Review: *Wind turbine wake detection and characterisation utilising blade loads and SCADA data: a generalised approach*

General Comments

This article presents a model for the detection and characterisation of wakes via estimating wind fields from blade load data. The model is well-explained, and the paper reads very clearly, with informative visualisations of the results. The approach developed here would be of interest to readers of this journal. There are a few areas that could be expanded on, including a deeper look into the accuracy of the wake impingement classification and wake characterisation. Additionally, a detailed flow-chart of the full process would guide others looking to reproduce these results.

Specific Comments

1. Metrics / Accuracy:
    a. Is there a metric by which it is decided whether a wake is impinging on a rotor, e.g. a velocity deficit threshold? In line 39, "significant" impingement in terms of both magnitude and time is mentioned, but there is no further detail on the training data labelling for wake detection and classification. Could the details of how flow was classified as containing a wake be included in e.g. Section 3.4?
    b. For the reported wake detection accuracy of 91% in Section 3.4, did this vary by "class" of impingement, e.g. was the model more or less accurate at predicting partial impingements? This may be relevant for future work using this model in wake steering controllers.
    c. It would be informative to include accuracy metrics of related wind flow estimators or wake classifiers, to provide context for the model(s) developed in this paper.
2. Results:
    a. When the trained model was tested on a new receiver turbine in Section 4, were metrics for the accuracy of the wake detection or classification models calculated? In particular for the wake impingement predictions under 9% turbulence intensity, were the results in e.g. Figure 15(d) confirmed to be sensible given the increase in turbulence compared to training data?
    b. Is there an explanation for the "fake" wakes seen in Figure 17(c) / 13(a), or a proposed method to alleviate this? These simulated areas were mentioned as potentially resulting in mis-classification, is there any way to quantify how often this might occur?
    c. Did the superposition of wakes or the position of the turbine deep within the farm have any effect on model's accuracy in Section 4?
3. Flow Chart: It would be very useful to have a more detailed flow chart (i.e. more in-depth version of Figure 3) that includes the steps take for e.g. pre-processing to extract wind field from turbine blade loads, fitting of DCT factors, constructing wind fields, sampling frequency and fitting wake parameters.
4. Pre-Processing Diagram: A diagram of the turbine loads and how they are transformed would be informative in Section 3.3.
5. CNN Model: More detail on the CNN architecture is needed in Section 3.4.

6. <u>Conclusions</u>: The conclusions are very brief, they should be expanded to include a summary of the accuracy of the models developed, as well as a short description of current limitations before future work.

<u>Technical Corrections</u>

1. General: Please ensure all acronyms are defined with capitalisation at the first use, and used consistently thereafter.
2. General: Please be consistent with using either double or single quote marks.
3. Line 25: Please clarify "the aforementioned task".
4. Line 27: "altered" does not give enough information about the features of waked flow that lead to higher loads, suggest re-wording to e.g. "experience a **more turbulent** wind field".
5. Line 34: "yaw control" usually refers to control of a single turbine to follow the inflow, the standard term for farm-wide yaw optimisation is "wake steering"; suggest using this term instead.
6. Line 50: "**to date**"
7. Line 52: Typo: "turbine**'s** wake"
8. Line 65: Suggested re-word: "that **the** focus of the current work is **to develop** a solution"
9. Line 87: Please include a reference for the microscale length scale.
10. Figure 1: I think it should be $A_1 = A_0/(1-a)$?
11. Line 109: "as **a** *wake*"
12. Line 110: Please include a reference for the "2-4 rotor diameters" statement.
13. Line 119: Please include a reference for the Gaussian wake model relations.
14. Line 125: I think "**differs**" is meant rather than "defers"?
15. Line 135: The explanation around atmospheric shear and the location of maximum turbulence needs more detail.
16. Line 145: For the infinite wind farm case, the power extraction from the turbines is balanced by entrainment of kinetic energy from the flow above; the explanation given here seems to reference increasing vertical height in the ABL?
17. Lines 153 & 154: Unclear wording, is the data from the first 10 rows and first 8 rows of turbines per farm? And is the power loss between 45% and 70%?
18. Line 181: Suggested re-word: "distinguishes the **various impacts** of turbulence"
19. Line 187: Suggested re-word: "The **widely-discussed method** introduced by…"
20. Line 196: Suggested re-word: "in incoming **flow**"
21. Line 217: The phrase "accurate approximate estimation" does not make sense.
22. Line 225: "wind farm **flow** control" for consistency.
23. Line 264: This sentence is quite convoluted, please re-word.
24. Line 276: What kind of evaluation metrics were used to determine the model had reached sufficient accuracy?
25. Line 298: Please specify whether "left" and "right" are as seen looking at the front or the back of the turbine.
26. Line 314: A brief description of conditional dependence would be useful here.
27. Line 315: Typo: "**the** following"
28. Line 348: Typo: "the the"
29. Line 354: "with **a** few"

30. Line 358: Could a brief list of all the inputs be given, either in the text or as a table, for clarity on what the 96 variables are?
31. Line 361: Suggested re-word: "are ~~being~~ processed"
32. Line 382: More description of the "simple models" is needed.
33. Lines 396 & 411: It would be easier to read the proportions than the actual numbers of simulations, e.g. 10% instead of 1,120 on line 411.
34. Line 414: Suggested re-word: "case **was** approximately 91%"
35. Line 430: Definition of the "rotation angle" needed.
36. Line 433: "D" has already been used as dimension e.g. "2D".
37. Equation 6 (Line 446): Is the integral missing dt?
38. Section 3.6: This would make more sense as the first part of Section 4.
39. Line 460: Suggested added wording: "centrally located **within the wind farm**"
40. Line 480: "**have** a low mean RMSE"
41. Line 503: Suggested re-word: "simulations **showed** that"
42. Line 505: The term "amount of turbulence" is ambiguous, since the turbulence intensity has not changed but the wind speed has increased. Please re-word for a clearer explanation.
43. Line 527: Suggest using "**South and East**" rather than "**S and E**".
44. Line 534: Typo: "**inverse**"
45. Line 598: Suggested re-word: "after ~~the~~ consideration".
46. Line 599: Suggested re-word: "Firstly, ~~the~~ wind farm flow control brings **the largest benefits for below** rated operation"
47. Line 620: Suggested re-word: "(and **solution to** some of"
48. Line 643: "**2D**" and "**1D**" without hyphen for consistency.