

Clim. Past Discuss., referee comment RC2
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Comment on cp-2021-123

Anonymous Referee #2

Referee comment on "Uncertainties in the atmospheric loading to ice-sheet deposition for volcanic aerosols and implications for forcing reconstruction" by Ya Gao and Chaochao Gao, Clim. Past Discuss., <https://doi.org/10.5194/cp-2021-123-RC2>, 2021

Review of 'Uncertainties in the atmospheric loading to ice-sheet deposition for volcanic aerosol and implications for forcing reconstruction' by Gao and Gao

General comments

This paper addresses an important uncertainty in the derivation of past volcanic forcing reconstructions, which is the conversion factor between volcanic sulfate deposition on the ice sheets, and the atmospheric loading of sulfate aerosol. The authors revisit the conversion using a larger array of ice cores and look at the eruptions of Mt. Tambora, Mt. Pinatubo and Agung, and assess some of the uncertainty related to the factor, demonstrating that the conversion may vary among eruptions. Overall the paper is a useful contribution, and the uncertainty analysis is interesting, but I think the study should be taken further by quantifying the implications for volcanic forcing, especially given the title, which are currently only alluded to. Other comments that I think should be addressed before publication are as follows.

Specific comments

The introduction misses discussion of the scaling factors and the uncertainty derived by Toohey and Sigl (2017) and other studies related to uncertainties in past radiative forcing that consider different eruptions (Hegerl et al., 2006; Marshall et al., 2021). The notion that the conversion factor could vary for different eruptions has been previously stated and I think that the statements in this paper could be better written to reflect this agreement with previous studies (e.g. Toohey et al., 2013).

L34 – please add that the 2/3 dampening considers the reduction in stratospheric aerosol

optical depth derived from the deposition, not the atmospheric loading

L41 – The recommended forcing for PMIP4 is Toohey and Sigl (2017). Have these previous reconstructions been used in any CMIP6 simulations?

L50 – It would be useful to list what these 6 eruptions and the three methods are

L119 – please introduce the two groups in the text here

L125 – How different are these numbers compared to previous averages used to estimate the loadings?

L155 - How realistic is it that the Monte Carlo characterization is the same for all low latitude eruptions?

L174 – It would be useful to state the difference in the number of cores included for each ice sheet compared to Toohey and Sigl (2017)

L184 – It is not clear exactly how the loading for Agung has been calculated and it would be clearer to introduce the hemispheric partitioning at the beginning of this section.

L214, Table 4 and Figure 5 – Please check the units of the conversions - the model BTDF factors in Marshall et al. (2018) are between deposition in $\text{kg SO}_4 \text{ km}^{-2}$ and sulfate burden in Tg SO_4 , not the aerosol loading. I think there is therefore a mismatch, and these should be scaled for comparison with the LTD factors.

L246 – it would be useful to explicitly state why the sampling is important here and the implications for other eruptions

Figures 1 and 2 – these could be combined into one figure

Figure 3 – please add in the caption which records overlap

Figure 5 – please add a and b labels. Why is Tambora 80 Tg not included on the top panel?

Technical corrections

L20 - 'eruptions are'

L21 - 'the timing and magnitude of historical'

L44 – show --> showed

L54 – make the --> warrants a

L65 – This paragraph is overly complicated. Consider changing to 'The LTD factor is defined as:'

L71 – start --> starting

L115 – remove 'assessment'

L161 – reduces --> reducing

L177 – 'similar' or 'the same'?

L193 – 'series of'

L195 – the Pinatubo --> Mt. Pinatubo

L220– for 'the'

L252 – uncertain --> uncertainty

L255 – record tends --> records tend

L261 – eruption --> eruptions

L262 – matters --> mattering

L263 – none --> no

L264 – could --> can

Table 4 – omb --> Bomb

References

Toohey, M. and Sigl, M. (2017), Volcanic stratospheric sulfur injections and aerosol optical depth from 500â€”BCE to 1900â€”CE, *Earth Syst. Sci. Data*, 9, 809–831, <https://doi.org/10.5194/essd-9-809-2017>

Toohey, M., Krüger, K., and Timmreck, C. (2013), Volcanic sulfate deposition to Greenland and Antarctica: A modeling sensitivity study, *J. Geophys. Res. Atmos.*, 118, 4788– 4800, doi:10.1002/jgrd.50428.

Hegerl, G. C., Crowley, T. J., Hyde, W. T., & Frame, D. J. (2006). Climate sensitivity constrained by temperature reconstructions over the past seven centuries. *Nature*, 440(7087), 1029–1032. <https://doi.org/10.1038/nature04679>

Marshall, L. R., Schmidt, A., Johnson, J. S., Mann, G. W., Lee, L. A., Rigby, R., & Carslaw, K. S. (2021). Unknown eruption source parameters cause large uncertainty in historical volcanic radiative forcing reconstructions. *Journal of Geophysical Research: Atmospheres*, 126, e2020JD033578. <https://doi.org/10.1029/2020JD033578>