

Review of “An LES-based airborne Doppler lidar simulator for investigation of wind profiling in inhomogeneous flow conditions”

By Gasch et al.

Summary: This is an interesting and useful paper that utilizes output from a small-domain, large-eddy simulation to examine wind retrieval errors from an airborne Doppler lidar. The premise of the study is good, but there are a significant number of revisions needed. While the writing is not terrible, it is far from publication worthy at this point. I provide many fixes listed below, but have not gone through the whole document as that should be the job of the authors. The paper is much too long and I didn't have the time to get to everything. I had many major and minor comments on the methodology section that I only got briefly into the results section. I will review the results section more clearly on the second round of revisions.

Recommendation: Major revisions

Major comments:

- (1) The writing style, English and grammar needs work and many comments are listed below. I stopped after several pages because it was taking too much time. Significant re-writing and organizational changes are needed in the manuscript. I also think the paper is much too long. It appears that this journal does not have a page limit, but it would help readers to shorten the discussion in several places and remove sections that are not needed (some examples given below). The paper reads a bit like a dissertation with too much background and drawn out detail. A published paper should be more concise without sacrificing understanding of the problem. Please shorten the results section, it looks like too much information is presented and it might not be worthy to publish all of it.
- (2) Throughout the manuscript the word “homogeneous” and “inhomogeneities” are used and this represents a critical aspect of the study and results. For example, “...mismatch between assumed homogeneous wind field models and the wind field inhomogeneities during the measurement process”. These are ambiguous terms and I don't understand how they are being used in this context. Since they represent critical points of the paper, it is hard for me to assess the method and results. The authors need to lay out in detail what they are referring to here and clarify this throughout the manuscript. Are you talking about wind variability below the scale of the instrument footprint, grid spacing of the wind retrievals, something else?
- (3) The LES domain size of 5 km X 5 km X 1.8 km is extremely small and I have doubts that this domain will represent a realistic environment to test the lidar wind sampling. The authors state that a single flight through the LES does not yield sufficient statistics. However, making 25 different aircraft trajectories through a very small box, probably does not generate any real independent statistics since the retrieved winds are sampling

almost the same flow (the decorrelation spatial scale is probably larger than the box itself). It appears the grid spacing of the wind retrievals might be 1.3 – 1.9 km for along/across track. Given this spacing, I don't think the authors can generate independent flight tracks and statistics through a 5 km X 5 km domain. The authors should try their simulations with a flow in a larger domain (with coarser resolution) in order to study a more realistic environment and allow for independent statistics.

Specific comments (some major, some minor):

Page 1

Line 2: should say "...additional insights **relative** to ground-based systems..."

Line 2: what does "spatially resolved" mean here? This term is too ambiguous.

Line 3: "...prepares the ground...", is poor English and needs a change.

Line 4: spell out LES for the first time used; what is meant by "first"? Note that other studies have used large eddy simulations to study remote sensing instruments.

Line 6: I believe it should be "...wind profiles **in** inhomogeneous flow...".

Line 7: Need to clarify with numbers what is meant by "acceptable error margins". Acceptable is ambiguous and could mean very different things to different people.

Line 7/8: sentence that starts with "Results allow for determination..." should be removed. This is an obvious outcome of the simulations.

Line 8: What is meant by "flow inhomogeneities"? Seems like this is key since much of the manuscript mentions this, but again, this term seems ambiguous to me.

Line 16: What is meant by "short horizontal averaging distances"?

Page 2

Line 3: Need a comma after "benefits".

Line 11/12: "considering both wind profiling and nadir measurements of the wind field"; I don't understand the difference between these two things as it is written.

Line 13: What is meant by "mean" horizontal flow? Average over space/time and what scales?

Line 18: I don't understand how winds are retrieved through "inversion of the beam matrix", this sounds like an incorrect statement or writing error. Winds are retrieved by inverting the least squares fit between the model and observations.

Line 25: "...assume homogeneous conditions throughout the sample volume.", what is meant by this statement? One can't measure things that are sub-grid-scale, but I don't understand what this is referring to.

Line 28: Statement about how high elevation angles are used to constrain the footprint. Tilt angles closer to nadir will provide a shorter slant path and thus smaller footprint, but there are other reasons for choosing this steep tilt. Some things could be hardware limitations, range limitations and attenuation.

Line 29: I think it should be "measured radial velocity" and not "retrieved radial velocity".

Line 34: I am still confused on what is meant by "homogeneity assumption".

Page 3

Lines 15 – 17: Sentence is too long, need to break up for clarity.

Line 24: Need a comma after "capabilities".

Line 25: Need a comma after "systems".

Line 29: "challenged" should be "challenges".

Page 4

First paragraph: I don't understand what "assume homogeneous wind field and inhomogeneities during the measurement process" means in this context. Need to make significant changes to clarify this and possibly make a diagram to illustrate what this is referring to.

Line 16: Need a period after "follows" instead of a colon.

Page 5

General question: what is this a large eddy simulation of, homogeneous, isotropic turbulence? The domain size of 5 km X 5 km X 1.8 km is extremely small and I have doubts that this domain will represent a realistic environment to test the lidar wind sampling. The authors state that a single flight through the LES does not yield sufficient statistics. However, making 25 different aircraft trajectories through a very small box, probably does not generate any real independent statistics since the retrieved winds are sampling almost the same flow (the decorrelation spatial

scale is probably larger than the box itself). The authors should try to find a simulation with a larger domain (with coarser resolution) to test the sampling and/or mention that the results of this study are limited to very idealized flow conditions.

Page 6

Line 19: 65 m/s seems like a low speed to me; what type of aircraft is this instrument targeted for?

Lines 20 – 25: regarding the difference between aircraft heading and ground track...I assume you are talking about drift here. Note that Guimond et al. (2018) found an error in the Lee et al. (1994) mapping equations for Earth-relative coordinates, which don't contain a correction for drift. If you are incorporating drift into your mapping coordinates, this correction should be applied.

Guimond, S.R., J.A. Zhang, J. Sapp and S.J. Frasier, 2018: Coherent turbulence in the boundary layer of Hurricane Rita (2005) during an eyewall replacement cycle. *J. Atmos. Sci.*, **75**, 3071-3093.

Line 25: I don't understand this sentence and the bold claim that this is the "first presentation of a correct airborne sampling simulation", please explain more clearly.

Page 7

Top half of page: I am confused with this section and Appendix A1. The aircraft position (lat,lon,height) are provided by the GPS on any aircraft and the mapping equations provide locations of the pulse volume centers relative to these positions. Can't the authors just generate a realistic aircraft position vector (possibly from real data) and sample the model winds with that? This extra stuff seems irrelevant. If there is a large aircraft head wind, then the plane might only go forward very slowly and the wind retrievals would only cover a small region. In reality head winds are usually very small relative to the aircraft speed so I don't understand the motivation to get into all this detail. Just use a realistic aircraft position vector because ultimately this will be applied to real situations.

Line 26: Is the 20-second full circle scan time (3 revolutions-per-minute) the lidar scan rate used in the remainder of the study? So with the aircraft speed of 65 m/s, the along-track spacing is 1.12 km? Make these parameters more clearly stated in the paper. Also, what is the grid spacing of the wind retrievals?

Section 2.4 Retrieval – nadir as an example application: I suggest removing this section. The paper is getting much too long and this method has little practical use. Also, the authors say that "wind profiling" is the focus of this study rather than the nadir method.

Page 12

Line 15/16: "The model is given by the beam geometry...". As stated, this is incorrect, the model is the radial velocity equation, which includes the beam geometry.

Line 22: "...the wind field is usually assumed to be homogeneous...". Again, I don't understand what you mean by homogeneous here. See major comments.

Page 13

Equations (8) and (9): The matrices U , S and W are not defined so I have no idea how they are used. It is hard for me to evaluate this paper without proper identification of variables.