Review Report: Wind energy science

On the lidar-turbulence paradox and possible countermeasures

This manuscript explores valuable methods for correcting CW Doppler lidar turbulence measurements through both a physics-based model and neural networks, utilizing data from CW lidars and sonic anemometers across various heights. While the lidar-turbulence model demonstrates good performance at lower altitudes, it faces challenges at higher levels, attributed to turbulence filtering and contamination effects. The neural networks appear to enhance the accuracy of lidar-based turbulence measurements, although some biases persist, particularly at elevated wind speeds.
Overall, this paper provides a contribution to the field by addressing the lidar-turbulence paradox with innovative solutions and providing a comprehensive analysis of lidar performance across different altitudes. It builds on existing literature while introducing new methodologies that could pave the way for more accurate and reliable lidar-based turbulence measurements. Several detailed comments are provided below.

Comments

1. L1-2 – "*lidar-based…standard turbulence measures*". I understand that it is impossible to provide accurate definitions in an abstract; however, this can be misleading because turbulence measurements can be performed with different instruments with different temporal and spatial resolutions, e.g. from lidars down to micro hot-wire anemometers; nonetheless, they are still considered turbulence measurements. I would rephrase it as "…that corrects lidar turbulence measurements to enable adequate turbulent statistics for atmospheric and wind energy applications", or something similar.
2. L50 – I would add $\langle u'w' \rangle$ are generally negative (Chowdhuri, S. and Deb Burman, P.K., 2020. Representation of the Reynolds stress tensor through quadrant analysis for a near-neutral atmospheric surface layer flow. *Environmental Fluid Mechanics*, *20*(1), pp.51-75.; Shig, L., Babin, V., Shnapp, R., Fattal, E., Liberzon, A. and Bohbot-Raviv, Y., 2023. Quadrant analysis of the Reynolds shear stress in a two-height canopy. *Flow, Turbulence and Combustion*, *111*(1), pp.35-57.)
3. L53 – If you define $v_r = u\cos\phi + w\sin\phi$, then you should get $\sigma_{v_r} = \sigma_u^2\left(\cos^2\phi + \frac{1}{4}\sin^2\phi - \frac{1}{6}\sin 2\phi\right)$. If that's the case, you should revise the following discussion with different ϕ. Please cross-check.
4. L64 – "…eddies with most energy". Actually, the energy-containing eddies are those at larger scales, larger than those belonging to the inertial subrange. I would rather say…a probe volume small enough to probe turbulence processes at small scales, ideally down to those responsible for dissipation, which are proportional to the Kolmogorov scale.
5. L197 – Can you provide references about the relationship between turbulence intensity and height? How much does it differ from other theories, e.g. Townsend wall-attached eddy hypothesis where $\sigma_u^2 = B_1 - A_1\log\frac{z}{\delta}$?
6. L 317 – In Fig. 4 – make sure y-axes and x-axes have the same scale.

7. Conclusions: You should provide an overall summary of work describing the strategy, the objectives, not only the results. Please rework on the conclusions.