Review of the manuscript AMT-2021-233, entitled "Modelling the Spectral Shape of Continuous-Wave Lidar Measurements in a Turbulent Wind Tunnel", by van Dooren M. F., Sekar A. P. K., Neuhaus L., Mikkelsen T., Hölling M., Kūhn M.

General comments

The study of van Dooren *et al*. addresses the problem of the spatial averaging effect performed by a continuous-wave lidar on the measured turbulent flow. This effect is quantified through a novel experimental technique, i.e. using a short-range Lidar in a wind tunnel environment and assessing it against hot-wire anemometry. The analysis is well performed by taking into account the most important aspects of the problem. Writing sometimes is unclear and colloquial; thus, some comments are reported in the following to improve clarity.

Specific comments

L94: Provide some details about the seeding procedure (e.g., seed type, mean particle mass and volume, point(s) of application, any measurement about the concentration etc.).

L125: Provide a quantification of the time lag and, if possible, a plot reporting the mentioned cross-correlation.

L145: The equality between the full-width half-maximum length (FWHM) and probe length holds for a continuous wave-lidar, whereas for a pulsed lidar those are distinct parameters. Please specify them.

L163: It is more correct to state that their contributions, weighted by the respective sine and cosine functions, are negligible with respect to u_p.

L212-213: Do you have any reference assessing this assumption?
In any case, this procedure does not make much sense to me as, in case of lidar measurements, the noise is related to random fluctuations of the backscattered signal, which introduces an uncertainty in the Doppler shift (see e.g. Frehlich and Yadlowsky, 1994; Frehlich, 1997 for pulsed Doppler lidar). Hypothesizing a connection between the noise and physical properties of the turbulent flow is a strong statement that needs to be better justified. As validation, you can quantify the noise from the lidar data in an independent way, for instance the auto-correlation method of Lenshow *et al*. (2000).

L253: Showing a correlation between instantaneous values may be questionable as the latter are affected by the uncertainty due to the lidar noise (which has not been removed) and the interpolation of the hot-wire signal onto the lidar time stamp. If you want to compare the recorded time distributions, I recommend to at least perform a moving average of the signals and then apply the linear regression. As an alternative, you can calculate mean velocity and standard deviation over non-overlapping periods (whose length must be carefully established) and then compare them.

L319: As for Figures 9 and 10, I recommend to compare either a moving average over a short time period.

Technical corrections

L2: Add the meaning of the acronym “lidar”.

L4-6: Please consider to change the statement to: “The hot-wire anemometer is used as theoretical reference to assess the lidar-based statistics, time series and spectra”. Remove the mention to the Taylor hypothesis as the spectra are evaluated in frequency.

L22: Please add some references to important wind tunnel studies of wind turbines.

L32: Please state that, in contrast to the probing techniques mentioned in the previous paragraph, the lidar technology has been originally developed for real-scale studies and you are proposing a novel implementation of this technology.

L34: Replace “[…] but make up for it […]” with “[…] but, on the other hand, […]”.

L55: Please add a short paragraph to describe the content of the next Sections.

L71-74: Replace “However, for the measurement campaign described in this paper, they are placed near the walls of the wind tunnel. Three of them can be seen on the right side of the nozzle in Fig. 1. The two remaining ones are parked at the back of the wind tunnel and serve as measurement platforms for the lidars, as illustrated by Fig. 2” with: “For the present campaign, only two test sections are used as measurement platforms for the lidars, as illustrated by Fig. 2.”

L78: Specify that two identical continuous-wave lidars are used in this campaign.

L81: Specify that the Doppler shift is calculated with respect to the emitted laser frequency.

L135: Add reference to Sjöholm *et al*. (2009).

L187: I think here you are referring to Eq. (7). If so, please correct.

L219: Please add: “The Kolmogorov spectrum in the inertial subrange is modeled as follows: […]”.

L226: Specify that, at this stage, the comparison is done in time between instantaneous values.

L243: Please add that this difference will be addressed in the following part of the Subsection.

L350: It is incorrect to state that the low-frequency peaks do not have physical significance. I would change this sentence with “As they result from external gust variations, these peaks are not deemed to be due to turbulence […]”.

L358: For the sake of clarity, please report the definition of coherence here.

L386: To my understanding, here you are applying the Lorentzian model described in Sec. 3.2 to the hot-wire spectrum and qualitatively compare the similarity with the WindScanner 2 streamwise spectrum. Please state this clearly at the beginning of the Subsection.

References:

- Frehlich, R. G., and M. J. Yadlowsky. "Performance of mean-frequency estimators for Doppler radar and lidar." *Journal of atmospheric and oceanic technology* 11.5 (1994): 1217-1230.

- Frehlich, R. G. "Effects of wind turbulence on coherent Doppler lidar performance." *Journal of Atmospheric and Oceanic Technology* 14.1 (1997): 54-75.

- Lenschow, D. H., Volker W., and Christoph S.. "Measuring second-through fourth-order moments in noisy data." *Journal of Atmospheric and Oceanic technology* 17.10 (2000): 1330-1347.

- Sjöholm, M., Mikkelsen, T., Mann, J., Enevoldsen, K., & Courtney, M. (2009). Spatial averaging-effects on turbulence measured by a continuous-wave coherent lidar. *Meteorologische Zeitschrift*, *18*(3), 281–287.