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Climate of the Past Discussions

Interactive comment on "Simulation of ash clouds after a Laacher See-type eruption" *by* Ulrike Niemeier et al.

Anonymous Referee #1

Received and published: 8 October 2020

General comments

This study explores the potential ash clouds after a Laacher See-type eruption using a series of model simulations with different sulfur and fine ash emissions and different injection altitudes. The study picks meteorological conditions in order to best match the ash deposits and analyses the dispersion of the ash and sulfate aerosol, and the radiative impact of the sulfate aerosol. The study finds that the ash cloud rotates, which is also dependent on the altitude of the injection and that the ash also impacts the dispersion of the sulfate aerosol and consequent aerosol lifetime and radiative impact of an extra-tropical eruption.

The study is interesting, multi-disciplined, and well-structured, and I recommend publication with some minor comments.

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Specific comments

The importance of ash for changing the sulfur distribution is clear and this could be emphasized in the conclusion as a necessity for future studies. However, I would also like to see some discussion on the importance of SO2 scavenging by ash and how this may impact your results (presumably this process is not included?) e.g., Zhu et al. 2020. Additionally, what is the role of the heating of the sulfate in changing the transport?

The simulations have two phases of the eruption, but there is little discussion of the impact of the separate phases. Can the influence of the two phases be seen in any of your results? Does it make a difference simulating the separate phases rather than the emissions all at once?

The authors state the importance of these simulations for risk assessments for future volcanism and also for understanding the social-ecological consequences of this eruption but do not give many details. Could the environmental and climatic impact (temperature, precipitation?) as predicted by these simulations be explored to support these statements?

The reconstructed ash is mentioned a lot in the introduction but not displayed until Figure 2. Could this be referred to in the text or included as a separate introductory figure, perhaps also with the reconstructed lobes?

The introduction also states that signals of this eruption in ice cores are elusive but then in section 3.2.4 mentions studies that have attributed some spikes to this eruption. This seemed a bit inconsistent.

Some of the text is difficult to read with missing words e.g. L136-142 – please check throughout.

L7 – also add the ash injection magnitudes here

L14 – ‘Resulting in a stronger transport’ than what?

L25 – how big is ‘some’ distance?

L81 – please add the length of the simulations

L136 – it is not clear to me why this might be

L146 - and also the tropospheric meteorology for deposition

Figure 1 – please add a symbol for the location of the volcano

L172-L177 – Can you justify this? Would it be better to continue each simulation to find the best meteorological condition for the second phase considering that the first phase changes the dynamics? Why are only LSE1 and LSE3 chosen for Figure A1?

L196 – can these plots show the same regional area, or can the deposits be marked on the model panels? It is hard to compare the model distribution directly with panel b.

L199 – how much is the heating?

L206-208 and throughout (e.g. L190) – It would be useful here to have the injection altitude in brackets after each simulation name, so you do not have to refer back to Table 1. Sometimes this is done but the other way around e.g. L266. Also on SI figures e.g. A2/S2.

Figure 3 – can the simulation name, ash altitude and altitude of the streamline be printed together or to the left side of the rows rather than above each separate plot as at first it was a little confusing as to what was being shown. Also, what about the results for the other simulations – these do not appear to be discussed. Are the results consistent?

L241 – extra-tropical ‘northern hemisphere eruption’

L251 – Reff not explicitly shown in Marshall et al. 2019 although inferred. Perhaps better to say ‘or suggest’ or similar for this study

Figure 5 and others – I don’t think the ‘plotted values’ sentence is needed, and these

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values seem inconsistent with the colorbar intervals. Please check.

L288 – what do you mean by the absorption in the near infra-red is important? Why specifically ECHAM-HAM? Figure A3 comes after A4, but perhaps should be introduced earlier with the magnitude of this heating stated, for example L199.

L313 – Please add here what the radii are in this study for comparison.

Figure A2 – please check the x label and ticks

Figure 10 – Can you be more explicit with the titles - NHET burden, NHET forcing, global burden, global forcing. Not hovmoller (also Figure A5 caption)

L317 – except for LSE9? Looks different in the first 6 months.

L318 – What about LSE7, which has the largest burden? Is the meteorological condition therefore more important than injection altitude?

L319 – how is lifetime defined? It is hard to see this on the figure. What about LSE10?

L321 – also depends on the spatial evolution – is this also at play?

L325 – Tg SO2. Could you add at the end of this sentence why this is or signpost to the discussion.

L329 – I think you can be a bit more explicit here e.g. 'caused by transport dynamics and consequently the amount of aerosol that moves into the southern hemisphere'

L335 – is 'decrease' correct here? Negative radiative forcing?

L343 – is this with respect to the control/climatology?

L360 – The 100 eruptions is not strictly true - 30 eruptions were simulated, but an infinite number of eruptions can be sampled from the emulator. Perhaps remove '100'. It is a bit unclear whether you're saying the lifetime increases or decreases and the exact comparison that is being made to the emulator study – is this for an equivalent eruption at 50N and 15 Tg? This study also considered eruptions in July.

L437 – consider moving the text related to LSE3 simulations having a more realistic injection scenario to the discussion.

Technical corrections

Abbreviations are not introduced in abstract.

Appendix vs. SI figures – duplicated?

13 ka vs. 13,000 vs. 13,000 ka – please check throughout!

Table 1 – June 20 'th'. May 7th missing space for LSE3. June 20th also needed for Figure A1/S1.

L13 – add hyphen between ash and cloud?

L23 – previously 'been' suggested

L53 - 'as well as' –> 'but'

L133 - of of

L160 - without 'a'

L170 – rile –> role?

L214 – towards 'the' south or turn 'southwards'

L236 – remove 'also'

L245 – the 'sulfur' injection rate

L248 – 'at' 100 hpa

L277 – were –> where

L278 – LSE9

L285 - simulations

L306 – ‘due to’

L310 – studies –> study, reaches –> reach

L317 - In sum – in general?

L322 – aggravated? Increased/magnified/larger would be better here

L334 – Opposite –> In contrast, comparable –> comparably

L371 – above –> section X

L404 - assumptions

References

Zhu, Y., Toon, O.B., Jensen, E.J. et al. Persisting volcanic ash particles impact stratospheric SO2 lifetime and aerosol optical properties. Nat Commun 11, 4526 (2020). https://doi.org/10.1038/s41467-020-18352-5

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