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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Extrapolating future Arctic ozone losses" *by* B. M. Knudsen et al.

B. M. Knudsen et al.

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Comments to reviewer 1:

Abstract

Done

Section 1

Done

Section 2

The difference between the 10x10 and a 2.5x2.5 degree grid was investigated for ERA40 for the period 1973 to 1981. The largest difference occurred in 1980 where the PSC areas were 1.52 and 1.47 %NH. The reason for the small differences is the averaging over most of the winter. We have added that the higher resolution used was 2.5 degree and that the averaging over most of the winter is the cause.

We have added that the ERA40 data were used at high-resolution for the comparison to the radiosonde data. Please refer to Knudsen (2003) for a full description.

Section 3

Done. It is significant without the water vapour trend

Section 4

Done

Section 5

This is a good point, which we have tried to address. We have added the following in the last paragraph before the conclusion:

It is, however, not straightforward to compare our depletions with the minimum column ozone given in WMO (2003). Austin et al. (2003) show that past trends of minimum column ozone are not significantly different from trends in Arctic mean column ozone. Since we predict a colder future, which usually is connected to reduced transport of ozone to the Arctic, including transport is likely to increase the difference in the predicted recovery. However, the difference in results may partially be able to explain why we do not get as much 'ozone depletion' as Shindell et al. (1998).

Figures

We think this could be overcome if ACP shows this figure at largest possible width. We'll ask for this during production. We also think adding another colour to the plot will make it too confusing.

Comments to John Austin

We have made short comments to his comments S1068 and S1073 (part 1 and 2). These comments were in fact author comments on behalf of all coauthors, but were erroneously put in as short comments. We have the following further remarks to these

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comments:

1. Section 6 has been omitted in the revised version.

2. We have commented on the transport effect on ozone in the revised paper (see comments to reviewer 1). Including transport effects would probably increase the differences.

S1287 (Part 3)

We have made an author comment to this comment already. We have 4 further remarks:

1. We have added the following about choosing 2001 as end year of the calculations: The calculation have been performed until 2001 because that is the end of the FU-Berlin record. Updating the trends to 2004 would result in smaller PSC trends. However, there have been major mid-winter warmings in 5 out of the last 6 Arctic winters, compared to a long-term average of 1 in 2 winters, and so there is a risk of introducing a bias in the analysis. To give some idea of the magnitude of this effect, the data record was extended using ECWMF operational data for 2002-04. Then the trends for all, the 50% largest, and the maximum PSC areas would reduce by 29, 33, and 4 % of the original trends, respectively. The trends would still be highly significant. Going to the other extreme of ending the trends in 1997 after 6 winters in row without major warmings would increase the trend for all PSC areas by 26%.

2. To try to make the conclusions in the paper more balanced we have switched from using Rosier and Shine (2001) to Schwarzkopf and Ramaswamy (2002) to estimate the effect on ozone depletion on temperature. The Schwarzkopf and Ramaswamy (2002) result is in the middle of the results given in WMO (2003) except for outliers. We have also refined our calculation of the effect of the reduced ozone depletion trend in the future on the prediction and this is presented already in the abstract. Figure 5 is revised as a result. These change did not lead to an increase in the estimated effect of

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the reduced ozone trend in the future - on the contrary.

3. The error bars shown in figure 9 Austin et al. (2003) are 2 sigma uncertainties of individual years. The uncertainty on the mean is much smaller. Therefore the figure does not show that each model predicts anything from full recovery to no change in ozone. However, we have added in the introduction that the chaotic nature of the atmosphere has some influence on the differences between models. A further discussion of this is out of the scope of the paper.

4. In order not to make our figures too complicated we find it scientifically sound to use only 2 out of three temperature data sets, when these two are known to agree with measurements and the thirds is known not to agree.

S1517

This comment is mostly reiterations of previous comments, and we have only one remark: According to the very comprehensive analysis of Andrews et al. (JGR, 32,295-, 2001) the age of air in the Arctic based on measurements is about 5 years.

S1520

This comment is mostly reiterations of previous comments, and we have only two remarks:

1. There is no connection between errors in the age of air from assimilation fields and the accuracy of their Arctic temperatures

2. The variability of Arctic temperatures is too large to infer stabilization from the recent data with confidence.

Other changes:

The abstract has changed considerably. We now present our prediction as a complementary approach instead of an alternative approach to CCM's

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In the introduction we have omitted the following excessively negative or outdated remarks: In fact current CCMs do not reproduce either today's amount of Arctic PSCs or the large increase since the 1960s. Even if analyzed temperatures are used in state-of-the art chemical transport models the observed depletion is not modelled correctly.

We also added the following in the introduction: The idea is that if the atmosphere is currently too difficult to model we need to let nature tell us what is going on.

We have added the following to the conclusions: However, due to the inadequacies of a simple extrapolation every effort should be undertaken to improve the CCM's.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 3227, 2004.