GOME NO_2 Retrieval with MOZART Profiles

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Introduction

Troposperic NO_x has its main sources in emissions from the soil, fires, lightning, transport and industry. It plays an important role in the formation of tropospheric ozone and together with SO_2 it is the main cause of acid rain.

The *Global Ozone Monitoring Experiment* (GOME) is a UV/visible spectrometer on board of the European satellite ERS-2. GOME is a 4 channel double monochromator covering the wavelength range of 230 - 800 nm with a spectral resolution of 0.2 - 0.4 nm. ERS-2 was launched into a polar sun-synchronuous orbit in April 1995. With a ground pixel size of 40 x 320 km^2 (40 x 960 km^2) GOME reaches global coverage at the equator within 3 days. The main objective of GOME is the global measurement of ozone columns, but other trace gases such as NO_2, SO_2, HCHO, BrO and OClO can be retrieved from the spectra as well.

MOZART (Model of OZone And Related Tracers) is a 3D global tropospheric chemistry simulation model with a resolution of 2.8° x 2.8° at 31 layers. It is developed by the National Center of Atmospheric Reseach in Boulder, Colorado, the General Fluid Dynamics Laboratory, Princeton, New Jersey and the Max-Planck-Institute for Meterology, Hamburg, Germany.

SLIMCAT is a 3D off-line stratospheric chemical transport model with a resolution of 5° x 7.5° at 18 layers. It is developed by the Univerity of Leeds, UK, the Cambridge University, UK and Meteo-France, Tolouse, Fance.

Data Analysis

Using the *Differential Optical Absorption Spectroscopy* (DOAS) technique, NO_2 is retrieved from GOME spectra in the wavelength range 425 - 450 nm. Only data of pixels with less then 10% cloud cover are taken into account.

The result of the fit is the total slant column which is converted to a total vertical column using the radiative transfer model SCIATRAN. The conversion depends on the vertical profiles of NO_2 for each pixel. The profiles are unknown, in therefore they are taken from MOZART. The output of SCIATRAN is the airmass factor (AMF), the ratio beween slant column and vertical column.

The stratospheric amount of NO_2 is removed by subtracting the stratospheric amount of NO_2 derived from SLIMCAT data.

Comparison between SLIMCAT and GOME data for a sector at the longitude 180°-190°, which is presumed to be free of any tropospheric NO_2 shows an excess in NO_2 for the GOME-data. To remove this excess in stratospheric NO_2, the excess of each latitude in this sector is removed from all the values at the same latitude.

Airmass Factors

The computation time for the AMFs for one day on the grid of MOZART (8192 pixel) with SCIATRAN is approx. 2.5 days on a 0.8 GHz PC. To faciliate an efficient, i. e. fast retrieval the block airmass factor scheme was implemented.

The basic idea is to substitute the radiative transfer calculation by summing precalculated AMF_i for different height layers weighted by the concentration of NO_2 V_{ci}:

$$AMF = \frac{\sum_i V_{ci} \cdot AMF_i}{\sum_i V_{ci}}$$

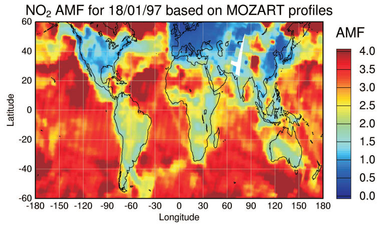
It is assumed that the atmosphere is optically thin for NO_2, i. e. the radiative transfer through the layers is independent.

The AMF_i values for layers of a height of 100 m from 0 km - 20 km above sea level are pre-calculated. To account for the suface height dependence of the reflectivity of the atmosphere below each layer there is one individual set of AMF_i for each ground height between 0 km - 9 km in steps of 100 m.

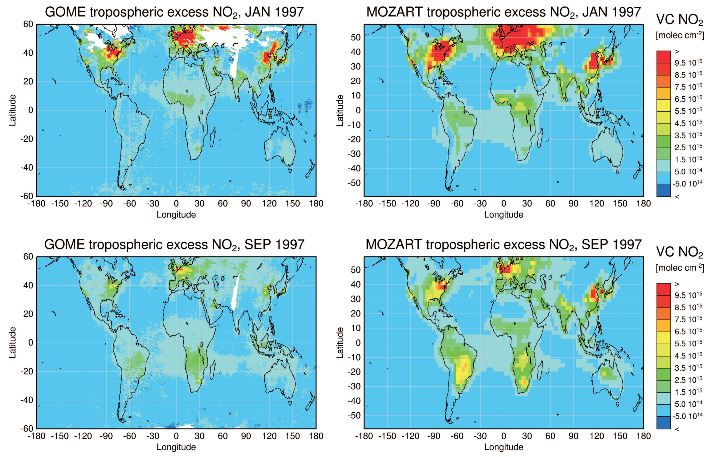
For each day an individual global AMF map is approximated. A comparison between a full SCIATRAN calculation and the block AMF approximation for one day at the resolution of MOZART shows a RMS < 3%. The computation time of the block AMF approximation is approx. 22s/day on the same PC.

Since the block AMFs are derived from the MOZART profiles and most of the tropsheric NO_2 is near the surface, the AMFs are small in regions with high NO_2 values near the ground (polluted areas) in MOZART and vice versa. This implies the risk that the retrieved data are systematically biased to the trends of the model data.

In turn low retrieved values in high polluted areas of MOZART are reliable.



Comparison GOME-MOZART



The trends in model and measurement are in good agreement for the highly polluted areas in North America, Europe, China, Japan and South Africa. The values shown by the model are approx. 1.5 times larger then the retrieved values and particularly higher in winter in industrialized regions.

Southern America, Sep: Model and retrieved data show increased NO_2 values over the continent. Furthermore there is an outflow of NO_2 over the Pacific Ocean and the Atlantic Ocean visible.

Jan: The increased NO_2 values over the continent are not confirmed by the retrieved data. As a result of cloud cover above the continent the NO2 values seen by the satellite could be underestimated, but there is also no export over the oceans.

India, Indian Ocean, Sep: The probably increased NO2 values shown by MOZART are not reproduced by the GOME data because of the thick cloud cover caused by the summer monsoon.

Summary and Outlook

There are several reasons why GOME NO_2 probably is too low, namely

- missing treatment of partially cloudy scenes (we simply use a threshold criterion of 10%)
- inadequate treatment of aerosols (soot, smoke, haze, ...)
- low sensitivity very close to the surface, where a large part of the NO_2 can be located in polluted regions

The first two points will be improved in the next data version.The last point however can not be solved and might explain some of the differences seen.

For the NO_2 exported from the continents over the oceans, none of the points is of concern, and there is hardly any reason why GOME NO_2 should be too low here. Because of the uncertanties in the retrieved data it is not yet possible to decide if whether the MOZART values are too big or the GOME values too small.

The next steps in the work are

- quantification of the impact of the use of MOZART based airmass factors
- comparison with airmass factors based on other models
- implementation of the cloud correction scheme
- analysis of SCIAMACHY data

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see also: www.doas-bremen.de

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