

High-resolution offshore wind resource assessment at turbine hub height with Sentinel-1 SAR data and machine learning

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REVIEW

GENERAL COMMENT:

The paper describes a machine learning (ML) approach to vertically extrapolate SAR-derived wind speeds in offshore domain. The problem addressed in the analysis is very relevant, and the solution proposed leverages state of the art techniques, and would be beneficial for the offshore wind energy community. However, at the current stage the quality of the presentation of the analysis is limited, and many more details are needed to fully understand and evaluate the procedure followed by the authors in the application of the machine learning models. Therefore, I invite the authors to consider my comments below, before I can recommend the paper for publication.

As a final note, this reviewer is not an expert in satellite retrievals, so this review mainly focuses on the atmospheric science and machine learning part of the study.

MAJOR COMMENTS:

1. In general, the main limitation of the current draft is the lack of scientific rigor in the presentation of the approaches used in the analysis. Please remember that you want to make your work replicable after one has read your paper. Below I have added several specific comments to provide examples of this issue. Please, re-consider your technical and statistical explanations and add details where needed. Also, the use of the word “error” and some other qualitative terms should be carefully revised, too.
2. The error quantification in Section 4.2 comes after the ML-derived wind speed distributions have been corrected based on hub-height observations in Section 4.1. If I got this right, this step does not make much sense from a scientific point of view. You are presenting error metrics for the ML-extrapolated winds after using hub-height observations to correct them: first, why should one even consider applying a ML-based approach to derive hub-height winds if observations are available? And then, the ML error quantification should NOT involve any correction using hub-height observations, as this would of course “artificially” improve the ML performance.

SPECIFIC COMMENTS:

1. Line 27: “floating lidars” are not a “method” to retrieve hub-height wind speed. Please rephrase.
2. L. 33: what type of “heterogeneities” are you referring to in the offshore wind context?
3. Please add references to the first and second paragraphs of the introduction (currently, the first paragraph has zero).
4. L. 38: a lidar IS a remote sensing instrument, too. Please rephrase to better convey your comparison between lidars and satellite-based retrievals.
5. Lines 65-70: please specify in which section you deal with each of the tasks you mention in the paragraphs.
6. Line 80: wasn’t WRF developed at NCAR? Add a reference.
7. Please add a reference for GFS, too.
8. Did you run WRF in chunks (e.g., separate runs every month) or as a single run?
9. Figure 1: please make the fonts bigger (in the axes and the colorbar). Also, specify in the caption what the considered time period is. Also, please specify if latitude is N or S, and if longitude is E or W.
10. Section 2.1: which planetary boundary layer scheme did you use in WRF? Please clarify.
11. Throughout the paper, please consider using a different color scheme. The rainbow color has quite a lot of issues, see for example <https://www.climate-lab-book.ac.uk/2014/end-of-the-rainbow/>
12. Line 93: again, lidars are not in-situ instruments.
13. L. 95: please provide more details on the QC – is there a reference?
14. L. 100: if two lidars were not used in the analysis, I guess there is no need to include them in the map and in the text.
15. Table 1: “lowest” and “highest” instead of “first” and “last” when talking about altitudes.
16. Figure 2: typo on the y-axis label. Also, what do the shading of the dots represent?
17. Line 115: what do you mean by “correct on average”? Please provide quantitative assessments.
18. L. 147: what do you mean by “around 5 AM or 5 PM”? Please be specific and provide a plot/histogram/table if necessary.
19. I don’t think Figure 3 is needed. In the text, you can simply state that you use data from 2017 to 2019 because the satellite constellation was not fully operational before that. No need to insert an histogram here (if you really want, please move it to the supplementary information).
20. What is the difference between the map in Figure 1 and what is shown in Figures 4 and 5? If it is just a matter of the years being plotted, I would suggest plotting the 2017-19 data in Figure 1 directly, so that Figures 4 and 5 can then be removed from the paper as they do not add much information.
21. Figure 6: “number” instead of “nb”. Also in the caption, please specify which methods you are using to provide more context.

22. L. 199: how do you quantify the “error”? What does “around” mean? Please be specific: you want to make your work replicable!
23. Figure 7: please specify the height at which wind speed is considered (y-axis label). Also, is time on the x-axis UTC or rather local time? Please specify.
24. L. 214: please provide context as well as references for the sentence “In addition, numerical model outputs are not as reliable as in-situ data, especially in coastal areas.”. Also, what do you mean here with in-situ data? Once again, lidars are not.
25. L. 222: from the text, it is not immediately clear the purpose of these two ML models. This becomes clear later in the section, but please state that here too.
26. L.224: you need to define what “error” means for you with a precise statistical metric. Bias? RMSE? R^2 ? Or...?
27. L. 225: what do you mean by “such a correlation”? Please provide a threshold or a quantitative measure of what you did.
28. L. 226: please clarify what the azimuth angle, the incidence angle, the elevation angle, the backscatter are for a reader not familiar with satellite data retrievals.
29. Figures 8, 11, 13: please label the x-axis with actual names (rotated to get enough space), not numbers.
30. L. 239: how was the test set built? Was a random half of the data, or...? At all sites, or...?
31. L. 240: please provide additional details on the machine learning models and their training. Did you use cross-validation? What hyperparameters did you set? What is the structure of the neural network chosen? Did you train the model at all sites together, or at one site at a time?
32. L. 240: are you talking about mean bias? Please clarify.
33. Figure 9: again, specify what the different colors for the dots means. Also, larger fonts please. Also, is this for the test set only? At all sites? Please clarify.
34. Figure 10: “error” is too vague. Do you mean bias? Also, I would suggest mobbing this figure to the supplement, as all the information in it is already included in Figure 9, and it is not discussed in detail in the main text.
35. Section 3.2: the first paragraph could be moved to the introduction.
36. Section 3.2: once again, more details are needed to fully understand how the machine learning approach was applied. See my other specific comment above for specific questions that need to be addressed.
37. Figure 12: the y-axis label is not clear to me.
38. Do you have any explanations on why for some lidars in Fig. 12 the performance decreases with height, while for some others it actually increases?
39. Figure 15: please correct the y-axis label.
40. Section 4.1: it is not clear to me how the correction is performed. Please provide additional details to make your work replicable.
41. In Section 4.2, you state that “Due to the short distances between the Lidars used in this study, such a validation could not be realized here.”. To me, lidars that are about 100 km from each other would still allow for a validation using one for training and another for testing.

- 42.** Figg. 16, 17: the y-axis labels are not specific enough.
- 43.** You can combine Figures 18 and 19 into a single one with two panels. Same for 20-21 and 22-23, and 24-25.
- 44.** A data or code&data availability statement is missing.
- 45.** A conflict of interest statement is missing.