Responses to referee comments:

The paper "Evaluation of Single- and Multiple-Doppler Lidar Techniques to Measure Complex Flow during the XPIA Field Campaign" presents an overview of single- and multi- Doppler scanning methods operated during the XPIA campaign. The focus is on the scanning method description and their ability to retrieve the wind vector components.

The authors thank the reviewer for taking the time to review this manuscript and providing their valuable inputs.

The described scanning methods consist of PPI and RHI scans, and thus the methods themselves are not novel.

The authors agree with the reviewer's opinion that the scanning strategies themselves are well known and have been discussed quite extensively in literature (many of which have been summarized and cited in the manuscript). In addition, the operation of the lidars was limited by the GUI provided by the manufacturer which allowed programming only simple scan geometries. The goal of this paper is to evaluate each of these techniques against one another and understand the trade-offs in terms of temporal resolution and spatial coverage and understanding flow heterogeneity (to our knowledge, this manuscript seems to be the first to do so). In addition, as many commercially available lidar systems currently are not capable of performing more complicated scanning trajectories, this paper discusses the possibilities available to such lidar systems.

From the manuscript, readers can conclude that retrieval of the wind vector components using unsynchronized multiple scanning lidars brings poor accuracy. This is logical due to the non-stationarity of the atmosphere (the author commented this as well). Therefore, this information does not bring anything new to readers.

In this paper the measurement precision of several temporally synchronized and temporally unsynchronized measurement strategies is discussed. To the authors' knowledge, these techniques have not been compared against one another using a common wind measurement standard. In addition, while the result that unsynchronized scanning will result in higher uncertainty is logical, the degradation has not been quantified. In addition, the degradation is not just due to the non-stationarity of the atmosphere, but also sampling errors introduced as a result of the scanning strategy. Apart from quantifying degradation in measurement precision due to unsynchronized scanning, this paper dwells into quantifying the instrument random error as well as uncertainty due to volume averaging of the laser pulse. The authors feel these aspects do bring new information to the readers and informs on the magnitudes of these errors with respect to differences observed in lidar versus sonic anemometer comparisons.

The author concluded that as the complexity of the scanning method increased the uncertainty in the wind vector retrieval increased as well. This is a misleading conclusion. In this specific case, the increase in complexity brought the increase in the lag between the lidars, which in turn resulted in a poorer estimation of the wind vector components (as expected).

The authors point to two possible sources (which depend on scanning technique) that add uncertainty to the wind measurement: (1) lack of temporal synchronization (or lag) in the measurements and (2) less-representative LOS velocity statistics. As the reviewer points out more complex scan strategies will result in higher lag. However, they can also result in less representatives LOS velocity statistics as there is not enough time spent in each measurement volume due to higher scan speeds and covering larger spatial extents. The authors refer to the combined effect of these two sources of error when referring to increase in complexity causes higher uncertainty. We have added further statements in the discussion to ensure this point is comes across clearly.

Furthermore, the author presented the comparison between the retrieved single- or multi-Doppler wind vector acquired over the shortest time period (not averaged = 'instantaneous') and the averaged sonic data. I find this approach odd.

The wind measurement from the various multi-Doppler are estimated by chi-squared fitting the radial velocity equation to the LOS velocity measurements. Therefore, when 5-seconds of LOS velocity measurements (for example) from various Doppler lidars are fitted to the radial velocity equation, we get an estimate of the 5-s mean velocity as represented by the LOS velocities from the different lidars. This estimate of the 5-s mean is then compared to the 5-s mean from the sonic anemometer measurements. Therefore, equally temporally averaged quantities from the lidars and sonic anemometers are compared.

The reason for using the measurement period to determine precision was to ensure each technique was evaluated fairly. For example, in the case of the virtual tower stares, each wind measurement is achieved every 5 seconds, while for the multi-Doppler volume scan it takes 5 minutes (but it covers a larger spatial area). If measurements were averaged to a common time period (say 10 minutes) there would be many more samples from the virtual tower stares compared to the multi-Doppler volume scan and hence, it will not be an equal comparison.

In the case of multi-Doppler retrievals, lidars were not synchronized and comparing the retrieved information without first averaging over a certain period will not produce good results (common sense). The same stands for the OI method. I suggest to the author to reformulate the paper and investigate trade-offs between the averaging period and spatial coverage instead.

This manuscript investigates both temporally synchronized and un-synchronized measurement uncertainty. The authors would like to note that while it is true the lidar measurements discussed here were not coordinated using techniques described in Vasiljevic et al (2016), temporal synchronization was achieved. As summarized in Table 2 and 3, the Doppler lidars were able to maintain pointing uncertainty of less than 0.15° (+/- 2.5m @ 1km range) and time uncertainty of less than 0.4 s. Since, all our averaging periods are much greater than 0.4 seconds and the common volume is much bigger than the pointing uncertainty, we feel that the lidars were able to make synchronized measurements (in time and space) when we aimed to do so. We have renamed the sections to make it clearer where synchronized scanning was used and where the measurements were allowed to be unsynchronized.

In the case of the OI method, a similar reasoning as explained in our previous response is used for evaluating measurement accuracy. The OI method uses all the LOS velocity measurements from a sector scan to estimate the 2-D wind field on the sector scan. Therefore, the OI results represents an estimate of the wind over the time it took to perform the scan (in this case 30 seconds).

Furthermore, I strongly suggested to the author to follow the Vancouver protocol, and include only those coauthors that substantially contributed to: 1) conception and design of the study, or analysis and interpretation of data 2) drafting of the manuscript or revising it critically for important intellectual content 3) the final approval of the version to be published

The XPIA field campaign was a multi-institutional effort involving deployment of a vast array of sensor, both in-situ and remote sensing. This paper was made possible through a close collaboration among all the persons involved in experiment design, field deployment, data collection and analysis. Therefore, I feel each of them has earned the authorship.
The reasoning behind including the authors in this manuscript is given below:

Julie Lundquist and James Wilczak – PIs on the proposal and responsible for conception and design of the field study

Alan Brewer, Michael Hardesty, Timothy Bonin, Valerio Iungo, Mithu Debnath, Laura Bianco Aditya Choukulkar, J. Lundquist and J. Wilczak – experiment design, data analysis, manuscript preparation and critical review

Scott Sandberg and Ann Weickmann (NOAA lidars), Ryan Ashton (UTD lidar), Ruben Delgado (UMBC lidar), Steven Oncley and Daniel Wolfe (BAO tower and sonic anemometers) – instrument deployment, instrument operation and maintenance, data collection and initial processing.