Geophysical Research Abstracts
Vol. 18, EGU2016-8897, 2016
EGU General Assembly 2016

First detection of ammonia (NH_3) in the upper troposphere

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Ammonia (NH_3) is the major alkaline trace gas in the troposphere. Neutralization of atmospheric acids, like HNO_3 and H_2SO_4, leads to formation of ammonium nitrate and ammonium sulfate aerosols. Further, there are indications that NH_3 may enhance nucleation of sulfuric acid aerosols by stabilization of sulfuric acid clusters. By far the largest source of ammonia is agricultural food production. Major global emissions are located in S-E Asia as e.g. shown by satellite nadir observations. Besides its importance with respect to air quality issues, an increase of ammonia emissions in the 21st century might lead to a significant climate radiative impact through aerosol formation. In spite of its significance, there is a lack of observational information on the global distribution of NH_3 in the mid- and upper troposphere. Observational evidence, however, would be important for testing e.g. model results on the fate of ammonia from its source regions on ground to altitudes up to the tropopause. In this contribution we will show, to our knowledge, the first unequivocal detection of ammonia in the upper troposphere. This result has been achieved through analysis of infrared limb-emission observations performed with the MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) instrument on board the Envisat satellite from 2002-2012. On a global scale, enhanced values of ammonia have been measured in the upper tropospheric region influenced by the Asian monsoon. We will present a quantitative analysis of the retrieved concentrations of NH_3 including an error assessment and further retrieval diagnostics. The results will be discussed with respect to the variability of NH_3 locally within the Asian monsoon region's upper troposphere and at different years. Further, we will show comparisons between global distributions of NH_3 from published model simulations and our observational dataset from MIPAS.