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Interactive Comment

Interactive comment on "Testing our understanding of Arctic denitrification using MIPAS-E satellite measurements in winter 2002/3" *by* S. Davies et al.

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We thank the referees for the useful comments made and have updated the manuscript accordingly.

1. MIPAS Version

   The results are very similar to the V4.61/V4.62 versions. All differences are within the random errors associated with and issued with the HNO_3 data product, except for a systematic offset of 14% in the HNO_3 data due to a

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spectroscopic change. This has a negligible effect on the results of this study where it is the relative HNO_3 values which are important (note that the model is initialised with consistent MIPAS HNO_3 data to those used in the results section).

2. Cloud Index.

   We refer the referee to the comments made by Referee 1 to our choice of Cloud Index and our response to these questions. We find that for CI$>$2, there is no measurable effect of PSCs on the retrievals. Uptake of HNO_3 into optically thin PSCs cannot be ruled out but we estimate the effect to be small when compared with the magnitude of the denitrification signal observed.

3. Comparison with the MarkIV balloon.

   We have amended the legend of the plot and adapt the text to more accurately reflect the renitrification. It is clear that the model used here is insufficient to accurately reproduce the renitrification observed by the MarkIV. We would suggest that the Eulerian formulation of the SLIMCAT model is most likely to be the explanation why the observed apparent renitrification is not reproduced. The CLaMS model with its Lagrangian gas phase transport scheme is more able to reproduce this feature (see comment by Grooß).

4. Spatial distribution of denitrification.

   We chose NAT fall speeds in the equilibrium model runs to try to match the magnitude of denitrification in the core of the vortex in late December at the level of interest (460 – 505 K) in the corresponding microphysical model runs (M1 and M2). When these fall speeds are chosen, it is clear that the equilibrium

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model runs overestimate the horizontal extent of denitrification. The vertical distribution of denitrification is also significantly different between microphysical and equilibrium denitrification schemes. Both equilibrium schemes denitrify at higher altitudes than their microphysical counterparts ($\sim$600 K rather than $\sim$500 K). We have not pursued the vertical differences in the denitrification produced by microphysical and equilibrium schemes.

Figure 4 is a timeseries of the 'average' of the model denitrification over the entire vortex (subject to the cloud index and temperature selection criteria) as sampled by MIPAS-E. We agree thet model run E1 appears to fit the magnitude of average denitrification far better that E2. The magnitude of denitrification in the core of the vortex at 465 – 505 K in model run E1, however, is too low when compared with that diagnosed from MIPAS-E which implies that this match is due to a cancellation of errors (weaker denitrification over a wider region of the vortex). Fig 2 shows that model run E2 produces denitrification in the core of the vortex which is comparable to that produced by MIPAS-E. We have included additional detail showing that model run E1 underestimates denitrification in the core of the vortex in the revised manuscript.

The bimodal probablility distribution evident in the microphysical model runs in Figs 5 and 6 is a result of continued denitrification occurring in the "cold closed flow" portion of the polar vortex (see Mann et al., 2003, ACP). Denitrification produced by the equilibrium scheme tends to be distributed over a wider region of the vortex than that produced by the microphysical scheme (see Mann et al., 2002, JGR) since the slow growth of the particles is not resolved — there is an implicit assumption in the equilibrium scheme that the particles immediately grow to their assumed size.

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A weak bi-modality is seen in the MIPAS pdf in Figure 5.

5. Conclusions.

   We have amended the conclusions to more accurately reflect the situation described in point 4 above. The early onset of denitrification in model run E1 is most apparent at 545 K where the significant offset in observed HNO_3 - NO_y^* makes accurate comparisons more difficult. Model run E1, in common with model run E2, actually shows weak renitrification at 505 K, prior to the onset of denitrification.

6. Technical issues

   The technical corrections to the manuscript listed by the referee have been done.

Mann, G.W., Davies, S., Carslaw, K.S., Chipperfield, M.P., Factors controlling Arctic denitrification in cold winters of the 1990s, Atmospheric Chemistry and Physics, 3, 403–416 2003.

Mann, G.W., Davies, S., Carslaw, K.S., Chipperfield, M.P., Kettleborough J.A., Polar vortex concentricity as a controlling factor in Arctic denitrification, Journal of Geophysical Research, 107, 4663, 2002.

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 10997, 2005.