Full-Scale Field Test of a Blade-Integrated Dual-Telescope Wind Lidar - DTU Orbit
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Introduction
In recent years the use of wind lidars mounted directly on wind turbines has received increasing attention, and such systems are becoming commercially available. One aim of turbine-mounted wind lidars is to use them for prevision in connection with advanced feed-forward control systems for load reduction and power optimization. To date, main attention has been on control schemes where measurements of wind speeds and direction upwind are used for yaw and speed corrections. In this study we investigate experimentally the feasibility of using lidars integrated in the turbine blades for alleviating loads and also for active individual pitch control.

Approach
Two small telescope units with 1” optics were mounted on either side of one blade of a Vestas NM80 turbine, 15 m from the spinner and connected through fibre optical cables to a modified ZephIR 300 continuous-wave Doppler lidar from Natural Power, UK. The ZephIR was installed in the tip of the spinner of the turbine. The two telescopes’ line-of-sights were converging with 10 angle, resulting in an intersection at 5 m in front of the blade along the cord extension line. By using an optical switch, the line-of-sight wind speeds could be measured alternately from the two telescopes.

Main body of abstract
The two telescope blade lidar system was installed in the turbine in the summer of 2012 and the following measurement campaign ran from July 13 through August 19. At the same time a spinner lidar intended for measuring the inflow in a two-dimensional plane upwind was installed in the turbine and the first results from these experiments will be presented in another EWEA 2013 contribution. The lidar logged the raw Doppler spectra and the wind speed estimation was done subsequently using software designed specifically for the blade-mounted lidar. Simultaneously, data regarding wind speed, rotational speed, and pitch angle recorded by the turbine was logged as well as data from a nearby met mast. The encouraging results of this first campaign include wind speed measurements at 20 Hz data rate along the rotor plane, acquired during the co-rotation of the telescopes and the wind turbine blade. Because of the placement 15 m down the blade the measured speeds are high, typically in excess of 25 m/s. However, the lidar can measure up to about 40 m/s and has no difficulties measuring the required speeds. In addition to providing interesting information about the wind very close to the blade, the measurements were further used for assessing the blade angle-of-attack (AOA) as function of the turbine rotation. This showed that even for the pitch-regulated turbine the AOA could be several degrees away from perfect pitch because of the different wind speeds in the top and bottom of the rotor plane.

Conclusion
We present here what we believe is the first successful wind speed measurements from a dual-telescope lidar installed on the blade of an operating wind turbine. The full-scale field test performed in the summer of 2012 has clearly demonstrated the possibility of integrating telescopes into turbine blades as well as the capability of the lidar to measure the required wind speeds and to operate in the challenging environment of a rotating spinner and vibrating blade. The use of two separate telescopes allows a direct measurement of the blade’s AOA demonstrating its potential use in future advanced control systems.

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