Atmos. Chem. Phys. Discuss., 6, S7492–S7495, 2009
www.atmos-chem-phys-discuss.net/6/S7492/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The contribution of anthropogenic bromine emissions to past stratospheric ozone trends: a modelling study" *by* B.-M. Sinnhuber et al.

B.-M. Sinnhuber et al.

Received and published: 2 April 2009

We thank all the referees for their detailed and helpful comments. We have now revised our manuscript taking into account the specific reviewer comments. In particular we have repeated the model calculations with the now available JPL-06 reaction rate recommendations, as suggested by the referee Ross Salawitch. We also have modified the technical details of how to calculate alpha: calculations are now performed with increased chlorine and bromine loadings of 10, 30 and 50%. With the new calculations the values of alpha have slightly changed (annual averaged alpha is now calculated as 64, in contrast to a value of 69 from our earlier calculations). Below we give a detailed reply to Referee #1's comments.

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

Reply to specific comments:

p. 6499, line 4: It is true that both studies (Salawitch et al. and Feng et al.) showed the largest effect on the ozone trend for situations of enhanced aerosol loading after large volcanic eruptions, while the effect on the trend was relatively small for other periods. We have modified the text accordingly.

p. 6500, lines 1-5: Yes, all published studies on global alpha are based on 2-D models. We have included a note in the introduction.

p. 6500, lines 25-26: Unfortunately, the radiation code of our 2-D model does not include the direct radiative effects of the ODSs (CFCs, HCFCs).

p. 6501, line 25 - p. 6502, line 7: The 2006 WMO/UNEP Ozone Assessment gives a range of 18 - 25 ppt for the stratospheric bromine loading and a likely contribution of 3 to 8 pptv from VSLS. We have now included this and have changed the text accordingly.

p. 6507, lines 17-19: We have now performed all the calculations for perturbations of 10, 30, and 50%. Overall the effect on the calculated global alpha value is small, changing calculated alpha by less than 10%. However, we found that a 10% change resulted in certain locations in an ozone change that was too small to calculate local alpha values reliably. Consequently, we have used the results from the 30% perturbation experiments in the text and have changed the text accordingly.

p. 6508, lines 10-16: For our new updated calculations the details of the effect on alpha for differences in Bry have changed somewhat. We now find consistently a decrease in alpha in the lowermost stratosphere and a slight increase above for enhanced bromine loading, independent of the season or hemisphere. However, overall the effect on alpha due to additional bromine from VSLS is small. We have modified the text accordingly.

p. 6509, line 9: The decrease in modelled ClO between JPL-97 and JPL-06 is a result of the incease in NOx for the more recent reaction rate recommendations. We have included a note in the text.

ACPD

6, S7492–S7495, 2009

Interactive Comment

p. 6509, line 11-22: We realize that a direct comparison to the bromine efficiency factor calculated by the AER model is difficult, as the fractional release factor from the AER model is not known. Consequently we remove the reference to the AER model, as it is not really needed here.

Comparison with alpha calculations from Chipperfield and Pyle (1998): Chipperfield and Pyle give an Arctic winter averaged alpha of about 60. This value is similar to our column alpha for Antarctic winter, in particular if one compares it to the calculation using JPL-97 kinetics. For the Arctic we get slightly larger values when using JPL-97 kinetics (winter averaged column alpha of about 70), and considerably larger values for JPL-06 (winter averaged column alpha of about 85). However, our 2-D model calculations using the 1980/81 wave forcing have temperatures warmer than observed during the cold winters of the 1990s, resulting in only little Arctic ozone depletion. So a direct comparison with the 3-D CTM results in the Arctic is problematic.

Northern and Southern Hemisphere partitioning of ozone trends: For our updated model calculations the partitioning of ozone trends between bromine and chlorine has not changed significantly, with about 45% of the ozone trend in northern hemisphere mid-latitudes due to bromine and about 35% in the southern hemisphere. Thus one can estimate the average bromine efficiency factors for the NH with about 117 = 0.45/(1-0.45) * (1000/7) and for the SH with 77 = 0.35/(1-0.35) * (1000/7). In the text we give a global average BEF of about 100. As we write, this effectiveness results partly from the quicker release of bromine from its source gases, and partly from its greater chemical effectiveness, as expressed by the alpha factor. Our updated calculations give annual mean alpha values of 75 and 60 for northern and southern hemisphere mid-latitudes, respectively. I.e., much of the differences BEF between the hemispheres comes from differences in alpha, largely a result of the differences in the importance of polar ozone depletion in both (model) hemispheres.

page 6521, Figure 8: We now have included in the figure also the calculations for JPL-97 kinetics which do not show this "kink" at about 27 km. The increase in mid-

ACPD

6, S7492–S7495, 2009

Interactive Comment

stratospheric alpha corresponds to situations were NOx-cycles dominate local ozone loss.

page 6522 - aditional figure: We have thought about including the suggested figure for the ozone change due to the CFC-11 increase. However, as Daniel et al. 1999 show only a normalized ozone change profile, a direct comparison would still be difficult.

Technical corrections: Applied, thank you!

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 6497, 2006.

ACPD

6, S7492–S7495, 2009

Interactive Comment