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WIND ENERGY SCIENCE DISCUSSIONS

WESD

Interactive comment

Interactive comment on "Set-point optimization in wind farms to mitigate effects of flow blockage induced by gravity waves" *by* Luca Lanzilao and Johan Meyers

Dries Allaerts (Referee)

d.j.n.allaerts-1@tudelft.nl

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This paper aims to identify the optimal distribution of wind turbine set-points to mitigate flow blockage induced by atmospheric gravity waves and hence maximize wind-farm energy extraction. The authors simulate the response of the atmospheric flow to the wind-farm drag using a recently developed mid-fidelity model, and they introduce a corresponding optimization framework based on the continuous adjoint method. The results are promising and show that a non-uniform spatial distribution of wind turbine set points can increase the energy extraction of the farm by reducing the excitation of atmospheric gravity waves. I believe this paper is of interest to the wind energy community as it demonstrates the use of set-point optimization for wind farms and highlights the potential for new optimization and control strategies to cope with wind-farm scale blockage. I do have some scientific questions and technical comments as listed below.

Scientific comments/questions

1. Line 91: In the derivation of the three-layer model, no assumptions need to be made about the vertical component of the velocity. Rather, by averaging over the height of the respective layers, the horizontal momentum equations become independent of the vertical velocity.

2. Line 130: The relation between pressure and inversion layer displacement based on the complex stratification coefficient is not due to Gill 1982 (at least not the part concerning the atmospheric gravity waves). I think it is more appropriate to cite Smith 2010 instead.

3. Eq. 17: Can you elaborate on the function of the complex stratification coefficient in the adjoint equations? That is, what do you mean with the negation of the arguments x and t. I assume this arrives from the partial integration and is similar to the sign reversal of the convective term, but it is not clear to me how I should interpret the current notation.

4. Line 235: Can you comment on the numerical resources (time and number of processors if parallelized) it takes to compute an optimal set-point distribution? I am asking because a possible application could be using weather forecasts to update the set-point distribution when gravity waves are to be expected (e.g., forecast predicts shallow boundary layers in the next few hours).

5. Line 241: How did you select the relative turbine spacing?

6. Line 301: Favourable pressure gradients are also present in the bulk of the wind-farm, whereas the velocity deficits continue to increase throughout the farm and only

recover behind the farm. I believe the favourable pressure gradients do not necessarily accelerate the flow, but are instead balanced by a higher thrust force. Physically, this would correspond to the favourable pressure gradient re-energizing the wake flows and thereby reducing the turbine losses in the bulk of the farm. Can you comment on this?

7. Section 4.1: Did you consider optimizing for a uniform set-point distribution? What are the maximum gains to be expected there, and hence how much more is there to be gained by using a non-uniform set-point distribution? How would that uniform value compare to the average of the non-uniform distribution, and would the uniform value depend on the atmospheric condition as well?

8. Section 4.1: How does the power performance of the optimal set-point distribution compare to the idealized power output when all turbines would be operating in isolated conditions? I.e. how much of the power loss due to flow blockage is irreversible?

Technical comments

* Line 389: Typo in “dispersive”

* Label A12 and A13 reference the same equation split over two lines.

* Line 573: Typo in “through”

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