

Comment on acp-2021-145

Anonymous Referee #2

Referee comment on "Observation and modelling of ozone-destructive halogen chemistry in a passively degassing volcanic plume" by Luke Surl et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-145-RC2>, 2021

General comments:

The manuscript by Surl et al., presents a new dataset of airborne measurements made at Mount Etna volcano during summer 2012 and a new version of the WRF-Chem model, named "WRF-Chem Volcano" (WCV), that have been modified to incorporate volcanic emissions and multi-phase halogen chemistry. WCV shows good skills in reproducing the observed volcanic plume. This paper shows the importance of including halogen chemistry to model the chemistry-climate impacts of volcanic events. The paper is well-written, however, it would be very helpful if the authors include a paragraph summarizing the uncertainties in their model developments (e.g. uptake coefficient for heterogeneous reactions, surface area density, mercury chemistry). In addition, some of the model results need to be quantified in section 4.2. This study is scientifically relevant and I recommend the publication to Atmospheric Chemistry and Physics, after addressing general comments and, specific and technical comments listed below.

Specific comments:

1) The Abstract is long and the aim and the main results are not clear. Please shorten the abstract to include the overall purpose, the design and the relevant findings of this study.

2) Please enlarge the font size of the axis labels, keys and legends as appropriate (e.g. Figure 4 and Figure 11).

3) Consider mention the recent study of Hirtl et al., 2020 that presents the update of the WRF-Chem volcanic emission pre-processor towards more complex source terms and evaluates the results for the eruption of the Grimsvötn volcano in Iceland in May 2011 in the literature review (section 1.2.2).

Hirtl, M., Scherllin-Pirscher, B., Stuefer, M., Arnold, D., Baro, R., Maurer, C., and Mulder, M. D.: Extension of the WRF-Chem volcanic emission preprocessor to integrate complex source terms and evaluation for different emission scenarios of the Grimsvötn 2011 eruption, Nat. Hazards Earth Syst. Sci., 20, 3099–3115, <https://doi.org/10.5194/nhess-20-3099-2020>, 2020.

4) It will be useful to add another panel to Figure 3 with a terrain height map for the domain 4 (d04).

5) Line 258: 24 hours of spin-up seems a short period to initiate the chemistry in a regional model. Did you make any tests to make sure 24 hours was enough?

6) Line 323: Could you explain why encounter 10 and 12 displayed in Figure 4 and 5 give a positive correlation?

7) Figure 6, 7: Are the numbers “30, 31, 01” the days of the analysis? Please clarify this in the caption.

8) Lines 557-358: “The model SO₂ chemistry includes gas-phase oxidation by OH, generating secondary sulfate aerosol.” Was this chemistry already in the chemical mechanism or did you update it? If you updated these chemical reactions please mention where can we find their description.

9) Line 363: Please quantify this statement “Notably, the average mixing ratio of SO₂ in the plume of the 30th July is significantly less than on the other two days, although the trend is similar. ”

10) Line 381-382: Please quantify the statement “There is a substantial depletion of OH within the plume, and a moderate depletion of HO₂ (Figure 8).”

11) Line 382: Could you give more details about the study of Jourdain et al., 2016: “This result is consistent with model findings for the Ambrym plume (Jourdain et al., 2016)”

12) Line 394: Please quantify this statement "increasing the SO₂ lifetime"

13) Line 460: Please quantify "whereas HCl remains abundant."

14) Have you check changes in the O₃ Total Vertical Column between the *main* and *novolc* model runs? If so, are these changes significant that could be mention in section 4.4?

15) Line 553: Please quantify this statement with values from Table 6 and describe more in detail "In the absence of halogens (only), the plume is slightly ozone productive".

16) Line 571: Please quantify this statement "the plume is nearly totally depleted in NO_x (Figure 17a)."

17) Line 574: Please quantify this statement " the plume is elevated in HNO₃ compared to the background (17b)."

Technical corrections:

Line 8: Change SO₂ to SO₂

Line 216: Change "verion" to "version"