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Review of the article

“Advancing airborne Doppler lidar wind profiling in turbulent boundary layer flow - an LES-based optimization of traditional scanning-beam versus novel fixed-beam measurement systems “

submitted by Gasch et al.

(AMT)

Review Summary

LES simulations are used to compare the performance of airborne Doppler wind lidar measurements with conventional scanning techniques and a multiple fixed-beam approach for probing planetary boundary layer (PBL) winds. The paper is well written and clearly demonstrates a few of the advantages that a fixed-beam system would have especially regarding the reduction of the representativeness error in a turbulent wind field which is particularly interesting as such a fixed-beam approach is easily implementable with novel all-fiber-based laser transmitters. Hence, it is recommended to accept the paper manuscript after addressing the points that are raised below

General comments

- The main rationale of the paper manuscript is to compare the wind results retrieved from a fixed-beam approach (1 beam nadir, 4 beams off-nadir) with the one obtained from a scanning approach (continuous scanning with a 20°/s scanner rotation speed). However, a more suitable comparison to a scanning approach would actually be to consider a step-and-stare scanning with 5 LOS measurements (1 nadir and 4 off-nadir) comparable to the one provided by the fixed-beam approach. Considering 1-s for each of the LOS measurements, such a system would provide wind data for all 5 seconds with similar LOS information as available from the fixed-beam measurements, however, with a temporal discrepancy. Similar scanning schemes are already applied to airborne wind lidar systems. Thus, it would be recommended to replace or update the current analysis with such a scanning scheme. This would also further confirm and strengthen the benefit of using a fixed-beam approach for current wind lidar systems.
- Somehow related to this issue: In chapter 4, you investigate the error dependency of the elevation angle and the number of fixed LOS beams. Would a similar optimization procedure also be possible for a (step-and-stare) scanning approach? Probably, also scanning schemes could be optimized for the respective situation and would for instance easily allow correcting for crabbing/crosswind.
- As airborne wind lidars are also often used to probe the entire troposphere, it would be very useful to comment on the performance of a fixed-beam instrument in such a case. Probably there is no need to perform advanced LES simulations for that. But could you at least comment on the wind measurement performance in non-turbulent flow as it is expected in the free troposphere?
- It is appreciated and understood that LES simulations provide a lot of advantages for system optimization. Anyway, wouldn’t it be useful to directly compare the performance of a fixed-beam and a scanning system e.g. by ground measurements? Such a comparison would give further insights into the different approaches even without knowing the actual wind field truth. Although it is clear that such kind of measurements does not have to be included in

this paper, it should be stated that such kind of measurements are foreseen to be performed in the future.

General comments

- Page 2, line 37: O(10 km): Actually, this is constrained by the "old" scanner motors that are used. With an optimized system, horizontal resolutions of e.g. 4 km are feasible. Furthermore, this option is using 21 LOS! if 5 LOS would be used, the horizontal resolution would be ~1 km. This should be put into context here.
- Page 2, line 54: five independent lidar systems: Probably, you are talking about beams or LOS directions, right?
- Page 2, line 55: What is actually the vertical resolution of the lidar measurements (pulse length) that you are considering? 30 m? Do you use similar assumptions for the fixed-beam and scanning system?
- Page 3, line 83: retrieval error introduced by turbulence: It would be nice to read the number that you get (quantitatively)...how large can this error get, and how large is it typically.
- Page 4, line 98: question → questions
- Page 4, line 108: higher surface sensible heat flux: Is it still a realistic number or is it significantly higher than in the real world?
- Page 8, lines 173 ff: Rotation speed: Is 20°/s the maximum that can be reached without significant losses due to the lag angle? Have you, of curiosity, performed a similar analysis with a rotation speed of e.g. 35°/s? It would be interesting to state if this significantly influences the performance of the retrieved winds.
- Page 8, line 191, “zenith”. Shouldn’t it be nadir, as you are downward looking?
- Page 8, line 199: along/across-track components: Having these 4 LOS measurements (along and across track) would also be very beneficial for GW research, e.g. flux retrieval as recently shown in Witschas 2023.
- Page 11, line 262: Could you give examples of how the values change for each reference truth? Is it more cm/s or m/s? Would be helpful to read the numbers here.
- Page 11, Eq. 1: What is MAE standing for? Is it mean absolute error?
- Page 23: lines 536 ff: This is only true when equally separating the different LOS. What about an unequal separation e.g. by keeping the fore and aft beams? Have you ever considered such an option?