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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A model study of the impact of source gas changes on the stratosphere for 1850–2100" *by* E. L. Fleming et al.

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We thank the reviewer for their comments and suggestions. The reviewer has raised several issues for discussion, and we present these issues as submitted along with our responses.

(1) In section 3.4, the CH4 sensitivity experiment is described as 0.5 ppmv CH4 perturbation for the year 2000 conditions. Is this a steady state simulation using annual repeating transport parameters, or is it a 1-year time slice. I assume it is the former. It may make a bit of difference in the ozone response in the UT/LS, and the free troposphere.

Response: These are 20-year steady state simulations with annually repeating trans-

port fields. In these experiments we are trying to isolate the chemical impact on ozone due to the methane perturbation.

(2) The simulations in section 3.5 are clearly described, except for the CO2. For CFC-11, N2O and CH4, one can indeed do a steady state run. In this case, either mixing ratio boundary condition or flux boundary condition should give you the same answer. However, this is difficult for CO2. Was it simply assumed that there is a uniform mixing ratio change for CO2 and use the burden difference to derive an emission rate assuming a lifetime? This will make the connection to ODP somewhat difficult to make.

Response: For these simulations, the emission rate was calculated as the difference in the mass in the model surface layer immediately before and after setting the mixing ratio boundary conditions, given the 1-day time step used in the model chemistry. This mass difference is then the emission rate necessary to maintain the imposed mixing ratio boundary conditions over the course of 1 day. We do not assume any lifetimes for these calculations. This methodology was done for all four species (CFC-11, N2O, CH4, and CO2).

(3) It would be very useful to give the steady lifetimes for CFC-11, N2O and CH4 either in Table 1, or in Figure 13 so that they can be compared with the instantaneous lifetimes in figure 13.

Response: This is a good idea. We have added the steady state lifetimes in Figure 13, along with some additional discussion (see also our response to item 5 below).

(4) Would forcing at the tropopause be useful numbers to have in section 4?

Response: We assume the reviewer is referring to the IR radiative forcing across the tropopause. This would be useful information to have, but we feel it would require too much additional discussion, and would be beyond the scope of the present paper. We wanted to keep section 4 relatively short and just examine the general temperature responses in the model for the different perturbations as we have shown.

(5) The results on instantaneous lifetimes in section 6 are very interesting. Again, it would be useful to have some steady state lifetimes from the section 3.5 simulations for comparison. It is a bit surprising to see the "green curves" stay constant after 2000. The surface mixing ratio from IPCC are estimated using the WMO lifetime and emission from banks. The assumed lifetime is different from the model lifetime. Is the result telling us that as long as the lifetime is sufficient long, the relation between the stratospheric distribution and the surface mixing ratio will be similar to the steady state relation?

Response: We have added the steady state lifetimes in Figure 13. The updated figure illustrates that once the surface mixing ratios and the stratospheric distribution/loss reach equilibrium, the time dependent and steady state lifetimes are similar (i.e., after 2000 for the CFCs and CCl4, and throughout the time period for N2O). Therefore in the simulation depicted by the green curves, the stratospheric distribution after $\sim$2000 is driven by the surface mixing ratio time dependence, with a constant stratospheric lifetime.

Minor (1) Please add a sentence in section 5 to refer to Appendix B2 on how the age of air is calculated.

Response: Done.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 11205, 2011.