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Atmospheric Measurement Techniques Discussions

Interactive comment on "Wind sensing with drone mounted wind lidars: proof of concept" *by* Nikola Vasiljević et al.

Anonymous Referee #2

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1 General comments

In the manuscript by Vasiljevic et al. a proof of concept is presented for a drone-mounted lidar for wind measurements. This concept is an important development in wind measurement technology and opens a lot of possibilities for scientific applications. The results that are presented are very promising and are definitely worth publishing in the journal "Atmospheric Measurement Techniques". I have some concerns about the presentation of the results and requests for changes which the authors should consider before submitting a revised manuscript:

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Discussion paper

- Drone-mounted lidar measurements are introduced in this manuscript as a possible replacement for ground-based lidar measurements or meteorological masts. I am very skeptical if this is a realistic scenario, given the logistical constraints that drone measurements have. With this I mean flight time, regulations, operation in all weather conditions (what are maximum wind speeds for example? What about rain?). The authors mention in the conclusion that a lot more development needs to happen before drones can be a serious alternative for power and load verification. However, I think that even with the present research version of this system, a lot of important measurements towards validation of ground-based lidars, studying of wake dynamics and especially turbulence research can be done. I think these applications should be emphasized much more. For this purpose, I wish to see a comparison of turbulence spectra between sonic anemometers and drone lidars for the presented measurements.
- The description of the state of the art is very weak on external references to both, drone-based measurements and short-range lidars. Most of the references are DTU-internal, although a lot of work is done world-wide on Doppler wind lidars. What are other CW-lidar systems and how is the used system different. Drone measurements are the topic of many research groups within the ISARRA community. It would be good to evaluate the presented system to other concepts which exist internationally (for example sonic anemometers or flow probes on drones). I want to urge the authors to improve their literature research and give credit to other researchers working in the field.
- A major concern for many drone-users are regulations and flight permissions. It would be great if the conditions for flights at the Riso campus could be explained in the experiment section.
- More specific comment are given below.

2 Specific comments

2.1 Abstract

p.1,l.1: The authors mention substiantially lower costs at the very beginning of the abstract and thus the manuscript, but do not mention the costs of the presented system at all. Can they make any comment on the costs? If not, please remove the statement.
p.1,l.8: I suggest to make the statement "Generally, very good agreement was found" a little more specific.

2.2 Introduction

p.2,l.20: Maybe any kind of precipitation should be added to problematic conditions for lidar measurements.
p.2,l.9: Give references for CW-lidars for wind energy research or atmospheric research in general. Same for pulsed lidars.
p.3,l.11: The explanation that the AOM can be eliminated should go into the system description in Sect. 2. A literature review of other methods to sense wind with drones would be very adequate in the introduction. There are a lot more references than Brosy et al. 2017.
p.3,l.20: Are measurements above thick forests with a drone lidar with fibre connection to the ground really realistic?

2.3 Section 2

p.4-7, Fig. 1-3: Instead of pictures of the single components, it would be good to have a picture with the lidars mounted on the drone gimbal.
p.3, l.8: What does 100% duty cycle mean here?
p.5, Tab. 1: Please add lidar wavelength and weight of the telescopes, as well as the focal range that can be adjusted.
p.5, l.9: "... with payload." How big is the payload?
p.5, ll.10ff: If I understand correctly the system has three GNSS-systems, plus another DGNSS system. This seems quite excessive. Isn't the RTK-DGNSS-system more than enough? Real-time DGNSS is not a synonym for RTK. RTK needs a feed of correction data from a nearby base station (not on the rover) to achieve the cm-accuracy. Is this really given in the setup? I think the most important feature are the two antennas for improved pitch and yaw estimation. With the short baseline of only 25 cm it is however quite questionable if this information really improves the IMU-information. Has this been evaluated? Please be momre specific in this explanation and distinguish between a dual-antenna setup with a baseline between the two antennas on the rover and an RTK setup with a baseline between base and rover that can be up to a few kilometers and I am not sure if this is really given here. If not (as suggested in the discussion), it is not relevant in this study and should not be "advertised" here.
p.7, Fig.3: Please indicate the lidar telescopes. Since they look much different than in Fig.1, this is quite confusing. I suggest to remove Fig. 1 and label Fig. 3 accordingly.
Section 2: How big is the actual take-off weight of the system in this configuration?

p.8, ll.1-14: I think it does not really add much to the study to present the preliminary tests with yet another system that has not been fully described, so I suggest to just skip this test and only present the results of the POC system introduced in Sect. 2. Figure 4 could be removed in my opinion as well because there is no reference instrument or further evaluation.
p.8, l.22: Does 'VT' and 'TW' have any specific meaning?
p.9, l.1: Please mention what kind of sonics are mounted.
p.9, l.2f: I am not sure if I understand the positioning procedure. What does it mean that adjustments were done using the GoPro camera?
p.10: I would suggest to make a list of flights that are analyze in this study, with flight time, flight height, telescope orientation and wind and weather conditions.
p.11, l.12: Giving a probed area of 7.07 m x 0.15 m seems a bit awkward and confusing. Maybe it would be easier to understand if you say that homogeneity at the two measured lidar focus points needs to be assumed.
p.13, ll.11ff: I think this conclusion can not be drawn. The higher R^2-value is probably due to the higher number of samples at 70 m. The standard deviation is mostly a measure for turbulence in this case, and in fact the slope of the linear regression is furthest from one. I doubt if a statistical analysis of these very short measurement periods makes any sense at all. I would suggest to show the time series and a comparison of the vertical profiles of tower and drone lidar, including the standard deviation as error bars and quantifying the mean difference instead of the linear regression and point clouds.
p.15, Figs. 11-15: I would suggest to combine these plots in some way. It is probably not necessary to show the single telescope radial wind speeds. I do also not think that the point clouds and linear regressions are necessary and even statistically significant. So, maybe just show the comparison of time series of drone lidar horizontal wind compared to sonic anemometers on all heights in one plot with subplots.

2.5 Section 4

p.20, l.11f: I actually disagree and think this is a very good way to show the influence of the out-of-line wind component on the reconstruction from a single beam. I do not think this could be done any better with drone-internal data which is subject to many other uncertainties. However, a comparison of these drone-internal methods with the lidar would be very interesting in future, of course.
p.20, ll.16ff: Has any indication been found that the downwash distance depends on wind direction and wind speed? If not, this could be a field of further research and a reason to be more conservative in future tests as well.
p.21, ll.23ff: I would recommend to not describe technical details of possible future developments in a scientific paper. Depending on how developments go, concepts might have to be adapted and it is not really relevant for the scientific ideas and visions.

3 Technical corrections

p.2,l.15: Use the proper
texteurosign instead of EURO.
p.3,l.23: The abbreviation POC is only introduced in the abstract, but should be introduced in the main text as well.
p.4,l.5: There is something wrong here: what is a "demonstrator for an nairborne wind speed requirement"?
p.20,l.9: Some grammar issue here.

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