Answers to: RC3 '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 2'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 # 3, 07 Dec 2022

General comments

This manuscript deals with the interesting idea of estimating vertical profiles of aerosol extinction in the troposphere and stratosphere from ground-based active remote sensing measurements with a search light facility. The measurement principle is quite interesting and unusual and the re-evaluated measurements provide information on the stratospheric aerosol loading during the declining phase after the Agung eruption in 1963. In find the basic approach of re-evaluating these older measurements very good and the initiative commendable.

I do have, however, several major concerns regarding the applied methodology:

You determine the Tp profiles required for the re-calculation of the aerosol extinction profiles now with Modtran using climatological extinction profiles, if I understood correctly? (The descriptions are not entirely clear, e.g. the magnitudes with asterisks TR*, TO3* and Tp* appear in section 4.4.3.1 without an explicit introduction or additional explanations. I assume these are the quantities that you finally used to calculate the aerosol extinction profiles from the reconstructed normalized detector response?). The main issue here is that you made different assumptions to calculate the aerosol effect on the transmission than in the original retrieval by Elterman. Of course one would expect different results then, right? We don't really know which assumption is better.

Answer: We agree it was not clearly explained in the first manuscript version.

For the preliminary re-calibration (Section 7.1), before any adjustments. In the first step, where the assumption $T_p^*(z) = 1$ was applied, 105 initial $\beta_p(z)$ profiles were calculated. Then the second step was conducted, whose only purpose is to apply the slant transmission correction to those 105 initial $\beta_p(z)$ profiles. To that end we calculated 105 $T_p^*(z)$ profiles with the MODTRAN validated algorithm using the 105 initial $\beta_p(z)$ profiles. Following the slant transmission correction is applied to the 105 initial $\beta_p(z)$ profiles to obtain the 105 $\beta_p^{Recal}(z)$ profiles.

The final recalibration, considering the adjustments, In the first step, where the assumption $T_p^*(z) = 1$ remained, 36 initial daily $\beta_p(z)$ profiles were calculated. Then the second step was conducted, using the 36 initial daily $\beta_p(z)$ profiles to calculate the 105 $T_p^*(z)$ profiles and then apply the slant transmission correction to the 36 initial daily $\beta_p(z)$ profiles to obtain the final 36 $\beta_p^{Recal}(z)$ profiles.

To make it clear we changed the former subsection **4.5 Preliminary re-calibration results and subsequent adjustments** into the section **7 Re-calibration, adjustments, quantification of the updated parameters impact on β_p and errors** with 4 subsections:

- **7.1 Preliminary re-calibrated results**
- **7.2 Subsequent adjustments of the updated parameters**
- **7.3 Quantifying the impact to the updated parameters on β_p:**
- **7.4 Errors**

Where the 3rd was introduced and the 4th moved here and updated to address an issue associated to the comments made by the reviewers.

Elterman used an iterative approach to determine the aerosol extinction profile, but you did not. It would be very important to estimate the impact of this difference. The iterative approach is certainly more realistic and should provide better results. Perhaps the differences between your extinction and AOD values and the Elterman values are mainly due to this difference? In my opinion this is an essential aspect that needs to be tested and can probably be tested with little effort. At the moment the paper presents two different datasets (the old one and your new one) that differ significantly and the reader cannot tell which one is better. Perhaps the Elterman values are more realistic, because they are based on the more correct iterative approach. If this is the case, then your retrievals would have little value, right? But the reader cannot judge, which dataset is better, because this important aspect has not been investigated.

Answer: To clarify the issues in this comment we introduced the section **7.3 Quantifying the impact to the updated parameters on β_p**

The error estimation provided is incomplete and neglects some important effects, such as the effect of uncertainties in the aerosol phase functions on the retrieved aerosol extinction profiles. You used different aerosol scattering phase functions than in the original studies and my guess is that this leads to significant differences in the obtained extinction values. The different transmission calculations and the related uncertainties will probably also be an important source of error. Right now the differences between the "old" and "new" aerosol extinction profiles are larger than the respective errors. The authors simply state that this is the case, but no explanation is given and no attempt to improve on this is made. This can be considered a major issue or weakness of the presented results and the reader does not know how to deal with it. To me the differences mean that at least one of the two retrievals does not work well or that the error estimates are incomplete or not robust.

Answer: We agree. The new section **7 Re-calibration, adjustments, quantification of the updated parameters impact on β_p and errors,** address the issues pointed by the reviewer in its last two sections.

In addition, the manuscript is in a poor general state. There are many typos, incomplete sentences and statements whose meaning is not fully clear. Several of the co-authors are native speakers and it looks like none of them has actually read the paper. That should not be the case!

I apologize for the somewhat harsh judgement, but in my opinion the manuscript requires at least a major revision to become acceptable. It may well be that the original aerosol extinction profiles are in better agreement with reality than the new ones, because of the issues mentioned above and below. I would be glad to be convinced otherwise.

Specific comments

Line 91: "by modulating a searchlight beam"

How was this done? By modulating the intensity? Or by focusing/defocusing the beam?

Answer: They used a rotating shutter. That part of the sentence now reads:

…"by modulating a searchlight beam with a rotating shutter,"…

Line 115: "within the same ESSD paper"; please cite the paper

Answer: Cited: *"(Antuña-Marrero et al., 2021)"*

Line 132: "Figure 2 and 3"

In this paper or an another, older paper? Your Figures 2 and 3 show profiles for a different date.

Answer: Those figures refer to the paper cited in lines 129-13. For clarity we added it again to "Figure 2 and 3":

"(Figures 2 and 3 in Elterman and Campbell (1964))".

- Line 140: "referring to the component Rayleigh/molecular"
  Does this mean Rayleigh scattering and molecular absorption? Please state explicitly.
- Line 143: "the precursor words "molecular/Rayleigh""

Does "molecular/Rayleigh" mean:

Rayleigh scattering by molecules only or

Raleigh scattering and molecular absorption?

This is not clear and should be explicitly mentioned.

Answer: This answer is related to the two comments above (Lines 140 and 143).

The molecular term was replaced by Rayleigh regarding the molecular extinction.

A review of all the available publications from Elterman that we have been able to compile found no mention to molecular absorption, however he mentions and worked with the ozone absorption. Molecular absorption assumed negligible at 550nm.

Lines 165 to 163: These two paragraphs were presented above more or less in identical form. This information fits better here in my opinion and I suggest reducing the text in the previous section.

Answer: We agree with the reviewer. The two sentences in lines 129-133 (in the original manuscript version), about the new searchlight setup in 1964 in section 1.2, were erased. The 1st paragraph at the beginning of section 1.2 is now:

> *"Early searchlight observations of the stratospheric density have already been cited above. In 1964 a new searchlight setup for aerosol observations both in the troposphere and in the stratosphere was installed in White Sands, New Mexico. It consisted of a detector located at Sacramento Peak (32°47'N, 105°49'W, 2.76 km a.s.l.) at 30 km from the projector, whose exact location was not identified in Elterman and Campbell (1964). It was neither identified in the rest of the publications associated to the aerosol's observation from this searchlight. After multiple searches we found a report to the projector location at Two Buttes (also called Twin Buttes) 32°42'N, 106°08'W, 1388m (Hinds et al, 1975)."*

Line 166: "Synchronous demodulation" ; what does this mean here?

Same line: what does "for those times" refer to? This is not clear.

Answer: The synchronous demodulation of the light pulses modulated signal, generated by the shutters, is to limit the exposure time of the photomultiplier to the pulses bandwidth to minimize the sky background, still present in the moonless nights the observations were conducted.

The paragraph describing all this process was rewritten:

> *"The instrument consisted in a beam from a earchlight (the projector) collimated by a 36-inch mirror and modulated by shutters at 20 cycles sec^{-1}, converting the continuous light emission in pulsed signals. The source intensity was measured by an auxiliary detector, mounted on the searchlight and also generated a signal synchronous with the modulation. The intensity level and synchronous signal were transmitted by conventional telephone to a site around 30 km distant, where the optical collector, synchronous detector (photomultiplier), amplifier and recorder were located. The sky background was minimized using the very narrow frequency band pulses generated by the shutters and the synchronous modulated signal to limit the exposition time of the photomultiplier to the one corresponding to the emitted light pulses."*

Line 224: "The second is due to the convergent iteration procedure applied to solve the same equation (1), introducing new correction factors (a new profile of $T_p(z)$) in each step."

Why is this an "issue"? This appears to be the correct way to treat this problem?

Please explain, what the problem is here. I guess the issue is that you do not carry out this iteration? This should then be stated explicitly.

Answer: Yes, it was a right way to treat this problem when the observed $E_{rp}(z)$ profiles were available, but unfortunately it is not the case. Yes, it is right we did not carry up this iteration.

The new section **4. The re-calibration procedure: constrains, improvements and design:** explains that observed $E_{rp}(z)$ profiles are not available and why we cannot retrieve them exactly. There are important

pieces of information missing, that upon conducting the iteration procedure may produce spurious values f $\beta_p^{Recal}(z)$ profiles. This new section discusses those issues.

Lines 226 and following: Perhaps I'm missing a point, but if the final $T_p(z)$ is not known, then the Erp ratio cannot be calculated by inverting equation (1), right? Are the "final" $T_p(z)$ profiles also available?

Answer: Yes, the reviewer is right, the final $T_p(z)$ are not available.

Line 231: "The iteration convergent procedure .. was not conducted .."

This may be a big issue, because the extinction profiles directly depend on this, right?

The question is, how much a limitation this is. I think you should at least test, how the results after a 2nd or 3rd iteration differ from the results after the first iteration. Otherwise, differences to the original retrievals by Elterman cannot really be interpreted.

Last part of the same sentence: I don't fully understand it, to be honest and the critical piece of information here is, whether Elterman also tabulated the "final" $T_p(z)$ profiles or not. Is this the case?

Answer: Yes, it is an issue. However, the iterative convergent procedure cannot be conducted, because there is not enough information to reproduce it. What it is clear is that introducing an iterative convergent procedure in the re-calibration has associated a high risk of introducing spurious errors in the $\beta_p^{Recal}(z)$ profiles.

Elterman did not tabulate $T_p(z)$. To contribute to clarify it the Table 1 from Elterman (1966a; b) with its caption: "*Computer Output (partial tabulation). Measurement on 13 April 1964 at 00:18" was included as Table 2 in the Supplement.*

Line 248: "Most of the missing levels were filled in with the daily aerosol extinction profile averages, and the very few remaining were filled by linear extrapolation."

Sorry, but this is confusing. In the sentence before you said that missing data were flagged with a value of -999.99 and now you write that averaged profiles/interpolations are used. Perhaps these steps apply to different things, but this is not well explained here?

Answer: Yes, this steps apply to different things. Changes in the two sentences were introduced to clarify it. They are underlined.

> *"In the archived datasets version, submitted to PANGAEA open-access dataset repository (Antuña Marrero et al., 2022), all the missing levels were flagged with a missing data indicator (-999.99). For the purposes of this research most of the missing levels were filled in with the daily aerosol extinction profile averages, and the very few remaining were filled by linear extrapolation."*

Line 269: "in figure 1" ? Should this be "figure 2"? Figure 1 shows something else.

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

- Line 270: "The absolute differences .. is" -> "The relative differences .. are"
- Line 273: "The relative errors .. has" -> "The absolute error .. has"; "absolute" and "relative" were mixed up here and above.
- Line 274: "while its mean value is lower than 1%."
  This was already mentioned two sentences above.

Answer: This answer is related to the three comments above (Lines 270, 273 and 274). The sentences from line 270 to 277 were corrected according to the first two comments. Based on the third we eliminated redundant information and configured all the sentences in the following paragraph.

> *"The relative differences between the tabulated and the re-digitized Aerosol Extinction Coefficients with respect to the tabulated values are a little lower than 4% and the average is 1.2%. In the case of the altitude, using its values tabulated in Table T2 and the ones re-digitized, the error produced by the re-digitalization has a mean value of 0.08km equivalent to a relative error lower than 1%. This error is inside the 0.05 km to 0.09 km error interval reported for the searchlight altitudes*

determination (Elterman, 1966a). The results discussed above demonstrate that the errors introduced in the re-digitalization procedure do not have a significant impact on the values retrieved using this procedure"

Equation (2): Please state, whether the "final" Tp profiles are also available from the older papers or not.

Answer: The final Tp profiles were not available from older papers. It is explicitly stated in the first paragraph on the new Section **5.2 Slant transmission algorithm** of the manuscript new version after major reorganization of several subsections in Sections 4 and 5.

Line 291: "and the aerosol ($T_p(z)^{Orig}$) transmissions"

Again, are those the transmission values after the final iteration?

Answer: No, they are not the final Tp profiles. They were not available from older papers. $T_p(z)^{Orig}$ are the values used in Equation 2 for the retrieval of the normalized detector response.

Line 357: "Then the pressure and temperature in each sounding, from 31 to 36 km, were filled using monthly mean values from the COSPAR International Reference Atmosphere – COSPAR-86 (Fleming et al., 1990)."

If you filled in gaps in this way, does this lead to discontinuities in the T, p and hence density profiles? Or are the resulting profiles smooth?

In addition, the quality of the CIRA-86 atmosphere, particularly in the troposphere & stratosphere is questionable, I think. It would be good to provide some error estimates here.

Answer: We filled the pressure and temperature gaps from 31 km to 36 km with CIRA-86. Section S2 was added in the Supplement discussing the reasons to use CIRA-86 and showing that the 36 Rayleigh extinction profiles between 25 and 35km show a smooth course above 30 km.

Line 361: what does "modern conventional algorithms" mean?

Answer: It was a reference to $\beta_R^*(z)$ calculated using the algorithm for Rayleigh scattering applied for CALIOP (Hostetler et al., 2006) at 550nm. The sentence was corrected to be specific; it reads now:

"Then $\beta_R^*(z)$ were calculated using the algorithm for Rayleigh scattering applied for CALIOP (Hostetler et al., 2006) at 550nm."

Section 4.4.2.1: It would be interesting to show a sample of the tAPF and also the derived size distribution parameters.

Answer: The former section 4.4.2.1 is now section **6.2.1 Tropospheric aerosol phase function.** To calculate the tAPF at 550nm we used all the available daily APF at 440nm and 675nm, between 2006 and 2021, at HELSTF AERONET site. The averages of the APFs at 440nm and 675nm are shown on the new Figure S6 in the Supplement. Also, in the Figure new S6 the interpolated APF at 550 nm is shown. In addition, for comparison purposes, all the phase functions are shown in the new Figure S7.

Line 377: "Finally, the resulting tAPF at the two cited wavelengths were used to calculate the tAPF at 550 nm by interpolation."

How was this done exactly? I'm not sure there is a straight-forward approach to do that?

Answer: The APF at 550nm was linearly interpolated between the mean APFs at 440nm and 675nm as it is explained in section **6.2.1 Tropospheric aerosol phase functions.** This APF, from a period of 15 years in the same region the searchlight observations were conducted is a much better representation than the one used by Elterman (1966a; b). The magnitudes of both APFs at 440nm and 675nm show a similar pattern along the 0º to 180º and in the interval the searchlight observations were conducted. In addition, there is no reason to expect a discontinuity of the APFs in the interval between them. That support the interpolation to 550nm instead of using one of them.

Section 4.4.2.2.: It would also be interesting for the reader to show these PSDs here?

What are the size distribution parameters, or typical values of the mean/median or effective radius?

Answer: The former section 4.4.2.2 is now section **6.2.2 Stratospheric aerosol phase function.** Considering the reviewer suggestion, the average PSD used to derive the sAPF is shown on the new figure S8. Also, the sAPF is shown on the new Figure S7 together with the rest of the phase functions.
The information about the 4 size distributions averaged are reported by Friend, (1966).

- Line 400: "$T_R^*(z)$, and $T_{O3}^*(z)$,"
  These asterisk quantities suddenly appear, but they are not introduced, I think. Please explain what they are.
- Line 401: "In the case of $T_p^*(z)$, the aerosol extinction profile for desert aerosols embedded in the MODTRAN-4 code was used."
  Why? this will be different from the actual Tp profile, right? If no iterations are performed this will introduce errors in the re-calculated aerosol extinction profiles, right?
  Next sentence: the second "showed" should be deleted.

Answer: This answer is related to the two comments above (Lines 400 and 401).

The asterisks represent transmission profiles produced only for testing the algorithm designed with the MODTRAN code. The aerosol extinction profile for desert aerosols embedded in the MODTRAN-4 code was used only for the testing the slant transmission algorithm for aerosols. We are aware that errors will be introduced in the re-calibrated extinction profiles if we make use of it.

The sentences from line 401 402 were rewritten:

> *"The algorithm used to calculate $T_r^*(z)$, $T_p^*(z)$ and $T_{O3}^*(z)$ was validated with the commercially available MODTRAN-4 atmospheric radiation transfer code, run in the transmittance mode (Berk et al., 1998). In the cases of $T_r^*(z)$, and $T_{O3}^*(z)$, the validation was conducted using the molecular and ozone profiles from the 1976 US Standard Atmosphere (U.S. Standard Atmosphere, 1976) both for the algorithm and for MODTRAN-4. In the case of $T_p^*(z)$ the combined profiles for desert aerosol extinction in the troposphere and moderate volcanic stratospheric aerosols in the stratosphere aerosols, in the embedded in the MODTRAN-4 code, was used. The purpose of this combined profile was to resemble the conditions at White Sands both in the designed algorithm and in MODTRAN-4.."*

Line 416: "deg K"; Kelvin does not come with a degree sign.

Answer: The degree sign is in the manuscript.

Line 421: "The lower altitude of the monthly mean tropopause"

What does this mean, "lower altitude of the monthly mean tropopause" ?

Answer: The degree sign is in the manuscript.

Line 427: "the 36 daily profiles of $\beta_R^*(z)$ and $T_R^*(z)$,"

Why was TR*(z) this used for the retrieval "without" transmission correction? Does "without transmission correction" in the previous sentence only refer to the effects of the aerosols on the transmission? This is not clear.

Answer: We agree, the term *"without" transmission correction* was not appropriate to describe the assumption made in the first step regarding the aerosol slant transmission. It was, $T_p^*(z) = 1$. In the new version of the manuscript the paragraph introducing the section **7 Re-calibration, adjustments and quantification of the updated parameters impact on $\boldsymbol{\beta_p}$** explain that assumption:

> *"The re-calibration, briefly described in section **3.2**, consisted in using Equation (1) together with the retrieved $\frac{E_{rp}(z)}{E_{rp}(35)}$, the updated parameters $\overline{\beta_R^*(z)}$, $T_{O3}^*(z)$, $tP_p(\varphi_s(z))$, $sP_p(\varphi_s(z))$, $T_R^*(z)$ and $T_p^*(z)$, to calculate $\beta_p^{Recal}(z)$. The procedure consists of two steps. The first uses all the updated parameters, except $T_p^*(z)$, which is in this case assumed $T_p^*(z) = 1$ at all levels for all observations nights, producing a first set of 105 $\beta_p(z)$ profiles ($\beta_p^o(z)$). The second's only purpose was to apply the aerosol's slant transmittance correction to the 105 $\beta_p^o(z)$ profiles derived in the first step. To that end a new set of 105 $T_p^*(z)$ profiles is calculated using the set of 105 $\beta_p^o(z)$ profiles and the*

MODTRAN-validated transmission algorithm, that will replace the initial assumption of $T_p^*(z) = 1$. That is, the second step consists of repeating the first step, with the same updated parameters than before, except the new set of 105 $T_p^*(z)$ profiles producing the final set of 105 $\beta_p^{Recal}(z)$ profiles, one per each observation night."

Line 445: "Together with the 36 daily profiles $\frac{E_{rp}(z)}{E_{rp}(35)}^{Orig}$ in equation (1) these changes produced a set of 36 daily-re-calibration aerosol extinction profiles …"

What Tp profiles were used here? This is not clear to me at all? Please explain in detail.

And what Pp profiles are used?

Answer: We agree; it was not clearly explained in the original manuscript. The 2nd and 3rd paragraphs in section **7.2 Subsequent adjustments of the updated parameters explain applied adjustments:** explains what aerosol slant transmission profiles were used in each step:

"For the re-calibration three adjustments were introduced, all of them in both the first and second steps. The first two, adjustments to deal with the variability between the 36 daily $\beta_R^*(z)$ and $T_R^*(z)$ profiles. The first consisted in using a single profile $\overline{\beta_R^*(z)}$, resulting from the average of the 36 daily $\beta_R^*(z)$, and the second adjustment to calculate a single profile for $\overline{T_R^*(z)}$ using the single profile $\overline{\beta_R^*(z)}$ with the MODTRAN-4 validated slant transmission algorithm. The third adjustment was implemented to deal with the discontinuity in the $\beta_p^{Recal}(z)$ profiles below the tropopause altitude. It consisted in smoothing the transition between $tP_p(\varphi_s(z))$ and $sP_p(\varphi_s(z))$ just below the tropopause. It replaced the $\beta_p^{Recal}(z)$ at 11.7 km by the average of the $\beta_p^{Recal}(z)$ values at 11.2 and 12.2 km, the levels above and below 11.7 km.

The rest of the variables were unchanged. Together with the 36 daily profiles $\overline{\frac{E_{rp}(z)}{E_{rp}(35)}^{Ret}}$ in equation (1) these adjustment produced a set of 36 $\beta_p^o(z)$ profiles derived in the first step. Then 36 $T_p^*(z)$ profiles were calculated using the 36 $\beta_p^o(z)$ profiles. In the second step the 36 $T_p^*(z)$ profiles replaced the initial assumption of $T_p^*(z) = 1$, producing the final set of 36 daily $\beta_p^{Recal}(z)$ profiles. No negative values were present in the set of 36 daily $\beta_p^{Recal}(z)$ profiles and no abrupt changes in the daily $\beta_p^{Recal}(z)$ profiles below the tropopause were present."

Line 448: "Both in the second and third steps"

What is the third step? Please mention it explicitly.

Answer: The referee is right. There was not an explicit explanation of all the procedure. One of the new new sections (**4.3 Design of the re-calibration:)** explains the main idea behind every step:

"Considering the limitations described above, we designed the re-calibration procedure. It begins with obtaining the retrieved $\frac{E_{rp}(z)}{E_{rp}(35)}$ profiles by inverting Equation (1) and using the same originally used values/profiles variables described by Elterman (1966a; b), except the original slant transmissions for the reasons explained on section 5.2 below.
Then Equation (1) was used to calculate a first set of $\beta_p(z)$ profiles ($\beta_p^o(z)$), using all the updated variables except $T_p(z)$ which was assumed equal to 1 at all altitude levels. The ozone slant transmission, not used in the original processing (Elterman, 1966a, b), is included in this step. In the next step $T_p^o(z)$ was calculated using $\beta_p^o(z)$. Finally, using again equation (1) $\beta_p^o(z)$ is corrected by the slant transmission $T_p^o(z)$ to produce $\beta_p^{Recal}(z)$, and the process stops. The iteration convergent procedure for adjusting $\beta_p^{Recal}(z)$ with a new $T_p(z)$ was not conducted to avoid the risk of spurious $\beta_p^{Recal}(z)$ due to the fact that an unknown amount of the retrieved $\frac{E_{rp}(z)}{E_{rp}(35)}$ profiles are not the original ones, because they were adjusted by the iterative-convergent procedure. This issue will be discussed further in section 7.2.

It is important to note that we are dealing with three series of $\frac{E_{rp}(z)}{E_{rp}(35)}$ profiles. The first two, related to processing conducted by Elterman (1966a; b): the observed $\frac{E_{rp}(z)}{E_{rp}(35)}$ and the final $\frac{E_{rp}(z)}{E_{rp}(35)}$ corresponding respectively to the one from the instrumental observations and the second the one resulting in the last iteration of the iteration convergent procedure. Only in the cases that no negative value in the $\beta_p(z)$ profile was present in the first iteration the observed and final $\frac{E_{rp}(z)}{E_{rp}(35)}$ are the same. The third, associated to this study, the retrieved $\frac{E_{rp}(z)}{E_{rp}(35)}$ resulting from the inversion of equation (1).*"*

Line 453: "That precludes applying any new normalization-correction .."

I don't understand this statement? Why would you want to apply a new normalization?

Answer: We do not want to apply any new normalization. It was the lead author mistake to use the term "new normalization correction" to identify the reduction of $E_{rp}(35)$ repeatedly by 0.001 until only positive $\beta_R(z)$, in the case of any negative $\beta_R(z)$ value, during the iteration procedure. This issue is discussed in the detail in the new section **4. The re-calibration procedure: constrains, improvements and design:**.

Lines 478/479: extinction values without units

Answer: Added.

Line 504: what does "mixing layer" refer to here? Is this the planetary boundary layer?

Answer: Yes, it is. The term "mixing layer" was replaced by "boundary layer" in the text.

Line 504: "The agreement in winter .." ; sentence incomplete.

Answer: The sentence was divided to gain in clarity. They read now:

"The agreement in winter could be explained by contemporary estimates of the average boundary layer height diurnal cycle at White Sands. The boundary layer heights were determined for the period from 1961 through 1972 using 8236 radiosonde soundings from White Sands Desert Site (32°24'N, 106°22'W and 1216 m MSL)."

Line 509: "Average mixing layer height diurnal cycle for December showed a maximum of 929 m"

What does this mean? Statement is incomplete and unclear.

Answer: Corrected. It reads now:

"The diurnal cycle average mixing layer height for December showed a maximum of 929 m (2,145 m MSL) at 1430 MST and minimums lower than 10 m in earliest and latest hours."

Line 513: "these maximum averaged values"

Unclear what you mean by "maximum averaged"

Answer: Corrected. It reads now:

"During the whole year the average of the maximum values of the mixing layer heigh…"

Section 5.5.1: Please mention briefly what the Sato and Stothers values are based on, i.e. which methods are used.

Answer: Added. It reads now:

"The first, the monthly mean sAOD in the whole northern hemisphere (hereinafter sAODSato) from Sato et al., (1993), relying especially for the period 1960 to 1978 on the astronomical observations summarized by Dyer and Hicks [1968]. Sato's dataset also used, for the same period, the coarser information from the analysis of lunar eclipses throughout this period by Keen [1983]. The second, the monthly mean sAOD between 20°N and 40°N (hereinafter sAODStothers) from Stothers, (2001), using astronomical observations or pyrheliometric direct sunlight observations taken from the published literature."

Section 5.6, errors: What about the contribution of the uncertainty in the extinction profiles used to determine Tp? This uncertainly will also contribute to the overall errors. If I understand correctly you are now using a climatological extinction profiles for dust/sand from Modtran?

And what about the errors caused by uncertainties in the assumed aerosol phase function? This may also be a potentially larger source of error.

These contributions could be estimated relatively easily.

Answer: We are not using a climatological extinction profile for dust/sand from MODTRAN for the re-calibration. We used it, together with the Rayleigh extinction and ozone absorption profiles from the 1976 US Standard Atmosphere (U.S. Standard Atmosphere, 1976) to validate the slant transmission algorithm with MODTRAN, described in section A1 in the Supplement.

Regarding the error introduced by the original $P_p(\varphi_s(z))$ and the correction of it by the updated $tP_p(\varphi_s(z))$ and $sP_p(\varphi_s(z))$ see (b) in the next answer.

Section 6.2: You should also discuss possible reasons for the large differences between the original and the new aerosol extinction profiles. In my opinion important reasons are/may be:

(a) different extinction profiles used to calculate the Tp profiles

(b) Different phase functions

(c) missing iteration approach in case of your retrievals

Answer:

(a) There are no different extinction profiles used to calculate T_p profiles. See the Answer above.

(b) Regarding the aerosol phase function, there was an estimate of the error introduced in the original β_p, not accounted in the original estimates from Elterman (1966a; b). The original phase function introduced an error ranging between 15% and 25% according to Wells (1968). It raises the original estimated range of errors between 33% and 48% (Elterman, 1966a; b) to the range of 48% to 63%, considering the lower value of 15%. Table 1 in the new section **7.3 Impact to the updated parameters on $\boldsymbol{\beta_p}$**, shows a -12% impact in the troposphere and -16% in the stratosphere after applying the updated $tP_p(\varphi_s(z))$ and $sP_p(\varphi_s(z))$. Then a new error estimate for the troposphere is 36% to 51% and for the stratosphere %32 to 47%.

(c) It is not possible to estimate the error introduced by not conducting the iterative convergent procedure, because there is not enough information to reproduce it. What it is clear is that introducing an iterative convergent procedure in the re-calibration has associated a high risk of introducing spurious errors in the $\beta_p^{Recal}(z)$ profiles.

Line 587: "which is significantly higher than the estimated error in β_p^{Recal}, between 37% and 52%.."

This means that the retrievals or the error estimates are not robust, right?

Answer: We agree with the reviewer, the error estimate was not robust. It is corrected in the new version of the manuscript, with the introduction of section **7.3 Impact to the updated parameters on $\boldsymbol{\beta_p}$**, and updating and expanding section **8.6. Errors.**

Line 597: "Photometric measurements on twilight photographs"

What does this mean?

Answer: The available information in the referenced paper and in a second one, just added, describe Vostok 5 and Vostok 6 astronauts were trained to operate a camera with a special film to conduct the observations during twilights. Upon returns, only the film from Vostok 6 had useful information of the twilights, the one from Vostok 5 was overexposed.

To clarify the text the first part of the sentence was rewritten and a 2nd reference was addedd, giving more details on how this experiment was designed.

> *"Photometric processing of the photographs taken in the twilight, the first taken by a spacecraft, from spaceship Vostok-6 over the southern coast of Africa on 17 June 1963, showed a two-layer*

structure, with a major aerosol layer at 19.5 km and a minor one at 11.5 km (Rosenberg and Tereshkova, 1965; Sushkevich, 2018).”

Line 602: “The mean of the monthly means, in table 2”

The monthly mean results are shown in table 3, not in table 2. CORRECTED

Line 644: “That procedure ..”

Which one? The original one by Elternman or the one used here?

Same sentence: I'm sorry, but I don't get the meaning of this sentence: "introduced changes that were not possible to be accounted for ..." ?? Did you introduce these changes or not?

Answer: We did not introduce these changes. The new section **3.1 Motivation for the re-calibration:** explains the convergence iteration procedure, in particular the changes introduced in $E_{rp}(35)$, that we have not been able to track. In addition, there is no information at all about the final $T_p(z)$.

Typos, grammar etc.

The paper contains many typos and inconsistencies. In the following I’m only mentioning some of them. Please read the paper carefully. DONE

Title: “profiles dataset” -> “profile dataset” CORRECTED

Introduction, line 1: “large-magnitude explosive volcanic aerosol physico-chemical processes”

Does this phrase make sense? “Large magnitude” should refer to volcanic eruptions, not to “processes”, right? CORRECTED

Introduction, first sentence: the sentence is incomplete CORRECTED

Line 63: “Of these eruptions ..” ; Sentence is incomplete CORRECTED

Line 68: “to the SAGE-II” -> “due to the SAGE-II” CORRECTED

Line 95: “Measured brightness .. were” -> “Measured brightnesses .. were CORRECTED

Line 108: “be rescued and re-calibration” -> “be rescued and re-calibrated” CORRECTED

Overall many cases were “re-calibration” should be “re-calibrated”. Please search the entire document. DONE

Line 108: the last part of this sentence is incomplete. CORRECTED

Line 112: “re-calibration” -> “were re-calibrated” CORRECTED

Line 116: “the two datasets both published” -> “and both datasets were published” CORRECTED

Line 122: “complimenting” -> “complementing” CORRECTED

Line 124: “.. are derived” -> “.. is derived” CORRECTED

Line 140: “used when” -> “was used when” CORRECTED

Line 161: “who’s” -> “whose” CORRECTED

Line 179: “its original processing” -> “their original processing” CORRECTED

Line 187: Sorry, but what does "textually" mean here? Do you mean verbatim or a word-by-word citation? CORRECTED

Line 241 and several other lines: “There-digitalization” -> “The re-digitalization”; please search the entire document. CORRECTED

Line 254: “the the” CORRECTED

Line 256: “two three” ? CORRECTED

Line 265: “Their values are ..” ; sentence is incomplete CORRECTED

Line 268: “an order of” -> “, i.e. an order of” CORRECTED

Line 295: "on table" -> "in table" CORRECTED

Line 305: "shown on" -> "shown in" CORRECTED

Line 310: "when it addresses .."; statement unclear; "when" doesn't appear to fit here. CORRECTED

Line 321: "with also" ? The las part of the sentence was erased.

Line 411: "Then each of the 36 profiles .. were -> was" CORRECTED

Line 439: "Next" -> "Next," CORRECTED

Line 470: "Looking at the lower levels .." ; Sentence is incomplete and does not make sense.

Answer: The complete paragraph was moved to the new section **8.1 Rescued profiles of $\beta_p^{Orig}(z)$:**. The sentence pointed by the reviewer was completed.

> *"Table 1 shows the reports of blowing dust events reported at the cited weather stations. The days the seven events were reported the values of the $\beta_p^{Orig}(z)$ cross sections are equal or higher than $7x10^{-3}$ km^{-1}, with the reports on February 14th being the exception. This fact contributes to the confidence on the original dataset to represent the real aerosol features in the conditions of White Sands".*

Line 479: "maximums" -> maxima" (this occurs several times; please check entire paper). CORRECTED

Line 530: "respect to" -> "with respect to" (also several cases throughout the paper) CORRECTED

Line 554: "It includes" -> "They include" (referring to "considerations") CORRECTED

Line 637: "conducted byre-digitalization" CORRECTED

Line 638: "has been" -> "have been" CORRECTED

Reorganization of the manuscript and additional corrections:

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 β_p dataset and estimated β_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".