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Interactive Comment

Interactive comment on "Implementing growth and sedimentation of NAT particles in a global Eulerian model" *by* M. M. P. van den Broek et al.

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We thank referee#2 for the clear and succinct review of our paper entitled Implementing growth and sedimentation of NAT particles in a global Eulerian model. In this reply we address the main points and queries raised by the referee, which are listed below:

i) Denitrification:

The 10-day simulation periods chosen for this study were selected so that comparisons could be made directly with a previous Lagrangian model study from which the microphysical parametrization of our algorithm was taken (see Carslaw et al., 2002). Particle observations have been made during the time periods we studied here (Fahey et al., 2001; Northway et al, 2002), which have also been compared to our results. However, regarding (de)nitrification, we agree with the referee that the validation of the extent and coverage of the denitrification simulated by our algorithms should be done

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by comparing the results against a more extensive set of observations. Our future goal is to perform simulations over entire winters using a full stratospheric chemistry scheme, including heterogeneous chemistry on STS droplets. Currently, we are focusing our efforts into performing such runs for a number of different Arctic winters. For this we will initialize with realistic HNO3 fields, which will allow more meaningful comparisons to be made with field observations.

ii) Dependence on total NAT number density:

We agree with the referee that the performance of both approaches seems to be dependent on the total NAT particle number density prescribed in the model. The referee suggests that we attempt to elucidate a total number density which can accurately simulate denitrification over timescales ranging from 10 days through to the entire winter. However, we feel that this is beyond the scope of this paper and feel that such a number could only be derived upon conducting a statistical analysis of the measurements of NAT made during campaigns such as the one which occurred in the 1999/2000 winter (see Fahey et al., 2001), but then performed throughout the whole winter covering a representive vertical and horizontal area. Such observations have not yet been performed. Attempting to elucidate it using a global CTM could introduce unwanted bias into simulating PSC formation and is thus no satisfactory alternative. Both the particle number density and the average radii of NAT are critically dependent on the temperature history of a particular airmass (i.e. the longer the temperature is below TNAT the larger the particles and the greater the denitrification). Given that the temperatures within the Arctic Vortex are variable from year to year (Manney and Sabutis, 2000) determining a single fixed number density which covers all possible scenarios may not be possible unless one can relate it to a physical parameter such a temperature. This problem is inherent throughout all stratospheric models designed to predict the influence of PSCs. Moreover, our results suggest that the algorithm introduced here is still a marked improvement on the equilibrium approach used in most other global models.

For future climate predictions we can artificially increase important parameters (e.g.

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$[H_2O]$) and examine whether such a perturbation would result in an increased amount of denitrification. A comment was made regarding whether a production rate is used in the model. This is implicitly included into the model by instantaneously filling the bin once the temperature or the saturated vapor pressure criteria have been exceeded, and further by ensuring that the first size bin (i.e. the production bin) is never empty as long as these criteria are met. The rate of particle nucleation and the way this occurs, are still the subject of debate in microphysical science community. For this reason we did not prescribe a fixed rate but allowed the model to determine whether new particles should form according to available precursors and atmospheric conditions, as we have been advised by some microphysists. Once a realistic nucleation rate or a parametrization is available we will incorporate this new information in our algorithms.

III) Constant initial HNO_3 and water profile

The profiles were chosen to be equal to those used in the previous Lagrangian modeling study, which acted as a benchmark with which to compare our results. Moreover, these were considered averages representative of the $[HNO_3]$ and $[H_2O]$ resident in the Arctic vortex during a typical winter. Therefore, this profile implicitly takes account of the HNO_3 scavenged in STS droplets (which form at a higher temperature than the NAT particles discussed here).

IV) Typographical errors

All typographical errors highlighted by the referee have been amended in the final draft

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Interactive comment on Atmos. Chem. Phys. Discuss., 4, 3089, 2004.