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Atmospheric Measurement Techniques Discussions

Interactive comment on "Automated Wind Turbine Wake Characterization in Complex Terrain" *by* Rebecca J. Barthelmie and Sara C. Pryor

Anonymous Referee #3

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Summary: The manuscript presents a method for detecting the location of the wake center from ground-based scanning Doppler lidar measurements, which is then applied to detect the wake of a wind turbine on a crest. Results show that the detection of the wake works in the majority of the cases (against a subjective control). Further, the results show that, after an initial raise in the near wake region, the wake center descends following the terrain slope with a height a. g. l. depending on the stability parameter.

Positive are the description of the challenges of scanning a wind turbine wake with a movable-head Doppler lidar and the interesting findings on the wake center evolution (especially considering the general sparsity in literature). Weak points are the description of the wake center detection itself and the presentation of some results could be

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improved (see main comments below). If those issues are addressed, the paper could be considered for publication.

Main comments:

1) The description of method of the wake center detection should be improved (see detailed comments for pages 10 and 13 and Fig. 4).

2) The paper should touch upon possible false-positive detections of the wake center (see detailed comment on Fig. 12).

3) The presentation of some results could be improved and the observed dependencies could be quantified (see detailed comment on the lower panel of Fig. 16 and Fig. 17).

Language: I noticed a few missing comma and typos (see detailed comments for the ones I noticed). Given that I am not a native English speaker, there are probably more than those. Some phrasings are complicated and required me to read sentences twice to understand them.

Detail comments:

Abstract, line 10: insert “a” in “by scanning” (the information that it is a ground-based scanning Doppler lidar and that Perdigão is in Portugal could be included, too).

Abstract, line 11: “possible wake cases” could be more precise so that it relates to the wind speed and wind direction criteria.

Abstract, line 12: The first association with “spit centers” is for me the (idealized) double-peak/donut structure of the wake near the nacelle. I believe the meaning here is more general and should be described more precise.

Abstract, line 16: In connection with the comments to Fig. 16 and 17, the word “strongly” could be replaced with a quantitative statement.

Page 1, line 28: remove inner brackets at the citation

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Section 1.2: It would be a great improvement, if the flow behaviors introduced in this section would be picked up by the discussion of the wake center location in section 4.4.

Page 3, line 3: “in” instead of “is”

Page 3, line 4: not sure, but I believe it is “interaction with” instead of “interaction of”

Page 3, line 5 and line 9: L_h and H are introduced twice.

Page 3, line 20: Based on Eq. (4), it seems that an overbar indicates averaging. Then the sensible heat flux in the text should also have an overbar.

Page 4, line 12-13: The text in the brackets seems to be redundant to Eq. (8).

Page 5, Eq. (11): The variable x is sometimes an uppercase letter and sometimes a lowercase letter. Are they the same? If they are the same, then its usage should be consistent.

Page 5, line 14: It might be better to start with the dependency of k on various ambient parameters and then introduce the assumption of k=0.075 to get some approximate figures.

Page 9, line 39: Is this azimuth range (199-295°) the same for all elevation angles and other heights have more/less points (i.e. azimuth resolution changes) or is the azimuth range also different at other elevation angles?

Page 10, line 20: I believe “wakes” should be singular.

Page 10, lines 23-25: I did not understand this refinement of the first estimation. Why is it done for wind directions of exactly 210° or 240°? As I understood it, this refinement works similar to first estimate, but with an extended vertical range and more elevation angles. Is that correct? (The sentence could be rephrased for better understanding).

Fig. 4: A lot of the boxes have unclear labels and in some cases I cannot understand what the algorithm is doing exactly. I believe some of my problems come from an

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inconsistent use of variables/names. Below are the problems I have:

a) Differentiation of VAD DIR (wind direction retrieved from VAD scan?), PPI DIR (wind direction from the arc scans?), wake direction (the direction from the wind turbine to the Doppler lidar?), DIR (no idea), and wake DIR (short for wake direction?)

b) VAD DIR is used in the third check, but later it is checked, whether VAD values can be retrieved.

c) What is checked at the box with the label “Inflow U/DIR”?

d) WTHHH should be WTHH?

e) Wake center location has arrows coming in from both “Vertical slice 2-6D” (I assume this would be the un-interpolated data) and “Cubic spline interpolation” (the interpolated data). According to the text, it is only detected from the interpolated data. If not, how are they combined?

f) I assume that the box with “Gaussian fit” and “Wake metrics. . .” is part of the mentioned future work and not relevant for wake center location analyzed in this paper? Then they could greyed-out or removed.

Page 13, line 7-8: The velocity deficit is introduced with two variables (delta U and v_d).

Page 13, line 11: What does the “X D +/- 20 m” in the brackets mean?

Page 13, line 13-14: The sentence “Then the plane of radial velocities is discretized into 20 m horizontal planes and a mean radial velocity is computed.” needs some clarifications: a) Are the radial velocities averaged or a corrected velocity depending on az/el of the beams and wind direction? b) If I understood correctly, the 20 m are referring to the vertical height of each plane – so that in the end a U_0 is gained that only depends on y and z?

Page 13, line 15-16: The detection of the wake center should be explained in more de-

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tail. As I understood it, the algorithm searches the nearest local maximum from x=z=0. I did not understand what is meant with “refining that location by checking it moving around the grid cells”. From the next paragraph, I understand that an interpolation takes place before detection of the wake center - that should be mentioned here.

Fig. 5: It should be stated that axis are distance from the lidar.

Fig. 6 and Fig. 7: x and z could be used for axis labels.

Page 16, line 13: comma before but

Section 4.2 (headline): I believe “Data availability” would better describe the content of this section.

Page 22, line 4: I do not understand what is meant with “wake centre of gravity”.

Page 22, line 12: “at” instead of “as”.

Page 22, line 14: comma before but

Page 22, line 14: I believe it should be either “identifies a part of the wake” or “identifies parts of the wake”.

Page 26, line 11: Remove inner brackets and replace with “or” or “; also see” (I first thought it is a reference to section 1.2 in Whiteman and Doran).

Fig. 12: The example of wake type B (and comparing it with with type D) makes me concerned about misdetections. How does the wake center of type B cases develop downwind – i.e does it evolve in a continuous manner or is the wake center “jumping arround” for successive downwind distances? For an automated wake detection, a quality flag system providing indication on the reliability of the detected wakes would be a great enhancement (beside the above, other possible routes could be the spatial standard deviation compared with the amplitude of the detected wake center or the number of local minima/maxima above a certain threshold).

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Fig. 16, lower panel: The usage of the symbols to show the hour of day is not working, because they cannot be read within the figure. And I could not make sense of the text in the top right (I got the z/L intervals, but what is the meaning of the S, N and U?). In my opinion, the time dependency is better illustrated in Fig. 15 and therefore Fig. 16 should focus on the dependency with the stability parameter. One idea could be, to pick one exemplary downwind distance and plot distance from WTHH vs. z/L. Then a linear fit /correlation (if significant) could quantify the relation with stability parameter. The remaining downwind distances could be reported in the text or in a table.

Fig. 17: The color coding is unfortunate, because two similar greens and purples are used. Grey scales or a linear color map (e.g. blue -> red) would better illustrate a dependency. Similar to the comment on Fig. 16, the dependency could be quantified with a linear fit and correlation (if significant).

Section 5 (headline): “Summary” would be a better description for the content of the section.

Page 28, line 10: What is physical forcing?

Page 28, line 18: Insert “to” between “applied identify”

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