Atmospheric Chemistry and Physics Discussions

Interactive comment on "Nitric acid partitioning in cirrus clouds: a synopsis based on field, laboratory and model studies" *by* M. Krämer et al.

M. Krämer et al.

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Reply to Referee 2:

General comment:

At first, I want to thank both referees for their helpful suggestions. Following their recommendations, I have vastly revised the manuscript.
The major changes are:

- The part of the manuscript dealing with the coverages of ice surfaces with nitric acid is removed from the manuscript and maybe submitted as an extra publication.

- The part on the partitioning of nitric acid between the gas phase, interstitial and

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ice particles is expanded. Ammonia containing particles are considered for the field experiments; additional model sensitivity studies on the dependence of the partitioning on the initial nitric acid content and the in-cloud RH_{ice} are included.

- Because of the large changes of the manuscript, I also have changed the title to:

  'Nitric acid partitioning in cirrus clouds and the role of interstitial aerosol'

Reply to the specific comments:

- **1)** The 'general picture' is cancelled from the manuscript.

- **2)** Altitude, ozone and pot. temperature are added to Table 3.
  Read new section 3.1, page 4, left column:

  'During POLSTAR 1998, two cirrus events were encountered at the flight from Kiruna to Stockholm on January 26 in 1998. The measurements of H_2O and O_3 (see Table 3) indicate upper tropospheric air: H_2O with 20–40ppm is larger than the stratospheric value of about 5ppm and O_3 showing values up to at most 200ppb is smaller than in the stratosphere. Both clouds are cold, thin cirrus with a low water content and small ice crystals. The same type of clouds was detected during POLSTAR 1997 (see *Meilinger et al.,* 1999).'

- **3)** This error was removed from the manuscript...

- **4)** See new section 2.1.1, page 2, right column: A reference is now given for the sampling characteristics of the inlet: Krmer and Afchine, 2003.
  80% uncertainty means +/-80%.
  The results of the erros propagation are shown in Table 3 and Figure 3.

- **5)** A clearer explanation is given in the new section 2.1.2, page 3, left column.

  'HNO_3^{gas} was sampled with a forward pointing inlet. Therefore, HNO_3 from evaporating particles might contaminate the HNO_3^{gas} signal, especially inside a cirrus: in case of strong contamination with HNO_3 from particles, a sudden increase of

the HNO_3^{gas} signal should be seen when a cirrus cloud is penetrated because ice particles are sampled with an enhancement factor of 4.5. This is not the case, as can be seen from Figure 1 (upper panel), where HNO_3^{gas} is shown as green curve and the signal of HNO_3^{ice} –enhanced by a factor of 140– in red. This finding is consequent, because even with the enhancement factor of 4.5 of the HNO_3^{gas} inlet the signal from particles show values much lower than the signal from the gas phase. Therefore, we conclude that the error in the HNO_3^{gas} measurement caused by evaporating particles is small compared to the large uncertainty mentioned above.'

- **6)** The data points are included in Figure 1, lower left and right panel. The factor of +/-2 is included in the error propagation shown in in Table 3 and Figure 3.

- **7)** Sensitivity studies are performed for $HNO_3 - H_2SO_4 - H_2O$ as well as $HNO_3 - H_2SO_4 - H_2O - NH_3$ solution particles.
  Read new section 3.2, page 5 ff, see new Figure 2.

- **8)** See answers to Points 6 and 2.

- **9)** The statements on the 'competition' are hopefully more clear now, read especially section 3.2.3. page 5, last paragraph - page 6, first paragraph:

  ' ... The amount of remaining HNO_3 available for capture on the ice surface is now determined by the current RH_{ice}, temperature and particle composition. At a high value of RH_{ice}, competition can take place between the processes taking care for equilibrium conditions with the ice surface at the one hand and the interstitial particles on the other hand, similar to the Bergeron-Findeisen process known for water.'

- **10) - 13)** are concerned with the cancelled part of the manuscript.

- **14**) Table 1: the unit means the cutoff size of the particle probe (as indicated in the Figure caption now) and should be nm.

- **Ov**erall comment: I followed this comment and hope that the manuscript is more convincing in its present form.

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