MLS Scientific Publication

Scientific Theme: Atmospheric Chemistry

Three-dimensional structure and evolution of stratospheric HNO_3 based on UARS Microwave Limb Sounder measurements, M.L. Santee, G.L. Manney, N.J. Livesey, and W.G. Read, *J. Geophys. Res.*, **109**, D15306, doi:10.1029/2004JD004578, 2004.

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Summary

Nitric acid (HNO_3) plays several pivotal roles in the processes controlling stratospheric ozone depletion. By far the most complete observational record has been obtained by the Microwave Limb Sounder (MLS) onboard the Upper Atmosphere Research Satellite (UARS), which measured the global distribution of stratospheric HNO_3 over annual cycles for much of the 1990s, albeit with reduced sampling frequency in the latter half of the decade. Here we present an overview of the seasonal, interhemispheric, and interannual variations in the distribution of HNO_3 throughout the lower and middle stratosphere from 420 to 960 K potential temperature based on the UARS MLS version 6 HNO_3 measurements. Version 6 data have much better precision and a larger vertical range than previous MLS HNO_3 datasets, and have also been corrected to account for an oversight in the retrieval algorithms that led earlier versions to overestimate HNO_3 abundances by as much as 35% at some levels in the stratosphere. We examine time series of different slices through the data to develop a comprehensive picture of the mean evolution of stratospheric HNO_3 during the UARS timeframe, and seasonal "snapshots" illustrate the typical behavior of HNO_3 during several intervals of particular interest in the annual cycle. Composite fields are derived by averaging together the results for individual years.

HNO_3 exhibits little vertical, seasonal, or interannual variability in the tropics. For the first $\sim$1.5 years of the mission, however, a persistent enhancement is seen at low and midlatitudes that we attribute to perturbations in reactive nitrogen chemistry under conditions of high aerosol loading from the eruption of Mount Pinatubo. HNO_3 abundances increase towards the pole in both hemispheres at all levels and in all seasons, with the exception of the severely-denitrified region inside the Antarctic vortex. A pronounced seasonal cycle is present at middle and high latitudes up to at least 960 K ($\sim$34 km), with a winter maximum and a summer minimum. Large interannual variability in the timing, magnitude, and duration of enhanced wintertime HNO_3 abundances is seen in both hemispheres. Even in the coldest Arctic winters, HNO_3 depletion is modest and limited in both horizontal and vertical extent. In contrast, virtually complete removal of gas-phase HNO_3 occurs at the highest southern latitudes by July in every year throughout the lower stratosphere. Indications of denitrification are present up to at least 740 K, well above the highest altitude at which dehydration is observed, providing further evidence that denitrification can proceed in the absence of dehydration. This climatology of stratospheric HNO_3 based on UARS MLS data provides a valuable baseline for comparison with observations expected from NASA's Earth Observing System (EOS) Aura mission.

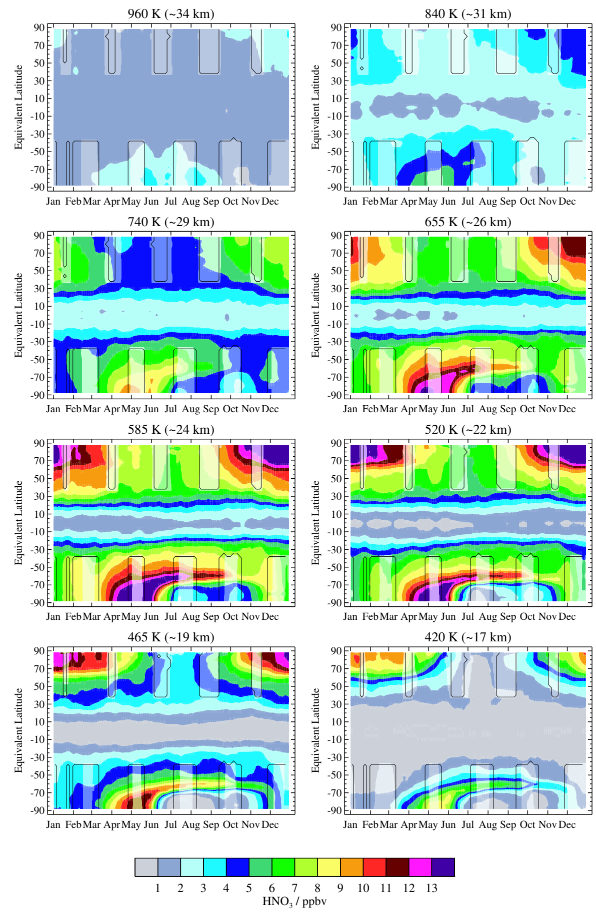

Figure 2. Composite MLS HNO_3 fields derived by averaging together results for 7 individual years at each level. To fill in data gaps, Kalman smoothing has been applied to the averaged HNO_3 values at each level; paler colors denote the regions in which no MLS data are available. Black contours delimit the regions in which data from fewer than 3 distinct years contributed to the averaged values.