

Authors' Response to Reviews of

Assessing the Accuracy of a Three-Year High-Resolution Mesoscale Wind Farm Wake Simulation with Lidar and Satellite Radar Data

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Wind Energy Science (WES) Journal,

RC: *Reviewers' Comment*, AR: Authors' Response, □ Manuscript Text

List of relevant changes

- Momentum deficit, as defined in Equation (4), has been changed to momentum flux deficit throughout the manuscript, as it is a more appropriate term for the metric used.
- Figure 15 has been updated to include latitudes and longitudes in degrees on the y and x-axes, respectively.

1. Reviewer #2

1.1. General comments

RC: *The authors have addressed my comments and suggestions very well. Thus, I believe this paper can be accepted for publication.*

I have left a few minor comments below, which I trust the authors will consider carefully, as they have throughout the review process. I do not believe another round of review is necessary.

AR: Dear Reviewer,

We sincerely thank you for taking the time to review our manuscript. We believe the proposed technical corrections will improve the readability and the overall quality of our manuscript.

1.2. Specific comments

RC: *1. Is the momentum deficit metric introduced in Eq. (4) a temporal tendency or not? Based on the N/m^2 unit, it looks like a temporal tendency. If so, please clarify in the text that it refers to a temporal rate of change in momentum.*

AR: The quantity defined in Eq. (4) is not a temporal tendency. It represents the area-averaged difference in horizontal momentum flux between the NWF and WF runs. The units of the metric are $N\ m^{-2}$, which correspond to momentum flux rather than a rate of change of momentum. To avoid ambiguity, we have clarified this interpretation in the manuscript (line 141).

For simplicity, we consider the area-averaged momentum **flux** deficit:

RC: *2. You present U_{wf} as a 2D field to compute the wind speed deficit, but also use it for turbine thrust in Eq. (5). Naming a new variable to represent the hub-height wind speed within a grid cell would be more appropriate e.g., U_{hub}*

AR: This has been addressed, and Equation (5) has been updated as proposed (lines 145-149):

The thrust force for each wind turbine is also computed:

$$T = \frac{1}{2} \rho_0 C_T A_T U_{hub}^2, \quad (1)$$

where A_T is the area swept by the rotor blades, estimated using the rotor diameter of each turbine, and U_{hub} is the hub-height wind speed within a grid cell when the Fitch scheme is activated (WF).

RC: 3. Can you clarify the meaning of “momentum redistribution”? Perhaps wake recovery or the spatial advection and mixing of the wind speed deficit? If so, I would modify this statement as follows: “the concurrent expansion of the 5% wind speed deficit area results in greater downstream momentum recovery.” If not, I would briefly explain the meaning of “momentum redistribution”, which appears two times and without prior explanation in the text.

AR: We thank the reviewer for highlighting this ambiguity. By "momentum redistribution" we do not refer specifically to wake recovery, but rather to changes in the spatial distribution of momentum caused by wake advection, expansion, and mixing. However, since the different underlying mechanisms are not investigated separately in this study, we agree that the original terminology may be misleading. Therefore, we have revised the text as proposed. More specifically, in lines 521-524:

An increase in momentum flux deficit within the blockage zone is observed for wind speeds between 5 and 8 m s⁻¹. Furthermore, although higher wind speeds enhance momentum extraction from the wind farms, the concurrent expansion of the 5% wind speed deficit area results in a larger fraction of the momentum flux deficit being distributed downstream of the wind farms.

RC: 4. In the Abstract, perhaps the following modification improves the flow: “..within and upstream the wind farms”.

AR: The proposed modification has been added in the abstract (line 3).

Wind farm operation and power production are affected by wakes produced both within and upstream of the wind farms.

RC: 5. Explicitly stating that the sentence below refers to wind-farm wakes rather than to individual turbine wakes is important, as mesoscale simulations cannot represent turbine wake structure. In the Abstract, I would replace “..effectively captures the wake structures” with “effectively captures the larger-scale structure and wind speed deficit of the wind-farm wake”.

AR: The proposed modification has been included in the abstract (lines 14-15).

Finally, synthetic aperture radar images from selected wake events are compared with the model output, demonstrating that the wind farm parametrization scheme effectively captures the larger-scale structure and wind speed deficit of the wind-farm wake at the analyzed timestamps.

1.3. Technical corrections

RC: 1. Figure 15 needs X and Y axis dimensions

AR: Thank you for noticing this. Figure 15 has been updated to include latitudes and longitudes in degrees.