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Comment on acp-2022-177

Anonymous Referee #1

Referee comment on "The effect of ash, water vapor, and heterogeneous chemistry on the evolution of a Pinatubo-size volcanic cloud" by Mohamed Abdelkader et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-177-RC1, 2022

In this paper, an atmospheric chemistry general circulation model was used to simulate the volcanic plume from the 1991 Pinatubo eruption. The authors conducted several sensitivity tests and compared the simulations with satellite-based SO_2 and aerosol retrievals. They showed that the injection height, water vapor injection, and volcanic ash all played an important role in the loading and the transport of volcanic aerosols in the stratosphere. They also showed that heterogenous reactions on volcanic ash aerosols had an impact on the formation of sulfate aerosols. Overall, this is a quite comprehensive modeling study with some very interesting results. The paper is generally well written although a bit too long. I would recommend that the paper be accepted for publication in Atmos. Chem. Phys., after the specific comments have been addressed.

Specific comments:

- The authors may consider shortening the paper. There are sentences that do not provide much additional information and can be removed. For example, lines 457-458 basically repeats the previous sentence.
- In most sensitivity tests, volcanic material was injected in a relatively thin layer in the atmosphere. There is recent evidence that the plume height can be quite different for different parts of the plume (and not necessarily 20 km). Can the authors comment on how this may or may not affect the simulations and conclusions?
- Similarly, as the recent Tonga eruption showed, ash and SO2 could be separated during the initial stage of the eruption. Can the authors also comment on any potential impact on the simulations, if ash was indeed injected at a different height than SO2 for Pinatubo?
- Introduction: Lines 57 and 87 seem to be redundant. Overall, the introduction is quite long and can be shorter.
- Figure 1 is only mentioned in the passing in the text. Perhaps it is not completely necessary.
- Section 3.1: I'm not entirely sure if R1-R5 need to be included in a research paper.
- Line 223: Fig. 8 doesn’t show refractive index.
- Line 232: specify what RRTM is.

- Line 233-234: It appears that IR absorption by SO2 was ignored? Would that have any significant effects on the plume transport?
- Lines 405-415: elaborate a bit more on how NOx and NOy are affected?
- Figure 8, 9, 11, 13, 15: missing letters from labels.
- Figure 9: are the data points in the plot temporally averaged? The initial mass does not match with the injected amount.
- Figure 12 and lines 520-524: what is the mechanism for OH change between the cases with and without ash aging?
- Conclusions - given the results here, can the authors make some comments on the Tonga eruption? For example, with the strong perturbation of water vapor in the stratosphere, do the authors expect any significant differences in terms of sulfate formation for Tonga?