

## ANSWER TO THE EDITOR

We thank the editor for her prompt answer and we provide below a detailed answer to her comments. The difference file collates the difference file with respect to the submission and the difference file with respect to the first revision. The two separate files are also available from the following link

<https://filesender.renater.fr/?s=download&token=dd19bafa-93d8-4f3c-ad06-c8f07c047291>

I really appreciate the effort you have put in the revision of your manuscript and in keeping the word limits despite all the additional information requested by the referees.

However, now the first part of the manuscript is difficult to read and hard to follow. I am wondering if you are somewhat too ambitious with trying to discuss and describe six figures in a short letter paper. I guess that this was also the reason why referee 1 thought this is supposed to be a regular manuscript.

We agree, for instance, that the sentences near P3L35 are somewhat difficult to read and do not make a good start for the discussion but this is due to your request to expand the names of the three satellite instruments made in your first report. This does not need to occur in standard ACP format as the data and method section comes first. The problem arises here because the data and method section has been transferred in the appendix. The practice of other journals with such format is to allow also the full definition to be transferred to the appendix when there are many instruments involved (e.g., see Khaykin et al., 2020). It is not also that MLS, CALIOP and OMPS-LP are very new instruments which have never been heard of in ACP. In the absence of a clear policy for ACP Letters and to improve clarity, we remove the expanded acronyms from the main text.

We maintain the full spelling in the text for ALADIN and IMS as this is, for the first, a fairly recent and not so well-known instrument and, for the second, a new product used only in a few papers so far.

We have also tried to improve other parts of the text where you found necessary to clarify and some where we found this need by ourselves.

Therefore, I suggest another round of major revisions. I am really sorry for that, but in the end this will be a nice, clear paper that is useful for the scientific community. Therefore, these changes are worth the effort.

First of all you should rethink your choice of manuscript type. If you still prefer the letter style, you probably should skip the detailed discussion of some figures in the main text and put these rather in the appendix and provide there the necessary information. Otherwise, if you still have difficulties keeping the word limits with the content you would like to provide, then you should extend and rewrite your paper to a regular ACP paper. It then still can be a highlight paper.

The appendix is used to describe the methods, following the recommendations for the preparation of ACP Letters manuscript [https://www.atmospheric-chemistry-and-physics.net/about/manuscript\\_types/acp\\_letters.html](https://www.atmospheric-chemistry-and-physics.net/about/manuscript_types/acp_letters.html) and we done thing it is where the discussion of results should take place.

As the consequence, the two figures that were in the appendix are now numbered with the others, thus satisfying another requirement of the editor.

Mainly revision for sections 2-4 are necessary. The discussion and conclusion were fine. Here are my detailed comments:

General: To my knowledge the Stratospheric Aerosol Optical Depth is abbreviated SAOD without a slash in between. I would thus suggest to remove the slash.

SA/OD is for Sulphate Aerosol / Optical Depth. Other aerosol types are not retrieved with this product which is based on the specific spectral properties of sulphate aerosols (H<sub>2</sub>SO<sub>4</sub>, water and sulphur-containing ions in sulphate aerosols droplets). The second referee explains at length why it would be confusing to use SAOD. He unfortunately makes a suggestion which would be equally or even more confusing (to call this "SO<sub>4</sub>-AOD"). The product is new and has been produced by two of the co-authors of the paper who might have a say on how it is named. After discussion with them, and in order to remove any further source of discussion, it has been decided to rename it as "SA optical depth" in the text and "SA OD" with a separating blank in the figures. SA is the general acronym used for "Sulphate Aerosol" in many publications.

Title: The length is definitely ok, but I cannot understand the second part. What do you mean with "vertical separation from the water vapour"?

We prefer the short initial version but this was added at the request of the second reviewer. Both reviewers wanted to expand the title and we followed the suggestion of the second one who is apparently a native English speaker. We are not very happy of that since the new title focuses on only one of our main results. If you make such a recommendation, we would be inclined to return to the initial version but since, after all, our paper is mainly about the layer of sulphate aerosols, and there are other papers published or in review that are more focused on the water plume, we can take the suggestion of the first referee and the title is now "The evolution and dynamics of the Hunga Tonga-Hunga Ha'apai sulphate aerosol plume in the stratosphere"

P1, L4: You mean "sulphate aerosols"? Then you should also add "aerosol".

Done

P1, L8: hydration is here not the correct term. You mean condensation? If the particles take up the water vapour it is condensation, if the water vapour in the atmosphere is enriched due to the water containing aerosol particles then you may talk about hydration. You have to be definitely clearer when you use these terms.

We find that condensation alone would be ambiguous here as it is not clear which species condensates. Hydration is indeed a shortcut for hygroscopic growth, water uptake or water condensation. Hygroscopic growth is the most accurate as this notion is usually associated with the thermodynamical equilibrium. Hence, for the sake of clarity, we modify hydration to hygroscopic growth

P1, L8-9: ".....and separate from the equally persistent and ascending moisture in the Brewer-Dobson circulation." Also here the different processes are not clear and the discussion rather confusing. When you have moisture entrained then this is related to the upward motion within the Brewer-Dobson circulation, but the sedimentation is the gravitational settling of aerosol particles, thus a downward motion.

We changed “As sulphate particles grew through hydration and coagulation, they sediment and separate from the ascending moisture entrained in the Brewer–Dobson circulation” to “Sulphate particles, undergoing hygroscopic growth and coagulation, sediment and gradually separate from the moisture anomaly entrained in the ascending branch Brewer-Dobson circulation.”

It occurs to us that the editor is not unfamiliar with the idea that sedimentation of particles in the stratosphere leads to a vertical separation of the compounds which then follow a different evolution (e.g. Khosrawi et al., 2011, <https://doi.org/10.5194/acp-11-8471-2011>)

P1, L10-11: I would suggest to combine the last two sentence, so that it reads: “.....with vorticity anomalies that may have enhanced the duration and impacts of the plume”.

General on the abstract: In order to have a clear, concise abstract I would suggest that you define three key points reflecting your results first and then write from this your abstract.

P1, L13: of -> on

P1, L17: space before the comma obsolete

P2, L22: add missing reference

All done

P2, L26: The major point is that you “advocate that its climatic effect is very significant”: I would suggest to rephrase the sentence so that this becomes clearer (try to put this at the end of the sentence).

Done

P2, L28: It is really weird that you start your paper with discussing an appendix figure. If this figure is important it should belong to the main text.

We agree it is somewhat unusual to start by referring to an appendix figure. Our general choice was to have only figures showing instrumental results in the main text. This figure is ancillary but nevertheless important. It has been moved as Fig. 1 without any other change, than shifting the figure numbers. Fig. A2 has followed as it makes no sense to keep it isolated.

P2, L30: add “at” so that it reads “except at a narrow....”

Done

P2, L31: rotation? Do you mean rotation speed? Then you should also write “rotation speed”.

Done.

P2, L32: effects -> effect

P2, L34: add “latitude” so that it reads “latitude band”.

P2, L36: one comma obsolete and delete “below”. Rather than the section you should refer to the respective figure.

P2, L37: a mid-April maximum -> a maximum in mid-April

P2, L43: delete “calculated following” and just give the appendix in parenthesis, thus write “(Appendix 3)”.

All done

P2, L44: “.....using Eq 9.42 from Seinfeld and Pandis (2016)” put this information into the appendix

Unfortunately, it does not fit in the Appendix A3 and we cannot reasonably make an appendix just for that. We can safely remove this information from the text as it is also given in the caption of Fig. 3 (now Fig. 4).

P3, L50: “..... ERA5 upwelling” .....not clear, rephrase.

We have added “the” in front. The word upwelling is common in papers about the stratospheric circulation.

P3, L53: aerosol size after growing up to -> aerosol particle size growing to

Done

P3, L54-56: Rewrite as follows (make one sentence): The observed trend of the extinction-to-backscatter ratio obtained from OMPS-LP and CALIOP (Fig. 2f) is consistent with the theoretical trend direction for sizes between 1 and 2  $\mu\text{m}$ . What are the theoretical trend directions? Is a reference needed here? The information on the calculation using the Mie code can be provided in the appendix or add after backscatter ratio in parenthesis obtained also from the Mie code. However, the “also” is quite confusing here. You haven’t mentioned any Mie code calculation before in the text.

The three sentences have been rewritten as “The extinction-to-backscatter ratio, obtained by combining OMPS-LP and CALIOP data (Fig. 3g) exhibits a growth followed by a decay which are qualitatively consistent with the aerosol equivalent sedimentation speed evolution (Fig. 3e) and the expected behavior of the ratio (Fig.3f) in the 1-2  $\mu\text{m}$  size range.” Previous Fig.2 is now Fig.3.

P3, L57: something missing here? The textpart “and the decoupling between aerosols and moisture” makes no sense.

We have changed the word “decoupling” by “progressive vertical separation”. All the previous paragraphs are about the opposite vertical motion of aerosols and water. Notice that the sedimentation alone is responsible for the separation. It does not matter whether the ambient air is rising, as it is here, or descending like in the winter polar vortex (as in Khoswari et al., 2011).

P3, L58: hydration -> here you mean condensation. Particles grow by condensation.

We use hygroscopic growth, see above

P3, L58: skip “growth” and just write “coagulation” or write “growth by coagulation”

Coagulation alone saves two words, so this is the choice.

P3, L63: such -> these

Done

The two lines P3L64-66 have been discarded as this remark does not contribute to our conclusions.

P3, L70: within -> of

P3, L74: brings confirmation -> confirms this

P3, L78: suggesting -> suggesting that

P4, L91: add "ratios" so that it reads "depolarization ratios".

All done

P4, L94: skip here the text in parenthesis and add this rather at line 96 where you mention again the movie.

We prefer to keep it with no change. This was specifically added here under the request of referee 1 who wanted to be sure that Fig.5 (now Fig.6) alone is able to support what follows and that the movie is only provided an extended view)

P4, L99: Be clearer here. An early case of what?

Of concentrated patches. We think it is clear from the two previous sentences.

P4, L104: What do you mean with section? The track?

A capital was missing, we mean Section

P4, L105: we? You mean CALIOP? Then write CALIOP.

We the authors and the reader.

P4, L108: in SAOD -> in the SAOD

P4, L109: supplement -> supplemental

P5, L117: suggest -> suggest that

All done

P5, L123: "normal" obsolete?

We replaced "normal" with "background"

P5, L129: as shown from -> as seen in the

"as seen from" since the raw measurements need to be processed to make the result apparent

P5, L130: water vapour -> water vapour distribution (?)

P5, L133: hydration -> condensation

P5, L143: evaporation causes a shrinking rather than a growing and hydration should read condensation.

We use "hygroscopic growth". See above

P8, L217: skip "the" before stratospheric

P8, L217: are pure -> are on pressure

Done