

Review 1:

We thank Reviewer 1 for their valuable comments and for the timely review submission. We carefully considered all remarks, and the manuscript has been improved accordingly. Below, we address each point in detail.

This manuscript of 'Cross-Hemispheric Transport of the Hunga Aerosol Plume: In Situ Evidence and Radiative Effects from the Northern Hemisphere' by Kloss et al. investigated the cross-hemispheric transport and the impact of the southern hemispheric Hunga eruption on the northern hemisphere mid-latitudes, which is a meaningful supplement to previous studies primarily concerning the southern hemisphere and tropics. In this study, both satellite observations and in situ measurements with OPCs were used to analyze the significant aerosol plumes transported into the NH mid-latitudes and their transport pathway. Balloon borne OPCs observations revealed the total bimodal distribution and an effective radius of ~ 330 nm within the aerosol plume layer. Based on analysis of aerosol extinction coefficients from SAGE III/ISS, the Hunga eruption was estimated to have a shortwave top-of-atmosphere (TOA) radiative forcing of $-0.05 \pm 0.01 \text{ W m}^{-2}$ during October 2022 to April 2023. These results underscored that even a volcanic eruption with moderate aerosol output can have measurable effects in the opposite hemisphere.

Some minor issues:

Line 76: 2.5 mm --> 3.0 mm

We changed this accordingly, thank you.

Line 140: It should be noted at which levels no background aerosol conditions are observed.

We added more values on the background aerosol condition and also adapted the Figure to show pre-Soufriere conditions: *'The general stratospheric aerosol situation in the northern mid-latitudes, for the period 2021 -2024, is visualized in Fig. 1. The presented time frame starts just before the La Soufriere eruption in April 2021 at 13 °N and 61 °W, with background aerosol extinction values of around $0.3 \cdot 10^{-3} \text{ km}^{-1}$ at 19 km altitude. Following the La Soufriere eruption, the stratospheric northern mid-latitudes were significantly affected by an increased aerosol load (e.g., Li et al., 2023; Bruckert et al., 2023; Taylor et al., 2023), with aerosol extinction values up to around $0.5 \cdot 10^{-3} \text{ km}^{-1}$ at 19 km altitude, an increase by a factor of around 1.7. From Fig. 1, the increase is evident up to around 22 km altitude until early 2022. The exact phase-out time of aerosols from La Soufriere cannot clearly be identified, because the Hunga eruption (at 20 °S, 175 °W) in January 2022 produced a slight influence on the northern-hemispheric stratosphere as early as March 2022 (Taha et al., 2022).*

Therefore, because of already enhanced background conditions in the stratospheric northern mid-latitudes, the actual beginning of the general influence of the Hunga eruption on the NH in terms of increased aerosol values cannot clearly be identified. However, a significant increase in aerosol extinction from October 2022 to May 2023 was observed between 16 and 23 km altitude, about 4 km above the respective tropopause, and can clearly be associated with enhancements from the Hunga eruption. Peak enhancements were observed around December 2022 and January 2023, with aerosol extinction values of around $0.6 \cdot 10^{-3} \text{ km}^{-1}$ at 19 km altitude.

Even though the eruption at La Soufriere occurred in the NH with direct stratospheric injections of sulfur-containing gaseous and aerosol species, its impact, as seen in Fig. 1, in terms of aerosol extinction is by a factor of around 1.2 smaller than that of the Hunga eruption.'

Figure 1: I maybe miss the time interval for this figure, daily or twice daily?

Each profile is averaged over 15 days. We added this information in the text: *'averaged over 15 day intervals'*

Figure 1: It speaks twice of vertical dashed line.

The last sentence is now deleted, thank you!

Figure 1: It's seen that the most enhanced signals are located at the levels of mean tropopause height, but obviously these signals are not from volcano eruption, probably from cirrus in the upper tropopause at the lower latitude. Therefore, my suggestion is to use the highest tropopause instead of the mean tropopause at the latitude range, in this way, all the enhanced signals will be below the tropopause.

We like the idea and changed the Figure. The corresponding text: *'The horizontal dashed line shows the maximum MERRA-2 tropopause height for the respectively averaged SAGE III/ISS extinction profiles.'*

Line 144-150: Could you draw the outline of the plumes from Hunga eruption in Figure 1? It's not easy to get what you said.

We don't think outlining the plume would represent the fading nature of the plume well.

Line 152: Could you show us the exact values of aerosol extinction from these two eruptions? It's not easy to see a factor of around 1.5.

We added more explanation to the text: *'in terms of aerosol extinction is by a factor of around 1.2 smaller than that of the Hunga eruption (0.65 compared to $0.5 \cdot 10^{-3} \text{ km}^{-1}$).'*

Figure 2: It's not easy to tell the difference among different profiles. Could you plot the figures above 15 km, below which is not used?

We corrected this accordingly.

Figure 3: This figure shows the trajectories originated from 20.6 km. How about the lower levels, such as 16-18 km also with volcanic eruption plumes, where the flow should be different?

We performed such 7- day back trajectory calculations, see below. We added explanations to the text: *'The respective trajectories starting below the observed plume altitude, between 16 and 18 km, follow a distinctly different path and remain within the Northern Hemisphere, originating from the west, between 90° W and 40° W , not shown here.'*

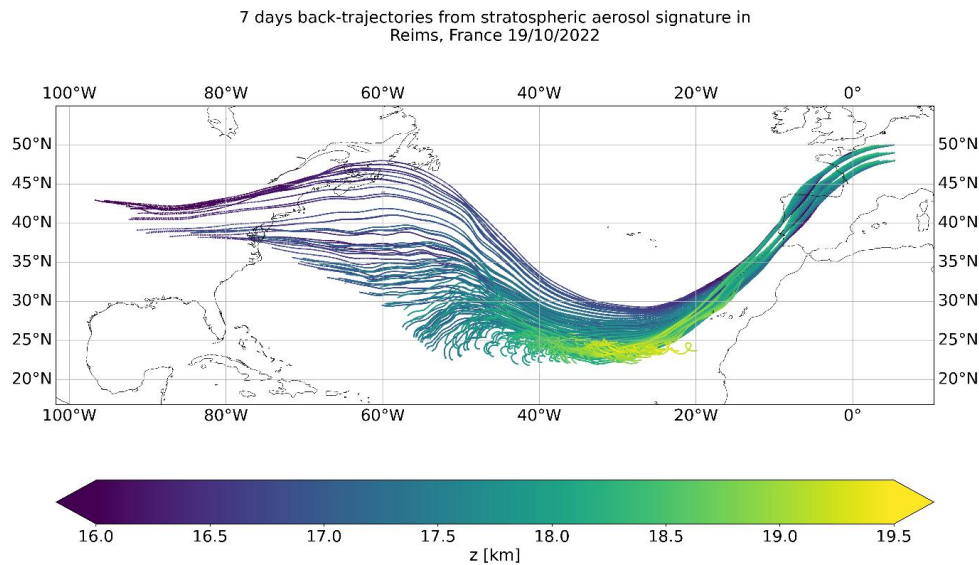


Figure 4: Could you check the tropopause height in the figures, particularly in Fig. 4a, which changes too rapid?

We adapted the Figure and added more information in the Figure caption: ‘Cross-sections of OMPS LP aerosol extinction at 675 nm as a function of latitude and altitude. Each panel shows a two-day average, with data gridded on a 1 km vertical and 1° latitude grid. Between around 30 and 130 profiles are averaged within each bin. The dashed line indicates the mean tropopause altitude. Whenever no tropopause value is available, the dashed line decreases to 0. Arrows highlight aerosol features discussed in this study and corresponding to the trajectories presented in Fig. 3.’

Figure 5: What's the time interval for this figure?

The time interval is hourly. We added this information in the figure legend: ‘The mean profile is calculated hourly within a 1~km altitude bin, using data from a 1000~km radius..’

Figure 6: Could you draw the outline of the plumes from Hunga eruption in Figure 6? It's not easy to get what you said.

Similarly to the comment on Figure 1, it would not be straight forward to outline the plume patches. However, we added more information and some arrows to the Figure pointing to some of the patches and added explanations to the figure legend: ‘Five-day mean aerosol extinction at 675 nm from OMPS at 21–22 km altitude, binned to 2° (latitude) × 3° (longitude) from January 2022 to January 2024. Each panel shows the period indicated in the title. The arrows point to clearly identifiable plume patches. The respective detailed transport is shown in the supplementary material video <https://zenodo.org/records/15343728>.’

Line 276: 676 nm --> 756 nm. Yes, thank you.

Line 281: Why use the size distributions obtained with satellite observations, not use those from POPS measurements?

The complete offline radiative transfer calculations are done with SAGE III/ISS observations to stay consistent.

Review 4:

We thank Reviewer 4 for the detailed comments and the time invested in reviewing this work. We carefully considered all remarks, and the manuscript has substantially benefitted from them. We also added a sentence to the acknowledgements to thank all reviewers: “We thank the reviewers for their valuable comments and constructive suggestions, which helped improve the quality of this study.”

This paper describes the impact of the Hunga-Tonga eruption on the norther mid latitudes. Overall this point is established by the paper, but the presentation is poor and needs a lot of work to bring it up to a publishable standard. Presently it is difficult and cumbersome to read and some figures need a lot of work. The writing includes lots of numbers and details on locations and times of measurements, yet these are of no real use to the reader, who would like to know, not the location of each individual measurement, but the separation in space and time between the measurements. The dates are presented in three or four different formats challenging the reader to figure out what format is used for each figure. Yet important details like the extinction levels used to trace the Hunga plume, or the wavelengths used for the AOD and Angstrom exponent calculations, are left out. The writing is a bit convoluted, using lots of parenthetical expressions to explain what is meant, when a little care in the writing, and shorter sentences, would eliminate this necessity.

In Fig. 2 the authors present extinction coefficient calculations from in situ measurements and from SAGE III measurements, yet do not offer any quantitative extinction comparison between the different OPCs used and the SAGE III measurements for either the Hunga plume or the surrounding background. Considering that all three measurements, two OPCs, and SAGE III, occur in relative coincidence it seems this would be a natural thing to include.

Oddly the authors sneak in an OPC comparison in the appendix with an OPC not described in the text. Why is this done and what does it have to do with this paper? It should be eliminated and presented somewhere else where that OPC is presented.

Here follows, by line number, figure, and table specific comments to improve the manuscript.

36 should be “Antarctic”

We corrected this accordingly, thank you.

61 What is meant by “partial aerosol concentrations”? Shouldn’t the wavelength of the laser be listed above rather than qualifying “aerosol size distribution”? Presumably the aerosol size distribution does not depend on the wavelength of the laser.

We added information on the partial aerosol concentration and changed the corresponding text pieces also with respect to style as suggested above:

‘We use version 1.5, which includes improvements over Renard et al. (2016), featuring increased laser source power at a wavelength of 650 nm and reduced stray light through the design of a new optical chamber.’

‘This compact instrument, including batteries (flight configuration), weighs 1 kg. It provides measurements of aerosol size distributions from 200 nm to 50 μm and partial aerosol concentrations corresponding to the measured size range, as well as a coarse classification of aerosol types.’

65 This description is poorly worded. If the sampling frequency of LOAC is 0.1 Hz why does that lead to a final profile with a sampling frequency of 1/60 to 1/600 Hz? Presumably the 0.1 Hz samples have to be averaged from 6 to 60 samples to achieve a final resolution? This is confusing. But in any case isn't the important thing the vertical resolution, which can be calculated once the sampling frequency used is known, assuming a nominal balloon ascent rate. This is the quantity of most interest for the reader.

We improved the wording and added the required information: *'The LOAC samples every 10 s (0.1 Hz). For the final profiles, individual measurements are averaged over time intervals of 1 to 10 minutes, depending on particle concentrations and balloon ascent speed. This averaging corresponds to a vertical resolution of 500 m -1.5 km in the upper troposphere and lower stratosphere (UTLS).'*

74 "aerosol properties" very generic. Be specific.

76 again, "partial aerosol concentrations"?

The exact aerosol property parameters are mentioned in the following sentence. We adapted the style of the text and added information: *POPS measures aerosol properties in the atmosphere at a wavelength of 405 nm and weighs around 1 kg, including batteries (Todt et al., 2023). The instrument provides data on aerosol size distributions from 140 nm to about 2.5 μm, as well as partial aerosol concentrations, i.e., the aerosol concentration between two size thresholds (sometimes referred to as differential concentration), corresponding to the respective size range.'*

80 Good. Such a similar statement should be included with the LOAC description.

[See answer to comment above.](#)

90-91. Do the authors mean that for this study they use the extinction measurements at 675 nm? OMPS measures and reports extinction at many wavelengths.

That is true, the phrasing is not clear. We changed the sentence to: *'Aerosol extinction profiles are provided at wavelengths of 510, 600, 675, 745, 869, and 997 nm. Here, we use the 675 nm channel.'*

97 Does anyone use the limb scatter data from SAGE III? Is an extinction product even produced from this data? If not it should not really be mentioned.

The information was removed for more clarity: *'SAGE III/ISS, launched in February 2017 and operational on the International Space Station (ISS) since June 2017, measures profiles of trace gases and aerosol extinction coefficients using solar and lunar occultation.'*

106 The current SAGE III/ISS version is 6.0. It seems the authors should use a later data version as these have been available for some time. It may make no difference, but the version used should be more up to date.

We updated the data version and the corresponding parts in the methods section: *'This study utilizes version 6 of the solar occultation aerosol extinction coefficient profiles at multiple wavelengths'*

124 Why "i.e." and the parenthetical expression. Just state ... with output of potential temperature,

The phrasing was changed to: *'In total, 63 backward trajectories were calculated with outputs of potential temperature, pressure, longitude and latitude every 15 minutes.'*

Fig. 1 caption. Why the repetition that Tonga is represented by the dashed vertical line(s). Only one line is shown.

We corrected this.

Fig. 1 If this figure were started in Jan 2021 then the whole La Soufriere cycle could be seen and the background prior to La Soufriere? Then the La Soufriere plume would be clear and contrast with the Hunga plume. Such inclusion would not significantly expand the figure.

We changed Figure 1 to include the whole time frame starting from January 2021.

We rephrased the whole paragraph 3.1 accordingly, included aerosol extinction background values and avoided most parenthesis:

'The general stratospheric aerosol situation in the northern mid-latitudes, for the period 2021 - 2024, is visualized in Fig. 1. The presented time frame starts just before the La Soufriere eruption in April 2021 at 13 °N and 61 °W, with background aerosol extinction values of around $0.3 \cdot 10^{-3} \text{ km}^{-1}$ at 19 km altitude. Following the La Soufriere eruption, the stratospheric northern mid-latitudes were significantly affected by an increased aerosol load (e.g., Li et al., 2023; Bruckert et al., 2023; Taylor et al., 2023), with aerosol extinction values up to around $0.5 \cdot 10^{-3} \text{ km}^{-1}$ at 19 km altitude, an increase by a factor of around 1.7. From Fig. 1, the increase is evident up to around 22 km altitude until early 2022. The exact phase-out time of aerosols from La Soufriere cannot clearly be identified, because the Hunga eruption (at 20 °S, 175 °W) in January 2022 produced a slight influence on the northern-hemispheric stratosphere as early as March 2022 (Taha et al., 2022).

Therefore, because of already enhanced background conditions in the stratospheric northern mid-latitudes, the actual beginning of the general influence of the Hunga eruption on the NH in terms of increased aerosol values cannot clearly be identified. However, a significant increase in aerosol extinction from October 2022 to May 2023 was observed between 16 and 23 km altitude, about 4 km above the respective tropopause, and can clearly be associated with enhancements from the Hunga eruption. Peak enhancements were observed around December 2022 and January 2023, with aerosol extinction values of around $0.6 \cdot 10^{-3} \text{ km}^{-1}$ at 19 km altitude.

Even though the eruption at La Soufriere occurred in the NH with direct stratospheric injections of sulfur-containing gaseous and aerosol species, its impact, as seen in Fig. 1, in terms of aerosol extinction, is by a factor of around 1.2 smaller than that of the Hunga eruption.'

142-143 "From Fig. 1, the increase is evident up to around 22 km altitude until early 2022." This statement is hardly supported by the figure. Considering the region from 20-22 km, there is little difference between late 2021 and near Sept. 2022. Again it would be worthwhile to show the data prior to La Soufriere to let the reader get a sense of the changes and the timing of the changes. With the current figure only the period late 2022 to fall 2023 seems to be really different than the prior and subsequent aerosol.

This has been addressed and accounted for above.

144 "Hunga eruption (at 20°S, 175°W) in January 2022 produced a slight influence on the northern-hemispheric stratosphere as early as March 2022" Perhaps this can be stated from the OMPS data but it is not apparent in Fig. 1.

That is true and this is why we have the respective reference at the end of the sentence. To make it more clear we rephrased the sentence to: *'The exact phase-out time of aerosols from La*

Soufriere cannot clearly be identified, because the Hunga eruption (at 20 °S, 175 °W) in January 2022 produced a slight influence on the northern-hemispheric stratosphere as early as March 2022, as shown in Taha et al. (2022).'

147 "... the actual beginning of the general influence of the Hunga eruption on the NH in terms of increased aerosol values cannot clearly be identified ...". Have the authors considered looking at the water vapor signal to get a better handling on the timing? There the timing of the Hunga plume may be more clearly identifiable.

We appreciate the suggestion to consider the water vapor signal. However, our focus in this study is specifically on the aerosol component. By mid-2022, the vertical distributions of water vapor and aerosol had already diverged, as shown by Legras et al. (2022, ACP, <https://doi.org/10.5194/acp-22-14957-2022>). Therefore, using the water vapor signal to infer the timing of the aerosol influence in the NH would furthermore not provide an accurate comparison.

152-153 This statement would be much clearer if the authors include earlier data in Fig. 1.

This has been addressed and accounted for above.

153 change to ... extinction, is a factor of around 1.5 smaller than the Hunga eruption ...

We did this, accordingly. Thank you.

160 19/10?

158-162, 80-82, ..., and figures. Date format: day/month/year or month/day/year or year/month/day!? It doesn't matter which is used, but it should be consistent throughout the text and figures. Here the authors switch between all three and even a fourth leaving the reader floundering. Please be consistent.

The date format has been corrected throughout the manuscript for consistency: dates are now written as 19 October 2022 in the main text and as 19/10/2022 in figure captions.

Figure 2 needs a lot of work. The interest is above the tropopause so start the figure there. This then allows the extinction scale, covering 4 orders of magnitude, to be reduced to 2 or maybe even 1 so the reader can compare the estimates from the different instruments. Something the authors should also consider doing. Fix the date format and organize the dates chronologically ascending or descending but consistent throughout. In a,d) dates ascend. In b,c) they descend. (c) "LOAC observations of aerosol plumes of volcanic origin from MeteoModem, France 48.3°N, 2.6°E" Why is this panel included? What volcanic plumes are sampled? How is it known they are volcanic plumes? Why isn't the 14/11/22 plume included in b)? In fact all the c) LOAC profiles could appear in b). While it is good the authors know the locations of the SAGE III plumes in d,e), providing the latitude/longitude to the reader doesn't add any useful information. Much more helpful would be the distance and time difference of the satellite measurements from the in situ measurements. And to the extent possible, such information should be in the figure legend. This would not be hard, just two numbers following each date and adjustments to the legend location. Do the latitude longitude and time of each in situ measurement need to be included in the figure caption? What is the reader to do with that information. Just a general location statement would be enough. There is no description of panel (d) in the figure caption.

The appendix figure A1 displays the data as it should be in Figure 1, but then A1d) makes no sense and is off topic of this paper. It appears the authors are trying to sneak in a figure showing results from another OPC, which hasn't been introduced except in the appendix, and while the

measurement comparison is encouraging it has nothing to do with the subject of this paper. Such information has to appear in another paper.

- Starting the plots above the tropopause: We now present only measurements above 15 km within Fig. 2. The respective full plots are now shown in the Appendix A1. Some features below the tropopause are mentioned within the manuscript and are therefore necessary to show. Respective changes to the text: *'A distinct increase in aerosol extinction is observed at around 12 km altitude, below the tropopause on 19 October 2022 (Fig. A1b, respective to Fig. 2b).'*
- Organization of the dates chronologically: The plots have been updated accordingly.
- Why measurements of Fig. 2c not in Fig 2b: Figure 2c shows a different aerosol plume one month later compared to 19/10/2022. The other two measurement profiles from the same location serve as background observations for this profile. Hence, a separate plot within this Figure 2 is necessary.
- How do we know that the features visible come from a volcanic plume?: This is answered within the last paragraph of this subsection. We added a helpful reference to the video in the supplementary material: *'using the Chemical Lagrangian Model of the Stratosphere (CLaMS) and analyzed satellite-based aerosol extinction observations from OMPS; this is shown in Fig. 3 and 4 and the respective video in the supplementary material.'*
- Description of (d) missing in Figure caption; including information on distance of SAGE III/ISS profiles to in situ observations: This was actually not missing in the manuscript, however, we changed the description from *'(d) Closest SAGE III/ISS (at 756 nm) aerosol extinction profiles compared to the POPS in (a) and LOAC (b) measurements on 19/10/2022, at 47.08°N, 3.23°E at 06:28 UTC on 28/10/2022 in black; 4.39°E, 48.27°N at 6:30 UTC on 30/10/2022 in grey; 4.85°N, 48.1°E at 6:30 UTC on 01/11/2022 in light blue; 4.46°N, 46.54°E at 6:31 UTC on 03/11/2022 in blue. Horizontal dotted grey lines represent the tropopause height by MERRA-2 on 19/10/2022.'* to *'(d) and (e) SAGE III/ISS aerosol extinction profiles (756 nm) within around 250 km of the in situ measurement locations. Panel (d) shows profiles from the same year as the in situ observations, while panel (e) presents profiles from one year later. Light grey lines in (d) and (e) indicate background profiles observed in October 2018 above central Europe.'*
- Excluding lat/lon information for in situ data: Latitude and longitude information are needed for comparison and positioning within later Figures.
- POPC observations in A1: The purpose of the POPC Figure in A1 is the validation of the measurements as seen in Figure 2 with a different measurement technique. We modified the respective sentence in the Appendix to make this more clear and added respective references: *'... instrument for weather balloon-borne applications (Dumelié et al., 2024; Li et al., 2023)'* and *'Comparison and validation of the POPS observations from 12 October 2022, as shown in Figure 2, with coinciding POPC observations are shown in Figure A1d.'* and *'The good comparability between the POPS and POPC profiles gives confidence in the reliability of the POPS and LOAC measurements.'*

Why is figure A2 not included as part of Fig. 1, replacing the current panel c)? Note in this figure the dates are now in a third format.

The date format in Figure A2 has been corrected for consistency. As this study primarily focuses on OPC in situ measurements, the COBALD backscatter observations shown in Figure A2 are used only for validation and represent an independent measurement technique. All observations shown in Figure 2 are converted to aerosol extinction for comparison. Furthermore, converting backscatter measurements to aerosol extinction is not straight forward and would

require additional information on aerosol properties. For this reason, we consider its placement in the Appendix to be most appropriate.

166 14/11? This statement would be clearer if the 14/11 plume were in panel b) particularly if the scale as in A1 was used for the abscissa.

1. This statement cannot be confirmed by the figure. Where are the optical depth calculations that might confirm it?

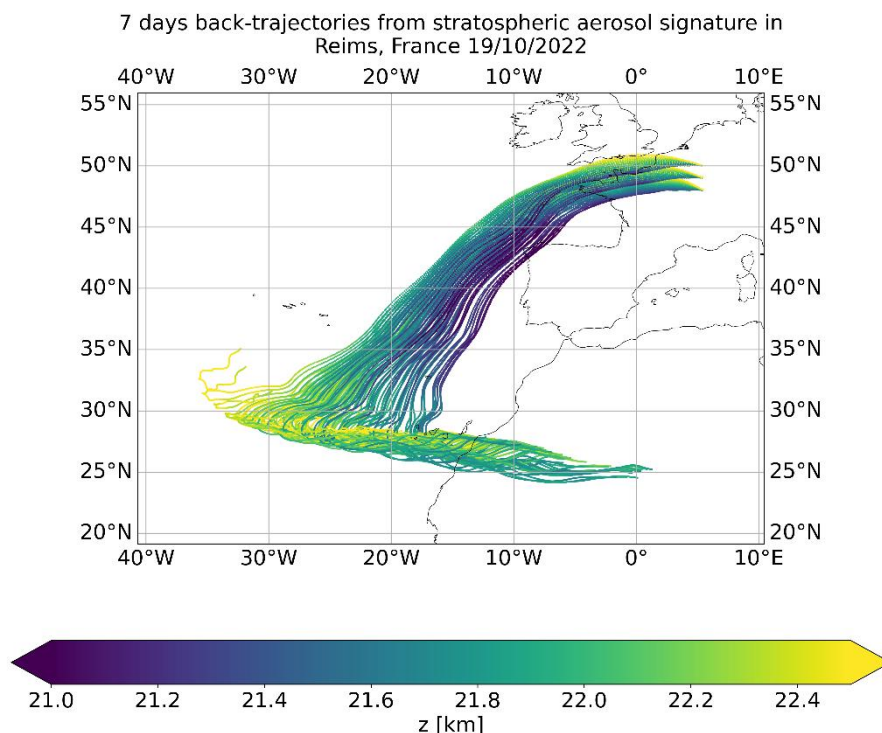
This was answered above: The scale was adapted and the reason for keeping this in a separate panel as well.

169-171 What are the authors saying. If there is a “general aerosol enhancement ... up to 20 km” why do the 2022 data agree with the background gray lines in 2018?

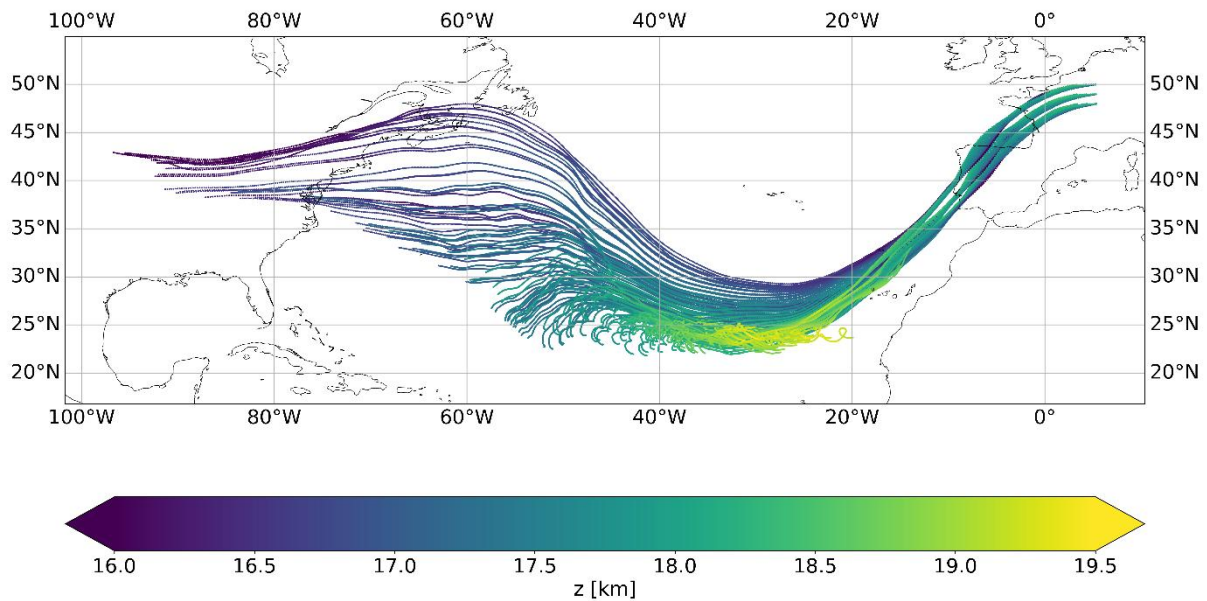
2022 data and 2018 data between 15 and 20km differ by $0.1 \cdot 10^{-3}$ in average with a significance level of $> 95\%$. With the changed scale this is better visible now. The respective increase in SAGE III data in 2022 is also visible in Figure 1.

174 and Fig. 3 Why don't the air parcels end near 21.5 km? 20.6/4 km is at the base of the perturbed layer.

Both altitude levels are within the aerosol plume layer. Using the lower base of a perturbed signal is usually the more conservative approach, less sensitive to diabatic heating processes for example. However, here it doesn't make a big difference. Below you find the respective calculations for the suggested ending altitude at 21.5 km. Slightly lower starting altitudes at 16-18 km, result in completely different trajectories, see below. We added the following text: *'The respective trajectories starting below the observed plume altitude, between 16 and 18 km, follow a distinctly different path and remain within the Northern Hemisphere, originating from the west, between 90° W and 40° W, not shown here.'*



7 days back-trajectories from stratospheric aerosol signature in Reims, France 19/10/2022



176-178. Why all the parenthetical clauses? There is no reason for them. They are very cumbersome to read. If the information is important include as part of the sentence. If not leave it out.

We rephrased this to avoid parenthesis, as requested: *'The back trajectories indicate a clear transport pathway along isentropes from the tropics and mid-latitudes on 12 October 2022, around 25°N and between 0° and 30°W at approximately 21.2 km altitude, to the location of the POPS and LOAC in situ observations in Reims on 19 October 2022 at 49°N and 4°E at around 20.6 km altitude.'*

Fig. 4 caption is brief and not very helpful. Try: Altitude, latitude cross sections of aerosol extinction from OMPS at 675 nm for the time period 12-20 October 2022. Each panel is a two day average(?) over the longitude ranges listed in each panel. The arrow identifies an aerosol plume believed to arrive over France at the end of the time period...

We agree and adapted the Figure caption accordingly: *'Cross-sections of OMPS LP aerosol extinction at 675 nm as a function of latitude and altitude. Each panel shows a two-day average, with data gridded on a 1 km vertical and 1° latitude grid. Between around 30 and 130 profiles are averaged within each bin. The dashed line indicates the mean tropopause altitude. Whenever no tropopause value is available, the dashed line decreases to 0. Arrows highlight aerosol features discussed in this study and corresponding to the trajectories presented in Fig. 3.'*

180-182 The longitude ranges are confusing. They begin encompassing only two of the CLAMS backtrajectory plumes, then move further west while the plume moves east. Is there a labelling error?

We redid Figure 4 and with that adapted the labelling.

183-193 The paragraph indications are confusing. It seems that lines 183-187 form a paragraph, but there is no indentation of the first line. While directly below there is an indentation indicating a new paragraph. How is the reviewer supposed to read this? Similar problems exist throughout.

This has been corrected throughout the whole paper.

192-195. While the CALIOP data confirm an aerosol layer at 22 km at the time of the balloon flights, the figure is also suggestive that the source of this aerosol is from a plume originating at 18 km 4 days earlier on 15 October. How can this be separated from the Hunga plume? The authors should mention this coincidence and explain why the lower and upper plume are not connected.

To re-construct the Scattering Ratio from CALIOP over Reims on a daily basis, we have combined CALIOP with the Langley Trajectory model (see appendix). The figure indicates that the Hunga plume which moved across France was first located at lower altitudes (~16-18 km on October 15th) and was observed more progressively at higher levels when the balloon flight took place (October 19th). It probably indicates a more rapid transport of the lower plume which arrived 5 days earlier over France than the plume observed on 19 October.

Fig. 6 Why are 5 days chosen for each time period, why not a monthly average? If that were the case then the panel labelling would be much easier and the reader could follow the progression of the aerosol since the panels would be labelled e.g. as January 2022, March 2022, May 2022, ... With the current date labelling the reader has to struggle to figure out the time sequence and correlating the figure to the discussion. At the very least each panel should be labelled clearly with the year and month in easy to read format.

Single plume patches transported from the tropics to higher northern latitudes are not visible when averaged over longer time periods. We added some arrows to the Figure pointing to some of the patches. Please also refer to the supplementary video <https://zenodo.org/records/15343728>, which we have now referenced at several points in the manuscript.

The panel labelling was changed according to the reviewers suggestion.

Respective to the comment on the Figure caption of Figure 4, we also added more information to the caption for Figure 6: *'Five-day mean aerosol extinction at 675 nm from OMPS at 21–22 km altitude, binned to 2° (latitude) × 3° (longitude) from January 2022 to January 2024. Each panel shows the period indicated in the title. The arrows point to clearly identifiable plume patches. The respective detailed transport is shown in the supplementary material video <https://zenodo.org/records/15343728>.'*

198-206 What aerosol extinction are the authors using to identify the Hunga plume. This should be stated so the reader can follow the discussion. Likewise what is meant by “light aerosol plumes”? For example in the March 2022 panel aerosol extinction > 0.008-0.01 km⁻¹ is observed to barely 30 N, while the authors state, “...but rather light aerosol plumes (in terms of aerosol extinction enhancements) are observed being transported to higher latitudes in the NH to around 35°N.” Where is this seen? And again why the parenthetical clause? Clear writing does not require such clauses.

All the above issues have been addressed and the paragraph adapted accordingly with more information: *'Figure 6 presents a still representation of the supplementary video, illustrating the evolution of the aerosol plume following the Hunga eruption. While the impact on the stratospheric Northern Hemisphere extends over altitudes from 17 to 23 km, distinct filaments are found mainly around 20 km. Therefore, Figure 6 focuses on the representation of denser aerosol plumes and filaments transported to the Northern Hemisphere mid-latitudes at 21-22 km altitude. From late January to March 2022, the tropical stratosphere (at 21–22 km altitude) up to 10° N becomes increasingly filled with aerosol particles originating from the Hunga eruption. In March, occasional light aerosol plumes with extinction values at around $0.4 \times 10^{-3} \text{ km}^{-1}$, compared to*

surrounding conditions at around $0.2 \times 10^{-3} \text{ km}^{-1}$, are observed. By the end of March 2022, most of the tropical to subtropical regions up to 20°N are filled with aerosols. Distinct filaments continue to move northward, reaching approximately 40°N . From October 2022 until January 2023, denser and more extensive plumes in both latitude and longitude are transported to higher latitudes, with aerosol extinction values increasing from background levels of about $0.4 \times 10^{-3} \text{ km}^{-1}$ to around $0.8 \times 10^{-3} \text{ km}^{-1}$. During this period, the filaments gradually mix with the surrounding background air.'

Fig. 7 Do the authors means as presented in Fig. 2? Is the fit to an average of the data from 20-22.5 km, or to a single measurement within that altitude range? If the former it would be nice to show the standard deviation of the concentration data at each size.

The standard deviation for LOAC and POPS values was added to Figure 7 as requested.

The Figure caption reads now: 'POPS and LOAC observations on 19 October 2022 in Reims, France, as also shown in Fig. 2, for the 20–22.5 km altitude range. Black dots indicate POPS measurements, while grey crosses represent the corresponding LOAC measurements. Error bars denote the standard deviation of the averaged profiles. The red solid line represents the bimodal lognormal fit to the POPS observations, and the dashed lines show the individual modes of the fit.'

Fig. 8 Since these profiles are averages it would be appropriate to shade in, or otherwise present, the standard deviation along with the means.

The standard deviation was added to Figure 8 and the Figure caption now states: 'Average SAGE III/ISS stratospheric aerosol extinction coefficient profiles and respective standard deviation,...'

274-276. All these numbers are lost on the reader. They are already in Table 2, or should be, so just refer to Table 2 and point out the important point of the Hunga contribution to AOD. In addition these numbers don't agree with Table 2, where the Hunga contribution is estimated at 0.0011, while the text here states the Hunga impact at 0.009 – 0.003. The difference is because the latter are at different wavelengths, but the wavelengths aren't specified. If this information is important include it, and the wavelengths in the table. Otherwise leave it out. There is plenty of space in the table to add columns at wavelengths in addition to 756 nm. In fact that would be useful and easily done. Table 2 could be made much more useful with a little bit of work, it has plenty of space. So add a column to the left indicating: Background, Background+Hunga, Hunga only. Then add AOD at the wavelengths the authors wish to quote in the text. An Angstrom Exponent is always calculated between two wavelengths. Here those wavelengths are not specified. Finally the SW TOA RF, what is the time period, does it include both background & Hunga, or just Hunga?

We changed the table and added more information as suggested. We also noticed inconsistencies for the reported time frames and corrected this.

'This produced an increase in the Hunga-perturbed sAOD (to about 9×10^{-3} to 2×10^{-3} , depending on the wavelength..'

277-279. An Angstrom Exponent without specifying the wavelengths is useless. Be specific or eliminate this text. What is the difference between an experimental value and a theoretical value of an Angstrom exponent. These exponents are all calculated the same way. What does the theoretical value use for extinction coefficients?

In the caption of Tab. 2, it is stated that “The Ångström exponent is obtained by fitting the spectral SAGE III/ISS AOD observations using the Ångström power-law relation.” Thus all the available wavelengths are used.

282 Presumably the TOA RF is calculated using the UVSPEC radiative transfer model. If so it should be so stated. The current text rather suggests the number is from Sellitto et al.

We corrected this and the line now states: ‘. a TOA radiative forcing of $-0.05 \pm 0.01 \text{ Wm}^{-2}$ is calculated with the UVSPEC RTM (Table 2).’