GOME NO_2 Retrieval with Model Profiles

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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

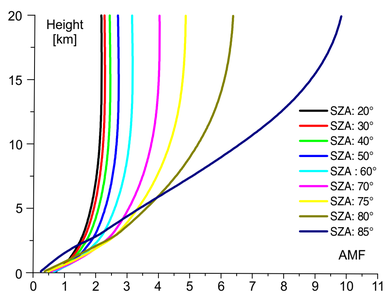
Using the *Differential Optical Absorption Spectroscopy* (DOAS) technique, NO_2 is retrieved from GOME spectra in the wavelength range 425 - 450 nm. Only data of pixels with less then 10% cloud cover are taken into account.

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.

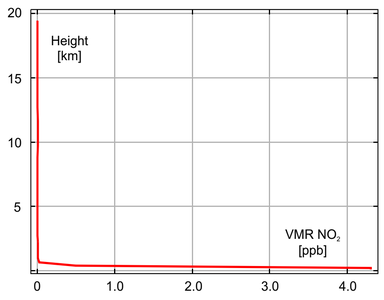
The stratospheric amount of NO_2, which is derived from the 3D stratospheric chemical transport model SLIMCAT[4], is removed.

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.

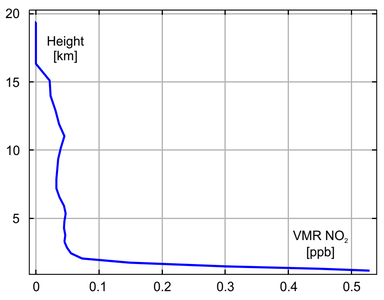
Airmass Factors



Height dependence of the AMF



NO_2 distribution over anthropogenic sources

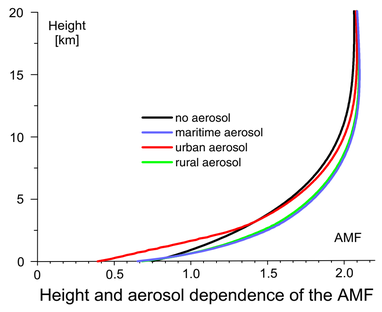


NO_2 distribution over biogenic sources

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 leeds 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 enlarges 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_{ci}:

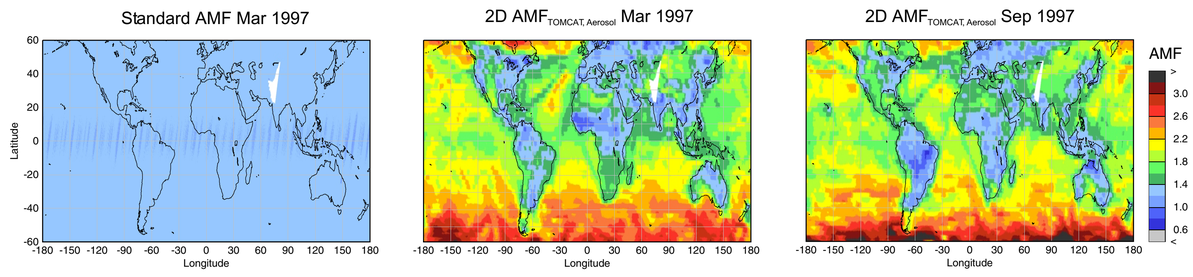
$$AMF = \sum_i V_{ci} \cdot AMF_i / \sum_i V_{ci}$$

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 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.

Sources and Block AMF



The standard AMF is based on a profile, in which the whole NO2 is homogeneous distributed over the first 1.5 km. Above source regions the NO_2 concentration is high within the layers near the ground, therefore the 2D AMF is lower or equal to the standard AMF.

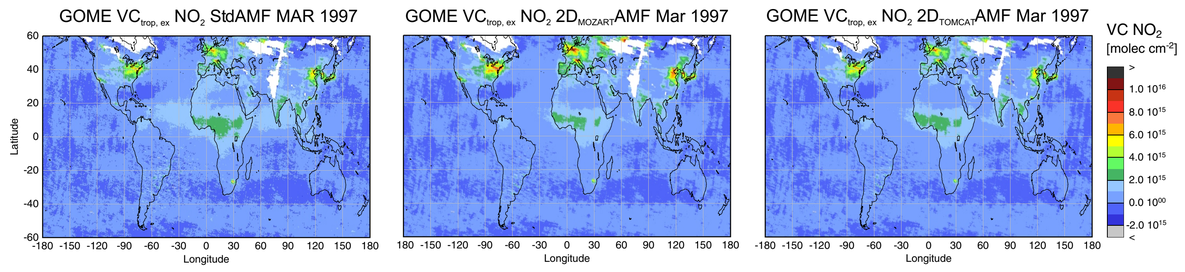
To show the seasonal impact on the AMF without the influence of the SZA an average of the AMF of March and September is compared.

Above biogenic source regions on the southern hemisphere like Africa, South America and South East Asia the 2D AMF decreases.

Above anthropogenic source regions on the northern hemisphere like Europe, North America and East Asia the 2D AMF_{MOZART} increases.

In congruence with the premise that the value of the 2D AMF depends on the NO_2 profile derived from the model, low AMF values not imply high NO_2 VC in the model; although high NO_2 VC in the retrieval are correlated with low AMF.

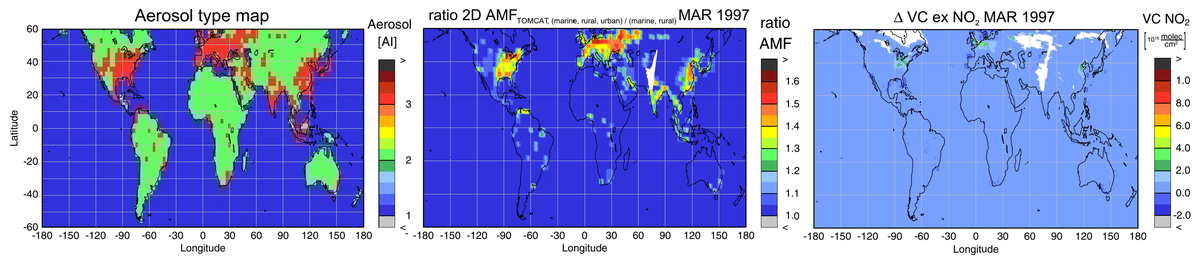
The prominent lines across the north and (TOMCAT only) south Atlantic a caused by model



Using the 2D AMF the VC above biogenic sources are smaller, as the profile above biogenic sources with is maximum in higher altitudes gives a large AMF.

Above anthropogenic sources the MOZART derived block AMF leeds to larger VC because the high values in low layers in MOZART produces small AMF. The TOMCAT derived block AMF causes only small changes since the maximum of the NO2 concentration is slightly shifted to higher altitudes in the profile, which causes larger AMF.

Aerosols



An urban aerosol is assumed for all regions with high CO_2 emissions. (EDGAR3.2[5] pixel > 10^9 kg / yr 1995).

The AMF is reduced over CO_2 source regions if the model shows a NO2 profile typical for anthropogenic sources.

The retrieval increases linearly with the AMF by up to 50% over anthropogenic sources.

Outlook

The next steps in the work are

- implementation of the cloud correction scheme
- implementation of the surface albedo
- analysis of SCIAMACHY data

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Acknowledgements

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