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WIND ENERGY SCIENCE DISCUSSIONS

Interactive comment on "Adjoint-based Calibration of Inlet Boundary Condition for Atmospheric CFD Solvers" *by* Siamak Akbarzadeh et al.

Anonymous Referee #2

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This manuscript discusses a method of determining the inflow conditions needed to match measured wind velocities for wind resource assessments or wind farm design. The proposed adjoint-based method is a reasonable and efficient approach to this problem and would be useful to readers of the journal. Significant reworking of the manuscript, however, would greatly improve the clarity and usefulness of the paper.

1) In general, I found the notation confusing and difficult to understand. In some cases I was unable to follow the derivations because of the confusing notation. Below are a few specific suggestions to clarify or reword the notation:

a) It would be clearer if vectors and tensors were clearly identified in the text. Using

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Discussion paper

Gibbs notation, either denote vectors as boldface italic and tensors in boldface or use vector symbols above. Alternatively, use index notation. For example, it's confusing to differentiate between the vector V and (scalar?) $V(z)$.

b) What is meant by the subscripts x, y, z in equation 6?

f) Equation 8: Why not use an equality instead of the right arrow?

c) $V(z)$ is never defined. I assume it is the magnitude of the planar-averaged velocity vector.

d) Equation 12: I'm not sure what is meant by $(U, q)R$. I would guess that U and R are vectors and that term can be expanded as $U_x R_1 + U_y R_2 + U_z R_3 + q R_4$.

e) In equations (14)-(16) What do δV δp mean? What are J_Γ and J_Ω? Without knowing what this means, I was unable to follow the adjoint equation derivation.

2) I would significantly rework the structure of the paper to better integrate related ideas. As written, I'm not sure that someone could replicate this algorithm from the details of the paper.

(a) I would combine Section 3-5. Section 3 and 4 are closely related since the adjoint equations are needed to calculate the gradient. Section 5 is part of the adjoint equation derivation and should be included in Section 4. As it stands, it's hard to follow which sections are part of the adjoint-based optimization method description.

(b) Pg. 12 line 16 through pg. 13, Figure 6, and parts of pg. 9 lines 14-19 are related to the flow solver. I would put these details at the top of Section 2: "Flow Model" or with the details of the adjoint equations and gradient-based solver. It would be particularly helpful to have the k-ε turbulence model mentioned in Section 2.

3) This method appears to be related to existing methods in meteorological applications (3DVar) or in existing wind energy papers (see the 4DVar implementation in Bauweraerts and Meyers, BLM, 2019). This is touched on in the introduction, but a more

explicit discussion of how your method is related to existing approaches would be helpful.

4) Is Section 2.1 used directly in the paper? My understanding is that these inflow conditions are calculated from your algorithm. This section may not really be necessary if that is the case. Also, how are equations (3) and (4) used simultaneously? What is z_{ref}? How do you get n?

5) pg. 4, line 27: What do you mean by "error-prone"? Finite differencing is simply too expensive to really be used in a gradient-based algorithm. I think that is sufficient justification for using an adjoint-based derivation.

6) Top of p. 5: It's not really multiplication, but the inner product of the state equations and the adjoint variables.

7) p. 5, line 22: What is the effect of neglecting changes in eddy viscosity? Shouldn't changing the inflow conditions change the eddy viscosity of the simulation. How is assuming "frozen-turbulence" relevant to the RANS model?

8) Beginning of Section 4: Adjoint methods are generic and applicable to many problems. I don't think it's necessary to point out the specific differences between your application and the Othmer's application.

9) I'm not sure that Section 6 is really necessary. Showing that the gradient-based solver can find a solution is sufficient to demonstrate that the method works.

10) It would be nice to show the application of the optimized inflow boundary condition for evaluating a specific site's wind resources or designing a wind farm. This is the real application and importance of this work, so I would make this a bigger point with an example.

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