Response to Reviewer 2

April 4, 2025

Major Comments:

"This paper addresses some very interesting questions on kite dynamics using fusion techniques for the analysis of experiments. It draws on the substantial experience of the Delft team, which is undoubtedly the world's leading centre for kite studies. The paper is composed of 41 pages including 4 pages only for the introduction. Section 2, 3 and 4 present the material, i.e. system, sensors and fusion technics used for analysis. Section 5 presents many results in 4 subsections (kite kinematics, system dynamics (aerodynamic identification and turning dynamics), wind estimation and turbulence measurements). It ends with a broad conclusion.

The article could probably have been split into 2 separate articles. That would have made the point clearer. The language is highly technical, which often makes it difficult to read. It is often difficult to find the definition of one of the many variables. In such cases, an appropriate nomenclature is essential. Given the complexity of the problem being addressed and the large number of variables involved, the use of full variable names in the text should be preferred most of the time for easier reading.

One of the main gap in the document is a clear definition of the reference frames used in this study. With all the information available, the reader probably has all the information needed to find the definition of each variable. But this definition is uncertain, and the reader may make a mistake. An appendix at the end of the document gives the values of the experimental parameters and the model used during the tests. This should ensure reproducibility of the results. The codes are also provided."

Response:

We are grateful to the reviewer for the thoughtful and encouraging comments on our manuscript. We appreciate the acknowledgement of the Delft team's longstanding contributions to the field and the recognition of the paper's ambition in consolidating these insights.

We acknowledge that the manuscript is lengthy; however, we consider the topic to be a closed and coherent body of work. The aim was to integrate a broad range of experimental and modelling expertise into a single, comprehensive study. Given the depth of analysis and the novel fusion framework presented, we believe this integrated presentation will serve the airborne wind energy community more effectively than a fragmented approach across multiple papers.

In response to the specific points raised:

- A **nomenclature section** has been added to the manuscript, listing all relevant variables along with their definitions and units, to facilitate readability.
- The manuscript has been revised to **consistently use full variable names** throughout, particularly in technically dense passages, to improve clarity.
- The **main reference frame** used throughout the study is now explicitly defined in Section 4 as the East-North-Up (ENU) frame, in which all vector quantities (e.g., position, velocity, wind velocity) are expressed. The only exception is the definition of the Euler angles, which follows the North-East-Down (NED) convention to avoid discontinuities in angle representation. Furthermore, Figure 4 has been updated to reflect this clarification, with axis labels revised for improved consistency and readability.
- We have carefully revised the text following the reviewer's 121 in-line comments, aiming to improve clarity and accessibility throughout the manuscript. The response to these comments can be found in the appended pdf.

Minor Comment 1:

"Line 80, The authors claim that their model improves on the existing one by considering the sag of the lines and the dynamics of the KCU. We expect them to present comparisons of measurement results with and without taking these quantities into account. This would make it possible to visualize concretely the impact of taking these factors into account."

Response:

We thank the reviewer for this valuable suggestion. In response, we have revised the text to clarify that the contribution of this work lies in the introduction of a more detailed and physically representative model—rather than claiming direct superiority in estimation performance over previous, simpler models. The proposed model incorporates tether sag and the dynamics of the kite control unit (KCU), which are not commonly accounted for in existing approaches.

While a direct side-by-side quantitative comparison with models omitting these features is beyond the scope of the present study, the advantages of the enhanced model fidelity are illustrated through several key results. In particular, the incorporation of KCU dynamics enables partial estimation of the wing orientation and structural deformation, providing valuable insight into aeroelastic behaviour during flight. These estimations are obtained without substantial increases in computational cost.

To support this point, we have included a new appendix (Appendix C) presenting relevant filter performance metrics and convergence behaviour, which demonstrate the robustness of the implementation.

Minor Comment 2:

"Line 112-114: the KCU appears to be a reference for the orientation of the kite, which does not"

Response:

We appreciate the reviewer's observation. The original formulation may have implied that the KCU serves as a stable reference frame for the orientation of the kite, which is not the case. We have revised the text to clarify that pitch and roll angles are defined with respect to the orientation of the last tether segment, rather than to the KCU. The KCU frame is not used as a reference, as it is not rigidly fixed or well-defined due to its suspended configuration and motion. This correction ensures consistency with the later sections of the manuscript, where kite orientation is explicitly referenced relative to the tether.

Minor Comment 3:

"Line 113-114 The depower angle deserves a more rigorous definition."

Response:

We thank the reviewer for this comment. The text has been revised to provide a clearer and more rigorous definition of the depower angle. We now reference Figure 1 upon first mention and clarify that the depower angle is determined experimentally for each system. Additionally, we have introduced the definition of the tether angle of attack and the parameter λ_0 to better explain the relationship between the relevant aerodynamic angles.

Minor Comment 4:

"Line 119 Fig.3.a does not exist. Replace by Fig.3"

Response:

We thank the reviewer for noticing the typo, which is now corrected.

Minor Comment 5:

"Line 160 Figure 3 shows 4 boxes on 4 battens. We need to specify which one is the IMU and which other sensors are in the others."

Response:

We thank the reviewer for this observation. We have clarified in the caption that all four battens shown in the image are equipped with GPS+IMU units. Additionally, the specific sensor configurations used in the analysed flights—namely, the number and placement of the units—are now detailed in the results section. Please note that the kite depicted in the figure differs from the one used in the presented datasets.