Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 6, 3149-3161, 2006
www.atmos-chem-phys.net/6/3149/2006/

Testing our understanding of Arctic denitrification using MIPAS-E satellite measurements in winter 2002/2003

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Abstract. Observations of gas-phase HNO_3 and N_2O in the polar stratosphere from the Michelson Interferometer for Passive Atmospheric Sounding aboard the ENVISAT satellite (MIPAS-E) were made during the cold Arctic winter of 2002/2003. Vortex temperatures were unusually low in early winter and remained favourable for polar stratospheric cloud formation and denitrification until mid-January. MIPAS-E observations provide the first dataset with sufficient coverage of the polar vortex in mid-winter which enables a reasonable estimate of the timing of onset and spatial distribution of denitrification of the Arctic lower stratosphere to be performed. We use the observations from MIPAS-E to test the evolution of denitrification in the DLAPSE (Denitrification by Lagrangian Particle Sedimentation) microphysical denitrification model coupled to the SLIMCAT chemical transport model. In addition, the predicted denitrification from a simple equilibrium nitric acid trihydrate-based scheme is also compared with MIPAS-E. Modelled denitrification is compared with in-vortex NO_y and N_2O observations from the balloon-borne MarkIV interferometer in mid-December. Denitrification was clearly observed by MIPAS-E in mid-December 2002 and reached 80% in the core of the vortex by early January 2003. The DLAPSE model is broadly able to capture both the timing of onset and the spatial distribution of the observed denitrification. A simple thermodynamic equilibrium scheme is able to reproduce the observed denitrification in the core of the vortex but overestimates denitrification closer to the vortex edge. This study also suggests that the onset of denitrification in simple thermodynamic schemes may be earlier than in the MIPAS-E observations.

Final Revised Paper (PDF, 2218 KB) Discussion Paper (ACPD)

Citation: Davies, S., Mann, G. W., Carslaw, K. S., Chipperfield, M. P., Remedios, J. J., Allen, G., Waterfall, A. M., Spang, R., and Toon, G. C.: Testing our understanding of Arctic denitrification using MIPAS-E satellite measurements in winter 2002/2003, Atmos. Chem. Phys., 6, 3149-3161,

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