Answers to: RC2 '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 #2, 30 Nov 2022

This study shows the recovery and recalibration of an extensive dataset of stratospheric aerosol vertical profiles originally measured during 1963/64 by two searchlight measurement sites in New Mexico, US. A description of the original retrieval process and discussion of the source of its sources of uncertainty are provided. The different steps, including assumptions and additional processing of the recovery and recalibration processes are described. The goddess of the new vertical products is shown through comparison against independent stratospheric and column integrated AOD of different sites.

The complex methodological structure, with lots of references to specific tables, figures and data in the literature, makes it difficult to follow some parts of the manuscript. Inputs, outputs and assumptions have to be clearly indicated in the description of each step of the recalibration, recovery or retrieval.

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 $\beta_p(z)$** 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".

Use of English needs to be deeply revised. Lots of typos and poorly constructed sentences can be found along the text, making some paragraphs hardly understandable.

Answer:

A review has been conducted fixing the typos and sentences construction.

Some specific comments can be found below:

- section 2 needs to be revisited, it is not clear for me what is being described, the original method of the measurements or the new methodology applied after redigitalization or both are the same. A better explanation is required of how the iterative process is made. Please, state clearly which are the inputs, outputs and assumed parameters. A table or an explanatory box chart will be very useful.

Answer:

The reviewer is right. A new section **4. The re-calibration procedure: constrains, improvements and design:** it includes 3 sub-sections**: 4.1 Constrains:**, **4.2 Improvements:** and **4.3 Design of the re-calibration.** They include the issues that the reviewer referred as a separated section at the time it clarifies that there is only one methodology.

There is not sufficient information about the iterative process details, that will allow to replicate it. In this conditions applying a iterative convergent procedure implies a very

high risk of producing spurious values of $\beta_p^{Recal}(z)$ .That is the reason why it was not conducted.

- line 184: Table 1 is referred but further details are needed. Some column names are not totally clear (ToD (LST) and DD).

Answer:

There is confusion. Table cited in line 184 is the "**Table T1**" in the Supplement. However, to gain in clarity we rewrote that sentence, which reads now:

> *"The list of the 105 observations grouped by the nights they were conducted is on Table T1 (in the Supplement)."*

Also, in the caption of the Table T1 a description of the content was included

The Table 1 is referenced on the line 470 and the referee is right: there is no explanation of the acronyms (ToD, (LST) and DD). They were included in the caption of Table 1:

> *"Table 1: Reports of blowing dust in the vicinity of the projector location. The acronyms are Time of Day (ToD): quarter of the day in LST during which the bulk of the blowing dust occurred, the LST: Local Sidereal Time and DD: the wind direction. Original data from Hinds et al. (1975)"*

- line 207: Tp(z)init first mentioned here. Clarification of its meaning is necessary.

Answer:

Corrected. It reads now:

> *"Vertical profiles of the initial $T_p(z)$ ($T_p(z)^{Init}$) ..."*

- In line 242 is stated that only aerosol profiles are going to be considered in this work. And in the same paragraph some lines after it is said that a two component atmosphere is assumed. Thus, I do not understand the need of refilling the aerosol profile with Rayleigh values. If Rayleigh is already accounted for in the molecular profile, these points corresponding to aerosol should be zero according to my understanding. Unless the authors are referring to total extinction, in this case it should be clearly indicated.

Answer:

The sentence refers to the fact that two variables were re-digitized, total extinction (aerosol + molecular extinctions) and aerosol extinction, but only the information of the procedure to obtain the aerosol extinction is available. The two sentences wer moficfied and a third one added:

> *"Both total extinction and aerosol extinction profiles were re-digitized but only the last one was used for the work reported here, because only detailed information about the procedure to calculate the aerosol extinction profiles is available. We will use the Rayleigh extinction profiles from the US Standard Atmosphere 1962 and also derived from local soundings as will be explained below."*

Also, to gain in clarity and avoid confusion, we only use the term Rayleigh extinction for the molecular extinction.

- line 366: It is not clear what is the second molecular phase function that was applied to the top part of the profile.

Answer:

Corrected, the paragraph was rewritten and it is the last paragraph on section **6.2 Tropospheric and stratospheric aerosol phase functions**:

> *"The original aerosol phase function was replaced with two phase functions, corresponding to the tropospheric and stratospheric aerosols respectively. The first was applied from the surface to the tropopause altitude and was derived from AERONET observations between 2006 to 2021.The second was applied above the lower tropopause altitude to the top of the searchlight profile, calculated using particle size observations conducted in the northern hemisphere stratosphere in 1963, right after the Agung eruption. The original Rayleigh phase function* $P_R(\varphi_s(z))^{Orig}$ *remained unchanged in the re-calibration procedure. They are described in the following two sections.*
> "

- line 460: It is difficult to understand what is represented in figure 4. This sentence needs to be revised.

Answer:

Corrected the sentence reads now:

> *"The 36* $\beta_p^{Orig}(z)$*, the daily averages of the 105* $\beta_p(z)$ *re-digitized profiles, were interpolated in time and altitude. The resulting cross sections are on Figure 4, showing only the months when observations are available."*

- What is the wavelength corresponding to AERONET AOD represented in figure 7?

Answer:

It is 550 nm. The information was included in line 505 and in the caption of figure 7.

- What is the meaning of the whiskers in figure 7? Standard deviation?

Answer:

Yes. That information was included in the text (line 505) and in the Figure 7 caption.

- It is surprising the spiky behaviour of the monthly averages of AOD of the recalibrated and original datasets in the months of October, November and December. Some clarification is needed in the text.

Answer:

Yes, it was suspicious for us too. Moreover, the magnitudes of the 3 highest values were quite similar and for the 3 lower too. The scripts used were double checked and the data too. It was one of the reasons we checked for contemporary data on dust events, reported on former Table 1 (now Table 2), which allow to explain the high values of the tAOD for the measurements on October 3rd and November 4th. From Table T1, in the Supplement, those measurements were conducted between the night of October 2nd (November 3rd) and the early morning of October 3rd (November 4th). Back on current Table 2 blowing dust was reported on October 2nd from 12:00 to 18:00 LST and November 3rd from 6:00

to 12:00 LST around half a day before the cited measurements. No blowing dust was reported for the 3 days with the low tAOD, but neither for the December 10th.

- To my understanding the objective of section 5.5.1 is not clear. From the figure and the explanations in the text it seems that the original AOD is more adequate than the recalibrated values. If the message is that the reference stratospheric AOD and sAODorig do not retain information of stratospheric aerosol load because of different reasons, it should be clearly stated.

Answer:

Former subsections **5.5.1** and **5.5.2** are now subsections **8.5.1** and **8.5.2**. Both were rewritten addressing the Reviewer concerns, including in the first of them the comparison of daily $sAOD^{Recal}$ with $sAOD^{Eclipse}$. In addition, the variability of $sAOD^{Recal}$ with $sAOD^{Orig}$ is discussed.

- line 569: "A second study reported the climatology of the mixing height (MH)" What is the reference for this study?

Answer:

The second study is the one reported at the end of the paragraph. To make it clearer the reference was moved to the first sentence and parts of the paragraph rewritten:

> *"A second study reported the climatology of the mixing height (MH). In reporting that in general, at night MH is minimum because of radiative cooling of the ground and heat loss from the air to the ground (Norton and Hoidale, 1975). MH reaches reaching its maximum during the afternoon because of solar heating of the ground and the subsequent heat exchange with the air. Relevant features of climatological MH at White Sands Desert Site (32°24'N, 106°22'W; 1216 m asl) from that study, computed using 8236 diurnal radio soundings from 1961 through 1972 between 5:30 and 20:30 MST (Norton and Hoidale, 1975), are shown on table 3."*