

Review comment on “New submodel for emissions from Explosive Volcanic Eruptions (EVER v1.1) within the Modular Earth Submodel System (MESSy, version 2.55.1)”

The paper describes a new submodel within the MESSy framework for better simulation of mainly SO₂ emissions from volcanic eruptions. Other potential applications are mentioned, such as emissions from wildfires, or volcanic degassing. In the study, the submodel is used to assess different distributions of SO₂ emission distributions for two case studies. An explosive volcanic eruption (Nabro) and an effusive/surface emitting eruption (Kilauea). A setup for historical simulations from 2007 to 2011 is also presented. The model output is then discussed and compared with satellite retrievals.

The paper presents advances in modelling with the new submodel EVERv1.1 and is therefore fitting for GMD. EVER is a new tool to implement the emissions of SO₂ from volcanic eruptions more flexibly and could be the basis for a more unified way to represent volcanic emissions in the future.

However, some restructuring of the text is needed to facilitate understanding. The manuscript is also very long and could be shortened considerably. I find the general structure of the presented manuscript very confusing. The methods used in this paper are generally stated but spread throughout the whole manuscript, which makes it difficult to read. I therefore recommend a more traditional structure with the introduction of the model, the different observations used in the analysis and the experiment description all in one dedicated chapter. Currently it reads more like the methods precede the respective result chapter and sometimes more information e.g. on the datasets is stated within the respective result sections. Also some information on the observational datasets is missing in the methodology. For example what gases are measured by what instrument. Some of this is explained later in the manuscript. There is also a section called “results” which would mean that everything before this is methodology? But this is not the case here. More detailed comments on this are below. This could also help making the paper more concise, since there are currently a few repetitions.

The results show how different set ups of the emissions can influence the SO₂ plume. It is discussed thoroughly, how the different SO₂ injections influence the plume evolution after an eruption and finally is able to show, how the new set-up improves this with respect to observations. It is mentioned, that the Asian Monsoon influences the plume evolution, “simultaneously probing the dynamics in the model”. This is not followed up with the necessary sensitivity simulations or discussion on the implications of dynamics and performance of the model.

Since the code is not currently available, the results are currently not fully reproducible. However, the description in the paper should allow for a similar model to be constructed. But it is stated, that this submodel is portable to other base models, while it was only tested for three very specific modal models. Would this submodel not function with a different type of sectional model?

Some more previously published research on the topic should be considered. E.g. different injection scenarios for the Pinatubo eruption in various models by Quaglia et al. (2023).

While the title sufficiently describes the presented model, the abstract is currently still missing some comment on the models performance but rather only summarizes the methods. Some statement on the performance of the new model should be added here.

Also please check all abbreviations, some of the abbreviations are not explained while others are specified several times. Similarly, some of the sources don't conform to the GMD format.

Throughout the manuscript there are several very technical explanations and formulas, code snippets etc. that would fit better in the appendix or supplementary material. Figure 1 does not fit in this manuscript. This is only an example of a namelist, not a result and should be kept in the supplementary material. Particularly the first figure should represent the main results of the paper.

Line by line comments

L20ff/L55ff: Both of these paragraphs introduce heterogeneous chemistry on aerosol surfaces and ozone chemistry

L134: “Up to 800 volcanic eruptions” why is there a limit? Is it impossible to simulate 801 eruptions?

L150: This formula is very general and not new to this paper, it should therefore be moved to the supplements.

Fig1: The namelists are already in the supplementary material. This is also just an example and not a result. I suggest removing this figure and referring to supplementary material

L143: Unexplained acronym AER

L156: Why is this not possible?

L170ff: Is there a reference for how this is done in EVER 1.0?

L186ff: “and width” I find the term “width” misleading here as I understand that as spreading over several horizontal grid boxes. Or does this refer to the mass emitted? Vertical extent? If there is a fixed definition, please specify.

L191ff: There are important microphysical implications for this, see e.g. in Fig. 3 in Tilmes et al. (2023)

L201: What variables are nudged? What are the implications of nudging?

L209: What does simplified chemistry mean, is OH prescribed?

L223ff: The following paragraphs lack some consistency, consider also summarizing some of the key properties of these measurements in a table. E.g. resolution, extent, what gases are measured, time when they were/are in operation. Just from reading this, I am not sure where these measurements are used later. Is it about SO₂ or aerosol, tropospheric or stratospheric?

L313: “width of 2km” again I find the use of the word “width” a bit confusing, do you mean vertical extent?

L360ff: This information on what limitations the different satellite instruments/retrievals have fits better in the methods section with the description of the instruments/datasets.

L374: “AKM” was already defined previously, it is again defined several times throughout the manuscript.

L376: “Vertical width”

L473ff: This reads like it should be in the discussion/conclusion

L479ff: Parts of these section introduce more motivation for the study again, which belongs in the introduction. I also recommend combining the methodology with the ones in the other chapters.

L509: The title for this subsection is misleading, is everything before this methodology?

L595: What about availability of oxidants in these spatially confined plumes? There would also be some differences between simplified chemistry and a more sophisticated chemistry scheme.

L634: “emission emission”

L639: How are eruptions after 2012 currently simulated?

L915-925: Check sources/format

References

Tilmes, S., Mills, M. J., Zhu, Y., Bardeen, C. G., Vitt, F., Yu, P., Fillmore, D., Liu, X., Toon, B., and Deshler, T.: Description and performance of a sectional aerosol microphysical model in the Community Earth System Model (CESM2), *Geosci. Model Dev.*, 16, 6087–6125, <https://doi.org/10.5194/gmd-16-6087-2023>, 2023.

Quaglia, I., Timmreck, C., Niemeier, U., Visionsi, D., Pitari, G., Brodowsky, C., Brühl, C., Dhomse, S. S., Franke, H., Laakso, A., Mann, G. W., Rozanov, E., and Sukhodolov, T.: Interactive stratospheric aerosol models' response to different amounts and altitudes of SO₂ injection during the 1991 Pinatubo eruption, *Atmos. Chem. Phys.*, 23, 921–948, <https://doi.org/10.5194/acp-23-921-2023>, 2023.