

Interactive comment on “Impact of the eruption of Mt. Pinatubo on the chemical composition of the stratosphere” by Markus Kilian et al.

Markus Kilian et al.

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We thank referee 1 for the quick report. Here are our replies to the comments:

- *The introduction does a good job of explaining the context of your study and exactly what the knowledge gaps are.*

Reply: Thank you very much for your positive feedback!

- *However, what was missing is why those knowledge gaps are important to address. More specifically, why is it important to separate the chemical effect of*

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heterogeneous chemistry from the heating effect of the volcanic heating? I think a sentence or two would be useful here.

Reply: Volcanic aerosols in the stratosphere modify the atmosphere in two ways: they increase the surface area for heterogeneous reactions and modify the radiation budget by absorbing shortwave incoming sunlight and subsequently heat the stratosphere, resulting in a stronger transport of heat and ozone towards the poles. A reduction of degrees of freedom in a model simulation (“separation of effects”) helps to understand the interplay of different processes and allows for estimating the respective quantitative contributions (transport versus chemical change in ozone) to the total effect in the ozone budget. Well, overall it is an academic question, but the separation helps to advance our understanding of the physical and chemical processes and their interplay. We will clarify this in the revised manuscript.

Moreover, this advanced knowledge is possibly relevant for geo-engineering by stratospheric sulfur injections, but we are hesitating to open a discussion about this here or in our manuscript, because it is clearly out of scope.

- *Since you’re using prescribed surface area density, it might be useful to talk about which processes/feedbacks you’re missing that might affect your results.*

Reply: With prescribed aerosol distribution we miss the primary feedback of the aerosol induced heating on the transport of the aerosol. But since we are interested more in the chemical effects here, this choice is advantageous, because the aerosol distribution is derived from observations. Yet, this approach might mask errors in the transport (incl. sedimentation) of aerosol of the model. We add this information to the revised manuscript (Discussion).

- *It would be useful to talk about how the nudging may have affected your results. For example, on Page 7 you talk about transport of SWV, increases in vertical*

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motion, and polar stratospheric clouds. Are these things affected by the nudging? Are others?

Reply: SWV, strengthening of the vertical motion, and polar stratospheric clouds are influenced by nudging only indirectly. Nudging (to ERA-interim analysis data) is applied to the prognostic variables temperature, divergence and vorticity (-> horizontal wind field), and the logarithm of the surface pressure. We apply this nudging in the spectral space by omitting the nudging of wave-zero of the temperature, thus we do not correct temperature biases, implying that the absolute temperature can evolve. Moreover, the nudging is applied as low-normal mode insertion, i.e. down to the synoptic scale only, with comparably long relaxation times. This means, that the synoptic situation is that of ERA-Interim, whereas sub-synoptic variations can evolve freely. Such as for instance the influence of the volcanic cloud on the vertical velocity and the temperature profile. This can be clearly seen in the results. We will discuss the effects of our nudging procedure in the revised manuscript in more detail. We will also refer to our sensitivity simulation with respect to nudging as described by Löffler et al., 2016¹ (see their Supplement and the open review discussion).

- *There are quite a few typos. I've pointed out some but not others. I'd recommend the authors spend some time proofreading.*

Reply: Yes, we will proofread the manuscript again.

Specific Comments

- *Page 2, line 12: Poleward misspelled*

¹Löffler, M., Brinkop, S., and Jöckel, P.: Impact of major volcanic eruptions on stratospheric water vapour, Atmos. Chem. Phys., 16, 6547–6562, <https://doi.org/10.5194/acp-16-6547-2016>, 2016.

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Reply: Yes, corrected!

- *Page 5, lines 2-5: These read like throwaway comments. What are the sociopolitical impacts?*

Reply:

"Besides the scientific relevance, the obtained results are supposed to also have political and social impacts. This is especially important for the contribution to the WMO/UNEP (World Meteorological Organization/United Nations Environment Programme) ozone and IPCC (Intergovernmental Panel on Climate Change) climate assessments (WMO, 2019)."

Indeed. claiming a sociopolitical impact here is a bit exaggerated. We will remove this statement from the revised manuscript and reduce our comment to the relevance of a better process understanding for the WMO/UNEP and IPCC assessments.

- *Page 5, line 5: Assess misspelled*

Reply: Yes, corrected!

- *Page 10, line 1: Is this really exactly linear? I think you need to demonstrate this more clearly.*

Reply: At this point, we just wanted to clarify the superposition of both simulations, which indeed does not necessarily be linear. Thus, we will remove the word "linear".

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-147>, 2020.

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