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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Stratospheric ozone in the post-CFC era" *by* F. Li et al.

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Reply to Comment # 1:

Shepherd (2008) (hereafter referred as S08) investigated past and future stratospheric ozone using CMAM simulations. S08 has made two important points that are presented in this study. These are 1) climate change causes tropical ozone decrease and extratropical ozone increase; and 2) lower stratospheric ozone changes play an important role in total column ozone changes. S08 suggested that the strengthening of the Brewer-Dobson circulation causes the lower stratospheric ozone changes, particularly the "dynamical super-recovery" of the Northern Hemisphere extratropical ozone. We regret we didn't cite these original contributions from S08 in our manuscript. We have revised the text to acknowledge S08's original contributions.

We'd like to point out that the conclusions in S08 regarding the role of the strengthening of the Brewer-Dobson circulation in ozone recovery are inferred from latitudinal structure of ozone changes. Our study is the first, to the best of our knowledge, to actually calculate the mean ozone advection changes due to strengthening of the Brewer-Dobson circulation that show qualitative consistence between circulation changes and lower stratospheric ozone changes.

Also importantly, we have made points that are either not presented or are different from those in S08. We found that GEOSCCM simulations project a global mean total ozone "super-recovery" in 2060s compared to the 1980 levels. We also found that in the lower stratosphere (below 15 hPa) the tropical ozone decrease and the extratropical ozone increase between 2060-69 and 1975-84 nearly cancel each other, and therefore the "super-recovery" of global mean total ozone is mainly due to GHG-induced upper stratospheric ozone increase. In the revised manuscript, we have added discussions of the similarities and differences between S08 and our study.

Reply to Comment #2:

First it should be noted that the timing of ODSs returning to historic levels (1980 or 1960) is significantly different in different regions. The recovery of the near-global EESC to the 1980 levels in the lower stratosphere is about 20 years earlier than in the upper stratosphere in GEOSCCM simulations. Waugh et al. (2009) also showed that while EESC levels in the tropics and Northern Hemisphere lower stratosphere return to 1960 levels at the end of the 21st century in GEOSCCM simulations, EESC amounts in the upper stratosphere and Antarctic lower stratosphere do not return to 1960 values in 2100. For this reason, there are no perfect time periods between 1960 and 2100 from which the effects of ODS can be completely removed. It is true that halogen loading is higher in 1980 than in 1960 in GEOSCCM, but we think what really matters for the purpose of this study is that halogen loading in the pre- and post-CFC baselines should be the same in regions where Cly and Bry have direct effects on ozone depletion. This is why we choose 1975-84 and 2060-69 as the pre- and post-CFC baselines because EESC amounts in the upper stratosphere and polar lower stratosphere are about the same in these two decades (Fig. 1).

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A straightforward approach to test whether ozone changes between 2060-69 and 1975-84 in the FREF simulation can be attributed mostly to climate change is to compare with results from the climate-only simulation Cl60 in which the halogen concentrations are fixed at 1960 levels. As described in our manuscript (Page 20231 and Fig. 3), the decadal ozone differences between 2060-69 and 1975-84 in Cl60 are very similar qualitatively, and in many aspects quantitatively, to those in FREF. These agreements strongly support our interpretation that ozone differences between 2069-69 and 1975-84 are mainly caused by GHG increase.

Another method to separate the effects of ODSs is to use a regression analysis. The time series of ozone is regressed onto local EESC. The regression coefficients of the EESC term and the residual term are interpreted as contributions to ozone evolution from ODSs and climate change, respectively. Using this method, we found that the decadal ozone differences between 2060-69 and 1975-84 almost completely result from climate change.

Finally, in order to illustrate why EESC differences between 2060-69 and 1975-84 (mostly in the extra-polar lower stratosphere) do not contribute "a significant part of the column ozone changes", we calculated and compared the mean ozone advection, chemical ozone loss and chemical ozone production in the ozone tendency equation. It is found that in the extra-polar lower stratosphere changes in the mean advection between 2060-69 and 1975-84 dominate changes in the chemical loss. Therefore EESC differences between 2060-69 and 1975-84 have little effect on ozone increase between these two decades.

In summary, as verified by the climate-only Cl60 experiment and the regression analysis, our conclusions that EESC differences between 2060-69 and 1975-84 have little effect on column ozone changes, and therefore that ozone decadal differences between 2060-69 and 1975-84 can be largely attributed to climate change are robust.

Reference:

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Shepherd, T. G.: Dynamics, stratospheric ozone, and climate change, Atmosphere-Ocean, 46, 117-138, 2008.

Waugh, D. W., Oman, L., Kawa, S. R., Stolarski, R. S., Pawson S., Douglass, A. R., Newman, P. A., and Nielsen, J. E.: Impacts of climate change on stratospheric ozone recovery, Geophys. Res. Lett., 36, L03805, doi:10.1029/2008GL036223, 2009.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 20223, 2008.