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

S. Davies¹, G. W. Mann¹, K. S. Carslaw¹, M. P. Chipperfield¹, J. J. Remedios², G. Allen³, A. M. Waterfall⁴, R. Spang⁵, and G. C. Toon⁶¹Institute for Atmospheric Science, School of Earth and Environment, University of Leeds, UK²Earth Observation Science, Space Research Centre, University of Leicester, UK³School of Earth, Atmospheric and Atmospheric Sciences, University of Manchester, UK⁴Rutherford Appleton Laboratory, Chilton, Didcot, UK⁵Institut 1: Stratosphäre: Forschungszentrum Juelich, 52 425, Juelich, Germany⁶Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

Abstract. Observations of gas-phase HNO₃ and N₂O 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 N₂O 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.

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