

## ***Interactive comment on “Assessment of virtual towers performed with scanning wind lidars and Ka-band radars during the XPIA experiment” by Mithu Debnath et al.***

**Mithu Debnath et al.**

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We thank the Reviewer for his/her comments and the constructive review. Our replies are reported below.

1. *Page 2, line 1: I think it would be a good addition here to explain briefly why Doppler lidars/radars only measure the line of sight velocity (or cite a work where it is explained).*

**Reply:** It is now added to the text: “A Doppler-based remote sensing instrument allows measurements of the wind velocity component parallel to the direction of the emitted wave source, e.g., a laser beam for a lidar or radio waves for a radar.

C1

The measured wind velocity, which is referred to as radial or line-of-sight velocity, is proportional to the Doppler shift on the backscattered signal generated by the aerosol suspended in the atmosphere [Pena et al. 2013]”. Reference added: Alfredo Pena, Charlotte B. Hasager, Julia Lange, Jan Anger, Merete Badger, Ferhat Bingol, Oliver Bischoff, Jean-Pierre Cariou, Fiona Dunne, Stefan Emeis, Michael Harris, Martin Hofsass, Ioanna Karagali, Jason Laks, Soren Larsen, Jakob Mann, Torben Mikkelsen, Lucy Y. Pao, Mark Pitter, Andreas Rettenmeier, Ameya Sathe, Fabio Scanzani, David Schlipf, Eric Simley, Chris Slinger, Rozenn Wagner and Ines Wurth, Remote Sensing for Wind Energy, DTU Wind Energy-E-Report-0029(EN), ISBN: 978-87-92896-41-4, 2013.

2. *Page 2, line 10: Maybe more precise “3D nature of the atmospheric boundary layer wind field”?*

**Reply:** We mean a 3D variability in the ABL of the time-averaged wind velocity field, such as in presence of wind shear, veer, or wakes produced by upwind obstacles (e.g. wind turbines, buildings, topography), or for stratified wind turbulence (Segalini and Arnqvist 2015, JFM, 781, 330-352)

3. *Page 2, line 14-16: The authors are clearly aware of this, but it should be written in the text that the accuracy of the retrieval is a function of not only the beam intersect geometry, but also the measurement errors of the individual instruments going into the retrieval.*

**Reply:** This comment has been added to the text.

4. *Page 3, line 14: Does the 3 m leg spacing of the tower has any importance like less tower effects on the wind field?*

**Reply:** For the XPIA experiment, accuracy in the sonic anemometer measurements and possible tower effects have been discussed in the paper McCaffrey et al. 2017, now accepted for publication in the same AMT special issue of this manuscript. A reference to this paper is reported at page 3.

C2

5. *Page 4, line 1-6: Please provide more information about this reference instrument (accuracy, serial number, year of production . . .).*

**Reply:** the V2 lidar was a Windcube Offshore 8.66, unit WLS-16, with an absolute mean deviation smaller than  $0.1 \text{ m s}^{-1}$  in wind speed and smaller than  $2^\circ$  in wind direction.

6. *Page 5, line 4: What was the pulse length of these two Doppler lidars?*

**Reply:** The pulse length for the Doppler lidars is 200 ns. This detail is now added to the manuscript.

7. *Page 5, line 17 and 21: Accuracy or precision?*

**Reply:** It is accuracy.

8. *Page 5, table 3: What kind of errors (percentage, standard deviation) and do they have a unit? Also a sentence explaining that this is the error of a single lidar propagated through the rotation and being boosted up for small angles between the laser-beams could be considered here.*

**Reply:** As explained in the text (page 5, lines 17-22), error analysis is performed through the L2-norm of the rows of the matrix in Eq. 1. Error in the retrieved velocity components increases for values diverging from 1. The numbers in table 3 are dimensionless.

9. *Page 6, line 3-4: If the sampling period at each point was 25 seconds and there are 6 levels between 100m and 200m, than I would expect the total time for a virtual tower to be longer than 127s?*

**Reply:** We apologize for this wrong information. The average time required for a virtual tower is 151.6 s.

10. *Page 6, line 7: I think it would be important to include information how the north orientation of the lidars/radars was determined, as this is very important for correct beam intersect.*

C3

**Reply:** Estimate of the azimuthal bias from north for each lidar was retrieved through hard-target tests performed by hitting reference towers present on site with the lidar laser beam, and using their GPS coordinates with respect to the lidar location. These details are now added at the beginning of page 6.

11. *Page 8, line 6: I associate the term confidence level with results of tests of significance in statistics, which were not made here. The authors might think about rephrasing with other words.*

**Reply:** We absolutely agree with the Reviewer's comment. It is now reported: "Given the good agreement between the sonic anemometers and the profiling lidars, we felt confident that the data sets from these two types of instruments can be used to evaluate the accuracy of virtual tower measurements with scanning radars and lidars."

12. *Page 8, line 15-17: This sentence is unclear to me. I understood: The profiles of wind speed and direction where vertically interpolated to the heights of the ultrasonic anemometers. Is this correct?*

**Reply:** The Reviewer is right.

13. *Page 11, line 16: Is there any reason to assume it wouldn't be working for higher velocities or does this statement just refer to the velocity range during the measurements?*

**Reply:** We want simply emphasize that the measurement systems observed significant variability in wind speed and direction during the experiment.

14. *Page 1, line 18-19: Sentence structure.*

**Reply:** This sentence has been rephrased.

15. *Page 2, line 3: Maybe write out atmospheric boundary layer? The abbreviation is not used later on.*

**Reply:** Added in the text.

C4

16. *Page 3, line 7: "from" instead of "since"?*  
**Reply:** Added in the text.
17. *Page 3, line 10: Abbreviation CNR not introduced yet (it is written out on page 5, line 11 later).*  
**Reply:** Added in the text.
18. *Page 5, line 6: Missing brackets for citation*  
**Reply:** Edited.
19. *Page 6, line 16: Missing brackets for citation.*  
**Reply:** Edited.
20. *Figure 5b: Lines of identity and linear regression are behind data points.*  
**Reply:** Figure 5 is edited.
21. *Page 11, line 18: Remove crisply*  
**Reply:** Removed.
22. *Page 12, line 1: Delete first "wind" in "retrieval of wind horizontal wind speed"*  
**Reply:** Removed.
23. *Figure 8b: Inconsistent rounding compared to table 7*  
**Reply:** Table 7 (now Table 6) has been corrected.
24. *Figure 10: Labels on the color map of direction are missing.*  
**Reply:** A revised figure is now provided.

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-325, 2016.