GOME NO_2 Retrieval with individual AMF for Aerosol, Albedo, Orography and Profile

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Introduction

Tropospheric 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-synchronous 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.

NO_2 Retrieval from GOME

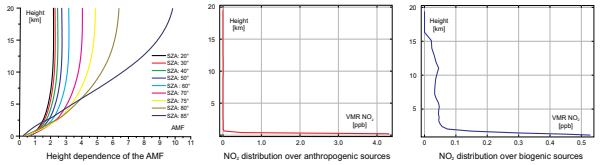
Using the *Differential Optical Absorption Spectroscopy* (DOAS) technique, NO_2 is retrieved from GOME spectra in the wavelength range 425 - 450 nm. Only data of pixels with less then 10% cloud cover are taken into account.

The result of the fit is the total slant column (SC) which is converted to a total vertical column (VC) using the radiative transfer model SCIATRAN[1]. The conversion depends on the vertical profiles of NO_2 for each pixel. The profiles are unknown, therefore they are taken from the 3D tropospheric chemical transport models MOZART[2] and TOMCAT[4]. The output of SCIATRAN is the airmass factor (AMF), the ratio between SC and VC.

The stratospheric amount of NO_2, which is derived from the 3D stratospheric chemical transport model SLIMCAT[4], is removed.

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.This excess is removed by zonal subtraction.

Airmass Factors

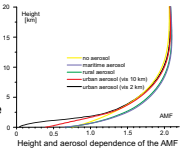


Height dependence of the AMF | NO_2 distribution over anthropogenic sources | NO_2 distribution over biogenic sources

The sensitivity of the GOME retrieval depends on the height of the absorber within the atmosphere. Therefore the AMF_i of a given layer i is a function of the height. The AMF of the total column depends on the concentration profile of the absorber, not on the total concentration. The very high concentration near the ground over anthropogenic sources leads to small AMF, whereas the NO2 above biogenic sources is mostly located in the free troposphere and causes larger AMF.

As the AMF depends strongly on the solar zenith angle (SZA), this variable must be taken into account for the retrieval.

The AMF depends also on the aerosol type: The optical thick urban aerosol absorbs photons and causes small AMF from ground up to 3 km. The rural and maritime aerosols are reflecting light, which increases the albedo of lower layers. This causes a smaller AMF for layers above 500 m since the sensitivity depends on the number of backscattered photons.



Height and aerosol dependence of the AMF

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 facilitate an efficient, i. e. fast retrieval the 2D 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_{Gi}:

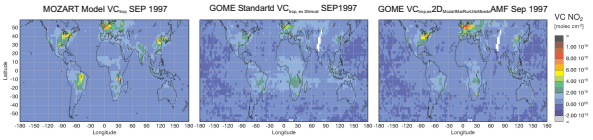
$$AMF = {}_{i} V_{Gi} \cdot AMF_i / {}_{i} V_{Gi}$$

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 precalculated. To account for the surface 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 2D AMF approximation for one day at the resolution of MOZART shows a RMS < 3%. The computation time of the 2D AMF approximation is approx. 22s/day on the same PC.

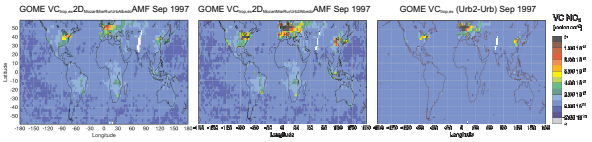
Model - Retrieval comparison



The standard GOME retrieval shows in general lower values then the MOZART model.

Consideration of the individual aerosol, albedo, orography and NO2 profile for each day and geolocation leeds to a good agreement between retrieval and model data.

Influence of the Visibility

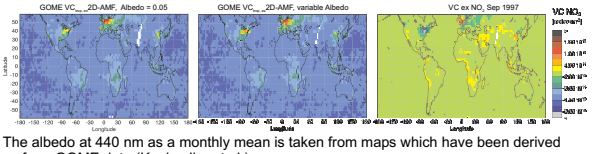


For the retrieval 2D AMF are used, which are based on different areosol szenarios. For all regions above the oceans a maritime aerosol type, and for all other regions a rural aersol with a visibility of 23 km is asumed. Additional for regions with high CO_2 emissions (EDGAR3.2[5] pixel > 10^9 kg / yr 1995) an urbanly aerosol with a visibility of 10 km respectively 2 km is applied.

Comparison between the retrieval based on the different 2D AMF and the tropospheric vertical columuns of the MOZART model shows that the assumption of an urban aerosol with a visibility of 10 km leads to a retrieval which is in good agreement for most of the anthropogenic source regions.

Only above china the urban aerosol szenario with the lower visibility of 2 km produeces values that agree better with the MOZART VC.

Albedo Influence on the Retrieval



The albedo at 440 nm as a monthly mean is taken from maps which have been derived from GOME data (Koelmeijer et al.).

The implementation of the albedo leeds to an increase of the NO2 VC above Europe, China, Southeast Asia and biogenic source regions in South America and Africa and a decrease over the northeast of the USA.

The influence on the retieval is small in comparison to that of the aerosol typs.

Outlook

The next steps in the work are

- implementation of the cloud correction scheme
- precalculation of level AMF for an urban aerosol with a visibility of 5 km and a biomass burning aerosol
- analysis of SCIAMACHY data

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