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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Three-dimensional model study of the arctic ozone loss in 2002/2003 and comparison with 1999/2000 and 2003/2004" *by* W. Feng et al.

W. Feng et al.

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Reply to Referee #1

We thank the reviewer for his/her comments and suggestions. We have revised the paper based on these and our response is detailed below.

Specific Comments:

The paper has been revised into clearly differentiated sctions on 1) the simulated winters and 2) model simulation differences and their causes.

For example:

a) We have now moved old Section 4.4 to Section 4.1 to show first the differences between the winters and degree of ozone loss. In this section, we also discuss how model resolution affects the distribution of ClO_x, Cl_y and NO_y.

b) We have added Figures of N_2O vs time that have been averaged insided the vortex. For example, the new Figure 3 shows comparison of the averaged modelled N_2O inside the vortex at 456 K for three winters. The new Figure 10 shows the vortex-averaged N_2O for 2002/2003 from runs CH02 and MH02 and the relative difference. Detailed discussion can be found in Section 3 and Section 4.2.

c) We have kept Figure 8 (old Figure 4) because it reveals some features of modelled chemical species vertical profiles and differences with observations which provides some useful information on how to improve models.

d) The old Section 4.4 has been moved before the comparison of ozone losses. We did not compare ClO because we do not have the updated ClO Geophysica data at the moment (although we did request it). However, the comparison with MKIV ClO shows that the model using CCM radiation scheme can reproduce the ClO profile while the model using MIDRAD underestimates the observations. The maximum modelled ClO at Esrange on December 16 from run CH02 was 1.6 ppbv at 24 km which is consistent with MKIV observation (plot not shown).

Other changes:

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Interactive Comment

1) We have revised the A, B, C, D, E table as referee suggested.

2) We have replotted the figures and use less contour labels which now eliminates the box.

3) The averaged N_2O inside the vortex has been given in Figure 3 and Figure 10.

4) We have added discussion in Section 3 about the difference vortex averaged N_2O for three winters.

5) Yes, the CH_4 using CCM radiation scheme underestimates the observations. likely related to the specified CH_4 value in the troposphere being too small. We have added the comments in Section 4.2.

Reply to Referee #2

We thank the reviewer for his/her comments and suggestions. We have revised the paper based on these comments and suggestions. Our response is detailed below.

Specific Comments:

1) We have changed Figures 12, 13 and 14 which now show the highest level (495K) at top and the lowest level (425K) at the bottom.

2) The description of the various SLIMCAT experiments have been added in the corresponding figure caption.

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3) Introduction. Old line 6. Kärmer et al. (2003) have done intercomparison of stratospheric chemistry models in the Arctic vortex. Their results showed that the all models (box, 2-D and 3-D) used in their experiments underestimated the ozone loss by about a factor of two in the height range of strong ozone depletion. Stowasser et al. (2002) showed that the agreenment of dynamic effects and NOy partitioning between the measurement (MIPAS balloon) and the CTMs are not satisficatory. Therefore, the two references have added in the sentence "Models still fail to reproduce many aspects of polar chemistry and transport".

4) Old line 15. Hansen et al. (1997), Guotail et al. (1999) and Kärmer et al. (2003) show that CTMs used in their comparisons with observations underestimated the chemical ozone loss during the cold winters. Therefore, the references have been added in the sentence "many models have tended to underestimate the chemical $O3$ loss during cold Arctic winters".

5) There is no formal reference for the "observed O_3 minihole around Scandinavia on 6 December 2002". However, it can be found in the VINTERSOL report (http://www.ozone-sec.ch.cam.ac.uk/EORCU/Reports/wr0203.pdf).

6) The title has been changed to "Comparison of data for two winters 2002/2003 and 1999/2000".

7) No, either tracer should be good so long as the boundary condition is realistic. SLIMCAT with CCM radiation better reproduces the N_2O profile than using MIDRAD radiation scheme but underestimates CH4. We find that the modelled N_2O and CH_4 correlation is very similar with the different radiation schemes. We infer

that SLIMCAT has lower CH4 than observations. This may be caused by low surface value of tropospheric source gase CH4 which was specified from WMO (2003).

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8) The text has been added as suggested.

Minor comments

1) "also" removed in the text.

2) Figure 5 has been replotted. Now the NOy plot is consitent with Cly plot.

3) It should be "456K".

4) "." is removed.

5) It is corrected to "Signifcant changes in ozone were observed".

6) "results" is changed to "result".

Reply to K. Krueger

We thank K. Krueger for her comment on the description of the 2002/03 Arctic winter. We have changed the sentence based on the comment.

For the year 2002/2003, we changed it to:

"The year 2002/2003 can also be classed as a extremely cold early Arctic winter (e.g. Naujokat and Grunow, 2003)."

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and changed "major sudden warming" to "minor warming".

References

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[4] Stowasser, M., Oelhaf, H., Ruhnke, R., Wetzel, G., Friedl-Vallon, F., Kleinert, A., Kouker, W., Lengel, A., Maucher, G., Nordmeyer, H., Reddmann, T., Trieschmann, O., von Clarmann, T., Fischer, H., Chipperfield, M.P.: A characterization of the warm 1999 Arctic winter by observations and modelling: NO_y partitioning and dynamics, J. Geophys. Res., 107, 4376, doi:10.1029/2001JD001217, 2002.

[5] World Meteorological Organization (WMO): Scientific assessment of ozone depletion: 2002, Global Ozone Res. Monit. Proj. Rep., 45, UNEP/WMO, Geneva, Switzerland, 2003.

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