Impact of aerosol on the NO$_2$ air mass factors used for satellite retrievals

J. Leitão, A. Heckel, A. Richter, A. Kokhanovsky, and J.P. Burrows
Institute of Environmental Physics/Remote Sensing, University of Bremen, Germany
Email: jleitao@iup.physik.uni-bremen.de

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) Scatran (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 to 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 attempt to show the importance of such data by changing aerosol settings in the RTM.

Sensitivity Study

Radiative transfer calculations
- RTM: Scatran 2.2
- NO$_2$: 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 0.93 (Dubovik et al., 2000)

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 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

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.

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 "Crestel-Paris, France"

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$_2$.

References

Acknowledgements
Part of this project is funded by the European Community through the GEMS project.
Aerosol data from measurements performed at AERONET stations.

Sensitivity Study - results

- Absorbing aerosol will lead to lower NO$_2$. The difference to AMF
- The difference of AMF is more pronounced for high AOD values.

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.

Sensitivity Study - results

- NO$_2$ signal is amplified for larger SZA and longer wavelengths. However, for high SZA the absorptive 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. The effect of AOD enforces is much related to combination of aerosol load, layer height (and relative a trangressive 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.

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$_2$.

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 "Crestel-Paris, France"

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$_2$.