

Review WES-2026-141

The paper by Firpo et al. presents a numerical study, based on large-eddy simulations, of the wake dynamics of a large-scale floating wind turbine undergoing harmonic surge and pitch motion in a turbulent, conventionally neutral boundary layer. The study focuses on the spatial wake modes obtained by proper orthogonal decomposition (POD) and on how they depend on the motion parameters: frequency, amplitude and type (surge or pitch). The main outcome is the dependence of the modal energy on the frequency and amplitude of the motion, with significant differences from the fixed case observed at a reduced frequency of 0.5.

This article is sound and well-written. I find the topic and results relevant to the wind energy community, and I believe the paper fits the standards of Wind Energy Science. However, I feel that the physical analysis could be improved, particularly regarding the connection between the rotor motion, preferred modes and intrinsic wake dynamics.

Major comments

1. *Wake recovery.* The finding that the motion has no impact on wake recovery, in particular for surge at $fr = 0.5$ and $A^* = 0.1$, is at first sight unexpected given the strong motion-induced wake dynamics observed. In Figures 17 and 22, you quantify the large energy content of the coherent mode, which first increases with downstream distance (a typical non-linear amplification) before decaying beyond $x = 5D$. This suggests that these structures may be involved in the recovery. Recent results by Hu and Porté-Agel (2026, *Energy Conversion and Management*), obtained in a turbulent boundary layer with $TI = 8\%$ and $A^* = 0.08$, show a non-negligible effect of the motion on wake recovery, which contradicts your findings. I recognise that the paper focuses on wake dynamics and that recovery is somewhat secondary here. Still, coherent structures with such high energy content should in principle contribute to momentum transport and therefore to recovery, so it would be important to explain why no effect is observed and why your results differ from those of Hu and Porté-Agel. A momentum budget analysis would help quantify the effect of the motion on recovery and clarify this point.

2. *Physical interpretation of the modes.* Following on from the main comment on the paper, I suggest describing the modes (modes 1, 2, etc. in Figure 10) in terms of the classical unstable modes of a wind turbine wake, characterised by azimuthal wavenumbers $m = 0$, $m = \pm 1$, etc. (see for instance Li and Yang, 2024). Fore-aft motion generates coherent structures in the form of oscillating vortex rings (pulsing) as well as meandering structures, so it is of great interest to clearly separate the modes associated with each type. For example, linking Figure 10 with Figure 17 for surge at $fr = 0.5$ and $A^* = 0.1$, modes 1, 2, 3, 4 and 7 dominate. At first glance, modes 1 and 2 appear to be meandering-like, modes 3 and 4 closer to pulsing, and mode 7 a more complex combined mode. This should be discussed further.

3. *Coupling between platform forcing and intrinsic wake dynamics*. At line 561, you write: "As discussed previously, this extended downstream persistence, most evident in the transverse and vertical velocity components, is likely to the proximity of the platform motion frequency to the second harmonic of the wake-meandering frequency, suggesting a combined effect between the platform-induced forcing and the intrinsic wake dynamics." In my opinion, this observation is central to your study and should be developed further, in order to interpret the evolution of the modal energy in terms of motion-induced dynamics coupled with the intrinsic wake dynamics. In its current form it reads as a remark, more effort could be put into this point. For instance, Figure 17 shows that while modes 1, 4 and 7 decay beyond $x = 5D$, modes 2 and 3 gain energy, as if there were an energy transfer from the decaying modes to the others.

Minor comments

1. Abstract, line 7: "The results identify the reduced frequency as the dominant parameter governing platform-induced wake dynamics." Given your literature review and your justification for the chosen frequencies, this result is already known. I would suggest rephrasing, for example replacing "identify" with "further clarify" or "put into a new perspective".
2. The literature review is well conducted and convincingly motivates the study. Other degrees of freedom, such as yaw or sway, would also be of interest. I understand this is out of scope for the present work, but a case with $fr = 0.3$ and $A^* \sim 0.1$ would have been very valuable.
3. Lines 132–133: "This resolution was found to resolve more than 80% of the turbulent kinetic energy, indicating that the energetically relevant turbulent scales are adequately captured." Do you have data or previous work to support this statement?
4. Line 147: Is the unit of dT_0/dz correct?
5. Figure 3: Please clarify how the turbulence intensity is calculated.
6. The analysis focuses on YZ planes. Would it make sense to also consider XY and XZ planes? Do you expect this to provide further information on the mode shapes and their streamwise extent? I imagine this could be insightful for the physical interpretation.
7. Tables 1 and 3: Please also include the thrust coefficient, as this would make future comparisons with your results easier.
8. Figure 7: Visible differences in the mean wake profiles at $x = 5D$ disappear at $x = 7D$, which seems quite unexpected. Do you have an explanation? What about the

turbulence intensity in the wake: do the energetic modes lead to higher turbulence levels?

9. Figure 13: Please specify the type of difference shown (absolute, relative or percentage).
10. In connection with my comments on energy transfer between modes and their frequencies, Figure 15 could be extended to include modes 2, 3 and 4.
11. Figure 17: The sharp increase and subsequent decrease in the energy of coherent modes 1, 2, 3, 4 and 7 at $fr = 0.5$ reflects a non-linear amplification process. You could quantify the amplification for $A^* = 0.05$ and $A^* = 0.1$; I would expect it to be stronger at the lower amplitude. Building on this (possibly as future work), you could analyse the energy transfer between modes, as I suspect modes 2 and 3 receive energy from the decaying modes.

References

Hu, X., & Porté-Agel, F. (2026). Effect of the surge motion on wake characteristics of a floating offshore wind turbine. *Energy Conversion and Management*, 362, 121608.

Li, Z. and Yang, X. (2024). Resolvent-based motion-to-wake modelling of wind turbine wakes under dynamic rotor motion. *Journal of Fluid Mechanics*, 980, A48.

Note: The language of this review was edited with Claude (AI) for clarity. All scientific content and comments are the reviewer's own.