Master's thesis: "Wind speed measurements in an offshore wind farm by remote sensing: Comparison of radar satellite TerraSAR-X and ground-based Lidar systems"

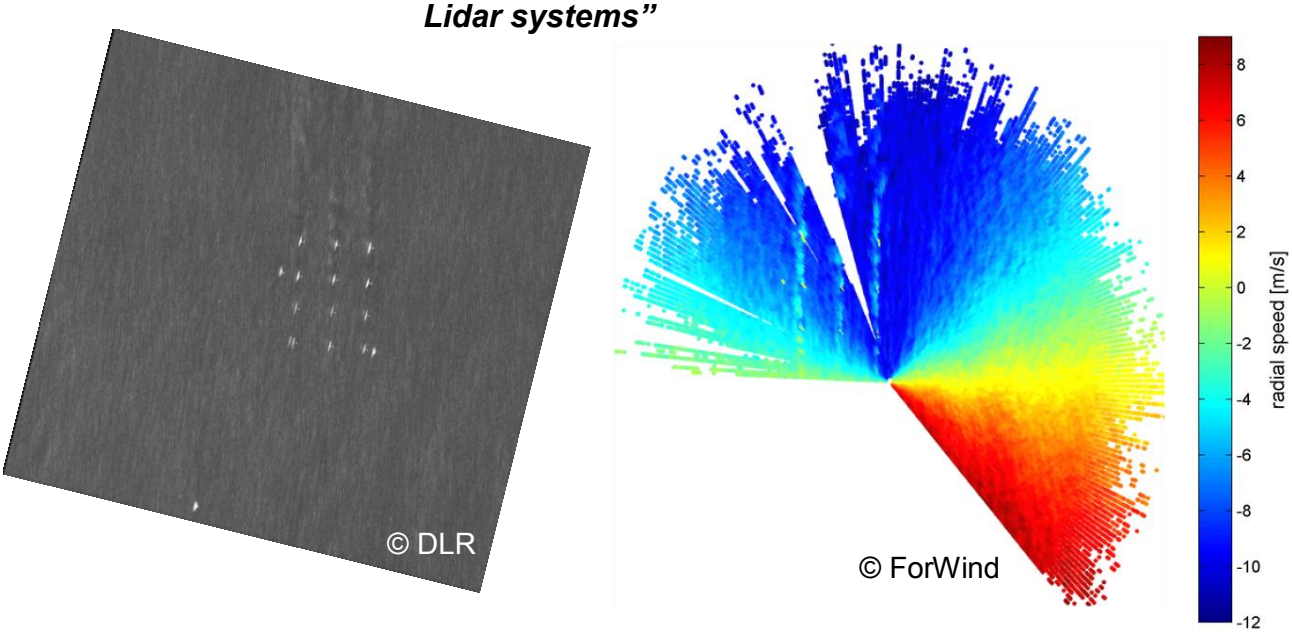

Figure 1: Left: TerraSAR-X image of the Offshore wind farm alpha ventus with 12 wind turbines, substation and met mast Fino1. Southerly winds cause wakes in the north of the wind farm (dark areas). Right: "line of sight" wind field in the alpha ventus area measured by a long range Lidar. The lidar is located on the substation in the southeast corner of the wind farm. Southerly winds cause clearly visible wakes.

Remote sensing, like Lidar and Radar offer fascinating new opportunities to measure atmospheric quantities like the wind speed from a distant location. Such techniques are of high scientific and economic interest for the quantification of the wind speed reduction (wake) caused by wind farms and especially for the interaction of large offshore wind farms, which can take place over tens of kilometers.

The Radar satellite TerraSAR-X scans the surface of the earth achieving image resolutions of down to one meter (Figure 1 left). The general principle of imaging turbine wakes is that the reduced wind speed downstream of offshore wind farms modulates the sea surface roughness, which in turn changes the Normalized Radar Cross Section (NRCS) in the SAR image and makes the wake visible. Using the wind streaks, visible in the TS-X image and the shadow behind the offshore wind farm, the sea surface wind speed is calculated using the latest generation of wind field algorithm XMOD2. Results have been validated against buoys equipped with anemometers at a low measurement height and the results of the German Weather Service (DWD) atmospheric model.
The Lidar technique has gained high popularity for wind measurements onshore and offshore in the last years. Lidars emit laser light that is scattered by moving aerosols in the atmosphere, from which the "line of sight" wind speed can be directly derived. Ground-based lidar scanners enable vertical or almost horizontal planar scans of the wind speed at different heights in the boundary layer (Figure 1 right).
Recently measurements of the wind field in the offshore wind farm "alpha ventus" in the North Sea have been taken with TerraSAR-X and a multi Lidar system.

Scope
The student will develop a method for comparing datasets of TerraSAR-X and the multi Lidar. Validation will be done against the present met mast Fino1 and the established meso-scale weather models (e.g. COSMO by DWD). Special focus will be on the detection of wakes caused by the wind turbines and the wind farm as a whole.

This master's thesis is announced in a cooperation of DLR - Maritime Security Lab (Bremen) and ForWind – University of Oldenburg.

Work steps

- Study of theory of wind speed measurements by classical anemometry, satellite based Radar and by Lidar
- Evaluation of relevant aspects of marine boundary layer theory, wind-wave interaction, wake deployment in a wind farm
- Development of a method for comparing the data of the different measurement systems in free flow and in wake conditions
- Analysis and comparison of the different data sets
- Validation against met mast and meso-scale weather model
- Discussion of the results with the goal to evaluate
    - differences in the results of the measurement techniques,
    - the possibility of the techniques to measure offshore wind fields and wake effects
- Recommendations for further investigations

Requirements

- Bachelor's degree in physics, meteorology, engineering or different comparable degree
- Basic knowledge in the fields of physics, meteorology and wind energy
- High motivation for team work and self-dependent working style
- Experience with Matlab and data analysis is desired

Begin	Feb./Mar. 2014		
Duration	min. 6 months		
Place	ForWind Oldenburg	DLR Bremen	
Supervision	Jörge Schneemann ForWind – University of Oldenburg +49 (0)441/798-5062 j.schneemann@uni-oldenburg.de	Dr. Susanne Lehner DLR Bremen +49 (0)421/24420-1850 susanne.lehner@dlr.de	Tobias Gies DLR Bremen +49 (0)421/24420-1861 tobias.gies@dlr.de