Atmos. Chem. Phys. Discuss., 14, C1027–C1031, 2014
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Atmospheric Chemistry and Physics Discussions
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14, C1027–C1031, 2014

Interactive Comment

Interactive comment on "Aerosol microphysics simulations of the Mt. Pinatubo eruption with the UKCA composition-climate model" *by* S. S. Dhomse et al.

Anonymous Referee #2

Received and published: 2 April 2014

The paper is a solid piece of work but overall a model validation paper with less new scientific results. The motivation of the paper is very model specific:" Here, we use both satellite and balloon-borne measurements to evaluate the UMUKCA simulated stratospheric aerosol properties, and seek to better understand the source of model biases" and therefore not of general scientific interest. Hence, the paper would be better suited in a journal like GMD or JAMES. In the paper model results are compared to satellite and in situ observations in a very extensive way. Model and observations agree to a certain extent however substantial differences are found between model and observations in the peak aerosol loading, the number of small particles and the

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Interactive Discussion

Discussion Paper

vertical extension. The discussion of potential errors remain often vague i.e. critical factors are discussed but a more concrete answer is missing. Additional sensitivity studies for some of the critical parameters e.g. nucleation, modal parameters (standard deviation, critical radius) could help to identify most critical processes, to assess the various model uncertainties and last but not least to improve the paper.

Major comments:

Role of aerosol induced heating.

AOD

Timmreck et al. (1999) show in their paper the difference in aerosol optical depth (AOD) between an interactive and a non interactive Pinatubo simulation. In their non interactive simulation the maximum AOD is higher and the aerosol load is more constrained to the tropical regions. However, these differences are much smaller ($\sim$10%) than in the current paper (factor of two to four). Similar results as in Timmreck et al. (1999) are found in Aquila et al. (2012). This suggests that the lack of aerosol induced heating might contribute to the overestimation of the tropical aerosol load but is probably not the major cause.

Vertical extension

The authors discuss a couple of times the bias in latitudinal extent in the first post eruption months due to the lack of aerosol induced heating. I miss however a detailed discussion about the bias in the aerosol surface area density (SAD) in the lowermost tropical stratosphere (Figure 7). In the model simulations there are really high values in comparison to observations during the first year. Partially this can be explained due to the missing aerosol induced heating as seen in Aquila et al. (2012) and Timmreck et al. (1999). Both model simulations show however a clear distinct maximum which is not seen in the UKCA simulations. I wonder if this might also be related to a bias in the cross tropopause flux in the model or to numerical diffusion. Aquila et al. (2012)

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also directly injected SO2 in a non interactive sensitivity study between 17 and 27 km and the bulk of their aerosol cloud remain between 50 and 20 hPa in December 1991 (Figure 7 in Aquila et al. 2012).

Mode number and sizes

The definition of mode ranges and boundaries play a very crucial role for the evolution of the aerosol size distribution, as for example discussed in Niemeier et al. (2009). Looking to Figs. 9 and 10 and to Figure 11 in the paper it seems that no nucleation is occurring around 20 km from October 1991 onwards but there are still too many small particles until spring next year in the model simulations in comparison to the observations. This implies that probably the particle growth is underestimated in the model. Possible reason could be found in the condensation and coagulation parameterization but might be also related to the chosen modal parameters, i.e. the standard deviation and the transition radius or critical radius. Particles need to be shifted from one mode to the other if they are growing so there exist very likely a transition or critical radius between the different modes in your model set up. How dependent are your results on these limits and on the selection of your size ranges? Sensitivity studies with respect to these parameters might help to explain the model bias and could be of general scientific interest.

Coagulation

Did you consider particle coagulation as well? You did not write anything about it in your model description. Could not it be another potential error source?

Further comments

P 2811 This is not clear to me. Do you use the expression of Kerminen and Kulmula (2002) in addition or as another option in general? How large are the differences between both applications if you use it as an additional option?

P 2816, l21 0.15 Tg S instead of 15 Tg S

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P 2817, l18 A factor of two is not slightly higher

P 2818, l2 5-29 The enhanced layer between 15-18 km originate from a small eruption plume from June 12 prior to the large one (e.g. Deshler et a 1993, Jaeger et al 1992), which injected material at lower altitudes

P 2819, l20 replace “good” with “some”

P2820, l20-25 “ lack of aerosol induced heating “ I do not understand this argument because if aerosol heating would be considered the particles would be lofted to higher altitudes

P2828, l17 Please clarify “why weaken particle growth would tend to reduce both N5 and N150 “

P2828 l11-18 This could for example be a nice sensitivity study.

Fig.9, 10 I would show only the Pinatubo simulated profile (except March 1991) this would make the comparison much clearer. You do not need the background files here.

References:

Aquila, V., L. D. Oman, R. S. Stolarski, P. R. Colarco, and P. A. Newman (2012), Dispersion of the volcanic sulfate cloud from a Mount Pinatubo–like eruption, J. Geophys. Res., 117, D06216, doi:10.1029/2011JD016968.

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Jäger, H. (1992), The Pinatubo eruption cloud observed by lidar at Garmisch–Partenkirchen, 19,91–194.

Kerminen, V.-M., and M. Kulmala (2002), M.: Analytical formulae connecting the “real” and the “apparent” nucleation rate and the nuclei number concentration for atmospheric nucleation events, J. Aerosol Sci., 33, 609–622.

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Niemeier, U., C. Timmreck„ H.-F. Graf, S. Kinne„ S.Rast, and S. Self (2009), Initial fate of fine ash and sulfur from large volcanic eruptions, Atmos. Chem. Phys., 9, 9043–9057,doi:10.5194/acp-9-9043-2009.

Timmreck, C., H.-F. Graf and I. Kirchner (1999), A one and a half year interactive simulation of Mt. Pinatubo aerosol, J. Geophys. Res.,104, 9337-9360.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 2799, 2014.

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