

# **Review of ‘Revealing inflow and wake conditions of a 6 MW floating turbine’**

**by Angelou et al.**

## **Summary of the article:**

The authors present novel results on the wind upwind and downwind flow characteristics of a floating offshore wind turbine using LiDARs. To my knowledge, this is the first time such an extensive measurement of the wake of a floating wind farm has been performed. In this study, the turbine wake is characterized (wake center, velocity deficit, upwind and crosswind radial wind speed gradients) in relation to a range of parameters (atmospheric stability, wind speed, turbulence intensity, distance downwind, LiDAR sampling statistics, yaw misalignment).

## **Significance:**

This study makes a first and important methodological contribution to the field, by suggesting the use of LiDARs, that have the advantage of providing both temporal and spatial measurements of the wake. This study is especially interesting considering the great scarcity of field observations of floating turbine wakes. Some limitations to the study are highlighted.

## **General overview:**

The research topic is well presented in the introduction, and the abstract clearly states the study objectives. The article presents a new methodology that is well adapted to the study of the wake of floating offshore wind turbines. This approach consists in the deployment of wind LiDARs. The scientific results are very promising. The results are produced through the analysis of a new and valuable dataset, as a result of a rigorous experimental setup.

Despite the very promising dataset, the article struggles to clearly transmit the key messages of the article to the reader. The article’s structure is confusing amid mistakes, repetitions, and an unnecessary count of 22 figures, some of which are not presented or described in the text. Furthermore, the study does not comment and discuss the results at sufficient depths. For example, the authors seem to observe contradicting effects of the yaw on the center of the mean wake center (Sect. 4.4) and struggle to explain the seemingly absent correlation between shear, yaw with the induction factor (Sect. 4.2) but do not sufficiently investigate possible explanations, and do not bring these issues to the discussion and conclusion. This is unfortunate, as these observations should be highlighted, so as to allow for improvement in future work.

In conclusion, I believe that this article should be published. However, major corrections are required in order to improve language, structure, and physical interpretations. I advise the authors to thoroughly read the article again to find possible typos, and provide a more concise and dynamic description of the work. Please find my comments and suggestions below.

## **Major comments/questions :**

- I find that the article is too long, boasting 22 figures. In Section 4.3 you lose control of your figures, and begin to list them instead of integrating them into an organized presentation of your results. Furthermore, you do not (from what I have seen) talk about or present Fig. 10D. In the same fashion, I have not found where you present and discuss Figs. 11 and 12. If you don’t discuss them, you may have to remove them. However, they are interesting. So you should maybe consider reducing the overall size of the article, and focus on the results that you do want to clearly present.

- What were the operating characteristics of the turbine ? What is the influence of operational variables such as turbine rotation speed, blade angles, etc, on the wake ? Maybe you don't have access to this data, but then you must very clearly state that you have not considered this, and that this is remaining research to be done on this (which should be indicated in the discussion and conclusion).
- In the discussion, I highly recommend that you make a clear summary of your assumptions, and the limits of your study. Among this, you should mention that you assume stationary conditions over your 30 minute periods, etc.
- What are the possible effects of ocean waves on the motion of such a platform ? Can we expect an interaction between the wake and atmospheric stability ? I think this should be better clarified in the conclusion, to provide an idea of what the perspectives are.
- In the conclusion, no strong link has been made between the fact that this is a 6 MW turbine. What is the significance of this study in the context of other wind turbines deployed around the world on floating platforms ?
- You should consider changing the structure of the article. Indeed, Section 4.5 'Wake characteristics' is very much the same as Section 4.3 'Wake'. Maybe 4.5 should be a subsection of 4.4, as these are the case studies.
- In section 4.5.1, you study the center of the wake. I think this deserves a deeper discussion considering that this is an active field of research, especially in the case of floating offshore turbines. Also, I am not convinced as to why, in Figure 17, cases I and IV are not the same. Is this because the higher winds are damping the transverse displacements ?
- You should check the whole text for clarity, and to correct the text in respect of editorial guidelines. For example, write 'Figure' and not 'Fig.' at the beginning of a sentence. When you present a figure for the first time, make a dedicated sentence to present it (axes, colors, curves, etc): 'Figure X presents...'. Other examples are listed below.

**Minor comments:**

L19: Reformulate sentence. What do you mean by a 'good wind resource' ?

L19-21: I suggest that you reformulate the sentence

L84: Is 1 Hz enough ? Why ?

L89: Do you know why there is a 3% decrease ?

L102: Please clarify 'area covered by the rotor'

L109: After the end of the sentence is probably the best place time to explain how long it takes to make a full PPI scan, as we don't want this important information to be buried later down in the text

L122: I wonder if this paragraph should be in this article. You only show this in the appendix. Also, is the HS2 the same as HS4 ?

Figure 3: The orange curve is not very clear. Maybe select a more visible color ?

Sect. 2.2.1: Can you clarify if you used the SNR to filter data ? Did you use a SNR threshold ?

Sect. 3.1: You present your assumptions. What about stationarity ? Do you assume that you are stationary in terms of incident wind speed conditions at 10 minutes ? At 2 hours ? I would appreciate that you mention stationary here, and later in the text.

L167: replace by 'weak at measurement height' and you should provide references for this assumption

L179-180: Maybe discuss what possible effects you are neglecting. How could this be affected by attitude (pitch etc) ? I see you already refer to Borraccion et al. 2017 later, maybe try to link the sentences ?

L258: Could you explain what you know of the stability on that day, so as to support your argument?

L264: You should explain the figure in the text. Also, please clarify this paragraph.

L266: Maybe you should show a fitting function to help show the trend. As it is hard to know where all your points are, it would be interesting to statistically illustrate your trend (add a fitting function, and provide statistical values).

L271: You are presenting Fig. 6 in brackets at the end of the sentence. Figure 6 deserves better, and should be presented and described in a clearer manner. You may also remove the mention of the SCADA, as this has already been presented before.

L280-282: This carries an important message. This deserves to be made more obvious, and move out of the middle of the paragraph.

L292: I suggest that you add references on actuator disk models.

L295: Please clarify sentence, as I do not understand it. From what I currently understand, it seems that the non-correlation is explained by the fact that they may be correlated.

L306: Maybe you should explain why TI is different for similar U10 wind speeds ?

L315: Please specify in what figure I can see this wind shear increase etc

L325: As of this paragraph, you use 30 minute, 2 minute, and 10 minute averages. Could you clarify this choice ? Maybe you can detail that you will be doing this a bit earlier, such as at the beginning of the section. It is quite hard to follow when you bring new averaging types at the beginning of each paragraph without prior notice.

L321-324: Could you provide some clearer explanation of why Fig. 8D does not show these 'stripes' ?

Figure 9: I wonder how useful this figure is to the discussion.

Figure 10: Maybe consider showing the slices (such as in Fig. 10c) for other  $x/D$  values ? I also realize that you do not refer to Fig. 10D in the text. If you don't mention it, then consider removing it. Finally, maybe you can remind what LiDAR you used in the caption of the figure.

Figures 11 and 12: They do not serve much in the discussion, maybe they should be removed ? However, I think that Figure 11 is quite interesting, and carries a more interesting and simpler message than Figure 14 that could be removed instead, and replaced with a couple of sentences.

Figure 13: I don't see the values at the higher end of the  $x/D$  range (near 9.6 in yellow), but they should appear on the front.

Figure 14: Also present the vertical axis

Figure 15: The label should specify 'horizontal velocity' ?

Figure 16: You show the constant  $du/dz$  and  $dv/dz$ , which you assume at the beginning of the article. Maybe you should make this clear, as this is quite a nice result.

L430: You should consider reminding the reader how you are detecting the wake center. Also make a proper presentation of Fig. 17.

L434: Where does this  $2^\circ$  value come from ?

L461: what is 'a' in the equation ?

### **Typos etc:**

L8: Replace by 'along the horizontal plane' ?

L23: replace by 'realistically model', or '...flows realistically'

L31: Add 'For example, the results...'

L32: remove 'for example'

L32: remove 'to' by 'in', add comma after 'recovery'

L39: 'Focused'

L45: Replace 'enhancing' by 'increasing'

Figure 1 label: Replace 'whose y-axis' by 'where the y-axis'

L72: Remove 'have been'

L80: Replace 'relative to that' by 'of the'

L81: End sentence at nacelle. New sentence: 'The MRU measured the rotation...'

L86: Replace 'Section' by 'Sect.'

L87: New paragraph after 'longitudinal'. And the longitudinal what ? Longitudinal axis ?

L95: add 'used for this study were the Wind Iris' ...

L101: Replace 'Leveled' by 'Level'

L103: Replace 'points' by 'dots' . Replace 'defining' by 'that define'

L109: replace 'spanned from' by 'spanning'

Sect. 2.2.2: Maybe add something like 'As described in Sect. 4.3, the Galion will be filtered for cases where the scans are horizontal'.

L153: Replace 'upwind and wake conditions' by 'upwind and downwind' ?

L171: Remove 'Further'

L172: A repetition, as you also define the induction factor alpha later (L177).

L191: Replace 'i=1,2,3 and 4' by 'i=1,2,3,4' ?

Sect. 3.2: Maybe it would be interesting to present why you want a radial speed model. What is your objective here ?

L221: I suggest a new paragraph after 'deficit', and write 'We assume, using Equation 9...'

L228: I suggest 'The solver was applied in each streamwise distance, and the measurements at  $x/D = 6$  were chosen as an input...'

L229: Suggest 'This choice is supported by the sufficient number of measurements'

L234: Suggest 'a total of 10529' and remove 'in total' later

L236: End sentence at 'periods'. Begin new sentence with 'They were selected'

L241: I suggest a new paragraph here

Figure 4: Consider moving the figure to this page

L277: Suggest replacing 'selection' by 'choice'

L293: Replace 'gets larger than' by 'exceeds'

L318-319: Replace with 1D, 2D, 4D

L324: Provide reference to figure instead of 'In the plot'

L325: Provide reference to the 'selected data', which is this selected data ?

L394: You should properly introduce Fig. 13

L397: Error with references