Atmos. Chem. Phys. Discuss., 15, C3725–C3730, 2015
www.atmos-chem-phys-discuss.net/15/C3725/2015/

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "The impact of volcanic aerosols on stratospheric ozone and the Northern Hemisphere polar vortex: separating radiative from chemical effects under different climate conditions" *by* S. Muthers et al.

Anonymous Referee #1

Received and published: 15 June 2015

Using an atmosphere-ocean-chemistry climate model, the authors assess the effects of a generic tropical volcanic eruption on stratospheric ozone and the northern hemispheric polar vortex. With a suite of simulation experiments, they separate the ozone effects of the eruption via eruption-related changes in heterogeneous chemistry and stratospheric dynamics, and the feedback of the induced ozone changes on the temperatures and northern hemispheric polar vortex.

General comments:

- This manuscript presents some new interesting results and confirm the findings of previous studies. In this current version the manuscript largely focuses on results that have already been published, such as the comparison between the effects of a Pinatubo-like eruption on the heterogeneous chemistry and dynamics (PD15_HET Vs PD15_RAD). While a reanalyses of previous studies is always useful, I think that this manuscript would gain novelty by focusing on the comparison between present-day and preindustrial, or among the different magnitude of SO2 injections. To my knowledge such a systematic assessment of tropical eruptions in present-day and preindustrial conditions has not been published. While the figures are present (at least for the PD15 and PI15 cases, but not for the 30Tg and 60Tg experiments), they are often rushed in the description. There are nearly no figures with PI30 and PI30. The contribution of the chemistry-climate interaction is also interesting, even though I am not sure that the title of Section 3.3 is appropriate. I suggest "Effects of the coupling between ozone and stratospheric dynamics on the stratosphere".

  Aquila et al. (2013), which is included among the references, is a very similar study but limited to the PD15 experiments. I suggest to include more quantitative comparisons with their results, and to extend the conclusions not covered in their study. For instance, Fig. 3 is very similar to Fig. 7 of Aquila et al. (2013). I suggest adding the same figure for PI15, PD/PI30 and PI/PD 60.

- The manuscript is very confusing in the description of the figures. I have found very difficult to follow which figure the authors are describing, and if they are referring to PD or PI.

- Are aerosol and radiation coupled in AER2D? If not, the dispersal of the aerosol, and therefore the spatial distribution of the forcing, could be totally unrealistic, especially in the case of the 60Tg injections. For instance, a visual comparison of the panels in Fig. 1 suggests that the residence time of the volcanic aerosol is similar for all three injection magnitudes. Is this true, and, if true, is it reasonable?

Larger injections should lead to larger particles and faster settling (e.g. English et al., 2012), but also to a larger vertical extent of the volcanic aerosol (Aquila et al., 2014), which would extent the stratospheric lifetime.

Specific comments:

- P14285 L28: PD15 resemble Pinatubo only for the initial conditions (time of the eruption, order of magnitude of the SO2 injected) and GHG scenario, but not in the sense of the initial meteorological conditions and QBO phase (or is the QBO nudged to observations for the period?) nor in the sense of the actual forcing, given that the SAD shown in Fig. 1 does not resemble the one from SAGE observations, which show that the peak of aerosol was south of the equator. I would rather write that the injection amount and timing of the eruptions are compatible to the eruption of Mt. Pinatubo.
- P14287 L5: what is the significance level?
- P14287 L 21: Cite relevant literature for the chemical mechanism (e.g. Tie and Brasseur (1995) or Granier and Brasseur (1992))
- P14287 L 25: Is the reduction of N2O5 by 80% a model result or is it from previous published literature? Adding "not shown" would help clarify, if it is a model result, otherwise please cite the relative reference.
- P25399 L10: The authors write that the oscillations in column ozone anomalies are due to polar ozone depletion in the northern and southern hemisphere. However, in Fig. 3b no polar depletion is visible in the southern hemisphere, except for the the non-significant depletion in August-September at 60S. Is that negative anomaly what the authors refer to?
- P14288 L13: the polar ozone depletion in RAD is said to increase with forcing strength, but this is not shown in any figure.

- P14289 L11: "In the following" or "later" (to indicate the following months)?
- P 4289 L16: Do the authors mean Fig. 3h or 3d?
- P14289 L25 to L28: This is true for the northern hemisphere, while in the southern hemisphere PD15_RAD and PI15_RAD are not very different from each other. If the reason was the reduced polar ozone depletion, shouldn't the difference between PD and PI be even larger in the southern hemisphere?
- P14290 L11: the warming in PD60 is not shown, correct? Why is there a warming at northern high latitudes in PD15_HET, even though not significant?. Is this warming a consistent feature of all ensemble members?
- P14290 L16: The black line in Figure 7 is not described anywhere (I suppose it is the average of the reference simulation). Am i suppose to compare the purple line in the upper left panel of Fig. 7 to the black line? If so, u60 is outside of the shaded area only in January and February in the case of PD15.
- P14290 L25: Is the temperature anomaly in PD30 shown anywhere? If not, how do we know that it is linear? What do the author mean with "the temperature response seems to saturate" in the PD60 case? Is it because it is not equal to three times the PD15 temperature response? The upper limit of the color scale is not indicated, so it is difficult to understand if the temperature response really saturates.
- P14291 L7: To which figure do these lines refer to?
- P14291 L111: how does the different patterns of the temperature anomaly exactly translates into a different dynamical response?
- P14291 L23: The comparison between Fig. 5c and Fig. 5g is difficult, I would add a third line with difference plots.

- P14296 L6: a comparison with observations is not very significant, since the forcing itself of Fig. 1 does not look like the observed aerosol distribution. However, I agree that the reason is probably the excessive warming of the lower stratosphere. Are brominated very-short lived substances included? Oman et al. (2014) shows that it could enhance ozone depletion.

Refenreces

English, J. M., Toon, O. B., and Mills, M. J. (2012). Microphysical simulations of sulfur burdens from stratospheric sulfur geoengineering. Atmospheric Chemistry and Physics, 12(10), 4775–4793. http://doi.org/10.5194/acp-12-4775-2012

Aquila, V., Garfinkel, C. I., Newman, P. A., Oman, L. D., and Waugh, D. W. (2014). Modifications of the quasiâĂŘbiennial oscillation by a geoengineering perturbation of the stratospheric aerosol layer. Geophysical Research Letters, 41. http://doi.org/10.1002/(ISSN)1944-8007

Aquila, V., Oman, L. D., Stolarski, R., Douglass, A. R., and Newman, P. A. (2013). The Response of Ozone and Nitrogen Dioxide to the Eruption of Mt. Pinatubo at Southern and Northern Midlatitudes. Journal of Atmospheric Science, 70(3), 894–900. http://doi.org/10.1175/JAS-D-12-0143.1

Tie, X., and Brasseur, G. (1995). The response of stratospheric ozone to volcanic eruptions: Sensitivity to atmospheric chlorine loading. Geophysical Research Letters, 22(22), 3035–3038. http://doi.org/10.1029/95GL03057

Granier, C., and Brasseur, G. (1992). Impact of heterogeneous chemistry on model prediction of ozone changes. Journal of Geophysical Research, 97(D16), 18015–18033.

Oman, L. D., and Douglass, A. R. (2014). Improvements in Total Column Ozone in GEOSCCM and Comparisons with a New Ozone Depleting Substances Scenario. Journal of Geophysical Research-Atmospheres, 119, 5613–5624.

http://doi.org/10.1002/2014JD021590

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 14275, 2015.