General comments:

"Improvements to the Dynamic Wake Meandering Model by incorporating the turbulent Schmidt number" makes an important contribution to the wind energy community's understanding of wake meandering. While the Dynamic Wake Meandering Model has conventionally treated the wake velocity deficit as a passive tracer advected by large-scale turbulent structures, the current manuscript addresses the shortcomings of this assumption. The connection with previous experiments indicating that momentum is transported less efficiently than scalars in turbulent wakes and the subsequent incorporation of the turbulent Schmidt number is insightful and significant for the implementation of low-cost wake prediction models. While the manuscript's contribution is novel, it lacks clarity in some parts, particularly around the discussion of the benchmark in Section 3.2. Please see below for specific comments.

We are grateful to Reviewer #1 for the valuable feedback and taking the time to review manuscript. Because of the reviewer's comments, we have made major changes to section 3.2, which has been completely restructured. The benchmark has been removed from the manuscript and instead we validate the DWMM directly against the observations, now. We hope that those changes have improved the clarity of Section 3.2. Please see our replies to the specific comment no. 10 below for further details.

Our replies are shown in blue and the provided line numbers refer to the revised manuscript. Additionally, a tracked-changes manuscript is provided. In response to Reviewer #2, we indicate the measurement uncertainty as error bars in many figures, now.

Specific comments:

1. Page 1, line 18: Is it worth mentioning the theory that wake meandering is caused by bluff body vortex shedding (e.g., Medici & Alfredsson 2006)?

There are two hypothesis on the origin of wake meandering: (1) large-scale turbulence of the atmospheric boundary layer flow (Larsen et al., 2008) and (2) an intrinsic shear instability of the wake leading to periodic vortex shedding (Medici and Alfredsson, 2006). Experimental support exists for both in literature. We added the above to the revised manuscript in lines 15-16.

2. Page 2, lines 41-43: This sentence is not very clear. The paper will discuss how what affects the predictions of the DWMM?

We rephrased the sentence (lines 43-45) and it now reads: "Therefore, this paper will compare the wake dynamics modelled by the DWMM to the wake dynamics observed with field measurements. Further, we investigate how differences between modelled and observed wake meandering dynamics affect the predictions of the DWMM for the effect of wake meandering on the mean velocity deficit and the turbulence intensity."

3. Page 3, line 53: Even though the small-scale turbulence part of the DWMM is not used in the current study, a very brief description of how the small-scale turbulence is modeled would be nice to provide a more complete summary of the DWMM.

The following description of the small-scale turbulence part of the DWMM was added to the manuscript (lines 56-57): "[…], and (iii) small-scale turbulence based on a homogeneous Mann (1994) turbulence field that is scaled based on the local depth of the quasi-steady velocity deficit and its radial gradient".

4. Page 4, equation 8: Please explain here how the thrust coefficient is obtained.

The thrust coefficient was selected based on the mean wind speed from the thrust curve shown in Figure A1. An explanation was added to the manuscript in lines 95-97.

5. Page 5, lines 111-112: The definitions of t and ΔT are not entirely clear. Is t the time the wake leaves the rotor plane or the time it reaches the downstream location where wake center position is predicted?

The variable t is the time the wake reaches the downstream distance and ΔT is the time delay the wake took to get there. This was wrong in the previous version of the manuscript and has now been corrected (lines 116-117). Other implementations of the DWMM in literature have t as the time when the velocity deficit leaves the rotor area, but it was more convenient for the comparison with the observations to use the timestamp of the wake measurements as the reference time.

6. Page 8, lines 173-174: What averaging period is used for the SCADA data?

Information on the averaging period has been added (lines 187-188): "Because the SCADA data has a 10-minute resolution, we use the average of a 20-minute period for the mean wind speed, which is longer than the 14-minute measurement period of the front-mounted Doppler LiDAR."

7. Page 8, lines 177-178: This line further contributes to my confusion about the definition of ΔT. Doesn't ΔT depend on $\bar{u}_a$, per equation 13? Does that mean the low-pass filter threshold changes for each time period?

Yes, the filter threshold changes each period in the time domain, but it is constant in the spatial domain. We use a low-pass filter threshold that is proportional to the downstream distance, which is then transformed into a temporal threshold with $\bar{u}_a$ that can change for each time period. Using a length scale as the low-pass filter threshold rather than a time threshold is in line with other literature (e.g. Larsen et al. 2008). While the physical reasoning for the threshold in the DWMM is to isolate scales that transport the entire wake instead of deforming it, we additionally want to remove scales from the comparison that would have become de-correlated during the transport process (hence the proportionality with x). We state now explicitly in the manuscript that the low-pass filter threshold is proportional to the downstream distance (line 196).

8. Pages 8-9, lines 178-179: What is the low-pass filter threshold in terms of D?

The filter threshold is proportional to the downstream distance x (added in lines 196). Specifically, the filter threshold in the spatial domain was $\beta 5D$ for Fig. 5, 7, 10, 11, and 12 as well as for Table 1. In case of Fig. 6, 8, and 9 the low-pass filter threshold varied from bin to bin according to the x-values on the abscissa.
We believe it is an appropriate filter threshold because it extracts the large-scale turbulence as required by the DWMM model and it also removes all scales from the comparison between the DWMM

and the observations that have become uncorrelated due to the evolution of the turbulence during the downstream transport.

9. Page 13, figure 6: It would be helpful to see the actual values for both plots in addition to the differences.

A version of Fig. 6 with the actual values is shown below. Additionally, values for the downstream distance x=5D are shown in Figure 5 of the manuscript, which explains the range of the data. The steady decrease of correlation and increase of the RMSE for x>4D is explained by a general decrease of the prediction quality with larger separations. Towards the nearest distances (x=3D), in the near wake, the velocity deficit becomes donut shaped with two peaks instead of a Gaussian profile, which can bias the centroid because they are usually asymmetrical.
However, we believe that the original Figure 6 that just shows the differences better illustrates the effect we want to highlight and additionally allows to display the variation of the differences. For that reason we did not include the below figure in the manuscript.

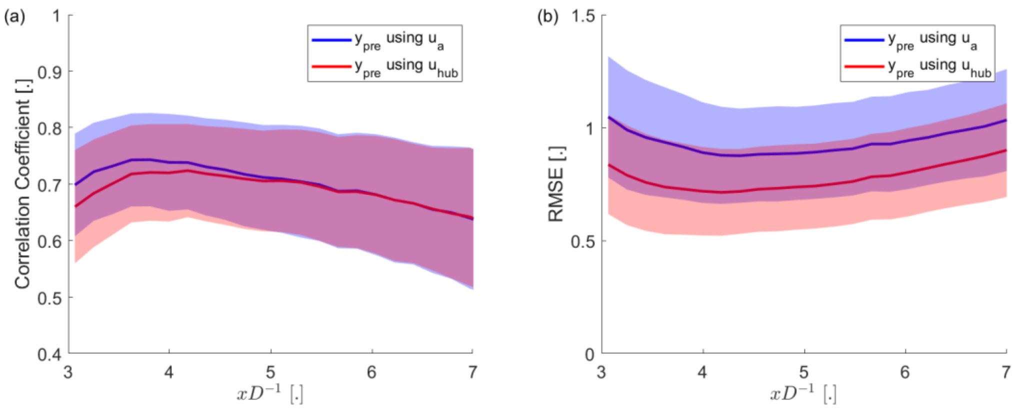

Figure 1: Correlation coefficient (a) and normalized root-mean-square error (b) between the predicted wake center position of the dynamic wake meandering model and the observed wake center position from the wake scanning Doppler LiDAR. The shaded area indicates the standard deviation. The shown values are averaged over all cases of the data set. The red line uses DWMM predictions with the mean wind speed as downstream transport velocity and the blue line shows DWMM predictions with a downstream transport velocity slower than the mean wind speed.

10. Page 19, section 3.2.1: What is the purpose of the extensive comparison between the observations and the benchmark? The differences discussed based on figure 12 were already described in the definition of the benchmark.

We have removed the benchmark from the manuscript and instead compare the DWMM directly to the observations. This led to a complete restructuring and significant shortening of Section 3.2 and required changes to the data processing that we explain in the following and summarize as a bullet-point list at the end.

In the original submission, we included the benchmark as a vehicle to explain differences between the observations and the DWMM predictions. However, it became clear to us that the benchmark failed to meet this goal and that it made the manuscript needlessly long. In the revised manuscript, we partly mitigated the need for the benchmark by removing a mean instead of a linear trend from the lateral velocity (v). This makes the observations and model predictions in Section 3.2 more comparable, because removing a linear trend from the observations was one of the purposes of the benchmark.

The remaining bias between predictions and observations at small wake meandering strengths is explained in the text of the manuscript without the benchmark.

Removing a mean instead of trend also affected Sect. 3.1, where the results were updated accordingly. The effects are minor and Fig. 6b and Fig. 8a are impacted the most. For Fig. 6b, the improvement of the correlation with a slower downstream advection velocity has been halved. The reason is that a steady change of the wind direction can be a major source of correlation between v and y_{wc}, which does not depend on the advection velocity. For Fig. 8a, the predictions of the wake meandering strength using the mean wind speed have now a bias towards overestimation. However, none of those changes affected the discussion and conclusions of Sect. 3.1.

Lastly, while the benchmark was insightful to explain the differences between the model and the observations, those insights are ultimately not needed for the conclusions of the manuscript. In the new Section 3.2, we only show that the modified DWMM has similar errors as the original DWMM for the statistics (in addition to the better dynamics established in Section 3.1). Together with streamlining the discussion, this shortened the manuscript by three pages.

We list below all changes to the manuscript in response to the comment:

- Section 2.3.1, line 194: The mean instead of a linear trend is removed from v.
- Section 2.3.2, lines 230-231: The mean instead of a linear trend is removed from y_{wc}. The sentence referring to the benchmark was removed.
- Section 3.1: Fig. 5 to Fig. 10 were updated to show the new results for a removed mean and minor changes were made to the manuscript text.
    - Fig. 5a has now overall higher correlations and Fig. 5b has smaller normalized RMSE due the included linear trend. This does not affect the discussion in the manuscript text.
    - Line 260: The mentioning of the detrending was removed.
    - Fig. 6 is the most strongly affected part of Section 3.1. Including the linear trend has halved the increase in correlation shown in Fig. 6a. The reason is that a steady change of the wind direction can be a major source of correlation between v and y_{wc}, which does not depend on the advection velocity.
    - We added a sentence stating that Fig. 6 has a larger improvement in correlation if the time series have a trend removed instead of the mean (lines 272-275).
    - Fig. 7 was updated.
    - Fig. 8 was updated. The bins for $x > 5D$ show a small positive bias for the predictions using the mean wind speed in Fig. 8a. This does not affect the finding that using u_a increases the overestimation of the wake meandering strength.
    - Fig. 9 and Fig. 10 are updated as well, but changes are minor.
    - The values for the Schmidt number provided in the text have been updated (lines 335).
- Section 3.2 has been completely reworked and rewritten.
    - The section describing the benchmark has been removed from the manuscript.
    - The new Section 3.2.1 compares the predictions of the DWMM directly to the observations in Figures 11 and 12.
    - The new Section 3.2.2 investigates the impact our modification to the DWMM on the model predictions. Table 1 was streamlined in the restructuring and only shows the RMSE now.
- Conclusions

- The percentage values for the error changes were updated (lines 411 and 413). The impact of the model modification is not as pronounced with the mean removed instead of a trend, but the conclusion remains the same.
- We added another suggestion for future research (lines 414-415).

11. Page 19, lines 356-357: It's hard to compare figures 13 and 12 when they are not next to each other. Could they even be plotted on the same plot?

The model predictions and the observations are now plotted together in the new Fig. 11 and Fig. 12. The benchmark has been removed from the manuscript (see reply to comment no. 10 above).

12. Page 19, lines 359-361: If the benchmark doesn't show the benefit of the non-passive DWMM, why is it included? Why not just compare directly with the observations?

We included it initially, because the DWMM and the observations had large differences in a direct comparison, which we wanted to explain with the benchmark. However, we agree that tackling this problem in such a convoluted manner made it difficult to follow for the reader. Following our reply to specific comment no. 10, we no longer use the benchmark.

13. Page 22, table 1: Can correlations with observations be shown in addition to (or instead of) correlations with the benchmark?

The benchmark has been removed from the manuscript (see reply to comment no. 10 above) and Table 1 shows the RMSE with the observations, now. The statistics of a linear regression where removed (and can be seen in the new Fig. 11 and Fig 12 for fully-modified DWMM).

Technical corrections:

1. Page 5, line 122: Equation A2 is in appendix A, not B.

Corrected (line 128).

2. Page 15, line 277: Appendix B, not C.

Corrected (line 305).

References

Medici, D. and Alfredsson, P. H.: Measurements on a wind turbine wake: 3D effects and bluff body vortex shedding, Wind Energy, 9, 219–236, https://doi.org/10.1002/we.156, 2006.

Larsen, G. C., Madsen, H. A., Thomsen, K., and Larsen, T. J.: Wake meandering: a pragmatic approach, Wind Energy, 11, 377–395, 2008.

Madsen, H. A., Larsen, G. C., Larsen, T. J., Troldborg, N., and Mikkelsen, R.: Calibration and Validation of the Dynamic Wake Meandering Model for Implementation in an Aeroelastic Code, J. Sol. Energ.-T. ASME, 132, https://doi.org/10.1115/1.4002555, 041014, 2010.