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Standardization of meteorological data from offshore platforms

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WIND FINO

Introduction

In order to investigate conditions for offshore wind power generation in the German coastal areas, three research platforms were constructed in the North Sea (FINO1 and 3) and the Baltic Sea (FINO2). Measurement masts at each platform are equipped with a range of meteorological sensors at heights of 30 m to 100 m above sea level. Standardized analysis and interpretation oft he data is necessary to compare the results oft he different platforms and will improve the knowledge oft he marine ambient conditions att he three locations. Standards given in the IEC can only be partly applied as some requirements are not applicable to offshore masts e.g. due to the wake oft he structure. One aim oft he FINO-Wind projecti s the correction and standardisation of offshore mast measurements. All three FINO masts, which are either square or triangular shaped and have different boom constellations, are intensively investigated by comparison with remote sensing techniques as Light Detection and Ranging (LiDAR), Computational Fluid Dynamics (CFD) calculations, the Uniform Ambient Mastf low (UAM)-method [1] and wind tunnel measurements. As an example oft he topics in FINO-Wind an analysis of different possible mast corrections is performed and discussed.

UAM correction

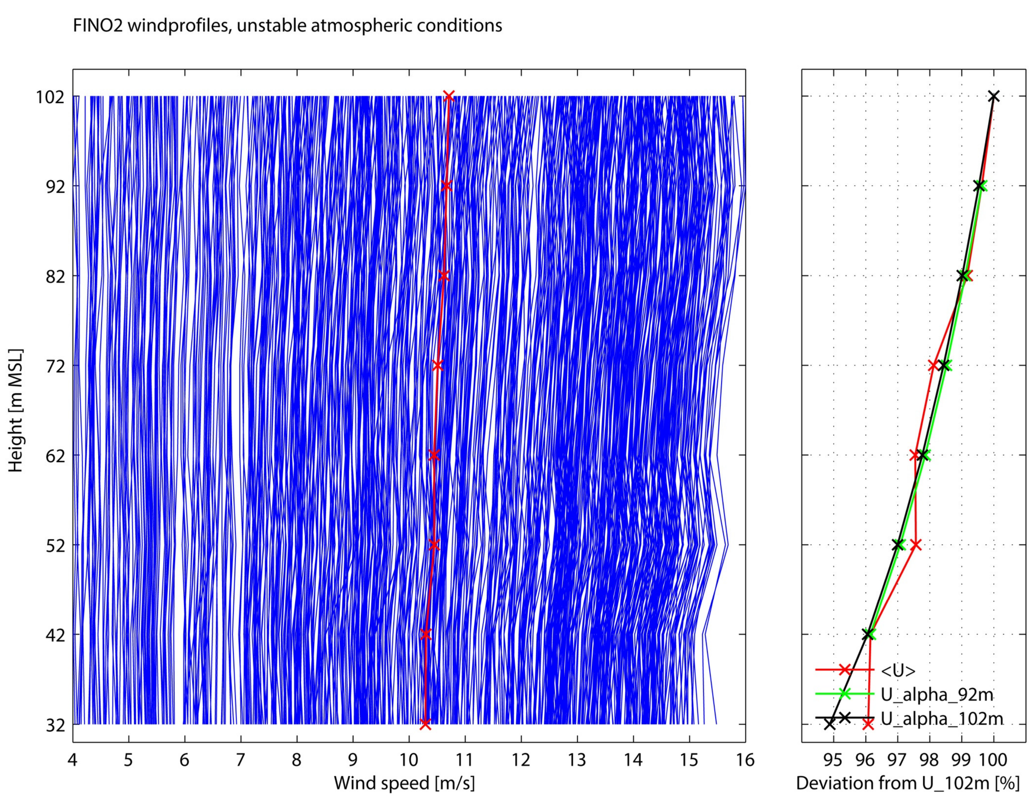

Fig. 1: Based on the assumption thatt he vertical profile ofh orizontal wind speed almost vanishes during unstable atmospheric conditions and that any deviation from thati s due to mastf low distortion a mast correction can be derived. A logarithmic wind profile is calculated from measurements from the least disturbed wind direction sector during unstable conditions. This profile is applied to the top-anemometer measurementf or any other wind direction during unstable conditions to calculate the undisturbed wind speed at every boom. The ratios oft his calculated and measured wind speeds resulti n mast correction factors after bin wise averaging with regard to wind direction.

LiDAR mast correction

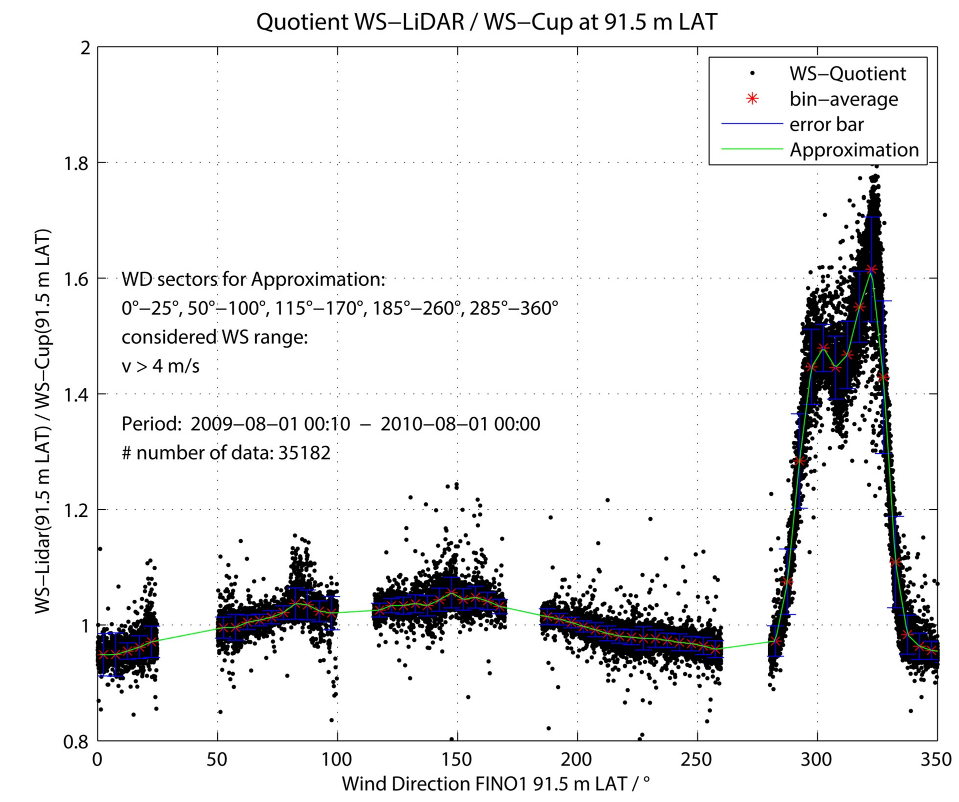

Fig. 2: Prerequisite for a LiDAR based mast correction is the assumption that the LiDAR measurementi s undisturbed. Datasets with one oft he LiDAR beams downwind oft he mast are removed as the gaps show in the picture on the left. The mast correction function can be derived from the mean bin-wise quotientf rom LiDAR and cup-anemometer wind speed measurements. The black dots are showing every single wind speed quotient, the red crosses reflectt he bin average values. By interpolating the bin mean values correction factors for every wind direction can be derived.

CFD calculations – wind tunnel tests

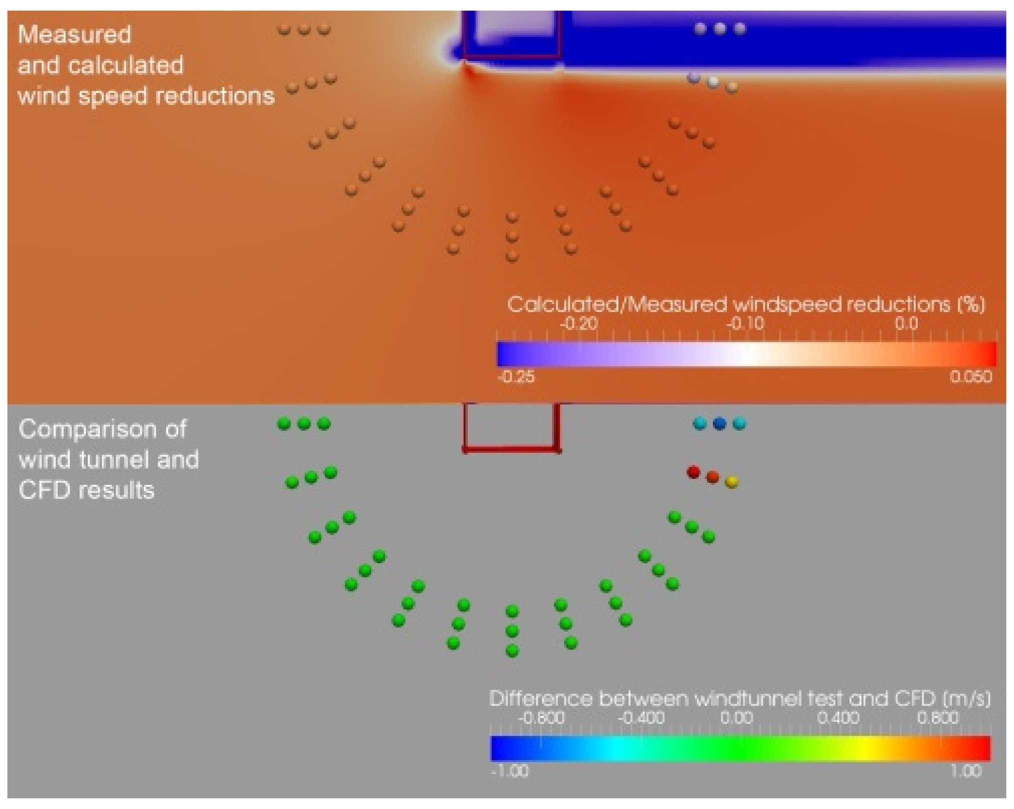

Fig. 3: Wind speed reductions calculated by CFD methods are in good agreementt o wind tunnel measurements of a simplified mast segment model. Followed by this study CFD calculations of detailed 10 m FINO1 mast segments were carried out with OpenFoam®. Turbulence was considered by using the k-ε Re-Normalisation group-model [2]. The ratios oft he modeled inflow wind speeds and the wind speeds calculated att he cup-anemometer positions are derived for differenti nflow directions and shown in Fig. 5.

Composed wind speed method

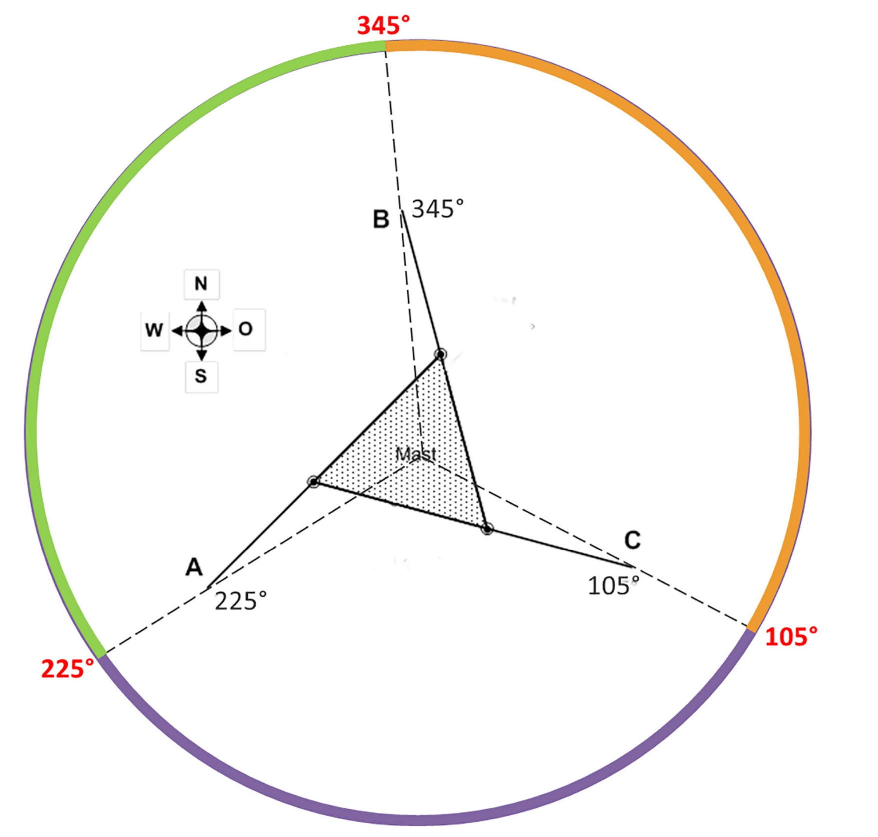

Fig. 4: If a triangular shaped mast and an instrumentation set-up with three cup-anemometers orientated to three different directions is available an alternative is the calculation of a composed wind speed. Ift he wind flow approaches from the wind direction interval 225° -345° (between boom A and B) the average of cup at boom A and B would be calculated - the same applies for the wind direction intervals 345° -105° (between B and C) and 105° - 225° (between C and A). Wind speed lowering flow distortion effects at one cup-anemometer are compensated by wind speed increasing flow distortion effects at the second cup-anemometer.

Results

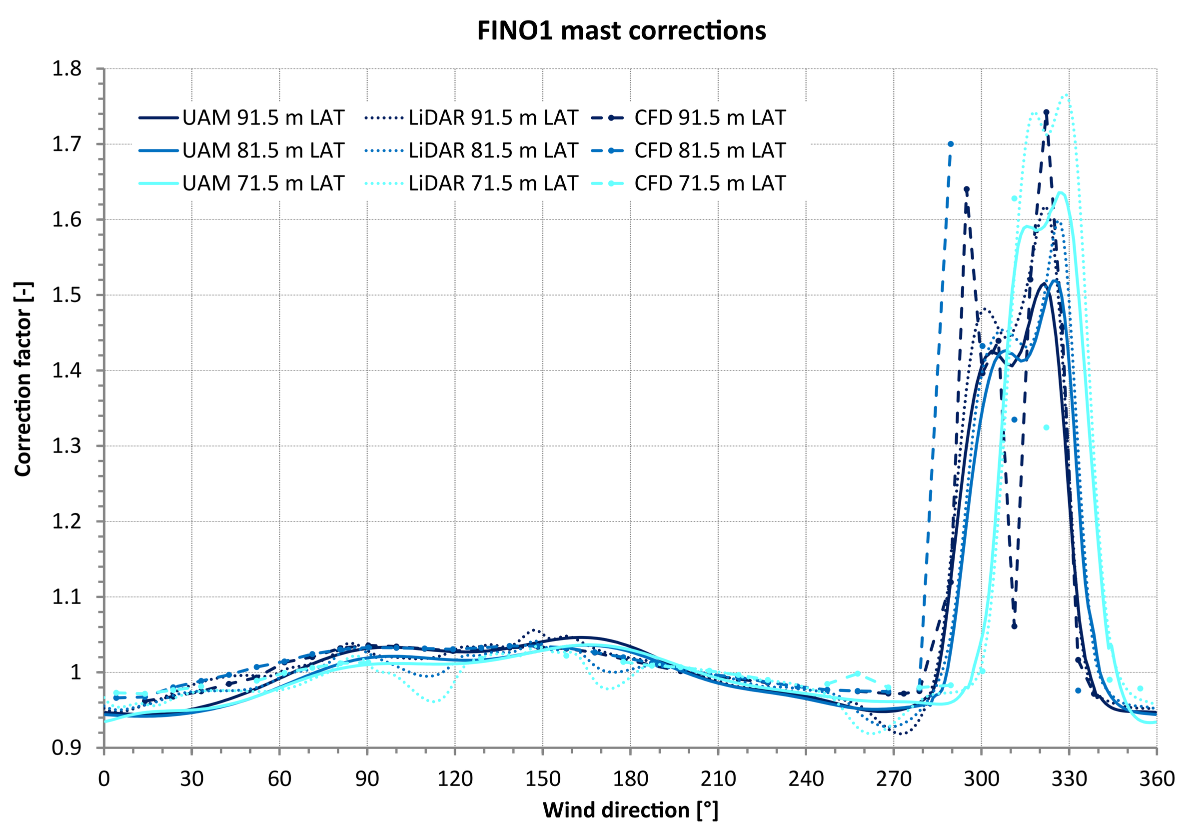

Fig. 5: Mast correction factors derived for FINO1 from UAM, LiDAR and CFD method.

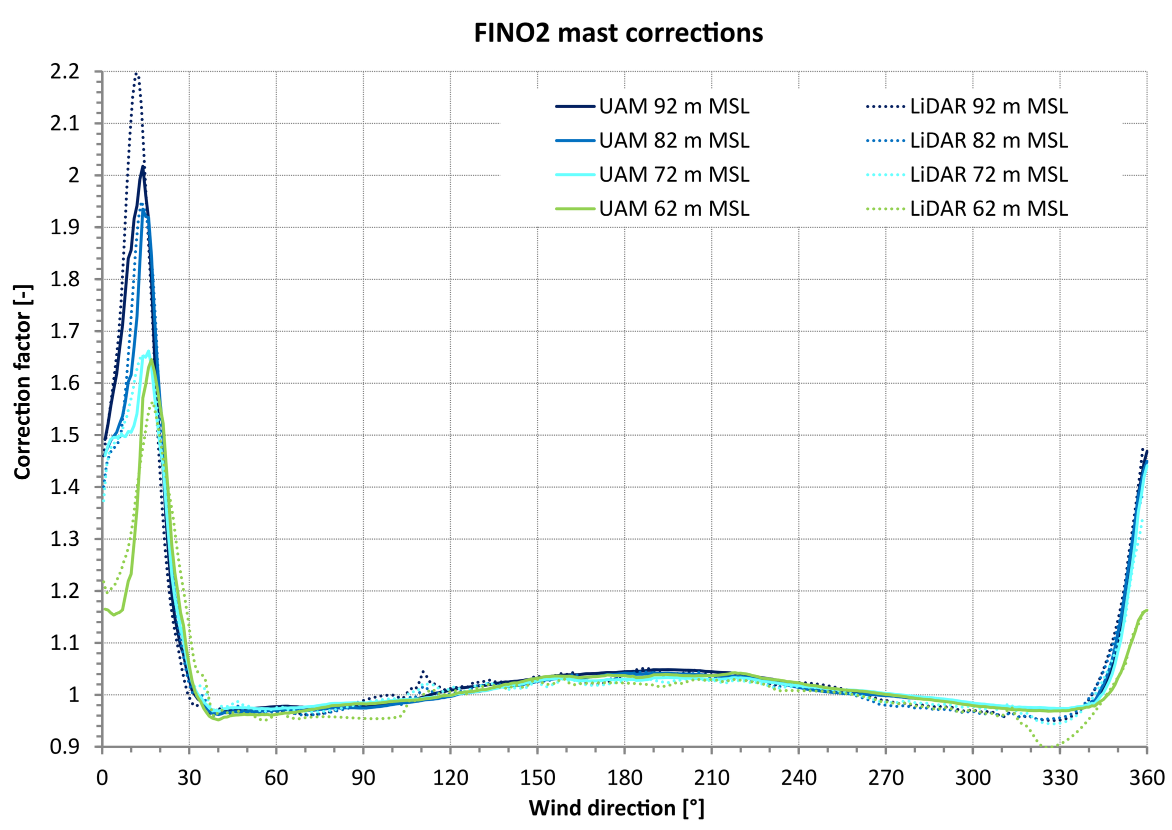

Fig. 6: Mast correction factors derived for FINO2 from UAM and LiDAR method.

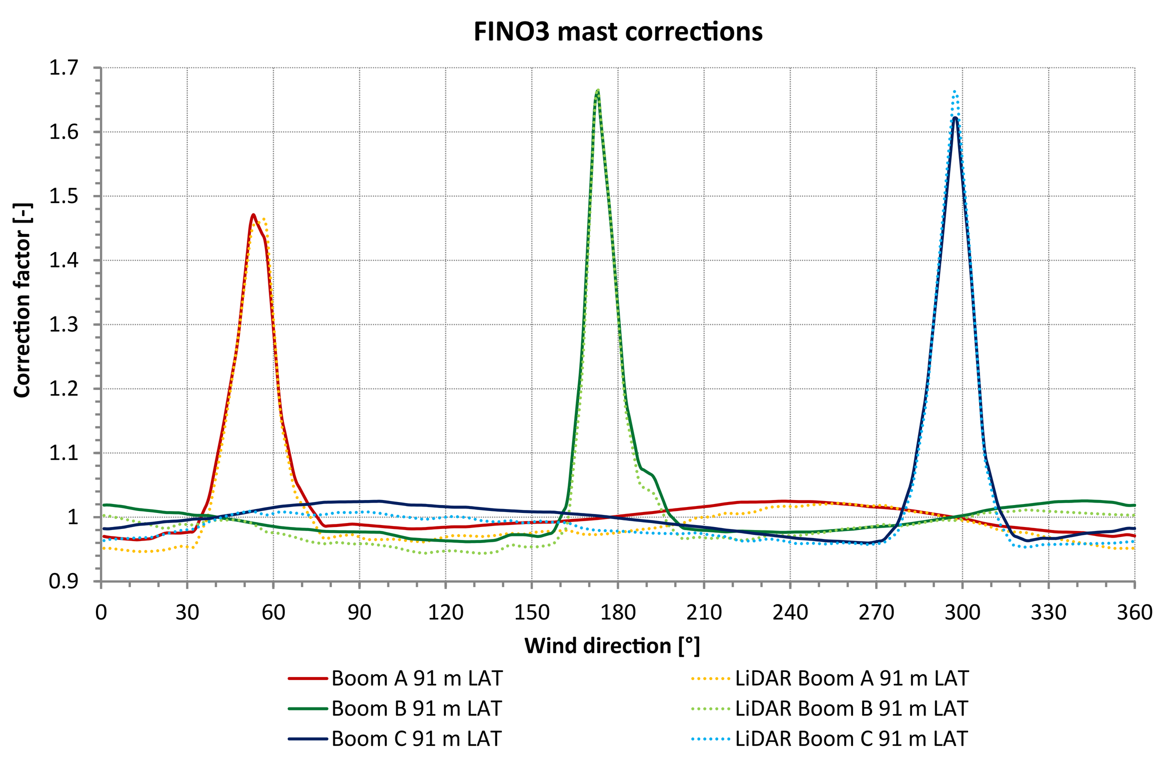

Fig. 7: Mast correction factors derived for FINO3 from LiDAR method (dotted line). For comparison the ratio oft he composed and the measured wind speed is also shown (continuous line).

Conclusions and Outlook

All oft he derived mast corrections show similar mast distortion effects for each oft he FINO masts with large wind speed reduction for the anemometers if downwind oft he mast and slight wind speed reduction if upwind oft he mast. The anemometers receive speed-up effects during lateral inflow. For each oft he FINO masts one distinctive mast correction method with least uncertainties can be identified and shall be applied to measured wind speeds in the future. Wind farms are being erected close to each FINO platform, therefore at a next step wake field situations for each mastf rom existing and planned wind farms in the surroundings shall be investigated in order estimate these effects on the measurements.

[1] A. Westerhellweg, T. Neumann, V. Riedel, FINO1 Mast Correction, DEWI Magazin, 2012.

[2] F. Wilts, B. Canadillas, F. Kinder, T. Neumann, CFD calculations of FINO1 mast effects, CEWE 2014, Hamburg.

Acknowledgements

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