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Supersaturation, dehydration, and denitrification in Arctic cirrus

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Abstract. A polar cirrus case study is discussed with the help of a one-dimensional model with explicit aerosol and ice microphysics. It is demonstrated that continuous cooling of air in regions with small amounts of ice and slow ice deposition rates of water vapor drives significant in-cloud supersaturations over ice, with potentially important consequences for heterogeneous halogen activation. Radiatively important cloud properties such as ice crystal size distributions are investigated, showing the presence of high number concentrations of small crystals in the cloud top region at the tropopause, broad but highly variable size spectra in the cloud interior, and mostly large crystals at the cloud base. It is found that weakly forced Arctic cirrostratus are highly efficient at dehydrating upper tropospheric air. Estimating nitric acid uptake in cirrus with an unprecedented treatment of diffusion-limited trapping in growing ice crystals suggests that such clouds could also denitrify upper tropospheric air masses efficiently, but a closer comparison to suitable observations is needed to draw a definite conclusion on this point. It is also shown that low temperatures, high ice supersaturations, and the absence of ice above but close to the cloud top region cause efficient uptake of nitric acid in background aerosol particles.

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