Wind Energ. Sci. Discuss.,
doi:10.5194/wes-2016-59-RC1, 2017

WIND ENERGY SCIENCE DISCUSSIONS

Interactive comment on "Demonstration and uncertainty analysis of synchronised scanning lidar measurements of 2D velocity fields in a boundary-layer wind tunnel" *by* Marijn F. van Dooren

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Received and published: 6 February 2017

This manuscript deals with an assessment study of dual-Doppler measurements performed with two synchronized short-range continuous lidars against triple hot-wire data. 2D velocity measurements were performed at the wind tunnel of the Politecnico di Milano. The experimental campaign consisted of fixed point measurements, horizontal traverse in the wake of a wind turbine model and horizontal scan of three interacting wind turbine wakes.

The introduction briefly introduces to the topic under investigation, namely velocity measurements of wind turbine wakes, both for field and wind tunnel measurements. In my opinion this section is a bit too short, and it could be expanded by providing an overview of the most representative studies for characterization of wind turbine wakes both for utility-scale wind turbines and down-scaled wind turbine models, which have been performed with different measurement techniques. In the introduction, I would also suggest to emphasize the importance of characterizing variability of wind turbine wakes with the daily cycle of the atmospheric static stability. In my opinion, this is a hot topic, which should be reproduced or mimicked through wind tunnel experiments as well. At the end of the introduction, I would add a paragraph stating clearly the aims of the project or the scientific questions that you aim to address with this research. This paragraph should be focused on the characterization of lidar capability to perform wind velocity measurements in a wind tunnel environment. Finally, I guess it will be convenient to add a description of the structure of the paper to facilitate reading.

A description of the wind tunnel, wind turbine model, lidars and hot-wire anemometer then follows. The different tests are presented in Sect. 2.5, while the results of the three different measurement strategies are reported in Sect. 3. An interesting uncertainty analysis is also provided in Sect. 3.4, and finally conclusions are reported in Sect. 4.

I commend the scientific contribution of this manuscript to the topics of characterization of wind turbine wakes and multiple-Doppler lidar measurements. I definitely recommend this manuscript for publication. However, in the following I report some minor comments, which might help to increase the thoroughness of the data analysis and impact on the wind energy community.

Comments:

1. P1 L21: I agree that a wind tunnel provides the great advantage of fixing different flow parameters, such as speed and turbulence intensity. However, I would mention that we should be able to reproduce the wind field variability consequent to the daily cycle of the atmospheric static stability, or mimic a realistic wind rose.

2. Sect. 1: I would suggest to expand this introduction to an overview of the most relevant works focused on characterization of wind turbine wakes both for utility-scale wind turbines and wind turbine models, which have been performed with different measurement techniques.

3. Sect 1: Add a paragraph to state clearly the aims of this project and the scientific questions you are attempting to address. I guess the main focus will be assessing the capabilities of continuous lidar to measure wind speed and turbulence in a wind tunnel environment.

4. Sect 1: Add at the end of the section a description of the structure of the paper.

5. P2 L15: Add some references for the wind turbine models and wind energy projects performed at the wind tunnel of PoliMi.

6. P3 L4: In my opinion, it is a bit too simplistic affirming that we can reproduce an ABL flow in a wind tunnel with spires and turbolators. We would need also to reproduce the temperature profile and typical length scales of the coherent structures. I would say that we can reproduce similar vertical profiles of wind speed and turbulence.

7. P3 L4: Please add a figure reporting the vertical profile of wind speed and turbulence intensity at the beginning of the turntable.

8. P4 L9: I would remove “averaged”. Each measurement is a sample corresponding to a given sampling frequency.

9. P4 L11: Does this lidar have any blind region close to its location?

10. P4 L19: I think the setup and installation of the lidars in the wind tunnel is not described in detail. It would be interesting for the reader learning about the procedure you applied for the positioning and pointing of the two lidars.

11. P4 L27-28: In my opinion the elevation angle of 3° rather than a contamination from the w velocity, implies an under-estimation of the u and v velocities. It will be interesting to quantify error introduced on the horizontal velocities through the uncertainty analysis discussed later in Sect. 3.4.
12. P5 L9-13. Did you use the Dantec software for the calibration or do you have your own calibration procedure? In the second case, please provide a description and references.
13. P6 L5-11: It would have been interesting to estimate effects of the probe length on the turbulence statistics by varying the distance between the lidar and the measurement point. Do you have any available data to address this point?
14. P7 L1-3: The characteristics of the incoming velocity field should be reported in Sect. 2.1. Please provide a figure with the vertical profile of velocity, turbulence intensity and integral length scale of the wind tunnel flow.
15. P7 L6-10. It would be more effective to show a chunk of velocity signals for both anemometer and lidar showing the different filtering steps starting from the raw data. Something like Fig. 10, but starting from the initial sampling frequency of the two instruments.
16. Table 1: I would add to the statistics skewness and kurtosis in order to learn more from the statistical behavior of the two signals. Furthermore I would provide statistics for the raw signals (with their sampling frequency), and after 1-s averaging.
17. Fig. 16. I am not sure if you clarify a significant energy damping for frequencies lower than 28 Hz. I guess you should emphasize that the size of the virtual measurement volume might be much larger than 0.1 m and it's a function of the relative angle between the two-laser beams. A more detailed discussion

in this direction may help to better clarify this disagreement with the theoretical expectations.

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