

This paper presents a validation of the EarthCARE ATLID stratospheric aerosol extinction profiles and stratospheric aerosol optical depth by comparison against SAGE III/ISS solar occultation measurements and the ground based lidars at the Table Mountain Facility and the Observatoire de Haute-Provence. The paper is well organized and presents an important validation of the ATLID stratospheric aerosol retrievals. After edits for clarification and readability I recommend this paper for publication.

We thank the referee for the careful reading of our manuscript and for the positive assessment of our work. The comments helped us to improve the clarity of the paper; in particular, following the referee's suggestion, the profile comparisons with SAGE III/ISS are now presented as a function of altitude relative to the local tropopause. Our point-by-point responses are given below.

General comments

1. **Analysis in altitude above tropopause** – When analyzing vertical profiles from scattered latitudes it is sometimes clearer to present analysis in altitude above tropopause. This may make the features in your altitude plots more distinct and give the reader more confidence in your statements with respect to altitude. Such as the statements made in section 3.2, which discuss features at specific altitudes. With geometric altitude the altitude plots may be spreading out the near tropopause features. As well the latitude plot (Figure 5a) may be affected by this.

Following the referee's suggestion (also made by Referee #1, minor comment 5), Figs. 1b and 2 now show the relative extinction difference as a function of altitude relative to the local tropopause, using the ATLID tropopause height and all levels located at least 1 km above it. As anticipated by the referee, this representation changes the picture near the tropopause. The moderately positive bias found at 10–13 km in geometric altitude, which relied on a small number of profiles with a low tropopause, is no longer present. The median relative difference is negative in the first ~3 km above the tropopause (about –10 to –15 %), close to zero between about 5 and 15 km above the tropopause, and negative again further up. The overall median relative difference is essentially unchanged (–2.2 %, compared with –2.3 % in geometric altitude), since only the vertical coordinate differs. The description of the vertical structure in Sect. 3.2, its discussion in Sect. 4.1, the abstract and the conclusions have been revised accordingly. In particular, near the tropopause the SAGE III/ISS comparison now agrees with the ground-based lidars, which also show a negative bias just above the tropopause, so the SAGE-specific explanations proposed in Sect. 4.1 for a positive offset are no longer needed.

Regarding Fig. 5a, the sAOD of each matchup is integrated from 1 km above the local tropopause to 30 km, so the lower bound of the integration already follows the tropopause.

The latitudinal distribution of the sAOD bias is therefore not affected by the geometric-altitude representation in the same way as the profiles, and Fig. 5a has been kept in its present form.

2. **Use of the L2 lidar ratio in the L1-derived extinction**– Problems with L2 extinction are well discussed, however the L2 lidar ratio is used in calculating the L1-derived extinction. Could the issues affecting the L2 retrieval be of any concern for the L1-derived values through the use of the L2 lidar ratio? What are the possible effects on the resulting error? A short discussion of this seems warranted.

We agree that this point deserved a discussion, which has been added to Sect. 2.2. The L2 lidar ratio enters the L1-derived extinction only at the levels where it is available and lies between 30 and 90 sr; elsewhere, a value of 50 sr is used. The issues affecting the L2 retrieval can therefore affect the L1-derived product only at these levels, and only through the lidar ratio, not through the L2 extinction itself. Since the extinction is proportional to the lidar ratio, a relative error on the lidar ratio gives the same relative error on the extinction; with the 30-90 sr bounds, an erroneous L2 value can change the extinction by –40 % to +80 % relative to the 50 sr value at the levels concerned. Finally, the backscatter comparison with the ground-based lidars (Sect. 3.5) does not involve any lidar ratio and shows the same negative bias just above the tropopause, which indicates that the main features of the comparison are not driven by the L2 lidar ratio. See also our response to the first main comment of Referee #2, where the effect of the lidar ratio is illustrated for the case studies of Fig. 3.

Specific Comments

3. **Section 3.2: noise-floor interpretation** – The statements that the scatter at low extinction is “consistent with the additive retrieval noise floor” and that the relative differences approach zero above 25 km as both instruments approach their respective noise floors could use more explanation or supporting references. In particular, it is not obvious why approaching the noise floor should cause the relative difference between the instruments to approach zero. Some additional justification of this interpretation would be helpful.

We agree that these two statements needed clarification.

(i) By "additive noise floor" we meant the random noise of the ATLID L1 extinction, which comes from the detection noise of the ATLID channels (in particular the Mie channels, whose signal is weak in the stratosphere) and whose absolute magnitude does not depend on the aerosol loading. A random error of roughly constant absolute magnitude produces a constant absolute scatter, and therefore a relative scatter that increases as the extinction

decreases. This is why the scatter in Fig. 1a is largest, in relative terms, at low SAGE III/ISS extinction. The sentence has been rewritten to explain this.

(ii) We agree with the referee that approaching the noise floor should increase the scatter of the relative differences, not bring their median toward zero, and this interpretation has been removed. Moreover, with the tropopause-relative coordinate now used in Fig. 1b (see our response to general comment 1), the median relative difference no longer converges toward zero at the highest levels: it is close to zero between about 5 and 15 km above the tropopause and becomes negative further up. The revised Sect. 3.2 describes this behaviour without invoking the noise floor, and the corresponding sentence in Sect. 4.1 has been removed.

4. **Figure 7 / treatment of missing L2 retrievals** – The text describes unsuccessful L2 retrievals as fill values, while Figure 7 appears to assign zero sAOD to cases where no stratospheric retrieval is returned. It would be helpful to clarify exactly how these cases are handled. Are fill values explicitly converted to zero during the sAOD calculation, or does the L2 product actually report zero extinction? It would also be useful to explain why Figure 7 contains 652 SAGE comparisons when the overall collocation dataset contains 895 profiles.

The L2 product itself reports zero extinction at the levels where no aerosol is detected, and these zeros are used as such in the sAOD integration: $\text{sAOD_L2} = 0$ therefore means that the L2 extinction is zero at all levels of the integration range. True fill values are rare (about 2–5 % of the stratospheric levels) and are discarded, not converted to zero. The manuscript wrongly referred to these cases as fill values; this has been corrected.

The L2 comparison includes fewer matchups (652) because the daily L2 files used here contain fewer profiles than the L1 files: about 6,400 profiles per day for L2, compared with about 22,750 for L1. This is now explained in Sect. 3.6 and in the caption of Fig. 7.

5. **Line 51: “season”**. “time” would be more appropriate I think, there is no real seasonal analysis.

Agreed. "Season" has been replaced by "time" (line 51).

6. **Dist in the Figure 3 extinction plots** – I like this detail added to the plot. Am I right in thinking this is the distance between the SAGE tangent point and ATLID's footprint? If so, this should be stated somewhere. Since multiple ATLID profiles are averaged for each collocation, it would also be helpful to clarify exactly how this distance is defined.

Yes. "Dist" is the great-circle (haversine) distance between the SAGE III/ISS tangent point and the closest of the ATLID profiles averaged in the collocation; all the averaged ATLID profiles lie within 50 km of the tangent point (Sect. 2.5). This definition is now given in Sect. 2.5 and in the caption of Fig. 3. In addition, the time difference Δt shown in the panel titles is now computed from the time of the collocated ATLID overpass (it was previously computed from the median time of the daily ATLID file, a mistake), and the corrected values are reported in Sect. 3.2.2.

7. **lines 67–68: “Successfully retrieves extinction”.** Seems to be too strong a statement, or perhaps just accidentally misleading, considering what is said about the performance later in the paper.

We agree that this wording was misleading. Lines 65–68 have been rewritten as: "However, as suggested by Khaykin et al. (2026) (hereafter K26) and confirmed in this study, the L2 processor frequently returns zero extinction under low-aerosol background conditions, in the absence of a sufficiently strong aerosol signal. For optically thicker layers such as volcanic plumes, the L2 algorithm does return non-zero extinction, but it overestimates the peak extinction (Sect. 3.2.2), and the resulting sAOD is only weakly correlated with the reference measurements (Sect. 3.6)."

8. **Lines 382–384:** The statement that “the true physical lidar ratio is expected to be close to the 50 sr assumed value” should be supported by a reference, or the language softened. Kremser et al. (2016), cited earlier, reports typical stratospheric lidar ratios of approximately 45–50 sr at 532 nm. Since ATLID operates at 355 nm, please clarify whether there is evidence that 50 sr is similarly representative at this wavelength for the aerosol conditions considered here.

We agree that this statement was too strong and have softened it. Direct estimates of the lidar ratio of stratospheric sulfate at 355 nm are scarce. Vaughan et al. (2021) retrieved the 2019 Raikoke and Ulawun sulfate layer at 355 nm with a lidar ratio of 40 sr (50 sr on two nights), checked against Raman measurements on a few nights. A constant value of 50 sr, representative of sulfate aerosol, is also used for the 355 nm LiO3S lidar at Maïdo (Khaykin et al., 2026; K26). The 50 sr value thus lies at the upper end of the values used at 355 nm. Because the L1-derived extinction scales linearly with the lidar ratio, a ± 10 sr departure from 50 sr changes the extinction by ± 20 %. This sensitivity is now shown as an envelope in the revised Fig. 3, at the levels where the 50 sr fallback is used (40–60 sr for the background and volcanic cases, 40–70 sr for the smoke cases; see also our response to Referee #2, main comment 1).