Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC2
https://doi.org/10.5194/amt-2021-417-RC2, 2022
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Comment on amt-2021-417

Anonymous Referee #2

Referee comment on "Scan strategies for wind profiling with Doppler lidar – an large-eddy simulation (LES)-based evaluation" by Charlotte Rahlves et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-417-RC2, 2022

Scan strategies for wind profiling with Doppler lidar - An LES-based evaluation

by

C. Rahlves, F. Beyrich and S. Raasch

AMT-2021-147

General comments

This manuscript investigates the impact that turbulence has on the profiling of wind in the atmospheric boundary layer with a Doppler lidar. Most single-instrument wind profiling retrieval techniques assume horizontal homogeneity, which is rarely the case in a turbulent atmospheric boundary layer. This study uses virtual measurements within a large eddy simulation (LES) model in order to examine the error associated with making this assumption. Different scan strategies and scans at different elevations from zenith are evaluated. That there is an error in making such an assumption has been known, but has previously been rather difficult to quantify without a reliable reference profile, especially at altitudes above typical mast-top heights.

The topic of optimal scanning strategies for obtaining vertical profiles of the horizontal wind is highly relevant and timely given the rapid increase in long-range scanning Doppler lidar deployments for both research and operational networks. The results from such a study are valuable for designing and optimising scan strategies, which need not be the same for instruments in different measurement scenarios. The paper is well-written, presented in a logical order, and the explanation of the methodology is clear.

There are a few items that should be explored further in order for this manuscript to be ready for publication.
It is understood that it is not possible to generate new LES simulations for every case, however, the dataset already generated should be sufficient in order to answer the questions.

Specific comments and questions

The uncertainty for each retrieval configuration is given as a single value for the whole profile. How does the uncertainty vary with altitude, and particularly with scanning angle? The vertical profile of the uncertainty arising from the impact of turbulence is of clear interest, especially if there is a relationship between altitude and the size of the coherent turbulent structures being generated. Figure 2 shows that the larger scanning circles may match or exceed the coherent turbulent structure scales by 500 m altitude, but not at low altitudes (for this example). Figures 3 and 5 also suggest that the impact may vary with altitude substantially, particularly with respect to the zenith angle used. Since the profiles have already been generated, including such results (and adding a figure or two) would greatly enhance the impact of these results.
Quantifying any vertical variation in the uncertainty is important because a major goal of the wind profiling community is to provide an estimate of the overall retrieval uncertainty (i.e. combine these uncertainties with the instrument measurement uncertainties, which are likely to vary with range).

This study generates the averaged wind profiles by averaging the radial measurements first from all scans within the averaging period, before the wind retrieval is performed. What is the impact if the wind retrieval is performed per scan, and the retrieved wind profiles then averaged (in vector form)? Does this make a difference to the conclusions? This may be important in operational situations where rapid update is requested (e.g. a wind retrieval is provided within five minutes for aviation forecasters or for data assimilation); waiting for 30 minutes may not be an option for these users.

The difference in performance between the 6-beam VAD and 24-beam VAD is a surprising result, although the authors do provide a reasonable suggestion for why this is the case. As clearly stated in the manuscript, this study was only intended to quantify the impact of turbulence on wind retrievals and not to attempt to create a fully-featured Doppler lidar simulator. However, all retrievals presented here implicitly assume that the radial velocity measurement has no instrument measurement uncertainty. What would be the impact on the retrievals if a random uncertainty with a standard deviation of 0.1 m s-1 (for example) was added to each radial velocity?

It is understood that it is not possible to generate new LES simulations, however, the dataset already generated should be sufficient in order to answer these questions.

Technical comments

Line 2: Suggest using 'Doppler lidar scanning' rather than 'Lidar scan'.

Line 5: Suggest 'virtual Doppler lidar measurements' in place of 'virtual measurements'.

Line 14: Suggest 'measurable impact' instead of 'relevant effect'.

Line 16: Suggest 'monitoring air quality' instead of 'air quality control'.

Lines 21-22: Do you mean 'Long-range scanning Doppler lidar'? Not all Doppler lidars have this range. Is vertical resolution an important part of this statement? If so, give a typical resolution. Do you mean 'nearest 100 m in range' as the minimum height depends on both the minimum range and the choice of elevation angle.

Line 26: Replace 'to expected' with 'to be expected'.

Line 36: Do you mean the scales of turbulent motion relevant for Doppler lidar? This may be true for DNS but for LES this would depend on the both the temporal and spatial configuration.

Line 40: Replace 'like' with 'as'.

Line 41: Do you mean one scan sequence - i.e one VAD scan at one elevation?

Line 44: Replace 'Those' with 'These'. Be clear here that you do not include the radial measurement (instrument) error.

Line 49: Replace 'such features as cellular structures, streaks or roll convection is' with 'features such as cellular structures, streaks or roll convection are'.

Line 64: Replace 'reference' with 'the reference profile in the LES simulation'.

line 67: Replace 'confidence of' with 'confidence in'.

Lines 85-86: Suggest stating 'the vertical profile of the horizontal wind' rather than 'vertical wind profiles' here and elsewhere in the manuscript (e.g line 88).

Line 93: Is it strictly necessary for the beam to rotate clockwise? Can state that the beam is then rotated in azimuth.

Line 103: Italic 'n'.

Line 114-115: Is this always the case? Could sample N-E-S-W for example (less time spent scanning), or sample all 4 simultaneously. Also note that this describes only one version of the DBS scan, there are also 3-beam and five-beam variants.

Line 122: Should u, v, w, denote the wind vectors rather than the components?

Line 183: Replace 'truth' with 'reference'.

Line 196: Replace 'buoyancy to shear driven' with 'buoyancy-driven to shear-driven'.

Line 199: Replace 'literature' with 'the literature'.

Line 237: Replace 'until a turbulent flow' with 'until turbulent flow'.

Line 240: Replace 'domain averaged resolved-scale turbulence' with 'domain-averaged resolved-scale turbulent'.

line 484: Only out of the zenith angles studied in the manuscript!