On the improvement of satellite retrievals of NO_2 using aerosol measurements

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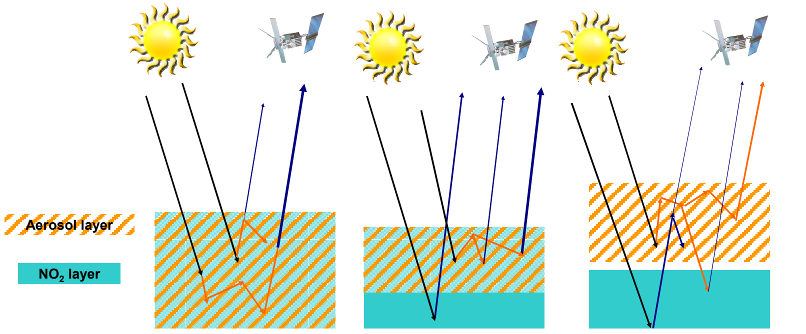
The background…

The several instruments flying on satellite (e.g., GOME, GOME-2, SCIAMACHY and OMI) allow for the observation of atmospheric pollution from space. Concentrations of trace gases (such as ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2)) can be inferred from the measured backscattered solar radiation.

The retrieval of tropospheric columns of NO2 from satellite measurements is based on several a priori assumptions used in the computation of an airmass factor (AMF). The improvement of those is essential to obtain more accurate tropospheric NO_2 values.

This sensitivity study was performed by changing in the radiative transfer model (RTM) Sciatran (Rozanov et al., 2005) the aerosol optical depth (AOD) and vertical distribution of aerosol layer, independently from the trace gas distribution. Like this we uncertainty key factors are identified and the current retrieval can be improved.

In this poster, we show the latest results obtained for the analysis performed



Why is this study important?

The aerosols present in the atmosphere will interfere with the satellite measurements of tropospheric NO_2. The signal can be :

- enhanced because of multiple scattering in aerosol layer;
- or shielded by an aerosol layer standing for example above the trace gas.

The effect of aerosol scattering is quite complex and depends both on their profile (like vertical distribution and optical depth) as well as their optical properties (e.g., size distribution and refractive index).

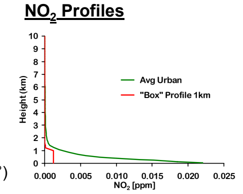
Currently in IUP-Bremen, the NO_2 retrieval method uses data taken from climatological assumptions (Richter et al., 2005). A synergistic approach is ideal to account with the full spatial and time variability of aerosols and its characteristics: using data of aerosol optical properties and/or vertical profiles measured either at ground (e.g. AERONET, EARLINET) of from space (e.g. MODIS, MERIS, CALIPSO).

The settings for the sensitivity study

Radiative transfer calculations

- RTM: Sciatran 2.2
- Surface albedo = 0.03
- Wavelengths: 425, 437.5, 440, 450nm
- SZA: 20° to 70° (every 10°)
- AOD: 0.1, 0.5, 0.9

NO_2 Profiles



"Avg Urban" profile from CHIMERE model for Paris downtown.

Aerosol Settings (440nm):

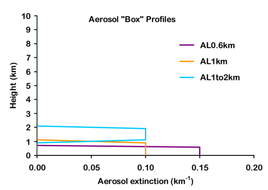
Optical properties and size distribution mostly from Dubovik et al. (2002) – 12 AERONET stations – and some from the literature consulted for profiles.

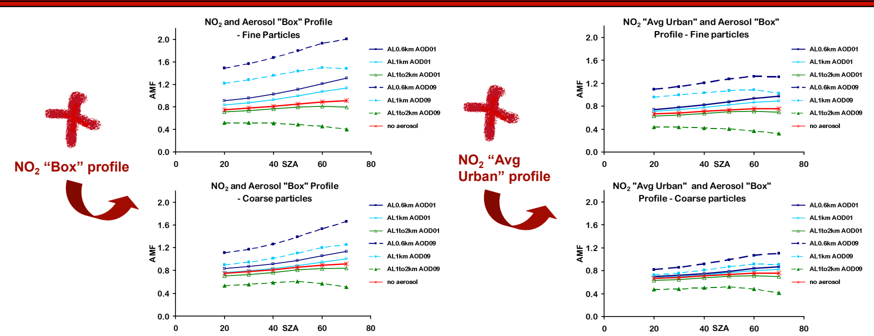
Phase function calculated with a FORTRAN program developed by Michael Mishchenko (de Rooij et al., 1984; Mishchenko et al., 1999).

Legendre expansion coefficients - fine and coarse particles.

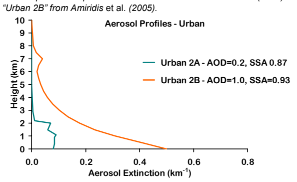
The results

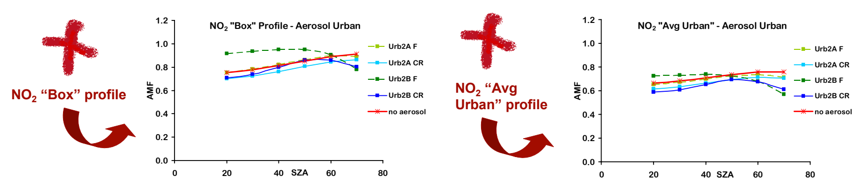
These profiles correspond to the AOD of 0.1. For the scenarios with AOD=0.5 and AOD=0.9 the shape was kept but extinction increased in proportion.



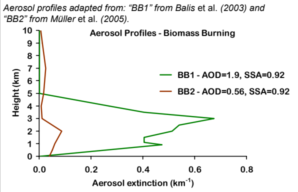


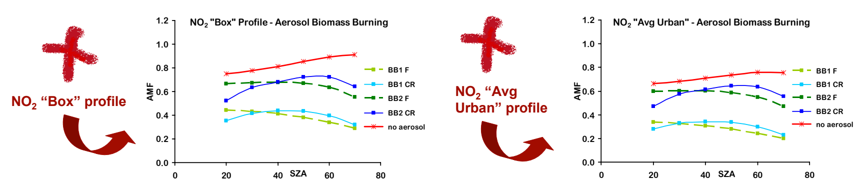
Aerosol profiles adapted from: "Urban 2A" from Chazette et al. (2005) and "Urban 2B" from Amiridis et al. (2005).





Aerosol profiles adapted from: "BB1" from Balis et al. (2003) and "BB2" from Müller et al. (2005).





- **Aerosol mixed with the trace gas** (equal layer or lower than it) will enhance the measured signal by means of multiple scattering.
- A discrete **aerosol layer above the trace gas** will act as a shield and the AMF decreases. This is often the case observed when applying the measured aerosol profiles.
- Changes in **NO_2 profile** also influence the AMF values and the higher values are obtained for the box profile.
- **More aerosol** in the atmosphere will result in the intensification of either the shielding effect or multiple scattering.
- NO_2 AMF are usually more enhanced by **fine particles**.

Acknowledgements

The CHIMERE data used to define the NO_2 profiles was kindly provided by Matthias Beekmann and Qijie Zhang.

Part of this project is funded by the European Community through the GEMS project.

Most of the aerosol data used is from measurements performed at stations from the AERONET and EARLINET network.

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What have we learned…

- The AMF are dependent on many factors and the correct definition of both aerosol and trace gas (NO_2 here) vertical profiles is important for the accuracy of the retrieved tropospheric columns.
- Depending on the **relative vertical distribution of NO_2 and aerosol**, sensitivity changes of up to **+/- 50%** can be obtained.
- For more **realistic urban profiles** of both NO_2 and aerosols, the effect of aerosol is much smaller.
- Distinction between **fine and coarse aerosol** is significant to determine the magnitude of the aerosol influence. In addition, it is also recommended to consider the **particles' optical properties and the load of aerosol**.