In the previous round, question 21 from Reviewer 2 question 21 was:

"Line 454 and Table 1. This sentence implies that the higher S/N of the MPL led to a better performance when measuring aerosol gradients, which in turn, led to a better performance in determining the PBL height. If this is the case, then why were Raman lidar measurements of aerosol profiles (e.g. aerosol attenuated backscatter, aerosol unattenuated backscatter, extinction, and/or depolarization) not used in any of these analyses? The Raman lidar S/N should be much greater than the MPL S/N and hence be more likely to see weaker aerosol gradients than may correspond to PBL HT, especially at night. (If for some reason this was not true the paper should explain what was wrong with the RL.) These measurements have inherently high vertical and temporal resolution that could be very useful for such analyses. Furthermore, the RL provides (or is at least supposed to provide) high temporal and vertical resolution water vapor profiles during both daytime and nighttime operations. It would be interesting to see if the gradients in water vapor would be more or less useful than aerosol gradients to determine PBL HT, especially at night. This reviewer was surprised (and disappointed) that such RL measurements were not included in these analyses. This omission is even more surprising when considering that RL measurements of temperature were included. Consequently, the paper should address why such RL measurements of aerosols and water vapor were not included when RL measurements of temperature were included."

I disagree with the authors' responses regarding their choice not to use data from the SGP Raman lidar (RL). They do not attempt to compute PBL heights from RL water vapor profiles and instead state that, "…based on Ferrare et al. (2012) methodology, that ML heights from Raman lidar water vapor measurements have a large high bias as compared to BL heights from radiosonde potential temperature." This statement is misleading for the following reasons.

1) They apparently base this response on the statement in slide 8 of the Ferrare et al. (2012) reference which states "Nighttime: ML heights from Raman lidar water vapor have large high bias as compared to BL heights from radiosonde potential temperature." What they do not indicate is that on the same slide in this reference is the statement "Daytime: ML heights from derived from Raman lidar water vapor gradients and radiosonde potential temperature are comparable."
2) They also do not discuss the example shown on slide 5 in this same reference that shows and states "in general, water vapor provided more reliable ML height retrievals (than aerosol gradients)". (see also Chu et al., 2022)
3) They also do not mention the example and statements on slide 7 that both water vapor **AND** aerosol gradients are often associated with residual layers above the nocturnal BL so that both types of gradients (aerosols and water vapor) lead to high biases in nighttime ML heights. Thus, the Ferrare et al. (2012) reference indicates that both water vapor and aerosol gradients lead to high ML height biases at night.

Therefore, there is no basis for the authors to reference Ferrare et al. (2012) to give the impression that BL heights derived from water vapor gradients would be less accurate than BL heights derived from aerosol gradients, when, as discussed in number 2 above, the exact opposite is true. Moreover, since the authors found aerosol gradients determined from the MPL to be very useful in their algorithm, the aerosol **and** especially the water vapor gradients from the Raman lidar can also be very useful in a similar manner.

The authors also contend that: 1) the MPL backscatter provides a clearer contrast between the PBL and the free atmosphere than the RL, and 2) the reason for this is because of greater molecular scattering at the RL wavelength (355 nm) than the MPL wavelength (523 nm).

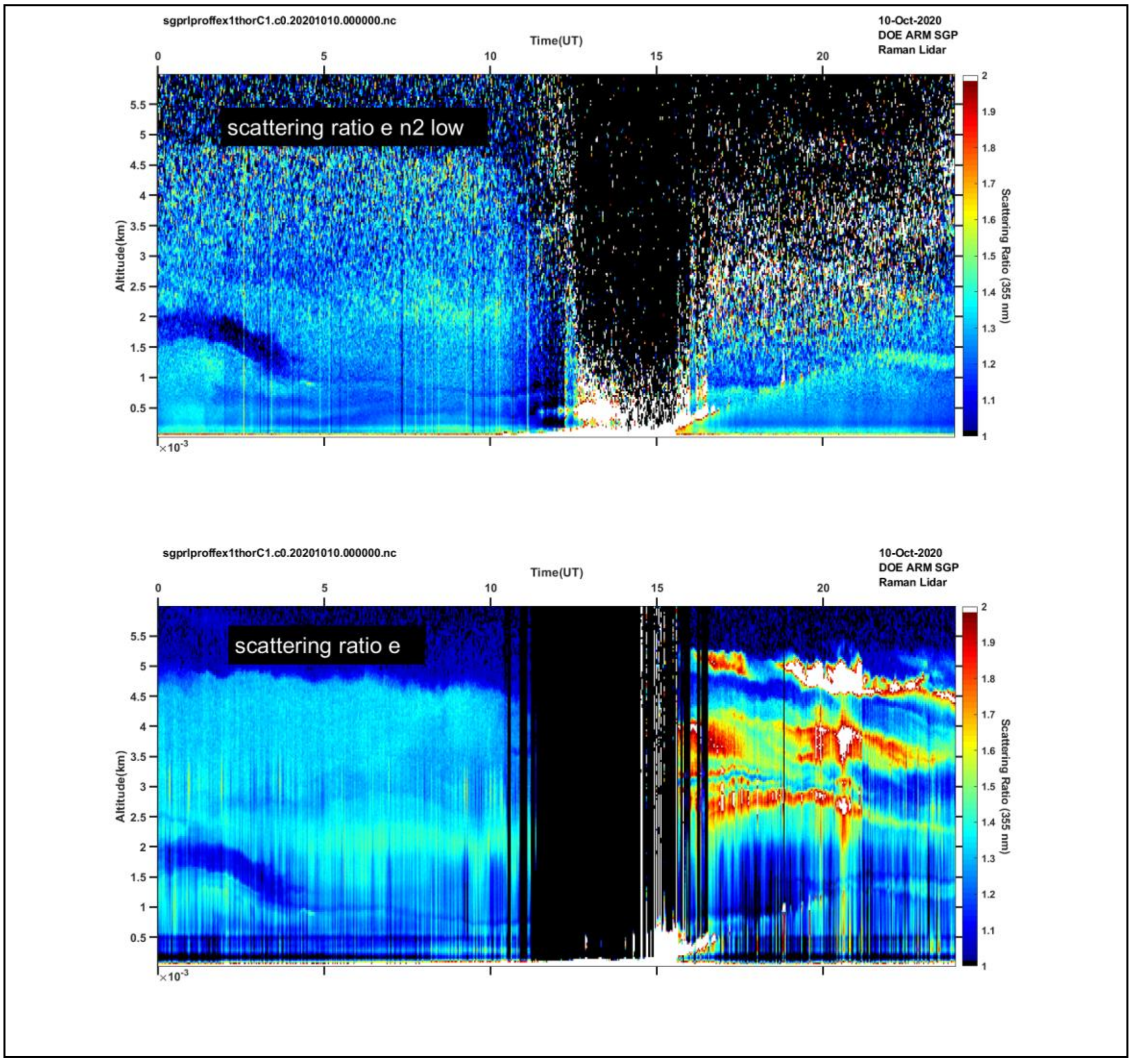
Regarding (1) the authors provide images that seem to support their statement. However, note the images of scattering ratio from the RL low sensitivity channels (top) and the combined (low+high) sensitivity channels (bottom) for this same day shown below. The images show the name of the parameter plotted. For those who are used to viewing lidar data, these images clearly show the location of the top of the BL, particularly during the daytime. I will contend that these images show this at least as clearly as the MPL example provided by the authors in their response.

Regarding (2) the reason for the claimed lower contrast in the RL data is not because of molecular scattering. The RL retrievals of scattering ratio (and consequently aerosol backscatter) are computed from the ratio of aerosol+molecular elastic backscatter (355 nm) to the Raman vibration-rotation scattering from nitrogen (387 nm) (see Turner et al., 2002; Thorsen and Fu, 2015). Because Raman scattering from nitrogen is much weaker (a couple of orders of magnitude) than the elastic backscatter, the uncertainty is dominated by the noise of the Raman scattering nitrogen signal. It is this dependence on measurement of the Raman nitrogen scattering which increases the noise in these particular retrievals of scattering ratio and aerosol backscatter.

More importantly, consider if instead the Raman lidar measurement of elastic backscatter at 355 nm is used, by itself, to derive BL heights in a similar manner as the MPL measurement of elastic backscatter. The much higher output power (9 W) and larger receiver (61 cm diameter telescope) would provide a much stronger backscatter signal than from the MPL and, therefore, would lead to a much stronger representation in aerosol gradients to derive BL heights.

My main point in this discussion is that: 1) the RL aerosol and water vapor data provide strong indicators of boundary layer height (recall Ferrare et al. 2012 and Chu et al. 2022 references) and, 2) the authors should indicate that the RL aerosol and water vapor data could be used to do so rather than neglecting this in the paper. Considering that the RL was designed to be first and foremost a lidar to measure water vapor and aerosol profiles, and that such profiles were used to derive PBL heights and published previously (e.g. Chu et al. 2022) this is a serious omission.

My recommendation is that the authors include some statements as to the applicability of the RL data for determining BL height and preferably also some reason(s) why such data were not used. Looking at the image of scattering ratio derived from combining the low and high sensitivity channels shown in the second image below, I may suggest a good reason for not using the Raman lidar aerosol scattering ratio data is the presence of many artifacts in the data; the image shows what appear to be temporal oscillations in the data (i.e. vertical stripes) as well as horizontal bands at various altitudes. It is easy to see how these could cause considerable difficulty in automated algorithms to derive BL height. Also, there are apparently no RL water vapor profiles available from the ARM archive for this date so the periodic lack of water vapor profiles could be a reason for not using the RL water vapor data to determine BL height.



References:

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