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Interactive comment on "Wake steering optimization under uncertainty" *by* Julian Quick et al.

Julian Quick et al.

julian.quick@nrel.gov

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Response to Referee 1

We greatly appreciate the time taken by the referee to read our manuscript. We have taken into consideration and addressed all comments, questions, and suggestions from the reviewer, and we feel that the revised manuscript is now substantially stronger as a result. Changes made to the text at the request of the reviewer have been highlighted in red in the revised manuscript. In the following, reviewer comments are repeated in italics and our responses are provided in the bulleted sections of text.

The x, y labels of figure 1 are not showing up correctly.

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• The axis labels on this figure have been fixed, and we have also added arrows directing the reader to the correct vertical axis for each curve.

Page 6, line 4: The parameters are assumed to be independent, is this a reasonable assumption? How about dependence between them, how would the dependence impact the results? Some discussions would be helpful.

• We have added more discussion of the assumption of independence in the Results section. Specifically, on page 7 lines 26-29 of the revised paper, we now note that the uncertainty values assumed will be unique and different for each wind power plant, as several factors influence the ability to measure the relevant inputs to the FLORIS model. We also note that correlations, such as between wind speed and shear, turbulence intensity or yaw error, would change our results. Although we do not consider these correlations in the present study, we now note in the Conclusions on page 18 lines 7-8 that this should be examined in future work.

Section 2.3.2, line 8-9: Is polynomial chaos expansion used to approximate f_{10} for given value of mu, sigma? What are the inputs and output for the polynomial chaos expansion? The size of the training set? A bit more details can be added. Also, some discussion on the computational effort of the numerical model could be helpful to motivate the use of polynomial chaos expansion.

• We now note on page 8 lines 4-8 of the revised paper that polynomial chaos expansion was selected to compute f_{10} instead of a simple lower-order quadrature, which would require a very fine-spaced grid of quadrature points or a Monte Carlo approach involving on the order of millions of simulation evaluations. On page 8, lines 13-14 we also now reference the DAKOTA theory manual, which explains the relationship between the number of points sampled, the input dimension, the quadrature order, and the refinement scheme.

Following the earlier comment, unless I am misunderstanding some of the discussions in first paragraph of section 2.3.2, the statement in line 10-11 in section 2.3.2 may not be accurate. Polynomial chaos expansion is some surrogate modeling technique to reduce the computational effort of directly running the expensive numerical model, while quadrature is for integration, they are two different methods for two different purposes, and they cannot be directly compared.

• We agree that this is a potentially confusing point. The referee is correct that the polynomial chaos expansion approach fits surrogate models to the more expensive numerical model, however we are integrating this surrogate model in our estimation of f_{10}, allowing for fewer quadrature points and better accuracy. We have clarified this starting on page 8 line 4 of the revised paper.

Page 8, line 6-8: What is the nested sampling routine? Some explanation could be helpful, since this is related to the calculations/simulations that are done.

• We have now clarified this to note that we are referring to the polynomial chaos nested sampling routine.

Page 9, line 1: The meaning of this sentence is not clear.

• We agree that this sentence was potentially confusing, and we have subsequently expanded our discussion of how the uncertain parameters in the 11 turbine wind plant case were selected. As is now noted on page 9 lines 7-9, and starting on line 3 of page 14, we used results from the two-turbine case in order to down-select the number of uncertain parameters considered in the 11 turbine wind plant case. In particular, given the maximum VSS results summarized in Table 4 for the two-turbine case, we chose to consider only uncertainties in the wind inflow direction and speed for the 11-turbine wind plant case. This choice was driven by both the relative impacts of different uncertainties, as well as by the computational cost associated with accounting for each uncertainty. The maximum VSS for y is roughly half that for u_∞, which is itself nearly an order of magnitude smaller than the maximum VSS for θ. However, consideration of yaw offsets for each turbine in the wind plant case increases the stochastic dimension of the problem by 11, resulting in substantial additional computational expense in the OUU problem. Consequently, we only considered uncertainty in u_∞ and θ for the wind plant case, with the understanding that the approach is readily extended to include other sources of uncertainty given sufficient computational resources.

Sincerely, the authors.

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