Wind Energ. Sci. Discuss.,
https://doi.org/10.5194/wes-2018-78-RC2, 2019

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Interactive comment on "Detection of wakes in the inflow of turbines using nacelle lidars" *by* D. P. Held and J. Mann

Anonymous Referee #2

Received and published: 20 February 2019

General Comments:

The paper discusses one of the problems that can arise when measuring wind direction using a nacelle lidar, that the assumption of horizontal homogeneity used to derive the wind direction is not valid when a wake impinges some of the lidar measurement points. However, using a novel approach, the authors discuss how the spectral broadening in the Doppler spectra from the lidar measurements due to small scale wake turbulence can be used to identify measurement periods when wakes are present. Using an empirical correction method based on the measured spectral broadening, the wind direction during waked periods can be corrected.

The paper is well written overall and explains the novel algorithm relatively clearly. However, I believe further discussion on two topics described below should be provided

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Discussion paper

to strengthen the paper. Additional specific comments are provided as well.

One area I feel could use more discussion in particular is missed detections and false alarms. What is the probability of a false detection of wake impingement from the experiment, and the same for missed detections when wake impingement actually occurred? How were these probabilities accounted for when deciding which thresholds to use for the detection algorithm?

The other area that I believe should be discussed more is the applicability of the algorithm to different wind turbines, sites, and wind conditions. This research demonstrates that the LOS Doppler spectrum can be used to detect waked conditions well for the site and conditions analyzed. Although briefly discussed in the conclusions, it is unclear what steps would need to be taken to implement the method at a different site with a different rotor size, turbine spacing, or atmospheric conditions. For example, simulations of the algorithm for different conditions using CFD would be a useful approach. Further analysis of the wind conditions during the experiment, such as turbulence intensity and atmospheric stability, would help show how applicable the algorithm is to a variety of wind conditions.

Specific Comments:

Section 1: There could be value in identifying when a turbine is waked for purposes such as wind farm control, but this is not discussed much in the paper. Do you have any ideas about the potential usefulness of the algorithm in wind farm control strategies?

Pg. 5, ln. 18: "The effect is strongest for negative turbine misalignments" From Fig. 2 it appears that the impact of increasing wake deficits on the measured direction bias is roughly equal for all misalignments. Can you explain this statement further?

Pg. 5, ln. 18: "The kinks that appear for the negative turbine misalignments" In Fig. 2, it appears that the kinks are for some "positive" misalignments.

Pg. 6, ln. 20: "high frequency components of the streamwise component increased fourfold in the wake" How far behind the turbine was this increase found?

Eq. 12: By using the LOS Doppler spectrum TI to detect wake impingement, what would happen if a naturally occurring gust was present on one side of the rotor but not the other? Even if the turbulence is the same at the two beams, the lower velocity at one beam would cause an increase in TI, which could trigger a wake detection.

Pg. 7, ln. 2: "calculated from one minute average spectra." Did you look at the sensitivity to different averaging times, and how did you settle on one minute?

Pg. 7, ln. 11: "At the initialization the algorithm requires some observations to establish correct values of the running averages." Explain in more detail how the initialization of the algorithm is performed. Does the algorithm require that the wind conditions during operation be similar to the conditions during initialization? And how frequently does the algorithm need to be calibrated? Especially for detecting full wake conditions when the absolute TI is used to detect wakes, how do you account for the possibility of the freestream TI increasing after the algorithm is initialized, in which case higher freestream TI could be detected as a full wake?

Fig. 5: How comparable are the wind conditions for these two spectra? For example, was the freestream TI the same for both periods, so that the difference should be due to the impact of the wake? Some further discussion would be appreciated.

Pg. 13, lns. 1-5: Does the empirical relationship used to correct wind direction measurements when wakes are detected need to be determined for every site where the algorithm is used? Or is the relationship found valid in general? Additionally, after correcting the wind directions, how does the RMS error between the corrected lidar wind direction and the sonic anemometer compare to the error during freestream conditions? Although the corrected directions look reasonable, some quantification of the error would strengthen the results.

Technical Corrections:

Pg. 6, ln. 28: "From both properties mentioned above" Which properties are being referenced here?

Pg. 7, ln. 17: "Further, data from a meteorological mast at a distance of 120 m…" Incomplete sentence

Pg. 8, ln. 16: "In situations where the right half of the rotor …" Check grammar in this sentence.

Pg. 10, ln. 11: "TI_LOS2" -> "TI_LOS1"?

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