Answers to: RC1 'Comment on essd-2022-272':
"The recovery and re-calibration of a 13-month aerosol extinction profiles dataset from searchlight observations from New Mexico, after the 1963 Agung eruption" by

Juan-Carlos Antuña-Marrero et al.

We have replied to each of the Reviewer 1's comments, showing the reviewer's comments in black (Arial font), and our replies to these in brown color (Times font). Where excerpts of text are shown from the original or revised manuscripts, these are shown in italics with quotation marks.

Anonymous Referee #1, 14 Nov 2022

This study reported the recovery and re-calibration of an extensive dataset of vertical profile measurements of the 1963~1964 stratospheric aerosol layer measured from a two site searchlight measurement facility at White Sands missile base and Sacramento Peak observatory, in New Mexico, US. This work has scientific significance for the observation of stratospheric aerosol increase due to historical volcanic eruptions.

However, the authors heavily cite figures and tables from previous studies and do not have a comprehensive flow chart of this study, and the manuscript is not written with sufficient standardization, making it difficult to read. In addition, calibration or re-calibration is often done with reference to higher standards and is a bottom-up effort to seek higher accuracy. This is also the guarantee of traceability of measurement results. Only in this way can the results after calibration or re-calibration be more reliable and comparable. If more uncertainty is introduced into the re-calibration process, the results are hard to convince.

Answer:

The text in the manuscript was reorganized in general some sections were included together with several figures cited in the original version and several section were rewritten partially:

- Section **3 The re-digitization of the searchlight 550nm aerosol extinction profiles and estimated errors** was renamed **3 The recovery of the searchlight 550nm aerosol extinction profiles and estimated errors**.
- A new section was introduced **4. The re-calibration procedure: constrains, improvements and design:** It is aimed to describe the limitations and improvements of the re-calibration and to provide a broad view it, identifying the retrieval of the normalized detector response and the re-calibration as to linked but separated procedures.
- Former Section **4.4.3.1 Transmission algorithm** moved to the new Section **5 Retrieving the normalized detector response.**, becoming Section **5.2 Slant transmission algorithm**, with the corresponding changes in the rest of the section numbers.
- Section **4.4 Parameters used to re-calibrate** $\beta_p(z)$, became Section **6 Parameters used to re-calibrate $\boldsymbol{\beta_p(z)}$.**
- Former Section **5.3.1 Transmission algorithm** moved to the new Section **5 Retrieving the normalized detector response**., becoming Section **5.2 Slant transmission algorithm,** with the corresponding changes in the rest of the section numbers.
- In the Section **6 Parameters used to re-calibrate $\boldsymbol{\beta_p(z)}$** the section **6.4 Tropopause altitudes:** was introduced, replacing the original analysis with NCEP reanalysis by an updated one with the ERA5, one of the most recent reanalysis.
- The sub-sections associated with the same subject in the former sections ***"5. Results and Discussion"*** and ***"6. Discussion"*** were merged and all of them are now in the renumbered section ***"8. Results and Discussion"***. Then the tables 2 to 4 were reorganized. Tables 2, 3 & 4 became Tables
- The former subsections **4.5 Preliminary re-calibration results and subsequent adjustments** and **5.6. Errors:** were transferred to the new section **7 Re-calibration, adjustments, errors not accounted for in the original $\boldsymbol{\beta_p}$ dataset and estimated $\boldsymbol{\beta_p^{Recal}}$.errors.** with 4 subsections:
    7.1 Preliminary re-calibrated results

7.2 Subsequent adjustments of the updated parameters
7.3 Errors not accounted for in the original β_p dataset:
7.4 Estimated β_p^{Recal} errors:

In addition, the new section 7.3 discusses and quantifies the improvements associated to each of the updated parameters.

Other changes-corrections introduced:

1) To be more precise with the geometry of the instrument the term transmission, in relation to the instrument variables and its processing, is now "slant transmission".
2) A change in the subscript "R" in the variable $T_R(z)$, representing the Rayleigh transmission, was corrected on the equation 2, line 202. It was also corrected on lines 298, 299 and 395.
3) The identification of the information in the Supplement have been changed for the figures, they are now identified by an "F" instead of and "S". Detailed information is identified by "S". Tables remain identified by "T".

There are some detail comments as followed:

- According to the introduction, the detector response and aerosol extinction profile are given in the original literature table, why do the authors need to invert the detector response using the aerosol extinction profile and then compare the accuracy of the detector response with the original table?

Answer:

The search in all the available literature (articles and reports) only found the same Table 1 both in an article and in a report (Elterman 1966a, b) attached as Annex A. The Table 1 caption is the same in both the article and the report: *Computer Output (partial tabulation) Measurement on 13 April 1964 at 00:18*. That night 4 observations were conducted, listed on Table T1 in the Supplement, at 0018, 0058, 0219 and 0320 MST. However, Table 1 do not list the three other observations that night. Table 1 only list part of the detector response and the aerosol extinction vertical profiles from only one of the 105 profiles reported in "An Atlas of Aerosol Attenuation and Extinction Profiles for the Troposphere and Stratosphere" as plots of the aerosol extinction vertical profiles (Elterman, 1966a).

There are not any similar table or any other source of "Detector Response Normalized" info for the rest of the 104 aerosol extinction profiles, eliminating the possibility of reproducing the calculation procedure implemented by Elterman for those 104 profiles.

- I can understand that many parameters need to be reacquired when recovering historical data, however, the use of these data in section 4.4 requires more rigorous argumentation and validation to prove that they are plausible and do not introduce too much error into the re-calibration data. The authors have not argued enough in this regard and suggest a fuller justification of the uncertainty analysis of the data used and its impact on the results, e.g., scattering phase functions, etc.

Answer: On line 313 of the manuscript, a sentence explain that a former study (Wells, 1968) determined the $P_p\left(\varphi_s(z)\right)^{Orig}$ was considered the major source of error in determining the aerosol extinction coefficient profile from single scattering theory because it was measured at a different time and geographical location than that used for the searchlight experiment
However, to clarify more this issue we moved that sentence to the beginning paragraph of the renumbered section **6.2 Rayleigh, tropospheric and stratospheric aerosol phase functions.**
In addition, the former section 5.3.1 Other variables was renumbered and renamed, it is now: **6.4 Tropopause altitudes.**
Also, we included a new section: **7.3 Errors not accounted for in the original β_p dataset:**
, to discuss the improvements associated to each of the updated para meters.

- For the aerosol extinction profile, did the authors re-digitize the figure data from the original literature in order to obtain observations for each layer and thus use Fernald's algorithm?

Answer:

Yes, we re-digitize the figure data (aerosol extinction profiles) from the original literature (Elterman, 1966a) in order to obtain observations for each layer.

No, we did not use Fernald's algorithm. We used the algorithm described by Elterman (1966a). It should be stressed that Elterman´s algorithm is based in the assumption of the atmosphere consisting of two main scatterer's: aerosol and molecules. That is the same assumption made by Fernald.

We used the equation he derived for that algorithm. First backward to retrieve the set of "normalized detector responses" from the re-digitized aerosol extinction profiles and the old set of parameters Elterman reported he used. Then, we used the same equation in the way forward having as inputs the retrieved "normalized detector responses" and replaced several of the old parameters by updated, new ones.

- However, it is possible that the large uncertainty of the data in the near surface layer caused a large error of the re-calibrated results from the literature digitization results (Fig. 6). In this regard, the authors should give other supporting information to show that the reader can trust the rescaled data.

Answer: We used all the available contemporary available information about the stratospheric aerosols from the 1963 Mt Agung eruption in the northern hemisphere to show the trust in the recalibrated data. However, it was placed in the subsections of the former section "**6 Discussion**". For clarity we moved the individual subsections to the corresponding subjects in the renumbered and renamed section "**8 Results and Discussion**".

In particular in the section "**8.2 Re-calibrated profiles of $\boldsymbol{\beta_p^{Recal}(z)}$:**" we compared the presence of two layers in the searchlight aerosol extinction cross sections, above and below the tropopause, against twilight observations, Lexington lidar and twilight from a satellite. In section "**8.5.2 Monthly Mean sAOD:**", the magnitude of the $sAOD^{Recal}$ are compared to the $sAOD^{Eclipse}$ derived from lunar Eclipses. The comparisons show a reasonable agreement between the results reported in this paper and the contemporary available information.

- From the AOD assessment in Figure 7, the recalibration data only systematically increased the value of AOD, while the correction of the overall trend was more problematic. Why not use AOD as a constrain to retrieve the atmospheric column aerosol extinction when simultaneous AOD data are available?

Answer: Former figure 7 (now figure 9) shows the tropospheric AOD (tAOD). The magnitudes of $tAOD^{Orig}$ and $tAOD^{Recal}$ were calculated from the original and recalibrated measurements of the tropospheric sections (both from 4.8 to 10.7 km) of the vertical aerosol extinction profiles respectively. The $tAOD^{AERONET}$ monthly means were obtained from the AERONET website and belongs to measurements conducted between 2006 and 2021. There is not simultaneous AOD data available.

- There are also some puzzling descriptions in the text, such as
  - Line 268-269: "…… an order of magnitude lower than the values in figure 1", but the figure 1 is the "searchlight scenes geometry".

Answer: The referee is right, it is not figure 1, but figure 2. CORRECTED.

  - Line 323: "…… in the digitization procedure (see section 2.3 above)", but section 2.3 is not included in this manuscript.

Answer: The referee is right, there is not section 2.3. It refers to section 3. CORRECTED.

  - Line 638: "…… from one of the major volcanic eruption of the XX century.", what does this XX mean? I did not list all of these problems. Please revise them carefully.

Answer: XX is twenty in Roman numbers. It was changed to:

"…from one of the major volcanic eruptions of the twenty century".

References:

Elterman, L., 1966a, An Atlas of Aerosol Attenuation and Extinction Profiles for the Troposphere and Stratosphere. Report AFCRL-66-828, AFCRL, Bedford, Mass., 128 pp., https://apps.dtic.mil/sti/pdfs/AD0649778.pdf

Elterman, L., 1966b, Aerosol Measurements in the Troposphere and Stratosphere, Appl. Opt. 5, 1769-1776. https://opg.optica.org/ao/viewmedia.cfm?uri=ao-5-11-1769&seq=0.

Annex A:

Table 1. Computer Output (partial tabulation)
Measurement on 13 April 1964 at 00:18

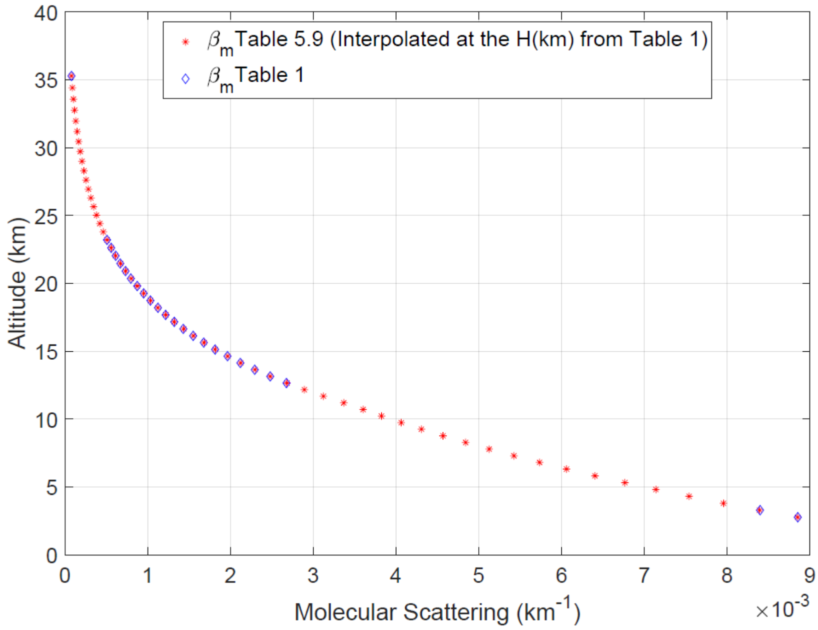
Collector Elevation (degrees) ϕ_d	Scatter Volume Altitude (km)	Scatter Angle (degrees) ϕ_s	Detector Response (normalized) E_{rp}	Rayleigh Coefficient β_r (km^{-1})	Aerosol Coefficient β_p (km^{-1})
0	2.76	75	93.95	8.852x10^{-3}	9.50x10^{-3}
1	3.28	76	89.20	8.396	9.72
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
20	12.65	95	23.49	2.674	5.74x10^{-4}
21	13.14	96	22.03	2.478	5.85
22	13.63	97	20.93	2.291	7.49
23	14.13	98	19.83	2.117	8.79
24	14.63	99	19.26	1.962	1.20x10^{-3}
25	15.12	100	18.53	1.812	1.45
26	15.63	101	17.80	1.675	1.66
27	16.13	102	16.34	1.547	1.44
28	16.64	103	14.87	1.428	1.17
29	17.16	104	13.73	1.319	1.03
30	17.67	105	12.89	1.214	1.04
31	18.20	106	11.95	1.122	9.33x10^{-4}
32	18.73	107	11.17	1.031	9.09
33	19.26	108	10.23	9.491x10^{-4}	7.63
34	19.80	109	95.10x10^{-1}	8.715	7.20
35	20.35	110	88.38	7.940	7.08
36	20.90	111	81.19	7.301	6.06
37	21.46	112	73.07	6.662	4.44
38	22.03	113	66.87	6.114	3.49
39	22.61	114	62.05	5.567	3.46
40	23.20	115	55.91	5.065	2.40
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
57	35.28	132	10.00x10^{-1}	7.711x10^{-5}	0.00 (neglected)

Table 1 both in an article and in a report (Elterman 1966a, b)

Elterman, L., 1966a, An Atlas of Aerosol Attenuation and Extinction Profiles for the Troposphere and Stratosphere. Report AFCRL-66-828, AFCRL, Bedford, Mass., 128 pp.

Elterman, L., 1966b, Aerosol Measurements in the Troposphere and Stratosphere, Appl. Opt. 5, 1769-1776. https://opg.optica.org/ao/viewmedia.cfm?uri=ao-5-11-1769&seq=0.

Annex B:



Rayleigh Coefficients at 1km vertical resolution reported on Table 5.11 in Elterman (1964) were interpolated at the altitudes listed on Table 1 to verify the consistence of the content of Table 1 with all possible means,

Elterman, L., Altitude variation of Rayleigh, aerosol, and ozone attenuating components in the ultraviolet region. AFCRL-64-400, 27p, 1964.