

Atmos. Meas. Tech. Discuss., referee comment RC2
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Comment on amt-2022-138

Anonymous Referee #2

Referee comment on "Quantification of motion-induced measurement error on floating lidar systems" by Felix Kelberlau and Jakob Mann, Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2022-138-RC2>, 2022

General Comments

Floating Lidar Systems (FLS) are being accepted in the wind energy industry as a trustable mean wind measurement source. The motion influence on mean HWS measurement by FLS has not been quantified as it is usually lower than the sensor uncertainties. This paper provides a convenient method based on a FLS motion simulator to estimate the mean HWS measurement error, which is validated by analytical methods. The paper contents are more focused towards a theoretical understanding than towards an experimental implementation. A complete review of the state of the art is given in the introduction, providing a solid background to motivate the study.

A thorough analysis of the error as a function of different motional parameters and the wind shear is given. Further, two motional case examples are studied: "normal" and "strong" wave motion. The estimated HWS mean measurement error figures obtained are of an order of magnitude lower than those observed experimentally, and they could not be validated experimentally by the authors.

The analytical formulation of the Appendix is nicely formulated and its description permits the reader to follow its derivation in a structured way. Moreover, its description as a function of the motional scenario allows the reader to better understand the HWS mean bias sources. However, some steps are unrelated to or isolated from the manuscript and more context is required.

Although the paper contents are aligned with the state of the art and give original results, the presentation of methods and the discussion of results are somewhat misleading and/on unclear, and could be improved (please see SPECIFIC COMMENTS below). This considered as well as the long list of specific comments below I'm recommending a major revision. The manuscript looks promising and it will definitely improve by implementing

the proposed changes below.

Specific Comments

ALL OVER THE MANUSCRIPT

Please CONTEXTUALISE: There are some equations and assumptions which are uncontextualized and require some background explanation for the inexpert reader to be understood. As an example, the VAD algorithm is briefly introduced (figure-of-eight fitting), and expressions derived from its computation procedure (such as Eqs. A1 and A2) are presented without any context and assumed to be known beforehand. This can be found in the simulator explanation (e.g., the law wind profile and the lidar scanning procedure) in Sect. 2.1 and the equations of Sect. 2.5 and the Appendix, please revise.

Sect. 2 Materials and Methods

Errors discussed in the paper must be defined formally. It is hard to discern between single-scan and 10-min errors. Is the 10-min error derived from the average of 600 simulated scans? Are the errors in sections from 2.4 to 2.9 defined for 10-min observations?, or only for a scan? The difference between systematic and random errors is also unclear. Please notate variables accordingly.

2.1 Lidar simulator

A more detailed description of the lidar measurement procedure and how the motion is emulated in the algorithm is required. This could be carried out by means of a block diagram, or a list, explaining more in depth the lidar scanning procedure (VAD algorithm) and the rotational motion influence on the lidar pointing direction. Consider adding equations to define the wind vector, power law wind profile, and the real lidar pointing direction. Some simulator steps added later in the manuscript are not explained, e.g., the influence of pitch motion phase.

Regarding the first phase angle consideration, are each of the 100 simulated test cases carried out considering the same phase offset for all 600 lidar scans? In other words, is the initial phase angle randomness considered individually for each of the 600 scans, or a single value the same for the whole set? Please clarify. Consider providing an equation for it.

2.4 Lidar motion in six degrees of freedom

The translational motion is disregarded by assuming that the displacement around a fixed point for FLSs anchored to the seabed is null in average. Is the average translational velocity equal to exactly 0 m/s for 10-min periods? Since the HWS bias figures found show small values as well, does not the translational motion contribute to it? Further information or references should be provided to motivate this assumption.

2.5 Pitch motion with no wind shear

Both the lidar first phase angle and the pitch motion phase nominal values have influence on the HWS bias in a scan. Is this considered for the results of the paper (Fig. 6 for example)? How? Or is only the phase offset considered for the 1-Hz case (Fig. 5)? Please clarify.

3.1 Tilt Frequency

Please justify that the SWLB is restricted to a narrow band, i.e., one narrow spectrum peak. Is Fig. 9 just an example case, or most of the scenarios are equivalent? Please justify this assumption or give a reference.

4 Discussion and conclusions

The experimental results obtained are not validated experimentally as the theoretical error is too small in comparison to the instrument uncertainties. Please, could the authors suggest an approach to validate these results? How these results compare with similar ones (if any) in the state of the art?

Appendix

Please, provide a more accurate contextualization of the expressions derived in the Appendix: see technical corrections below. For example, explain either in the appendix or in the manuscript (and then cross-reference) the origin of Eqs. A1 and A2. Consider to provide more crossed references with respect to the manuscript.

Technical Corrections

Line 23: Reference needed for the wind speed - production relationship.

Line 56: Rephrase to "10-min mean wind velocity by a FLS."

Line 58: Rephrase to "wind lidar, taking as a reference the ZX 300M...".

Line 58: "Computer simulations are validated by means of an analytic model."

Line 61: "The bias is quantified for the SWLB by Fugro (Trondheim, Norway) under "normal" and "strong" wave conditions."

Line 64: "with and without".

Line 70: Remove line break.

Line 74: Include the lidar scan time.

Line 76: Please explain the vector transformations as well as the real azimuth and elevation angle derivation procedure.

Line 80: Mention the VAD algorithm.

Line 81: Please include a sentence explaining how the mean bias is derived.

Line 88: Please, use the acronym everywhere or do not use it.

Table 1 is not needed. It can be embedded in the text.

Line 96: subsections from 2.4 to 2.9 as subsections of subsection 2.3.

Line 114: Add reference to justify the wind direction disregarding.

Line 116: Add reference to justify the assumption of no translational motion influence.

Line 130: Remove the period after "important".

Line 135: How Eq. 2 is reached?

Line 141: Rephrase to "... for static tilt ($f_p=0$)."

Please homogenize the font size in all figures of the manuscript.

Figure 2 caption: Please define in the text upwind and downwind.

Figure 3: Please add "a)", "b)", etc. labels to each of the figure panels. "Projection", "Top view", etc. labels must be included in the caption. Same for the rest of figures.

Lines 187-189: Please add a reference or clarification with regards to the scalar averaging and vector averaging influence on the bias.

Line 198: Please rephrase to "This can be explained by the approximation of A by means of the second order Taylor's expansion (see Eqs. A12-A13). Expanding A to a higher order would probably eliminate these small deviations due to approximation."

2.6 Roll motion with no wind shear: This section could be omitted and merged into 2.5.

2.7 Yaw motion: This section could also be merged into 2.5.

Line 212: Please add a reference.

Line 216: Please specify what "results" refer to. Is it 10-min mean HWS bias or similar?

Line 248: Please provide more information about the measurement campaign from which the measurement data is used. Exact location, measurement time, etc.

Line 253: Please provide the exact time of the measurement.

Line 253: Please give more information on the bin average procedure, e.g., number of averaged bins.

Line 253: Please specify what "tilt" refers to. It is not clear if it is only pitch tilt or a combination of roll and pitch.

Line 263: Please provide a reference for significant wave height.

Line 264: Please provide exact location and campaign dates.

Line 273: Rephrase to "The mean tilt amplitude is defined here as the average of the local maxima of the rectified tilt time series". Does tilt refer to pitch?

Figure 10: Markers for "normal" and "strong" cases under study could help the reader.

Line 281: Please provide reference.

Line 297: Please add a coma after "UK".

Line 310: Please refer to the particular experimental campaign.

Line 316: Please provide a reference or give typical mean HWS measurement bias figures.

Line 318: Please provide a reference to justify "the sensitivity of measurement error of SWLB to motion and sea-state parameters is insignificant".

Line 323: What does random error refer to? What is the difference between systematic bias and random error? Please clarify in the text.

Line 345: Please clarify the origin of equations A1 and A2. Relate to VAD algorithm.
Equation A2: Please add a coma after the equation.
Line 353: Please rephrase to "The pitch angle $\hat{\alpha}$ is defined as a harmonic variation as a function of time".
Line 357: Please rephrase to "The actual beam direction is obtained as the dot product between \mathbf{n} and the rotation matrix \mathbf{M} , which is given by"
Line 382: Please rephrase "can be expanded to second order" to "can be approximated by its second order Taylor series"
Line 403: Please change ", see Eq. 4" into "(see Eq. 4)".
Line 414: "we are left with the result **of** Eq. A10".
Equation after line 430: There is no equation number. Period after the equation required.
Line 436: Please refine the sentence.
Equation A26: Please add a period after the equation.
Line 440: Rephrase to "To complete the analysis of the impact of roll and shear on the average lidar speed we need to calculate C2, according to Eq. A15".
Line 441: Change "expanding only to first order in $\hat{\alpha}^2 z/z$ " into "and expanding $\hat{\alpha}^2 z/z$ to its first order Taylor series,".
Equation A27: Please add a period after the equation. Add punctuation to the remaining equations.
Line 444: Please remove "equation".
Line 449: Please rephrase "The first three are, when integrated over φ_r , independent of θ' and θ'' so the integrals over θ' and θ'' of those terms give zero. We are left with" to "The first three are independent of θ' and θ'' when integrated over φ_r , and thus, the integrals over θ' and θ'' of those terms are null, leading to".
Line 452: Please rephrase to "We now substitute Eq. A29 into Eq. A30 and retain only terms of up the second order in A."
Line 454: Please rephrase the sentence, it is hard to understand.
Line 456-459: Please rephrase. Its meaning is unclear.