First Results of Multi Axis DOAS Measurements in Nairobi

UP 3.8

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Introduction

Pollution and climate change are significant global environmental issues. To improve our understanding of the impact of both natural phenomena (e.g. lightning, volcanic eruptions) and anthropogenic emissions from fossil fuel combustion and biomass/bio fuel burning, global measurements of key atmospheric constituents are required. Differential Optical Absorption Spectroscopy (DOAS) is a remote sensing measurement technique, which enables many important trace gases to be detected e.g.: a) tropospheric ozone, nitrogen dioxide, formaldehyde during pollution episodes and smog, b) stratospheric ozone, nitrogen oxides and halogen compounds and c) water vapour.

DOAS instrumentation is in use in ground based observations (e.g. Network for Detection of Stratospheric Change - NDSC), aboard aircraft (e.g. the DLR Falcon) and balloon platforms and on satellites in sun synchronous orbits around the earth (e.g. Global Ozone Monitoring Experiment - GOME, aboard ESA ERS-2 and Scanning Imaging Absorption Spectrometer for Atmospheric Chartography SCIAMACHY aboard ENVISAT).

The ground based measurements yield high temporal and spatial resolution at selected locations whereas the satellite currently provide global coverage at selected times. Combining the different data sets enables the measurements to be validated and in addition yields synergistic advantages and tests our theoretical understanding of the physical and chemical processes, which determine the behaviour and nature of the atmosphere..

In this poster a short overview explaining the BREDOM network and the measurement site Nairobi is provided. In particular the experimental arrangement of the ground based instrument in Nairobi is described and some first results of the Nairobi measurements presented.

BREDOM

The Bremian DOAS Network for Atmospheric Measurements (BREDOM) consists of seven ground based stations at different latitudes (see Fig. 1):

- Ny-Ålesund (79°N, 12°E), Bremen (53°N, 9°E), Zugspitze(47°N, 10°E) and Nairobi (1°S, 37°E) in operation (UV range), second detector-spectrometer system for visible range planned for 2003,
- Setup of new sites: Summit (72°N, 38°W) June 2003, Merida (8°N, 71°W) fall 2003, Maledives not before fall 2003.

All BREDOM instruments will be operating with a similar setup and the new off-axis viewing geometry - a new application of the DOAS method to distinguish between stratospheric and tropospheric absorbers up to a determination of slightly resolved profiles.

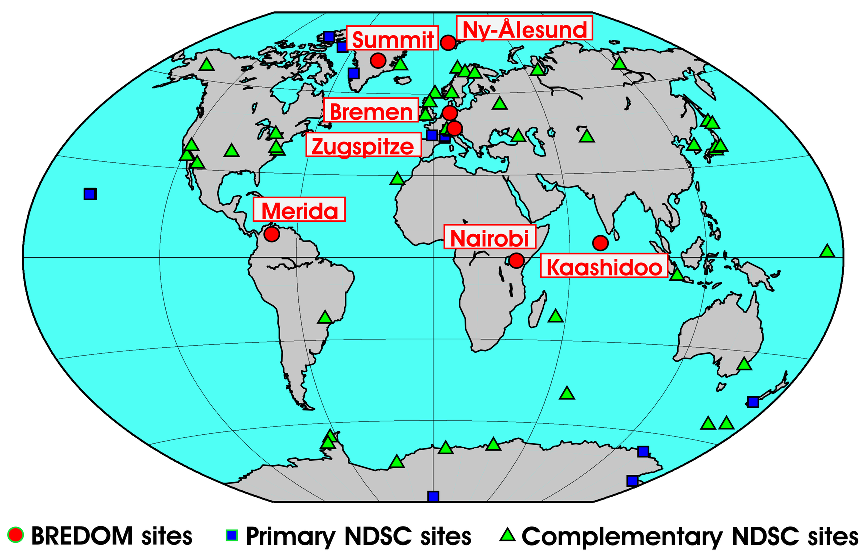

Figure 1: Map of the BREDOM and NDSC sites

Measurement Site Nairobi

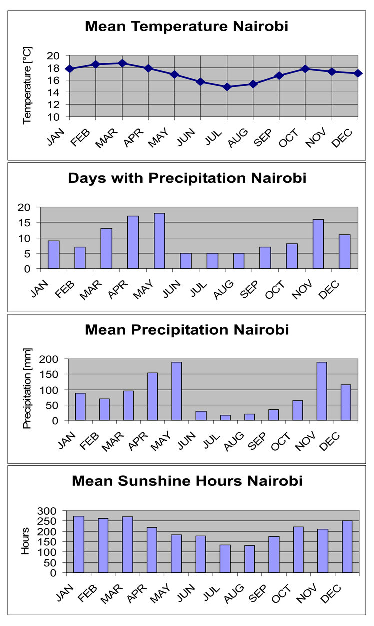

Figure 2: Climatic conditions of Nairobi [4]

Nairobi is one of our tropical stations and lies near the equator, 1,2°S and 36,8°E. The high altitude of about 1620m above sea level keeps it in a moderate climate (Figure 2). Temperatures rarely drop below 15°C or get warmer than 30°C year-round. January-March is usually warm, with temperatures rising to about 28-30°C. The cool time of year is April-July, when temperatures can dip below 20°C. Rainy seasons typically occur April through May and October-December, though August is known to be a wet month as well. Mean sunshine hours ranging from 130 hours in August to about 270 hours in January.

The ground based DOAS instrument is installed in the headquarter of the United Nations Environmental Programme (UNEP), at the outskirts of Nairobi. Its telescope (Figure 3) is mounted on the top roof stairs of a building with viewing direction of the of axis measurements to the south, downtown Nairobi.

Figure 3: Telescope with viewing direction downtown Nairobi

Experimental Setup

- Czerny-Turner Spectrograph L.O.T. MS257(focal length 257 mm, 1200 l/mm grating)
- CCD Andor DV440-BU (2048 x 512 Pixel)
- UV/vis wavelength region: 320 – 410 nm
- Spectral resolution: ~0.5 nm
- Targeted trace gases: O_3, NO_2, BrO, HCHO, IO, OClO
- Atmospheric Viewing: continuous alternating observations between zenith and horizon (4 off axis viewing directions: 4°, 7°, 16°, 30°), achieved by employing a mirror on a turntable moved by a computer controlled servomotor as shown in Figure 4

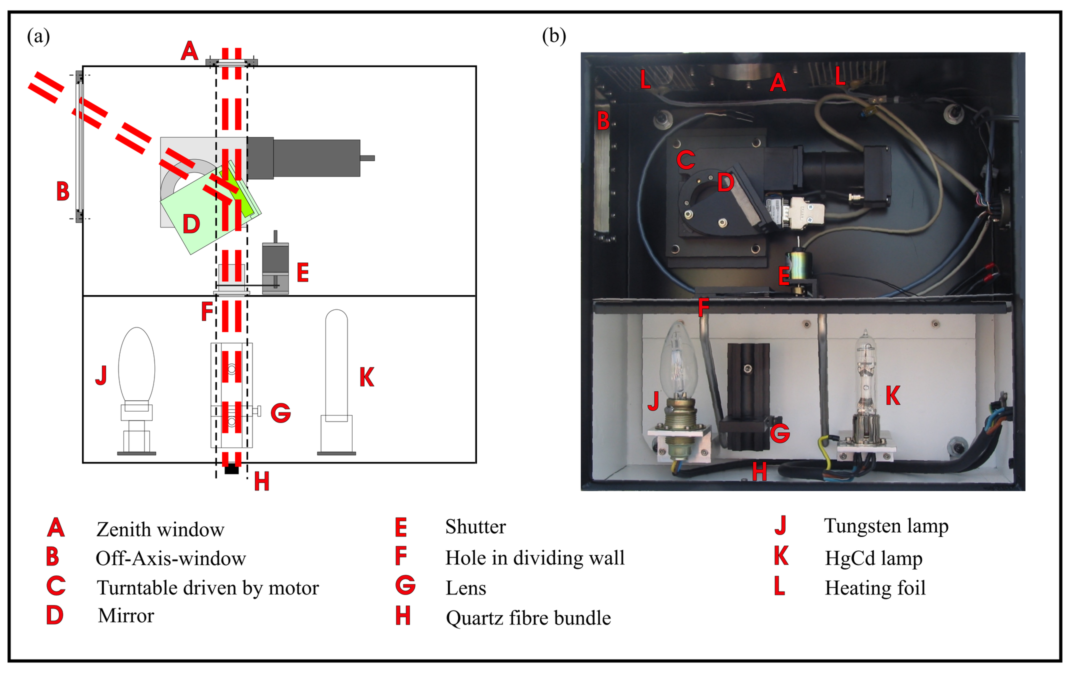

Figure 4: Setup of the telescope

References

[1] TOMS data provided by NASA, http://toms.gsfc.nasa.gov/
[2] SHADOZ: Thompson, A. M. et.al., Southern Hemisphere Additional Ozonesondes (SHADOZ) 1998-2000 tropical ozone climatology, 1, Comparison with Total Ozone Mapping Spectrometer (TOMS) and ground-based measurements, *J. Geophys. Res., 108*(D2), 8238, doi:10.1029/2001JD000967, 2003.
[3] Wittrock, F., M. Eisinger, A. Ladstätter-Weißenmayer, A. Richter and J.P. Burrows, Groundbased UV/VIS measurements of O_3, NO_2, 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.
[4] Urban Climate Homepage at the Meteorological Institute of the University of Freiburg, www.stadtklima.de

First Results

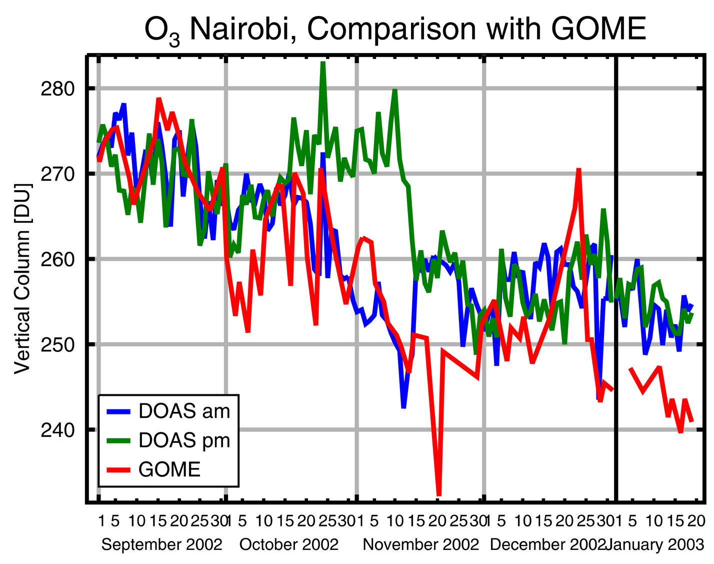

Figure 5a: O_3 Nairobi, Comparison with GOME

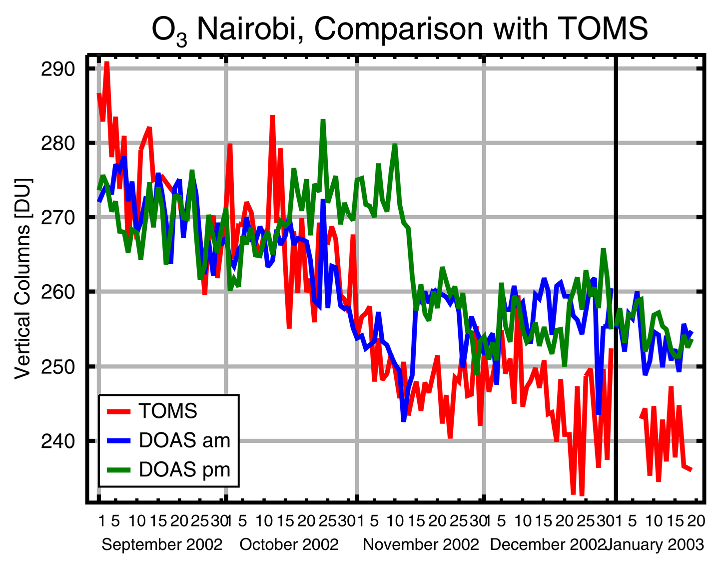

Figure 5b: O_3 Nairobi, Comparison with TOMS [1]

In Figures 5a to 5c comparisons of the ozone measurements with GOME, TOMS and SHADOZ sondes from Nairobi are shown. There is a good agreement of the GOME, TOMS and SHADOZ data with the Nairobi measurements, the absolute values as well as the variation with time. But from mid November there is a difference of 5-15% of the SHADOZ data to the ground based measurements. For the ground based measurements morning and afternoon values are given. There appears to be no strong diurnal variation of ozone except the time from mid October to mid November 2002. This appears to be stratospheric rather than tropospheric in origin. Up to now there is no well founded explanation for this phenomenon.

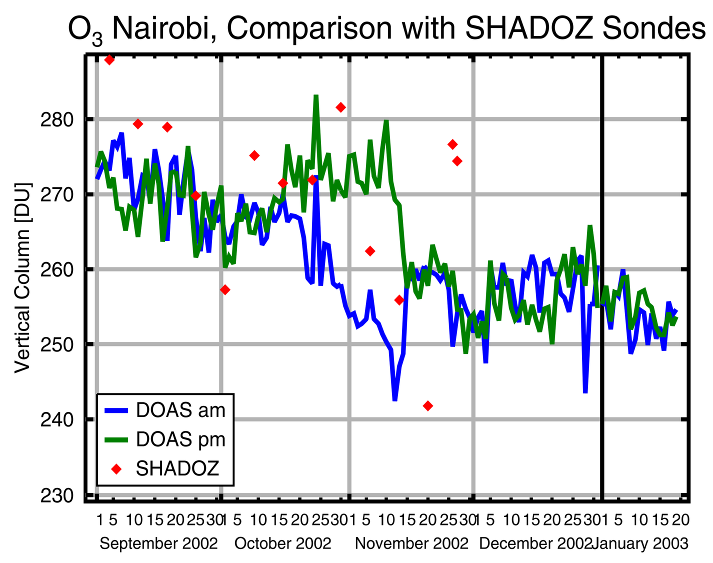

Figure 5c: O_3 Nairobi, Comparison with SHADOZ [2]

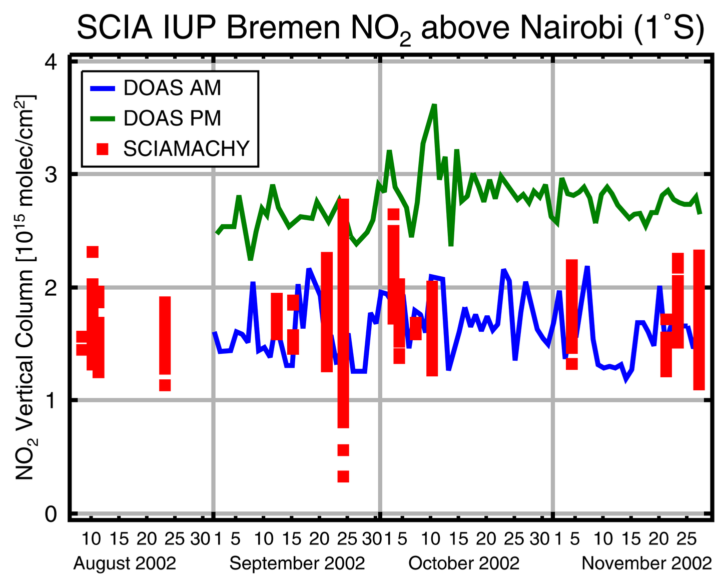

Figure 6: NO_2 above Nairobi

The results of a comparison between SCIAMACHY NO_2 observations and the Nairobi measurements are shown in Figure 6. As can be seen, both the absolute values and the variation with time is well captured by the SCIAMACHY data. The ground based measurements showing morning and evening columns show a pronounced diurnal variation. This is part due to photolysis of N_2O_5 in stratosphere and the diurnal variation of NO_2 in the troposphere. This is being investigated. The time of the ENVISAT overpass is close to 10 AM, so that the SCIAMACHY data should be close to the morning measurements. This is in deed the case!!

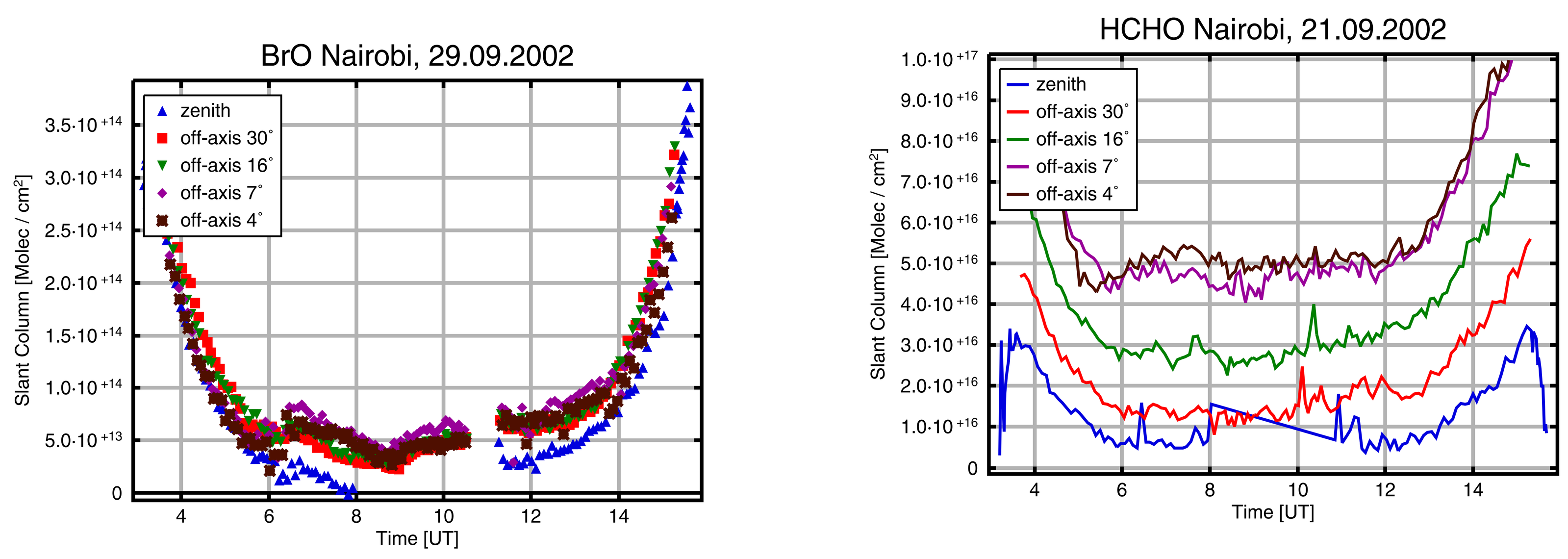

Figure 7: Slant columns of BrO (29.09.2002) and Formaldehyde (21.09.2002) for the different viewing directions

Figure 7 shows results of slant columns of BrO and HCHO from the ground based measurements. From the differences in the values of HCHO for the different viewing directions it can clearly be seen that there is a tropospheric amount of Formaldehyde. In contrast to that there are only stratospheric amounts of BrO on the 29th of September 2002, only small differences in the slant columns of the different viewing directions can be seen.
This example demonstrates the capability to derive not only column amounts of different trace gases but also some information about the vertical distribution of these absorbers.

Conclusions

At end of August 2002 the Nairobi DOAS station started its measurements and since then has been measuring continuously in operation. The results demonstrate the reliability and accuracy of the instrument and it is already providing scientifically important and challenging observations of different trace constituents.
Significantly it has also been demonstrated that the ground based DOAS station in Nairobi is well suited for validation of both GOME and SCIAMACHY column and profile measurements.
For more information about tropical ozone measurements see also talk UP 5.5 of A. Ladstätter-Weißenmayer.

Acknowledgements

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