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Interactive comment on "Vortex-averaged Arctic ozone depletion in the winter 2002/2003" *by* T. Christensen et al.

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Comments to referee 1

Uncertainties in transport terms

Regarding Fig. 2. It is our modeled results that are shown as black lines, not SLIMCAT results. The SLIMCAT comparison is made by Greenblatt et al. (2002). This will be clarified in the manuscript.

Regarding the diabatic cooling rates, we unfortunately don't find it possible to give a clearer idea of the uncertainties involved. In Fig. 2 it is correct that horisontal transport

is not taken into account. Mixing was taken into account by Ray et al. (2002) as we have described, but we cannot use their results for our comparison in Fig. 2 as they cover a different period.

Regarding the in-mixing in our calculations for 2002/2003, the uncertainties are mainly caused by errors in the calculated PV (Sobel, 1997). Instead of discussing the errors in the trajectory calculations, it is more relevant to discuss the effect of the bin size used in the PV-θ mapping. Doubling the bin width to 12 PVU or halving it to 3 PVU gives results within 4% both for the ozone loss rates (the slopes in Fig. 5) and for the height-integrated ozone loss. A comment like this will be included in the revised version.

We will include the size of the in-mixing term in Table 2.

p. 6676 l. 16–17

Small differences in the subsidence can give rise to large differences in ozone loss as the loss rate can vary significantly with height. This can be seen in a figure in M. Streibel et al., to be submitted. The figure shows vertical and temporal variations of ozone loss in the Arctic winter 2002/2003. Between the 475 and 500 K descent lines the ozone loss rate decreases by about 50%. Match-calculated descent is 45 K at 475 K, whereas our descent at this level is 81 K. The Match approach is sensitive to inhomogeneities in ozone loss rate. Possibly this can explain the discrepancy at 475 K. Generally, though, an underestimate of the descent at this level should lead to an underestimate of the ozone loss which would increase the discrepancy. Perhaps the uncertainties are underestimated. We will modify the explanation of the discrepancy at 475 K in the revised manuscript.

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Uncertainties in Tables 3 and 5

The following will be clarified in the revised manuscript. The uncertainties in Table 3 on our calculated column ozone loss are solely based on the standard deviation of the best linear fits in Fig. 5. Likewise for our results in Table 5, except the linear fits are not shown. The Match uncertainties are described by Streibel et al.

Comparison with other results

The comparison with Match is done with great care, i.e. recalculating both Match and vortex-average results using the same vortex edge definition, the same height range (to the extent possible) and the same time period. Making similarly careful comparisons with other methods (as did Harris et al. (2002)) is beyond the scope of this paper.

We could compare with results published by others for different time and space intervals, (Tilmes et al. (2003), Goutail et al. (2004), Singleton et al. (2004)) and could include this in a revised version.

Minor corrections

The two corrections suggested at the end of the Referee comment will be implemented.

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Comments to referee 2

Abstract

Uncertainty estimates and height range will be included in the abstract.

line 17, 19, p. 6669

I guess the sentence is hard to read. It will be rewritten for the revised version, and a reference to Rex et al. (2004) will be included.

line 4, p. 6670

Will rewrite as suggested.

line 20, p.6670

Please see above comment for Referee 1 on comparison with other results.

line 25, p. 6670

This method of determining the edge of the vortex is quite similar to the method of Nash et al. (1996), but simpler to use because wind fields are not necessary. This comment will be included in a revised version.

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line 6, p. 6671

We find that this is covered already.

line 4, p. 6672

Will do.

Sect. 4.1, p. 6672

Differential descent is not considered in this paper. Since the descent only has a moderate influence on modelled ozone depletion, the impact of differential descent would probably be a minor increase in the uncertainties.

line 12, p. 6673

We cannot quantify the differences since Greenblatt was unable to give us the numbers used in his plot. This judgement is based on visual inspection of the plots in our study and the Greenblatt paper. The SLIMCAT descent rates are those given in Chipperfield (1999). It is out of scope of this paper to discuss the reasons for the differences in heating rates.

line 20, p. 6673

Will correct.

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lines 9–21, p. 6673

The accuracy of the descent calculations is not easily assessed. We can include a comment on how sensitive the method is to the descent: If the amount of cooling is changed by $\pm$20% the slopes in Fig. 5 are changed by less than 20% for the levels 380–475 K and by 30–40% for 350 and 525 K. The height-integrated ozone loss is changed by 10–15%.

Sect. 5/Table 4

Will include uncertainties and height range.

line 2,3, p. 6676

True, but for this intercomparison the same value was chosen for all theta levels. Both Match and vortex-average results were recalculated with these common criteria. This will be stated more clearly in the revised paper.

Table 5

We will make a new uncertainty estimate.

The comparison with Match is done with great care, i.e. recalculating both Match and vortex-average results using the same vortex edge definition, the same height range (to the extent possible) and the same time period. Making similarly careful comparisons with other methods (as did Harris et al. (2002)) is beyond the scope of this paper.

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line 15, p. 6676

Below 475 K the descent rates agree well, but from 475 K and up the Match descent is much lower. Please see also the comment above for Referee 1. Reducing our descent at 475 K and above by 60% (estimating Match descent), we get a 10% lower ozone loss rate at 475 K and 9% lower height-integrated ozone loss (63 DU).

line 7, p. 6677

We find that this is quantified in the following sentence (lines 8–10). We will replace the full stop between the sentences with a colon to make this more clear.

Figs. 1 and 4

Of course. (The reason why the plot shows MPV, not PV, is simply that our plotting tool is also meant to be used for other theta levels, and then an MPV scale is preferred).

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 6667, 2004.