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Subject Response to Reviewers

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Anonymous Reviewer #2
Reviewers, Wind Energy Science

Dear Reviewer(s),

We sincerely thank you for the constructive and thoughtful feedback on our manuscript *LiDAR-enhanced Closed-Loop Active Helix Approach* (Ms. Ref. No.: wes-2025-161). We have revised the paper thoroughly. Below, we respond point by point, quoting each comment and indicating the changes made. A clean manuscript with highlighted changes is provided in the resubmission.

Yours sincerely,

Zekai Chen
Aemilius A.W. van Vondelen
Jan-Willem van Wingerden

Enclosure(s): Response to comments of Anonymous Reviewer #2

Response to comments of Anonymous Reviewer #2

Reviewer: *Overall, the revisions made to this paper have led it to be a much more understandable and cohesive presentation of the closed-loop helix method. Although the paper is slightly long and brevity should be sought after wherever possible, the use of the appendix helps tighten the focus of the paper on the results and relevant methods. The authors did a very good job in providing strong justifications for the critiques presented, and I appreciate their effort. At this stage, I believe the methodology and results are sound and well presented. My only suggestions at this stage are regarding organization.*

Authors: We sincerely thank the reviewer for their positive comments and for the time and effort dedicated to reviewing our work. We agree that the manuscript has been significantly improved through this revision process. Following the reviewer's constructive feedback, we have reorganized the paper to reduce its overall length and ensure that the focus remains on the proposed framework rather than the background introduction.

Reviewer: *As I mentioned above, the paper still stands a bit long, and much time is spent establishing the methodology and background. The appendix sections are relatively short, so it could be beneficial to move more of the background to the appendix. For example, the LiDAR introduction on pages 3-4 is somewhat unnecessary, and could be split between the LiDAR Subsystem Design section and Appendix A.*

Authors: We appreciate the reviewer for pointing this out, and we agree with the reviewer that the original LiDAR introduction was overly detailed. Consequently, we have reorganized Section 2 by moving non-essential background to Section 3.2 and Appendix A. Specifically, Section 3.2 now focuses solely on the functional role of LiDAR and our motivation for choosing a continuous-wave LiDAR. Technical details regarding the Doppler effect, scanning patterns, and their influence on wake sampling have been moved to Appendix A. We believe this structural modification makes the narrative concise and keeps the reader focused on the proposed framework.

Inserted text: LiDAR is a remote sensing method for measuring wind speed that has gained attention in the wind energy industry in recent years. It enables additional wake measurements to be incorporated into wind turbine controllers, thereby facilitating the development of advanced control strategies [5]. A detailed explanation of LiDAR, the model, and the practical concerns can be found in Appendix A. In this work, we adopt a continuous-wave LiDAR due to its uniform return time of all measurements, which simplifies controller design.

Reviewer: *In addition, it could be worth considering a restructuring of the Discussion section. Only 1/3 talks about the potential impact of the CL helix method on wind turbine loads, which is of particular interest to potential stakeholders and readers who are interested in the viability of this method. Some of this discussion is already integrated into the Results section, so some reshuffling of the information already presented would be beneficial.*

Authors: We thank the reviewer for this insightful suggestion. We agree that the original Discussion section lacked a clear focus, which may have obscured the practical implications of our findings. To address this, we have reorganized the section to center specifically on the trade-off between power production and structural loads, as this is a primary concern for stakeholders regarding the viability of active wake mixing. To ensure the narrative remains focused and concise, we have relocated secondary topics as follows:

- Inflow Estimation: The discussion on incorporating inflow wind speed prediction has been moved to the future work part in Section 6 (Conclusion).
- Practical LiDAR Implementation: Technical considerations regarding the use of realistic LiDAR systems have been moved to Appendix A.

We believe these changes significantly improve the clarity of the discussion and highlight the core trade-offs essential for evaluating the method's real-world feasibility.

Inserted text: Simultaneously, the framework's adaptivity to naturally varying wind fields can be enhanced by integrating real-time inflow estimation techniques, such as BEM-based methods [1, 3], ensemble Kalman filters [2], or immersion and invariance estimators [4].

Reviewer: *Lastly, the structure of the Results and Discussion is somewhat overwhelming. There is a large number of different sections, and although this naturally extends from there being six test cases, it can be easy for the reader to get lost in all of this information. While Figure 14 contains much of the relevant information, it is still quite large to digest, so perhaps the authors could consider a table summarizing the major effects of the closed-loop helix controller. This could help structure and summarize sections 4.4.X.*

Authors: We thank the reviewer for this constructive suggestion regarding the manuscript's structure. We agree that the previous organization was somewhat repetitive and potentially overwhelming. To improve the narrative flow and clarity, we have implemented the following changes:

- Data Summarization: As suggested, we have replaced Figure 14 with Table 5. This new table provides a concentrated summary of the major effects of the closed-loop helix controller, making the core findings much easier to digest at a glance.

- Structural Consolidation: We have merged the previous Section 4.4 (Result Analysis) into Section 4.3 to keep the paper concise by integrating the performance data with its corresponding analysis into new subsections (4.3.1, 4.3.2, and 4.3.3).
- Section Retitling: To reflect this integration, Section 4.3 has been renamed from "Closed-Loop Framework Performance" to "Closed-Loop Framework Performance and Analysis".

We believe these revisions significantly enhance the readability of the results and provide a more cohesive, logical chain for the reader.

Reviewer: *Overall, the state of this paper is very strong, and the minor changes suggested above could be optional. It may be worthwhile to pursue some additional proofreading as well. For example, line 429 should be corrected to "actuation", and the EKF abbreviation at 448 could be omitted for clarity (since it is not referenced again. Also, EKF could be confused with Extended Kalman Filter).*

Authors: We sincerely thank the reviewer for the encouraging feedback and for the meticulous attention to detail. We have performed a comprehensive read-through of the manuscript to ensure grammatical consistency and technical clarity. Based on the reviewer's suggestions, we have implemented the following corrections:

- Abbreviation Clarity: The "EKF" abbreviation has been removed as it was not referenced again, thereby avoiding potential confusion with the extended Kalman filter.
- Section Titles: We corrected the typos in the titles of Section 2 (changed to "Preliminary Knowledge") and Section 3.1 (changed to "Overall Framework Structure").
- Terminology Consistency: All instances of the word "chapter" have been changed to "section" to align with the standard journal naming system.
- General Proofreading: We have audited all abbreviations and mathematical notation throughout the manuscript to ensure there is no ambiguity for the reader.

References

[1] Marta Bertelè, Carlo L Bottasso, Stefano Cacciola, Fabiano Daher Adegas, and Sara Delport. Wind inflow observation from load harmonics. *Wind Energy Science*, 2(2):615–640, 2017. doi: 10.5194/wes-2-615-2017.

[2] BM Doekemeijer, Sjoerd Boersma, Lucy Y Pao, and Jan-Willem van Wingerden. Ensemble kalman filtering for wind field estimation in wind farms. In *2017 American Control Conference (ACC)*, pages 19–24. IEEE, 2017. doi: 10.23919/ACC.2017.7962924.

[3] Torben Juul Larsen, Helge A Madsen, and Kenneth Thomsen. Active load reduction using individual pitch, based on local blade flow measurements. *Wind Energy: An International Journal for Progress and Applications in Wind Power Conversion Technology*, 8(1):67–80, 2005. doi: 10.1002/we.141.

[4] Yichao Liu, Atindriyo Kusumo Pamososuryo, Riccardo MG Ferrari, and Jan-Willem van Wingerden. The immersion and invariance wind speed estimator revisited and new results. *IEEE Control Systems Letters*, 6:361–366, 2021. doi: 10.1109/LCSYS.2021.3076040.

[5] Andrew Scholbrock, Paul Fleming, David Schlipf, Alan Wright, Kathryn Johnson, and Na Wang. Lidar-enhanced wind turbine control: Past, present, and future. In *2016 American Control Conference (ACC)*, pages 1399–1406. IEEE, 2016. doi: 10.1109/ACC.2016.7525113.