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Full-scale wake measurements with three long-range lidar at the Perdigão 2017 experiment

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The interaction of the wake of a full-scale wind-energy converter (WEC) with the atmosphere is of major concern for the wind-energy community. It controls the deviation of the wake, the wind speed deficit and the dispersion of the wake as a function of the distance to the WEC. These parameters are important for wind farm design in order to evaluate how the wakes of the WECs affect each other, and thus the efficiency of the wind farm and the life time of the turbines. Financed by the German Federal Ministry of Economy and Energy1, the German Aerospace Center (DLR) contributes to the NEWA (New European Wind Atlas) experiment in the province of Perdigão (Portugal) with three long-range Doppler wind lidars of type Leosphere Windcube 200S from May to June 2017. In the experiment, a single WEC of type Enercon E82 is situated on a mountain ridge. In main wind direction, which is almost perpendicular to the ridge, a valley and then a second mountain ridge in a distance of approximately 1.4 km follow. Two of the DLR lidars are placed downstream and in line with the main wind direction. One of these lidars is placed in the valley, and the other one on the distant mountain ridge. This line-up allows coplanar scanning of the wake in the ideal case of a wind-direction which is parallel to the scanning plane. These measurements will allow identifying flow structures in the wake from directly behind the WEC up to at least twelve rotor diameters downstream. The third lidar is placed on the first ridge, approximately 300 m from the WEC. With this lidar, the wake can be cut with a vertical scan in distances from 1-4D to the WEC, in order to identify the location of the wake center. Other scenarios that are planned for the experiment are volumetric scans of the whole valley and triple-doppler measurements of defined points in the wake, using all three lidars. In wind situations when the lidars are upstream the WEC, the same scanning scenarios can identify the flow through the valley, which hits the turbine and thus defines its loads.
The results of the lidar measurements will be related to the atmospheric stability, which can be identified with the help of a microwave radiometer (MWR) that is placed 1.7 km upstream of the WEC and can measure vertical profiles of temperature and humidity with a resolution of 50 m in the boundary layer. Additionally, a vast number of measurements of the flow around the mountain ridges is carried out by other research groups with in-situ as well as remote sensing instrumentation and can be taken into account for the analysis.
Besides the meteorological measurements of the flow field and the thermal stratification, the DLR also carries out acoustic measurements of the sound immission in the environment of the WEC. With the help of these measurements, the influence on atmospheric conditions on sound propagation is studied and its models can be validated and improved.
Lessons learned and preliminary results of the experiment will be presented at the conference.