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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Factors controlling Arctic denitrification in cold winters of the 1990s" *by* G. W. Mann et al.

**G. W. Mann et al.**

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> Comments on "Factors controlling Arctic denitrification in cold winters
> of the 1990s" by G. W. Mann et al.
>
> 1) Interactive comment by D. Fahey
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> This paper would be improved by adding a discussion about how
> denitrification as observed compares to the simulations in the years other
> than 1999/2000. For example, the Waibel paper (Science, 1999) shows
> significant denitrification from a balloon profile in Feb 1995. If no
> observations are available or used, judgement of the value of the
> conclusions remains in limbo until such a comparison can be made for
> another variable set of winters. For example, if the model simulations

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> compare poorly to the observed denitrification, then perhaps it is the
> variation in nucleation rate with meteorological factors etc. that
> controls the intensity instead of the closed flow area.

We have added sentences which summarise initial comparisons between data from the MIPAS-B balloon (1994/5) and the ILAS NOy instrument (1996/7) in the relevant winter section. We have also added a more general statement in the overview section which outlines the general comparison between the model and measurements of denitrification from these winters. It should be noted that we are also preparing a separate paper to describe these comparisons in much more detail (Davies et al, in preparation).

> A helpful addition to the paper would be comments or analysis concerning
> how the simulation denitrification amounts would scale with the assumed
> constant value of the nucleation rate. This may help the study "age well"
> if we learn/deduce in the future that the effective rate is not constant
> or has a different value.

This is a good point also. We have inserted an extra figure to illustrate the sensitivity of the modelled denitrification to the assumed constant value of the nucleation rate. The following discussion has also been added at the end of the 1999/2000 winter section:

To investigate the sensitivity of the modelled denitrification to the value of the assumed constant nucleation rate (and hence the particle number density), we have repeated the 1999/2000 winter simulations with the nucleation rate increased and decreased by a factor of 5. Figure 2 shows model profiles of vortex-mean and vortex-minimum HNO3 profiles from January 20, 2000 for these 2 simulations. For the run with the nucleation rate increased by a factor of 5 (the red line in Figures 2 a and b), minimum total nitric acid concentrations are below 1 ppbv at all levels between 430K and 560K and the vortex average denitrification/nitrification is significantly higher. The higher nucleation rate results in higher number densities (around $10^{-3}$ per $cm^3$) and slightly reduced radii due to the competition for available HNO3. However, Figure 2 shows that despite this



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slight decrease in particle radius, the denitrification is still increased by the increase in nucleation rate. This result is broadly in agreement with the 1-D model calculations of Jensen et al. (2003).

When the nucleation rate is decreased by a factor of five (the blue line), the mean denitrification is reduced by about 50%. From this sensitivity simulation, we conclude the the NAT particle number densities and sizes observed in the January 2000 vortex (Fahey et al., 2001) are sufficient to almost reduce HNO3 concentrations to the minimum possible. Increases in number density lead to only a small increase in the magnitude of denitrification. On the other hand, decreases in number density lead to significant reductions in the magnitude of denitrification. This sensitivity to number density (and therefore to volume average nucleation rate) makese it important to determine a physical explanation for the NAT particles observed.

> The Northway et al. flux paper (GRL, 2002b) is in the reference list but
> does not seem to be cited. One point of comparison with the simulations
> that it affords is with the instantaneous flux values in 1999/2000 and
> limits in these values.

This provides an opportunity for a comparison between particle flux values predicted by the model with the values inferred from the measurements of the NOy instrument aboard the ER-2 in 1999/2000. We have added the following sentence describing how well the calculated model HNO3 fluxes compare with the values reported in Northway et al. (2002b):

Calculated mean and maximum values of downward HNO3 flux for 20th January 2000 are around $1 \times 10^9$ and $9 \times 10^9$ molecules per cm$^3$ km per day, which compares well with the value reported by Northway et al. (2002b) of $5 \times 10^9$ molecules per cm$^3$ km per day for that day along the ER-2 flight track.

We have also added an extra sentence to Appendix B describing how these HNO3 flux values are converted to molecules per cm$^3$ km per day.

> It is perhaps worth adding the caveat that the composition phase of the
> particles observed in 1999/2000 is inferred to be NAT rather than
> measured.

We have revised statements in the introduction section to include this caveat.

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