Ship-based lidar measurements for validating ASCAT-derived and ERA5 offshore wind profiles

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My main problem with this paper is that your aim is to provide a means for offshore wind resource assessment which is an alternative for ERA5, but

1. You still need ERA5 to modify ASCAT
2. You do not take into account wake and blockage effects. This is probably okay for now (there are no wind farms yet in the Baltic according to https://map.4coffshore.com/offshorewind/), but it will become a problem during the lifespan of the wind farm when more wind farms are built (the effect is already significant on the North Sea). ERA5 does not take these effects into account and ASCAT is too course to measure them (SAR can: WINS50 - Winds of the North Sea in 2050 | Publications *I Wijnant, A Stepek (2023): Fit(ch) for shipping Wind farm wake effects at 10 m height, KNMI WINS50 Report.*). The only way to predict how much power a wind farm will produce during its lifespan is to understand and properly model wind farm effects and then to use this knowledge/ these models for future wind farm scenarios. The old method for wind resource assessments (measure-correlate-predict) no longer works.
3. Mean values of the wind are not relevant if you want to predict power: you need to look at correlation on a 10 min (or hourly) basis, especially for wind speeds between cut-in and rated (power curve).

The concept of doing lidar measurements on a ferry is interesting and probably even more interesting on the North Sea where you no doubt can measure wind farm effects this way. How to compare these measurements to ERA5 is as you describe not straightforward (ship-motion compensation algorithm), comparing them to ASCAT I presume even harder. You can only do that when ASCAT is available which is around 09 and 19 UTC when the ferry is in the harbour or reasonably close to the coast and you say that there the ASCAT-signal is disturbed? Are there other measurements available near the harbours (or in the Baltic Sea) that you could use to compare the lidar measurements to?

I think that comparing ERA5 to 'ASCAT extrapolated to hub height with ERA5' is not very useful (and scientifically sound). What would be interesting is to do triple collocation with (1) ASCAT-winds extrapolated to hub height with your method (or different methods) based on ERA5, (2) ship based lidar measurements and (3) a mesoscale model in hindcast mode, for now without Wind Farm Parametrization (WRF? Unless you can get hold of COSMO-CLM or HARMONIE?). The aim of your paper then would be the best possible extrapolation of ASCAT to hub height. Why that is useful is something you will have to explain (not for wind resource assessments).

Comments more in detail:

- Bias ERA5 at hub height 0.5 m/s is also what is found on the North Sea in Characterisation of offshore winds for energy applications — Research@WUR and at Cabauw in Energies | Free Full-Text | Dutch Offshore Wind Atlas Validation against Cabauw Meteomast Wind Measurements (mdpi.com). NEWA comparable to ERA5 (at least on the North Sea). Undisturbed winds in DOWA (2008-2018) and WINS50 (2019-2021) are much better than ERA5 (including correlation) and the domain

covers most of the Baltic Sea, but hourly data unfortunately not available for 2022 and 2023 when you have the lidar measurements (Home | Dutch Offshore Wind Atlas; WINS50 - Winds of the North Sea in 2050).

- Line 52: Unclear sentence: *Lastly, the trustworthiness of satellite retrievals remains a knowledge gap, due to the lack of available in situ datasets for validation especially in deep water regions.*
- We know that the Dutch part of the North Sea (DEEZ) does not experience a trend in offshore wind speed, only an Interannual Variability (IAV) of 3.5 and 4% for sites in the northern part of the DEEZ and between 4 and 4.5% in the southern part of the DEEZ (Inter-annual wind speed variability on the North Sea | Report | KNMI Projects). Is any information like this available for the Baltic Sea? How representative is 28-6-22 until 21-2-23 for the wind climate in the Baltic Sea? This you can check e.g. with ERA5 data (compare ERA5 28-6-22 - 21-2-23 to ERA January1940-now).
- Line 143: (fig 3) maybe I missed it, but what ASCAT data did you use?
- Line 189: (typo): *Several methodologies to vertical satellite extrapolation…* not to, but for.
- Line 201: *This method involves a long-term correction of atmospheric stability effects, obtained from the numerical model dataset ERA5, along with an adaptation of the MOST to vertically extrapolate the satellite wind measurements.* What is long-term about it? Why the name '**long-term** extrapolation method'?
- Line 203-205 not clear: do you mean that a wind profile can be stable up to a certain height and above unstable and that this 'long-term extrapolation method' can handle this?
- Line 206-217 not clear: what is the difference between the 'instantaneous stability correction' and the 'long-term stability correction'?
- Line 221-268: so basically the stability correction has only 2 values for C per height which are the same for the whole Baltic Sea, one for stable and one for unstable. It does not matter how (un)stable the atmosphere is or whether the grid box is near the coast or further offshore: correct?
- Line 302: (fig 7). You compare the collocated approach (only ERA5 stability information at moments when ASCAT overpasses is considered) to the full campaign approach (all ERA5 stability information from the whole duration of the campaign is used). Both approaches do not include spring which is often the most stable period (cold sea water and warmer air above). Also, mean wind speed is not really relevant for wind resource assessments. So I do not really understand the sentence: '*This highlights the robustness of the employed methodology and indicates that the dataset size allows for an accurate characterization of atmospheric stability conditions during the campaign and along the entire ship track*'.
- Line 307-320: 'pronounced instability in the morning?' Why would ERA5 produce stronger unstable conditions (lower 1/L) in the morning at Nynashamn? What do we know about the water temperature near Nynashamn and how it is modelled by ERA5 (shallower/warmer water between Bedaron and the mainland maybe?)? ERA5 has grid boxes of 31 km^2 so model values are probably very land-contaminated in that area: can you show the ERA5 grid boxes near the harbours? What is the prevailing wind direction? Basically ERA5 and ASCAT are not very good in coastal area: maybe you should take them out of your analyses?
- Line 341 (fig 9 10m validation): compare to *Validation of DOWA ('undisturbed wind' = HARMONIE without WFP) with ASCAT (too coarse to measure wind farm effects)*

at 10 m height: TNO report - DOWA validation against ASCAT satellite winds | Report | Dutch Offshore Wind Atlas.

- Line 341 (fig 9 100m validation): so we can conclude that ERA5 is internally fairly consistent (profile depends on ERA5 stability parameters)?
- Line 354: *'… highlighting the consistent overestimation of wind speed from ASCAT at this height'.* At 100m this is not ASCAT, but ASCAT extrapolated with ERA5. And we all know that ERA5 is not unbiased at 100m (0.5 m/s underestimation) so you cannot draw this conclusion. See also Line 364/365.
- Line 364/365: Characterisation of offshore winds for energy applications — Research@WUR and Energies | Free Full-Text | Dutch Offshore Wind Atlas Validation against Cabauw Meteomast Wind Measurements (mdpi.com)
- Line (section 3.3): you need to address the uncertainty in the lidar measurements. are the differences that you find with ERA5 and/or modified ASCAT significant? Page 14: TNO report - DOWA validation against offshore mast and LiDAR measurements | Report | Dutch Offshore Wind Atlas

Other relevant literature:

- Comparing available Wind Farm Parametrisations for mesoscale models (Fitch and EWP best): Review of Mesoscale Wind-Farm Parametrizations and Their Applications | Boundary-Layer Meteorology (springer.com)
- Wind farm effects modelled with COSMO-CLM and Fitch WFP: https://wes.copernicus.org/articles/9/697/2024/
- Quadruple collocation: KNMI Technical report - Uncertainty analysis of climatological parameters of the Dutch Offshore Wind Atlas (DOWA) | Report | Dutch Offshore Wind Atlas.
- Validation of HARMONIE+Fitch WFP with e.g. lidar measurements: A One-Year-Long Evaluation of a Wind-Farm Parameterization in HARMONIE-AROME - Stratum - 2022 - Journal of Advances in Modeling Earth Systems - Wiley Online Library
- Wake effects: https://www.researchgate.net/publication/340838550_Long-range_modifications_of_the_wind_field_by_offshore_wind_parks_-_results_of_the_project_WIPAFF
- Internal boundary layer caused by change in surface roughness (coast): An effective parametrization of gust profiles during severe wind conditions - IOPscience