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Interpretation of PAN, acetone and acetylene measurements from the MIPAS-E

D. P. Moore, J. J. Remedios, and R. J. Parker
University of Leicester, Physics and Astronomy, Leicester, United Kingdom (dpm9@le.ac.uk)

Emissions of anthropogenic pollution, from biomass burning events in particular, result in the injection of a wide range of carbon compounds into the atmosphere. Carbon monoxide (CO), methane (CH4) and volatile organic compounds (VOCs) are released in significant amounts, affecting both the oxidation capacity of the troposphere and ozone production. Upper troposphere (UT) measurements of PAN, acetone and acetylene have, in the past, been generally limited to sporadic in situ sampling during specialised campaign periods. The recent rapid progress in both the detection and retrieval of many VOC species from spaceborne instrumentation has been large. It has recently been established that the observation of the global distribution of VOCs in the UT can be made by measurements provided by instruments such as the Michelson Interferometer for Passive Atmospheric Sounding onboard ENVISAT (MIPAS-E) or the Atmospheric Chemistry Experiment (ACE) onboard SCISAT-1.

In this work, we discuss the ability of MIPAS-E to provide new global measurements of acetone in the UT. We also describe both the distribution and seasonality observed in UT PAN volume mixing ratios (vmrs). From the MIPAS-E acetylene measurements, we analyse the extent and magnitude of the chemical isolation observed over the Middle East during August 2003. We show that this enhancement is due to fast westward transport from Asia via the Easterly Jet associated with the Asian monsoon anticyclone. A full error analysis is carried out for each of the three gases we analyse.

Previous work has shown that characteristic infrared signatures of PAN, acetone and acetylene can be detected in MIPAS-E thermal emission spectra, with the 787-790 cm-1, 1216-1218 cm-1 and 776.0-776.15 cm-1 spectral ranges respectively being particularly sensitive to changes in each of the gases. We invert the measured MIPAS-E spectra into vmrs using an independent offline-retrieval scheme based on the optimal estimation approach which was developed at the University of Oxford (MORSE). Both zonal mean and spatial distributions will be shown reflecting both the observed mean behaviour of acetone, PAN and acetylene in August 2003. We examine the correlations between these gases and show in particular that the sources which impact the distribution of acetone also have a substantial impact on PAN. Further, we explore the relationship between other species we can retrieve from MIPAS-E spectra, namely nitric acid and ozone, with PAN. We also evaluate the consistency between the MIPAS-E measurements for PAN and acetone and compare calculations from global chemical transport models such as TOMCAT. We use the acetylene vmr data, alongside the MOPITT carbon monoxide (CO) dataset, to show that the two are highly positively correlated with two distinct domains due to the Northern and Southern Hemispheres. Taking the ratio of acetylene and CO allows us to determine and age of air estimates, the time since the air mass last encountered a combustion source. A strong acetylene signal is observed over the Middle East region during August 2003; a result of fast outflow from Asia associated with the monsoon cycle. We show, in this work, that the MIPAS-E is a suitable instrument with which to study organic compounds in the upper troposphere.