Multi-axis DOAS observations of atmospheric trace gases in Nairobi and Bremen

S. Fietkau, T. Medeke, D.C. Adukpo, A. Ladstätter-Weißenmayer, A.G. Löwe, H. Oetjen, A. Richter, F. Wittrock and J. P. Burrows

Institute of Environmental Physics,
University of Bremen, P. O. Box 330440,
D-28334 Bremen, Germany
fietkau@iup.physik.uni-bremen.de, medeke@iup.physik.uni-bremen.de

Introduction

Global pollution and climate change require worldwide investigation of the atmosphere to evaluate anthropogenic causes. Differential Optical Absorption Spectroscopy (DOAS) is able to detect simultaneously many atmospheric trace gases relevant to global warming (e.g. carbon dioxide, methane, ozone), the development of the stratospheric ozone hole (e.g. ozone, halogen compounds) or smog which results from fossil fuel-combustion and biomass burning (e.g. tropospheric ozone, nitrogen dioxide, formaldehyde). In addition, these measurement technique can be used for both ground based observations (e.g. Network for Detection of Stratospheric Change - NDSC) and satellite instruments (e.g. Global Ozone Monitoring Experiment - GOME, Scanning Imaging Absorption Spectrometer for Atmospheric Chartography - SCIAMACHY) which allows to combine highly time and spatial resolved data of selected locations with data of global coverage.

In this poster a new approach to derive profile information for different trace gases from ground based UV/VIS measurements is described. Results from measurements at different latitudes within the BREDOM (Bremen DOAS Network for Atmospheric Measurements) are presented.

Experimental Setup

- CCD detector Andor DV-440BU (2048x512 pixel)
- spectrograph L.O.T. MS257 (focal length 257 mm, 1200 l/mm grating)
- telescope with five viewing directions (4 off-axis between 0° and 30° above the horizon, 1 zenith), realized by a mirror on a turntable moved by a computer controlled servomotor (figure 1)
- wavelength range 320-410 nm
- similar setup at all measurement locations:

  Bremen (53° 04' N, 8° 48'E)
  Nairobi (1° 19' S, 36° 55' E)
  Ny Alesund (78° 54' N, 11° 54' E)

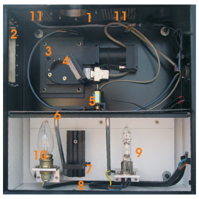

Figure 1 Setup of the telescope

1 Zenith window
2 Off-Axis window
3 Turntable driven by motor
4 Mirror
5 Shutter
6 Hole in dividing wall
7 Lens
8 Quartz fibre bundle
9 Tungsten lamp
10 HgCd lamp
11 Heating foil

Retrieval

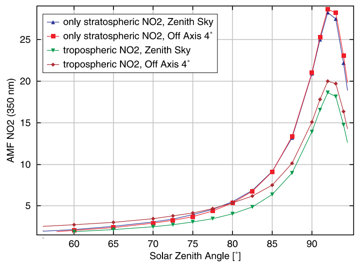

Figure 2 Airmass Factor Calculation for different Atmospheric Profiles

- DOAS algorithm to derive slant columns (SC) of the trace gases
- calculation of air mass factors (AMF) for different line of sights using the radiative transfer model SCIATRAN [1] (fully spherical, refraction included, full multiple scattering), an example for AMF calculation is shown in figure 2
- concentration of the absorbers is calculated in vertical columns (VC) by using the slant columns and the air mass factors: VC = SC / AMF

Measurements

Off axis DOAS measurements provide profile information about the absorber, since the light paths of the absorber through the troposphere will be enhanced for lower angles to the horizontal line.

The concentration of the absorber is given in vertical columns which are calculated from the SC and the airmass factor (AMF) by: VC = SC / AMF.

Since the VC has to be the same for all viewing directions for the right calculation of AMF, profile information can be obtained by using different AMF calculated with different profiles of the absorber. In Fig. 3 and 4, the calculation of the vertical columns for two different profile situations is shown.

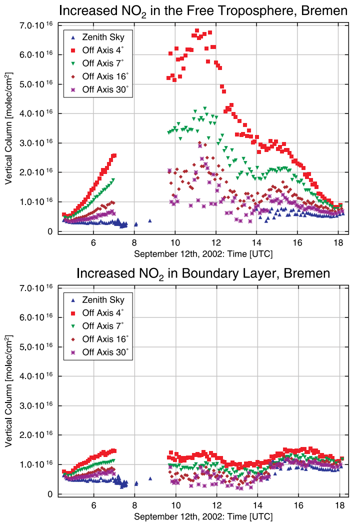

Figure 3 NO_2 above Bremen

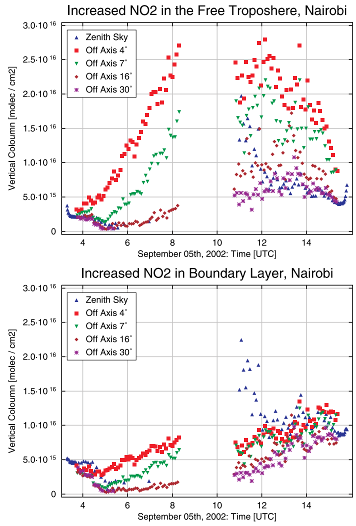

Figure 4 NO_2 above Nairobi

No_2 above Bremen (Figure 3)

- two different profile situations:
  increased NO_2 in the boundary layer,
  increased NO_2 in the free troposphere
- maritime aerosol
- stratospheric NO_2 from SLIMCAT [2] for mid latitude, tropospheric NO_2 with a constant vertical distribution
- most consistent results (vertical columns of the different viewing directions close together) with NO_2 in the boundary layer

NO_2 above Nairobi (Figure 4)

- similar results as in Bremen
- two different profile situations:
  increased NO_2 in the boundary layer,
  increased NO_2 in the free troposphere
- stratospheric NO_2 from SLIMCAT for equator, tropospheric NO_2 with a constant vertical distribution
- urban aerosol
- most consistent results with NO_2 in the boundary layer

Conclusions

Results of the new multi axis- (MAX-) DOAS instrument from measurements at different latitudes are presented. The capability to derive not only column amounts of different trace gases but also some information about the vertical distribution is demonstrated. This enables us to further investigate the consistency of trace column amounts derived from different platforms.

The similarity of the setup of the instrument at the different measurement sites gives us the opportunity to validate the SCIAMACHY instrument at different latitudes.

References

[1] Rozanov, A., V. Rozanov, and J.P. Burrows, A numerical radiative transfer model for a spherical plantary atmosphere: combined differential-integral approach involving the Picard iterative approximation, Journal of Quantitative Spectroscopy & Radiative Transfer, 69, 491, 2001.

[2] Chipperfield, Martin, et al., 1999: Multiannual simulations with a three-dimensional chemical transport model, *JGR*, 104,1781-1805.

[3] Wittrock, F., M. Eisinger, A. Ladstätter-Weißenmayer, A. Richter and J.P. Burrows, Groundbased UV/VIS measurements of O3, NO2, BrO and OClO over Ny Alesund (78°N), Polar stratospheric ozone, Air pollution research report 56, Proceedings of the 3rd European Polar Ozone Symposium, Schliersee, Germany, CEC, 329-334, 1996.

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