OBLO instrumentation at FINO1

Martin Flügge[1,3], Benny Svardal[1,3], Mostafa Bakhoday Paskyabi[2,3], Ilker Fer[2,3], Joachim Reuder[2,3], Stian Stavland[1] and Stephan Kral[2]

[1] Christian Michelsen Research AS, Bergen, Norway
[2] University of Bergen, Bergen, Norway
[3] Norwegian Centre for Offshore Wind Energy (NORCOWE)

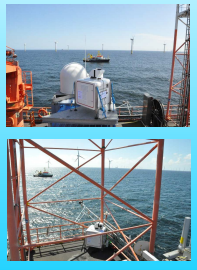
Background

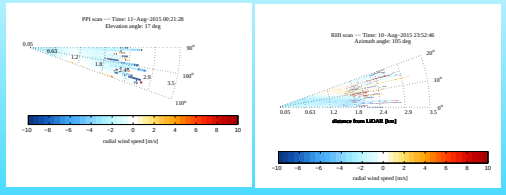
The Offshore Boundary-Layer Observatory (OBLO) operates state-of-the-art instrumentation and provides measurement capabilities for a wide range of atmospheric and oceanographic parameters relevant for offshore wind energy applications. As part of a measurement campaign performed by the Norwegian Centre for Offshore Wind Energy (NORCOWE), two scanning LiDAR systems and a passive microwave radiometer are deployed at the German research platform FINO1 in close vicinity to the Alpha Ventus wind farm. Simultaneous measurements of both wind speed, air temperature and humidity are performed up to an altitude of 1000 m, between May 2015 and June 2016. The oceanographic conditions, including sea temperature, salinity and current profiles, directional surface wave properties and turbulence levels in the water column were sampled from several submerged moorings, deployed between June and October 2015 in close vicinity to Alpha Ventus. The gathered data provides information on the interaction between the waves and the lower 200 m of the marine atmospheric boundary-layer. Such a combination of both meteorological and oceanographic instruments provide researchers with a unique data set that is highly relevant for offshore wind energy, e.g. wake propagation effects, boundary-layer stability and numerical model validation.

Meteorological OBLO instrumentation deployed at the German research platform FINO1 in the North Sea.

Measurement of the radial wind speed by scanning LiDAR systems

Two WindCube 100s systems perform measurements of the radial wind speed. The gathered data provide information on the wind conditions inside and around Alpha Ventus. This allows studies such as turbine inflow and turbine wake effects.

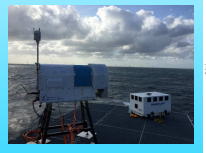


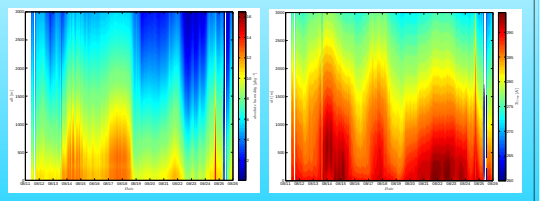


Example of an PPI (left) and RHI (right) scan directed into the Alpha Ventus wind farm. The changes in the wind speed due to the presence of a wind turbine is clearly visible

Measurement temperature- and humidity profiles

A passive microwave radiometer provides vertical profiles of atmospheric temperature and humidity up to more than 1000 m. These measurements are combined with the wind LiDAR measurements to obtain information on dynamic stability conditions at FINO1. This is the first time that such measurements are performed continuously nearby an offshore wind farm.





Example of Hovmøller diagrams for humidity (left) and temperature (right) obtained from radiometer data.

High frequency wind measurements

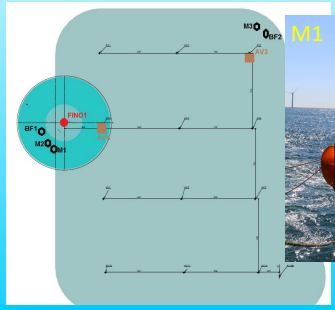
Two Gill-R3 ultra sonic anemometers (USA) have been installed at 15 and 20 masl, in addition to the already installed FINO1 USA at 40, 60 and 80 masl. The array of USA provide profiles of high-frequency 3D wind vector measurements. In addition, the USA installed at the lower levels provide information on heat- and momentum fluxes which is highly needed for the characterization of the marine atmospheric boundary-layer.

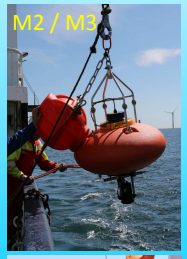
FINO1 mast measurements

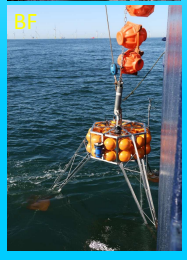
Measurements of wind speed and direction are performed from cup anemometers and wind vanes installed in the FINO1 100 m met-mast since its construction in 2003. Time series of air and water temperature, relative humidity and precipitation are also recorded at FINO1 at selected heights. In addition, wave parameters are recorded from a Datawell Directional Waverider Buoy moored nearby the platform.

Oceanographic measurements

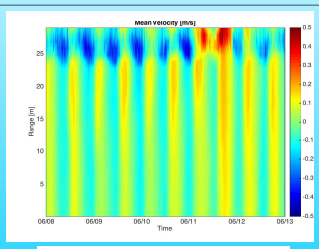
The overall aim of the oceanographic deployment is to gain a better understanding of environmentally significant interactions between the atmosphere, the ocean and offshore structures. This research focuses on the upper ocean turbulence characteristics in the presence of surface gravity wave-related processes such as wave breaking, non-breaking waves and coherent large-scale Langmuir circulations. This study intents to increase our knowledge about the interactions between offshore wind farms and upper ocean processes and to improve the understanding of single turbine and wind farm wake characteristics in the presence of combined wind and wave effects.

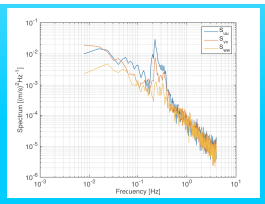






Several moorings have been deployed in close vicinity to FINO1 and the northeast side of the Alpah Ventus wind farm. The bottom frames (BF1 and BF2) and the submerged moorings (M2 and M3) were equipped with ADCP and ADV which provided current profiles and directional wave properties, in addition to turbulence statistics within the water column. The mooring M1 was equipped with airfoil shear probes and fast response thermistors in order to assess the Reynolds stresses.





Example of a Hovmøller diagram for current speed obtained from ADCP measurements (upper figure) and example of a power spectra obtained from ADV measurements (lower figure).

SailBuoy

In addition to the oceanographic equipment, the Sailbuoy "SB Wave" was deployed at FINO1. The Sailbuoy was equipped with a motion sensor to provide an additional source of wave properties during the measurement campaign.

This platform is a surface vehicle with autonomous navigation. It is able to stay at sea for several months and can be used for a variety of ocean applications. For more information, visit http://www.sailbuoy.no/ .

Infrastructure access

The presented instrumentation is available for public and private research institutions dealing with wind energy. The OBLO project offers services for planning and execution of field deployments and post-analysis of the gathered data through the University of Bergen and Christian Michelsen Research AS.

For more information and access to the infrastructure, please contact Joachim.Reuder@uib.no, University of Bergen or Martin.Flugge@cmr.no , Christian Michelsen Research AS.