Geophysical Research Abstracts
Vol. 13, EGU2011-11908, 2011
EGU General Assembly 2011

Comparison of acetone measurements by the MIPAS-E satellite instrument to CARIBIC aircraft data

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Emissions of anthropogenic pollution result in the injection of a wide range of carbon compounds into the atmosphere. Carbon monoxide (CO), methane (CH_4) and volatile organic compounds (VOCs) are released in significant amounts, affecting both the oxidation capacity of the troposphere and ozone production. It has recently been established that the observation of the global distribution of VOCs in the upper troposphere (UT) can be made by measurements provided by Earth limb-viewing instruments such as the Michelson Interferometer for Passive Atmospheric Sounding onboard ENVISAT (MIPAS-E). The use of satellite based remote sensing of the atmosphere, with characterised errors, has provided a greater understanding of the spatial distribution of these compounds in the UT and is beginning to address questions of the lifetimes of these compounds in this region from a global perspective.

The MIPAS-E samples vertically at 1.5 km intervals between 6 km and 21 km (with a vertical resolution around 3 km), making MIPAS-E a useful instrument with which to study organic compounds in the UT. The key for testing the quality of any satellite data-set produced is by comparison to in-situ measurements. Specific aircraft campaigns that include measurements of acetone are infrequent and often do not extend to altitudes above 8 km. The Civil Aircraft for the Regular Investigation of the atmosphere Based on an Instrument Container (CARIBIC) is an innovative scientific project which makes extensive measurements of important chemical and physical processes in the atmosphere. The automated scientific instrumentation is flown on commercial aircraft greatly improving spatial, vertical and temporal coverage, compared to specific campaigns which focus on a particular region. Hence CARIBIC measurements are an excellent tool for understanding detailed variability in particular regions and is complementary to MIPAS-E.

In this work, we show the ability of the MIPAS-E and CARIBIC to provide a unique dataset of global measurements of acetone in the UT and compare data retrieved from the optimised spectral resolution period of MIPAS-E in 2008 to CARIBIC aircraft measurements. We look at the great number of measurements made by CARIBIC between Germany and India, data which cross important regions such as the summer Indian monsoon and regions affected by biomass burning and agricultural processes which are thought to be important sources of acetone. Measuring long-range transport of acetone with MIPAS-E can also be studied and verified over the Atlantic Ocean using data from CARIBIC flights from mainland Europe to America. By using a coincidence of 6 hours and 1000 km horizontal distance between MIPAS-E and CARIBIC data we find that the MIPAS-E acetone compares well to the aircraft in most cases. The best comparisons are found where the CARIBIC data are least variable along-track and so where the acetone volume mixing ratios within the MIPAS-E field-of-view are most homogeneous. We show that the MIPAS-E is providing unprecedented global VOC data with good spatial resolution, providing very important new datasets with which to study the UT. This work on VOCs has the potential to feed into retrieval studies for higher spatial sampling satellites, such as PREMIER.