Global Tropospheric Measurements with GOME

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Introduction

One of the key parameters in improving the modeling 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.

NO₂

For the determination of tropospheric NO₂ columns, the data have to be corrected for the relatively large stratospheric NO₂ amount. This is achieved by using the area over the Pacific sea as a clean air reference.

In the GOME measurements, the industrial regions consistently show the largest NO₂ columns, with little variation from year to year. Biomass burning seems to be the next important emission source, which shows considerable year-to-year variability for the case of Indonesia. There is indication, that a large part of the NO₂ observed over Africa is produced by lightning as expected, surprisingly, other regions of strong convective activity do not show clear NO₂ signatures. In spite of the limited lifetime of NO₂, 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 extent 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 approxima-
tion, 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, where record high values were observed. In this case, a clear relation between NO₂ and hydrocarbon emissions from fires and cities, and a plume of O₃ could be established, highlighting the importance of interaction between different types of emissions.

SO₂

SO₂ is released to the troposphere mainly by fossil fuel combustion, volcanic eruptions and oxidation of organic material in soils as well as biogenic emissions over the oceans (DMS, H₂S).

While the global background concentration of SO₂ is difficult to quantify with GOME measurements, volcanic eruptions can readily be observed, and the emissions can 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 SO₂ 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 SO₂ emissions in Eastern Europe during the lifetime of GOME.

Acknowledgements

- GOME calibrated radiiances and irradiiances have been provided by ESA through DLR Oberpfaffenhofen, Germany.
- Parts of this project have been funded by the University of Bremen and the European Community contract EVK2-CT-1999-00011 (POET).
- This study is a TROPOSAT / EUROTRAC project.
- Helpful discussions with T. Wagner from the University of Heidelberg are gratefully acknowledged.

Selected References

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