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Denitrification in Arctic winter 2009/10: Study on shape and morphology of large dimension HNO_3-containing particles

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Flights of the high altitude aircraft M55 Geophysica in January 2010 during the RECONCILE campaign (Reconciliation of essential process parameters for an enhanced predictability of Arctic stratospheric ozone loss and its climate interactions) allowed probing polar stratospheric clouds inside the Arctic polar vortex with in situ instruments. Measurements by the Forward Scattering Spectrometer Probe model 100 (FSSP-100) frequently indicated large dimension potentially HNO_3-containing particles with maximum sizes around 30 μm in diameter when data processing was carried out assuming spherical particles. Such large particles can hardly be reconciled with current theory of nucleation and growth of HNO_3-containing particles capable of denitrification (i.e. Nitric Acid Trihydrate (NAT)) when assuming spherical shape and compact morphology.

We try to solve this issue by applying Chemical Transport Modelling with CLaMS (Chemical Lagrangian Model of the Stratosphere) and infrared remote sensing measurements from MIPAS-STR (Michelson Interferometer for Passive Atmospheric Sounding-STRatospheric aircraft) aboard the Geophysica aircraft to test the impact of alternative particle morphology and shape on HNO_3 redistribution. Alternative particle morphologies and shapes result in reduced particle sedimentation speeds compared to mass equivalent spherical particles and therefore in modified vertical redistribution patterns of HNO_3.

Assuming denitrification by particles composed of NAT, our study indicates that spherical “flake-like” particles with low mass density are unlikely to cause the observed denitrification. The assumption of aspheric particles (i.e. platelets or needles) with moderate aspect ratios is supported by our findings and offers an explanation for the particle sizes that have been derived from the in situ particle measurements. Reduced particle sedimentation speed through aspheric particle shape significantly influences denitrification efficiency. Consideration of this aspect therefore can improve chemical transport and climate chemistry modelling.