RC1: 'Comment on egusphere-2024-1688'

This paper calculates the radiative forcing of aerosol and water vapor volcanic cloud generated by the Hunga volcano eruption in January 2022. The calculations were performed for the specific location of Reunion Island. The perturbations of stratospheric aerosol were calculated, neglecting the effect of background aerosols, which can cause a 20-25% error; for water vapor, it was assumed that the unperturbed value is 4.5 ppmV for all altitudes, which was not precisely correct. The authors used a Line-by-Line radiative transfer model with the highest resolution of 20 cm-1 for radiative transfer calculations. That might be the course for resolving the effects of stratospheric water vapor, but it worked well. The authors extrapolated the imaginary part of the sulfate aerosol refractive index from near IR to visible and UV. As a result, they overestimated aerosol short wave (SW) absorption. This is especially well seen in stratospheric radiative heating, as the paper reports warming of the stratosphere during, e.g., the first four months after the eruption, while observations show significant cooling. The radiative forcing at the top of the atmosphere is reasonably correct, but SW aerosol radiative forcing at the bottom of the atmosphere (BOA) is exaggerated. These drawbacks have to be rectified before the paper can be published.

Reply: Thank you very much. We greatly appreciate the reviewer feedback and critical comments. In this new manuscript new estimations of the aerosol and WV radiative effects are presented. The greatest modification (wrt the initial estimations) is that the single scattering albedo in visible and UV has now been forced to 1 → no absorption, only scattering. This has had the effect of increasing (in absolute value) significantly the TOA radiative effect while reducing the BOA radiative effect, resulting now in a negative atmospheric (TOA-BOA) SW+LW radiative effect caused by the aerosols and the water vapor on the stratosphere. The discussion in Section 4 has also been changed accordingly.

As volcanologist recently updated the name of the volcano to “Hunga”, the name was updated everywhere in the manuscript, including in the title.

Specific comments:

L38: The mass of water retained in the stratosphere was unprecedented, not the amount of emitted water.

Reply: Corrected.

L42: Do you mean at the location of Reunion Island or globally? I do not think it is right globally.

Reply: Some precisions have been brought in this sentence which now reads:

“Still, the stratospheric aerosol optical depth (sAOD) has been recorded **globally** as the largest since Pinatubo eruption (Taha et al., 2022) and peaked **locally** at values never observed before**, e.g. in the Indian Ocean** (Baron et al., 2023).”

L77: In this context, the reference should be "Jenkins et al. (2023)." Please correct the text in many other similar cases.

Reply: All references have been revised and the format Lastname et al. (yyyy) has been applied everywhere it was needed.

L108: Legrand et al. (2022) reported that the aerosol spatial distribution was patchy due to dynamic instabilities for more than six months.

Reply: The referee probably refers to Legras et al. (2022), as we have not found any article of Legrand et al. from 2022 about the HTHH. Legras et al. (2022) say that "volcanic sulfates and water still persisted after six months". It is true and our work shows that 14 months after the eruption volcanic sulfates and water still persist. Legras et al. (2022) also say that the aerosol spatial distribution was patchy due to dynamic instabilities, but only during the first 2 months (see their Section 6).

L190: Extrapolating the imaginary refractive index could cause spurious absorption in the UV and visible wave bands. It is well known that sulfate aerosols do not absorb in those wave bands.

Reply: In the dataset used, the last value of IRI at 2.36 µm is 4×10^{-6} and it is this value (and not strictly 0) that has been assumed for IRI from 0.2 to 2.36 µm. Although very small, we realize now thanks to this comment that the associated SSA below 2.36 µm is indeed different from 1. We have now forced SSA in all shortwave spectral bands of GAME to the value of 1.00. The results are quite different. Fig. 4, 6 and 7 are new and the discussion has been totally revised.

Figure 1: Please show your aerosol LW SAOD for 10 um.

Reply: Figure 1 shows the spectral refractive index used for the calculation of the aerosol radiative properties. So, we are sorry to say that we don't understand this request at this place.

L236: You should use the word dispersion instead of dilution. SAOD is also defined by the rate of SO2 to SO4 conversion. OMPS-LP misses the initial stage of the SAOD generation, so it is not surprising that you see a discrepancy with OMPS observations at the initial stage.

Reply: Dispersion is used now everywhere in the manuscript instead of dilution.

L257: "zonal scale" - please clarify the sentence.

Reply: The sentence has been reformulated as:

"Such a difference, although not so accentuated, is observed zonally at 15º S during the first six months of year 2022 (Schoeberl et al., 2022)."

L263: Please be more specific.

Reply: The complement “although other mechanisms of volcanic aerosol removal exist” has been removed. Although it is true in a general sense, no other mechanisms in the case of HTHH are mentioned in Schoerberl et al. (2022).

L307: "probably correlated" > "caused"

Reply: Corrected.

L309: These results from (Zhu et al., 2022) cannot be used for comparison with your calculations, as without water vapor, volcanic clouds have different evolution and cannot be correctly interpreted.

Reply: The comparison with Zhu et al. (2022) for the aerosols has been removed.

Figure 7 shows Hunga's aerosol heating rate reaching 0.8 k/day in the first four months after the eruption, while after Pinatubo eruption the aerosol stratospheric heating rates were below 0.3 K/day. This cannot be right.

Reply: The new estimations of the radiative effect after the modifications mentioned in our first reply now show an aerosol stratospheric heating rate below 0.25 K/day for the period M2-M4 and below 0.07 K/day for the period M5-M14. Fig. 7 and the discussion have been changed accordingly.

L433-436: This conclusion about stratospheric warming contradicts observations that reported significant stratospheric cooling.

Reply: The new estimations of the radiative effect after the modifications mentioned in our first reply now show a slight stratospheric cooling.