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Comment on acp-2021-1025

Anonymous Referee #2

Referee comment on "Modelling SO_2 conversion into sulfates in the mid-troposphere with a 3D chemistry transport model: the case of Mount Etna's eruption on 12 April 2012" by Mathieu Lachatre et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-1025-RC2, 2022

Review of Lachatre et al., "Modelling SO_2 conversion into sulphates in the mid-troposphere with a 3D chemistry-transport model: the case of Mount Etna's eruption on April 12, 2012."

In this paper, Lachatre et al. attempt to test a model of SO_2 chemical conversion in a volcanic plume, focusing on a particular eruption of Mount Etna in Italy. The authors focus on one day, and follow the plume with the CHIMERE chemical transport model. Results show that sulfate is produced mainly through oxidation of SO_2 by OH in the gas phase (70%) and also by aqueous-phase oxidation of O_2, catalyzed by Mn^{2+} and Fe^{3+} ions (25%). The authors test the model with different plume heights, water availability, and transport algorithms. Given the low abundance of H_2O_2 in volcanic plumes, better characterization of these SO_2 oxidation pathways is of interest. The work also has importance for better understanding the role of volcanic particles as cloud condensation nuclei and for better constraining radiative forcing of preindustrial climates.

While not breathtakingly novel, the paper merits publication with minor revisions.

Minor issues.

- The reader would like to learn a bit more about why explosive volcanic eruptions emit large quantities of water. (Page 2, Line 30).
- More information on how plume heights were determined would be helpful. (Page 5, Lines 25-31).
- Figure 1. The figure is not interesting and should be move to the Supplement.
- The text states that "useful information" can be extracted from a comparison of model output and observations from IASI. (Page 9, Lines 26-27). Could a more quantitative comparison be made? True, the middle panel of Figure 2 looks something like the

model results, but a more substantive comparison would be appreciated.

- Table 2 and all tables. Please identify the acronyms in a footnote. Also state in the caption of the Tables which simulation is the most realistic.
- Figure 3 and most of the figures. There is an abundance of figures in the paper that do not seem to contribute much to the overall message. I recommend that the authors choose one panel from each Figure like Figure 3 and keep these panels in the main text. (Likley these will be the panels showing the timeseries of volcanic sulfate mass.) Put the remaining panels, if deemed necessary, in the Supplement. Also, the thin lines could be fattened to improve the visual message, and less white should be retained in the panels. Having so many figures with so much white space dilutes the main messages of the paper. The figures in the appendix can also go in the Supplement.
- Captions for Figure 3 and similar figures. Please write out, without symbols or acronyms, what is being presented. Many readers will just browse through the paper and look most closely at the captions.
- The Conclusions section mentions the need to better constrain emissions of Fe^{3+} and Mn^{2+} from volcanoes. (Page 20, lines 10-13). Do such emissions vary greatly among different volcanoes? What steps can be taken to constrain these emissions?