

“Mesoscale modelling of North Sea wind resources with COSMO-CLM: model evaluation and impact assessment of future wind farm characteristics on cluster-scale wake losses” by Borgers et al.

Review by David M. Schultz

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.

1. Does the paper address relevant scientific questions within the scope of WES?
Yes.
2. Does the paper present novel concepts, ideas, tools, or data?
Yes.
3. Is the paper of broad international interest?
Yes.
4. Are clear objectives and/or hypotheses put forward?
Yes, very clear.
5. Are the scientific methods valid and clear outlined to be reproduced?
Yes, very clearly described.
6. Are analyses and assumptions valid?
Yes.
7. Are the presented results sufficient to support the interpretations and associated discussion?
Yes, they are.
8. Is the discussion relevant and backed up?
Yes, the discussion, which is interspersed throughout section 3, is relevant and defensible.
9. Are accurate conclusions reached based on the presented results and discussion?
Yes.
10. Do the authors give proper credit to related and relevant work and clearly indicate their own original contribution?
Yes, they do.
11. Does the title clearly reflect the contents of the paper and is it informative?
The title is quite appropriate and detailed. Yes, it is informative.
12. Does the abstract provide a concise and complete summary, including quantitative results?
The abstract is well written.
13. Is the overall presentation well structured?
In general, yes. I have some suggestions below about different ways to structure section 3 that would make it more readable. More signposting of the structure within

section 3 is needed, along with that renumbering of the subsections and sub subsections.

14. **Is the paper written concisely and to the point?**
Yes.
15. **Is the language fluent, precise, and grammatically correct?**
For the most part, yes. I have a few suggestions for the authors, enumerated below.
16. **Are the figures and tables useful and all necessary?**
I think so. I didn't see that the supplemental figures were all that necessary, but I don't see the harm in including them.
17. **Are mathematical formulae, symbols, abbreviations, and units correctly defined and used according to the author guidelines?**
Mostly. I have enumerated a few issues below to consider.
18. **Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?**
Mostly, no. The paper is mostly fine the way it is. I have some suggestions that will improve the readability of the figures and the text.
19. **Are the number and quality of references appropriate?**
Yes. Some care should be taken with the citations, as better scholarship there would benefit the readability of the manuscript. See below.
20. **Is the amount and quality of supplementary material appropriate and of added value?**
I don't see that it adds that much value, but it is appropriate. Other than changes to the figures, I don't see that it needs to be changed.

Major comments:

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.

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.

Stauffer, R., G. J. Mayr, M. Dabernig, and A. Zeileis, 2015: Somewhere Over the Rainbow: How to Make Effective Use of Colors in Meteorological Visualizations. *Bull. Amer. Meteor. Soc.*, **96**, 203–216, <https://doi.org/10.1175/BAMS-D-13-00155.1>.

Please fix similar problems with Figures 3 and S5.

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.

https://www.edwardtufte.com/bboard/q-and-a-fetch-msg?msg_id=00040Z

<https://en.wikipedia.org/wiki/Chartjunk>

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.

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?

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.

Minor comments:

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 km⁻².” 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?

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.

3. Lines 25, 33: Why these three citations of all the citations that have been published on the efficiency of wind-farm wakes? In such instances, it would help to precede the list of citations with “e.g.” to indicate that these are a sampling of all the possible sources that could have been cited. You may wish to consider adding “e.g.” to other lists of citations, as well.

4. Line 64: In contrast, the “e.g.” is not needed here because presumably there is only source for “documentation”.

5. Line 47: should be “and/or”, with no spaces.

6. Line 67: The verb tense changes back and forth from present to past tense in this paragraph. I think past tense sounds better, but whatever you pick, aim to be consistent.

7. Line 71: I think more careful wording of “deep convection is explicitly resolved at the meso-gamma 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.

Bryan, G. H., J. C. Wyngaard, and J. M. Fritsch, 2003: Resolution Requirements for the Simulation of Deep Moist Convection. *Mon. Wea. Rev.*, 131, 2394–2416, [https://doi.org/10.1175/1520-0493\(2003\)131<2394:RRFTSO>2.0.CO;2](https://doi.org/10.1175/1520-0493(2003)131<2394:RRFTSO>2.0.CO;2).

8. Lines 80, 340: “Hence” cannot be used as a conjunction in this context.
<https://langeek.co/en/grammar/course/752/since-vs-hence>

9. Line 89: I’m unclear what role these two citations are supporting. Period of 13 years? Need for sampling inter-annual variability? Other studies doing model evaluation? More explanation is needed for why their citation is relevant to this sentence. That may involve rewriting the sentence so that the reason for the citations becomes more clear.

10. Lines 93, 264, 367, 396: “Cf.” means “compare”. So what is being compared to section 2.4.1? It isn’t clear. Write instead “cf. A and B” to compare A to B.

11. Line 99: Change “constructions” to “construction”.

12. Line 104: Delete the comma.

13. Lines 107, 112, 213, 216, 243, 269, 402, 424: Please insert \noindent before “where”.

14. Lines 104 and elsewhere: Italicize *R*, as it is a variable.

15. Line 112: Italicize *b*.

16. Lines 109, 116, and elsewhere: Change hyphens to en dashes (i.e., two hyphens in LaTeX) to connect two items in a range. Fix also in Tables A1 and A2. Fix throughout the manuscript.

17. Line 118: Capitalize “Figures”.

18. Lines 118–120: I am having a hard time understanding this sentence. I think there is too much being communicated within. Break it up, perhaps.

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.

20. Lines 157, 219, 230: Is this a new paragraph? If so, indent it. If not, then combine it with the previous line.

21. Line 164: Change “since” to “because” to avoid implication of time that “since” implies. See also lines 207, 239, 257, 266.

22. Line 170: spell out “including”.

23. Lines 195, 311, 445, 447: Change “while” to “although” to avoid the implication of simultaneity that “while” implies.

24. Line 199: Change “resolution” to “grid spacing” for consistency and precision.

25. Line 208 and throughout the manuscript: Hyphenate “10-minute period”. Fix throughout.

26. Lines 214, 241, 267: Delete the colon.

27. Line 270: Italicize P.

28. Line 295: “further” should be “farther”. <https://www.dictionary.com/e/farther-vs-further/>

29. Line 297–299: This sentence should cite Fig. 3. You were talking about Figure 3, but then cited Figure 2. You should return to citing Figure 3 to avoid any confusion and point the reader to the right figure.

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.

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.

32. Line 315: Is “stable” the right word? “Consistent” would be better.

33. Line 343: The title of this subsection is vague: “characteristics”. It could be more clear what characteristics are being varied.

34. Line 347: Put a comma between “conditions capacity”.

35. Line 360: Change “while” to “whereas” to avoid implication of simultaneity.

36. Line 364: Why is “weakly” in parentheses? You don’t include the parentheses when that term is used in line 366. I suggest deleting the parentheses.

37. Figure 8 caption: Use the \pm symbol.

38. Lines 373, 384: Delete “(blue)” as that information belongs in the legend and figure caption, not the text.
39. Line 387: Change “wit” to “with”.
40. Line 404: Be careful of the difference between \cite and \citep.
41. Line 404: Insert a comma after “IEA8.1”.
42. Line 405: Insert a comma after “IEA10.0”.
43. Lines 414–415: “negative bias” in “wind climate” is unclear. Can you just say that the “model was underpredicting the wind speed”? That is easier to understand. Look for other similar opportunities throughout the manuscript to convey your message more simply and more clearly.
44. Line 417: A comma is needed after “95%” to join the two independent clauses.
45. Line 417: Delete “both” because you describe three things: “seasonal, inter-annual, and directional variability”.
46. Lines 418–419: This sentence is unclear. Also, what about biases in other stability conditions?