

## Reviewer 1

**RC1.01)** The manuscript still does not convincingly demonstrate that the remaining errors are solely due to the RNA modeling. The authors need to either provide evidence that these errors cannot arise from other sources, including those inherent to the MDE, or proof by comparing results with and without RNA modeling. Alternatively, if this influence cannot be substantiated, the novelty of the RNA modeling should not be emphasized but can be included as a possible cause in the discussion.

**RC1.01)** The authors thank the reviewer for this comment and recognise that the MDE errors cannot be solely attributed to the blade flexibility being disregarded. However, in the authors' opinion, this is reflected in the paper, although the conclusions regarding rotor flexibility might be too firm. To accommodate this comment, the authors have adjusted statements regarding the importance of flexibility, and changed the statement about the paper's novelty to (line 84-86):

“The paper demonstrates the structure-wide performance of multi-band MDE by quantifying the error in terms of DES and DEL along the IEA 15-MW RWT support structure, while applying a state-of-the-art lumped inertia model for deriving mode shapes used in the MDE.”

Furthermore, the conclusion of the paper regarding this has been adjusted (line 664-670):

“The errors at the tower top are highly linked to the second and third tower bending modes for DLC 1.2 and various rotor modes for DLC 7.2. As these modes are sensitive to rotor flexibility, the MDE performance in the tower top region may be improved by including rotor flexibility in the Rotor-Nacelle-Assembly (RNA) model rather than using a lumped inertia RNA model. Furthermore, the MDE errors at the MSL may be attributed to limitations of the Ritz vector used to represent the wave loads for DLC 1.2 in the FA direction, whereas the error may stem from erroneous tower mode shapes in the SS direction. It is also suggested that the linear dependency between the mode shapes and Ritz vectors used in the MDE in the low-frequency band B3 may result in MDE errors.”

**RC1.02)** It is necessary to clarify which of the model setups listed in Table 2 are being used and how each setup influences the results of the virtual sensing.

Additionally, comparing the mode shapes of the different model setups to those from HAWC2, in conjunction with evaluating eigenfrequencies, could provide valuable insights, given that the MDE is dependent on mode shapes.

**RC1.02)** The authors thank the reviewer for this comment and agree that it is not clear which of the model setups are being used in the virtual sensing. This has been addressed by adding a sentence at the end of section 4.3.1 specifying what model setup is used (line 371-373):

“In the following sections, where the mode shapes used for the subsequent multi-band MDE are presented, only Model setup 3 is considered, as it represents the most complete structural model that includes both soil support and hydrodynamic mass.”

The objective of Table 2 and section 4.3.1 is to ensure that the mass and stiffness parameters of the IEA 15-MW RWT are included correctly in the prediction FE model. This is done by making a stepwise model comparison (in terms of natural frequencies), gradually increasing the model complexity, until the (final) prediction FE model used in the virtual sensing is obtained. The authors recognise that this objective might not be clear, and therefore, the introduction of Section 4.3.1 has been rephrased (line 344-348):

“The objective of this validation is to ensure the correct interpretation of the input parameters

derived from HAWC2 and used in the prediction FE model in Figure 6. Therefore, this validation does not compare the prediction FE model against the full HAWC2 model of the IEA 15-MW RWT. Instead, the comparison is performed stepwise using the simplified HAWC2 model setups 1, 2, and 3 for the IEA 15-MW RWT, in which the rotor flexibility is deactivated so that the model comparison is performed accounting for the contributions to the mass and stiffness terms.

The authors agree that a mode shape comparison would be valuable. However, the model comparison presented in Section 4.3.1 does not consider the full model of the IEA 15-MW RWT, and hence, a comparison of mode shapes would not represent the actual discrepancies in the virtual sensing. For a mode shape comparison to really create valuable insight, it should compare the actual aeroelastic modes of the IEA 15-MW RWT with the mode shapes of the prediction FE model. Unfortunately, these cannot be obtained directly from HAWC2.

Furthermore, mode shapes obtained from HAWCStab2 cannot account for, e.g. hydrodynamics and rotor tilt, and hence, they would not suffice for accurate comparison. Finally, the mode shapes could be obtained from OMA, however, while it might give valuable information, this would be a comprehensive task and is considered to be outside the scope of the present paper.

**RC1.03)** The reviewers appreciate the inclusion of time series plots in Appendix C. However, the naming conventions for these figures are confusing, and the descriptions need to be more detailed than simply stating "demonstrating a poor MDE performance" for all figures. For many of the displayed time series, the estimation appears quite accurate rather than poor. This observation should be supported by error metrics to provide a more rigorous evaluation.

**RC1.03)** The authors thank the reviewer for this comment, and recognise that Appendix C might be confusing. To accommodate the comment, the following changes have been implemented in the manuscript:

- The naming of the figures has been changed to DLC, direction (FA/SS) and the elevation. Furthermore, the figures containing the moment response PSDs have been added to the main manuscript (Figures 17-22) instead of the appendix, and the discussion has been separated in sections (5.3.1-5.3.4) to improve the overview for the reader.
- A more elaborate description of the moment history figures has been added, removing the "demonstrating a poor MDE performance" from the caption.
- It has been clarified why the selected time series has been considered, e.g.: "To contextualise the behaviour observed in Figures 13 and 14, the moment histories from DLC 1.2 corresponding to the five largest MDE errors at an elevation of 144 m in the FA and SS directions, respectively, have been selected for further analysis."
- The value of the MDE error calculated for each of the time series has been added to the figures, thus representing a relevant error metric. The range of the MDE error of the considered moment histories has also been added to the PSD figures.