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Analysis of polar stratospheric cloud (PSC) composition from infrared limb observations by the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS)

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To improve models of future ozone loss it is necessary to answer still open questions regarding nucleation processes of nitric acid containing solid polar stratospheric cloud (PSC) particles. The mid-infrared limb-emission sounder Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) on Envisat is the first instrument able to monitor continuously the development of PSC appearance and composition with full coverage of the polar regions even during polar night.

We have analyzed MIPAS observations during the Antarctic winter 2003 with respect to PSC composition. Coincident lidar observations from McMurdo were used for comparison. By application of new refractive index data we could indentify a distinct spectral signature of PSCs at around 820 cm^{-1} as observed by MIPAS as the ν_2-band of NO_3^- of NAT. This assignment is supported by spectral fits over a broad region in the mid-IR. This has been the first evidence for the existence of NAT PSCs on a large scale. MIPAS infrared spectra collocated with Lidar observations of Type 1b and Type 2 PSCs could only be reproduced by assuming a composition of supercooled ternary $H_2SO_4/HNO_3/H_2O$ solution (STS) and of ice, respectively. Particle radius and number density profiles derived from MIPAS were generally consistent with the lidar observations. Only in the case of ice clouds, PSC volumes are underestimated due to large cloud optical thickness in the limb-direction. A comparison of MIPAS cloud composition and lidar PSC-type determination based on all available MIPAS-lidar coincident measurements revealed good agreement between PSC-types 1a, 1b and 2, and NAT, STS and ice, respectively. We could not find indications for the presence of the

ν_2-band of NO_3^- of nitric acid dihydrate (NAD) at 810 cm^{-1} in the atmosphere from any MIPAS PSC observation.

During the initial phase of PSC development over Antarctica the MIPAS measurements reveal the formation of a belt of NAT PSCs in mid-June 2003. By mesoscale microphysical simulations we have shown that this sudden onset of NAT was caused by heterogeneous nucleation on ice in the cooling phases of large-amplitude stratospheric mountain waves over the Antarctic Peninsula and the Ellsworth Mountains. This suggests a more significant role for mountain waves in Antarctic PSC formation than has heretofore been appreciated. MIPAS observations of PSCs in a period of three weeks before this event show no indication for the presence of NAT clouds, but are consistent with supercooled droplets of ternary $H_2SO_4/HNO_3/H_2O$ solution (STS). Simulations indicate that homogeneous surface nucleation rates have to be reduced by three orders of magnitude to comply with these observations.