Referee report to the revised version of the "The Aerosol Limb Imager: Multispectral Polarimetric Observations of Stratospheric Aerosol" manuscript by Daniel Letros et al.

In their response the authors claim that additional investigations required by me to justify the validity of the presented approach are beyond the scope of their paper. Unfortunately, I cannot agree that the scope of the paper defined by authors is sufficient for the publication. The authors neither investigated most crucial error sources in the synthetic retrievals nor provided a statistically significant validation. At least one of these issues needs to be addressed properly to justify the trustability of the retrieval results. Although this information is not provided in the paper, I assume that one balloon flight does not provide sufficient number of measurements to do a statistically significant validation. Concerning the synthetic retrievals the following investigations have to be done in addition:

1. Investigate influence of the assumption about the negligible amount of stratospheric aerosols above 30 km. This must be done for both aerosol and albedo retrieval. In general, the statement made by the authors that this amount is negligibly small is false. Multiple studies report that the aerosol extinction around 30 km is about 10^{-5} km^{-1} and is still above 10^{-6} km^{-1} in the 32 - 33 km altitude range [1, 2, 3]. Thus, it is definitely non-zero in the 30 – 33 km range used by the authors for the normalization. It is essential to check how this amount of aerosols affects the retrieval.

2. Investigate how a change in the surface albedo affects the retrieval. In the current version of their retrieval, the authors do no change the value of the surface albedo when doing synthetic retrievals. This makes impossible to evaluate how the retrieved albedo value depends on the aerosol state and how the uncertainties in the albedo retrieval affect the resulting aerosol extinction coefficient profile.

Detailed comments

- Author replies, page 14: "The caveat to this statement is if true state conditions and a-priori conditions differ significantly - i.e. the underlying a-priori information given to the Kalman filter is no longer appropriate to reach the true state solution." $\longrightarrow$ This formulation is too imprecise. How different the aerosol state should be to cause a retrieval failure? Is it still within realistic values? Will the retrieval fail, e.g. after a strong volcanic eruption like the one of Hunga Tonga?

- Author replies, page 19, my comment to Fig.7: The paper claims that DoP is a suitable measure to distinguish between the aerosol and clouds. To justify this, it is not enough to show you can see a cloud, you also need to show that there is no false identification for strong aerosol levels. Furthermore, it is unclear if the method also works for water clouds.

- Introduction: I do not understand why you cannot describe how the capabilities of the ALI balloon-borne instrument are compared with those of current satellite instruments.

- Page 2, line 55 (tracked changes version): "…. so the top lines of sight are flat and level with the (idealized) surface of the Earth." $\longrightarrow$ I do not understand what you want to say here, please reword the sentence.

- Fig. 1 caption: please spell out SPS and LCR also in the figure caption.

- Page 6, line 119 (tracked changes version): please replace "flat" by "homogeneous".

- Page 6, line 136 (tracked changes version): please replace "flat uniform" by "homogeneous".

- Fig. 1 caption: black dots in the left panel are still not explained.

- Page 7, line 143 (tracked changes version): please replace "flat" by "homogeneous".

- Page 7, line 172 (tracked changes version): "However, for the scope of the present work we select only three of these science scans for demonstration." $\longrightarrow$ please write how many states are available in total and justify why only 3 of them are used.

- Page 12, line 253 (tracked changes version): "The measure we take to quantify the albedo is the integration of the high-altitude radiance with respect to wavelength" $\longrightarrow$ What happens if the surface albedo is wavelength dependent? Please check the wavelength dependence of the surface albedo for common surface types and investigate implications for the retrieval if albedo of any of them shows significant wavelength dependence in the relevant spectral range.

- Page 15, line 340 (tracked changes version): "This albedo informs θ of a simple Rayleigh atmosphere (no aerosol or ice) which constructs the a-priori profile." $\longrightarrow$ I do not understand what you want to say with this sentence, please reword.

- Page 25, line 501 (tracked changes version): "produced a true state DoP approximately ranging between 0.3 - 0.4" $\longrightarrow$ As you do not show the corresponding plot it is completely unclear where these values come from.

- Page 26, line 520 (tracked changes version): "This does still present a polarized aspect to the ALI retrievals of this exercise which hampers a completely level methodology to the comparison." $\longrightarrow$ I do not understand what you want to say with this sentence. Please reword.

- Page 29, line 597 (tracked changes version): "we find encouraging indication of size agreement between ALI and SAGE III/ISS with the metric of effective radius." $\longrightarrow$ I think this statement is too optimistic.

- Figs. 17 and 18: Last sentences in the figure captions should be moved to the main text.

Technical corrections

- Page 15, line 342 (tracked changes version): "Fig. 7 is discussed" $\longrightarrow$ "Fig. 7 are discussed"
- Page 15, line 348 (tracked changes version): "that is not" $\longrightarrow$ "that are not"
- Page 20, line 329 (tracked changes version): "consists of the of the 10 wavelengths" $\longrightarrow$ "consists of the 10 wavelengths"
- Page 21, line 460 (tracked changes version): "states is is well" $\longrightarrow$ "states is well"
- Page 28, line 587 (tracked changes version): "is shown" $\longrightarrow$ "are shown"

References

Rieger, L. A., Zawada, D. J., Bourassa, A. E., Degenstein, D. A., A Multiwavelength Retrieval Approach for Improved OSIRIS Aerosol Extinction Retrievals, J. Geophys. Res. Atmos., 124(13),7286-7307 https://doi.org/10.1029/2018JD029897, 2019.

Pohl, C., Wrana, F., Rozanov, A., Deshler, T., Malinina, E., von Savigny, C., Rieger, L. A., Bourassa, A. E., and Burrows, J. P.: Stratospheric aerosol characteristics from SCIAMACHY limb observations: two-parameter retrieval, Atmos. Meas. Tech., 17, 4153-4181, https://doi.org/10.5194/amt-17-4153-2024, 2024.

Kovilakam, M., Thomason, L. W., Verkerk, M., Aubry, T., and Knepp, T. N.: OMPS-LP aerosol extinction coefficients and their applicability in GloSSAC, Atmos. Chem. Phys., 25, 535-553, https://doi.org/10.5194/acp-25-535-2025, 2025.