Authors' response to Review 2 (3nd revision): Evaluation of lidar-assisted wind turbine control under various turbulence characteristics

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02.01.2023

We would like to sincerely thank all the reviewers for taking their valuable time to read our manuscript and provide constructive comments. Special thanks to Review 2 for your careful review of the paper and further constructive comments in the third round of review.

Please find below our response to the reviewer 2's comments. The reviewer's comments in the report are repeated in black text, our response should be given in blue text, and if necessary, the corresponding corrections are provided in red text.

Response to comments of Anonymous Referee #2 (3nd round)

Overall comments

The manuscript has been greatly improved and almost all of my comments have been addressed. I just have a few last comments I hope the authors can address.

We are very appreciative of the referee for the positive feedback after the second round of revision on the manuscript.

3. Reviewer comment 1: Eq. 20: Why is the real number operator needed here? By definition, won't the coherence be a positive real number? Otherwise, can you explain how coh11 can contain imaginary components? Author response: Thanks for the your comments. Indeed, the magnitude squared coherence is real and positive. In terms of the least square fitting in Equation (21) (previously 20), we are fitting the co-coherence. We have corrected the equation now and added Equation (10) to explain the definition of co-coherence. Reviewer comment 2: Can you explain why you are fitting the co-coherence instead of the magnitude squared coherence? Author response 2: Thanks a lot for the reviewer's comments. We chose to fit the co-coherence because the exponential coherence model (used for Kaimal spectra) is a real function and it only has co-coherence. We have added explanations in Ln 220. Reviewer comment 3: This makes sense. But I suggest also clarifying that this is necessary because the yz-plane coherence from the Mann model includes quad-coherence, for example "...because the exponential coherence model (Equations 13 and 19) only includes the real co-coherence, whereas the Mann coherence model includes both co-coherence and quad-coherence.", unless if this has been discussed earlier.

Thanks a lot for the suggestion, we have added the sentence as : whereas the Mann coherence model includes both co-coherence and quad-coherence.

10. Reviewer comment 1: Line 315: "If a filter with the gain. . . " This sentence is hard to understand and appears to be incomplete. Author response: Thanks for pointing this out, this sentence is now rewritten as: "If a filter is designed to have a gain of GRL(f), it turns out to be an optimal Wiener filter (Simley and Pao (2013), Wiener et al. (1964)), which results in minimal output variance for a multi-inputs multi-outputs system." Reviewer comment 2: The phrase "results in minimal output variance for a multi-inputs multi-outputs system" could use some explanation. What does this mean in the context of the LAC application, and what specific variance does the filter minimize in this application? Author response 2: Thanks for your feedback, we have added the explanation in Ln 345 as: "For example, in LAC, if the system is modeled as a system with two inputs: REWS and lidar-estimated REWS, and one output: rotor speed, the Wiener filter leads to minimal rotor speed variance (Simley and Pao, 2013).

Reviewer comment 3: The Wiener filter minimizes the mean square error between a signal and the estimate of the signal, so I still don't understand the phrase "results in minimal output variance for a multi-inputs multi-outputs system." Is there a reference that explains this idea more? Or is this true if the Wiener filter is used in a specific way in the MIMO system? Further, for the example provided from Simley and Pao, 2013 with a system with two inputs: REWS and lidar-estimated REWS, and one output: rotor speed, the reason the Wiener filter minimizes rotor speed variance is that the problem is formulated so that the output rotor speed is a function of the difference between the REWS and the lidar-estimated REWS. I don't know if using the Wiener filter would, in general, lead to minimizing output variance for MIMO systems.
We appreciate that the reviewer points out his or her detailed thoughts, we totally agree with the reviewer. Indeed, it was because Simley and Pao formulated the problem by using the Wiener filter for a specific MIMO system so that it results in results in minimal output variance for the MIMO system. A single Wiener filter, by definition, only produces an estimate of a desired or target signal and minimizes the mean square error between a signal and the estimate of the signal. We have now rewritten the sentences as: If a filter is designed to have a gain of $G_{\mathrm{RL}}(f)$, it turns out to be an optimal Wiener filter (Simley and Pao, 2013; Wiener et al.,1964), which results produces an estimate of a desired or target signal (here the u_{RL}). The Wiener filter minimizes the mean square error between the target signal and the estimate of the signal. When used for LAC, if the system is modeled as a system with two inputs: REWS and lidar-estimated REWS, and one output: rotor speed, the Wiener filter leads to minimal rotor speed variance as formulated by Simley and Pao, (2013).

6 (from New Comments section). Reviewer comment 1: Section 3.2: I think more details about how the lidar-estimated REWS is formed should be provided here to better understand the spectrum calculations. In particular, how do you combine measurements at different range gates? Do you delay the measurements from the farther range gates according to Taylor's hypothesis so they are in phase with the measurements from the closest range gate before averaging? Or do you average all measurements at the same time? This decision should affect the spectrum equation in Eq. 29. Author comment 1: Thanks for your suggestion, we have added more discussions after Ln 300.
Reviewer comment 2: One small comment is that in Eq. 32, I think the sign of the time shift might be wrong. According to the sign convention for the "x" dimension shown in Fig. 3, (x_i - x_{nrg}) will be negative, leading to a shift forward in time. But I think the correct time shift for range gates farther away from the turbine should be a shift backward in time when adding the measurements from different range gates. Should the numerator of the time shift term actually be (x_{nrg} - x_i)?
We appreciate the reviewer's careful reading and review. The reviewer is correct and it should be x_{nrg} - x_i. We have made corrections in the revised version.