Impact of aerosol on the NO_2 air mass factors used for satellite retrievals

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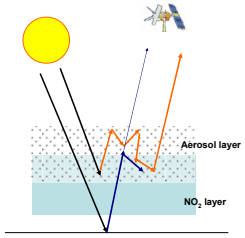
Introduction

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 Slant columns measured are converted into vertical columns using an air mass factor (AMF). Therefore the improvement of the a priori assumptions used for the computation of this 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 aerosol vertical distributions 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 (e.g., 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.

Here we attempet to show the importance of such data by changing aerosol settings in the RTM.

Sensitivity Study

Radiative transfer calculations

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

Aerosol phase function

The phase function (Fig.1) is 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 (effective radius and variance, refractive index) of aerosols taken from Dubovik *et al.* (2002) – average data obtained from measurements from worldwide AERONET stations
- "Typical" aerosol compositions from urban/industrial
- Legendre expansion coefficients for fine and coarse particles

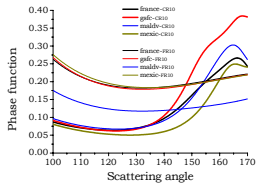
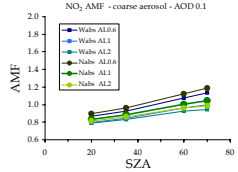
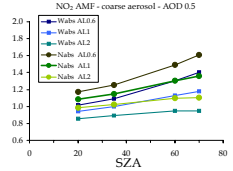


*Figure 1: Aerosol phase function for relevant scattering angle (110° to 170°) calculated for fine (FR10) and coarse (CR10) aerosol with average optical properties measured at different AERONET stations: Crete-Paris **France**; **GSFC**, Greenbelt, MD; **Maldives** (INDOEX); and **Mexico** city.*

Sensitivity Study - results

NO_2 AMF were calculated for 4 urban/industrial locations and in general the results are very similar (see Fig.2 below). Therefore Figure 3 and 4 show only results obtained with data measured in the AERONET station "**Creteil-Paris, France**".





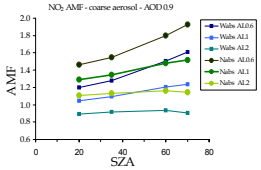
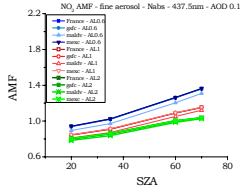


Figure 3: NO_2 AMF at 437.5nm for AOD of 0.1 (left), 0.5 (middle) and 0.9 (right). AMF showed for different AL (0.6, 1, 2km) and for absorbing (Wabs) and non-absorbing aerosol (Nabs). SZA considered: 20°, 35°, 60°and 70°.



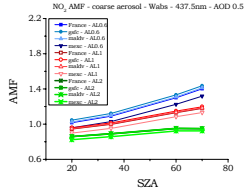


Figure 2: Two examples of NO_2 AMF at 437.5nm determined for several AERONET stations and with different aerosol layer (AL) heights: 0.6, 1 and 2km. Left picture for fine non-absorbing (Nabs) particles with. Right picture for coarse absorbing (Wabs) particles with AOD=0.5. SZA considered: 20°, 35°, 60° and 70°.

- NO_2 signal is amplified for larger SZA and longer wavelengths. However, for high SZA the shielding effect of aerosol might be very pronounced and the NO_2 signal decreases.
- Due to multiple scattering, the **increase of AOD** will lead to **higher NO_2 AMF**. Yet the extent of enlargement is much related to combination of aerosol load, layer height (and relative arrangement to NO_2) and SZA considered.
- The difference in the NO_2 AMF values calculated with **fine and coarse aerosol** is rather **small when low aerosol load** is considered and much **higher for high AOD values**.

- Absorbing aerosol will lead to lower NO_2 AMF. The difference to AMF calculated with absorbing and non-absorbing aerosol becomes more relevant for high AOD values.
- In general NO_2 **AMF decreases** with the **extension of the aerosol layer**. The difference of AMF is more pronounced for high AOD values.

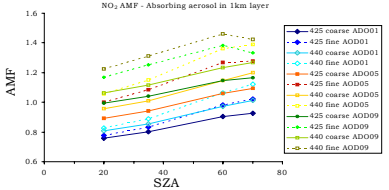


Figure 4: NO_2 AMF with aerosol profile and trace gas well mixed in 1km height, at 425nm and 440nm and for several AOD values. Coarse mode aerosol is represented by solid line and fine particles with hatched line.

Conclusions & Future work…

- From the sensitivity study performed it is clear that the vertical position of the NO_2 in relation to the aerosol layer can have a large influence on the NO_2 AMF.
- Also it is concluded that the aerosol load is an important factor to obtain accurate AMF. Information on aerosol type is also significant for these calculations.
- It is concluded that the NO_2 AMF is dependent on many factors that need to be selected carefully. The profiles of both, trace gas and aerosols, is an important and required information to access precise tropospheric NO_2 columns. 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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