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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Initial fate of fine ash and sulfur from large volcanic eruptions" *by* U. Niemeier et al.

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Answer to the comment by B. Langmann:

We thank B.Langmann for her comments expressing serious doubts that the amount of emitted fine ash, as well as the emission height are well chosen to reproduce the Mt.Pinatubo ash cloud. These help us clarifying the text.

The purpose of our paper is to study the impact of fine ash, emitted into the stratosphere, on transport and climatic impact of the volcanic cloud mainly during the first month after the eruption. We consider only stratospheric ash load and do not aim at reproducing the total ash cloud nor total ash deposits. Fine ash particles are still rather large and fall out very fast. Only very fine particles ($< 10\mu$m) stay long enough in the

stratosphere to have any influence on the transport of the volcanic cloud. We may clarify this in the introduction as the author of the comment seems to have misunderstood this.

Amount of ash:
Rose and Durant (2009) define very fine ash as particles with a radius $< 30\mu$m, which is still large compared to the 6μm emitted in this study. Their data show ash-fall values and not the amount in the stratosphere. The contribution of particles with $< 6\mu$m in ash-fall is given as about 2 % in Rose and Durant (2009).

Vertical emission height of ash:
In this study we assume an emission height for fine ash of about 21 km. This follows the results of satellite studies, indicating that ash is injected below the SO2 layer. The transport height of fine ash to 16-18 km as given in Fero et al (2009) has been derived from 500 simulations with the Lagrangian ash-tracking model PUFF, with the aim to fit the results to satellite data. The PUFF model is driven by reanalysis data and does not include coupling of the aerosols to radiative processes. Our study shows the important influence of radiative heating on the horizontal and vertical transport of the volcanic cloud, like e.g. internal movements within the cloud slowing down the transport velocity. The ash cloud height given in Fero et al (2009) possibly is not the best fit for a transport in the stratosphere, especially as the satellite image in the article suggests a greater height of the cloud. The vertical distribution of ash is determined by sedimentation processes and dispersion. Both are calculated in the GCM ECHAM5. Therefore in ECHAM5 ash is not only transported at the emission height. Large amounts of ash are found below this height, some parts due to vertical motion caused by radiative heating even above (see Fig. 18).

Cerro Hudson:
We obtain in our simulation a similar geographic distribution in the Southern and Northern hemisphere as given in satellite data without the Cerro Hudson aerosol. The slightly too strong poleward transport in the model may cause an overestimation of aerosol

from the Mt Pinatubo in the Southern hemisphere. Anyhow, an assumed dominance of Pinatubo aerosol does not exclude the presence of aerosol caused by the 3 Mt SO2 emitted in the Cerro Hudson eruption. We will revise our manuscript regarding to this aspect.

Tuning:
The model has not been tuned to the measurements of Guo et al (2004). The emitted amount of SO2 is taken from the literature (Read et al, 1993, Krueger et al, 1995). Regarding fine ash, also a higher stratospheric emission like 300 Mt of fine ash with a particle size of 10μm compare reasonably well to the measurements given in Guo et al (2004). Figs. 3 to 6 show the good representation of transport and micro physical processes in the model. From this analysis we conclude that a rotation of the volcanic umbrella cloud during the first hours after the eruption, which of course cannot be resolved by the model, probably does not have the strong effect suggested by Baines (2008) on the overall transport characteristics of the cloud after the Mt.Pinatubo eruption. We do not deny the existence of a rotating umbrella, we just question its relevance for larger scale transport.

SO2 lifetime:
Our simulation results show the similar SO2 lifetimes in the stratosphere for Mt.Pinatubo and the Mt.Katmai eruption. The climatological concentrations of background gas-phase species contain three-dimensional monthly mean values. The diurnal cycle of OH is parameterized in the model, depending on latitude and day of the year.

References
For references see article and comment.