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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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> Interactive comment on "Factors controlling Arctic denitrification in cold
> winters of the 1990s" by G. W. Mann et al.
>
> Anonymous Referee 2
>
> General comments
>
> The manuscript presents 3D Lagrangian simulations of denitrification with
> a particle model for four cold arctic winters of the 1990s. It focuses on
> the meteorological factors determining the denitrification. They are
> recognized as the extent, depth and concentricity of the cold pool and
> vortex. A definition for a "closed area flow" as a principal

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> meteorological influence is proposed. I regard this paper as a worthy
> contribution for ACP and recommend publication after consideration of the
> comments below:
>
> Specific comments:
>
> 1) p. 2558, l.14: Here you mention that the closed flow area applies for
> air trajectories. This should be repeated when you introduce the
> definition of the closed flow area in the plain text (Section 4.2) instead
> of using the misleading particle trajectories (p. 2568, l. 19 25)

We have clarified the section as suggested.

> 2) p. 2561, l. 1-3: it would be good to write "In one case study, using a
> highly idealized approach, we show ..." because in your case study the
> flow was unbalanced (i.e. not realistic).

Added.

> 3) p. 2562, l. 18: "as was observed in Jan to Mar 2000 (Northway et al.,
> 2002)". If you mean Northway et al. 2002a, their Figure 6 and plate 2 are
> in contradiction with your citation (their data showed significant
> temporal and spatial variability).

By saying that the particles "become well distributed though the vortex" we do not mean that the particles necessarily become evenly distributed. In fact it is worth noting that the particle size distributions in both size and number density are not homogeneous even with this constant volume-averaged nucleation rate. The large heterogeneities are caused by the meterological processes which we are describing in this paper. A sentence stating this has been added.

> 4) p. 2567 l. 13-14: I recommend to repeat at this place the uncertain

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> role of the nucleation of the particles.

Added.

> 5) p. 2569, l. 16: do you consider the mean of the full simulation height
> range or do you just fix an isentropic level? Please clarify.
>
> 6) Figure 8: I guess you could easily get rid of the first (and possibly
> most important) factor causing the large scatter in the plot by showing a
> mean relative denitrification rate instead. That is dividing the mean
> denitrification rate by a similar mean of the available gas phase HNO3.
> Further, the normalized denitrification [% per m per s], by comparison
> with your original Figure, becomes a mean to qualitatively assess the
> effect of this thermodynamic equilibrium factor.

In the original figure we took the mean of the absolute denitrification rate over the height range where there is a non-zero NAT region (and there is no re-nitrification). In response to your comments 5 and 6 we have changed Figure 8 to show the mean normalized denitrification rate in % per day (as calculated in Appendix B) and we have also taken the mean of the closed flow fraction and the mean normalized denitrification rate over all levels between 350 and 600K except for those which are net renitrifying (the red areas in panel f of Figures 1,3,4,5).

> 7) Figure 8: as a suggestion, I recommend to add a sensitivity study of
> the time shift would have been welcome as elsewhere you underline the
> crucial role of the time available for particle growth. You show the
> correlation only for a 3 days shift, but in the text you mention 8 days as
> an optimum for denitrification.

We had carried out a sensitivity study for the size of this time lag and found that 3 days seems to be the optimum value. If no time lag was used then it was clear from looking carefully at the values in Figure 8 (now Figure 9) that the system required some time to

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be react to the change in closed flow fraction. In idealised model runs with a constant forcing wind and temperature field in Mann et al, 2002, "Polar vortex concentricity as a controlling factor in Arctic denitrification", it was found that there was no denitrification for the first 1 or 2 days and only after around 3 days would the denitrification "get going". This adds further backing to the need to use a time lag in the scatter plot. Ultimately however, such a time lag is rather a crude attempt to improve the correlation. As Figures 1,3,4 and 5 show, the denitrification rate is in fact "tilted" in altitude-time space, so a simple mean (which is vertical in altitude-time space) will not produce a perfect correlation.

> Technical corrections:
>
> p. 2559, l.14 : "to answer directly this question" woudl be more precise
> than "to answer this question"

Changed as suggested.

> p. 2559, l.23: Which winters are meant?

The winters referred to in each paper have now been specified.

> p. 2562, l.16: the quotation of Fueglistaler et al. is not listed in the
> references.

Added

> p. 2563, l.25: the descent can be seen in all winters

Added "and all" between "this" and "winter"

> p. 2564, l. 4: "to carred out" should read "to be carried out"

This line has been modified to flag that a paper is coming out on this topic.

> p. 2564, l.10: "mid winter" should read "early winter"

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Changed

> p. 2565, l.26: "Fig 3b" should read "Fig 3c"

Changed

> p. 2567, l. 5: "winter 1996/97" should read "winters 1995/96 and 1996/7".
> The end of the paragraph should then be adapted.

Done.

> Figure 6: negative denitrification mean (re)nitrification ?

This is clarified in the opening section to the "Winter-long denitrification simulations"

> p. 2568, l. 2: I gauge the "significant" reduction in mean radius as
> exaggerated.

We have replace "significantly" with "noticeably".

> Following technical corrections rely on the Web of Science
>
> p. 2574, l.20: "18800" should read "1880".
> p. 2575, l.11: "aerosols" should read "aerosol"
> p. 2575, l.12: "winters" should read "Winters"
> p. 2576, l.15: "during winter" should read "during the winter"
> p. 2577, l. 9: "differences" should read "variations".
>

All done

Interactive comment on Atmos. Chem. Phys. Discuss., 2, 2557, 2002.