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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Airborne measurements of the nitric acid partitioning in persistent contrails" *by* D. Schäuble et al.

D. Schäuble et al.

dominik.schaeuble@dlr.de

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We would like to thank the referee for his/her valuable comments.

Sedimentation:
On 24 and 29 November 2006 the measurements were made in the upper region of frontal cirrus according to ECMWF analyses. These are the data at temperatures below 220 K. We argue that sedimentation of large ice crystals out of this region results in relatively small ice water contents when compared to the ice water content climatology by Schiller et al. (2008). On 28 November the cirrus was penetrated deeper at temperatures above 220 K. Measurements near the center of the cirrus cloud yield ice water contents comparable to those in the Schiller-climatology.

The HNO_3/H_2O molar ratios of large ice crystals are dominated by the uptake of HNO_3 and H_2O from the gas phase. The low HNO_3/H_2O molar ratios can be explained by small gas phase concentrations of HNO_3 during particle growth and subsequent sedimentation of these ice crystals into the measurement region. The μ data are still captured by the lower limit of trapping estimated in Kärcher and Voigt (2006). We integrated this explanation in section 4.

Small ice crystals:
Even at temperatures around 215 K and background HNO_3 partial pressures, the HNO_3/H_2O molar ratios in the freezing aerosol particles may reach several parts per thousand when ammonium is present in the aerosol. Several of the cirrus clouds with high HNO_3/H_2O molar ratios (around T = 215 K) have small mean ice particle diameters which still may be influenced by the aerosol composition in terms of the HNO_3/H_2O molar ratios. However, the majority of the cirrus with high HNO_3/H_2O molar ratios probably trapped large amounts of nitric acid due to high HNO_3 partial pressures and low temperatures during particle growth.

Thin ice clouds:
If the thin ice clouds ($0.1\,mg\,m^{-3} < IWC < 0.25\,mg\,m^{-3}$) are removed from the IWC analyses, the mean IWCs (black squares) shown in Fig. 2 (bottom panel) increase for temperatures below 220 K. The maximum relative change is 34 % for the mean of the IWC bin centered at T = 217 K ($1.31\,mg\,m^{-3} \rightarrow 1.75\,mg\,m^{-3}$). A comparison with the IWC climatology by Schiller et al. (2008), IWC(T=217 K) = $3.4\,mg\,m^{-3}$, illustrates that the integration of the thin ice clouds results in a minor change of the IWC. The ice clouds with $0.1\,mg\,m^{-3} < IWC < 0.25\,mg\,m^{-3}$ were measured as identified from a combined increase in IWC and FSSP data, therefore we would like to include cirrus with such low ice water content.

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Figure 1:
Figure 1 was enlarged in the vertical to make it clearer. We show the whole flight to point out that extended cirrus clouds were sampled and several contrails were encountered during the flight on 24 November. In addition, the reader can estimate the mean and the variability of the different measured quantities during the flight.

References

Kärcher, B. and Voigt, C.: Formation of nitric acid/water ice particles in cirrus clouds, Geophys. Res. Lett., 33, L08806, 2006.

Schiller, C., Krämer, M., Afchine, A., Spelten, N., and Sitnikov, N.: Ice water content of Arctic, midlatitude, and tropical cirrus, J. Geophys. Res., 113, D24208, 2008.

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