The FINO1 measuremen

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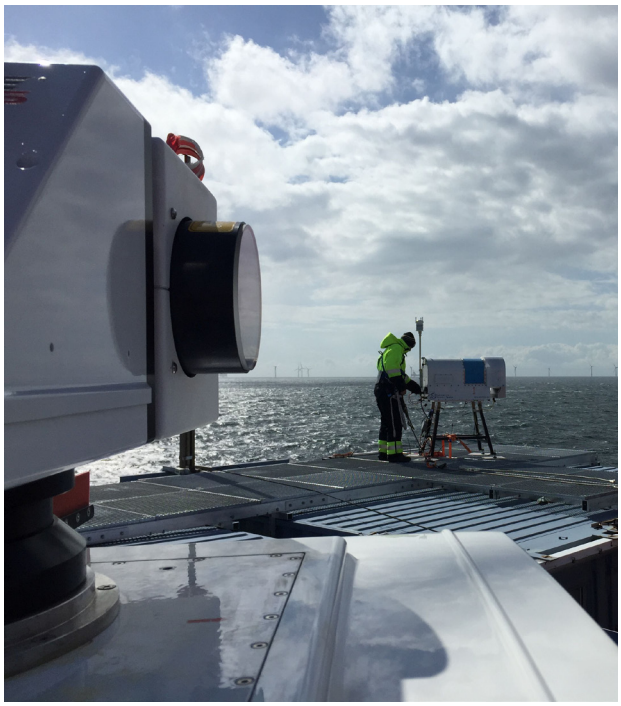

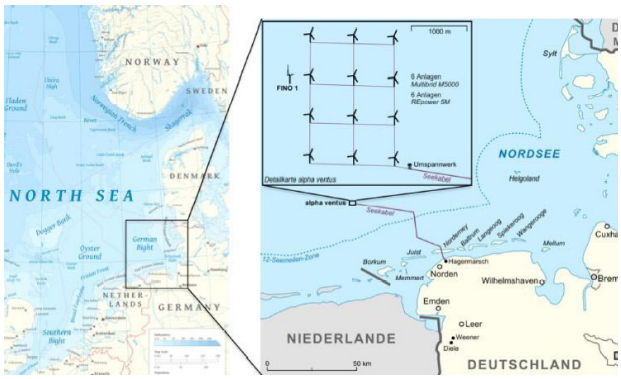

In May 2015 NORCOWE started up an extensive offshore measurement campaign at the German research platform FINO1 close to the Alpha Ventus wind farm. The key purpose of the campaign is to improve our knowledge of the marine boundary layer stability, air-sea interaction and offshore wake propagation effects. The collected observational data will be used to validate and improve numerical models and tools for i.e. weather forecasting, marine operations, power performance and wind farm layout.

Two scanning lidar systems (Leosphere WindCube100S) and a microwave-radiometer (RPG-HATPRO) have been installed on the research platform. This is the first time that such a combination of instruments is installed at an offshore location. By employing microwave radiometer and long range lidar remote sensing technology together, we are able to continuously map the boundary layer conditions up to an altitude of several kilometers by simultaneous measurements of wind, temperature and humidity profiles. This provide unique datasets for the study of boundary layer stability in offshore conditions.

One scanning lidar is placed underneath the met mast, and one on top of a measurement container specifically adapted for FINO1 by ForWind Oldenburg. In this way the lidars cover different inflow and wake sectors, in addition to having overlapping field of view in key directions e.g. towards the Alpha Ventus wind farm. For ten minutes every hour, the scanning lidar on the container provides vertical wind profile measurements in parallel to the radiometric temperature and humidity profiling. The rest of the time the lidars are mapping inflow and wake beahviour in different preconfigured scanning scenarioes including horisontal (PPI) and vertical (RHI) scan trajectories. The scanning patterns of both lidars can be remotely reconfigured, and we have online access for data retrieval. This means we are also able to perform more dynamic studies adapted to actual wind conditions, such as e.g. synchronized dual doppler operation and steering mode measurements targeted towards mean wind direction for wind turbulence characterisation, as performed in a collaborative project between the University of Stavanger, University of Bergen (UiB) and Christian Michelsen Research (CMR).

For reference and validation of wind measurements, the FINO1 metmast is equipped with cup, vane and sonic wind sensors up to 100m. Additionally, a vertical lidar (Windcube V1) was installed by DEWI in September providing vertical wind profiles up to 200m altitude. Two sonic anemometers (DCF systems) were mounted under the met mast at approximately 15 and 20 m LAT (Lowest Astronomical Tide) to expand the turbulence characterisation capability at FINO1 and provide wind measurements closer to the sea surface.

The experience gained from our pilot deployment of the lidars and radiometer at the UiB, StormGeo and CMR rooftops in Bergen proved to be invaluable in preparation of the novel

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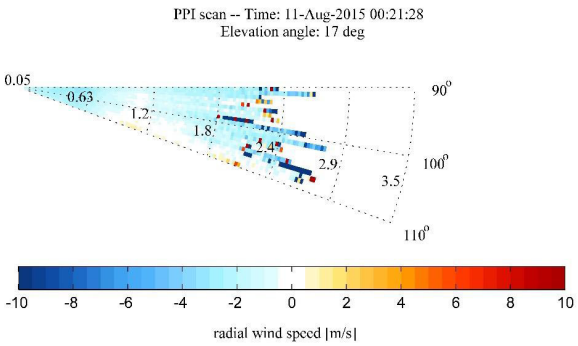

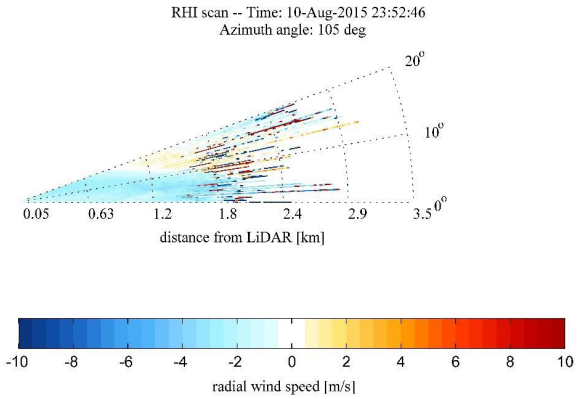

The figure shows two types of scan done by the lidar. In the PPI (Plan Position Indicator) scan (left) the elevation angle is held constant while the azimuth angle is varied during the scan. In the RHI (Range Height Indicator) scan the azimuth angle is constant while the elevation angle varies.

The characteristics of the lidars we use, the Leopsphere Windcube 100s, are as follows:

- *Azimuth angle: 0 –360 deg, Elevation angle: -10 –190 deg, Angular resolution: 0.1 deg*
- *Maximum rotation speed: 0.5 –8 deg/s while acquiring data*
- *Measurement resolution: from 50 m up to 3500 m, 25 m intervals*