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Atmospheric Measurement Techniques Discussions

Interactive comment on "Vertical profiles of the 3D wind velocity retrieved from multiple wind LiDARs performing triple range-height-indicator scans" *by* M. Debnath et al.

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

1. *...The amount of data used is very low and there are problems with the way the experiment has been planned.*
   Reply: During the XPIA experiment, twelve measurement strategies were tested, and the triple RHI scan is one of these strategies. Approximately one day of measurements was devoted to the triple RHI scan; however, in early Spring aerosol conditions were such to limit the carrier-to-noise ratio, thus data availability. We agree that duration of the presented wind data, which has been selected after

   a quality control process of the measurements, is relatively short for an assessment study. However, we consider that this assessment against met-tower and two lidar profiler data provides an initial benchmark for the scan capabilities. Important information have been achieved through this study, such as the typical low accuracy in the retrieval of the vertical velocity. More comments are now reported in the manuscript.

2. *It is hard to point out what new knowledge is generated by the paper.*
   Reply: Co-planar and triple RHI scans have been already performed for different experiments (e.g. Hill *et al.* 2010 for mountain-wave events; Cherukuru *et al.* 2015 for down-slope-windstorm-type flows; Iungo *et al.* 2013 for wind turbine wakes) and never assessed. This experiment represents the first validation of triple RHI scans against data obtained from sonic anemometers and lidar profilers.

3. *The experiment is not planned very logically. All scanners use elevation angles from 0-45 degrees while have very different distances to the virtual towers ranging from 98 to 955 m. This means that a lot of measurements are wasted, i.e. that the overlap in measurements is quite poor. Furthermore, the scanners are not synchronized which means that they interrogate the same intersecting volume at the virtual mast at different times. The implication of both these issues is that the calculation of the wind vector becomes more uncertain than it needed to be. Also the azimuth angles are not ideal. They should have been closer to 120 degrees apart to reduce uncertainties on the horizontal wind, or, if reduced uncertainty in the vertical component is wanted, have one close to the foot of the virtual tower and the two others at roughly 90 degrees apart. For the virtual mast 2 one instrument is in fact close to the base of the virtual mast (8 in fig 1) but the two other lidars are at 180 degrees to each other, virtually the worst configuration one could choose.*
   Reply: The aim of this manuscript is not performing triple Doppler measurements

for optimal setups, which can be rarely performed during real experimental campaigns. The aim of this study is rather to assess accuracy of triple RHI scans for the three velocity components under sub-optimal scanning conditions. The errors consequent to the setup of the azimuthal and elevation angles of the three lidars is systematically documented. In Table 3 expected errors in the retrieval of the three velocity components, for the two virtual towers and different heights are reported.

Regarding the overlapping time among the three lidars, the lidars as used do not provide any synchronization through a master supervisory computer. Therefore, as might happen for the majority of field experiments according with the existing lidar technology, instruments were programmed while a certain delay might occur among the various lidars. The overlapping time is statistically documented in Figure 2. We believe that, as long as a significant overlapping time is ensured among the various lidars and data retrieval is only performed for simultaneous data, there is no specific concern on the accuracy of the 3D data retrieval. However, we agree that the scanning strategy is not very efficient due to a significant rejection of non-simultaneous data.

Regarding the setup of the lidars, multiple RHI scans allow obtaining multiple measurement points over the plane of interest by using the different range gates of the pulsed lidars, thus achieving small sampling periods. Furthermore, the third lidar enables the retrieval of the three velocity components as a vertical profile. Performing these measurements as consecutive triple fixed-point measurements, i.e. with three lidars setup as suggested by the Reviewer, will allow obtaining only one virtual tower without the remaining 2D velocity measurements over the plane of interest. Obtaining the remaining velocity data over the plane would lead to extremely long, thus unfeasible, sampling periods. The drawback of performing co-planar and triple RHI scans consists in probing the vertical velocity with only two lidars rather than three as for the fixed-point triple scan. Thus, for

relatively low elevation angles of the lidar laser beams, a lower accuracy in the vertical velocity might be retrieved. These aspects are now better highlighted in the manuscript.

4. *The comparisons in figure 6 are unimpressive which is probably due to the bad setup of the experiment as mentioned above. Slopes between the sonic are up to 15% off for the horizontal components and much more for the vertical.*
Reply: The goal of this paper was not to demonstrate the accuracy of the wind lidar retrieval using the absolute best possible setup configuration, but rather to show the errors when using setups that have to meet multiple objectives and with siting limitations, leading to sub-optimal geometries for most of the individual wind retrievals. It is reported in the text that the estimated difference is the result of lidar accuracy, post-process, relatively short sampling time, accuracy in lidar pointing, configuration setup and separation distance among the virtual towers, lidar profilers and met-tower.

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