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Standardization of Marine Meteorological Data from FINO Offshore Platforms

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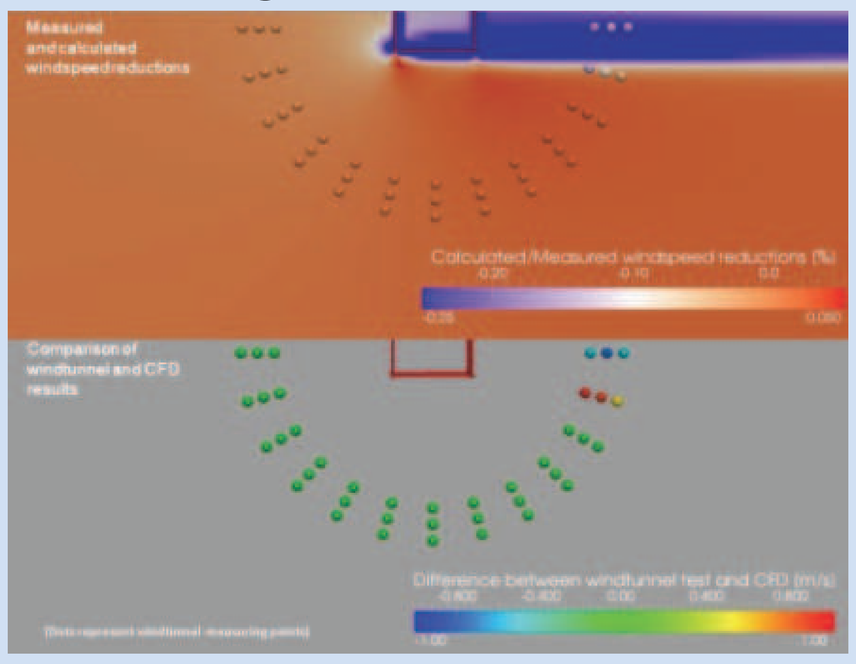
In order to investigate conditions for offshore wind power utilization in the German coastal areas, three research platforms were constructed in the North Sea (FINO1 and FINO3) and in the Baltic Sea (FINO2). To improve the comparison of the wind conditions measured at these platforms, the research project FINO-WIND is launched by Deutscher Wetterdienst (DWD) and partners. The project will establish a consistent archive of standardized wind data of the platforms adjusted for local effects.

Introduction

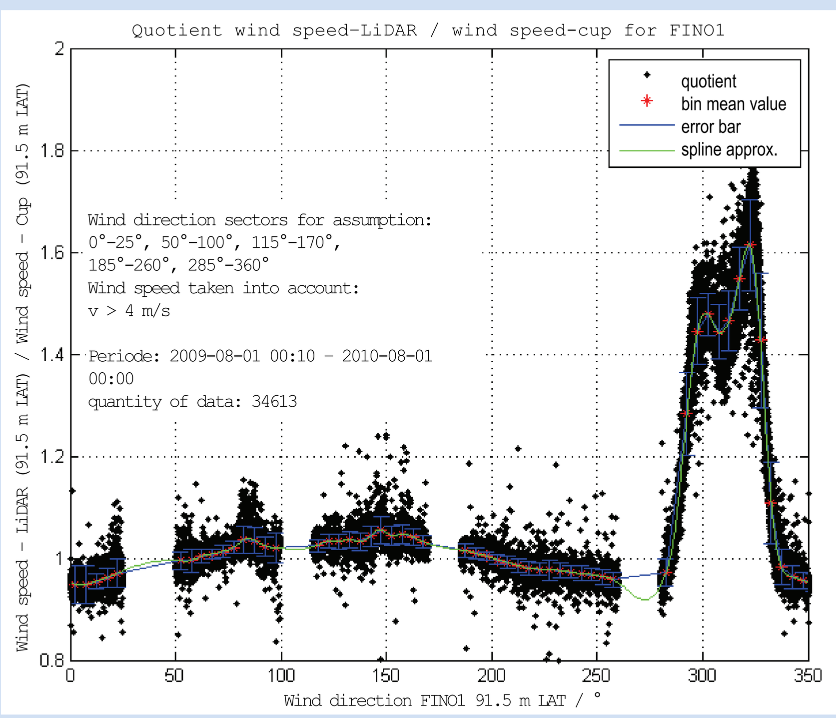
Measurement masts at each platform are equipped with a range of meteorological sensors at heights of about 30 m to 100 m above sea level. Standardized analysis and interpretation of the data is required in order to compare the results of the different platforms. This will improve the knowledge of the marine ambient conditions at the three locations. Quality control and data representativeness of wind data from offshore platforms pose a special challenge as the measurements are subject to a number of local influences, as there are effects from measurement mast, neighbouring wind parks, surface roughness, and tide. Moreover, standards such as IEC (International Electrotechnical Commission) are of limited use as some requirements do not cover the demands of offshore masts e.g. due to the wake effects of the structure. In the FINO-WINO project, therefore, a standardization method is developed. Focussing on wind data, the mast effects of all three masts are intensively investigated by comparison with remote sensing techniques such as Light Detection and Ranging (LiDAR), Computational Fluid Dynamics (CFD) calculations, the Uniform Ambient Mast flow (UAM)-method [1] and wind tunnel measurements. As a result of an overall evaluation of these analyses a correction for wind measurements will be derived.

Estimating Mast Effects



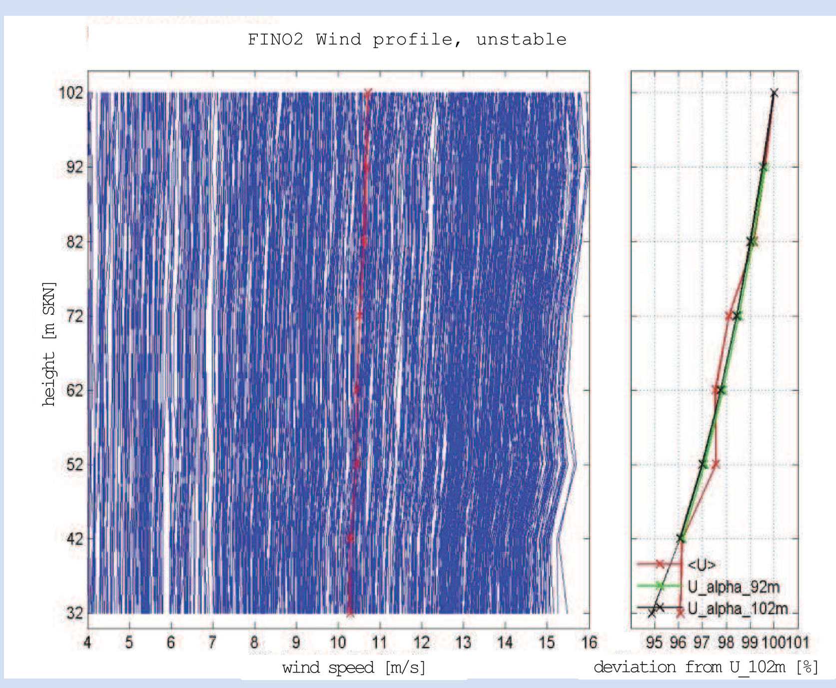
CFD calculations – wind tunnel tests

Figure 1: A 10-m-long segment of the FINO1 mast was modeled and simulated with OpenFoam®. Turbulence was considered with the use of k-ε Re-Normalisation group-model [2]. The ratio of the modeled inflow wind speed and the wind speed calculated at the cup-anemometer position is derived for every 10°-angle of the mast. By comparing wind speed measurements of a simplified mast segment model in a wind tunnel with the CFD calculations of a simply modeled mast segment, the CFD model is verified [Source: DEWI - UL International GmbH].



LiDAR mast correction

Figure 2: Prerequisite for LiDAR based mast correction is the assumption that the LiDAR measurement is undisturbed. Datasets with one of the LiDAR beams downwind of the mast are removed as the gaps in the figure show. The mast correction function can be derived from the mean bin-wise quotient from LiDAR and cup anemometer wind speed measurements. The black dots display the wind speed quotients, the red crosses reflect the bin average values. By interpolating the bin mean values correction factors for every wind direction can be derived. [Source: DNV GL]



UAM correction

Figure 3: Based on the assumption that the vertical profile of horizontal wind speed almost vanishes during unstable atmospheric conditions and that any deviation is due to mast flow distortion a mast correction can be derived. A logarithmic wind profile is calculated from measurements of the least disturbed wind direction sector during unstable conditions. This profile is applied to the top-anemometer measurement for any other wind direction during unstable conditions to calculate the undisturbed wind speed at every boom. The ratios of these calculated and measured wind speeds result in mast correction factors after bin wise averaging with regard to wind direction. [Source: DEWI - UL International GmbH]

Quality Control

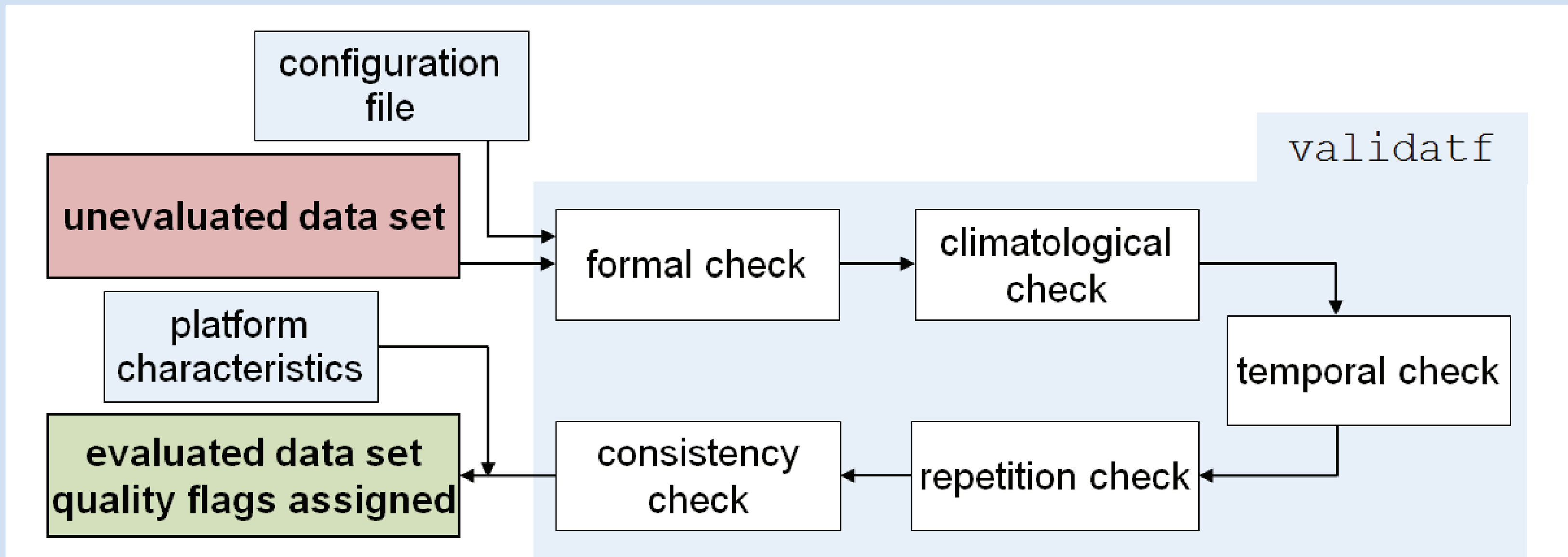
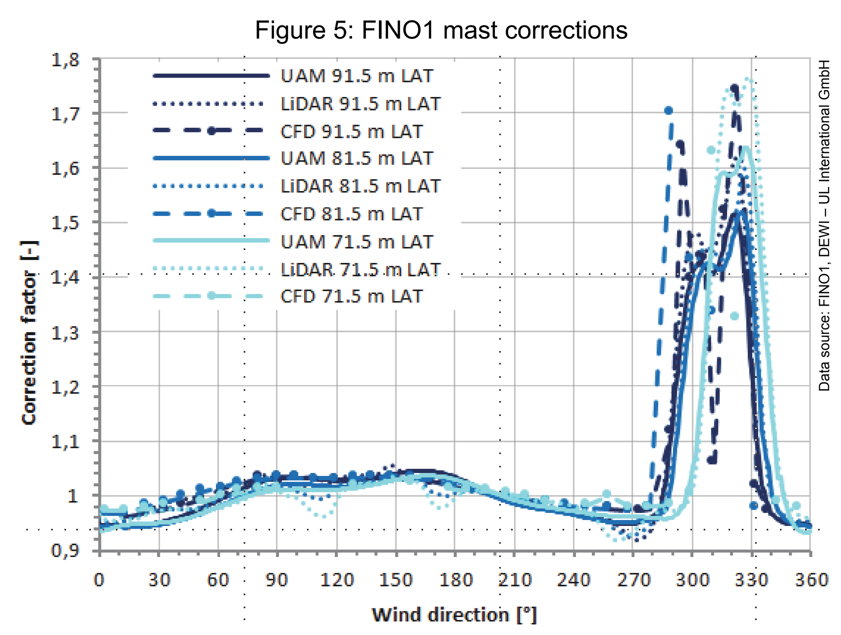
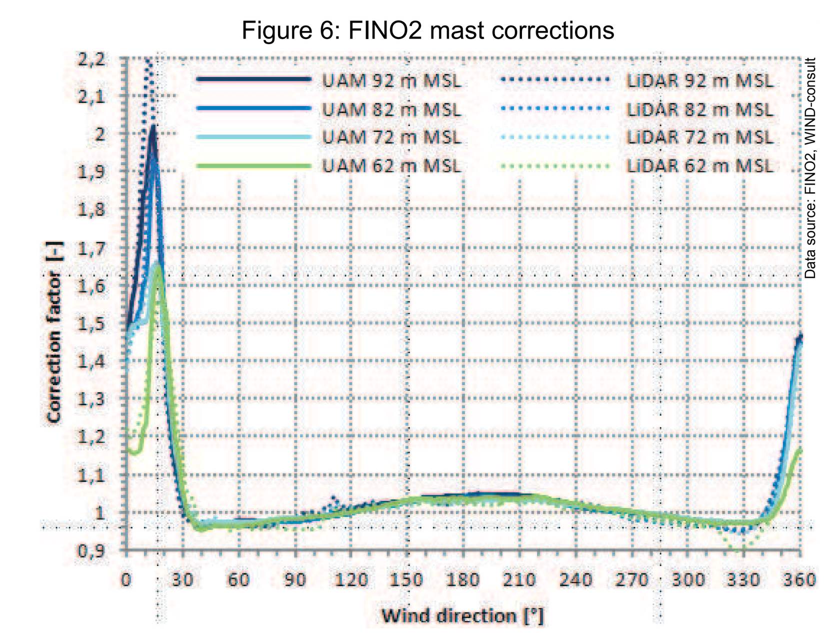
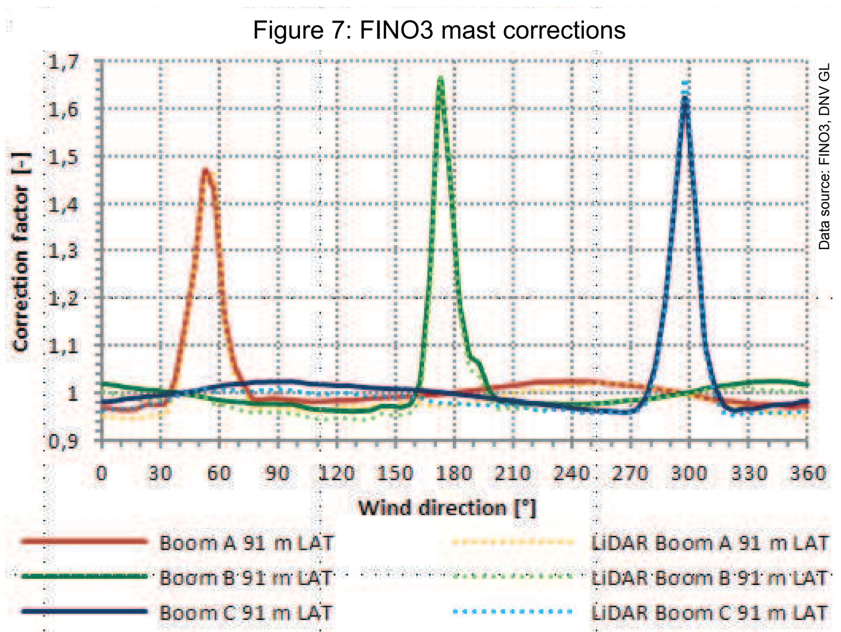


Figure 4: The wind data (10-minute averages) of the masts are checked automatically with a comprehensive quality checking routine developed by Deutscher Wetterdienst. The quality control of the data is performed in a sequence of tests. The routine starts with a formal check, followed by climatological, temporal, repetition, and consistency checks. After the successful completion of the sequence, the data are assigned standardized quality flags. Finally, platform characteristics are accounted for with regard to the local effects.

Results







Figures 5-7 show the mast correction factors for each platform derived from different methods. While the factors for FINO1 and 2 are derived from LiDAR, CFD and UAM, the correction factors for FINO3 are obtained from the LiDAR method (dotted lines) and composed wind speed method (solid lines). Assuming that data from different cup-anemometers, pointing in different directions, are available at one measurement level, the average of cups at two booms can be calculated in dependence of the inflow angle to compensate decreasing and increasing flow distortion effects. [source: DEWI – UL International GmbH, DNV GL, WIND-consult]

Conclusions and Outlook

All of the mast corrections derived here show the same mast distortion effects for each of the FINO masts. We find large wind speed reductions for the anemometers if they are downwind of the mast and slight wind speed reductions if they are upwind of the mast. The anemometers show speed-up effects during lateral inflow. For each of the FINO masts one distinctive mast correction method with least uncertainties will be identified to be applied to measured wind speeds in the future. As wind farms are being built close to each FINO platform, wake field situations for each mast from existing and planned wind farms in the surroundings will be investigated in order estimate these effects on the measured wind speeds.

References:
[1] A. Westerhellweg et al, FINO1 Mast Correction, DEWI Magazin, 2012.
[2] F. Wilts, et al, CFD calculations of FINO1 mast effects, CEWE 2014, Hamburg.

Acknowledgements
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