Measuring wind offshore in deep water depths will be a future challenge. Where the sea bed installation of foundations for fixed met masts is impossible, even the mooring of floating systems are more complicated. Ship-lidar systems are an alternative solution for a number of different applications.

In this poster we describe two motion-correction methods for motion-influenced lidar measurements. The ship-lidar system will be presented as well as the first measurements carried out as part of the EERA-DTOC project. Therefore a verification of one correction algorithm will be shown as well as first results from wake measurements behind the Alpha Ventus offshore wind farm.

Measuring set-up
The ship-lidar system comprises a Leosphere WindCube V2 device, different motionsensors (AHRS, satellite compass), a computer for data acquisition as well as equipment for power supply and wireless communication. The system is combined in a frame in order to ensure a fixed geometry, compare [1].

For the presented measurements, the system was installed on the offshore support vessel LEV TAIFUN with a length of 41.45 m. The system was located approx. 7 m above the point of rotation, whereas the roll rotation frequency is close to 1–5 s with extreme roll angles up to 20°.

Motion correction algorithms
Lidar measurements using line of sight (LoS) measurements in different beam orientations are solved under the assumption of homogeneity as well as constant wind velocity on each altitude, using a system of linear equations (SLE):

\[
\begin{align*}
\mathbf{a}_1(t_1) & = \mathbf{a}_1(t_2) + \mathbf{e}_1(t_1) \\
\mathbf{a}_2(t_2) & = \mathbf{a}_2(t_1) + \mathbf{e}_2(t_2) \\
\vdots
\end{align*}
\]

where \( \mathbf{a} \) is the 3D vector, \( t \) is the time, and \( \mathbf{e} \) is the error.

In general, these measurements can be influenced by translatory and rotary motions, that can be considered by modifying the SLE to:

\[
\mathbf{a}_1(t) = \mathbf{a}_1(t) + \mathbf{e}_{\text{trans}}(t) + \mathbf{e}_{\text{rot}}(t)
\]

where \( \mathbf{e}_{\text{trans}} \) and \( \mathbf{e}_{\text{rot}} \) are translatory and rotary motions, respectively.

Under the assumption of constant orientation and motion during the time period covered by the system of SLE, a simplified motion correction can be applied on the resulting wind vector from the SLE:

\[
\mathbf{u}_{\text{wind}} = \mathbf{u}_{\text{ref}} - \mathbf{u}_{\text{ship}}
\]

Especially periodical tilting motions in the frequency range of the lidar measurement frequency, combined with additional translatory motion due to the distance from lidar to center of rotation can lead to beating effects that are not considered by the simple motion correction.

Floating lidar corrections were studied in [2] and [3].

For the first analysis, the simplified correction algorithm was applied on the measured data. Figure 5 shows results of uncorrected, yaw corrected (rotated) and fully corrected data for one-minute mean values for the 5th of October 2013.

For longer distances, reference wind data are necessary.

Wake measurements
First wake measurements were performed with ships tracks perpendicular to the wakes, see figure 8. Results show distinct wakes for a distance of approx. 150, see figure 7. These wakes can be identified by decreased wind speeds and increased turbulence.

Conclusions
First ship-based lidar measurements next to met masts FINO1 show good correlations for wind speed and direction using the simplified correction. Nevertheless it is assumed that the complete motion correction will improve the data. Using the ship-lidar for wake measurements, wakes could be identified clearly for distances of approx. 15 rotor diameters. For longer distances, inflow reference data as well as a complete motion correction is necessary.

References
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Acknowledgements
This research project was funded as part of the Seventh Framework Programme.

Reference data was provided by the DEWI (wind data) and the German Federal Maritime and Hydrographic Agency (BSH), which was acquired as part of the FINO project, funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).