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Breakdown of the velocity and turbulence in the wake of a wind turbine - Part 2: Analytical modeling.

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Summary:

The manuscript entitled "Breakdown of the velocity and turbulence in the wake of a wind turbine - Part 2: Analytical modeling" endeavors to describe the turbulent velocity field in a wind turbine wake by accounting for energy in both the meandering and fixed frames of reference. Many of the comments that arose during the previous round of reviews were addressed by the authors, and I'd like to thank them for their frank and direct responses. In all, the manuscript describes important work deriving an analytical expression for wind turbine wake turbulence. However, because the work ends with a theoretical description, it remains unclear how effective the model will be in application for wind plant simulation, prediction, controls, design, etc. Without calibrating or validating the proposed model, training over a broader range of atmospheric conditions, error analysis, uncertainty estimation, and detailed comparison to existing models, the proposed work is incomplete and will not be likely to have the intended impact on the field of wind engineering.

Comments:

- The authors state in the opening sentence of the abstract that the novelty and benefit of the proposed model is that, "the expansion and meandering of the wake can be independently calibrated." However, no attempt is made to complete this step, and only a limited range of large eddy simulations were used to deduce model parameter values. This is a necessary step before the model can be validated and its range of application understood.
- The authors stated in their response to the previous comments that model parameters should be related to underlying causes (i.e., the standard deviations of velocities) rather than stability metrics. However variability in the velocity field is in fact a product of both mechanical and thermally driven turbulence. The results of the reference pointed out by the authors [1] concluded that, "With the same turbulence intensity, atmospheric stability can significantly change the turbulent kinetic energy distribution in the three spatial directions." This can only emphasize the importance of accounting for buoyancy in the model.
- The authors indicate that comparison to existing wake-added turbulence models would be confusing without calibration. I agree with this point in that results of such a comparison would be difficult to interpret, but I see it as another reason to pursue calibration data, rather than as a reason to omit model comparisons, error estimates, and uncertainty analysis.

References

[1] Bowen Du et al. "Influence of atmospheric stability on wind-turbine wakes with a certain hub-height turbulence intensity". In: *Physics of Fluids* 33.5 (2021), p. 055111.