Review of WES 2025-78

This article builds on the recently introduced concept of the center of wind pressure (CoWP) in turbulent inflow fields and shows a stochastic surrogate model for the position in time of CoWP. Good statistical agreement is shown between the reconstructed CoWP and BEM-estimated yaw bearing bending moments. Aerodynamic imbalances have been long linked to yaw bearing and rotor shaft bending moments. However a systematic method such as the introduction of the CoWP is novel. Regarding the extension of this concept and the development of the load surrogate model proposed in this article, some things to note below.

The authors state that the surrogate model is very fast, and can generate long timeseries. Thus it can be used to replace uncertain load extrapolation techniques or replace costly long-term simulations of the wind turbine – at least for certain load components. This is a very interesting prospect, but it's not thoroughly demonstrated in the paper. Regarding long-term load extrapolation (for example – loads with a one- or fifty-year occurrence probability) the PDF plots shown in Fig. 11 (and many other throughout the paper) – despite showing good agreement even in the tails of the PDFs, only reach relatively high levels of probability. I would recommend to show the ability of the method to predict extreme loads with a one-year occurrence period – which should not e computationally too intensive to achieve with a "traditional" BEM simulation-based approach. In alternative, authors could try to compare the proposed surrogate to existing long-term datasets in the literature. The dataset generated by Barone et al. – also used by Dimitrov and Zhang (cited in manuscript) in their study – contains long-term extreme loads for the same testcase used in this manuscript. Alternatively, the dataset by Papi and Bianchini contains 50 years of loads for the NREL 5MW – albeit on a floating foundation. Please note that other references may exist, although I am not aware of them. Here are the mentioned references
(https://www.sandia.gov/app/uploads/sites/273/2025/02/AIAA2012-1288-SAND2011-3780C.pdf
https://www.osti.gov/biblio/1078621
https://zenodo.org/records/10514143)
As per Journal reviewer guidelines, feel free to use or not use them as you see fit.

Some aspects of the introduction could be clarified. In particular:
L26: "However, they do not yet incorporate turbulent flow structures." – Spectral models include spatial coherence functions. They do not explicitly resolve eddies; I imagine this is what authors intend here. Please clarify.

L27-30: Why are increased dimensions related to additional uncertainty in the impact of turbulent inflow on loads?

L35-40: Can more details be added regarding the observation of manufacturers: "According to manufacturers and operators of WTs, numerical simulations of the specific WTs and the standard IEC wind modeling assumptions do not adequately reflect certain load events that may be important for the structural integrity of the machines in operation."

L45-53: This paragraph appears a bit confused. Some works on numerical models are mixed with works on load extrapolation techniques and work on control techniques. Please reorganize this section in the context of the introduction.

L190: is data also filtered for direction? If the flowfield is misaligned with respect to the inflow how may this affect the measured coherence of the eddies and the results in this study?

The way the GROWIAN data is stretched is unclear. Is it a mix of interpolation and extrapolation? More details would be requited here. Moreover, is wind direction included in the dataset? Wouldn't changes in the man incoming wind field affect the measured coherence and size of the eddies?

Results: The BEM results are low-pass filtered as CoWP is a good description of large-scale turbulent fluctuations. The signals are also zero-meaned and normalized to have a standard deviation of 1. In the context of developing a surrogate model the manipulations that are done to the data seem to be significant. What is the effect on the long-term statistics and extrapolated loads of the filtered-out high-frequency component?

Results: Regarding the normalization of the signals – given the excellent statistical agreement between the normalized signal statistics, it would be interesting to see a transfer function mapping the CoWP to yaw bearing bending moments or other wind turbine load sensors as the author see fit.

Figure 8: When commenting this figure I would highlight the fact that the DELS agree well in an aggregate sense, but less so on a simulation per simulation perspective. Indeed, while statistics are in very good agreement (c, d) and correlation is good (a, b) a large spread in the data con be seen in figures 8 (a) and 8 (b).

Finally, please provide more details on the BEM numerical setup. Some details are included in the provided reference but should be repeated herein since the simulations constitute the reference for the entire work.