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

Anonymous Referee #1

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general comments:

The paper handles the optimization of wind farm layouts using the discrete adjoint approach in CFD (solved via an FEM package in contrast to FVM codes). Instead of LES or 2D RANS, the paper uses 3D RANS in order to achieve a faster, but still reliable optimized layout, which is based on a high-fidelity model (in contrast to analytical wake models). The design parameters are the turbine positions (in contrast to control variables for fixed turbine positions) and the objective function is maximum power and AEP. The paper is very well written. The conception and scope are clear and the topic is of interest.

major specific comments:

section 4.2:

An intuitive guess for an optimized layout for Fig. 6(a) could be a staggered layout

with two rows orthogonal to the wind direction. You say that this results from nonlinear effects, speedup and flow curvature, but it is still surprising, since the wakes are more or less straight. Could there be any numerical issues in the implementation, which leads to this final layout (e.g. too high/low tolerances of the optimizer, negligence of the turbulence model in the discrete adjoints)? Did you run a simulation with a staggered grid from the naïve guess? And is it really worse than the final positioning from the optimization?

minor specific comments:

title:

The title uses the phrase "Adjoint Optimization", although the optimization is gradient-based and the gradients are computed using the adjoint approach (although other authors use a similar phrase, there is no adjoint optimization, since there are adjoints to the optimization are computed). I propose to use a title which considers this difference (e.g. "Optimization of Wind Plant Layouts using the Adjoint Approach").

abstract/section 1:

It should be noted here that you use the discrete adjoint approach.

section 1 et seqq:

It should be mentioned more often that the used RANS flow is steady-state (in contrast to unsteady RANS).

section 2.1:

A note could be made on "...simple terrain with few turbines.", since the paper does not deal with complex terrain, but in principle, the presented tool could be able to handle flows in complex terrain.

section 2.3:

1.) A note should be made that gradient-based optimizations can only find local minima (beside special, convex cases, where a local minimum is the global one). 2.) It is a little misleading that you talk about “backward in time”, but steady-state RANS is used later. A small note should be made on that. 3.) “The resulting adjoint gradients are typically more accurate than finite difference gradients”. Gradients by finite differences can be of second order, but are the adjoint gradients of second order? If not, the FD could possibly be more accurate.

section 3.1:

Why don’t you use a standard turbulence model like k-ε?

section 3.3:

The layout is rotated instead of rotating the boundaries. So after each CFD, do you rotate the layout back for the use in your optimization algorithm? A note on that should be made.

section 3.5:

The gradients of minimum spacing could be derived analytically, couldn’t they?

section 4/4.1:

You claim that the “RANS flow solver accurately captures wind turbine wakes”, but a verification/validation is not done (see also later: “providing confidence in the physical accuracy of the RANS flow solver”). You could mention that a verification/validation is not in the scope of the paper or you could refer to other publications, where the flow solver setup is verified/validated.

section 4.2:

1.) A graph with the convergence of the optimization could be shown (if there’s something interesting to see or in order to show that the optimizer is runs correctly). 2.) Is the Coriolis force included in the flow solver or why there is a curvature near the edges

of the plant? Is it an effect of the domain size?

section 5:

An idea for the future could be a comparison of your optimization setup (including a higher-fidelity model) and an optimization using standard analytical wake models.

technical corrections:

section 3.2:

1.) It should be written, which quantity is shown in Fig. 1(c).

section 3.5:

Shouldn’t there be a comma before “if”?

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