Design and realization of offshore measurement campaigns

Benny Svardal, CMR; Martin Flügge, CMR; Mostafa Bakhoday, University of Bergen and Joachim Reuder, University of Bergen

Reducing the total cost of energy is the primary challenge for the offshore wind industry. The partners in NORCOWE strive to achieve cost and risk reductions along with performance optimization in the whole value chain for offshore wind energy, e.g. through the development of novel tools and models for improving wind resource assessment accuracy, determining turbine and foundation design criteria, planning efficient marine operations, and optimizing wind farm power performance.

The meteorological and oceanographic conditions of an offshore site are key parameters to be taken into account over the whole life cycle of an offshore wind farm. Site assessment, planning and design of the turbines and support structures, wind farm layout, the determination of weather windows for installation and maintenance and the accurate prediction of the power production within the next hours and days are all crucially dependent on a profound understanding of the met-ocean conditions and their appropriate parameterization in our numerical model tools.

While the atmospheric boundary layer over land has been investigated in detail for already more than five decades, our understanding of the physical processes within the marine atmospheric boundary layer (MABL) is still very limited. This is highly due to the limited accessibility for meteorological measurements offshore. The new generation of offshore wind turbines creates a demand for detailed characterization of the MABL to an altitude of 200-300 m, matching the increased swept rotor disk area.

Data available from meteorological masts in the North Sea are limited to point-measurements of meteorological parameters such as wind speed and direction, temperature and humidity at a few predetermined altitudes with the highest measurement level at around 100 m above sea level. The development of LIDAR anemometer technology has enabled remote measurement of wind profiles up to and beyond the altitude of interest. However, simultaneous temperature and humidity profiling to the same altitudes is essential to enable a proper characterisation of the boundary layer stability, and very little data including these measurements are available so far.

In order to address the massive lack of observational meteorological data in key altitude ranges offshore, the acquisition of measurement data with sufficient quality and continuous duration from both the MABL and the OML (oceanic mixed layer) has become a prioritized activity within NORCOWE. The collection and analysis of such datasets are important for an improved understanding of the relevant physical processes. Proper verification data is also essential to validate and improve numerical tools, instruments and method developments related to floating measurement platforms, for example.

FINO1 offshore campaign

Benny Svardal, CMR; Martin Flügge, CMR; Mostafa Bakhoday, University of Bergen and Joachim Reuder, University of Bergen

To close some of the existing gaps between the demand and observational data availability, NORCOWE aims to perform a field campaign at the German research platform FINO1 from May 2015 to June 2016. The campaign will be carried out by CMR and UiB on behalf of NORCOWE, in cooperation with RAVE, FuE-Zentrum FH Kiel as platform operator, and Fraunhofer IWES and FORWIND as research partners.

One of the key purposes of the campaign is to provide unique datasets for the study of boundary layer stability in undisturbed offshore conditions by simultaneous measurements of wind, temperature and humidity profiles in the MABL up to an altitude of 1000m enabled by remote sensing technology. Additionally, the campaign focus will cover air-sea interaction, offshore wake propagation, and motion correction techniques for floating instrumentation platforms over the duration of the campaign, we seek to cover as many variations in weather and sea-state conditions as possible.

The FINO1 platform is located in close proximity to Alpha Ventus, the first German offshore wind farm, installed in the North Sea 45 km west of the Island Borkum.

Meteorological parameters such as wind speed and direction, temperature and humidity have been collected at FINO1 since its operation started in 2003. Wave statistics such as significant wave height and wave speed and direction are recorded by radar from the platform and from a nearby measurement buoy.

NORCOWE plans to install two scanning Lidar systems and a microwave-radiometer on the research platform to investigate the atmospheric stability around the wind farm, as well as the interaction of the Alpha Ventus wind turbines with the atmosphere and each other. The Lidars will provide data on the wind speed in front of, within and behind the wind farm (up to several kilometers) while the microwave-radiometer will provide temperature- and humidity profiles up to a height of 1000 m.

In additions to the meteorological measurements, oceanographic instruments mounted on two bottom frames, a submerged buoy, and the autonomous SailBuoy, will be deployed near FINO1 for a shorter period. This instrumentation will monitor wave statistics, surface currents and turbulence in the upper oceanic mixed layer. The collection of these data is essential for the estimation of turbine tower loads and scour formation. Moreover, these data are crucial for studying air-sea exchange processes, which are known to influence the structure of the wind profile and the atmospheric stability.

The deployed instrumentation will provide a highly versatile data set for investigation of the offshore wind profiles, wind shear and turbulence intensity as a function of atmospheric stability in and around the wind farm. The gathered data allows for the investigation of the structure, extension, dynamics and persistence of single turbine wakes and the near farm wake of Alpha Ventus.