Reply to reviewer #2
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The remarks of the reviewer are repeated in blue point by point followed by our answers, while the main modifications in the paper are red-marked in the revised manuscript.

Summary:
The authors describe an optimization method that uses data from low- and high-fidelity models employing a Bayesian framework. The authors test their optimization method in maximizing wind farm power production through micro-siting and wake steering. The authors compare the best-performing wind farm layout design from their optimization model against optimized wind farm layouts using FLORIS. The proposed framework can generate layouts with similar wind farm efficiency when compared to the optimized layouts obtained using FLORIS. For wake steering, the proposed optimization framework can overperform as compared to optimization using FLORIS. The LES-informed framework can leverage the high-fidelity model capabilities in capturing complex flow features for wind turbine siting and wake steering. The manuscript is well written, and the results are very interesting. However, I recommend major revisions to incorporate important details in the methodology and results.

We thank the reviewer for the time devoted to reading our manuscript and for providing helpful comments and feedback.

Major comments:
Incomplete description of LES framework: The authors perform an impressive number of large-eddy simulations, but the description of the model setup is lacking. The authors are simulating atmospheric flow, but do they incorporate Coriolis in their simulations? Is there a capping inversion in their model, or is the potential temperature profile constant over the entire domain? What are the boundary conditions for the LES used for wind farm layout optimization (Monin-Obukhov similarity at the surface? periodic lateral BC?)? The actuator disk model uses a constant thrust coefficient (not realistic), but how is turbine power estimated (especially for partially waked conditions, like in Figure 2)? The turbine's thrust coefficient changes with yaw angle (Gebraad et al., 2017), which might partially explain the extreme yaw misalignment for the first three turbines in Section 4.

We thank the reviewer for their analysis and suggestions. The atmospheric boundary layer that is fed as inflow to the wind farm simulations is a fully-developed, neutral (no thermal effects), turbulent boundary layer that is driven by an imposed pressure gradient (no geostrophic wind forcing and Coriolis effects). [2] offers a very insightful discussion on the similarities and differences between the two forcing approaches.
The boundary conditions for the layout optimisation problem are: periodic in the lateral boundaries, free-slip at the top boundary, and no-slip with a wall-model at the ground.
The actuator disk model computes the power as $P = Tu_d$ where T is the computed thrust and u_d is the temporally-filtered disk-averaged velocity normal to the disk plane. In our implementation (which considers a constant "local" or "modified" thrust coefficient C_T', see [2, 1]), both thrust and

power scale with the rotor-normal velocity, and are therefore functions of the turbine yaw angle. (The respective coefficients hence also change with the yaw angle, see also [5]). The predictions of our solver for the evolution of thrust and power with changing yaw angle [4] are matching those of other codes that employ the standard actuator disk method (see, for example, [5, 3]).
The above have been added as comments in an extended discussion of the LES framework in sections 2.2 and 3.1 of the revised manuscript.

Blockage and speedups: The authors report that front-row turbines produce less power than a stand-alone turbine due to blockage, and that downstream turbines can produce more power than a stand-alone turbine due to speedups. I think these statements need to be explained further. Bleeg and Montavon (2022) show the importance of including a capping inversion in the simulation domain and the sensitivity to domain size for simulating blockage. Regarding speedups, the maximum wind speed in Figure 4 appears to be close to 9 m s^{-1}, which is an $\approx 8\%$ speedup compared to freestream conditions. Furthermore, some downstream turbines are producing $\approx 10\%$ more power than a standalone turbine. These speedups can be an artifact of the width of the numerical domain. How did these speedup regions change when you tested the 3 times wider numerical domain?

The case where we tested the three times wider numerical domain is the one shown in Figure 7. In that case, the maximum streamwise velocity at hub height for the regular and extended domains was 8.845 and 8.807 m s^{-1}, respectively. This suggests that although limited, domain blockage effects are still present. In the revised manuscript, we have modified the discussion in section 3.2 to reflect the above:
"Here, an additional simulation with three times larger spanwise extent was performed to evaluate the effects of domain blockage. These were confirmed to be present but relatively small, with a $\approx 0.43\%$ difference in maximum streamwise velocity). Similar benefits owing to local blockage were also reported by King et al. (2017) and Antonini et al. (2018). Nevertheless, it is important to highlight that blockage effects are particularly sensitive to the atmospheric conditions besides the extent of the computational domain (Bleeg and Montavon, 2022)."

Computational requirements of this approach: The authors compare the optimized layouts obtained from LES- and FLORIS-informed frameworks, showing that the LES can produce better results about 70% of the time. It is important to highlight the computational requirements needed to perform the LES- and FLORIS-informed optimizations given that the layouts from FLORIS can overperform when compared to the LES-BO methodology. Furthermore, how realistic is performing 4200 LES for wind turbine siting as compared to optimizing the layout using FLORIS and then evaluating multiple possible layouts using LES?

To highlight the effectiveness of wake models in the layout optimisation problem (further to the discussion in section 3.2 of the manuscript), we have added the following comment in section 5 (Conclusions):
"…The performance of wake models was also found to be outstanding. This is particularly important, given the excessive computational requirements of LES-based layout optimisation."
The large computational demands of LES-based optimisation prevent it from being directly applicable in engineering design practices. However, the potential benefits in scenarios of increased flow complexity point towards the development of multi-fidelity methods as a particularly promising

line of research.

The authors show the capability of their methodology for optimizing a wind farm's layout and wake steering for a single turbine row. Can these two problems be addressed in the same optimization problem? Also, how feasible is it to optimize the yaw angles for wake steering for a whole wind farm rather than for a single turbine row?

The two problems can be addressed simultaneously by the proposed method. However, increasing the number of design variables (to three design variables per turbine, or potentially even more) is associated with an increase in the number of evaluations required, and thus further increases in the computational cost. Therefore, in large optimisation problems, multi-fidelity methods may be necessary to mitigate parts of the cost.
Optimising the yaw angles for the entire Horns Rev I wind farm would require a considerably larger number of evaluations, with each simulation also being costlier (a larger spanwise domain would be required to accommodate the additional rows with minimal blockage). While we believe this task could be realisable, especially given we can begin the entire farm optimisation from a well-informed state, we expect that the benefits may not justify the additional costs.

Minor comments:
Figure 4: Rotating the reference frame in Figure 4 can be confusing for the reader. It might seem as if multiple layouts are being tested rather than a single layout for multiple wind directions.

The caption of figure 4 has been modified to make this clear to the reader:
"The flow fields show the same layout exposed to different wind directions. In all cases, the wind is shown as blowing from left to right, ..."

What are the intermittent vertical lines in Figure 9 that appear in front of some turbines (e.g., turbines 11, 12, 13, 14, 16)?

These are numerically-introduced artifacts owing to the sharp and discontinuous nature of the passive scalar sources.

FLORIS can incorporate varying thrust coefficients for waked turbines. Did you try incorporating a thrust curve in your actuator disk model so that the velocity deficit in waked turbines is not underestimated?

Both FLORIS and the LES-ADM framework may incorporate information from thrust and power coefficient curves (see, for example, [6]). In the present study, we opted for the simplifiyng assumption of constant coefficients in both frameworks. However, this assumption could be addressed in future work.

References

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