Climate of the Past Discussions

Clim. Past Discuss., referee comment RC1
https://doi.org/10.5194/cp-2021-123-RC1, 2021


# Comment on cp-2021-123

Anonymous Referee #1

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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-RC1, 2021

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Review of Gao and Gao,

Gao and Gao compile additional Greenlandic and Antarctic ice core sulfate data to address the problem of inferring volcanic sulfate atmospheric loading. They primarily focus on the conversion factor (LTD) from concentrations in the ice core to total atmospheric loading for the Tambora eruption but also address Agung and Pinatubo. They find significant, i.e. factor of 2, differences in the conversion factor among the three volcanic events. They also address the uncertainty between hemispheres and for only using a few cores.

The atmospheric loading is an important climate forcing and thus improving the estimates of past atmospheric loading is necessary. Gao and Gao make modest improvement in the number of ice core records included in the analysis; however, many more cores could be included. The main additions in Antarctica are the Sigl et al. 2015 cores. Even the addition of ITASE cores on the two routes to South Pole from West Antarctica and Taylor Dome would provide valuable spatial information. It would also be interesting to assess multiple cores from the same location, such as South Pole or EDC, to better assess any single core uncertainty. This would complement the Monte-Carlos analysis the authors present. It would be interesting for the authors to comment on whether improving the conversion factor is limited by simply the number of cores, or whether the location and resolution of analysis are also important. If so, where would new cores be most advantageous.

The analysis of why different sites have different magnitudes of sulfate could be developed more. In Antarctica, the authors find an average for East and West Antarctica and then do a simple area weighting of 80/20. There is much more that could be done to understand the spatial pattern and thus provide a more robust picture. In particular, sites with higher accumulation appear to have higher total sulfate. The authors sort of plot this in Figure 3, but there is almost no discussion of it. The authors should see how much of the variance in the total sulfate can be explained by accumulation. In East Antarctica, the sites are largely concentrated on the high plateau yet the coastal locations have a much larger total sulfate. This could introduce a significant bias.

The authors also need to address the robustness of aerosol loading estimates for Tambora. They indicate a range of 60-80 Tg, but seem to base their estimates off of the 60Tg number. It seems like using the 70 Tg mid-value would be more justifiable. This then translates to the uncertainties. This uncertainty in atmospheric loading alone should introduce a ~15% error in the conversation factor, yet the uncertainties in table 4 are consistently smaller.

An additional two ways the manuscript could be improved are:

- Defining the different sources of uncertainty in the conversion factor, such as due to individual core representativeness, atmospheric loading uncertainty, and atmospheric/hemispheric transport (i.e. spatial variation), and volcano location. Then addressing each of these in a systematic way.
- Providing an example of how the new estimates change the volcanic forcing. Are the current estimates of volcanic forcing accurate? Does this new work increase or decrease the range in previously published volcanic forcing (e.g. Toohey and Sigl, 2017).

My overall impression of the manuscript is that it holds promise but it needs to: add more Antarctic ice core records, analyze the reasons for the sulfate differences among the cores more thoroughly, assess the specific sources of uncertainty, and describe the impact of the work more clearly.