

REVIEW OF WES-2021-159

Offshore wind farm cluster wakes as observed by a long-range scanning wind lidar

authors:

Beatriz Cañadillas,
Maximilian Beckenbauer,
Juan J. Trujillo,
Martin Dörenkämper,
Richard Foreman,
Thomas Neumann,
Astrid Lampert

Summary:

The manuscript entitled “Offshore wind farm cluster wakes as observed by a long-range scanning wind lidar” presents data collected with a scanning lidar during an offshore field campaign and compares to WRF simulations with and without the wind farm parameterization. The comparison shows very good agreement between model results and observations for most wind direction sectors and atmospheric stability conditions, which helps to establish the reliability of WRF predictions. However good the comparisons, the ultimate goal of the paper remains somewhat unclear. If the authors intend to perform validation of the WRF-WFP, there needs to be much more detail regarding the implementation of the model, known points or sources of uncertainty, and validation methodology. If the authors are creating a public data set for other researchers to use in future validation studies, much more detail needs to be included about data collection, quality control, and access to raw instrument data. Offering clear messaging about the purpose of the publication will help. Otherwise, the paper parses as, “WRF with the WFP matches lidar measurements better,” which is not a novel contribution. A discussion section might also help the authors clarify what results are important, and what the analysis contributes to the wind energy, mesoscale modeling, and remote sensing communities.

Comments:

- Abstract — Probably “quantify” or “characterize” wakes and wake impacts, in addition to simply detecting them. This sentence would be a good opportunity to tell readers what to expect in your work. The abstract also indicates that airborne measurements are compared to lidars, which doesn’t seem to occur in the text.
- Abstract— Error is noted as 30% in the abstract, but 45% in the conclusions. Is this inconsistent or are the authors discussing different points?
- page 1 — “which can be transferred to other regions.” The meaning of this phrase is not clear.
- page 2 — “the first phase of a potential offshore wind farm to assess accurately the wind resource,” preconstruction or resource assessment phase?

- page 6, line 127 — It is not clear what these coordinates imply. Azimuth and elevation? The unobstructed azimuth angles visible to the lidar (i.e., everything not within the sector 20° to 160°)? If this is the case, how are lidar measurements shown in the figures below obtained for this sector?
- Figure 8 — Linear interpolation across such a large range is sure to introduce uncertainty to the results, particularly near the wind plans. How do these measurements compare to the WRF model results? Are the green and yellow dashed lines relevant to the information in Figure 8b? Since those wind farms are downstream of the flights, I'm not sure what they communicate. Also, the spacing of dashed lines indicating wind farm clusters is very different from Figure 8a to 8b. Any idea why this is if they are showing measurements along the same transect? "...the closest flight traversal upstream of the lidar measurement point $x = -0.33$ km)" Can this be made more clear in the figure? I believe that this refers to the line closest to the black diamond in Figure 8a. Is that correct?
- page 14, end of Section 3.1 — How are the different scales reconciled. WRF, Lidar, and the instrumentation on the aircraft all make measurements at significantly different scales and resolutions—effectively observing different phenomena.
- Figure 9 — Showing scanning lidar returns would help to understand how the measurements and model results compare. Please show selected scans, or time averages, and give some indication of how much data are collected, measurement uncertainty, etc.
- Figure 10 — Please show histograms that data are fit to and fit quality. Also, R2 contains fewer observations than the other sectors. How does this impact the fit quality or the analysis?
- Figure 11 — Unstable conditions look to be bimodal, from WNW and WSW. Both peaks are captured in R4, indicating that there may be problems with statistical convergence in the other sectors. Observations during neutral conditions are spread over 2 sectors. Does this impact the quality of the analysis?
- page 18 — "Nevertheless, the reduction in wind speed caused by the wind farms in the other regions can be clearly seen." The polar plots in Figure 12 are very interesting (I love the maps of the wind farms in the background) but are difficult to interpret. Were the WRF simulations really long enough to provide an estimate of wind speed for all the stability conditions and wind direction sectors? Do the lines represent mean wind speeds? Are these the wind speeds at the lidar location or where the lidar scans at 120 m? At what elevation angle? The influence of wind plant wakes is also less pronounced than indicated in the text. Other than perhaps in the stable case (and only for R3), wind plant wakes are difficult to see in Figure 12.
- Equation (2) — It is unclear whether this metric quantifies error in a time series of velocity (i.e., how closely does WRF match the observed wind speed as a function of time), error between average velocities, stability-binned observations, etc. Please describe the error metric in more detail. Also, this definition casts the WRF simulation as the reference signal. How is uncertainty in the WRF simulations included in the analysis?
- page 18 — The two error metrics might be more easily understood as ϵ_{WRF} and $\epsilon_{\text{WRF-WF}}$.
- Figure 13 — It is difficult to understand what is important in this figure. Why does WRF-WF under or over predict the wind speed in certain sectors and heights? How is the reader to understand where the measurements are made (e.g., at the lidar location, at XX distance along the line of sight, etc.)? In the caption, please note as (a) and (b). Each subfigure has a top row.
- page 21 — Please include a discussion section. It is difficult to tell from the text which results are important, and what the authors are trying to demonstrate. What is the importance of the study?
- page 22 — "The smallest, but still most significant differences..." What makes them most significant? Statistically significant? Is significance tested?
- page 23, line 431 — This is unclear, do the authors mean, "... in this way we can reduce, but not eliminate, measurement error."?