Geophysical Research Abstracts, Vol. 7, 04397, 2005
SRef-ID: 1607-7962/gra/EGU05-A-04397

Simulation of denitrification and ozone loss for the Arctic winter 2002/03

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Simulations with the Chemical Lagrangian Model of the Stratosphere (CLaMS) are presented for the Arctic winter 2002/2003. We integrated a Lagrangian denitrification scheme into the three-dimensional version of CLaMS that calculates the growth and sedimentation of nitric acid trihydrate (NAT) particles along individual particle trajectories. From those, we derive the HNO_3 downward flux resulting from different particle nucleation assumptions. The simulation results show a clear vertical redistribution of total inorganic nitrogen (NO_y), with a maximum vortex average permanent NO_y removal of over 5 ppb in late December between 500 and 550 K and a corresponding increase of NO_y of over 2 ppb below about 450 K. The simulated vertical redistribution of NO_y is compared with balloon observations by MkIV and in-situ observations from the high altitude aircraft Geophysica. Assuming a globally uniform NAT particle nucleation rate of $3.4{\cdot}10^{-6}$ cm^{-3} h^{-1} in the model, the observed denitrification is well reproduced.

In the investigated winter 2002/2003, the denitrification has only moderate impact ($\leq$10%) on the simulated vortex average ozone loss of about 1.1 ppm near the 460 K level. At higher altitudes, above 600 K potential temperature, the simulations show significant ozone depletion through NO_x-catalytic cycles due to the unusual early exposure of vortex air to sunlight.