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Wake Development in Floating Wind Turbines: New Insights and Open Dataset from Wind Tunnel Experiments.

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Summary:

The manuscript entitled "Wake Development in Floating Wind Turbines: New Insights and Open Dataset from Wind Tunnel Experiments" introduces some early results from a battery of wind tunnel experiments involving a modeled floating offshore wind turbine. The experiments show a great deal of care and highlight some of the aerodynamic changes in the wake that arise due to imposed, periodic platform motions. The complete suite of experiments produced more results than could be succinctly shared in a manuscript, so only a subset of the results are discussed within. While these preliminary results certainly indicate the quality and value of the data set, some of the analysis requires more attention before it can be considered publication quality. One of the main considerations overlooked in the current work is potential interaction between periodic turbulence statistics in the wake, and the imposed platform motion. These interactions could lead to harmonics visible in velocity measurements, which are currently shown in terms of the phase of the imposed platform motion. I also point out a few concerns about the signal processing approach used by the authors. See specific comments below.

Comments:

- "NETTUNO" — Acronym used before it is defined
- "pre-commercial stage" — Is this still true? There are commercial deployments of floating offshore turbines already.
- "Very recently, Özinan et al. (2024) studied the near wake of a 2 MW floating wind turbine and found no evident impact of wave-induced motions on the average velocity of the wake, partially contrasting theoretical speculations." — Does this undercut the motivation for the work? Please clarify how findings in this reference influence the NETTUNO project.
- "10 MW" and "15 MW turbine" — Please specify the model of turbine used as a basis of the scaled experiments.
- "The design of the blades and tower focused on maximizing stiffness to minimize their aeroelastic response." — Since measurement of structural loads are among the project goals, can the authors provide some more detail on how aeroelastic scaling was approached for the wind turbine model? The authors state that the goal is to maximize blade stiffness, but this is not likely to produce results that scale up to the 10 MW turbine model. More justification for this choice would help readers understand the approach.

- "ensuring the rotor was vertical to the wind tunnel floor" — Does this mirror the 10 MW reference turbine design? Typically, the tower is nominally vertical but the rotor is not. Perhaps it would be instructive to state here that aligning the shaft with the mean flow is an intentional simplification, to limit loads to the axial thrust and moment in the baseline case.
- "six-component loads" — Please be more specific about the loads measured in the introduction. This statement seems to indicate that only aggregate rotor forces and moments were measured. Were the tower bending or twist measured? Blade loads?
- "The wind velocity in the turbine wake was measured using a hot wire anemometer." — While a hotwire is certainly a good system for pointwise turbulence measurements, using a single probe in isolation makes coherence and spatial correlations impossible. With such a capable traverse system, why not make multiple measurements simultaeneously?
- "The resulting average extended uncertainties, at a 95% confidence level, are 0.17 m/s for flow speed and 0.4% for turbulence intensity." — Thank you for including a quantitative description of the measurement uncertainty.
- "Turbulence intensity is 1.5%" — These are very low turbulence levels, likely to arise offshore during stable atmospheric conditions. Since the experiment presumably did not apply a temperature gradient across the boundary layer, I think "close to laminar," as the authors state it, is a good description.. Also, given the confidence interval stated above, does this mean that the actual TI has a $\pm$ 27% confidence interval (1.5% $\pm$ 0.4% TI)?
- "reduced frequency:" — It may be helpful to readers to state that the reduced frequency is a normalized frequency similar to the Strouhal number.
- "Normalized mean velocity and turbulence intensity (I)" — The inflow average wind speed and TI are surprisingly variable across the rotor area. Does this arise from obstructions in the wind tunnel? Is this level of variability in y and z expected?
- "This process was performed in the frequency domain by computing the complex FFT, keeping the frequency components up to 3 Hz, and then utilizing the inverse FFT to reconstruct the signal in the time domain." — This sort of low-pass filtering can introduce convolution errors that are visible in the filtered time-domain data. Were any other techniques used (e.g., zero-padding, Butter or other optimal filter design) to reduce convolution errors?
- "12 platform motion cycles" — Is this a large enough sample size to describe spectra and turbulence moments given the non-stationary (periodic) nature of the flow statistics?
- "This proves that rotor load fluctuations are mainly due to variations in apparent wind speed caused by platform movement (Fontanella et al., 2021)." — Are the aerodynamic thrust and rotor torque in Figure 4 nominal curves based on the imposed platform motion and a constant wind speed or from measurements? How do the shown trends averaged over the 12 periods of motion? How do measured forces for each period compare to the nominal curves? It is not entirely clear here that fluctuations are due to apparent wind speed variations. How much of the loads are from acceleration of the platform itself?
- "A linear regression is fitted to the measurements and is included in Figure 5a and Figure 5b. This method of representation demonstrates that the loads change linearly with respect to the platform motion amplitude, as evidenced by the normalized points aligning with the regression line." —item "The velocity profile has a double-gaussian shape, and it is mostly unaffected by platform motion" — Can the authors elaborate why the velocity profile is asymmetric with y? There appears to be a lateral shift in the mean profile of approximately 0.15 m and the peak deficit in the right side of the plot shows complex behavior for all cases.
- "Figure 7c examines the velocity at $x_w = 3D$ and $y_i = 0.6$ m over one motion cycle" — Wouldn't it be more meaningful to show the velocity measurements and apply the sinusoidal fit to the collective data of all 12 periods of motion? If the velocity trends are truly periodic and the phase relationship is consistent, this should provide a better least-squares fit. Please also indicate fit quality.

- "As shown in the graph, the sine wave at the motion frequency does not fit the velocity data as well as it does in the 0.5 Hz and 1 Hz cases." — How much of the high frequency oscillations in Figure 7c arise from the rotor motion? A rotor speed of 240 rpm corresponds to 4 Hz, which is similar enough to the imposed platform motion that one could expect some interaction.
- "Among the conditions explored in this study, the strongest perturbation of the wake occurs when the reduced frequency of platform motion is 0.6" — This case is not shown in figure 7. Should it be?
- "We believe that coherent flow structures, larger for $f = 1$ Hz at 3D (Fig. 7), are dissipated as they move downstream by generating small-scale turbulence, which increases the turbulence intensity and accelerates the wake transition." — It is not clear how this conclusion is drawn from the data in Figure 9.

Suggested References

[1] Endre Tenggren et al. "A Numerical Study on the Effect of Wind Turbine Wake Meandering on the Power Production of Hywind Tampen". In: *Journal of Physics: Conference Series* 1669.1 (Oct. 2020), p. 012026. ISSN: 1742-6596. DOI: 10.1088/1742-6596/1669/1/012026. (Visited on 09/12/2024).

[2] Zhaobin Li, Guodan Dong, and Xiaolei Yang. "Onset of Wake Meandering for a Floating Offshore Wind Turbine under Side-to-Side Motion". In: *Journal of Fluid Mechanics* 934 (Mar. 2022), A29. ISSN: 0022-1120, 1469-7645. DOI: 10.1017/jfm.2021.1147. (Visited on 09/12/2024).