.
3. IEC 61400-3 /NEK EN 61400-3:2009, Wind turbines - Part 3: Design requirements for offshore wind turbines.
4. Obhrai, C. and Eliassen, L. (2016), Coherence of turbulent wind under neutral wind conditions at FINO1, EERA DeepWind'2016 Deep Sea Offshore Wind R&D Conference, Trondheim, Jan 20-22, 2016.