Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2017-18-AC3, 2017
© Author(s) 2017. CC-BY 3.0 License.

Atmospheric Measurement Techniques Discussions

Open Access

AMTD

Interactive comment

Interactive comment on "Perdigão 2015: methodology for atmospheric multi-Doppler lidar experiments" *by* Nikola Vasiljević et al.

Nikola Vasiljević et al.

niva@dtu.dk

Received and published: 10 May 2017

Note: The structure of the replies to the reviewer comments is as following: (1) the original unchanged reviewer comments are given with regular text formatting , (2) the comments are enumerated and type of comment is indicated (general comment or specific comment), (3) following each comment a response to the comment and description of associated changes in the revised manuscript are provided while the text is formatted *italic*.

General comment 1: This manuscript is about multiple lidar measurements performed for the Perdigão 2015 campaign with two triple-Doppler units, both pulsed long-range lidars and continuous short-range lidars.

Printer-friendly version

Discussion paper

CC BY

Dear Reviewer,
We would like to thank you for all the care and attention given to our manuscript. Our answers are given below.

We partially agree with the general review remarks regarding our manuscript. In fact, the manuscript is about the methodology for multi-Doppler lidar experiments in the Perdigão-2015 field campaign, as evidenced by the title. Data analyses or discussions of particular flow situations are not the purpose of the present manuscript; the measurements are included only as a result of the presented methodology.

General comment 2: The first criticism is about the writing style. Rather than a scientist paper, this document reads like a romantic technical report, or maybe a long post on a blog. The manuscript is very very lengthy. The first lidar data is shown at page 20 (the last one at page 23). If I am not mistaken, no data from the short-range system is provided. I would rather recommend a more classical structure of the manuscript consisting of introduction, description of the site and setup, lidar scans and data retrieval, discussion of the results and conclusion.

The writing style is not a major issue in scientific publications, as opposed to contents, structure or accuracy. See for instance, that the structure of our manuscript is rather formal; i.e. IMRAD (Introduction-Methodology-Results-and-Discussion), as recommended by the referee.

This is a manuscript in the first place about the methodology for multi-lidar experiments, but also about a field experiment, the first of its kind. This experiment has been made with many difficulties where many of them had to be fixed while running the experiment.

We wanted to report our difficulties, even when the solutions failed, for the ben-

CC BY

efit of future field experiments. It is not a typical, standard, scientific paper, where difficulties and things that did not work as expected are ignored, because are considered irrelevant.

Science is made of decisions that in the end proof to be wrong and equipment that fails to work under more demanding conditions. This could not be achieved in the style of a standard scientific paper.

Science is also made by people, most of them are passionate about their work and enjoy the challenge of overcoming difficulties. We wanted that to transpire in our text, and we are glad we made it, though to the dissatisfaction of the referee, by not complying with the commonest and traditional papers of the last 20 years. We cherish the writing style and recommendations of excellent scientists and texts such as:

– Advice for a Young Investigator, S. Ramon y Cajal. 2004 new edition. Unabridged and unaltered reproduction of the first edition, published in 1897. 172 pages.

– On Being a Scientist: Responsible Conduct in Research. National Academy Press, 1995, 40 pages

– How to Write and Publish a Scientific Paper (2016) Cambridge University Press, Robert A. Day and Barbara Gastel. 8th edition. 350 pages

We like the clarity, the thoroughness and the simplicity of good classical scientific papers that manage to describe the work and the ingenuity of the experiments, and also pass the personal traits of their authors. Characteristics that are difficult to find in today's papers.

This manuscript is about the methodology for multi-Doppler lidar experiments.

CC BY

We did indeed report on the experiment and acquired dataset and it is not much different from (when it comes to its content and form) when compared to several publications reporting conducted experiments without in-depth data analysis. See for instance:

– Grubisić et al. 2008 on the T-Rex campaign

– Floors et al. 2016 on the RUNE experiment

The short-range WindScanner data are presented in Figure 13 of the reviewed manuscript. We updated the captions of Figures 11 to 14 to indicate whether data is acquired with the long- or short- range WindScanner system.

General comment 3: Besides the writing, I have also some concerns about the novel results presented in this manuscript. We have seen already dual-Doppler lidar measurements in wind turbine wakes or vertical transects for valley flows. Two figures are definitely not sufficient to describe effects of atmospheric stability on wind turbine wakes. Therefore, I suggest to provide a sharper focus on the data analysis and emphasize any new result.

Regarding the novelty of the manuscript, the following is a list summarizing novel contributions:

1. *Methodology for atmospheric multi-Doppler lidar experiments*
2. *Novel scanning methods, such as for example T-scan, ridge scan and diamond scan*
3. *Use of two different (CW and pulsed based) multi-Doppler lidar systems simultaneously*

Printer-friendly version

Discussion paper

4. *Dual-Doppler and triple-Doppler measurements of a single turbine wake and inflow conditions in complex terrain*

5. *Wind resource measurements along a ridge*

6. *Mapping valley flows over a vertical transect (novel since it was done for a double-hill site)*

Detailed data analysis of several aspects of the Perdigão flow has been presented in several communications (e.g., Rodrigues et al. 2016 and Hansen et al. 2016), which are referenced in our paper (see P19L12 – L14 in the reviewed manuscript). The atmospheric stability can and was addressed as a hypothesis, because there were no temperature or heat flux measurements. The impact of the atmospheric stability on wind turbine wake has been partially discussed in Hansen et al. 2016.

Specific comment 1: P1L3: "...measure mean flow conditions over an entire region...", this sounds a bit too vague, maybe better stating the typical measurement volume of the two systems.

Following the referee's suggestion, the sentence has been modified. It reads:

"Due to the costs of tall meteorological masts, especially in complex terrain, it is unrealistic to sample the wind within an entire region occupied by today's largest wind turbines or farms with traditional anemometry."

Specific comment 2: P2L3: "...it is unrealistic to sample...", actually it is real performing met-tower measurements. Maybe it is better mentioning the reasons why a multi-lidar system can be advantageous.

Following the referee's suggestion, the paragraph have been revised. It reads:

Printer-friendly version

Discussion paper

"Due to the costs of tall meteorological masts, especially in complex terrain, it is unrealistic to sample the wind within an entire region occupied by today's largest wind turbines or farms with traditional anemometry. This is exactly what can be achieved with multi-lidar systems."

Specific comment 3: Sect. 1: It seems to me that this introduction is lacking to provide an overview of existing works on triple lidar measurements, such as J. Mann et al. 2009, Meteor. Z. 18, 135-140, Fuertes et al. 2014, JTECH 31(7), 1549-1556, or papers from the AMT special issue on the XPIA experiment (http://www.atmos-meas-tech.net/special_issue645.html), which was focused on assessing various multiple-lidar scanning strategies (Lundquist et al. 2017, BAMS 98(2), 289-314). Therefore, I suggest providing a more comprehensive introduction on the topic.

We agree with the reviewer that an overview of multi-lidar experiments is missing in the reviewed manuscript. Therefore, the revised manuscript includes an overview of multi-lidar efforts among which the suggested references are included.

Specific comment 4: P3L7: Provide some references for the setup of the SRWS.

We updated manuscript with additional references to the short-range WindScanner system (Mikkelsen et al. (2011) and Sjoholm et al. (2014)).

Specific comment 5: P3L14: Discuss the motivations on developing a hybrid system.

The revised version was changed in accordance to the referee's suggestion. Now it includes clearer motivations for developing a hybrid WindScanner system.

CC BY

Specific comment 6: Sect. 3: these 10 steps are common for any (field) experiment and not specifically related to the LRWS and SRWS. Why these steps should have a special relevance or being different for this experiment?

The 10 steps are our proposal to a systematic approach to future multi-lidars (WindScanners) campaigns. The classification, ordering of the many activities from the beginning until the end of the campaign under these 10 steps appeared logical to us and was most useful while preparing the currently ongoing, much larger field campaign Perdigão-2017.

Yes, certainly there are steps which are common to any experiment, but there are steps which are specific for scanning lidars; for instance, the scanning patterns design.

We felt the need for the systemization of WindScanner campaings within the ESFRI European Infrastructure project where the main purpose is setting a distributed and mobile infrastructure for these type of activities, which we also believe will be useful when organizing future large field experiments.

Specific comment 7: Sect. 4 and throughout the paper: I understand the passion and excitement of the authors; however, this writing style is more adequate for a blog or a newspaper article rather than a scientific paper. Comments like "need to test both the equipment and human resources in highly demanding field experiments (P4L15)", "harsh conditions, high temperature and remote locations"... This experiment was carried out in Portugal, I cannot image what scientists in Antarctica should write to describe their experiments!

See above the reply to the general comment 2.

CC BY

Specific comment 8: Sect. 4.1-Sect. 4.4. This description is lengthy and unfocused. It would be easier to provide a classical description of the site and instrumentation.

Field experiments are very demanding in both human and financing resources, Perdigão-2015 was possible and justified by four independent projects (WindScanner.eu, NEWA, UniTTe and FarmOpt), which resulted in collecting experimental and unique datasets focused in the characterization of the wind turbine wake, the flow separation on lee sides of hills (also the valley flow and recirculation zone), etc.. Rigour in the description of the thinking, which was behind the organization and preparation of the field campaign, led to this section that seems lengthy in a first reading.

Specific comment 9: Sect. 4.4: You suddenly introduce these unexpected RANS simulations over the topography, without canopy performed with a commercial code, and finally just saying that the "...high complexity of the flow (Fig. 4) and large recirculation zone enclosed in the valley (Fig. 5)". I think these comments were highly expectable. Thus, I suggest removing the entire paragraph on the simulations and Figures 4 and 5.

The RANS simulations were extremely useful by guiding us in the positioning of the lidar units. The CFD code is not a commercial code and the presence or not of the canopies does not change the main features of the flow. The use of computer modelling prior to field campaigns is a must and a practice that will become more and more common. The self-imposed limitations in the extent of the manuscript did not allow for more detailed analysis of the flow pattern and that was left to the reader. The intricacies of the separated flow, namely in the lee sides, could not be foreseen without flow modelling.

Specific comment 10: P8L20: Maybe can be a personal issue of this reviewer,

CC BY

there is no way I can remember the names of these 3 lidars. I suggest to name them as LR1, LR2 and LR3 rather than with your nick names.

As suggested by the referee, the identifications ends with a number:

- *Koshava – LR1*
- *Sterenn – LR2*
- *Whittle – LR3*
- *R2D1 – SR1*
- *R2D2 – SR2*
- *R2D3 – SR3*

The names are part of the identification, to track the usage in field operations and for consistency with previous publications; for instance:

Floors, Rogier and Peña, Alfredo and Lea, Guillaume and Vasiljević, Nikola and Simon, Elliot and Courtney, Michael (2016). The RUNE Experiment–A Database of Remote-Sensing Observations of Near-Shore Winds. Remote Sensing, V. 8, page 884, N. 11, doi = 10.3390/rs8110884, url = http://www.mdpi.com/2072-4292/8/11/884

Specific comment 11: P8L22: What do you mean for "entailing the wind turbine"? Maybe a vertical plane along the line connecting a lidar with the turbine?

The quoted sentence was modified, accordingly to the referee's suggestion.

Specific comment 12: P8L25-29: Maybe add another table with distances among the

CC BY

different objects.

Following the referee's suggestion, we added two additional columns to Table 3 to show distance and direction of lidars and landmarks of interest respect to the wind turbine position. Also, we denoted WindScanners with short names in Figure 6.

Specific comment 13: Sect. 4.5: this section can be completely removed. It provides only unimportant information.

The manuscript was organized in such a way that each step in the procedure has a corresponding section. Steps (or sections) are the result of organizing (under a logical structure) a large number of activities. The number and ordering of steps took into consideration many aspects, including the importance and the number and relationships among the activities within each step.

Section 4.5 (step 5) is on infrastructures (power and data network, access roads, etc.) and infrastructures are independent, different and autonomous from other aspects of a field campaign that must be considered when planning an experiment. The infrastructure complies with all features to make it a step in the methodology for lidar experiments.

Specific comment 14: P12L30-P14L3: If the measurement plane of this dual Doppler lidar was inclined, how is it possible you retrieved horizontal wind speed and direction? I guess you retrieve the 2 velocity components over the measurement plane.

We agree with the referee. The two components were retrieved in the inclined plane. However, because the elevation angle was low these components are close to the components resolved in an absolute horizontal plane. The revised manuscript has been adequately updated to reflect the previous statements and additional calculations

CC BY

are provided in Appendix A of the revised manuscript.

Specific comment 15: P15L6-L11: The description of this scan is very confusing. You say that there was a time delay among the different lidars, and the delay was increasing with time. Therefore, you need to provide a statistical characterization of this delay and how you treat this time delay in the retrieval of the wind velocity components.

The commented paragraph was rewritten and the statistical characterization of the lag was given in term of a lag rate (i.e., the speed at which the lag increase in time). In the reviewed manuscript we indicated how we treated the time delay (P18L19-L20):

"To treat the synchronization issues that appeared in the expanded version of T-scan and vertical plan patterns, the data acquired using those pattern versions were additionally time averaged in 10-min periods."

Specific comment 16: Sect. 4.7: A general comment for all the presented scanning strategies: for multiple Doppler lidar measurements, accuracy in the retrieval of the wind velocity components is affected by the elevation and azimuthal angles of the various lidars. A criterion for quantifying this error over a scan has been proposed in Debnath et al. 2017 AMT, 10, 431-444. A similar analysis should be provided for the proposed scans.

This is a valid point, and we updated the manuscript with rather short discussion on the expected accuracy in the retrieved wind components.

When setting up the layout of a multi-lidar experiment we intend to have an intersecting angle of at least 30 degrees respect to the prevailing wind direction. Based

Printer-friendly version

Discussion paper

on our simple accuracy model (see Vasiljević, N. and Courtney, M. Accuracy of dual-Doppler lidar retrievals of near-shore winds, 2017, WindEurope Resource Assessment Workshop 2017, https://goo.gl/LFuimU) the intersecting angle of 30 degrees results in the accuracy of about 0.25 m/s for the retrieved horizontal wind speed. Following this rule of thumb and in connection to the prevailing wind directions (Northeast and Southwest) we design the layout of the Perdigão-2017 experiment.

In the revised manuscript, we: (1) indicated the mean intersecting and elevation angles for all scanning modes, (2) referred to the aforementioned simple model, (3) indicated the accuracy for the retrieved horizontal wind speed based on this model (i.e., 0.25 m/s), and (4) referred to Simley et al., 2016 and Debnath et al. 2017 as an alternative approach for assessing the multi-lidar setup suitability.

It is our opinion that this topic requires a separate publication as the reviewed manuscript covers a multitude of topics. We are currently preparing several communications on the scanning lidar accuracy topic.

Specific comment 17: Sect. 4.7: A general comment for all the presented scanning strategies: you haven't provided any information on the data retrieval of wind velocity components from the lidar radial velocities. This part should be included in the manuscript.

We agree with the referee. We updated the manuscript with the necessary equations for retrieving the wind vector components from independent LOS measurements (see Appendix A in the revised manuscript).

Specific comment 18: Sects. 8 and 9 can be removed or summarized in the description of the setup.

Printer-friendly version

Discussion paper

See the response to the specific comment 13.

Specific comment 19: Sect. 4.10 provides should significantly shortened.

See the response to the specific comment 13.

Specific comment 20: P19L9: what do you mean for . . . “show no turning of the wind for Northeast winds. . .divergency of flow lones”? This does not sound like a technical language.

The paragraph has been revised. It reads:

"The ridge scan, 2 km along the South ridge, shows no turning of the wind for Northeast winds. Thus, for this wind direction we observed a two-dimensional flow. On the other hand, for Southwest winds there is a slight turning of the wind..."

Specific comment 21: Fig. 11 is not described accurately in the text. Why you were not able to get measurements in the turbine wake?

In Figure 11 caption it is mentioned that measurements at the wind turbine location are erroneous. This is because the laser beams were hitting the wind turbine during the ridge scan. The ridge scan was designed such that the beam intersection followed the ridge line which includes the turbine itself. Therefore, the beam intersection hits the turbine (nacelle and blades). At this location, the reported radial velocity equals the velocity of the wind turbine and not the air (see CNR mapper P12L1 to L10 for more details). Therefore, those measurements must be removed as they are not measurements of the wind but a hard target velocity.

Specific comment 22: Figs 12 and 13. You should provide more information

Printer-friendly version

Discussion paper

about the wind condition, day, atmospheric stability, etc. No details are provided on the data retrieval.

Regarding the stability see our answer to the general comment 3. Captions of Figures 11 – 14 include information on day and time. The wind conditions can be concluded from these figures.

Specific comment 23: P20L1-2: “The inflow and wake of the turbine during a one full day is well represented in Vasiljevic (2016b)”. Why then you provide these figures if a deeper analysis has been already published?

The cited reference represents a link to the Youtube video that displays a 24h reconstructed wind field around the wind turbine. We followed common practices for citing web links.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-18, 2017.