Manuscript: wes-2026-161, *Wind Energy Science* (Brief Communication)

Title: Actuator Disk Models reproduce Actuator Line Model power and thrust fluctuation statistics in wind farm simulations

Authors: M. Ayala, D. F. Gayme and C. Meneveau | **Recommendation:** Major revision

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I thank the authors for a clear, short and enjoyable manuscript. Many wind-farm LES studies take ADM power and thrust fluctuations at face value, so testing this assumption against ALM results is genuinely useful, and building on the open JHTDB-Wind dataset makes the work easy to reproduce. The authors reconstruct ADM-type power and thrust at turbine 7 from the disk-averaged velocity of the stored ALM flow fields and compare them with the ALM signals in three windows of the diurnal cycle.

The paper suits the Brief Communication format well. My main concerns are how far the a-priori setup supports the claim in the title, a few aspects that may make the agreement partly built in, and the blade-passing content in the ALM spectra, which has an established physical explanation worth discussing. I hope the comments below are helpful.

Major issues

1. The ADM signals are reconstructed from a flow generated by the ALM, so the inflow to turbine 7 is shaped by ALM wakes and the ADM never feeds back on the flow through its own induction. The study therefore shows that disk-averaged inflow approximates the ALM rotor response, which is not quite the same as showing that an ADM LES would give the same statistics at a waked turbine. I would encourage the authors to add a matching ADM LES for at least one window or, failing that, to frame the work explicitly as an a-priori test and soften the title and conclusions accordingly.

2. The ALM spectra show clear peaks around 0.5–0.65 Hz and their harmonics, but these are only briefly mentioned (ll. 128–130) and removed by the low-pass filter. These peaks arise from rotational sampling of turbulence, which transfers low-frequency energy to the blade-passing frequency $N_b * \Omega / (2\pi)$ and its harmonics. Deskos et al. (2020, J. Fluid Mech. 904, A13) modelled this effect together with turbulence distortion upstream of the rotor and validated it experimentally (see also Chamorro et al., 2013; Tobin et al., 2015). Deskos et al. (2020) also showed that disk-averaged power captures large-scale fluctuations but misses blade-passing peaks and inertial-range filtering, which is particularly relevant here. Atmospheric shear and veer can also contribute to these peaks. I suggest the authors briefly explain their origin, clarify that an ADM cannot capture them by construction, and quantify the fraction of ALM variance removed by filtering for each window. This matters because blade-passing fluctuations contribute to cyclic loading and fatigue, as well as near-wake dynamics. The abstract and conclusions should therefore describe these effects as not resolved by the ADM, rather than simply “attenuated”.

3. Agreement is currently described qualitatively, and matching spectra do not guarantee that the time series move together. Since both signals here are driven by the same inflow, they can be compared directly in time: the ALM–ADM coherence (magnitude and phase), the correlation coefficient, RMS error and variance ratio per window, and the skewness and kurtosis of the PDFs would make the conclusions more convincing. The variance ratio matters in particular because the PDFs in Figure 3 are normalized.

4. The argument that one turbine suffices because farm power is a sum (ll. 79–82) does not fully hold for fluctuation statistics, which also depend on cross-correlations between turbines (Stevens and Meneveau, 2014; Tobin et al., 2019). A front-row turbine and the summed farm signal would strengthen the paper. It would also help to note that only region II is considered and that the ALM grid is coarse ($D/\Delta \approx 6.9$).

Minor comments

- Section 3.3 refers to "Figure 2a" for the filtered result, but the Figure 2 caption does not mention it.
- The Welch segment durations differ (~819 s vs ~1024 s); is there a reason not to use equal durations?
- The conclusions mention thrust PDFs, which are not shown.
- Eq. (5): please state the yaw sign convention and that vertical velocity and tilt are neglected; please also specify the ADM variant (non-rotating, uniform loading).
- Abstract: "has not been validated" may be a little strong; perhaps "has not been systematically tested".
- Typos: "ALM include" (l. 24); "8 NREL-5MW" (l. 61); "power-spectra densities" (l. 118); "0.05 s s" (l. 121); "24 diurnal cycle" (Fig. 1 caption); "Meyer, J." should be "Meyers, J." in Calaf et al. (2010).

Suggested references

Chamorro, L. P., et al.: On the interaction between a turbulent open channel flow and an axial-flow turbine, J. Fluid Mech., 716, 658–670, 2013.

Deskos, G., Payne, G. S., Gaurier, B., and Graham, M.: On the spectral behaviour of the turbulence-driven power fluctuations of horizontal-axis turbines, J. Fluid Mech., 904, A13, 2020.

Milan, P., Wächter, M., and Peinke, J.: Turbulent character of wind energy, Phys. Rev. Lett., 110, 138701, 2013.

Stevens, R. J. A. M. and Meneveau, C.: Temporal structure of aggregate power fluctuations in large-eddy simulations of extended wind-farms, J. Renew. Sustain. Energy, 6, 043102, 2014.

Tobin, N., Zhu, H., and Chamorro, L. P.: Spectral behaviour of the turbulence-driven power fluctuations of wind turbines, J. Turbul., 16, 832–846, 2015.

Tobin, N., Lavely, A., Schmitz, S., and Chamorro, L. P.: Spatiotemporal correlations in the power output of wind farms: on the impact of atmospheric stability, Energies, 12, 1486, 2019.

I hope these comments are useful, and I look forward to reading the revised manuscript.