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WIND ENERGY SCIENCE DISCUSSIONS

Interactive comment on "Performance study of the QuLAF pre-design model for a 10MW floating wind turbine" *by* Freddy J. Madsen et al.

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Referee 3 – Tor A. Nygaard

The authors thank the referee (and the additional contributors) for the suggestions, comments and insights, which has led to improvement of the paper. Please find below the referee's comments (RC), the corresponding author's comments (AC) and the changes in the manuscript. PXLY refers to page X and line Y in the revised manuscript, see the attached pdf-file under the Supplement tab.

RC: Although QuLAF is well described in the references, many of the readers working

on floating wind turbines have most experience with time domain models, and I think the article would benefit from some clarifications.

AC: We agree that a more extended description of the model would be helpful. We chose the present quite short description to save on paper length and to avoid overlap with the original QuLAF paper which is also published in Wind Energy Science. The model is extensively described in the companion paper by Pegalajar-Jurado et al. (2018), where the frequency-domain solution is introduced and compared to the time-domain solution.

RC: In the left plots of figure 2, we have several results for each wind speed. The way I read the paper, for each wind speed, three sets of Hs and Tp are generated from the joint probability distribution. Each of these three realizations are computed with six different wind and wave seeds (also realizations). If indeed the use of several wind and wave seeds for one particular combination of Vm, Hs and Tp are used for the frequency domain model, please explain why this is done. Many frequency domain models work with distributions as input and output, directly giving the results for an infinite number of realizations. Here, however, does the input to QuLAF contains phase information for the particular realization at hand? Can the QuLAF results then be transformed back to the time domain, to be directly compared with the time domain FAST results, and post-processed with the same methods, such as rainflow counting?

AC: Yes, QuLAF contains phase information, since time-series of precomputed aerodynamic loads and free-surface elevation are input to the model. As a consequence, time-series of the results are available for comparison to time-domain models and for further analysis (note that fatigue damage-equivalent loads at the tower base are one of the metrics in this paper and in the previous paper by Pegalajar-Jurado et al. (2018)). We have added a sentence, see P4L23, to make this more clear.

RC: The ultimate nacelle accelerations are underpredicted in QuLAF, whereas the ultimate tower-base bending moments agree well. Often, accelerations are more sensitive to higher modes than ultimate bending moments. I did not find information on the number of tower modes used in FAST for this application. If it uses more than one tower mode, the following comment may be relevant: In addition to the underprediction of the wave excitation loads for strong sea states due to the omission of viscous hydrodynamic drag forcing, could the omission of the second tower mode in QuLAF also be part of the explanation? One way to examine this would be to turn off modes two and higher in FAST, or look at the response-spectra from FAST. Please include information on the number of tower modes used in FAST, and, under model limitations for QuLAF, mention that only first tower bending modes are used. Have any sensitivity studies on the number of tower modes ben carried out?

AC: The number of tower modes in FAST has been added now, see P3L8. Regarding the effect of the higher tower modes, we checked the response, where mode two and higher in FAST were turned off. This only had very minor impact on the nacelle acceleration, thus we believe the under-prediction of the nacelle acceleration is due to the over-estimated damping of the tower mode.

RC: The aerodynamic damping model seems to be one area where changes could significantly improve the results. One possible improvement would be to perform the decay test in FAST with flexible blades, resulting in an eigen frequency closer to the coupled tower frequency in QuLAF, thereby reducing the over-prediction of aerodynamic damping. It should also be possible to have an aerodynamic damping model in QuLAF model derived directly from a linearized BEM model.

AC: We thank the referee for the ideas of improvement. We are already exploring better ways to extract the aerodynamic damping. The results, however, are still not mature. Inclusion of flexible blades could also lead to an improvement, but introduces choices as to what specific mode one should choose (blades in phase (anti-phase etc.)). We have chosen to stay with the current simple approach and simply accept its limitations.

RC: I find it quite surprising, interesting and perhaps under-communicated that an emergency stop can be successfully computed with a frequency domain model. More details, such as direct comparison of the time series of tower base bending moments and nacelle accelerations would be very welcome.

AC: We agree, it is very interesting that QuLAF is able to reproduce a transient event and thank the referee for the suggestion of improvement to this comparison. We have added a figure showing the time series of a specific case in the discussion of DLC2.1, see Figure 7, page 16.

RC: Page 4, line 14: Did you check that there is no numerical damping in the decay test? One way to test this is to scale down the lift-and drag coefficients, or somehow provide an excitation of the tower top without rotor aerodynamics present.

AC: Regarding the numerical damping, we did a clamped pre-study of the model in 0 m/s and forced excitations of the tower top. The study showed that the response was undamped, i.e. no numerical damping present.

Please note that other minor changes have been introduced in the text to improve readability and fix a few typos.

Please also note the supplement to this comment:
https://www.wind-energ-sci-discuss.net/wes-2019-20/wes-2019-20-AC3-supplement.pdf

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