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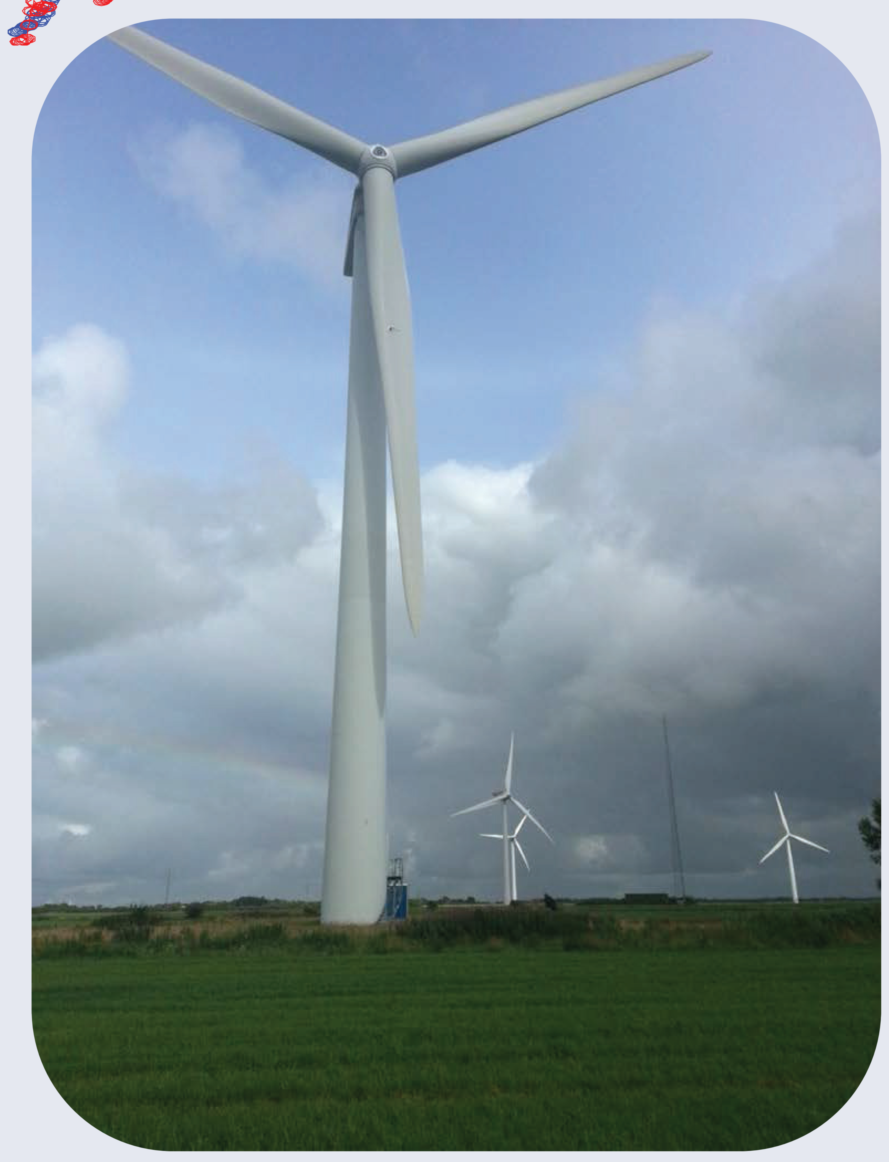
DTU

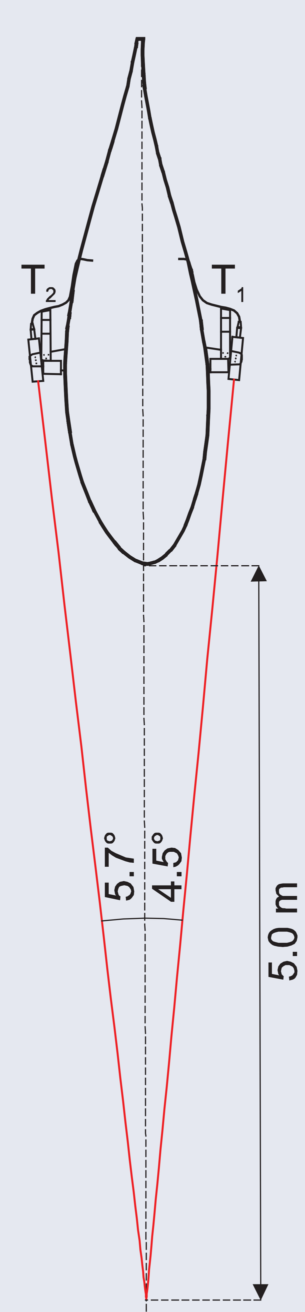
Introduction



In recent years the use of wind lidars mounted directly on wind turbines has received increasing attention. 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 optimization.

In this study we experimentally investigate the feasibility of using lidars integrated in the turbine blades for alleviating loads and also for active individual pitch control. The measurement campaign ran from July 13 through August 24 2012. 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 (PO. ID 126).

Mounting of lidar



The dual-telescope wind lidar consists of two small telescope units with 1" optics connected to a modified ZephIR 300 continuous-wave Doppler lidar[1,2] through fibre optic cables. The ZephIR lidar is installed in the spinner of a Vestas NM80 turbine and the telescopes are mounted on either side of one of the blades 16.2 m from the centre of rotation. The two telescopes' beam axes are converging with approximately 10 angle, resulting in an intersection at 5 m in front of the blade along the cord extension line where also the focus of the laser beams lie. By using an optical switch, operating at a switch rate of 10 Hz, the line-of-sight wind speeds can be measured alternately from the two telescopes.

References

1. Pedersen, A. T., Montes, B. F., Pedersen. J. E., Harris, M., Mikkelsen, T., Demonstration of short-range wind lidar in high-performance wind tunnel, *EWEA 2012*, PO.78, 2012
2. http://www.zephirlidar.com

Results

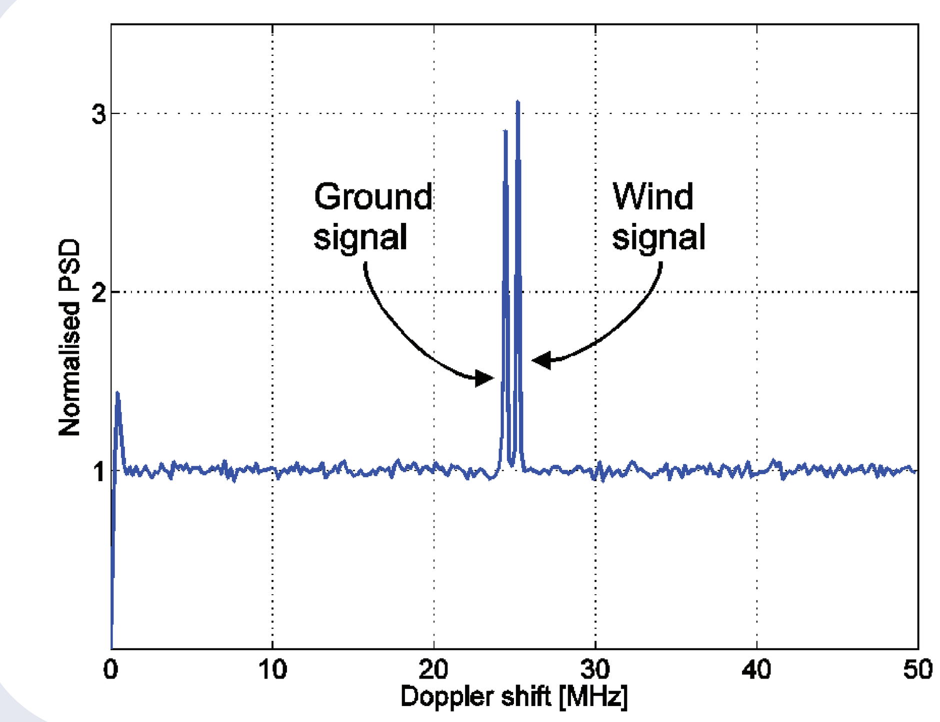
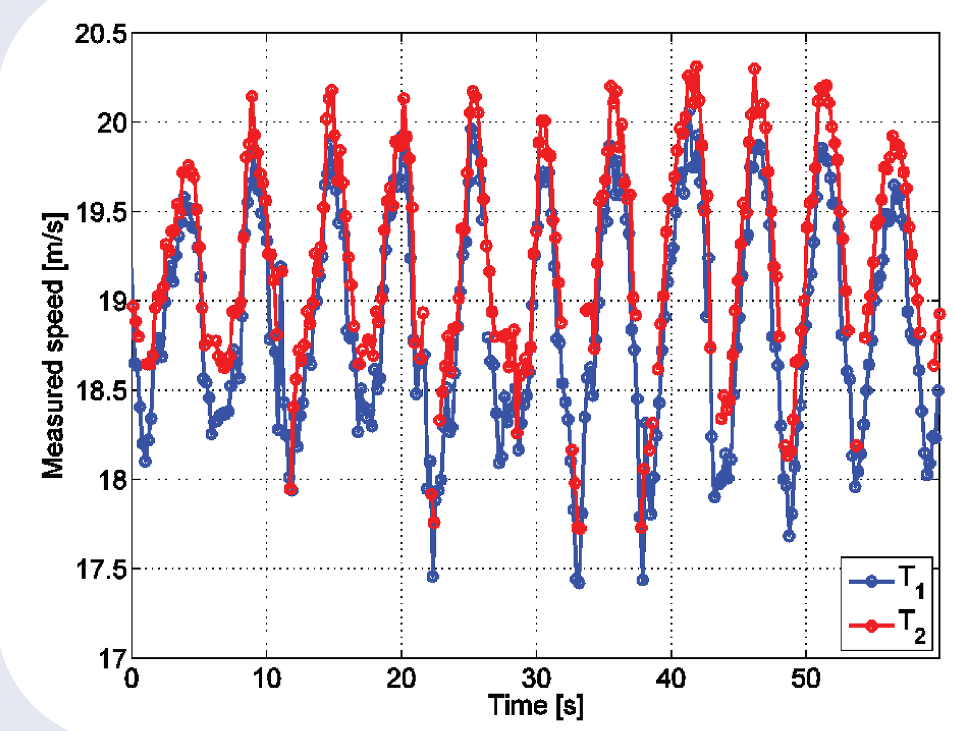


Figure 1. Example of a normalised Doppler spectrum obtained by telescope T_1. The spectrum is seen to contain two distinct peaks located at 24.4 MHz and 25.2 MHz, respectively. The first peak is due to reflections from the ground when the telescope is pointing downwards and if not filtered out this can lead to erroneous wind speed estimations. The second peak is the wind signal which is the combined effect of the wind and the motion of the blade.

Figure 2. Time series of the speed measured by the two telescopes over a one minute period. The measured speeds are seen to oscillate in excellent agreement with each other and also with the rotation period of the turbine. The peaks in wind speed coincide with measurement at the highest point of the rotation, where the wind speed is highest due to shear. Also noticed is a band between 18.0 m/s and 18.5 m/s where no measurements were obtained by Telescope 2. This is due to wind signals coinciding with ground signals and these are therefore filtered out.



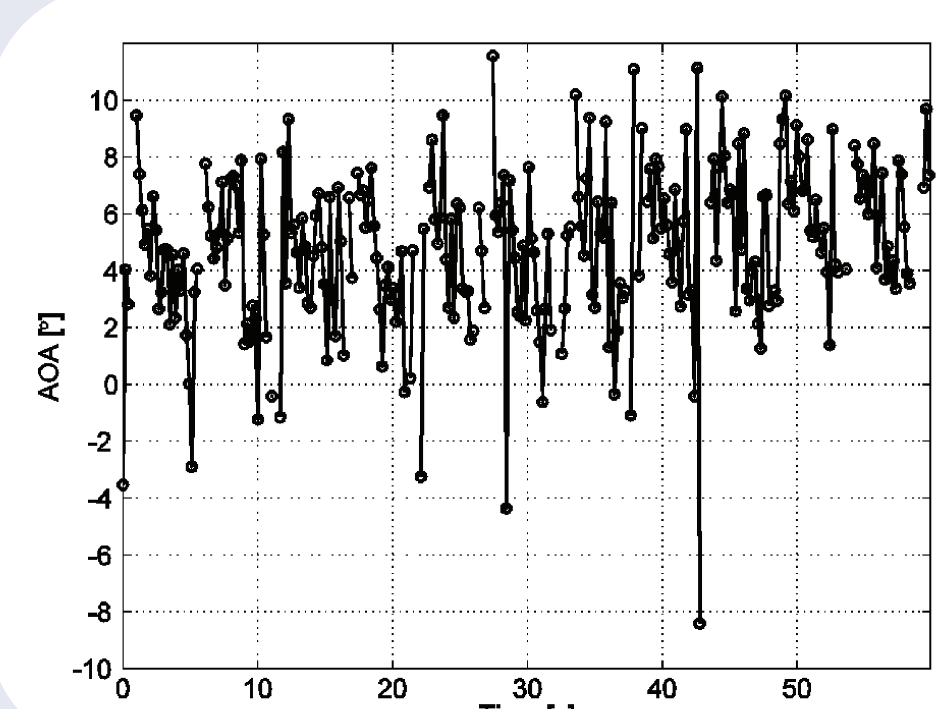


Figure 3. Angle-of-attack (AOA) calculated from the speed measurements shown above. In the beginning of the time series the AOA oscillates around 5 and increases to around 7 in the end. An oscillation with the same frequency as above can be seen, although also some noise is present. Missing data points are seen to appear where the ground signal filter has removed the wind signal from telescope T_2. This highlights the importance of high data availability.

Conclusions

We present here what we believe are the first successful wind speed measurements from a dual-telescope lidar installed on the blade of an operating wind turbine. The results show a variation in AOA as the blades cut through the shear profile. The full-scale field test performed in the summer of 2012 has clearly demonstrated the possibility of integrating lidar 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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