MLS Scientific Publication

Scientific Theme: Atmospheric Chemistry

3D microphysical model studies of Arctic denitrification: Comparison with observations, S. Davies, G.W. Mann, K.S. Carslaw, M.P. Chipperfield, J.A. Kettleborough, M.L. Santee, H. Oelhaf, G. Wetzel, Y. Sasano, and T. Sugita, *Atmos. Chem. Phys.*, **5**, 3093–3109, 2005.

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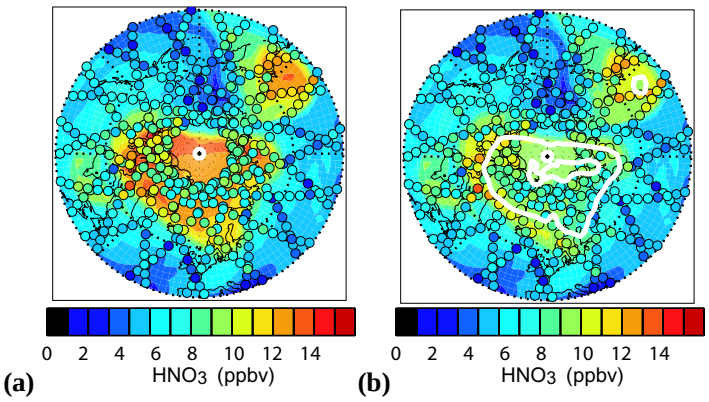
Summary

Simulations of denitrification using a novel chemistry-microphysics transport model are compared to observations obtained during three recent cold Arctic winters. The Denitrification by Lagrangian Particle Sedimentation (DLAPSE) model couples the full-chemistry SLIMCAT chemical transport model with a nitric acid trihydrate (NAT) particle growth and sedimentation scheme to explore the mechanisms by which denitrification occurs. Prior to this study, the most thorough comparison of a denitrification model with observations was limited to a single balloon flight. Here we compare model results with measurements made during the winters of 1994/1995, 1996/1997, and 1999/2000 by the Upper Atmosphere Research Satellite (UARS) Microwave Limb Sounder (MLS) and Improved Limb Atmospheric Sounder (ILAS) satellite instruments, the Michelsen Interferometer for Passive Atmospheric Sounding (MIPAS-B) balloon-borne instrument, and an NO_y in situ instrument flown aboard the ER-2. The simple NAT nucleation scheme employed in DLAPSE/SLIMCAT, whereby NAT particles are assumed to form at a constant rate in all air with temperatures below the NAT threshold, reproduces many aspects of the observed denitrification, although the degree of interannual variability in the magnitude of denitrification is not captured in the model. These comparisons suggest that a NAT-only denitrification scheme is a viable mechanism to explain the observed Arctic denitrification, in contrast to previous studies rejecting NAT nucleation and sedimentation as the cause of denitrification and asserting the necessity of an ice-mediated process. This study was hampered by the lack of frequent high-resolution measurements during critical periods in each of these years, limiting our ability to unambiguously diagnose the timing and extent of denitrification. New data from the next generation of satellites, including Aura, will provide invaluable additional data for testing model representations of NAT nucleation mechanisms. It is essential that these processes be modelled accurately if we are to predict the future stability of the stratospheric ozone layer with any confidence.



Contour plots of (a) modelled "passive" HNO_3 (i.e., from a control run without denitrification) and (b) modelled HNO_3, at 68 hPa on 14 February 1995. The model output has been smoothed using the UARS MLS averaging kernel. Version 6 UARS MLS HNO_3 data are shown by the overlaid filled circles. The white contour indicates the region in which smoothed model denitrification exceeds 3 ppbv. The passive model run significantly overestimates HNO_3 in the vortex core, whereas the denitrified run matches the observations reasonably well.