Global Tropospheric Measurements with GOME

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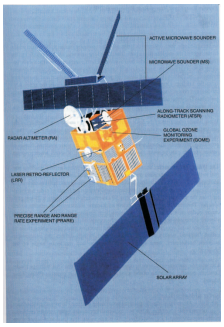
Introduction

One of the key parameters in improving the modelling of the earth's troposphere is a proper knowledge of the emissions of both natural and anthropogenic origin. Currently, most models use emission scenarios based on estimates and a number of local measurements. These data bases are often of limited accuracy and can not account for unforeseen trends, year to year variability or sporadic events.
With the current deployment of a new generation of UV/visible instruments observing the earth from space (GOME, SCIAMACHY, OMI), global data sets of the concentration fields for a number of tropospheric trace species become available for the first time. While these instruments do not measure the emission rates, but rather the resulting distributions; comparison of the measured data with model results will lead to significant improvements in our understanding of tropospheric chemistry and the quality of model predictions. Application of techniques such as inverse modelling may eventually also lead to better estimates of global emission factors.

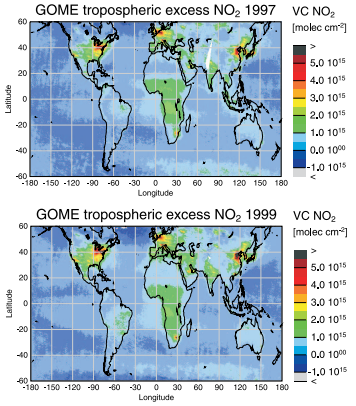
GOME Instrument and Analysis Algorithm



The *Global Ozone Monitoring Experiment* (GOME) is a grating spectrometer observing light scattered back by the atmosphere and reflected from the ground in a near nadir viewing geometry. GOME covers the spectral range of 240 to 790 nm with 0.2 - 0.4 nm resolution. The spatial resolution is 320 x 40 km2, resulting in a global coverage every three days. The instrument has been launched on ERS-2 in a polar sun-synchronuous orbit in April 1995, and is operational since fall of that year.
Using the *Differential Optical Absorption Spectroscopy* (DOAS) technique, a number of atmospheric trace gases can be retrieved from the spectra, including O_3, NO_2, BrO, OClO, SO_2, HCHO, and H_2O. In the absence of clouds, a large part of the photons observed by GOME have penetrated down to the troposphere, and global maps of tropospheric concentration fields can be derived from the measurements.
Due to the large pixel size, the spatial resolution of the data sets is limited, and also only (local) mid-morning measurements are available as a result of the ERS-2 orbit. To overcome these limitations, a geostationary observing platform is required as recently proposed in the GEOSCIA-project.

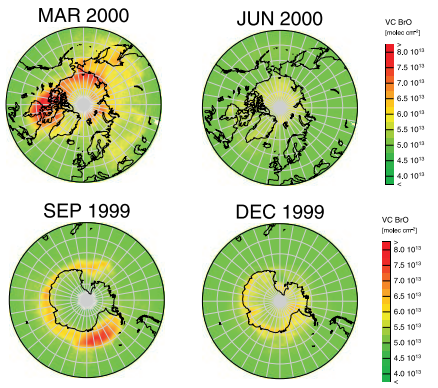
NO_2

For the determination of tropospheric NO_2 columns, the data have to be corrected for the relatively large stratospheric NO_2 amount. This is achieved by using the area over the Pacific as a clean air reference.
In the GOME measurements, the industrial regions consistently show the largest NO_2 columns, with little variation from year to year. Biomass burning seems to be the next important emission source, which shows considerable variability for example in the case of Indonesia. There is indication, that a large part of the NO_2 observed over Africa is produced by lightning as expected; surprisingly, other regions of strong convective activity do not show clear NO_2 signatures. In spite of the limited lifetime of NO_2, some export from the continents, in particular from Africa is evident from the data.



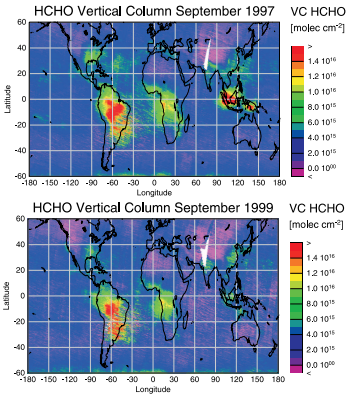
BrO

In polar spring, large amounts of BrO are observed in both hemispheres. This had previously been observed at several stations along the Arctic Sea, but the real extension of these events in space and time only became apparent from GOME measurements. BrO is involved in catalytic ozone depletion and conversion of volatile Hg compounds in the polar boundary layer, leading to dramatic changes in the constitution of the affected air masses.
From the GOME data it can be seen, that clouds of enhanced BrO concentrations appear with polar sunrise every year, more or less covering the sea ice for several months and disappearing in early summer.



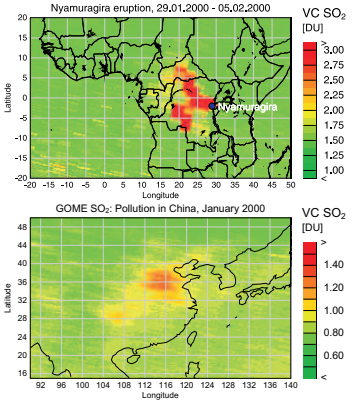
HCHO

Most of the formaldehyde is not emitted directly into the atmosphere, but rather is formed during the atmospheric oxidation of hydrocarbons emitted by anthropogenic sources, fires and plants. In first approximation, it therefore can be used as a proxy of hydrocarbon emissions that can not be directly observed.
In the GOME measurements, large HCHO concentrations are observed over forests in warm and humid conditions, consistent with enhanced isoprene emissions by trees. A much more variable source is biomass burning, in particular in Indonesia in 1997, when record high values were observed. In this case, a clear relation between NO_x and hydrocarbon emissions from fires and cities, and a plume of O_3 could be established, highlighting the importance of interaction between different types of emissions.



SO_2

SO_2 is released to the troposphere mainly by fossil fuel combustion, volcanic emissions and oxidation of organic material in soils as well as biogenic emissions over the oceans (DMS, H_2S).
While the global background concentration of SO_2 is difficult to quantify with GOME measurements, volcanic eruptions can readily be observed, and the emission plumes be monitored over several days. This also holds for minor explosions and continuous outgasing, that are difficult to monitor from the ground.
Under favourable conditions (no clouds, strong inversion), much smaller but still significantly enhanced SO_2 columns can be observed in regions with intense coal burning, in particular in winter. From these measurements, there is indication for a reduction in anthropogenic SO_2 emissions in Eastern Europe during the lifetime of GOME.



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see also: www.iup.physik.uni-bremen.de

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