Sensitivity of satellite NO_2 retrievals to aerosols

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Introduction

Satellite instruments such as GOME, GOME-2, SCIAMACHY and OMI perform measurements of the backscattered solar radiation from which trace gas distributions in the atmosphere can be retrieved. These data are of growing importance to investigate the global distribution of pollutants such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and several others. With the satellite derived global fields one can identify emission sources and analyse long-term trends of pollutant concentrations.

The retrieval of tropospheric columns of NO_2 from satellite measurements is based on several assumptions that in one way or another contribute to the uncertainty in the final retrieval. The improvement of the a priori assumptions used for the computation of the airmass factor (AMF) is a main concern to obtain the correct values of NO_2 present in the troposphere.

A sensitivity study is shown in this poster as an example of the impact of a **different aerosol characteristics** such as optical properties and optical thickness (AOD) on the computation of the NO_2 AMF with the radiative transfer model (RTM) Sciatran (Rozanov *et al.*, 2005). Also the effect of **different boundary layer heights** values is studied.

Motivation…

It is known that the **presence of aerosols** (and its scattering effect) has an impact on the measurements of tropospheric NO_2. This effect is related for example to the vertical distribution of aerosol and its type.

Currently in IUP-Bremen, the NO_2 retrieval method uses data taken from climatological assumptions (Richter *et al.*, 2005). Therefore, the full spatial and time variability of aerosols and its characteristics is not well accounted. Hence, we attempt to include in the retrieval method data that can be continuously updated, i.e. using independent measurements when available and dynamical "climatology" when it is necessary to fill gaps. This can be done using, for example, AOD values calculated with the BAER algorithm (von Hoyningen-Huene *et al.*, 2006) from MERIS data.

Sensitivity Study - settings

Radiative transfer calculations

- RTM: Sciatran 2.2
- Surface albedo = 0.03
- Wavelength: 425, 437.5, 440, 450nm
- SZA: 20°, 35°, 60°, 70°
- BL heights: 0.6, 1, 2 and 3 km
- NO_2 and aerosol profiles – "box profile" of well mixed gas and aerosol along BL considered (see Fig.1)

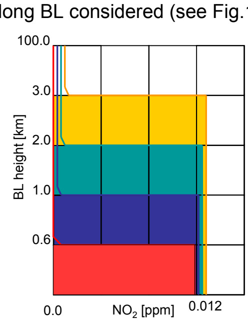


Figure 1: Profiles of NO_2 for different BL heights. The aerosol profile is represented by the shaded area.

Aerosol Settings:

Phase function calculated with a FORTRAN program developed by Michael Mishchenko (de Rooij *et al.*, 1984; Mishchenko *et al.*, 1999) and adapted by Alexander Kokhanovsky.

- Optical properties of aerosols taken from Dubovik *et al.* (2002) – measurements from 12 worldwide AERONET stations
- "Typical" compositions of aerosol considered: urban/industrial, biomass burning, desert dust and oceanic (according to location)
- Legendre expansion coefficients determined for fine and coarse particles
- Wavelength: 440nm
- AOD: 0.1, 0.5, 0.9
- Aerosol absorption profile was determined according to the extinction coefficient profile – single scattering albedo of 0.933 (Dubovik *et al.*, 2002)

Sensitivity Study - results

Here only the results obtained with data measured in the AERONET station **Creteil-Paris, France** are shown. However, NO_2 AMF were calculated for several locations but the difference of the results is not so significant (see the example in Fig.2 on the right for stations classified as "desert" and "urban").

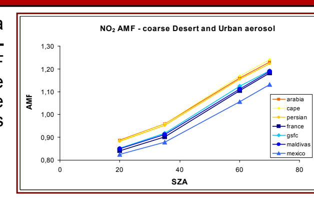


Figure 2: NO_2 AMF at 440nm, for BL= 1km, with AOD=0.5. Aerosol optical properties taken from AERONET stations data in urban (in blue) and desert (in yellow/orange) background (Dubovik et al., 2002).

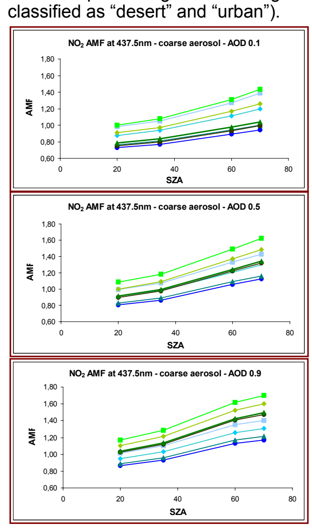
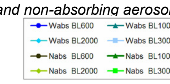


Figure 3: NO_2 AMF at 437.5nm for AOD of 0.1 (top), 0.5 (middle) and 0.9 (bottom). AMF showed for different BL and for absorbing (Wabs) and non-absorbing aerosol (Nabs):



- NO_2 signal is amplified for larger SZA and longer wavelengths.
- In general NO_2 **AMF increases** with the **extension of BL** to higher altitudes (Fig.3).
- The **increase of AOD** will lead to **higher NO_2 AMF**. Yet, in some cases, with AOD=0.9 it is possible to observe a decrease of AMF for SZA greater than 60°(Fig.4).
- When considering **absorbing aerosol**, the **NO_2 AMF** will be **lower** . The difference to the non-absorbing one is more relevant for high AOD values (Fig.3).

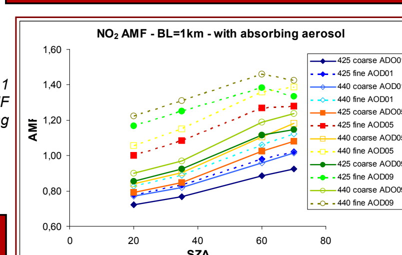


Figure 4: NO_2 AMF with profiles of BL=1km, at 425nm and 440nm and for several AOD values (0.1, 0.5 and 0.9). Coarse mode aerosol is represented by solid line and fine particles with hatched line.

- **Fine aerosol** well mixed with NO_2 will derive **higher AMF** than those calculated when considering coarse particles (Fig.4). This difference is more pronounced for high aerosol loads (e.g. AOD=0.9).

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Conclusions & Future work…

- From the sensitivity study performed it is clear that boundary layer height can have a large influence on the NO_2 AMF and such influence is intrinsically related to the NO_2 and aerosol profiles considered.
- Also, it was observed that changes of aerosol characteristics, such as load and type, are determinant variables in the calculations of AMF. Therefore, information on aerosol characteristics (e.g. if the aerosol is mainly composed by fine or coarse particles) is an important factor to obtain accurate AMF.
- It is concluded that the NO_2 AMF is dependent on many factors that need to be selected carefully. In order to improve the current retrieval method data from ECMWF (BL height) may be used to select and define the profiles and MERIS data (AOD measured) can be later incorporated in the retrieval method of tropospheric NO_2.

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