wes-2022-1: Impacts of wind field characteristics and non-steady deterministic wind events on time varying main-bearing loads

Response to Reviewer 1

Dear Reviewer,

Thank you for taking the time to consider our paper, and for making valuable suggestions regarding how it might be improved. We include your comments below in **blue**, followed by our responses in **black**.

Thank you for the nice publication, there are some minor spelling issues.

We will carefully review spelling and grammar throughout the paper prior to submitting the revised version.

Additionally, there some minor flaws.

- all figures are missing light grids

  We will look to add grids to figures where it will enhance interpretability and readability. Note, in some cases (e.g. dimensionless upscaling plots) we are concerned a grid might make the plots appear to 'busy'. We will check, and where that is felt to be the case we will keep the current form.

- p.1 l.11: wind turbines with 3MW offshore are past the state of art. Such a small size is currently erected onshore

  Here we are simply quoting the range as described in the cited literature (Barter et al., 2020). In addition, much of the existing main-bearing work has, to date, focussed on machines of power ratings less than 3MW, hence in that particular context there is still plenty of scope for improved understanding and scientific contributions from 3MW and upwards. We do take you point here, but, we feel it is appropriate to leave the stated range as it is, for the reasons given here.

- p.4 l.100: the paper would be more comprehensible, if some wind turbine characteristics would be stated (ex. rotor diameter, rated torque, rated wind speed)

  This is an excellent point. We will add a brief summary of such details when revising the manuscript.

- p.5 l.124: loads are modeled according to IEC 61400-1 but is only mentioned far later or in the appendix. BTW. why not use the current IEC 61400?

  We will reassess when we mention the standards as it may be relevant to point to them sooner, as you suggest. Thank you for pointing out that we are currently citing the old version of the standards. We do use the current standard, this is simply an error in the reference info. We will update the reference accordingly.

- p.6 figure 1: Thrust curve consists out of 3 segments before rated conditions, explanation missing

The three sections in the thrust curve relate to the two constant speed regions and a variable speed 'max aero-efficiency' tracking region. This is all quite standard for wind turbines, and so we hadn't gone into detail regrading this breakdown in the current paper. However, perhaps some more info would be useful and so we will consider how to provide more information when revising the paper. In particular, we will ensure the reader is pointed towards relevant literature which provides a more detailed description.

- p.8 l.201: a rigid shaft is quite a simplification. The reasonable justification is missing

This relates to the overall aims of the paper, the information available for modelling and the context in which readers are encouraged to interpret presented results. Crucially, this paper explicitly states that it is looking to explore "… characteristics, relative magnitudes and drivers" (Line 83) of main-bearing loads in these machines. Therefore, it is not claimed that the presented model exactly reproduces load responses at the main-bearing, but that it allows us to estimate these loads and load behaviours well enough to gain insights into the operating conditions of these components. Furthermore, we do justify this claim by indicating recent work where similar model have been shown to provide reasonable estimates of loading (including using those which assume rigidity of the shaft) "Models of this type have previously been shown to be able to reproduce main-bearing load reactions calculated using higher fidelity finite element representations of a shaft/main-bearing system (Stirling et al., 2021). Depending on model specifics, mean percentage errors of between 1.54% and 22.74% were reported." (Line 236). In addition, shaft-drivetrain systems in these machines are often required to prevent excessive displacements due to system tolerances, in particular in direct drive cases where the main-bearing is required to maintain generator air-gaps within their operating limits. Hence, these systems are designed to be very 'stiff' in the first place. But, again we are careful to caveat our results for the reader, e.g. "The presented models should therefore be interpreted as providing first order engineering estimates of load response for the main-bearings in question. Inline with the stated aims of this work, such models allow for the characteristics, drivers, and general orders of magnitude of main-bearing loading to be investigated for these machines. As such, they are sufficient for the work undertaken in the current paper. Model limitations should, however, be kept in mind when interpreting results." (Line 239). We therefore feel that the context and limitations of the current models are made clear to the reader, but, also that (for the reasons outlined here and in the paper) the presented model is sufficient for the aims and scope of this paper.

- p.10 l.265: you mention that you are using a reference load. Would that not mean that the output loads in the figure 4 are non-dimensional

No. The 'reference load' is provided to give the reader an idea of the nominal loading which might be expected to occur for that component. This assists with providing context for results. But, we felt the actual load values were important to include (in kN) on these particular plots, since then readers get a sense for what the real load inputs going into these bearings are.

- p.11 figure: 4: axis-labels are missing; please indicate the direction of the rotor weight, as 0° points towards a right.

Axis labels aren't missing. Both the radial magnitude units (kN) and directional units (degrees) are indicated in the plots. The reference frame being used, and hence the direction of rotor weight, is described in the opening paragraph of Section 4. When revising the manuscript we will consider whether an additional sentence or two might help connect these things together here for the sake of clarity.

- p.15 figure 7: Not traceable. Labels cannot be read. Maybe split the graphic into two. It is not clear which is centered, and which is overhang

The notation for centred and overhung loads is described in the opening paragraph of Section 4. We will try and enlarge the legend labels when revising the paper. Regarding traceability, we will see if these figures are improved by the addition of a grid, although as stated previously we will check to ensure this doesn't make things too 'busy'.

- p.15 l.348: explanation of how loop area is determined would be nice. As for my understanding: It is the area enclosed as shown in figure 4

This is indicated by a footnote in Line 348, but we will look to expand this a little to explain more clearly. Your interpretation is about right. Individual loops are identified in load time-series before an ellipse is fitted to them. The area of the loop is taken to be the area of this best-fitting ellipse. This is all based on previous work cited in the paper.

- p.19 figure:12: ideal thrust curve should be indicated differently, otherwise it is like the end of the gust

Excellent point. This is just an error in the plotting. The start of the time-varying thrust curve should be grey (rather than black) to match the other plots in Fig 12. We will correct this.

- p.20 l.405: perspective of centered support missing?

As shown earlier in the paper the behaviour of the two supports is very similar, with the order of magnitude the only major difference really. Therefore, centred support results may be inferred from those presented here for the single support.

- p.20 figure: 13: You show the control variable for corresponding wind speed. Please ad the corresponding star in control variable to improve clarity

Excellent point. We will add this in as suggested.

- p.21 l.420 cubical increase, is not clear as rotor diameter missing

The logic behind the observed cubic increase in loads is outlined in Section 4.2 "… Force results for all turbines were therefore non-dimensionalised using half of their respective rotor weights in each case. In order to consider load variability, ellipses were fitted to the identified load loops, with elliptical areas then calculated (Hart, 2020). Load loop area results were non-dimensionalised using the square of the W/2 value of each turbine. Recall that on upscaled models the rotor weights scale cubically with the turbine rotor radius (see Section 2.2); therefore, overlapping lines in dimensionless results plots for the three models indicate that main-bearing loads are also increasing cubically with the rotor radius." (Line 328). Hence, one does not need to explicitly know the rotor Radii in order for this conclusion to be reached. We will be adding rotor Radii values in response to a previous comment, but we feel it is important to highlight why we are able to reach this particular conclusion and where that discussion is presented in the paper. We will look to link back to that discussion in the conclusions to ensure clarity.

- p.21 conclusion: Your conclusion contains discussions and new references. A conclusion should only base on the work shown earlier. A split between discussion and conclusion might be better

The current format of the Conclusions section was selected as it seemed to provide the best balance in terms of insight and clarity for the reader, while also avoiding repetition. We will consider whether a split as you suggest might be helpful, or whether to stick with the current format.