Authors' response to the editor's review of "Sensitivity analysis of wake steering optimisation for wind farm power maximisation"

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Main comment

The authors would like to thank the editor for the review of the paper. The authors' responses (in blue) to all comments (in black) are included in this document. Modifications are marked appropriately in the revised manuscript.

Minor changes:

1. The use of the term "operating set-point" in some parts of the paper to refer to the layout or atmospheric conditions (e.g. in L58) could be misleading in a control context where set-point may refer to command. A rather preferred term could be for instance "operating conditions".

   The term "operating set-point" has been changed to "operating condition" following the recommendation from the editor.

2. Eq. (4). The total farm power (P) could be named as (P_{WF}) to better match the subsequent reference in Section 4. The subscript WF could also be applied to Eq.(5).

   The total farm power has been named P_{WF} in Eq. (4), Eq. (5), and in related occurences in the text.

3. L209, I'd suggest to include the explanation of the term multi-modality (L261: "the presence of multiple and distinct maxima") when the term is first mentioned in the text.

   An explanation of the term multi-modality has been added when first mentioned in the manuscript.

4. Table 2. Maybe you could include somehow that the second range for eps corresponds to the C1 constraint, since this is not explained until L454. Reference to Table 2 could also be made in L456.

   Table 2 has been modified with a clarification for *eps* values when referring to Constraint "C1". A reference to Table 2 has been added in Sect. 4.3, addressing the change in *eps* value.

5. Figure 2: The figure is not fully colour-blind friendly, specifically the lines corresponding to Gaussian and GCH models, which are very close, of similar line style and have the two most confused colours (green and red). Could you please kindly modify it to make it clearer for everyone?

   The line style of Figure 2 has been changed accordingly.

6. For the sake of clarity, please indicate in all figure captions to which layout corresponds the figure. Missing references in Fig. 2 (2x1 wind farm), Fig. 5-9 (5x5 wind farm) and Fig. 10-12 (Horns Rev wind farm).

   All figure captions now specify the corresponding wind farm layout.

7. For the sake of higher colour-blind friendliness, in the discussion about Fig. 5, when referring to the markers, please include not only the colour (blue, green, red), but also the type of the marker (square, triangle, circle). Please also include the type of marker in the figure caption. The same goes for the discussion of Fig. 9.

   Captions and discussions of Fig. 5 and Fig. 9 have been changed accordingly.

8. L295. Could you please provide any answer on RC1 comment about the statement "which saturates the upper bound constraints at 25$^\text{o}$ for all but the final turbine row", which refers the authors to previous results in the literature (Zong and Porté-Agel, 2020)? The comment is also related to those in Fig. 10 by RC1.

   In the manuscript, two wake models based on a Gaussian distribution of the streamwise velocity deficit are utilised. The first is the "Gaussian Bastankhah" wake model proposed by Bastankhah and Porté-Agel, 2014. The second is the "GCH" model developed by King et al., 2021. The wake model mentioned in RC1 refers to the "Gaussian Zong" model proposed by Zong and Porté-Agel, 2020, which also incorporates a Gaussian distribution for the streamwise velocity deficit. Both the "GCH" and "Gaussian Zong" models include secondary steering effects in their formulations, leading to optimal yaw settings exhibiting monotonically decreasing yaw angles with each turbine row. In contrast, the "Gaussian Bastankhah" model does not capture secondary steering effects, resulting in optimal yaw angles saturating the upper bound constraints at 25° for all but the final turbine row. Therefore, the discrepancies in optimal yaw settings between the "Gaussian Bastankhah" model used in our study and the "Gaussian Zong" model mentioned in RC1 are consistent with the respective modelling capabilities of these wake models.

9. L301. According to your answer to major concern 2 by RC1, you have selected the 10 random cases in Fig. 4 from the 50 cases studied in Section 4.3. It might be worth mentioning it in the section.

   A clarification has been added in Section 4.2.1.

10. L358. The comment refers to both Fig. 5-c and 5-g, so you could make reference to both sub-figures.

   The comment mentioned refers to the initial yaw angles shown in Fig. 5 (Fig. 5-c specifically for the Gaussian model although all models share the same initial conditions). The sentence has been rephrased to avoid this confusion.

11. L407. In the discussion about Figure 9, maybe the use of "the first case", "the second and third cases" is not the most adequate since this order does not match the order in the legend or in the velocity plots.

   The discussion of Figure 9 has been changed to avoid this confusion.

12. L412, I guess you refer to Figure 8-d specifically.

   Yes, this is now clarified in the manuscript.

13. L416, in the reference to the figure you could also include "Fig. 9-d"

A reference to Fig. 9-d has been added.

14. L418, you could also include a reference to "Fig. 9-b"

A reference to Fig. 9-b has been added.

15. L427, in the reference to Fig. 5, please specify to which sub-figure you want to make reference, if any in particular.

The mentioned reference to Fig. 5 refers to all sub-figures. A clarification has been included in the text.

16. L454. When introducing constraint C1, could you please include an indication on why you choose the positive yaw angles as supposed to lead to more global maxima or to preferred solutions?

A clarification has been added in Sect. 4.3 where constraint "C1" is first introduced.

17. L464. For the sake of clarity, please also include that the so-called nominal optimisation does not apply constraint C2 either, as RC1 suggested.

A clearer explanation is now included.

18. L467, please make reference to Table 2.

A reference to Table 2 has been added.

19. L476. To better complement the discussion and demonstrate the overall effect of the optimisation constraints, could you please include (e.g. in a table) the normalised farm power obtained by each of the optimisations depicted in Fig. 10? This might not be relevant in model comparisons for all the reasons discussed with referees, but can be of interest when analysing a particular model with different optimisation approaches. This may also help to differentiate the C1 and C1+C2 approaches. Do the results from the latter justify its greater complexity? Additionally, some comment about the number of runs required would be of interest, as RC1 commented.

A new table (Table 3 in the revised manuscript) with the resulting farm power improvements from the optimisation cases depicted in Fig. 10 has been added with a related discussion in the text addressing the points of the above comment. Moreover, the number of optimisation runs required for the statistical analysis of the Horns Rev case is 50. This is specified in the fourth paragraph of Sect. 4.3 (L463 of the revised manuscript submitted in response to RC1 and RC2).

20. L504. Could you please better support the statement "For all wake models, the row-averaged probability density functions indicate an overall reduction in optimal yaw angle dependency to initial conditions for the constrained cases" by indicating from which specific aspect of the results this conclusion derives? (Comment by RC1).

The increase in probability density function magnitudes for the constrained cases indicates a more consistent distribution of optimal yaw angles for different initialisations (i.e., improved robustness). The paragraph in the manuscript has been rephrased for clarity.

21. L506. Could you please specify in which subfigures it is observed the following statement: "Higher probability density function magnitudes can be observed, with more than double the values for some row distributions"? (Comment by RC1).

References to sub-figures have been added to the mentioned statement, as well as a clearer explanation.

22. There are several comments by RC1 pointing at the benefits that stochastic optimisation could also provide to the problem under study, referring to (Kuo et al., 2020). For the sake of completeness, the authors could include some comment (e.g. in the introduction) showing this as an alternative option, not covered in this manuscript but that could also be used to address the limitations of SLSQP approaches. It is true that the reference indicated by RC1 is now included in the introduction but just as part of a mere listing of optimisation techniques without further indication. If you do not consider RC1 comments as pertinent, please provide some explanation of why.

    Similarly to the algorithm employed in Kuo et al., 2020, TuRBO is a global stochastic optimisation method. Consequently, we believe stochastic optimisation is acknowledged in the manuscript as a valid choice to address the limitations associated with gradient-based algorithms. To provide clarity, an explicit statement highlighting the stochastic nature of TuRBO has been included in the introduction and in Sect. 3.1.

23. Some parts of the authors' answer to RC2 would be of interest in the text of the manuscript. For instance, aspects from the third paragraph of the answer to comment 1 could be nicely included in the discussion. Also, the main differences between SLSQP and TuRBO algorithms stated in your answer to comment 4.

    The suggested aspects have been included in the manuscript. In particular, a discussion on model robustness has been added to Sect. 4.2.1 (in lines 325–330 of the revised manuscript) and further insight into SLSQP and TuRBO comparison to Sect. 3.1 (in lines 195–197 of the revised manuscript).

24. Please check and harmonise the references to figures throughout the text so that they fulfil the journal guidelines: The abbreviation "Fig." should be used when it appears in running text and should be followed by a number unless it comes at the beginning of a sentence, e.g.: "The results are depicted in Fig. 5. Figure 9 reveals that...".

    References to figures have been adjusted to comply with the journal guidelines.

25. According to the journal guidelines, you will be requested to include a persistent identifier (DOI preferred) for all the references. So, you could already advance those modifications from now.

    A persistent identifier has been added to all references (DOI when available).

Typos:

1. Figure 5: required space "the(a)"

2. L508. Multizone and Gaussian nominal cases would be related to Fig. 12-a and 12-b instead of Fig. 12-b and 12-c.

3. L512. Fig. 12-c instead of Fig. 12-d?

4. L519. Please eliminate "a" in the sentence "This can achieved by a permuting the turbine".

5. L642. Subscript of the rotor velocity in the text would be with capital letter "R" to match the equations.

   We thank the editor for pointing these out. We have corrected all typos.