

Response to the comments of David Schultz for WES-2023-33

June 18, 2023

General feedback from the referee

This is an important paper because it shows that the increase in height of the turbines from 5 MW to 15 MW more than offsets the loss due to wakes. I approach this review as a meteorologist and mesoscale modeler. Hence, my comments are mostly focused on these aspects of the manuscript. I see no problem with the science and the results, only the presentation.

General reply

The authors thank the referee for pointing out several adaptations to improve the presentation of our results and for the suggested improvements of the text body. These suggestions will be taken up in a revision of the manuscript. We have formulated a response to each of the major comments and also to several subsets of the minor comments.

Major comments

Comment 1: The conclusion section is unbalanced. Lines 414–423 represent an unacceptably short, incomplete, and qualitative summary of the first part of the study. In contrast, lines 424–443 represent a much more detailed and quantitative set of conclusions. I prefer the latter, as I imagine most readers would who would want to read the conclusion to get a more clear picture of the results of this study. I suggest a revision to the first part of the conclusion section.

Reply: we recognize the imbalance in the conclusion. For the revised version, we will provide more detail and quantitative information with respect to the first part of the study.

Comment 2: Figure 2: The color scale needs work. First, the zero point should be white, not bluish-yellow, to indicate its true neutrality. It's hard to interpret otherwise. Second, the color scheme is not symmetric. Negative values are all shades of blue, but positive values are yellow, orange, and red. Instead, all positive values should be shades of red, opposite of the negative values. In any case, I recommend to the authors to avoid the rainbow color scheme. It distorts gradients, among other issues. Please fix similar problems with Figures 3 and S5.

Reply: We agree that better color scales can be used with a more clear zero-point and better symmetry to make the figures easier to interpret. Another colorblind-friendly diverging color scale will be selected for Fig. 2, Fig. 3, Fig. 5S.

Comment 3: An excessive number of grid lines appears on Figures 5, 6, S1–S4, and S6–S9. These are distracting from the data (i.e., what Edward Tufte calls chartjunk) and should be eliminated.

Reply: We recognize the excessive number of gridlines for most of the mentioned figures. For Figures 5,6, S1-S3, S6 and S7, the number of grid lines will be significantly reduced towards a later version. For Figures S8-S9, we would prefer to keep the gridlines as they are in order to aid the reader in reading the values from the y-axis.

Comment 4: Model output and observations have different colors in each figure where they are compared directly against each other: Figures 4, 5, and 6 (and comparable figures in the supplement). Can a similar color scheme (red for model and black for observations, for example) be employed across all three of these figures? It would sure simplify things for the reader having that consistency across all the figures.

Reply: Consistency is indeed lacking here and there is room for improvement. For Fig. 4, Fig. 5 and the bottom row of Fig. 6, the same set of colors will be used for the model and the observations.

Comment 5: Lines 282–284: I find three levels of organization (section 3 to subsection 3.1 to subsection 3.1.1) without any text introducing each confusing. The authors need to put these sections into context before diving down three levels to a very specific quantity (e.g., wind speed at 290 m). For example, after the title for section 3, there should at least be a paragraph explaining how this section is structured and any general information that pertains to it. Also, after the title for section 3.1, there should at least be a paragraph explaining what will be discussed in this subsection and any general information that pertains to it. The same is true for section 3.2. The text just jumps right in with results from Figure 7. Can you provide some context to the reader first?

Comment 6: Line 284: Are three levels of organization necessary? Usually sections and subsections are sufficient. Could you just have different sections for results? Section 3.1 becomes section 3, section 3.2 becomes section 4, etc.? Alternatively, you could just drop the third level of subsections. I'm not sure they are helping the reader. It would make the text more readable and less tedious. Also, the text of section 3 is just a little over 100 lines. Three levels of subsections seems excessive.

Reply to comment 5 and 6: the reviewer has a point that three levels of organization are redundant here. The third level, i.e. the sub-subsections of the evaluation part will be removed in a future version. At the start of section 3, a short paragraph can then be added to discuss the upcoming structure of this section.

Minor comments

Comment 1: Lines 13–15: “In contrast, the impact of wake losses is exacerbated with increasing capacity density, as the layout-integrated, annual capacity factor varies between 54.4% and 44.3% over the considered range of 3.5 to 10 MW km².” I have read this sentence multiple times, and I am having trouble making sense of it. I think it is phrase “impact of wake losses is exacerbated” that is the problem. Could it be written more clearly?

Reply: We suggest an adaptation of this part to: “In contrast, the efficiency losses due to wakes become larger with increasing capacity density...” - this might be less ambiguous.

Comment 2: Lines 15–16: “wind farm characteristics and inter-farm distances play an essential role in cluster-scale wake losses, which should be taken into account in future wind farm planning.” This sentence is too vague and general to be a meaningful conclusion to your paper. For example, this sentence could be the conclusion of just about every paper in Wind Energy Science. It does not do your study justice.

Reply: We agree that a better conclusive statement should be included. We suggest an adaptation of this part to (or a variant of): “In conclusion, our results show that the wake losses in future wind farm clusters are highly sensitive to the inter-farm distances and the capacity densities of the individual wind farms and that the evolution of turbine technology plays a crucial role in offsetting these wake losses.

Comment 3-6: *textual improvements*

Reply: These valid suggestions will be incorporated in the revised version.

Comment 7: Line 71: I think more careful wording of “deep convection is explicitly resolved at the mesogamma scale” is needed. Convective storms may start to be resolved at these scales, but the updrafts comprising that convection are not, as has been shown in Bryan et al. (2003). So, the phrase “deep convection is explicitly resolved” is ambiguous.

Reply: This is a valid point. We will be more careful in our wording here: at the mesogamma scale, the model no

longer blocks the explicit development of deep convection due to spatial resolution and excluding the deep convection parametrization at these scales has previously been found not to degrade COSMO simulations even though deep convection is not fully resolved at these scales (Vergara-Temprado et al., 2020).

Comment 8-18: *textual improvements*

Reply: These valid suggestions will be incorporated in the revised version.

Comment 19: Lines 118–120: On what basis can it be said that “the representativeness is high overall, but especially for the wind direction distribution,”? Please evidence that statement.

Reply: We will again refer to the supplementary figures mentioned in the previous sentence, these evidence the statement.

Comment 20-29: *textual improvements*

Reply: These valid suggestions will be incorporated in the revised version.

Comment 30: Figure 3: If the top part of the graph is gray (i.e., presumably no difference field plotted there), then why not trim it off? Also, does it make sense to make the graph encompass the same domain as Figure 7? If so, that would be helpful to the readers to compare figures that have the exact same map background.

Reply: This would indeed help the comparison, so the map will be adapted.

Comment 31: Figure 4: I am having a hard time understanding this graph. There are three colors (light green, dark green, and gray), yet only two colors are explained in the figure caption. Can you write the figure caption more clearly (or replot the graph) to make it easier to understand? I think the histograms are overlapping, but this is difficult to interpret.

Reply: It indeed makes sense to adapt the caption like this in the revised version to avoid confusion.

Comment 32-46: *textual improvements*

Reply: These valid suggestions will be incorporated in the revised version.