Atmos. Chem. Phys. Discuss., 5, S221–S224, 2005
www.atmos-chem-phys.org/acpd/5/S221/
European Geosciences Union

Atmospheric Chemistry and Physics Discussions

Interactive comment on "3-D microphysical model studies of Arctic denitrification: comparison with observations" *by* S. Davies et al.

S. Davies et al.

Received and published: 23 March 2005

We thank Referee 2 for their positive comments and will update the manuscript accordingly. Our responces to their comments as follows:

General comment

We acknowledge the difficulty of initialising a global 3-D CTM from a long-term model run and limited observations. We feel confident that the intial model NOy inside the vortex is sufficiently accurate in the region of interest (350-600 K) to allow reasonable conclusions to be made about the performance of the model denitrification scheme. The initial NOy in mid-latitudes appears relatively poor by comparison. However, studies by Greenblatt et al (2002) for this winter indicate that the vortex was well isolated from mid-latitudes throught the period of the comparison (January - March).

We partially overcome the difficulty in obtaining realistic initialisation of the model NOy by diagnosing denitrification from NOy - passive NOy rather than NOy - NOy* which removes the dependence on model N2O.

The advent of a new generation of high resolution satellites (ENVISAT and AURA) should allow better initialisation of 3-D model tracers for comparison with observations.

Page 7 Section 3.1.1 para 2: NOy* will be defined.

Page 11 Section 3.1.2 final para: We refer the reviewer to Figure 6d in Davies et al. (2002) which shows the denitrification produced by an equilibrium NAT scheme along the ER-2 flight track of March 11, 2000. The major differences between an equilibrium and kinetic treatment of denitrification are to be found at the edge of the vortex due to the differing times airmasses spend below Tnat (Mann et al. 2002). An equilibrium NAT denitrification scheme produced a significantly more denitrification at the edge of the vortex than the kinetic scheme described in this work although the ER-2 NOy data are not ideal for exploring these differences. A more detailed study of differences between an equilibrium and kinetic denitrification scheme is currently being undertaken for the Arctic winter of 2002/03. The availability of high latitude, high resolution N2O and HNO3 from MIPAS-E aboard ENVISAT will significantly improve our ability to evaluate the performance of a kinetic and equilibrium denitrification scheme throughout the polar vortex. We will include a more detailed discussion of comparisons with previous studies.

Page 19-20, section 4. Heterogeneous nucleation of particles containing NOy due to the presence of remnants of the Pinatubo eruption could theoretically contribute to the discrepancy between the model results in 1994/95 and the other winters. Recent observations by Voigt et al. (2004) have shown that heterogeneous NAT particle nucleation is the most likely mechanism to explain the existence of NAT particles with diameters ˜3 microns in air which has only recently cooled below Tnat although me-

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teoritic debris is proposed as the source. In this model we have not evaluated the potential mechanisms of NAT particle nucleation directly because they are poorly understood. We have shown that the an average NAT particle nucleation rate derived from NAT particle observations from a relatively short period of the ER-2 flight on 20th January 2000 produce denitrification which is in reasonable agreement with observations in 1999/2000 and 1996/97.

We do not think that the role of mountain waves is necessarily more important in the 1994/95 winter but we would be wary of over-interpreting a single balloon profile of denitrification, especially when the flight occurred close to the Scandinavian mountains and there was a significant possibility of ice PSCs along the back trajectory.

The factor of 4 increase in nucleation rate is interesting. The nucleation ratewas derived from ER-2 observations on 20th January 2000, by which time, the vortex was highly denitrified. The nucleation rate derived by by Voigt et al. (2004) for the 2002/03 Arctic winter is close to the higher value quoted here.

Any typographical errors will be corrected.

Other errors which I would like to correct before publication in ACP:

a) p348, line 18, "although the lack of observations north of 67N make it difficult ..." should be more precisely "although the lack of observations north of 67N in the beginning of February make it difficult ..."

b) Fig. 13a should be 11 February rather than 25 February and the error identified above will also be corrected.

Davies, S et al., Modeling the effect of denitrification on Arctic ozone depletion during winter 1999/2000, J. Geophys. Res., 107, 8322, doi.10.1029/2001JD000445, 2002

Greenblatt, J.B. et al., Tracer-based determination of vortex descent in the 199-2000 Arctic winter, J. Geophys. Res., 107, 8279, doi:10.1029/2001JD000937, 2002

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Interactive Comment

Mann, G.W. et al., Polar vortex concentricity as a controlling factor in Arctic denitrification, J. Geophys. Res., 107, 4663, doi:10.1029/2002JD002102, 2002

Voigt, C. et al., Nitric acid trihydrate (NAT) formation at low NAT supersaturations, Atmos. Chem. Phys., 4, 8579-8607, 2004

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