Measurements of Tropospheric NO_2 with SCIAMACHY

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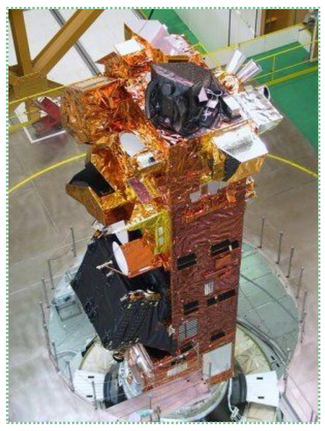
Introduction

In the last years, more and more measurements of atmospheric species from space have become available. The Global Ozone Monitoring Experiment (GOME) launched on ERS-2 in April 1995 has been one of the most successful instruments of this kind. Although primarily designed to deliver total ozone columns, measurements from the GOME instrument have been used to determine columns of NO_2, BrO, OClO, SO_2, HCHO, H_2O and also vertical profiles of O_3.

In March 2002, the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) was launched on board of ENVISAT. This instrument is in many respects an extended version of GOME, providing better spatial resolution, a wavelength range that extends into the NIR and most importantly the ability to measure alternatingly vertical profiles in the stratosphere and nadir columns.

In this poster, tropospheric NO_2 columns derived from SCIAMACHY nadir and limb measurements are presented and some aspects of spatial resolution, the limb/nadir matching technique and the consistency between GOME

SCIAMACHY Instrument

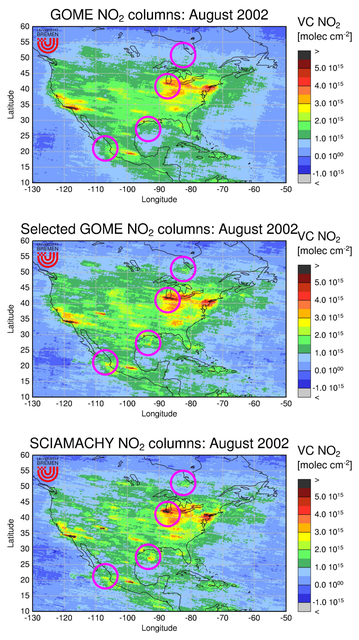


The SCIAMACHY instrument is a 8 channel grating spectrometer measuring in nadir, limb, and occultation (both solar and lunar) geometries. SCIAMACHY covers the spectral region from 220 to 2400 nm with a spectral resolution of 0.25 nm in the UV, 0.4 nm in the visible and less in the NIR. The size of the nadir ground-pixels depends on wavelength range and solar elevation and can be as small as 30 x 30 km^2. The instrument was launched on ENVISAT in a sun-synchronuous orbit on March 1st, 2002 and is in nominal operation since August 2002.

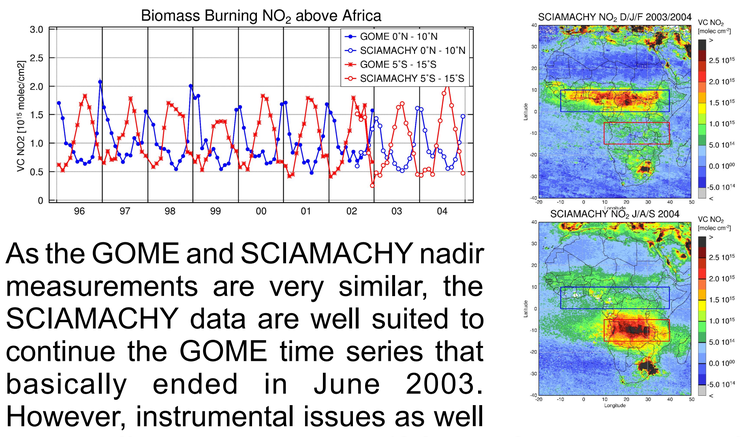
Using the *Differential Optical Absorption Spectroscopy* (DOAS) technique, a number of atmospheric trace gases can be retrieved from the spectra, including O_3, NO_2, BrO, OClO, SO_2, HCHO, and H_2O. In the absence of clouds, a large part of the photons observed by SCIAMACHY in the nadir have penetrated down to the troposphere, and global maps of tropospheric concentration fields can be derived from the measurements.

Compared to GOME, the SCIAMACHY instrument has several advantages for nadir measurements, in particular the better spatial resolution and the ability to provide a nearly collocated stratospheric profile for each nadir measurement, which enables accurate tropospheric columns to be derived without external information.

Extending the GOME Time Series

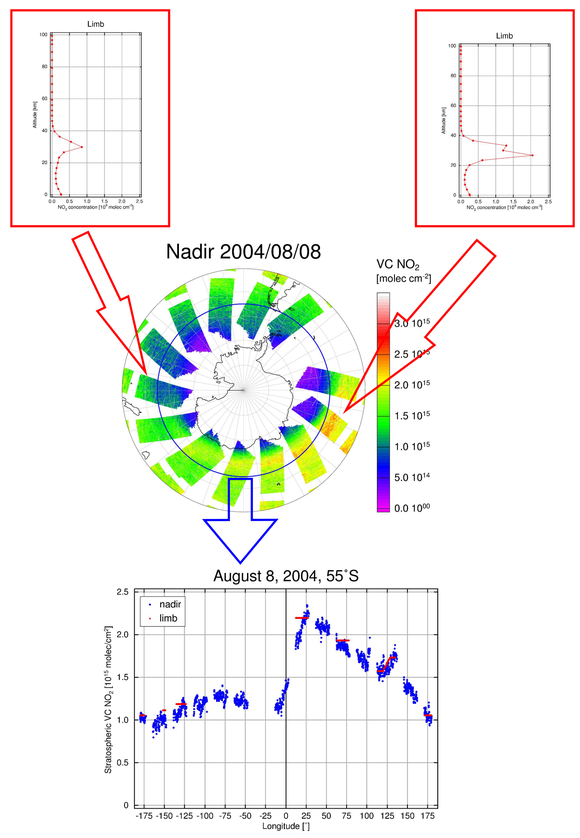


Effect of comparing GOME and SCIAMACHY measurements with and without selection for SCIAMACHY sampling.



As the GOME and SCIAMACHY nadir measurements are very similar, the SCIAMACHY data are well suited to continue the GOME time series that basically ended in June 2003. However, instrumental issues as well as the difference in sampling (SCIAMACHY has only half the coverage per day GOME has) and the different resolution can have an impact on the retrieved tropospheric NO_2 columns. As shown in the figures, the agreement for the time with parallel measurements is very good, in particular if the difference in sampling is taken into account. Some problems remain due to reduced data coverage in 2003 but this will eventually be solved. The example for Africa demonstrates, how the combined time series can be used to monitor bimomass burning emissions over now 10 years.

Using Limb-Nadir Matching

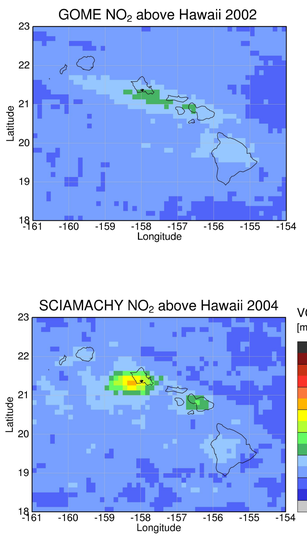


The nadir columns measured by SCIAMACHY contain both the stratospheric and tropospheric contribution. The stratospheric part is often removed by using measurements over a clean reference sector or by assimilating measurements over clean regions into a stratospheric model. SCIAMACHY has the unique feature to take a stratospheric limb profile measurement over the area which is probed 7 minutes later in nadir mode. This facilitates accurate and self contained correction of the stratospheric column.

As shown in the figure, the limb measurements nicely pick up the zonal variability observed under certain conditions which leads to large errors in the tropospheric columns if it is not corrected. Under these conditions, the limb-nadir product is clearly superior to the analysis using the reference sector method.

However, the use of limb profiles also removes some effects of self-calibration in the DOAS analysis, and constant offsets which often are a problem in DOAS retrieval do not cancel as in the reference sector method.

Effects of Spatial Resolution



The improved spatial resolution of SCIAMACHY is relevant for several aspects:

- it improves the spatial resolution of emission estimates
- it improves the detection limit for localised sources
- it simplifies the separation between transport and local emission
- it potentially improves the cloud statistics and thus increases the number of tropospheric measurements

The figures illustrate the effect for the example of Hawaii. While GOME measurements for 2002 see a slight enhancement that has the typical shape of a GOME ground-pixel, SCIAMACHY measurements (2004) can resolve the plume off Honolulu and also the enhancement over the other islands. While the average over the whole area is similar for both measurements, SCIAMACHY data reveal much higher values locally.

Conclusions

- Tropospheric NO_2 columns derived from SCIAMACHY measurements show unprecedented detail in the spatial distribution
- GOME and SCIAMACHY tropospheric NO_2 measurements agree well but differences are introduced by the difference in spatial sampling
- the combined time series now covers more than one decade
- The better spatial resolution of the SCIAMACHY measurements reveals both smaller spatial structures and weaker local emissions
- The limb-nadir matching technique provides an independent estimate of the stratospheric column which can improve the tropospheric columns in situations with large stratospheric gradients. The limb and nadir measurements agree well under such conditions in the absence of pollution

Acknowledgements

- SCIAMACHY raw radiances and irradiances have been provided by ESA/ ESRIN
- Parts of this project have been funded by the University of Bremen, the European Community under contract EVk2-2001-00370 (RETRO) and ACCENT the by the European Space Agency through PROMOTE.
- We would like to thank the Bremen SCIAMACHY team, in particular H. Bovensmann, K. Bramstedt, S. Noel, and J. Skupin for valuable support with software and explanations.

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