Using MERIS data in the calculation of NO_2 airmass factors

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Introduction

Nowadays the distribution of trace gases (such as O_3, NO_2, etc) in the troposphere can be determined from measurements performed by various instruments flying on satellites: GOME, GOME-2, SCIAMACHY and OMI. 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 for the impact of a different aerosol optical thickness (AOT) and albedo values on the computation of the AMF with the radiative transfer model (RTM) Sciatran (Rozanov *et al.*, 2005).

From data of MERIS instrument it is possible to obtain AOT and spectral surface reflectance values, and also cloud cover information. This can later be used in the calculations of the AMF for SCIAMACHY retrievals. However, in this poster, only an example of AOT data calculated with the BAER algorithm is presented.

Need for a change…

It is known that the **presence of aerosols** has an impact on the measurements of tropospheric NO_2. Depending on the retrieval method used, this effect is currently accounted for in different ways:

- included in the cloud treatment used (e.g. FRESCO used by KNMI)
- corrected based on model results (case of Harvard and Dalhousie groups)
- with data taken from climatological assumptions (IUP, Bremen) (Richter *et al.*, 2005)

In the IUP the **surface albedo** data used is currently taken from a database derived by R. Koelemeijer (2003) based on GOME climatologies.

Obviously, the current approach used in the IUP does not account for the spatial and time variability of both aerosols and albedo. Therefore, we attempt to include in the retrieval method data that can be continuously updated, i.e. using real measurements when available and dynamical "climatology" when it is necessary to fill gaps.

Sensitivity Study

Settings:
- RTM: Sciatran 2.0
- Type of aerosol: "continental average"
- Wavelength: 437.50 nm

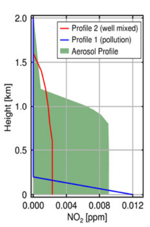

Figure 1: Profiles of NO_2 (red and blue) and aerosol used for this study.

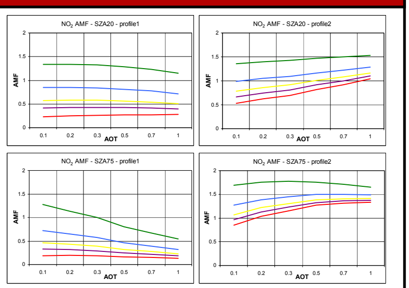

Figure 2: NO_2 AMF for profile 1 (left) and profile 2 (right) for SZA of 20° (top) and 75° (bottom) for different albedo values:

0.01 0.02 0.03 0.05 0.1

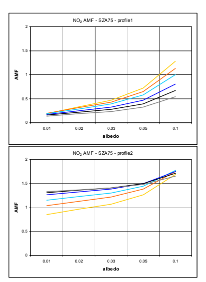

Figure 3: NO_2 AMF for profile 1 (top) and profile 2 (bottom) for SZA of 75° for different AOT values:

AOT01 AOT02 AOT03 AOT05 AOT07 AOT1

- AMF of NO_2 in lower layers (profile 1) tends to decrease with increasing AOT, especially for larger solar zenith angles (SZA).
- Signal of NO_2 can be amplified when it is homogeneously mixed in an aerosol layer, however this influence is not systematic.
- For all cases an increase of albedo values will lead to an increase of the NO_2 AMF. This effect becomes weaker with increasing aerosol load.

MERIS data and BAER algorithm

The AOT values are calculated with the algorithm BAER (Bremen AErosol Retrieval) (von Hoyningen-Huene *et al.*, 2003 and 2006).

In short this method comprises:

- **Aerosol reflectance** calculation by eliminating the surface reflectance and Rayleigh path radiance from the top of atmosphere (TOA) reflectance.
- **Land, ocean, desert and cloudy pixels** sorting through TOA reflectance levels in channel 8 (0.870 μm).
- **Land surface reflectance** estimation with a linear mixing model of vegetation and non-vegetation spectra, tuned by the normalized differential vegetation index (NDVI).
- **AOT** determination by look-up-tables (LUT) that represent a relationship between aerosol reflectance and AOT (LUT generated using RTM).

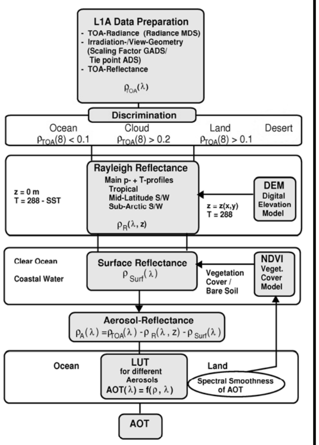

Figure 4: Schematic representation of the BAER retrieval procedure for the aerosol optical thickness.

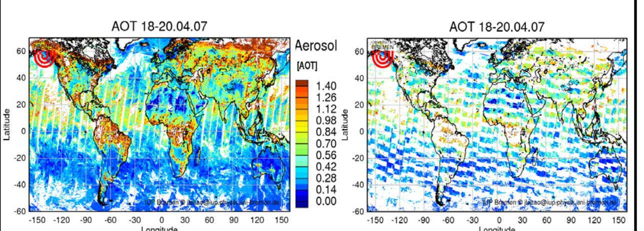

Figure 5: Global AOT values for the period of 18 to 20 of April of 2007 as retrieved using the BAER algorithm on MERIS data (left) and values when masked with available SCIA measurements (right).

Conclusions & Future work…

- From the sensitivity study it is clear that aerosol and albedo can have a large influence on the NO_2 AMF and such influence cannot always be predicted.
- The profile and type of aerosol considered influences greatly the AMF calculations and therefore it needs to be selected carefully – data from ECMWF may be used to select and define the profiles.
- Improvements in BAER are necessary to better identify clouds and eliminate artefacts that interfere with the calculation of accurate AOT values (e.g., effect of sunglint).
- The novel dataset of aerosol and albedo values (taken from MERIS) will be later incorporated in the retrieval method of tropospheric NO_2.
- This new method (with the latest a priori assumptions) can then be applied to a larger data set.

Acknowledgements

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References

- Koelemeijer, R. B. A., J. F. de Haan, and P. Stammes; *A database of spectral surface reflectivity in the range 335–772 nm derived from 5.5 years of GOME observations*; J. Geophys. Res.; 108(D2); 4070; doi:10.1029/2002JD002429; 2003.
- Richter, A., J. P. Burrows, H. Nüß, C. Granier, and U. Niemeier; *Increase in tropospheric nitrogen dioxide over China observed from space*; Nature; 437; 129-132; doi: 10.1038/nature04092, 2005.
- Rozanov, A., V. Rozanov, M. Buchwitz, A. Kokhanovsky, and J.P. Burrows; *SCIATRAN 2.0 - A new radiative transfer model for geophysical applications in the 175 - 2400 nm spectral region*; Adv.Space Res.; 36(5); 1015-1019; doi:10.1016/j.asr.2005.03.012, 2005.
- von Hoyningen-Huene, W., A. A. Kokhanovsky, J. P. Burrows, V. Bruniquel-Pinel P. Regner, and F. Baret; *Simultaneous determination of aerosol- and surface characteristics from top-of-atmosphere reflectance using MERIS on board of ENVISAT*; Advances in Space Research; 37; 2172–2177; 2006.
- von Hoyningen-Huene, W., M. Freitag, and J. B. Burrows; *Retrieval of aerosol optical thickness over land surfaces from top-of-atmosphere radiance*; J. Geophys. Res.; 108(D9); 4260; doi:10.1029/2001JD002018; 2003.

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