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Evaluation of wind field reconstruction methods for floating vertical profiler lidars

Salma YAHIAOU, VAISALA
AKROCEAN

VAISALA

BACKGROUND

As offshore wind energy grows, floating lidars are increasingly being used instead of fixed platforms or met masts. A key challenge in offshore conditions is buoy motion. This motion creates artificial turbulence, which increases uncertainty in the lidar measurements.

Recently, Vaisala developed Hybrid Wind Field Reconstruction (WFR) for its fixed vertical profiler lidars. The Hybrid WFR combines both scalar and vector averaging and reduces wind speed sensitivity to wind turbulences.

OBJECTIVE

The objective is to assess the performance of the various WFRs (scalar, vector and hybrid) in offshore conditions and determine which one is the best method for floating vertical profiling lidar.

METHODS

Scalar averaging
Generates a new horizontal wind speed (HWS) every second, using the last four line-of-sight (LOS) measurements. These 1 Hz wind speeds are averaged at the end of the 10-minute period to generate the average HWS.

Vector averaging
Generates an average radial wind speed (RWS) using all LOS within a 10-minute period.
These RWS are used to compute the average horizontal wind speeds.

Hybrid averaging [1]
Built as a blend between scalar and vector averaging via a weighted linear combination, hybrid averaging was found to reduce the sensitivity to turbulence onshore.

Measurements
The data are of a pre-validation campaign of the AKROCEAN WINDSEA buoy deployed near the offshore platform Lichteiland Goeree.
The study was conducted over 40 common days, November 2020 - January 2021, between the reference WindCube v2 installed on the fixed platform and WindCube buoy v2.1 (810m from reference).
Real time buoy data was averaged in scalar, vector and hybrid without motion compensation and compared to scalar and hybrid reference HWS.
The lidar is measuring at 10 different altitudes from 62m to 290m.
Correlation KPIs are based on the Offshore Wind Accelerator roadmap [2] .
Data filtering was done according to the pre-validation report.
A 100% data availability filter was applied to the reference and only wind speeds between 4m/s and 16m/s were considered.
Relative wind speed mean deviation was computed per bin of wind speed and a minimum of 40 data points for the analysis was applied.

A broad analysis of this parameter was performed.
Sensitivities to both turbulence intensity (reference TI) and 10-min wind direction fluctuations (reference and floating lidar wind direction dispersion) were analyzed.

RESULTS

Correlation
Scalar and hybrid have similar performance and **are both passing KPI**. Vector averaging method shows larger bias and dispersion against the reference lidar due the sensitivity to the buoy induced motion.
Relative wind speed mean deviation
For this campaign, a general underestimation trend is observed for the three WFRs methods but higher for vector.
Scalar averaging is above hybrid with less than 1%.
The **performances are similar** when comparing to both scalar and hybrid HWS.

Sensitivities to turbulence
No sensitivity with altitudes is observed for both turbulence intensity and direction.
Slight sensitivity to TI and wind direction reference is shown (higher for vector).
Strong sensitivity to wind direction turbulence (non-atmospheric turbulence) is observed for all WFRs.

PERSPECTIVES

- Investigate the correlation between TI and wind direction fluctuations.
- Additional in-depth analysis on other buoy lidars for different campaigns and atmospheric conditions.
- Theoretical study to investigate the impact of buoy motion on the WFR methods.
- Assess the performance of the WFRs with motion compensation.

REFERENCES

[1] **P. Rosenbusch, P. Mazoyer, L. Pontreau, . E. Allain, and J.P Cariou**, "Wind speed reconstruction from mono-static wind lidar eliminating the effect of turbulence", Journal of Renewable and Sustainable Energy 13, 063301 (2021).
[2] **Carbon Trust Offshore Wind Accelerator Roadmap for the Commercial Acceptance of Floating LiDAR Technology**. Version 2.0. The Carbon Trust, Oct. 2018.

CONTACT INFORMATION

Salma YAHIAOUI, salma.yahiaoui@vaisala.com

ILLUSTRATIONS