The authors wish to thank the reviewer for the insightful and helpful comments. Below and in the revised manuscript (as indicated) the authors have responded point-by-point to each comment.

Referee 1

The study evaluates the aerodynamic parked loads of a model-scale floating troposkein VAWT in a wind-wave basin under different conditions: a fixed tower base, floating without waves, and floating with waves. The influence of wind speed, solidity (via blade count variation), and rotor azimuth on the parked load is analyzed. In general, the paper presents a good approach and addresses an important aspect of floating VAWTs, an area that remains underexplored in the literature. However, several comments are provided below to enhance the quality of the paper, particularly in terms of the findings and discussions:

Response: Thank you for the insightful review and comments. The authors believe that addressing these suggestions has enhanced the quality of the paper.

Methods:

1. The authors highlight that using static airfoil polars is reasonable in the context of parked loads. However, this assumption holds only for the fixed-base system. For the other two cases (with the floating system and with floating system plus waves), the variation in the angle of attack could occur at a frequency high enough to impose unsteady load conditions. This aspect should be further discussed.

Response: Thanks for pointing out this critical issue. Use of static airfoil polars makes sense for the fixed-base system. For the two floating cases, we've performed some analysis of reduced frequency to address the point noted by the reviewer.

Reduced frequency is a parameter used to determine whether the inflow is unsteady and it can be defined as follows [1]:

$$K_i = \frac{\omega_{ptfm}\, C_i}{2\sqrt{(U_\infty^2 + r_i^2\, \Omega^2)}}$$

where, ω_{ptfm} is the platform pitching frequency, C_i is airfoil chord, U_∞ is freestream velocity, r_i is section radius, Ω is rotational velocity of rotor.

According to Theodorsen's theory, a flow can be categorized as unsteady if $K > 0.05$. The reduced frequency (K) does not go above a value of 0.05 for both floating wind only and floating wind wave conditions for any of the wind speeds, as shown in Figure 1. The highest reduced frequency

(K) of 0.0158 occurs in the 3B floating wind wave pitch case. As wind speed increases, the reduced frequency decreases. Specifically, for the 3B floating wind wave pitch case, the reduced frequencies (K) at wind speeds of 2, 3, 4, and 4.96 m/s are 0.0158, 0.0105, 0.0079, and 0.0063, respectively. This indicates that higher wind speeds result in a steadier inflow.

Therefore, the inflow can be considered as steady. Notes have been added on lines 154-165 to provide this information.

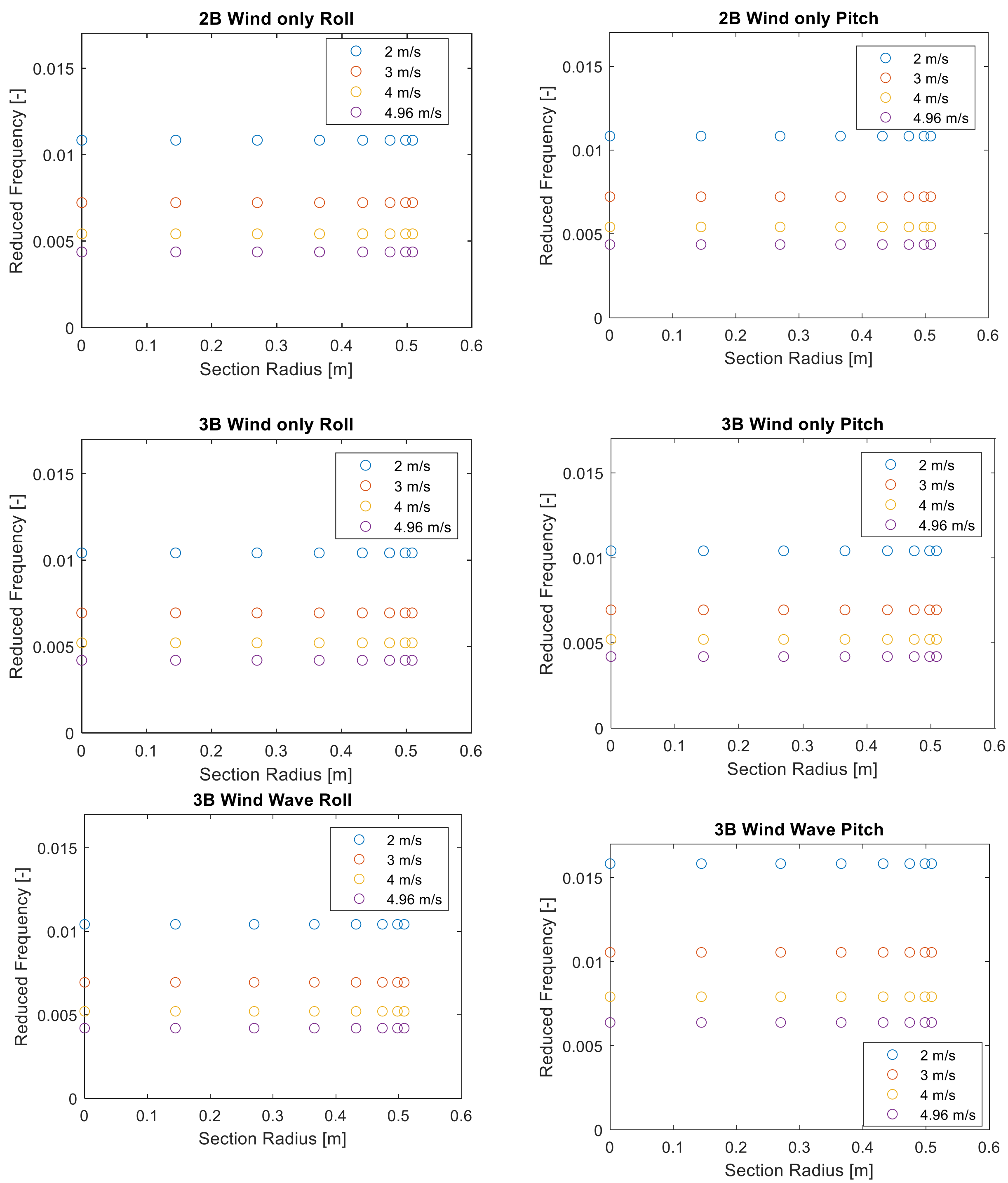

Figure 1: Reduced frequency for different platform and turbine operating conditions. Note: Section Radius refers to the rotor radius, which varies with rotor height.

2. There is a typo in equations (1) and (2); both equations are identical. Please correct this.

Response: Thanks for pointing this out. Equation 2 is related to tangential velocity (V_T). The equation has been modified and added in line 173.
Modified equation:
$V_T = T_X U_X + T_Y U_Y + T_Z U_Z$

3. Why not nondimensionalize all the parked load forces or even normalize them with respect to the rated forces? This would make it easier for readers to compare and interpret the results.

Response: Thanks for raising the point about normalization. Authors included both the dimensional and nondimensional parked loads in this version.

The nondimensionalized parked forces are defined as follows.

$$C_{Th} = \frac{F_{Th}}{\frac{1}{2}\rho\ A\ U_\infty^2}$$

$$C_{Lat} = \frac{F_{Lat}}{\frac{1}{2}\rho\ A\ U_\infty^2}$$

Where, C_{Th} is thrust force coefficient, C_{Lat} is lateral force coefficient, F_{Th} is thrust force, F_{Lat} is lateral force, ρ is density of air, A is the rotor area, and U_∞ is freestream velocity.

The revised manuscript shows both nondimensional and dimensional results. The nondimensional results are shown in Figures 15a, 17a, 18a, 19a, and 20 a for 2B locked with wind only, 3B locked with wind only, 2B floating with wind only, 3B floating with wind only, and 3B floating with wind and wave conditions, respectively.

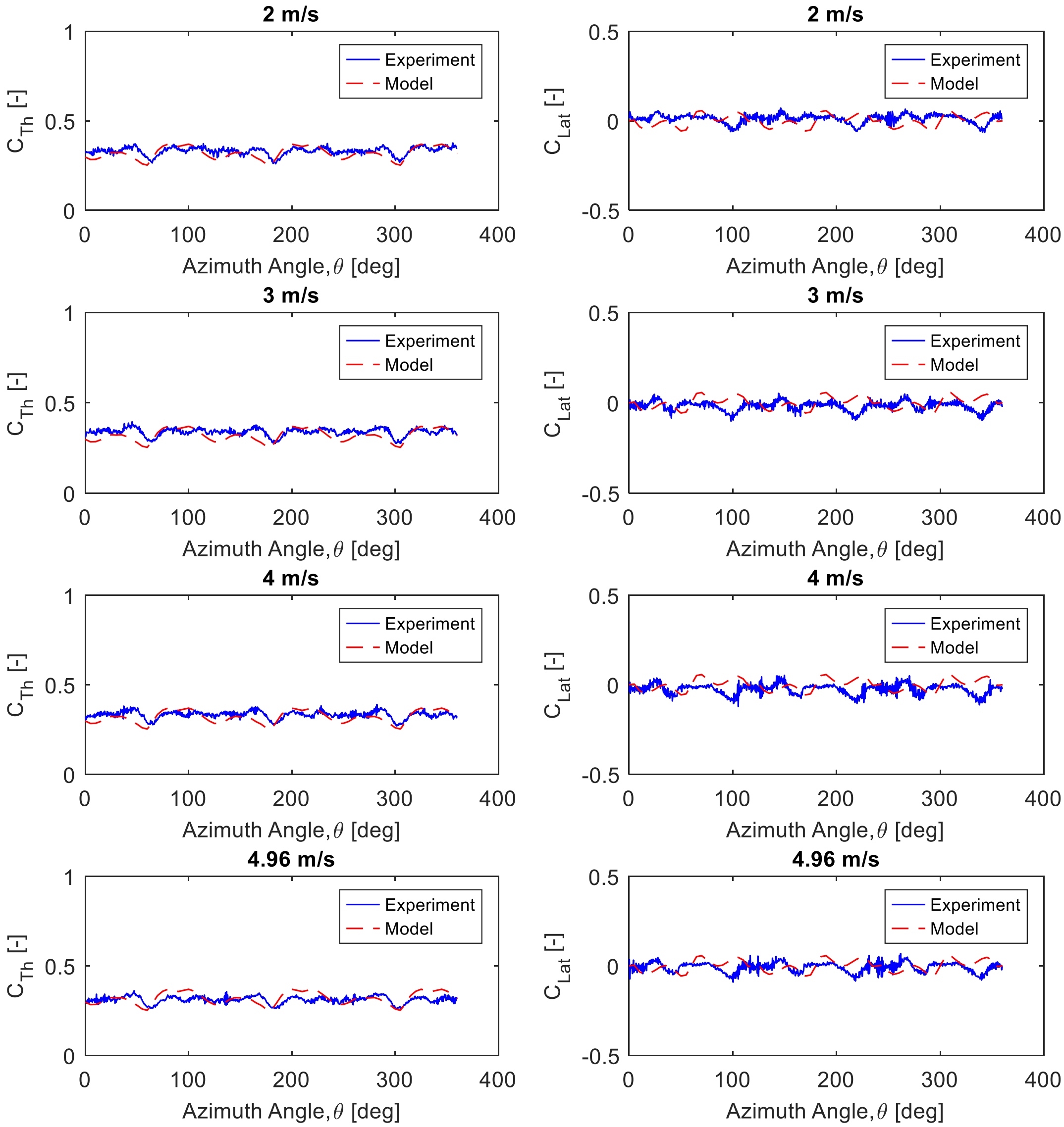

Figure 2: Nondimensional parked loads of 3B turbine for locked wind only condition.

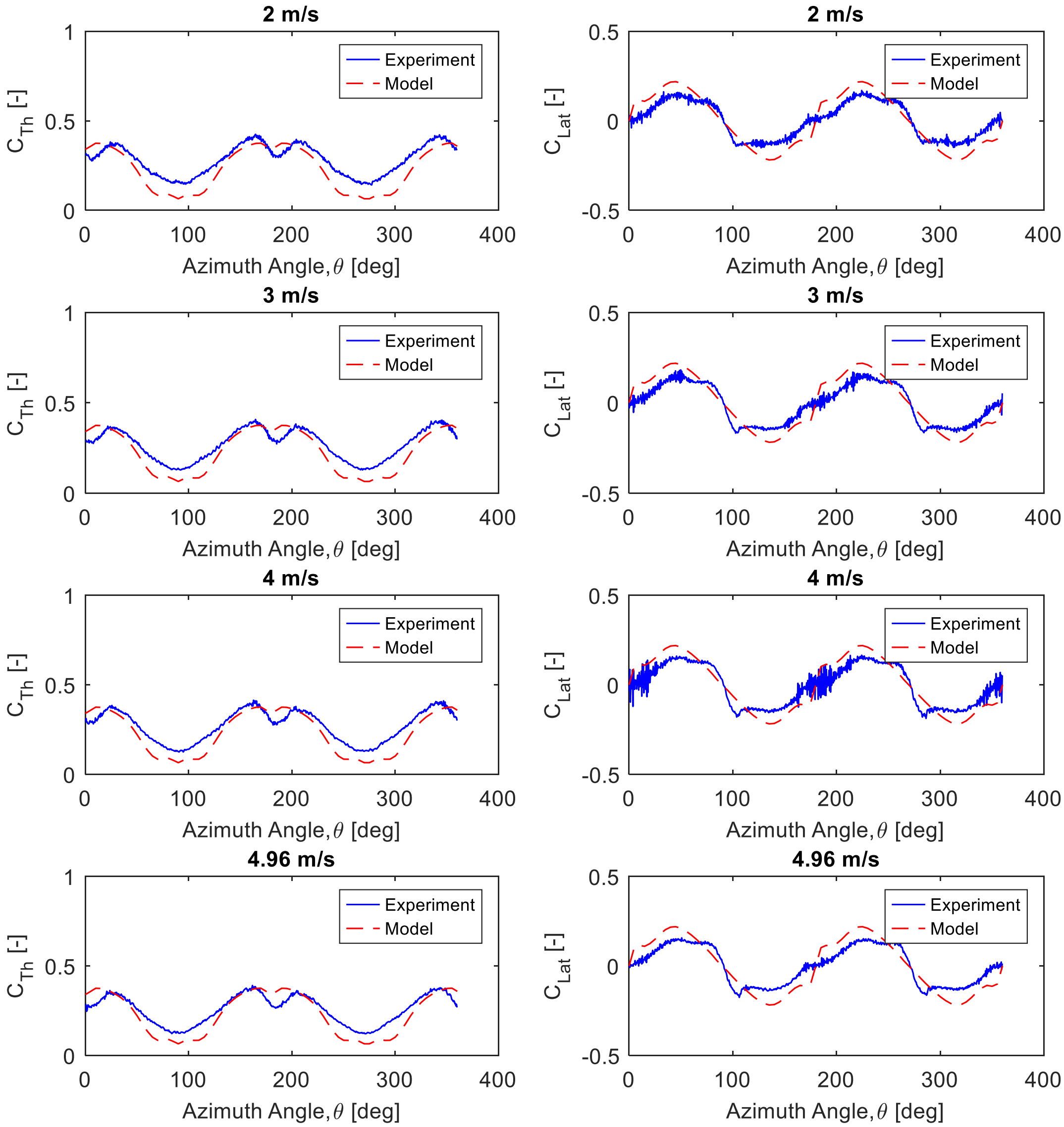

Figure 3: Nondimensional parked loads of 2B turbine for locked wind only condition.

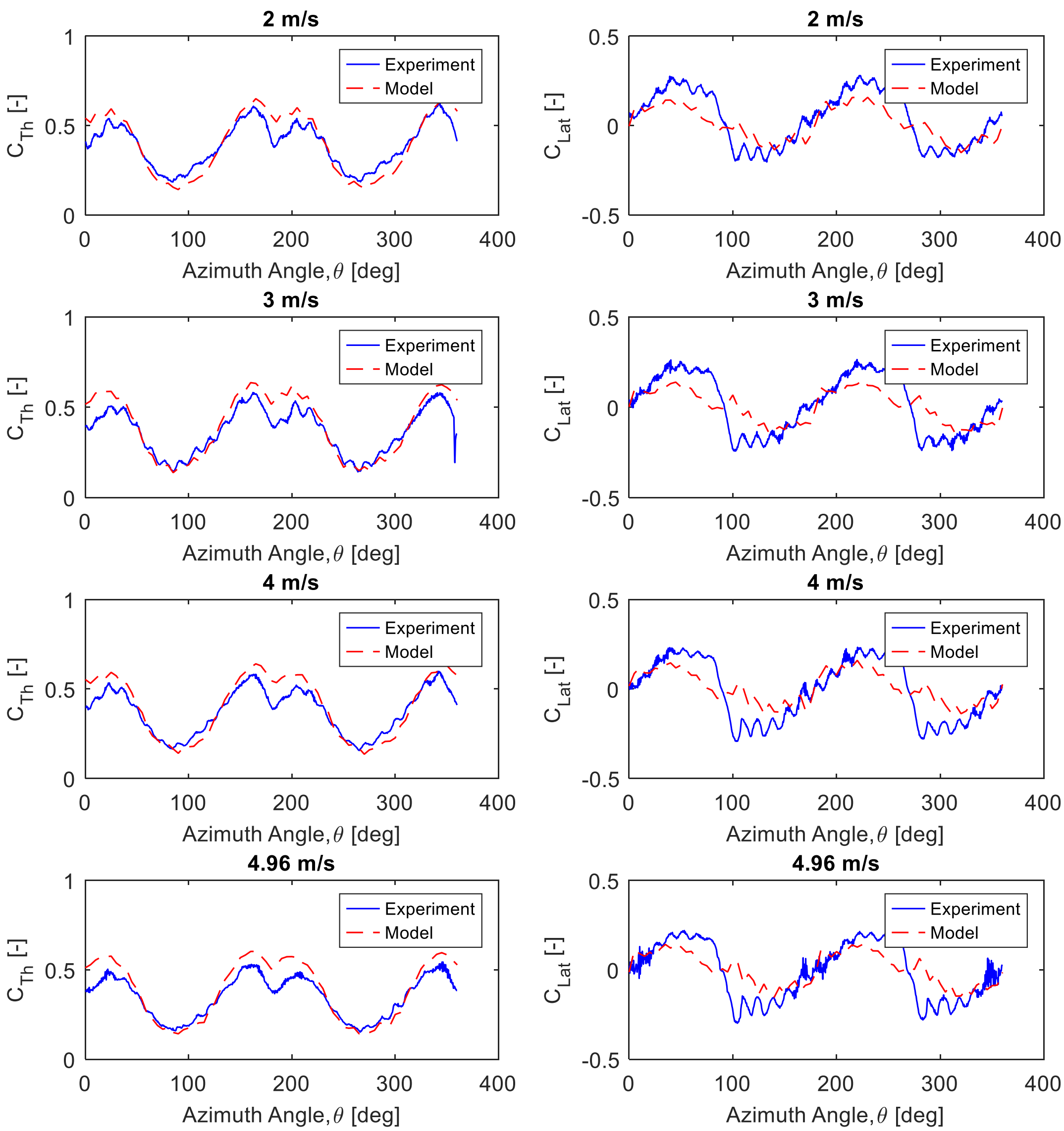

Figure 4 : Nondimensional parked loads for 2B turbine for floating wind only condition.

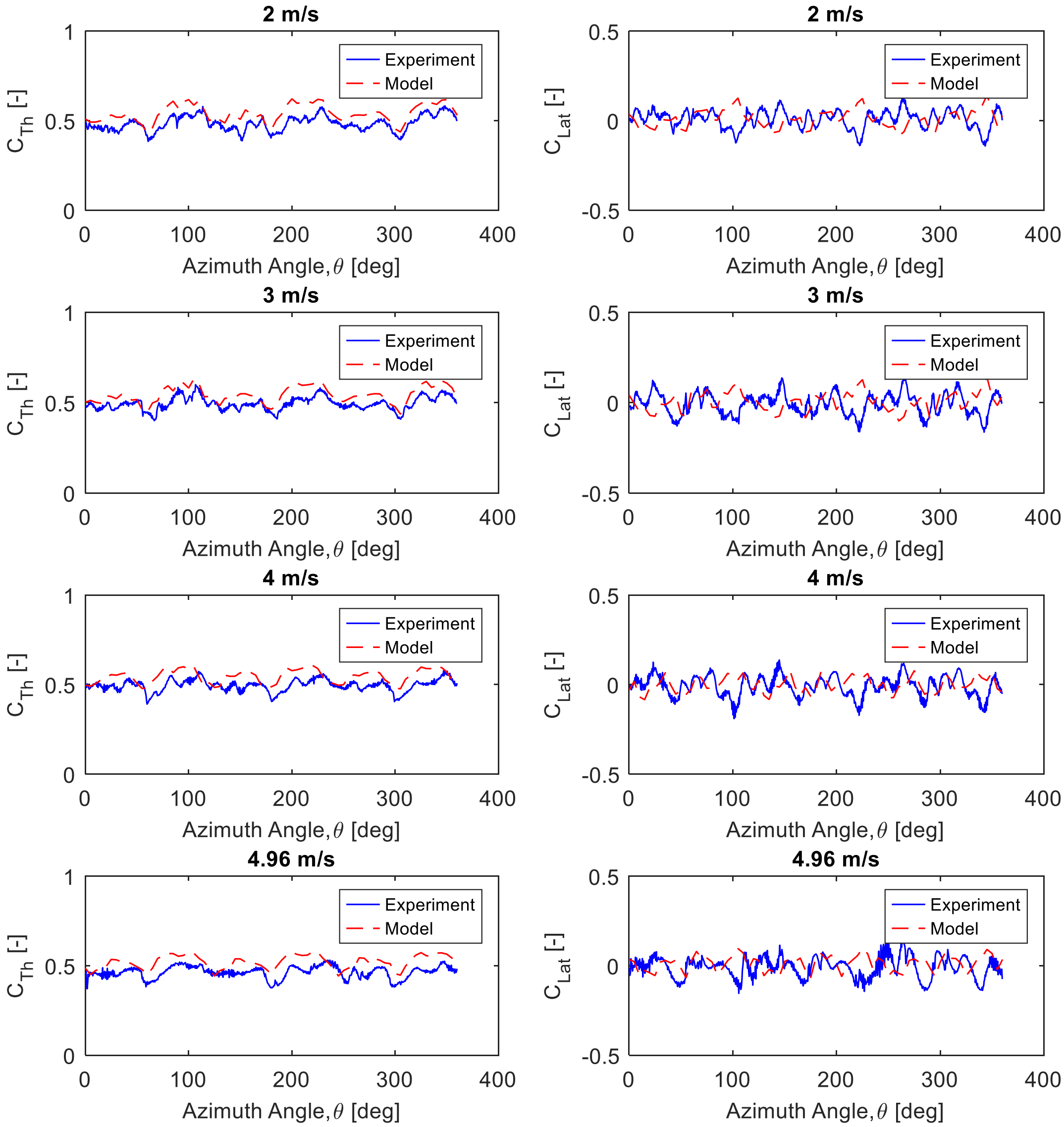

Figure 5: Nondimensional parked loads for 3B turbine for floating wind only condition.

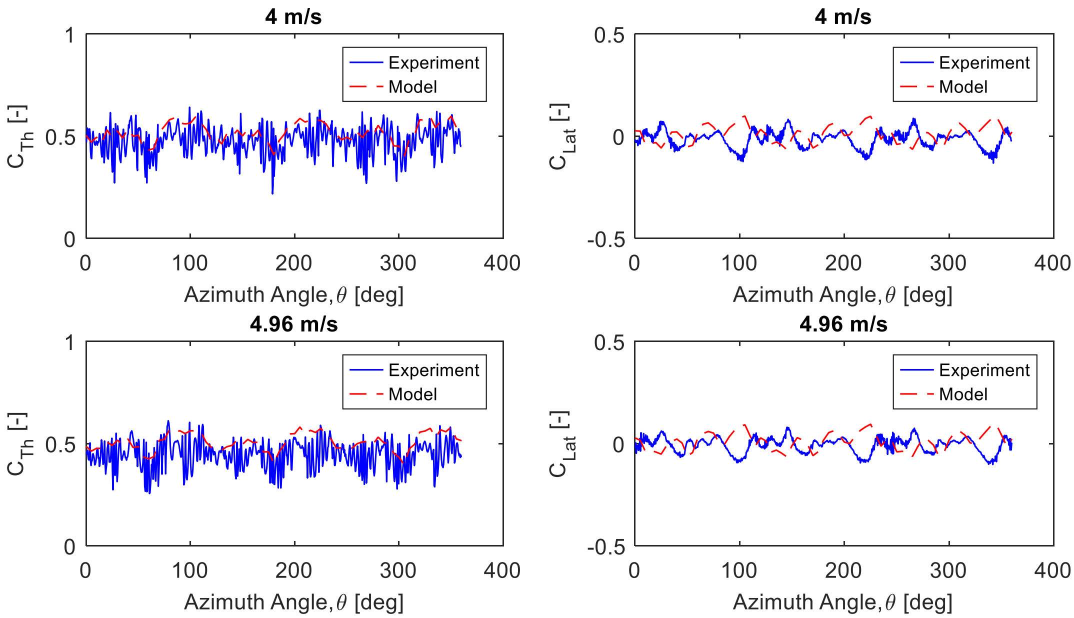

Figure 6: Nondimensional parked loads of 3B turbine for floating wind wave condition.

Results and Discussion:

4. Why not compare the experimental measurements directly against the UTD semi-numerical model, instead of presenting them in two separate graphs? How can the reader assess the accuracy of the numerical model if the results are not directly compared?

Response: Thanks for mentioning direct comparison between experimental and semi-numerical results. Authors reproduced the plots in the same graphs as follows and are now presented for non-dimensional and dimensional cases.

The direct comparison between experiment and semi-numerical model results for dimensional results are presented in the revised manuscript in Figures 15b,17b, 18b, 19b, and 20b for 2B locked with wind only, 3B locked with wind only, 2B floating with wind only, 3B floating with wind only, and 3B floating with wind and wave conditions, respectively.

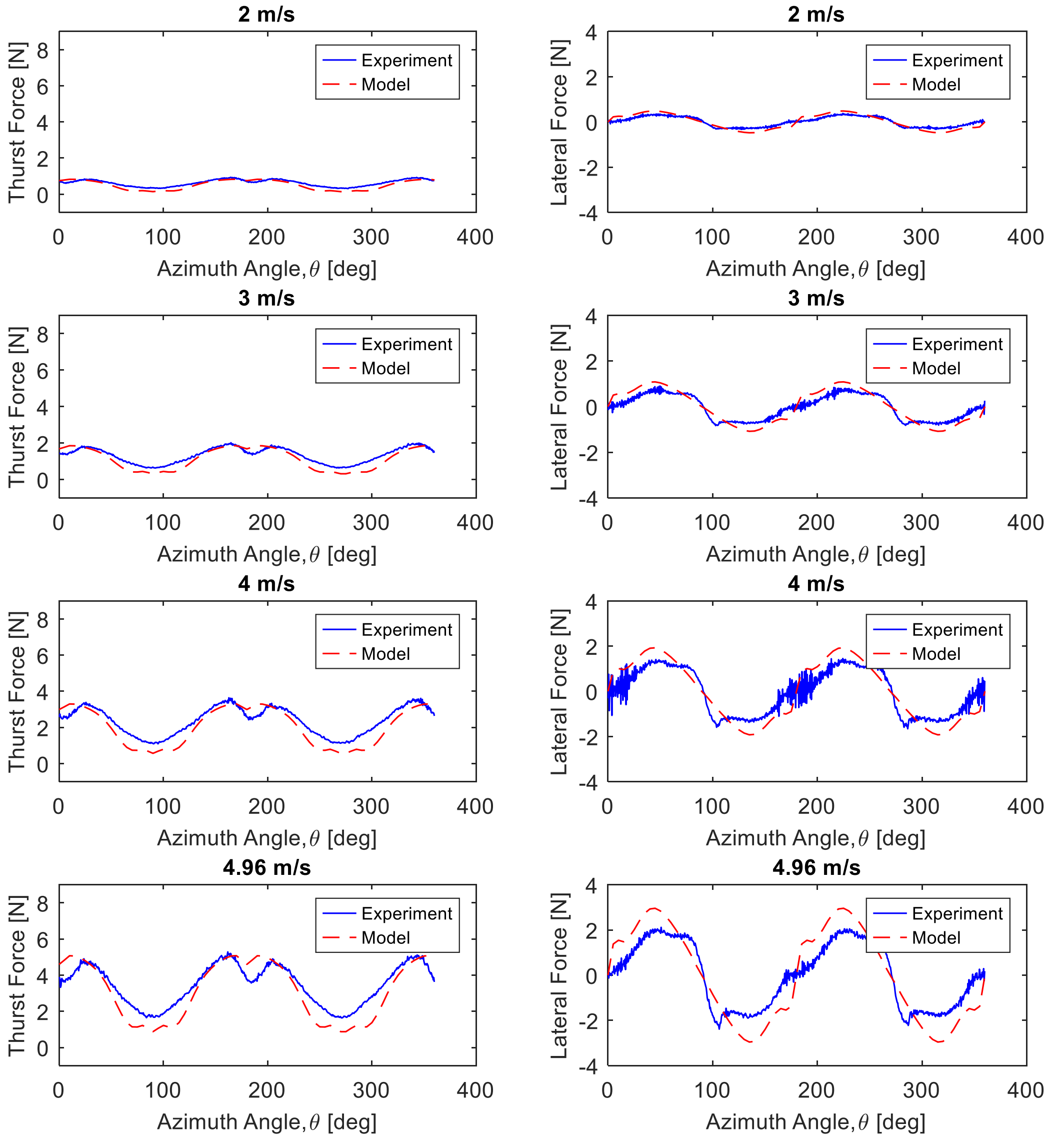

Figure 7: Comparison between experimental and semi-numerical parked loads for locked wind only tower base conditions of 2B turbine. The continuous lines represent experimental loads, where the dashed lines represent semi-numerical loads.

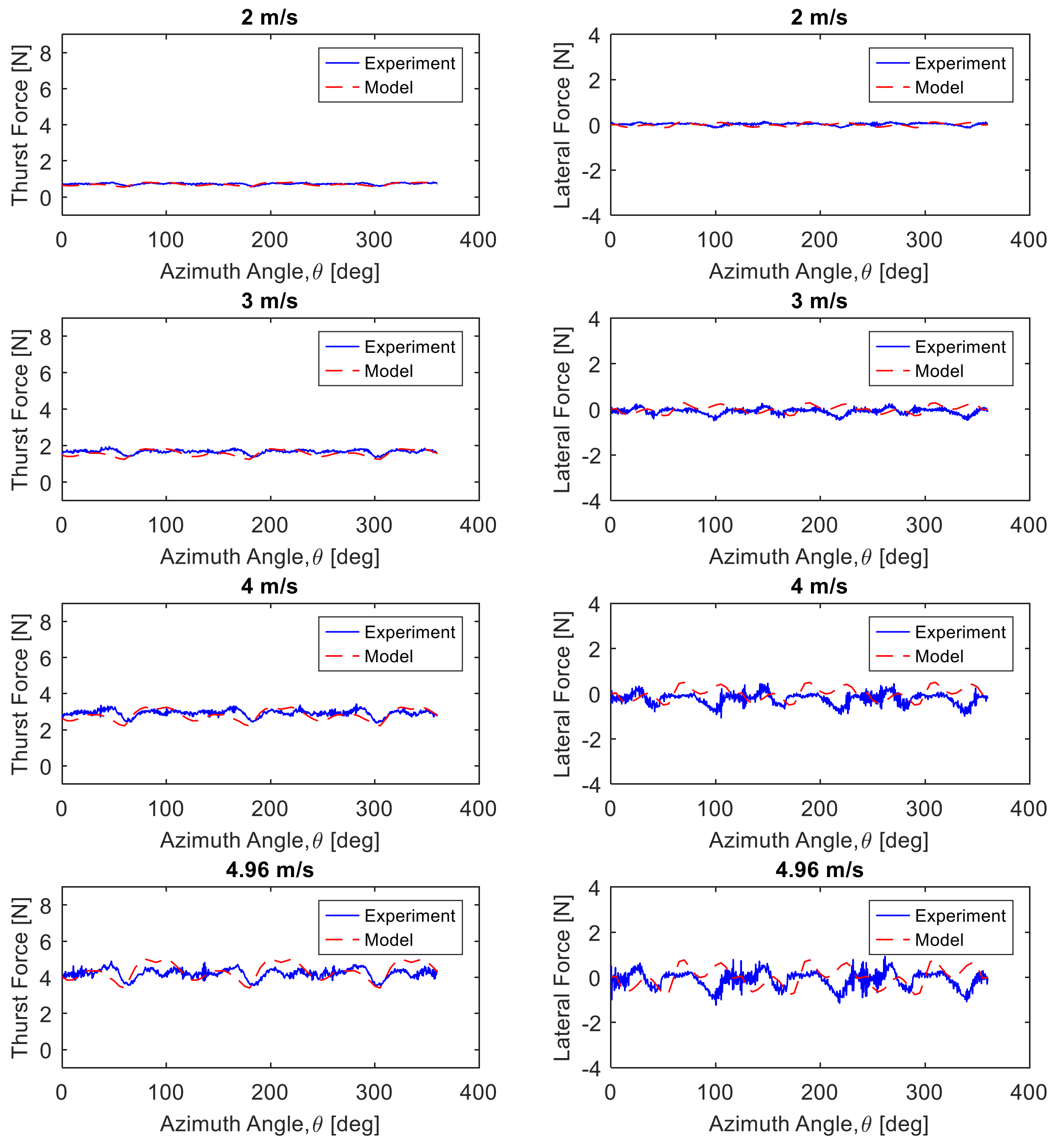

Figure 8: Comparison between experimental and semi-numerical parked loads for locked wind only tower base conditions of 3B turbine. The continuous lines represent experimental loads, where the dashed lines represent semi-numerical loads.

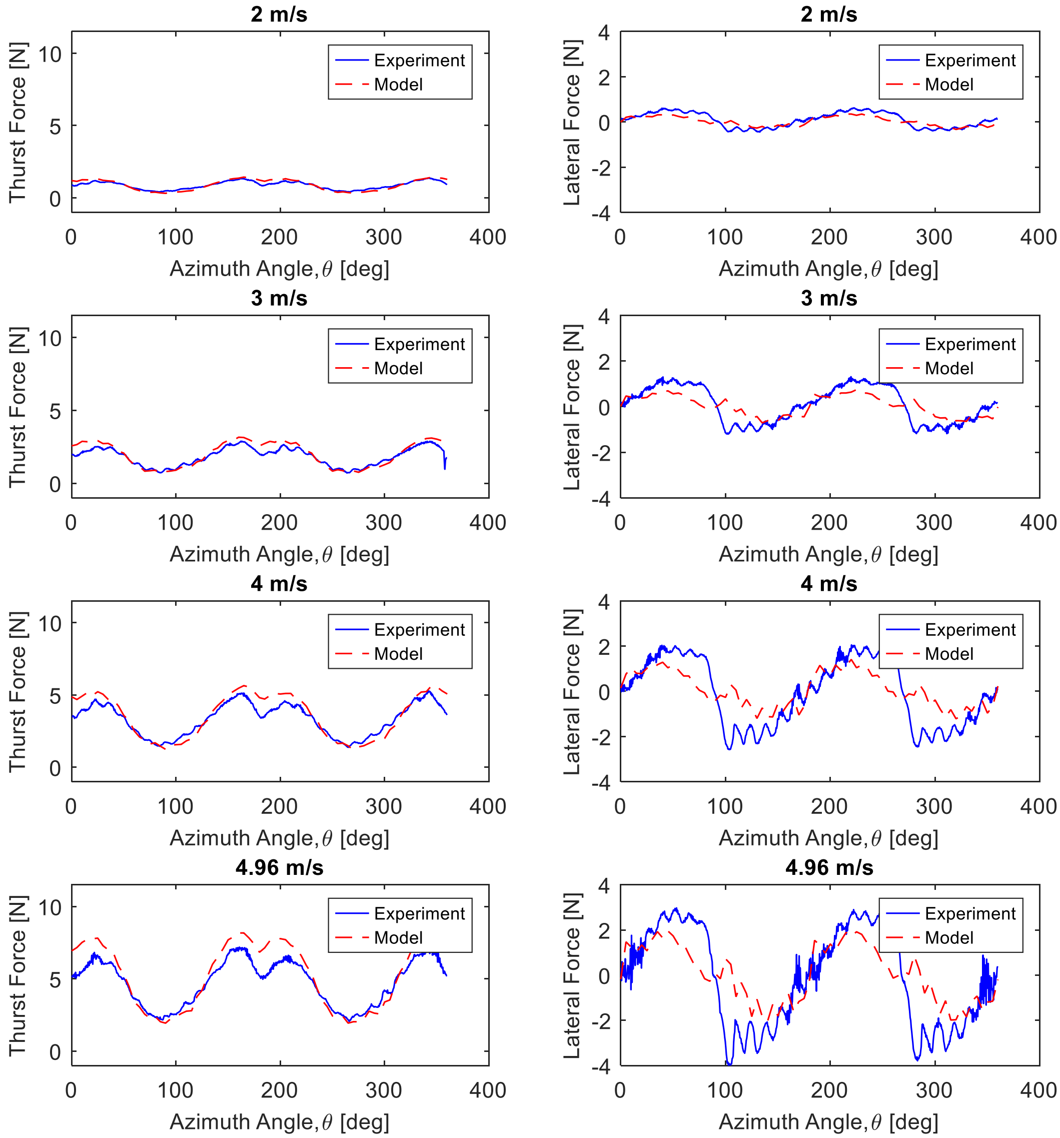

Figure 9: Comparison between experimental and semi-numerical parked loads for floating wind only tower base conditions of 2B turbine. The continuous lines represent experimental loads, where the dashed lines represent semi-numerical loads.

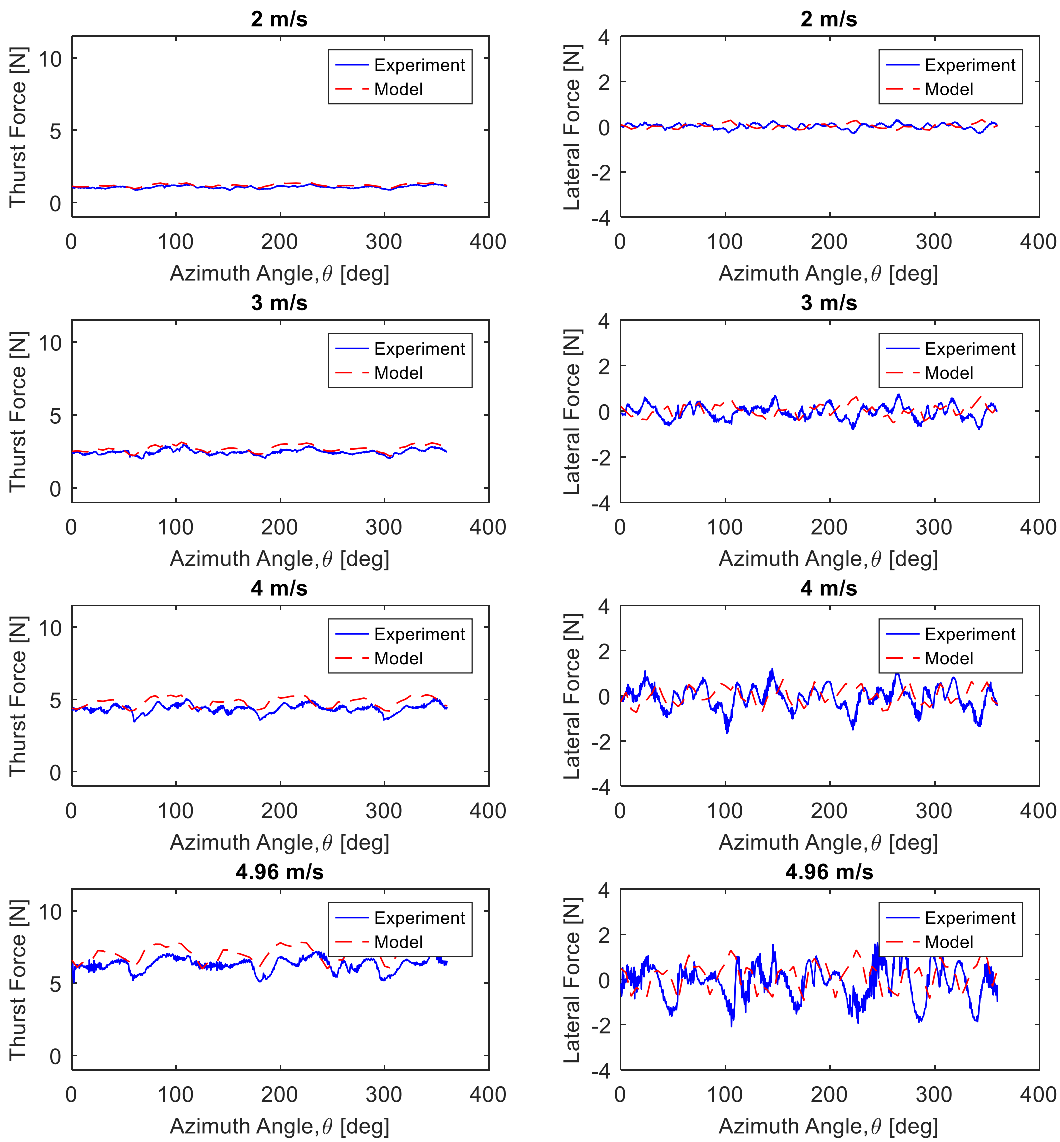

Figure 10: Comparison between experimental and semi-numerical parked loads for floating wind only tower base conditions of 3B turbine. The continuous lines represent experimental loads, where the dashed lines represent semi-numerical loads.

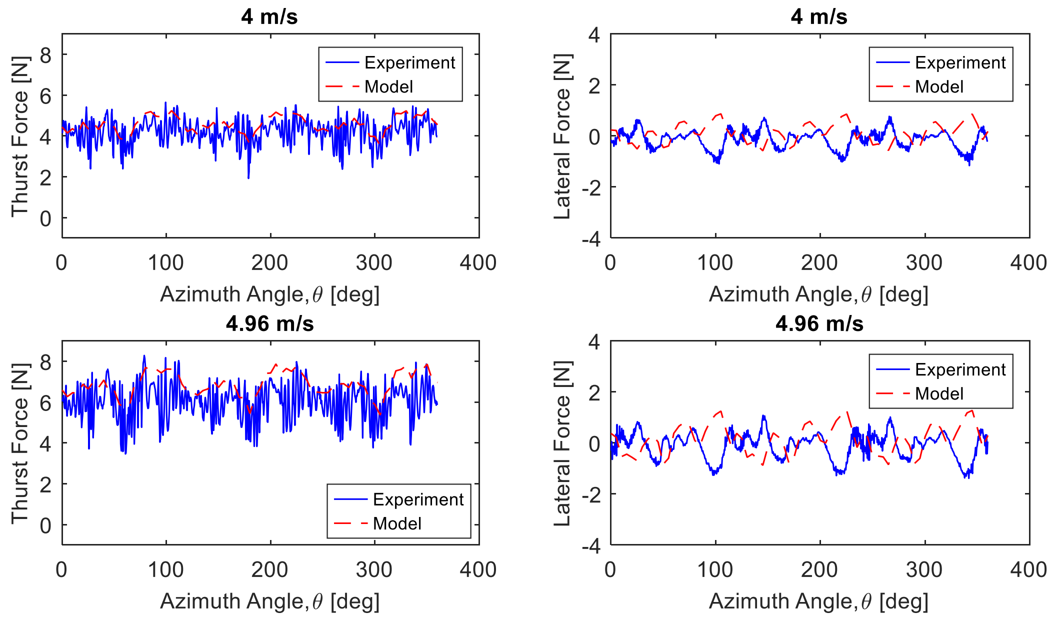

Figure 11: Comparison between experimental and semi-numerical parked loads for floating wind wave tower base conditions of 3B turbine. The continuous lines represent experimental loads, where the dashed lines represent semi-numerical loads.

5. I believe it is crucial to show the influence of tower tilting on the angle of attack variation, either in the case of floating alone or floating with waves. These changes are likely to impact the estimation of the aerodynamic loads and should be addressed in the analysis (at least reporting the values might give a reader a sense on how unsteady are the loads).

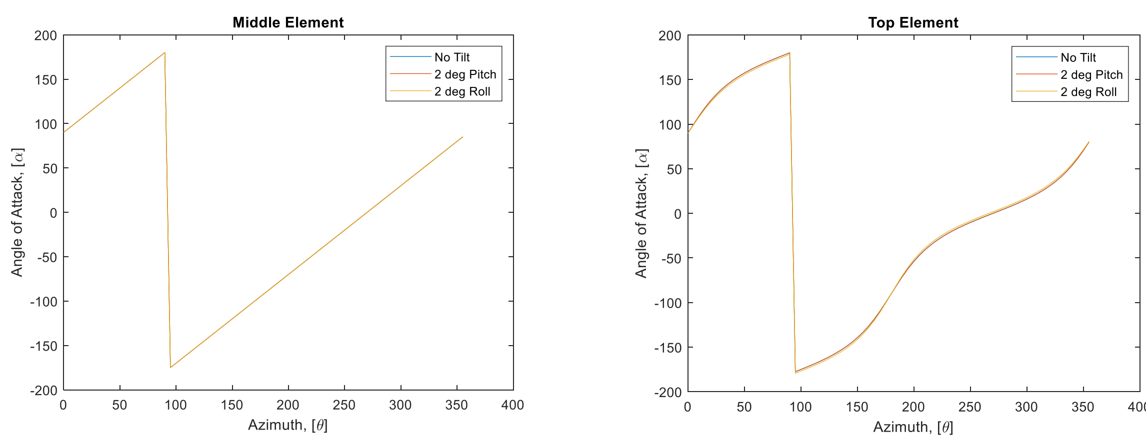

Figure 12: Variation of angle of attack with respect to azimuth for 1st blade of 2B turbine. The compared cases are no tilt, 2 deg pitch, and 2 deg roll.

Response: In the experiment we did not record any data for angle of attack. However, authors would like to show tilting effect on angle of attack for the case of a static pitch angle of 2 deg (average pitch at 4.96 ms^{-1} for floating wind only case). The influence of tilting on angle of attack is very minimal which is shown in Figure 12. The data presented here corresponds to the 1st blade of 2B turbine at 4.96 ms^{-1}, where the 0 ° azimuthal position represents the blade's direct wind ward position.

6. The general division of sections could be improved. In both the abstract and the introduction, the study compares the fixed tower system with the floating system and the floating system with waves, highlighting how results vary as complexity increases. However, throughout the results section, these comparisons are not directly made. It would be beneficial to address these differences directly within the results section.

Response: Thanks for pointing out the issue of general division of section. Section 3.1.4 of the initial manuscript provides description and comparison of the parked loads among different operating conditions (wind-wave-platform conditions) such as locked with wind only, floating with wind only, and floating with wind wave conditions.

7. In case of floating tower with wind and wave: "the numerical model neglects the dynamic nature due to floating wind and wave effect" please elaborate with more details, why the model neglects these effects, what are the implications on the model predictions and how can it improved?

Response: The existing model is not formulated to predict the dynamic nature of pitch and roll motions and respective dynamic thrust and lateral loads due to coupled wind, wave, and floating platform effects, although it does handle static pitch and roll motions. A prediction of pitch and roll motions requires integrating aerodynamic, wave, hydrodynamic, platform and mooring dynamic models. A code such as WAMIT [2], or an open source code Capytaine [3], can be used to model the hydrodynamics and then coupled with mooring and aerodynamic models to predict the platform dynamics [4]. Such a model can be used for pre-test motion prediction. Here, the authors have restricted their study to the current semi-numerical parked load model and comparison with the experimental data. Ongoing research is focused on developing a coupled wind-wave-floating dynamics model for both parked and operating cases, which will be presented in the future. This note has been added to the manuscript in lines 378-384.

Conclusions:

8. The statement in the conclusion that the numerical model is validated and optimized is unclear, as the numerical model was not directly compared with experimental measurements throughout the paper. Additionally, other data from the numerical model, such as the variation in the blade angle of attack, should be presented. This is important

for assessing the assumption that unsteady load corrections were not needed for the aerofoil polars.

Response: Thanks for those insightful comments. The data from the numerical model is directly compared with the experimental data in the revised version of the paper. The comparison shows that the semi-numerical tool well predicts the magnitude of parked loads, azimuthal dependence on loads, and the effects of wind speed, and solidity for all the operating conditions. Additionally, this tool accurately captures the tower shadow at the 180° azimuthal location. However, the model is not formulated to predict the dynamic nature of pitch and roll motions and respective dynamic thrust and lateral loads due to coupled wind, wave, and floating platform effects.

Due to limitation of the CACTUS tool, we were unable to analyze the variation of angle of attack (AOA) for dynamic tilting cases of the turbine. However, we conducted a comparison of the angle of attack by statically tilting the turbine at 2 degrees—representing the mean pitch angle at 4.96 m/s for the floating wind-only condition—against the no-tilt case. While the middle element showed no variation, the top element exhibited slight changes. This behavior occurs because, for a parked turbine, the AOA is solely influenced by the free-stream velocity, with induced velocity and rotational velocity assumed to be zero.

We also performed a reduced frequency analysis for the floating platform cases. The analysis shows that the inflow is not unsteady. Therefore, the assumption of 2D static airfoil makes sense.

9. The paragraphs starting at lines 359 and 364 are identical and appear to be replicated by mistake.

Response: Thanks for mentioning this. Authors removed the replicated paragraph.

10. In the wave+floating parked load scenario, the numerical model has some drawbacks as reported in the results section. This issue is not highlighted in the conclusions.

Response: Thanks for pointing out this. Authors really appreciate this point. We added the drawbacks also in the Conclusions in the 4th bullet point of the summary of the paper lines 414-416.

11. The sentence “This study has advanced our understanding of the experimental parked loads on VAWTs and their impact on turbine performance” seems to describe the main objective of the paper. The numerical model, while useful, should be considered a tool to gain insight into unmeasurable quantities after validating the load measurements. It might be better to frame this as the central goal of the study.

Response: Thanks for outlining the main theme and offering a thoughtful suggestion. The authors believe that the paper is already built on “advancing our understanding of experimental parked load of VAWTs” theme. To further clarify that the abstract and introduction sections are slightly revised. Additionally, the statement“ semi-numerical park load model is a tool to gain insight into unmeasurable quantities” has been added to conclusion of abstract (line 16) and to the main contribution part of introduction (line 65).

References

1. Matha, D., Cruz, J., Masciola, M., Bachynski, E.E., Atcheson, M., Goupee, A.J., Gueydon, S.M.H., and Robertson, A.N. (2016). *Modelling of Floating Offshore Wind Technologies* https://doi.org/10.1007/978-3-319-29398-1_4.
2. Lee, C. H. and Newman, J.N. (2006). *WAMIT® User Manual, Versions 6.3, 6.3PC, 6.3S, 6.3S-PC* at WAMIT, Inc.
3. Ancellin, M., and Dias, F. (2019). *Capytaine: a Python-based linear potential flow solver*. J. Open Source Softw. *4*, 1341. https://doi.org/10.21105/joss.01341.
4. Gao, J., Griffith, D.T., Sakib, M.S., and Boo, S.Y. (2022). *A semi-coupled aero-servo-hydro numerical model for floating vertical axis wind turbines operating on TLPs*. Renewable Energy *181*, 692–713. https://doi.org/10.1016/j.renene.2021.09.076.

The authors wish to thank the reviewer for the insightful and helpful comments. Below and in the revised manuscript (as indicated) the authors have responded point-by-point to each comment.

Referee 2

The manuscript presents results on the thrust and lateral forces of a laboratory-scale model of a Vertical Axis Wind Turbine (VAWT) tested in a wind-wave basin under parked conditions. Experimental data were compared with a semi-numerical code, which retrieves gravitational loads from the experimental measurements, in several cases: i) fixed-bottom – wind; ii) floating – wind – no waves; iii) floating – wind – waves. The goal of the work was to assess parked loads in relation to design parameters, such as the number of blades and free-stream velocity.

Scientific Significance:

The manuscript presents an original investigation using a laboratory-scale model to measure parked loads. Assessing forces in parked conditions is crucial for estimating the lifespan of a wind turbine in wind scenarios involving velocities higher than the cut-out wind speed. The authors also propose a semi-numerical code to predict the loads, which could be useful for designing full-scale turbines according to industry standards.
Response: Thank you for the insightful review and comments. The authors believe that addressing the comments below will enhance the quality of the paper.

Scientific quality:
Questions are addressed below in regards to scientific quality:

1. The authors propose a sensitivity analysis on the number of blades and wind speed. The effects of the number of blades on rotor loads have already been demonstrated in Sakib and Griffith (2022). The question that arises is: why should the number of blades have a greater impact on the design of a VAWT in parked loads than on the design of the turbine in operating conditions? Furthermore, why does the analysis focus solely on the number of blades, while the variation of solidity due to chord is disregarded? Please provide justification for these choices.
   Response: Thanks for asking these valuable questions.

   The authors have explored the effect of the number of blades on VAWT parked loads to study how the number of blades impact the azimuthal load variation in a revolution based on experiments, while Sakib and Griffith (2022) limited their study to numerical analysis only. A note has been added into the revised manuscript on lines 35–37.

   Further, the load variation due to the solidity difference between the two-bladed and three-bladed turbines has also been examined, and the effect of solidity is shown to impact the magnitude of the loads (as expected). The difference in solidity arises from the design of the test bed to limit manufacturing complexity and cost. It was easy to convert the two-bladed turbine into a three-bladed turbine using one set of blades**.** This note has been added to lines 93-94 of the revised manuscript.

2. Is there any comparison in operating conditions to validate the numerical code against experimental data? The numerical model depends on data obtained from experiments. Is it not possible to formulate the model in such a way that it does not rely on experimental measurements? A model that does not depend on experiments would be useful for estimating loads without the need for additional testing. Furthermore, comparing numerical results with experimental data would serve as proper validation.

   Response: Thanks for raising these questions.

   Yes, it is possible to estimate the tilt angles (pitch and roll angles) in the pre-test and independent of the experiments. One can use the method developed in Gao et. al. [1] to predict the tilt angles. The input aerodynamic loads in this model can be supplied using CACTUS, while the hydrodynamic coefficients can be obtained from a commercial software like WAMIT [2] or an open source code like Capytaine[3]. However, predicting tilt data is out of scope of this study, but the approach and references noted provide a means of pre-test tilt motion prediction.

   We've added a note in lines 228-231 (along with relevant references) for pre-test modeling and prediction of the tilting response.

   In terms of the results presentation, we present the park loads comparison across different operating conditions (wind-wave-platform conditions) based on experimental data only. And later validated the semi-numerical park load data with experimental data across different operating conditions (wind-wave-platform conditions). Therefore, the comparison of semi-numerical loads across different operating conditions (test cases) seems unnecessary in addition to results already presented. Please note that the authors replaced the term "operating conditions" with "wind-wave-platform conditions" in the revised manuscript.

3. Line 121: Please clarify the method used to obtain 'full-scale' wind speeds and the parameters the authors used to derive the range of 14.7 – 36.4 m/s according to Froude's law. It may be helpful to present the data in a table, showing both the scaled model and full-scale values.

   Response: Thanks for pointing this out. The method of full-scale wind speeds has been added to the updated Manuscript in lines 126-130.

   Authors used Froude scaling to convert the velocity with scale factor of $\lambda^{0.5}$. Geometric comparison of the test turbine, which has 0.51 m radius, to the UTD 5 MW VAWT Sakib and Griffith (2022), which has 54.011 m radius, reveals that the test turbine is 1:104.87 scaled version of the full scale UTD 5 MW turbine. Applying Froude scaling with a velocity scale factor of $\lambda^{0.5}$ results in a wind speed range of 20.48 ms-1 to 50.79 ms-1 for full-scale 5 MW UTD VAWT.

In the previous manuscript, the scale factor of the test turbine was incorrectly calculated as 54 instead of 104.87, leading to an incorrect wind speed range of 14.7–36.4 m/s. This has been corrected in the updated manuscript. However, it is important to note that the tested model is not a scaled version of UTD's 5 MW turbine. The wind speed scaling is presented solely to compare the wind speed selections in the test campaign to those at the 5MW scale.

4. Line 137: Are the values for wave period and height representative of full-scale scenarios?
   Response: Yes, they are representative of full-scale scenarios of IEA 15 MW wind turbines. The full scale height and period are 10.85 m and 13.5 s, respectively [4]. This information has been added to the updated manuscript in lines 146-147.

5. Please clarify the sentences in line 143: "No wake effects have been included..." and line 147: "Blade wake [...] were considered...". Two different wake effects are mentioned, one of which is included while the other is not. Please provide further explanation. Induction due to the wake should be accounted for anyway: also VAWT in steady conditions produces blockage caused by the wake despite the rotor is still.
   Response: Thanks for raising this important point.
   Induction due to blade wake was neglected as it is too small compared to freestream velocity and to make the model simpler. However, induction due to tower wake was included as it is easy to integrate. The updated manuscript noted these points in lines 165-167 and 170-171.

6. Dynamic stall is not considered, nor are unsteady effects in the case of wind and wave excitation. Have the reduced frequencies been evaluated to demonstrate that unsteady aerodynamics does not occur?
   Response: Thanks for the comment. As the turbine is parked, the chance of occurring dynamic stall is very minimal. Therefore, we did not consider the dynamic stall model in the semi-numerical tool.

   The authors have analyzed the reduced frequency in the updated manuscript. Reduced frequency is a parameter used to determine whether the inflow is unsteady, and it can be defined as follows [5]:

$$K_i = \frac{\omega_{ptfm}\, C_i}{2\sqrt{(U_\infty^2 + r_i^2 \Omega_\infty^2)}}$$

   where, ω_{ptfm} is the platform frequency, C_i is airfoil chord, $U_\infty$is freestream velocity, r_i is section radius, Ω is rotational velocity of rotor.

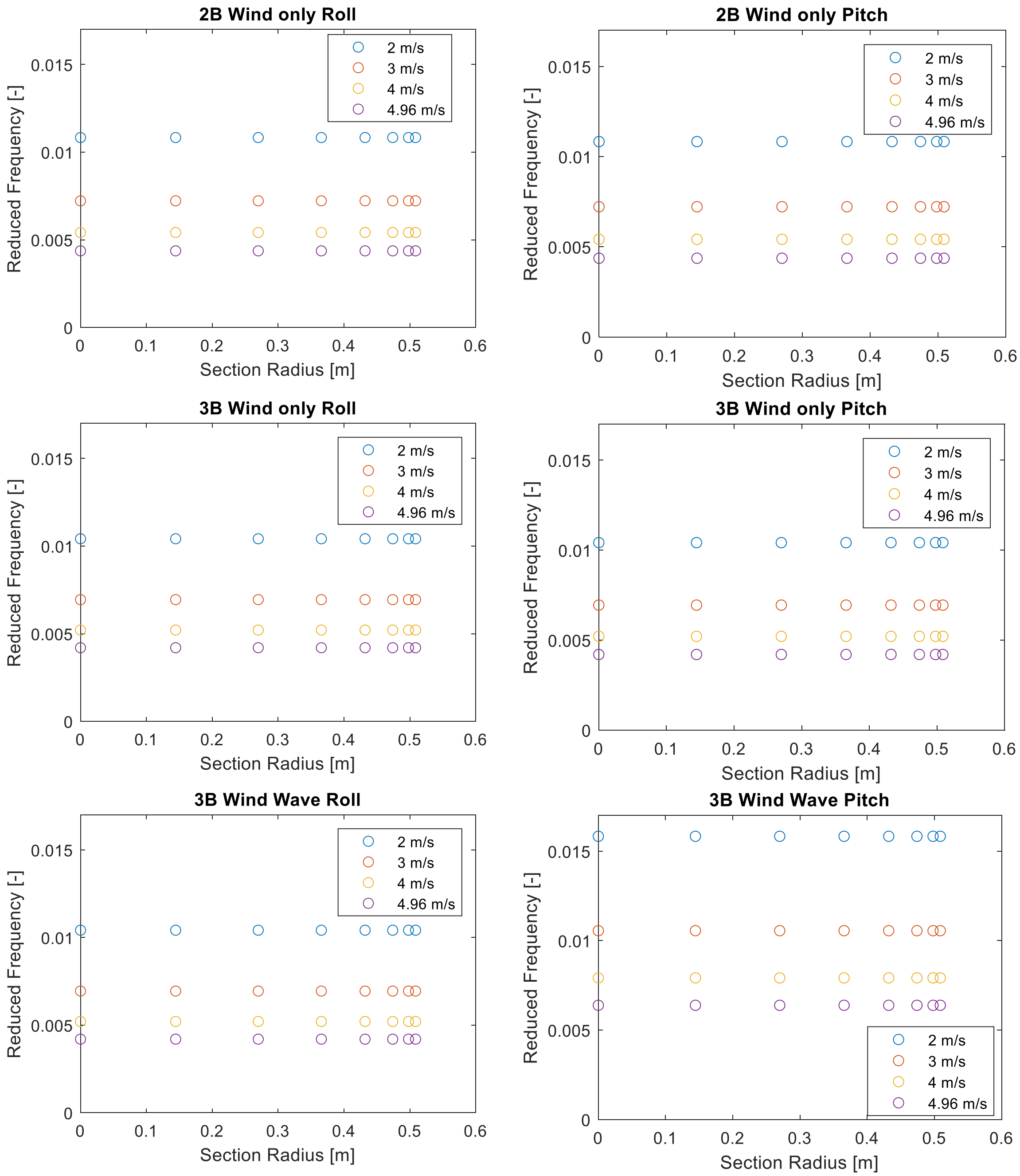

Figure 1: Reduced frequency for different platform and turbine operating conditions. Note: Section Radius refers to the rotor radius, which varies with rotor height.

Reduced frequency does not go above a value of 0.05 for both floating wind only and floating wind wave condition for any of the wind speeds, as shown in Figure 1. The highest reduced frequency (K) of 0.0158 occurs in the 3B floating wind wave pitch case. As wind speed increases, the reduced frequency decreases. Specifically, for the 3B floating wind wave pitch case, the reduced frequencies (K) at wind speeds of 2, 3, 4, and 4.96 m/s are 0.0158, 0.0105, 0.0079, and 0.0063, respectively. This indicates that higher wind speeds result in a steadier inflow. Therefore, the inflow can be considered as steady. Notes have been added on lines 154-165 to provide this information.

7. Equations 1 and 2 are identical.
   Response: Thanks for pointing this out. Equation 2 is related to tangential velocity (V_T). The equation has been modified and added in line 173.
   Modified equation:
   $V_T = T_X U_X + T_Y U_Y + T_Z U_Z$

8. How have the polars been adjusted to extend their applicability to VAWT operations, where angles of attack can reach very high values (especially in parked conditions, where peripheral speed is nearly zero)?
   Response: Thanks for pointing this out. The airfoil polars are applicable to VAWT operations. The airfoil polar is supplied with CACTUS code. The angle of attack ranges from -180 to +180 degrees. The details of how polars were calculated can be found in [6]. The note is also presented in manuscript in lines 152-153.

9. Inertial effects are defined as the projection of gravitational loads on the structure. Shouldn't proper inertial effects be considered when the turbine is subjected to both wave and wind forces? The entire structure experiences motion, with associated velocities and accelerations that affect the aerodynamics. Consider using a different term instead of "inertial effects," as this might be interpreted as including inertia forces in the model.
   Response: Thanks for pointing out another important issue. Authors replaced the term "inertial effects" with "gravitational effects" to make the point clear.

10. Figure 8: The use of 'uncertainty' bars is unclear. According to the authors, the variability of thrust and lateral forces is attributed to azimuthal positions. Are the uncertainty bars representing the amplitudes over a period?
    Response: Thanks for this comment. The bars do not represent uncertainty; rather, they represent the azimuthal variation of loads. A short description has been added in the manuscript to make the point more clear [line 264-265].

11. A general question regarding experimental data: Have the authors assessed the uncertainty in the measurements?

    Response: We have addressed the uncertainty in the measurements; for example, as shown in Figure 2 below and in Figure 8 on page 14 in the revised manuscript. Subsection 3.1.1 has been added to the revised manuscript for presentation of the uncertainty analysis [7]:

$$U$$

where, U is resultant uncertainty and t is the coverage factor of T distribution. The value of t is 1.96 at 95% confidence level.

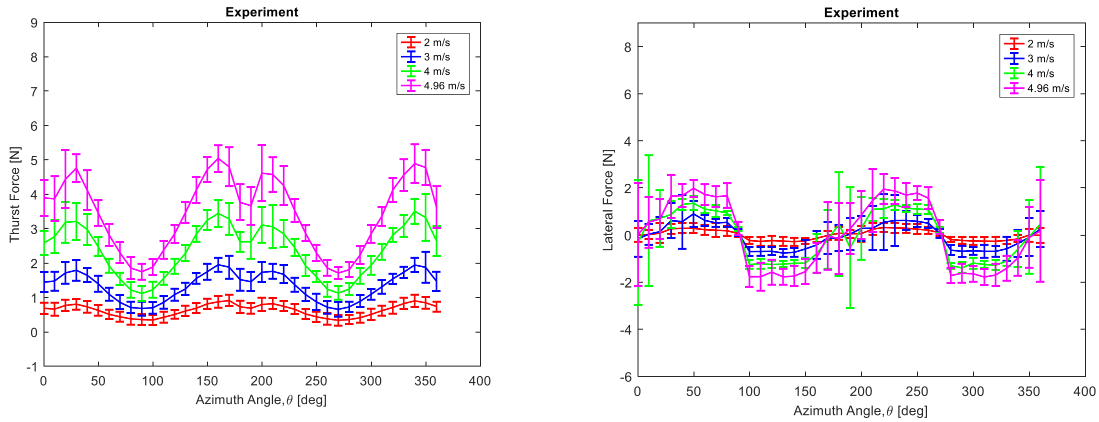

Figure 2: Parked loads with uncertainty of 2B turbine for locked wind only condition.

12. Figures 10, 11, and 12: The comparisons at different wind speeds in separate plots make it harder to understand the results. Consider merging them into a single plot or showing the effect of wind speed in one plot and the effect of the floating motion in another (e.g., in Figures 10 and 11). Additionally, consider discretizing the x-axis in increments of 90 degrees.
Response: Thanks for the suggestions. The author carefully reviewed your suggestions. However, we believe that combining all wind speeds into a single plot would make the figure overly crowded and harder to interpret. The primary goal of Figures 10 and 11 (Figure 11 and 12 in the updated manuscript) is to compare results across different operating conditions (test cases), such as locked wind only, floating wind only, and floating wind with wave cases. The current plotting approach effectively serves this purpose.

13. Figures 14, 15, 17, and 19: If the purpose is to compare measurements with numerical data, these comparisons should be shown in the same plot for clarity, for each wind speed.
Response: Thanks for the suggestions. The authors have merged the experimental and semi-numerical data into the same plot for easier comparison. The change can be seen in Figures 15, 16,18, 19, and 20. New figures are also added to provide the non-dimensional results as well.

14. Can the authors clarify how the data over one rotation have been considered (e.g., in Figure 19)? Is the force over the θ angle an average of several rotations or the last period? It could be useful to present the phase-averaged data.
Response: The experimental data represents the phase average of 5 revolutions. The semi-numerical model data is based on the last revolution values after the CACTUS simulation has converged. These points are noted in line 331-332.

Presentation quality

Please find a list of typos or request of clarification in the manuscript:

1. Line 39: the authors refer to HVAWTs, it is suggested to call H-shape/H-shaped since HVAWT might be confusing (between HAWT and VAWT).
   Response: Thanks for pointing out that. Authors understand that "HVAWT" and "HAWT" might seem similar. Now we have changed "HVAWT" to "H-VAWT". And the sentence already mentioned straight-bladed vertical axis wind turbine is termed as HVAWT. Which should clarify the confusion between "H-VAWT" and "HAWT".

2. Line 61: a instead of an
   Response: Authors replaced "an" with "a" in line 63.

3. Line 79: in instead of on
   Response: Authors did put " in" instead of "on" in the line 83 too.

4. Line 98 and Line 117: refer to the table 2 in the previous sentence, so it is clear that is connected to the concept explained.
   Response: The referring sentences are moved to the previous sentence on line 101 and line 122 to make it connected to the concept.

5. Line 128: is the operating condition
   Response: Authors inserted "the" in between.

6. Line 194: typo in " for are".
   Response: Thanks. We fixed the typo. Updated sentence: "The measured park loads are in the updated sensor measurement load direction."

7. Line 200: weight
   Response: thanks, replaced 'wight' with "weight".

8. Figure 9. The figure has no legend. Please provide for better understanding
   Response: Thanks for raising this issue. However, authors think that legend in this figure would be redundant.

9. Line 236-239: repetition
   Response: Removed the repeated sentence.

10. Line 263: a dot is missing
    Response: Thanks for mentioning this. Authors fixed the issue.

11. Line 317: delete a '.'
    Response: Thanks! We deleted the extra '.'.

References

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