

Interactive comment on “Assessing Spacing Impact on the Wind Turbine Array Boundary Layer via Proper Orthogonal Decomposition” by Naseem Ali et al.

Anonymous Referee #2

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Review of “Assessing Spacing Impact on the Wind Turbine Array Boundary Layer via Proper Orthogonal Decomposition” by Ali et al.

The authors use arrays of wind turbines in a wind tunnel to study the effect of stream-wise and span-wise spacing on the wind turbine boundary layer. They test four different arrangements of twelve turbines, examine the resulting power production, velocity deficits upwind and downwind, as well as Reynolds stresses and kinetic energy flux. They then apply POD to these fields and describe the differences, and create reconstructions of these modes. The differences between the four cases are moderately interesting, but unfortunately the manuscript as it is currently written does not clearly define any unique contribution of this work to the literature.

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Although it's clear that a lot of work went into this paper and the wind tunnel study behind it, substantial effort must be applied to it to make this manuscript suitable for publication. The scientific goal, or hypothesis, or driving question must be presented clearly (and it is not in the current form). The community understands the benefit of larger stream-wise spacing – is the goal here to assess the role of cross-stream spacing? Further, much text is devoted to describing the results of the POD and the differences between modes, but unfortunately it's not clear what new knowledge or insight is obtained from the POD analysis. What would a reader learn from this study that he/she did not know before?

Further, the authors should remember that one of their goals is to make their results as clear as possible to the reader. In its current form, the paper is very difficult to read and understand. The senior authors should provide a much more careful review of the writing style. Many sentences are confusing, even in the abstract (which should provide a very clear and concise summary of the paper – no one will read the paper if the abstract is confusing). For example: “The region of interest downstream to the turbine confirms a notable influence of the streamwise spacing is shown when the spanwise spacing equals to $3D$.” What is the subject in this sentence? What is the verb? Please try to make the sentences as short and simple as possible to ensure they are more clear. Unless the writing is revised carefully, I cannot see that this paper would be appropriate for publication.

Just as many individual sentences are very confusing, the overall structure of the paper is also confusing. For example, why does “Power Measurements” get a heading while everything else is folded into the “Results”? The power measurements should become part of the discussion of the streamwise velocity.

Specific major comments:

1. A clear hypothesis must be stated, and the value of the POD must be stated explicitly.
2. The figures are not designed intuitively. Although four test cases are examined

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repeatedly, they are given names with no correlation to what they stand for. I understand the appeal of brief labels for the cases – it's more convenient for writing – but it's also more confusing for the reader. Perhaps labels like 6X3, 3X3, 3X1.5, 6X1.5 would facilitate the interpretation of the images? Similarly, wouldn't it be more intuitive to have top left 6X3, top right 3X3, bottom left 6X1.5, bottom right 3X1.5? In this fashion, the rows are organized according to the span-wise spacing and the columns are organized according to the stream-wise spacing, which makes it easier for the reader to do comparisons between the cases.

3. Please try to start each paragraph with a topic sentence. For example, Line 16 jumps into a literature review, and the reader is not sure what the point is. Of the numerous wind tunnel studies and LES (many of which have been omitted from this literature review) studying wind farms, why are these studies the important ones in reference of this particular study? This is just an example of many cases where paragraphs jump into a description of this or that figure without indicating to the reader what the point is of the discussion.

4. Speaking of the literature review, numerous other LES of wind farms (<http://www.nrel.gov/docs/fy12osti/53554.pdf>, among others) have been presented in the literature. What is the justification for omitting them?

5. Is there any thermal forcing in these cases? This should be mentioned.

6. The upwind stream-wise velocity contours for cases 2 and 3 seem very surprising. If this decrease of velocity is due to an induction zone in front of the farm, shouldn't the lower velocities be closer to the turbines (ie at $x=-1 D$) rather than further away (at $x=-1.8D$)? The discussion in line 164 should explain this odd phenomena rather than just describe it.

7. All the velocities (Figure 4) should be normalized with respect to the desired inflow velocity at hub height.

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8. The motivation for the extensive POD discussion is never presented. What have we learned from the POD that we did not know before? It is not enough to state that “The findings of this study have a number of practical implications” without stating what those implications are directly.

Specific minor comments:

1. The abstract is organized in a confusing fashion: please put all the set-up information first, and then the results. Mixing them together (“Streamwise averaging...” appears after some of the results
2. Line 36: “optimal” is not the appropriate word here. “actual” makes more sense – the wind farm designers were considering many variables when constructing those wind farms.
3. lines 35-62: please break up this paragraph: the first idea is about density for aligned wind farms, then at some point staggered design is introduced. That should get its own paragraph (if it is important).
4. lines 63-66. Very abrupt transition to POD. It, and its use in wind energy research, should be introduced.
5. lines 63-66: Please provide a few sentences outlining the structure of the paper.
6. line 79: isn’t POD widely used in wind energy? Shouldn’t some of those papers be cited here? (I see now that I have read down to 97 that a short review is presented there, but it should come earlier in the paper.)
7. Figure 1: has the publishing company of Hamilton et al. given permission for the figure to be reproduced here?
8. line 145-146: how were erroneous field identified? How many were there? Does this undermine the reader’s confidence in the measurements?
9. Somewhere in the discussion of Table 1 it should be pointed out that no staggered

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grids were considered.

10. Table 1/Figure 3/Figure 7: I understand why you might want to use brief labels for the cases, but can you choose labels somewhat more clear, like 6X3, 3X3, 3X1.5, 6X1.5 to facilitate the interpretation of the images?

11. Figure 4, 5, 6: Please use small letters to clearly define what each panel is showing. (Thank you for using a clear color table.) Wouldn't it be more intuitive to have top left 6X3, top right 3X3, bottom left 6X1.5, bottom right 3X1.5? Also consider overlaying a contour level at some important threshold.

12. line 174: please summarize, providing a ranking of the cases corresponding to their spacings

13. In the conclusion, please first redefine the cases before describing their results.

Particularly confusing sentences: Please review the entire manuscript carefully to ensure coherency and correct English grammar. In many places the intent of the writing is muddled by the composition of the sentences. Some of these are noted below, but the entire manuscript should be reviewed.

1. abstract: "The region of interest downstream. . ."

2. abstract: "The impact of the streamwise. . . in power produce. . ." should be produced perhaps?

3. line 9: coalesce?

4. line 10-13: where is the verb?

5. many between 13 and 65

6. line 65: missing a word

7. line 68: "Balancing" should be "The balance"

8. line 71: "center" ?

9. line 76: misspelling of Lumley. Using bibliographic software can reduce errors like this.
10. line 89
11. line 118
12. line 122
13. line 132
14. line 137-140
15. Table I: is “spacing area” the correct term for this?
16. line 155: majority? Do you mean maximum?
17. 159-160
18. 173-174
19. 178-179
20. please carefully review the rest of the manuscript

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