Cloud effects in Tropospheric NO_2 Columns retrieved from SCIAMACHY Nadir Measurements

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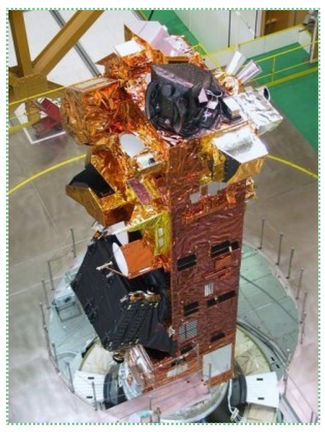
Introduction

In the last years, more and more measurements of atmospheric species from space have become available. One of the arguably most successful instruments for atmospheric chemistry research from space is the Global Ozone Monitoring Experiment (GOME) launched on ERS-2 in April 1995 and still providing data today. Although primarily designed to deliver total ozone columns, measurements from the GOME instrument have been used to determine columns of NO2, BrO, OClO, SO2, HCHO, H2O and also vertical profiles of O3.

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 and nadir columns.

In this poster, tropospheric NO2 columns derived from SCIAMACHY nadir measurements are presented and the impact of clouds and pixel size is studied.

SCIAMACHY Instrument

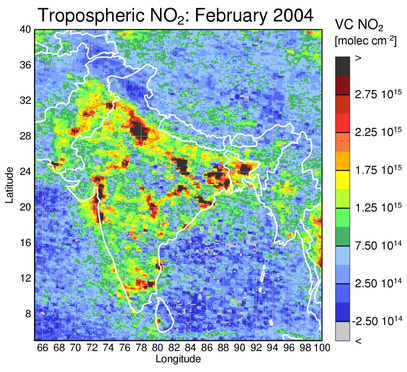


The SCIAMACHY instrument is a 8 channel grating spectrometer measuring in nadir, limb, and occultation (both solar and lunar) geometries. SCIAMACHY covers the spectral region from 220 to 2400 nm with a spectral resolution of 0.25 nm in the UV, 0.4 nm in the visible and less in the NIR. The size of the nadir ground-pixels depends on wavelength range and solar elevation and can be as small as 60 x 30 km2. The instrument was launched on ENVISAT in a sun-synchronuous orbit on March 1st, 2002 and is in nominal operation since August 2002.

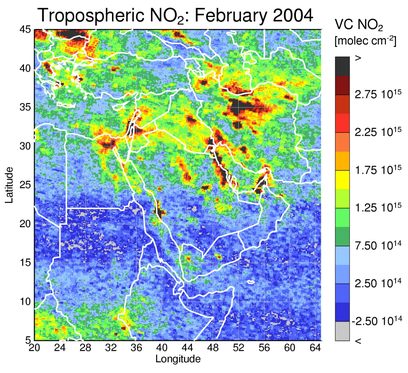
Using the *Differential Optical Absorption Spectroscopy* (DOAS) technique, a number of atmospheric trace gases can be retrieved from the spectra, including O_3, NO_2, BrO, OClO, SO_2, HCHO, and H_2O. In the absence of clouds, a large part of the photons observed by SCIAMACHY in the nadir have penetrated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

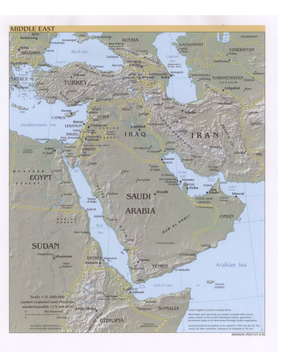
Compared to GOME, the SCIAMACHY instrument has several advantages for nadir measurements, in particular the better spatial resolution and the ability to provide a nearly collocated stratospheric profile for each nadir measurement, which in principle will enable accurate tropospheric columns to be derived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

Some SCIAMACHY Measurements



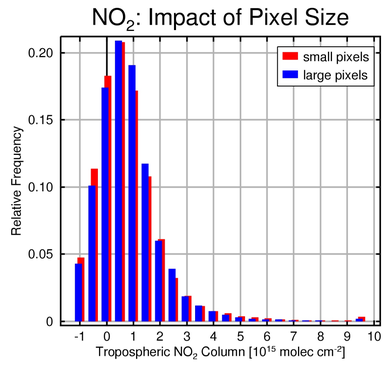
As shown in the figures to the left, SCIAMACHY measurements from February 2004 show enhanced values of NO_2 over all major cities on the Indian subcontinent, illustrating the potential of the satellite measurements to provide information on pollution on the regional level.

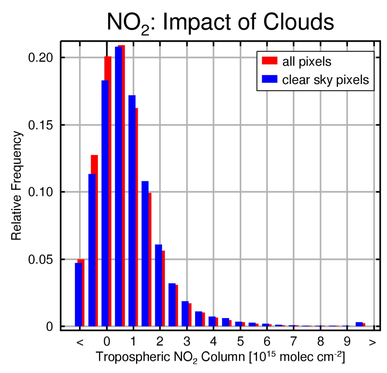




The second example shows NO2 in the middle east, a region where both emission s from cities but also to a large degree from oil mining and gas flaring can be observed.

Resolution and Cloud Effects

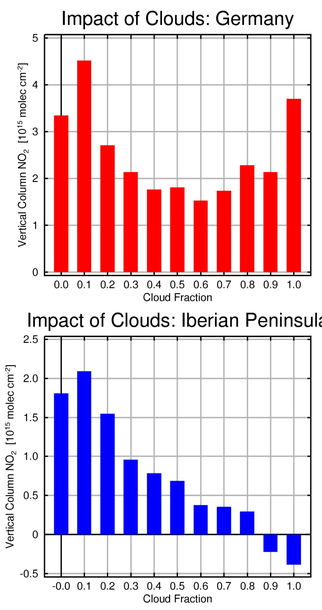




To investigate the impact of pixel size, data from August 2003 taken over the US have been selected for pixel size using either the forward scan only (30 x 60 km^2) or the backward scan (30 x 320 km^2). The frequency distribution of the measured tropospheric columns is shown in the figure to the left. As expected, the smaller pixels see more cases of very large NO_2, probably over localised sources. The effect is large in relative numbers but surprisingly small in absolute numbers

A similar selection has been performed to study the impact of clouds, again using the data from August 2003 over the US. The cloud selection was done using a simple intensity criterion, and no differentiation of cloud top height is included. As shown in the figure, the differences are relatively small but the frequency of very large values is higher for clear scenes. Also, the frequency of negative values is reduced for clear sky pixels, a finding that points at an effect of clouds on the data retrieval. One possible explanation is a change in tropopause height that is associated to pressure systems and might influence the stratospheric correction applied. another possibility is a subtle change in stratospheric AMF over clouds that would have a similar effect.

Some SCIAMACHY Measurements



When the average tropospheric NO_2 columns from SCIAMACHY are plotted as a function of cloud cover, the result is surprising:

- over some regions (for example the Iberian Peninsula), the tropospheric NO_2 columns increase with decreasing cloud cover as expected.
- over other regions, such as Germany, they are large for both clear sky and cloudy pixels.

This is illustrated in the figures shown at the left size for data from September 2003. The details of this effect are not yet fully understood. However, the most obvious interpretation is, that there must be substantial amounts of NO_2 above (low) clouds over Germany. as has also been recently observed by airborne DOAS measurements.

Conclusions

- Tropospheric NO2 columns derived from SCIAMACHY measurements show unprecedented detail in the spatial distribution as shown for some examples.
- The better spatial resolution of the measurements has in general the impact to increase the frequency of very large values, but the effect is surprisingly small judging from the analysis of one month of data taken over the US.
- The impact of clouds on the measurements is twofold: for clear pixels, higher values are observed, but also the frequency of negative values is reduced, probably due to an impact of clouds on the stratospheric correction applied to the data. Again, the changes are smaller than expected. There is also clear evidence for NO_2 above clouds over some parts of Europe.
- The results presented here for SCIAMACHY are in good general agreement with those from a recent study of GOME narrow swath data (Beirle et al., 2004)

Acknowledgements

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