Review of “Optimal tuning of engineering wake models through LiDAR measurements”

Summary: Input parameters of four engineering wake models are optimized by finding the set of model parameters that provide the smallest errors between the modeled wake velocity field and cluster-averaged LiDAR measurements of the wake velocity field. The conclusions concern the strengths and weaknesses of the four compared models.

General comments: The research goals are relevant to field and motivated in the introduction. The methods are missing some essential information. Apart from the open questions arising from this missing information, the optimization and the results are presented in a clear and comprehensible way. The conclusions could be improved with recommendations for the application of the models. My main comments are (details in the specific comments below):

1) The manuscript is missing information on the Doppler LiDAR measurements and their processing.
2) The Jenzen model and the Basthankhah model predict the normalized velocity deficit of the wake (Eq. 6 and Eq. 12). The optimization uses the longitudinal velocity (Eq. 1). Therefore, I believe an inflow velocity profile has to enter the optimization at one point, but the manuscript does not provide information on this.
3) It is not clear which spatial volume is used to compute the error between the model and the LiDAR measurements and, therefore, it is difficult to assess if neighboring wind turbine wakes or offsets of the wake center position might affect the error unintentionally.
4) It might be interesting if the conclusions could elaborate on the following questions: What are the benefits of optimally calibrated models compared to using some of the general assumptions for the parameters found in literature? How transferable are the results of this optimization to other sites?

Overall, I recommend considering the manuscript for publication after the authors have addressed those points.

Specific comments:

- Figure 1: Panel (a) could use a scale and what is the time period used for the plot in panel (b)? Does it correspond to the data used in the results?
- Lines 93-99: Information is missing for the Doppler LiDAR: What was the elevation angle of the PPI scans? What was the azimuth step? How much time does each scan take? And how are the wake centered for the comparison with the model? A brief summary of the data processing would be helpful, even if it is described in detail by Zhan et al. (2019).
- Eq. (1): Are the wake measurements of the LiDAR processed such that the wake is centered in the spanwise plane? Otherwise the error will include contributions from a different wake positions. And which downwind distances are used to compute the error?
- Eq. (1), Eq. (6), and Eq. (12): From Eq. (1) it seems that the model prediction of the mean longitudinal velocity field is compared with cluster-average from the Doppler LiDAR for the optimization. However, the Jensen model and the Bastankhah model predict the normalized velocity deficit in Eq. (12). To compute the longitudinal velocity field from the model, an inflow velocity profile is required. Therefore, the following things are unclear to me: where does inflow profile come from? Is it used to normalize the LiDAR measurements or combined with the model? Does it contribute to the model error?
- Figures 2a, 7a, and 7b: Some of the optimization clusters seem to hit a threshold (e.g. the optimization of the wake growth rate seems to plateau at 0.1 in Fig. 2a). Is there an explanation for this or could it be a too small search space of the optimization by mistake?

- Line 308 and Figure 8: I have difficulties to relate the mentioned peak at 7% with the shown data. It seems that only two of the clusters have a peak and most not.
- Figure 9: The caption should state that a normalized velocity is shown and that the green lines are the wake edge. Would it make sense to use σ as the wake width in case of the Basthankhah model?
- Figure 11: Which spatial volume is used for the computation of the percentage error? If large areas outside of the wake are used, then the error might also reflect undesired effects (e.g. neighbouring wind turbine wakes or inhomogeneous wind fields outside of the wake). Since the models only make predictions of the wake, it would be most sensible to use only the wake for the computation of the error.
- Conclusions: I am wondering what is the gain in error reduction with optimally calibrated models compared to using frequently made assumptions in literature? For example how much lower is the error of the calibrated Jensen model or Basthankhah model compared to using wake growth rate assumptions provided by Fuertes et al. (2018) or Peña et al. (2015)? Alternatively, it might be interesting to investigate the error as a function of the model parameters to gain insights into the sensitivity of the error to the parameters.

Technical comments:

- Line 67: I believe the abbreviation SCADA was not introduced yet.
- Line 88: The "while" in this sentence seems odd, because the topography data and meteorological data have no connection with each other.
- Line 89: Remove space before the comma.
- Line 95: Should be "of" instead of "on".
- Line 230: Remove the "e" before "Bastankhah wake model".
- Line 245: The citation should be "Larsen et al. (2003)" instead of "(Larsen et al., 2003)".

References

Peña, Alfredo, Pierre-Elouan Réthoré, and M. Paul van der Laan. "On the application of the Jensen wake model using a turbulence-dependent wake decay coefficient: the Sexbierum case." Wind Energy 19.4 (2016): 763-776.

Carbajo Fuertes, Fernando, Corey D. Markfort, and Fernando Porté-Agel. "Wind turbine wake characterization with nacelle-mounted wind lidars for analytical wake model validation." Remote sensing 10.5 (2018): 668.