**Review of the manuscript wes-2025-189, titled "PhyWakeNet: a dynamic wake model accounting for aerodynamic force oscillations" by X. Liu, Z. Li and X. Yang.**

This manuscript presents a physics-integrated generative machine learning model for predicting the wake velocity field of a wind turbine subjected to aerodynamic force oscillations. The model uses the mass and momentum conservation for the prediction of the time-average wake field, while a data-driven approach --using spatial and temporal modes of the flow field-- is used to model coherent velocity fluctuations that drive meandering. Small-scale turbulence in the flow field is generated with convolutional neural network that considers the mean flow field, wake meandering and inflow turbulence. Results show that the model can predict the temporal variations of the wake characteristics for the aerodynamic forcing with various frequencies with decent accuracy, demonstrating potential applications in wake management and mitigation.

The introduction and literature review are presented in the first part of the study, detailing prior efforts and the need for control of the wind turbine wakes. This is followed by a description of the methods used in the study, in which the time-averaged wake model, wake meandering models, and small-scale turbulence models are introduced along with their sub-models. Results from each of the models are then presented and compared with the data obtained from LES simulations. Moreover, the capability of the model to predict the instantaneous flow field and wake center is demonstrated. The manuscript is well structured and organized, and additional details are presented in the appendix. However, it may be helpful to add sentences in the main text that explicitly refer to the appendices. The figures are well prepared for clarity.

The manuscript presents a novel wake model capable of predicting the frequency-dependent variations in the wake characteristics. However, the study does not comment on the limitations of the data set and the presented model. Experimental studies from Messmer et al 2024 have shown that the frequency response of the wind turbine depends on the degree of freedom of the motion (e.g., side to side, front-back, etc.). While it can be inferred from the previous publications of the authors that the data used in this study and presented wake model is for side-to-side motion (or forcing), this has not been explicitly stated in the manuscript. Moreover, to facilitate the clarification of the derivation, a table or a figure showing the dependent and independent parameters for each of the wake models (or sub-models) would be helpful. In addition, there are several comments that need to be addressed.

1. Line 10: In the abstract, it is written that the result of turbulent kinetic energy is presented. However, no such results are presented in the manuscript. (only the variance of streamwise velocity fluctuations is presented). Please clarify or revise.
2. Check Line 32. Jensen is repeated with the reference.
3. Line 92: It is not clear how $\alpha$ has been defined. It would be nice to clarify this.

4. Line 132: Equations 13 and 3 appear to be defining the entrainment velocity. It would be nice if the differences between these equations are justified as one has the coefficient while the other does not.
5. Line 147: Lower and upper should be represented with the corresponding axes (y) as the upper and lower can also mean the boundaries in z-direction.
6. Line 160: Doesn't this suggest that the entrainment occurs mainly because of meandering or temporal variation of wake center location in time? How can this be justified in the near wake of a wind turbine, where meandering has not started yet?
7. Line 207: "Notably, the forcing term for the $i^{th}$ SPOD mode incorporates information from all considered SPOD modes' temporal derivatives ($\dot{a}_i$) rather than relying solely on its own temporal derivative." It is not clear how this has been incorporated into the model. It would be nice to provide further details.
8. Figure 6: It would be nice to provide some details on how these values are evaluated using the model (listing all the inputs and the method used for the solution).
9. Figure 9: In the caption, "Figures d, e and i, j" is mentioned. However, the figures are missing from the figure. Moreover, the statement "The fourth and fifth rows correspond to two inflow conditions with [I∞ = 0.8%, L∞ = 1.0D] and [I∞ = 0.2%, L∞ = 4.0D], respectively." It is not related to the presented figures.
10. Line 275: Figure 11 is presented before figure 10. This can be revised.
11. Figure 11: x-label of the figures is not clear. It would be nice to clarify. Why are the normalized velocity deficit and the velocity variance being multiplied by constants?
12. Figure 12: Annotation and caption need to be corrected as there are missing sub-figures (d, e, i, j).
13. Figure 13: It would be nice to present the TI and integral length scales distinctly using larger spaces. Moreover, the turbulent length scales and integral length scales should be introduced before in the manuscript.
14. Line 335: Some comments about the generalizability of the model for other data sets (turbine models) or motion cases should be presented.