



EGUsphere, referee comment RC1
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Comment on egusphere-2022-517

Anonymous Referee #1

Referee comment on "The evolution and dynamics of the Hunga Tonga–Hunga Ha'apai sulfate aerosol plume in the stratosphere" by Bernard Legras et al., EGU sphere, <https://doi.org/10.5194/egusphere-2022-517-RC1>, 2022

Review of "The evolution and dynamics of the Hunga Tonga plume in the stratosphere"

This manuscript discusses the dynamics and evolution of the Hunga Tonga sulfate aerosol plume using a combination of satellite instruments.

Major comments:

This article is formatted as if there was a limited number of words / pages (perhaps it was submitted to another journal and not change for submission to ACP). The manuscript needs to include all the sections in the appendix in the main body of the manuscript to improve readability.

Further, the flow of the science discussion needs to be changed. Currently the authors discuss how the plume evolve in time from January to June in section 2. Then, they discuss the composition of the plume in section 3 but this section mostly uses data from the first days after the eruption. Lastly, they discuss the circumnavigation of the plume over one month and half. *The change in time periods is really confusing.*

I suggest the authors discusses (current) section 3 first, the (current) section 4 next, and the (current) section 2 last. I also suggest that the authors add in the introduction a small plan for the study, for example: In this study we first discuss the composition of the aerosol plume focusing on the days following the eruption, then we discuss how the aerosol plume circumnavigate the globe in the following days (months), and lastly, we discuss the zonal mean patterns.

Through the study the authors refer to the plume meaning the sulfate aerosol plume but they also discuss the water vapor plume as well as the SO₂ plume. They need to be explicit through-out the manuscript about which plume are they discussing, for example the title should probably be changed to: The evolution and dynamics of the Hunga Tonga sulfate aerosol plume in the stratosphere

The entire section A3 requires more explanation and more details, why 21-day window and not 11 or 31 etc, is there a difference? How was this value selected? The same goes for the 2 and 6 ppmv offsets.

Has this been done before? If so, how did it? Are there any citations to be used. Are the ERA5 fields interpolated to the measurements time and locations, are the authors using 12UT 0UT, an average of all synoptic times, etc.

P5L130-L135. All this is really interesting but the authors have not shown anything to support this. Is this shown in S2022? If it is please cite S2002 again so it is clearer. If this is not, please provide evidence to support these statements or delete this discussion.

All the data descriptions require more details, for example resolutions, footprints, validations, validity on the hunga tonga plume conditions, error estimates, etc. Please be consistent in the amount of details through all datasets.

Minor comments:

P1L1 change stratospheric plume to stratospheric *sulfate aerosol* plume

P1L5 the phrase "The sulphate plume persisted until June" could be interpreted as if the plume flush out of the stratosphere in June please change to " the sulphate plume is mainly confined between 35S and 20N in June (due to the zonal symmetry of the summer stratospheric circulation at 24-25 km)". Or something along those lines.

P1L6. Swap the order of the latitudes, that is, "between 35S and 20N". (latitude ranges are typically expressed from the latitude further to the south to the latitude further to the north)

P1L17 Podglajen 2022 is not a good reference for this, use Carr et al 2022 and Proud et al 2022 (<https://www.essoar.org/doi/10.1002/essoar.10511092.1>)

P1L20. The SO₂ injection of only 0.5Tg needs a citation, the authors could use: Millan et al 2022 and Carn et al 2022 (<https://doi.org/10.1002/essoar.10511668.1>)

P2L21 the authors could add the reference Zhang et al 2022 (<https://doi.org/10.1007/s13351-022-2013-6>) to the Witze 2022

P2L26 Move Figure A1 to the main body

The color bars in Figure A1 need to be changed to divergent color bars so the zero value is always white (or gray) for example and positive values are different shades of one color and negative values are different shades of another color, for example blues white reds.

The titles for subfigures d and e need to be changed to Angular speed in 15S-5S (degree/day)

The titles for subfigures f and g need to be changed to Angular speed in 25S-15S (degree/day)

P2L28 after "positive everywhere except a narrow region near 27km over the equator" add "(Figure A1-b)".

P2L28 change to: These conditions are stable during the whole **January-March** period.

P2L29 In April-June, the rotation weakens and changes sign (**Fig A1-d and A1-f**) while the warming turns to cooling (**Fig A1-e and A1-f**)

P2L30 .. the **aerosol** plume stays mostly (or something similar)

P2L32 The sentence "By mid-February, the plume has already spread all around the Earth." is clearly wrong, the plume as the authors described in the abstract stays mostly confined between 35S and 20N, that is, it has not spread all around the Earth, I think the

authors meant "By mid-February, the aerosol plume has already spread through all longitudes." In any case, there is no evidence of this, so I suggest either adding a figure showing the longitudinal spread or not mention it in this part of the text.

P2L32. Delete However.

P2L34 and reaches and **early** April maximum

P2L35 The sentence "This suggests particle growth" is ambiguous. Do the authors mean, that the OMPS and CALIOP result suggest particle growth or do they mean, that the CALIOP results suggest particle growth. If it is the latter, change the sentence to "Meanwhile, the Cloud-Aerosol Lidar with Orthogonal Polarisation (CALIOP) scattering ratio decreases, which suggests particle growth."

P2L38 The citation Gorkavyi et al 2021 is only for OMPS. The sentence could be change to something like: The limb instruments suggest larger vertical plume extension than CALIOP due to their coarser vertical and horizontal resolution (i.e., Schwartz et al 2020 <https://doi.org/10.1029/2020gl090831>, Gorkavyi et al., 2021).

P2L40, either say Two separate descent regimes are identified from observations. For the first **regime** Or say Two separate descent **phases** are identified from observations. For the first phase

P2L46 In the second phase (**after mid-February?**) ...

Note that the dates in this discussion seems to be based in the results for the 15S-5S latitude band. For the 25S-15S latitude band the regimes are actually separated on March 1st. The authors need to specify which latitude band are they drawing their conclusions.

P3L54, if the initial growth of the particles was by hydration until mid march, why is the clear separation of the two regimes in February 15 (for 15S-5S) or march 1 (for 25S-15S)

P3L58 Fig 2e does not show any plume information thus, the sentence "The extinction-to-backscatter ratio is also smaller on the periphery of the plume (Fig. 2e)." is not clear.

P3L60 change to: The similarity of extinction-to-backscatter (**Fig 2g**)

P3L60 Figure 2g shows data for 3 latitude slices, hence the sentence "The similarity of the extinction-to-backscatter in those two latitude slices" is ambiguous, please modify it.

There is no discussion of the two humps in the vertical motion infer using the water vapor data (Fig 2b), any guesses? Could these be an artifacts of the methodology? How accurate are they?

P3L65 If I remember correctly Carr et al (2022) only talks about the ashes, there is no mention of ice in that study, please clarify.

P3L66. Please change to: What emerges on the west side are two greenish clouds (**Fig 3d**) without any hint of ash (**ashes would appear as yellow/reddish**)

P3L67 change The early CALIOP section -> The CALIOP cross section through these clouds show high scattering patches ...

P3L68 LOAC is not defined.

P3L71 Please clarify how Figure 3g and h shows that the conversion to sulphates started immediately after the eruption.

P3L75 I think this sentence will be better of changed to: Four days later (Fig. 4b), the two clouds are still separated but ...

P3L77 highest cloud? There is no information of height on these plots. Do the authors mean further to the north?

P3L80 How was the altitude determined? Please explain in the text.

P4L88 Which supplement movie B? Do you mean the movie described in appendix B. The reader should need to see a movie to understand the paper. Please include snapshots to reach the conclusions discussed in this paragraph.

P4L84 "The sulphates persist for several months". This could be interpreted as if they have already return to background levels. Please change

P4L92 I don't see patches in c and d do the authors mean Figure 5a and b shows a number of localized concentrated patches ...

If that is the case please mark the patches with circles or a contour of a distinct color. In particular the patches studied in Figure 6.

P4L95 due this western strip refers to the strips discussed in the previous section if it is please make it clearer.

P4L96 please add a patch near 11E and **XXS** (so that the reader identifies the patch easily).

P4L96 same question as before "the eastern strip" refers to the previous section? If yes please make it clearer if not please elaborate or add arrows to the figure.

P4L97 how can we be sure of "along an arc of same angular speed (Fig A1a)" if Fig A1a is an average over 3 months are Figure 6 are snapshots in time.

P4L100. What is a hairy pattern?

P5L120 Not all around the Earth but rather "dispersed the plume through all longitudes".

P5L120 how many weeks is a few weeks? 2,3, 10. Please be specific. Further, this has not been shown.

P5L122 “about 2km thick” This has not been discussed (shown) previously please specify on which plot are you basing this conclusion.

P5L126 “Our estimation of fall speed and extinction-to-backscatter ratio trends is consistent with a growth up to 1.5-2.0 μm and then a decrease in mean size”. This is only after the unrealistic values. Please also mention those here.

P5L129 delete strongly. There is no calculation in this study to suggest a strongly underestimation, there is only evidence of an underestimation but not of its magnitude.

P5L139 add i.e., before the Solomon citation (other studies have shown the potential of water vapor as well)

P5L139 add Millan et al 2022 to the S2022 reference.

P6L161. Why are you using the near real time data? there should be a more accurate product. Near real time data are normally only used for situations where near real time data is needed. The data discuss in this study is from 8 months ago.

P6L165. Do you mean SO_2 ?

P6L175. How was the conversion from pressure to altitude done for MLS data? Please specify in the manuscript.

P8L218. This details about the python based code should be in the code availability section. Here just say: The theoretical extinction-to-backscatter ratio for the plume has been calculated using Mie calculations. The extinction and backscatter coefficients have been ...

Figure 2

For panels b, d, and e, please add a vertical line indicating the separation of the two

regimes. In the caption you could say something like: The vertical line separates the two regimes (or phases) as discussed in section X.

The title for panel a and c need to be changed to "... band 15S-5S" and to ".. band 25S-15S"

The title for panel b need to be changed to Vertical motion in 15S-5S

The title for panel d need to be changed to Vertical motion in 25S-15S

The labels in e need to be changed to 15S-5S and 25S-15S (similarly the labels in g need to be changed)

Figure 3

Please add the location of the volcano in panels a-d.

Please repeat the color information in the caption. That is, in the caption include This product allows to qualitatively distinguish thick ash plumes or ice clouds (brown), thin ice clouds (dark blue) and sulphur-containing plumes (green). Mixed ash/sulphur-containing volcanic species would appear in reddish and yellow shades.

The (g-h) caption is wrong. It should say 16/01/2022 instead of 16/02/2022.

Also, I strongly recommend using the same format for all dates through-out the study. For example, use the format 28 Jan 2022 as used in Figure 1.

Figure 4 The color bars for SA OD through out the sub figures should match so the reader

could easily intercompare the values. The same for the SO2 colorbars.

That said, all SO2 plots and all SA OD should have the same color bar ranges so that the reader could easily intercompare them.

Figure 5 Either the D and N labels are wrong ore the caption is wrong. Please double check and fix.

Figure 6 All other figures al labeled (a,b,c,d,etc) from left to right and top to bottom. Please change the labels to be consistent.

Figure A2. Add latitude label. The color bar for this figure should also use a divergent colorbar.