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WIND ENERGY SCIENCE DISCUSSIONS

Interactive comment on "Adjoint Optimization of Wind Plant Layouts" *by* Ryan N. King et al.

Anonymous Referee #2

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General Comments

The paper deals with an important subject, e.g. the maximal power output of a wind plant by optimal placing of the turbines. The combination of RANS and adjoint is nowadays mainly used in shape optimization, so this application shows an approach that is not so widely used yet.

The chosen test cases and final case are well suited to build up the understanding of the optimization process, but I found some sketchiness of the analysis. So I would mainly suggest a more careful analysis of the results.

But overall, the paper is well written and for the most part well structured.

Specific Comments

section 2.2

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Discussion paper

Generally you talk often about something like realistic or fully turbulent flows. But in RANS it's still "just" a snapshot of the averaged flow, perhaps use steady-state sometimes instead of turbulent flow field. Reading this evoked a picture of a fluctuating flow field, which is not true.

second sentence: the information that cheap computational cost allows gradient-free methods implies that gradient methods are suitable for high computational cost. But that's only the case for low amount of design variables or very few methods. A little note on the limits would be nice.

last sentence of first paragraph: Do you expect improvements regarding the found optimum or regarding the computational effort of the optimization process?

section 2.3

generally: how do constraints and the amount of constraints influence the effort of the adjoint approach? As a well-posed optimization problem is crucial, a sentence on this would be nice. This could also be mentioned when introducing the optimization problem in section 3.1, as you could directly refer to your case.

Eq. 5: Usually this equation is given with other derivation (du/dm instead of partial operators, see: Giles and Pierce 2000) operators. Depending on the definition of u and m, this could be used differently. Perhaps add one explanation here.

after eq. 9: Can you give a reason for your statement regarding the accuracy of gradients?

section 3.3

Beginning: From my knowledge of wind farm simulations, the grid dimensions seem to be quite small. Was there a grid study or former set-up validation of the simulations you could refer to?

Is "'do nothing' boundary condition" perhaps better defined by saying "Neumann boundary condition"?

last paragraph: I am not quite sure – also when looking at your flowchart in the next section – when you are calculating your adjoints. Only on base of the averaged flow field or for each of the K wind states? Because if you could compute your complete gradients based on the very last, averaged step, this would mean an extraordinary reduction of complexity and computational effort of this approach.

section 3.4

second sentence after the numbering: you state that less optimization iterations are necessary for multiple inflow states. This is not intuitive on the first look, so perhaps move the sentence about the more convex problem upwards in order to give an explanation.

You mention line search without naming the optimization algorithm you will use. Perhaps move the description (or a shorter version of this part) of SLSQP from the end of section 3.5 to this section.

section 4.1

Plot: The speed-up is very difficult to see on the lower two plots. Perhaps adding the mean velocity in thin lines could be helpful to show where the current velocity is higher or below that value. Another idea would be to mark the areas of increased velocity, for example with shaded backgrounds.

This section is the part where the flow field, that is the base of the optimization, is investigated. Therefore, the statements are a bit weak. Can you either give a quantifying number of the error or cite some publication where this flow solver set-up is validated?

section 4.2

You justify the staggered layout with the speed-ups. But the speed-up only appears very close to the inducing turbine. Or do you talk about something like jets between

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Interactive comment

two neighbouring turbines? Also in figure 5 this becomes not very clear to me, as the maximal speed-up is less than 5% and only visible right behind the rotor disc. If you talk about two different speed-ups a clear wording has to be found.

Figure 6: The first plot for two wind directions shows a complex layout. I would have guessed either a fully occupied front row of turbines at the north and south boundary of the farm and then some turbines in between with maximal spacing in between in order to reduce the impact of wakes. Or if the speed-up effect is high enough, a pair-wise placing of the turbines along the diagonal from lower left to upper right corner of the farm boundaries, because with this layout the turbines either see the full wind or the speed-up wind from the one in front. Did you check these layouts? If so, how do they perform? How do the turbines move? Because the shown displacement of some turbines seems to be quite big, what is a bit surprising for a local optimum search. Perhaps a movement trajectory of some representative turbines helps to understand the final layouts. Discussing this most easy case more in detail also helps to understand and analyse the other results.

Technical Comments

Figure 2: Axis labels and numbers are quite small

In the figures where you show velocity fields it can be helpful to reduce the amount of colour steps (eg. between red and blue). That way differences (and speed-ups) can become more obvious.

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