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Uptake of nitric acid in cirrus clouds and contrails

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The uptake of nitric acid (HNO3) in cirrus clouds and contrails in the upper troposphere leads to a reduction of the gas phase NOx (=NO+NO2) concentration, resulting in a perturbation of the ozone budget within this region. During the CIRRUS-III campaign over Northern Germany in November 2006 aircraft-based measurements of gas- and condensed-phase reactive nitrogen species (NOy), water vapour, total water, and ice particle size distribution were performed to investigate the uptake of HNO3 in midlatitude cirrus clouds at altitudes between 8 and 12km. Contrails and cirrus clouds were frequently encountered in the course of this campaign. Contrails were identified by the detection of ice crystals in combination with enhanced gas phase NOy and condensation nuclei concentrations resulting from the aircraft exhaust. This method allows to unambiguously identify contrails and to separate contrails and natural cirrus clouds. The HNO3/H2O molar ratio in ice crystals and the particulate fraction of the total nitric acid (HNO3_part/HNO3_tot) were evaluated to quantify the uptake of nitric acid in ice clouds. We show the dependence of these two parameters on temperature, partial pressure of HNO3, and ice water content in the temperature range of 210 to 231K and at nitric acid partial pressures between about 1e-8 and 1.2e-7hPa. Further, we compare our data to previous observations in midlatitude clouds. Finally, differences in the chemical composition and trace gas uptake in natural and aviation-induced ice clouds will be discussed.