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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Quantification of transport across the boundary of the lower stratospheric vortex during Arctic winter 2002/2003" *by* G. Günther et al.

G. Günther et al.

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We thank the two anonymous Reviewers for their helpful comments and recommendations. We are submitting a revised paper to be considered for publication in ACP.

In response to the comments of anonymous referee 1:

One of the main conclusions of the authors, last paragraph of the abstract, is the small impact of polar ozone loss on mid-latitude ozone before the vortex break up. I consider that this conclusion should be moderated and more discussed. The fraction of 6% of polar air exported in mid-latitude by end of March should be put in relation of the relative areas covered by the vortex air at the beginning of the run (9% of North hemisphere area if I estimate a South limit at 65 in equivalent latitude for vortex air from Figure 15)

and the area of the latitude band 30-60N (36% of the North hemisphere). It means that about 24% percent of the vortex air has been exported to mid-latitude which is not negligible. Furthermore, in terms of the relative contribution to ozone depletion at mid-latitude, the contribution of exported polar air may be much higher because the in-situ mid-latitude depletion is much weaker.

We agree with the comment of referee 1, that the estimate of the maximum impact of ozone depleted air from the polar vortex on mid-latitudes should be more discussed. We did further analyses on our data and discovered an error in the program that computed the air mass fractions with respect to equivalent latitude. The correction of this error led to a reduction of the fraction of vortex air exported from 6% to 5% at the end of March. We have set this result in relation to the ozone loss for mid-latitudes derived from the study by Grooß et al. (2007) published in ACP and find an upper limit for the impact of dilution of ozone depleted vortex air on mid-latitudes of 50% ($\approx$ 12 DU) at the end of March 2003. This value is in agreement with former studies like Knudsen and Grooß(2000), Marchand et al. (2003) and Millard et al. (2002). Abstract and Conclusions have been changed with respect to these new results.

We agree that the fraction of air exported to latitudes south of the vortex edge should be set in relation to the volume of the vortex. In fact, our value was derived for the whole layer between 400K and 850 K. The 5% of vortex air exported to lower latitudes correspond to $\approx$ 60% of the volume of the polar vortex in this altitude range at the end of March. This is now mentioned in the paper.

The authors do not indicate if they consider their result as a new one and do not compare with previously published studies ... I have the feeling that their results are not in contradiction with previous publications but that they are presented in a different way.

A comparison with previously published studies has now been included in the paper.

In response to the comments of anonymous referee 2:

ACPD

7, S9369–S9372, 2008

I suggest to improve the presentation somewhat by mentioning more explicitly in the Introduction which questions are going to be answered in this paper. A general problem I have with the paper is that it contains rather long descriptive texts, without giving at the end of teh chapters some summary or conclusions that are be drawn from this. This is particularly a problem with the long chapter 5. I recommend to divide this chapter into different sub-chapters, each with a informative title, starting the sub-chapter with the question that is going to be answered and ending with one or more conclusions.

We agree with the referees recommendation to divide the long chapters in subchapters to improve the readability. This was carried out where applicable, especially in the chapters 3 and 5. We chose informative titles and added more conclusions to the text.

In its present form, the manuscripts suggest that there is one (main) conclusion, which is the one of the last sentence in the abstract (by the way, here 6% is mentioned whereas in the text it is 7%). But a paper need not to be so extensive to come just to this (albeit important) conclusion. There is now much more info in the manuscript, but I feel this is not really used to draw conclusions. So I recommend either to omit material that is not necessary for the main conclusions, or to draw more explicit conclusions from all this material.

As already mentioned in the response to the comments of referee 1, the last chapter was extended with more conclusions concerning the change of the composition of the polar vortex due to the dynamical situation, especially during the vortex splits and re-merging events, and the impact of dilution to mid-latitude ozone decrease.

6% vortex air loss is not much, but after the break up additional loss will occur. It would be nice if the authors could compare the loss before the break-up with the loss after it (or is the latter simply 94%?).

The values given for the loss of vortex air are meant as the fraction with respect to the air outside. These correspond to higher values if set into relation to the amount of air inside the vortex since the vortex volume is much smaller (see above).

ACPD

7, S9369–S9372, 2008

Interactive Comment

The simulation described in our study does not cover the complete vortex break-up, which did not happen before April 2003. But if ”loss of vortex air” is defined as the fraction of former vortex air being equatorward of the vortex edge, then all vortex air ist lost, when the vortex edge breaks down.

In discussing the impact on midlatitudes of the vortex air before and after the break up, it might also be useful to mention the higher solar elevation after the break up, and hence the larger effect on UV at the surface of ozone decreases after the break up.

The discussion on the impact of dilution already considers a complete ozone depletion in the vortex air masses being transported in the mid-latitudes, thus giving an upper limit for the effect of dilution on ozone decrease. We tried to make this more clear in the new version of the paper.

Likewise we added some text to make more clear, why the second vortex split and re-merging is quite important for the composition of the vortex air.

Thanks again to both reviewers for their constructive comments. We believe the current paper, revised in light of those comments, more completely fulfills its intended purpose of elucidating the impact of the dynamics, transport and mixing on the composition of the polar vortex and the mid-latitudes during the winter 2002/2003.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 17559, 2007.