SATELLITE VALIDATION OF TROPOSPHERIC TRACE GASES WITH MAX-DOAS MEASUREMENTS DURING THE DANDELIONS FIELD CAMPAIGN

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Hilke Oetjen[1], Ellen Brinksma[2], Andreas Richter[1], Folkard Wittrock[1], and John P. Burrows[1]

[1] Institute of Environmental Physics, University of Bremen, P. O. Box 330440, D-28334 Bremen, Germany
[2] Royal Netherlands Meteorological Institute (KNMI), 3730 AE De Bilt, The Netherlands

Introduction

This study presents time series for tropospheric amounts of nitrogen dioxide (NO_2), formaldehyde (HCHO) and glyoxal (CHOCHO) retrieved from MAX-DOAS measurements at the DANDELIONS (Dutch Aerosol and Nitrogen Dioxide Experiments for vaLIdation of OMI and SCIAMACHY) field campaign that took place at Cabauw (Netherlands) from May 9 to July 17, 2005. These results are compared to independent ground-based and SCIAMACHY satellite data.
It is shown that the multi-axis-DOAS technique in combination with an automated profile retrieval is a powerful tool in establishing long-term observations of tropospheric trace gases and facilitating the validation of tropospheric column amounts from satellite instruments.

Measurements at Cabauw

As part of the DANDELIONS project, MAX-DOAS measurements of different trace gases have been carried out in Cabauw (52°N, 5°E), Netherlands from May 9 to July 17, 2005. The objective of this experiment is the validation of OMI, SCIAMACHY and AATSR measurements of aerosols and NO_2 over the Netherlands. Additionally, the quality of ground-based MAX-DOAS observations will be investigated by the intercomparison of different set-ups and by comparison to an NO_2 LIDAR experiment as well as to an *in situ* monitor (see table 1). Cabauw is located in a rural environment but close to the cities of Utrecht and Rotterdam. The Cabauw experimental site is operated by the Royal Netherlands Meteorological Institute (KNMI). The following Table 1 shows some of the participating instruments, partly used in this study for the interpretation of the MAX-DOAS data.
The Bremian MAX-DOAS instrument was located inside a container with the telescope fixed to a small mast outside (see figure 1). The off-axis port was directed to the southwest parallel to a street with usually low traffic about 50 metres away.

Figure 1: Measurement site at Cabauw

Table 1: Selection of instruments that participated in DANDELIONS

Instrument	*Group*	*Products*
MAX-DOAS	IUP Bremen	NO_2 (HCHO, CHOCHO)
MAX-DOAS	IUP Heidelberg	NO_2
MAX-DOAS	IASB/BIRA Brussels	NO_2
NO_2-LIDAR	KNMI	NO_2
***in situ* monitor**	KNMI	NO_2 near to the surface
SCIAMACHY		NO_2 (CHOCHO, HCHO), absorbing aerosol index
OMI		NO_2, aerosol optical depth
Boundary layer LIDAR	KNMI	aerosol extinction
ozone and radio sondes	KNMI	T, p, relative humidity, ozone

Experimental Setup: Telescope

The MAX-DOAS-telescope is shown in figure 2. This set-up is able to switch between zenith and any elevation angle between 0° and 30°. Here, a scan in 1°-steps from 1° to 18° elevation in addition to a 30°-measurement and zenith measurement was chosen. The temporal resolution is then given as 20 minutes for a complete measurement cycle.

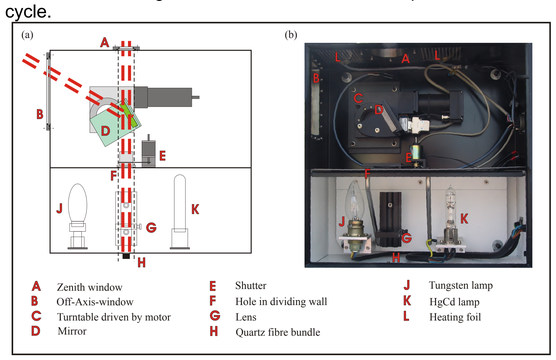

Figure 2: Schematic of the telescope. Left panel: mirror position for zenith measurements. Right panel: off-axis mirror position.

MAX-DOAS Data Analysis

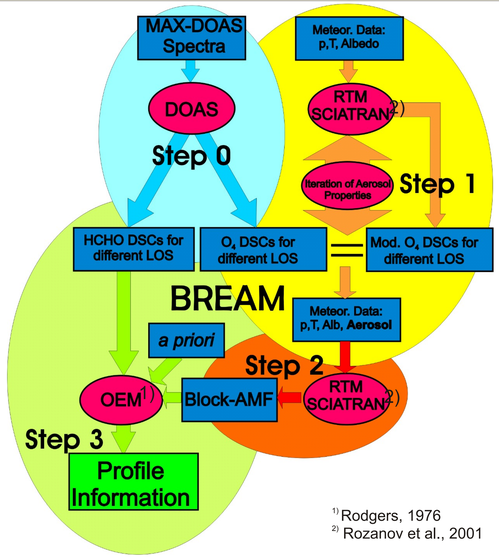

Figure 3: Flowchart for the retrieval steps applied to the measured differential slant columns (DSC) in order to obtain profile information (here illustrated for formaldehyde). The DSCs of O_4 are used to retrieve aerosol properties like the extinction profile of the atmosphere.

Nitrogen Dioxide NO_2

The figure 4 shows ground-based DOAS measurements compared to satellite data and to *in situ* measurements respectively. Excellent agreement is found for both tropospheric columns and NO_2 concentrations demonstrating the ability of the MAX-DOAS to work as a link between *in situ* and satellite observations.
The correlation of 0.72 between the ground-based measurements and SCIAMACHY tropospheric NO_2 columns (IUP Bremen data product) was found (see figure 5). For the ground-based data, days with clouds are included. For the satellite data, pixels with less than 30 percent cloud cover. The closest pixel on each day was used, subject to a maximum distance of 50km.

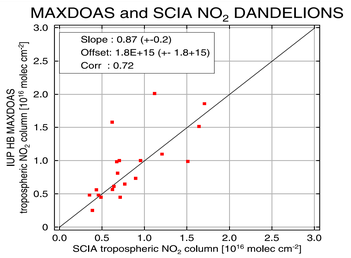

Figure 5: Correlation plot for the data shown in figure 4, upper panel.

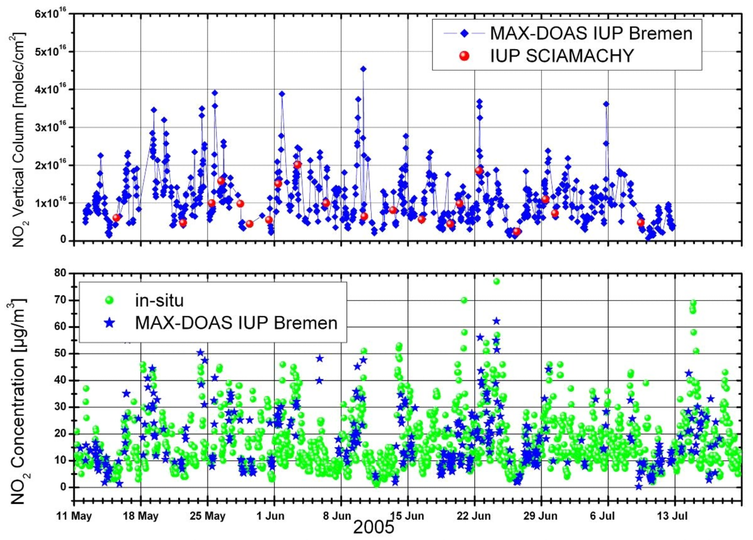

Figure 4: Upper panel: Comparison of tropospheric NO_2 columns from the MAX-DOAS and SCIAMACHY. Lower panel: Intercomparison plot showing data of an *in situ* NO_2 monitor (KNMI) and the NO_2 concentration derived from a ground layer of 50 m thickness.

Formaldehyde HCHO & Glyoxal CHOCHO

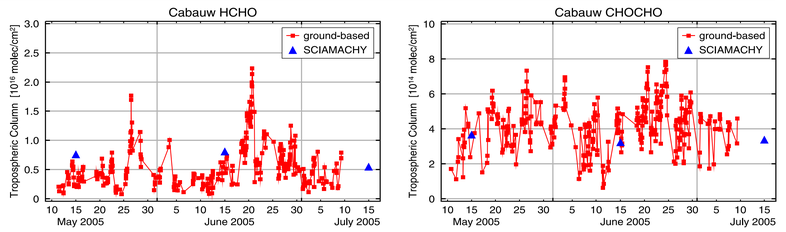

Figure 6: Validation of formaldehyde and glyoxal above Cabauw. For SCIAMACHY, monthly means were calculated. The tropospheric columns of formaldehyde are more variable than for those of glyoxal probably due to direct emissions from anthropogenic sources in the heavily polluted area. However, similarities can be observed: Enhanced HCHO is always associated with an increase in CHOCHO, e.g. 25/26 May or around 20 June.

Summary & Outlook

- It was shown that MAX-DOAS data can be used for the validation of tropospheric column amounts from satellites like SCIAMACHY: Excellent agreement for NO_2 and on average for CHOCHO and HCHO was found.
- Excellent agreement between the *in situ* No_2 from KNMI and the Bremen MAX-DOAS data.
- The 'new' species glyoxal (Volkamer et al., 2005) can be detected from ground and from the satellite.
- Future work:
  - Comparison of the NO_2 profiles with the LIDAR measurements and with model calculations.
  - Comparison of the MAX-DOAS aerosol extinction profile with independent measurements.

Selected References

- H. Oetjen, F. Wittrock, E. Brinksma, S. Fietkau, C. Hak, A. Heckel, W. Junkermann, T. Medeke, A. Richter and J. P. Burrows: BREDOM: Using MAX-DOAS Measurements for long-term Observations of tropospheric Trace Gases, in proceedings of the ACCENT symposium, Urbino, September 2005.
- Richter, A., Burrows, J. P., Nuß, H., Granier, C, Niemeier, U., Increase in tropospheric nitrogen dioxide over China observed from space, Nature, 437, 129-132, doi: 10.1038/nature04092, 2005.
- C. D. Rodgers: Retrieval of atmospheric temperature and composition from remote measurements of thermal radiation., *Rev. Geophys. Space Phys.*, 14 (4), 609-624, 1976.
- A. Rozanov, V. Rozanov, and J. Burrows, A radiative transfer model for a spherical planetary atmosphere: combined differential-integral approach involving the Picard iterative approximation, *J. Quant. Spectrosc. Radiat. Transfer*, 69, 491, 2001.
- R. Volkamer, P. Spitz, J. P. Burrows, U. Platt: High-resolution absorption cross-section of glyoxal in the UV-vis and IR spectral range, *J. Photochem Photobiol A*, 172[1], 35-46, 2005.
- F. Wittrock, H. Oetjen, A. Richter, S. Fietkau, T. Medeke, A. Rozanov, J. P. Burrows: MAX-DOAS measurements of atmospheric trace gases in Ny-Alesund - Radiative transfer studies and their application, *Atmos. Chem. Phys.*, 4, 955-966, 2004.
- F. Wittrock: The retrieval of oxygenated volatile organic compounds by remote sensing techniques, Dissertation, Institute of Environmental Physics, University of Bremen, Bremen, 2006.

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Please also visit the DANDELIONS webpage:
http://www.knmi.nl/omi/research/validation/dandelions/

Universität Bremen

www.doas-bremen.de

hilkeo@uni-bremen.de