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The MALIBU project: Developing a simulation environment for floating lidar systems

O.Bischoff[1], W. Yu[1], J.Gottschall[2], G. Wolken-Möhlmann[2], P.W. Cheng[1]
[1]Stuttgart Wind Energy (SWE), Allmandring 5B, 70569 Stuttgart, Germany,
+49 711 685-68213, bischoff@ifb.uni-stuttgart.de
[2]Fraunhofer IWES, Am Seedeich 45, 27572 Bremerhaven, Germany

University of Stuttgart

Abstract

Assessing the uncertainty of floating lidar systems (FLS) for different wind and wave climates is a challenging task. One possible solution to close this gap is a validated simulation environment for floating lidar systems. An approach for such a simulation environment is under development within the German research project MALIBU (code number 0324197). This poster gives an overview about the simulation model which is being developed. Furthermore first project results regarding the validation aspects for the moving lidar environment and the buoy model are presented. In addition the poster gives an outlook on further project goals.

Introduction

Floating lidar systems (FLS) provide a flexible and cost-effective approach to assess the wind resources at offshore sites [1]. However, buoy motions have an impact on the lidar measurements, and a detailed understanding of the measurement uncertainty is an essential pre-requisite for applying the technology at a fully commercial level.

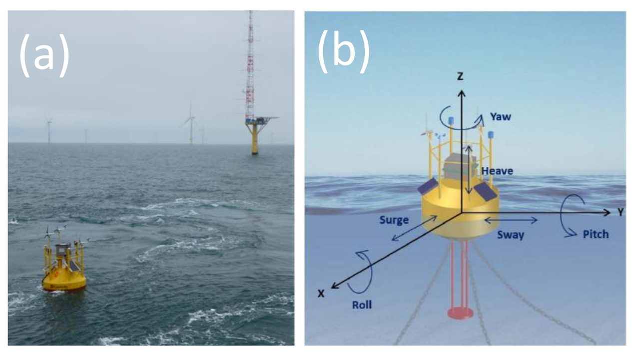

Figure 1: (a) IWES wind lidar buoy (b) degrees of freedom of an exemplary floating lidar system [1]

The FLS simulation model

In order to answer some of the relevant questions, to speed up the development process and to avoid time and cost intensive trials, a simulation method for FLS is being developed. The full FLS simulation environment will consist of a reduced hydrodynamic buoy model and a simulation model for a moving lidar system including a wind field reconstruction algorithm [2].

The hydrodynamic buoy model

The hydrodynamic model is based on the potential flow theory and Morison's Equation. To solve the linearized hydrodynamic radiation and diffraction problems for the interaction of surface waves, a three-dimensional numerical-panel method in frequency domain is used.

The lidar simulation model

The model makes it possible to simulate:

- a variety of different lidar systems (cw, pulsed) with different measurement trajectories (e.g. VAD)
- constant or turbulent wind fields
- Rotations (pitch, roll, yaw) and translations (x, y, z) of the lidar due to periodic and irregular (wave) motions

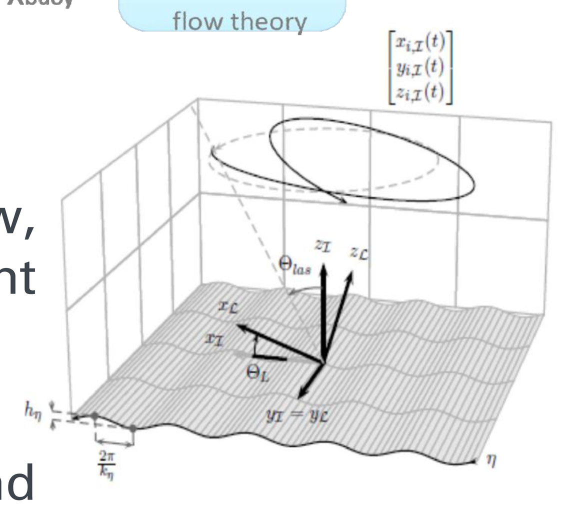

Figure 2: Example measurement trajectory for a moving lidar system

→ The 6 different degrees of freedom and resulting measurement trajectories can be simulated combined or independent of each other in order to understand the impact of the different motions.

Assessing FLS uncertainty

Different wind and wave climates at different offshore locations makes it very difficult to estimate a measurement uncertainty for an FLS prior to installation at a new location.

➢ To avoid FLS testing in various trials a validated simulation environment is needed and can fill this information gap

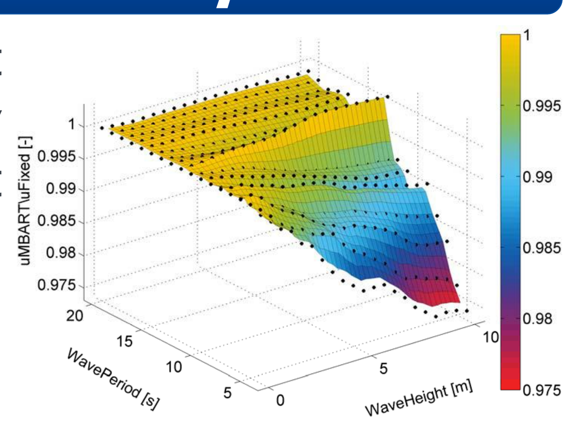

Figure 3: Uncertainty map for different wave motions [3]

Current project status – Model Validation

Validation of the moving lidar model

The validation for the lidar simulation environment is carried out by using measurement data from different experiments with motion tables enabling controlled oscillations (tilting angle and tilting period, see Fig.4). The comparison of measurement results with simulation data (see Fig. 5) shows a good agreement. For more results see also [3].

Figure 4: ZephIR 300 on a motion platform ©UPC

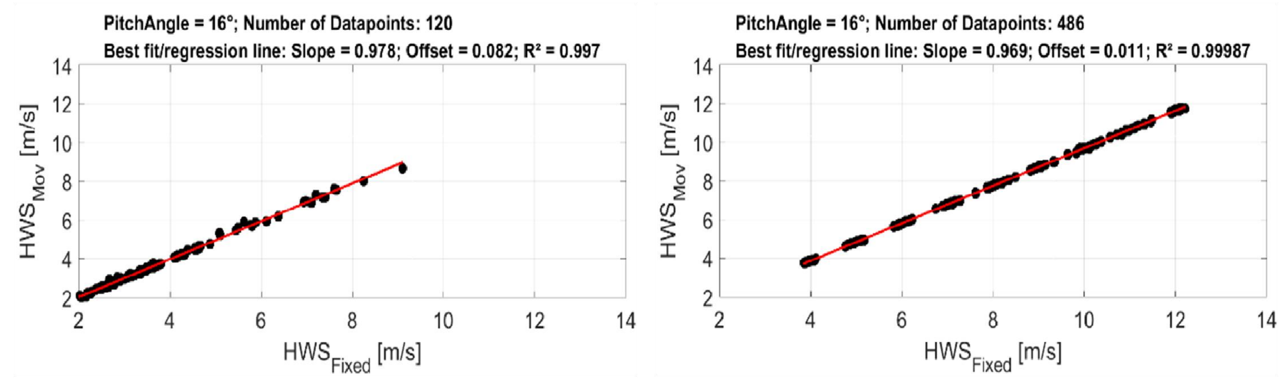

Figure 5: Scatterplot of measured and simulated horizontal wind speeds of fixed and moving ZephIR lidar systems

Validation of the buoy model

The buoy simulation model is initially checked with measurement data of simple decay tests performed at the harbor (Fig. 6).

→ Roll and heave motions of simulation and measurements show a very good agreement.

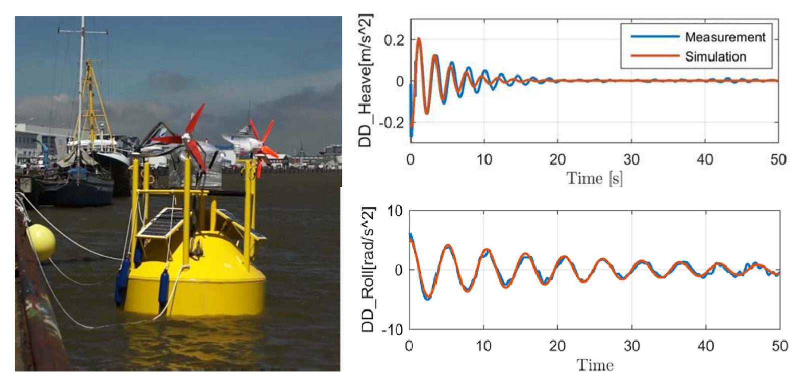

Figure 6: IWES Fraunhofer buoy at harbor decay tests and simulation model calibration results [4]

Following this validation step data from an offshore FLS campaign at the FINO3 offshore met mast (Fig. 1) is being used for further validation.

→ Simulation results for translational motions of the buoy model fit very well to the measurements. The results for rotational motions show some differences due to the uncertainty of the wave measurements. (Fig. 7). More information is given in [4].

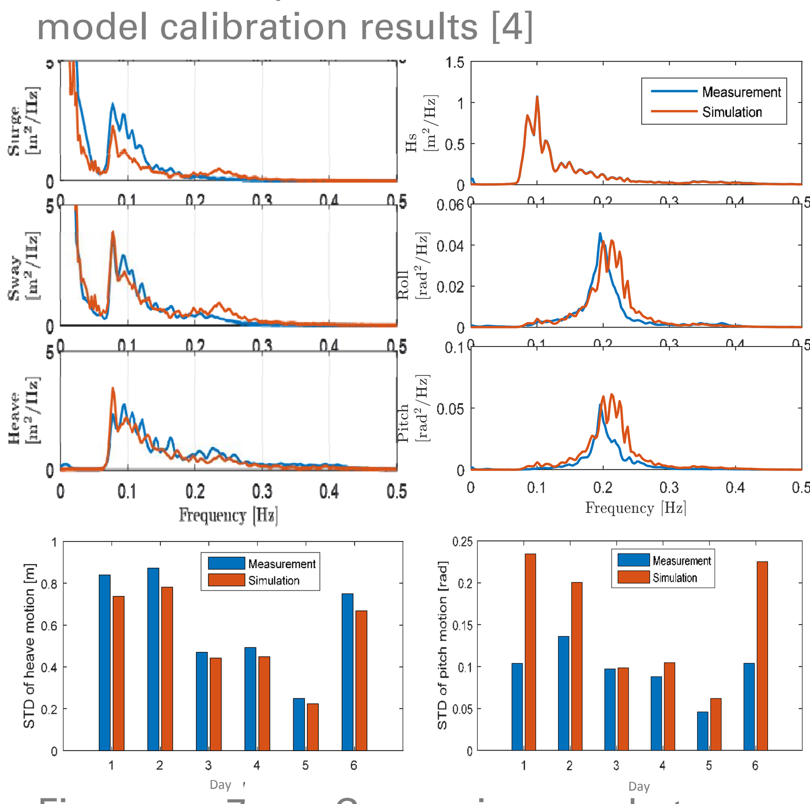

Figure 7: Comparison between simulations and measurements in frequency domain and for standard deviations of heave and pitch motions

Outlook

➢ Validated simulation models for moving lidar system and reduced buoy model
➢ Validated coupled model for FLS simulation
➢ Implementation and demonstration of uncertainty assessment
➢ Optimization methods for FLS

Acknowledgement

This work is part of the research project "MALIBU" which is funded by the German Ministry for Economic Affairs and Energy under the code number 0324197.

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Fraunhofer IWES

Supported by: Federal Ministry for Economic Affairs and Energy on the basis of a decision by the German Bundestag

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