BrO measurements in Nairobi (1°S, 36°E) with the multi-axis DOAS method

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Introduction

The discovery of a rapid decline in springtime ozone concentrations over Antarctica and also the decreasing of ozone in the midlatitudes of about 0,5% per annum since 1979 has led to a number of studies about the mechanisms of this destruction. Several studies have shown that halogen radicals involved in catalytic cycles play an important role in the stratospheric ozone depletion. While the majority of inorganic chlorine in the stratosphere is tied up in the relatively long lived reservoirs HCl and $ClONO_2$, leaving at most a few percent of inorganic chlorine available in the reactive form as ClO the destruction rates of HBr and $BrONO_2$, the main reservoirs of bromine oxide, are much faster. This makes BrO to the predominant inorganic bromine species in the stratosphere. Because of the partitioning bromine is much more efficient than chlorine on a per atom basis in destroying ozone. Observations and model calculations suggest that the catalytic cycles involving reactions of BrO with HO_x and BrO with ClO represent important destruction mechanisms for lower stratospheric ozone.

In this poster a short overview about the first systematic ground-based measurements of BrO at low latitudes over a period of several years is presented. In particular the experimental arrangement of the ground based instrument in Nairobi and the analysis is described and some results with respect to BrO are shown.

Experimental Setup

Nairobi is one of the tropical stations of BREDOM (BRemian DOAS network of atmospheric Measurements) which is operated by the University of Bremen. The ground based DOAS (Differential Optical Absorption Spectroscopy) instrument is installed in the headquarter of the United Nations Environmental Programme (UNEP), at the outskirts of Nairobi. Its telescope (Figure 1) is mounted on the top roof stairs of a building with viewing direction of the off axis measurements to the south, downtown Nairobi. The details and specifications of the instrument:

- Czerny-Turner Spectrograph L.O.T. MS257 (focal length 257 mm, 1200 l/mm grating) and CCD Andor DV440-BU (2048 x 512 pixels) for the UV spectral range
- L.O.T. MS260i(focal length 260 mm, 600 l/mm grating) and CCD Andor DV420-BU (1024 x 256 pixels) for the visible range
- UV/vis wavelength regions: 320 – 410 nm, 395 - 565 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 1
- daily calibration measurements

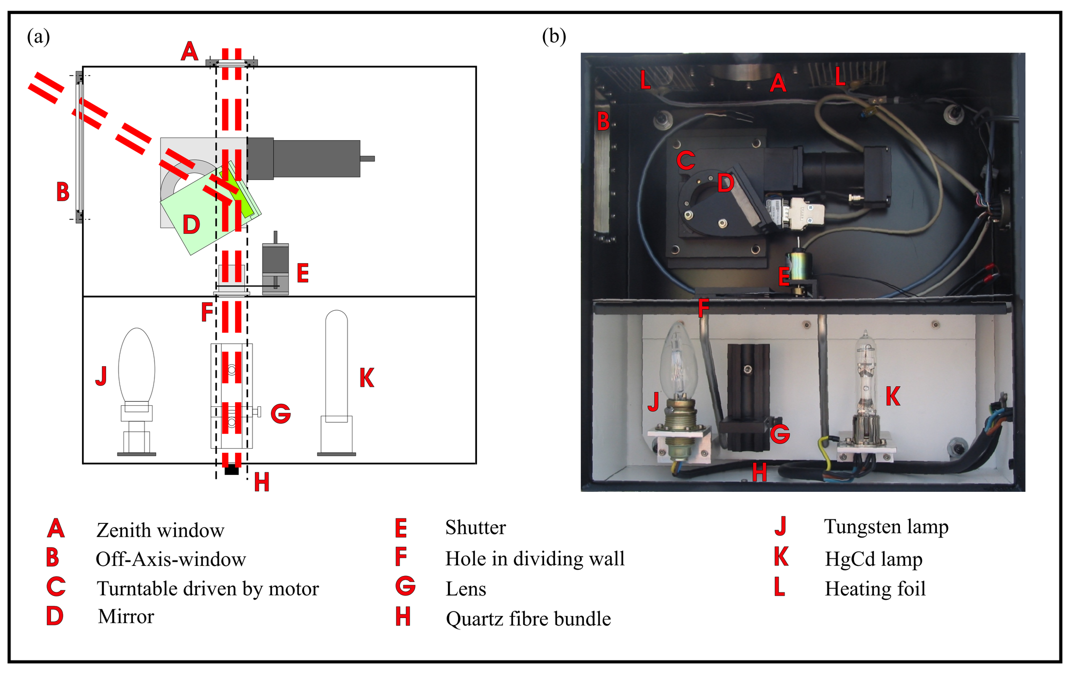

Figure 1: Setup of the telescope.

Data Analysis

Analysis method:

- to derive slant columns of trace gases the DOAS method is used
- to convert slant columns (SC) to vertical columns (VC) radiative transport model SCIATRAN calculation of air mass factors (AMF)
- full spherical, refraction and full multiple scattering included

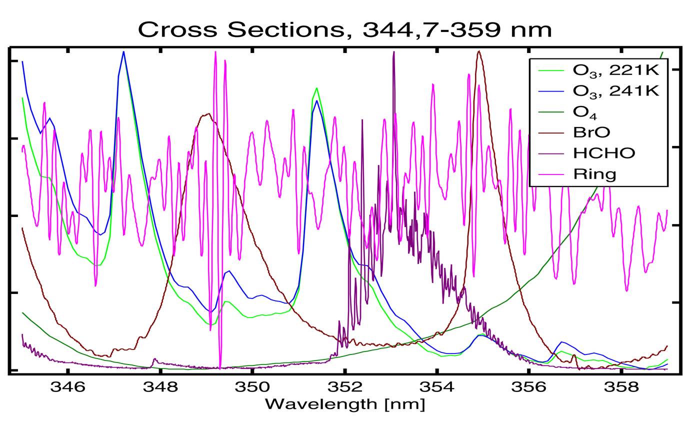

Figure 2: Relevant cross sections in the BrO fitting window 344,7-359 nm.

BrO fit:

- fitting window: 344,7-359 nm
- Cross sections (see Figure 2): O_3 (221 and 241K), NO_2, O_4, BrO, HCHO, Ring
- to derive the DSCD at 90° solar zenith angle (SZA) a spectrum at 80° SZA is used as background

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Measurements

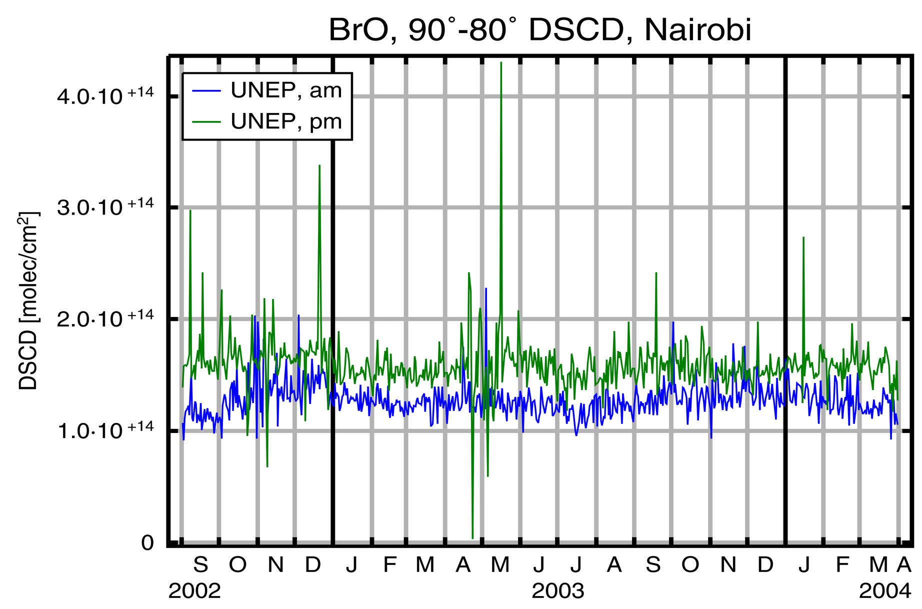

Figure 3: Observations of the daily morning and afternoon BrO Slant column values at 90° SZA. A spectrum taken near 80° solar zenith angle is used as background.

Figure 3 shows observations of the daily variations of differential slant column densities (DSCD) around 90° solar zenith angle (SZA). As background a spectrum at 80° SZA taken on the same day is used in the analysis. The total amount of these slant columns is around $1{,}5 \cdot 10^{14}$ molec/cm^2. Compared to measurements at other latitudes e.g. *Fish* at Aberdeen (1-$1{,}5 \cdot 10^{14}$ molec/cm^2), *Arpag* at Colorado (around $1 \cdot 10^{14}$ molec/cm^2) and *Kreher* at Arrival Heights (1-$3 \cdot 10^{14}$ molec/cm^2) the values are in the same order of magnitude.
It can be seen that the afternoon values (green) are slightly higher than the morning values (blue).
The seasonal variation of BrO is most likely controlled by the seasonal variation in stratospheric NO_2. With increasing NO_2 abundance an increasing amount of BrO reacts to its reservoir species $BrNO_2$. The fact that the observations of NO_2 in Nairobi don't show a strong seasonal variation (see Figure 4) is in agreement with the BrO measurements also varying only slightly.

A comparison with modelled BrO DSCD's is in preparation.

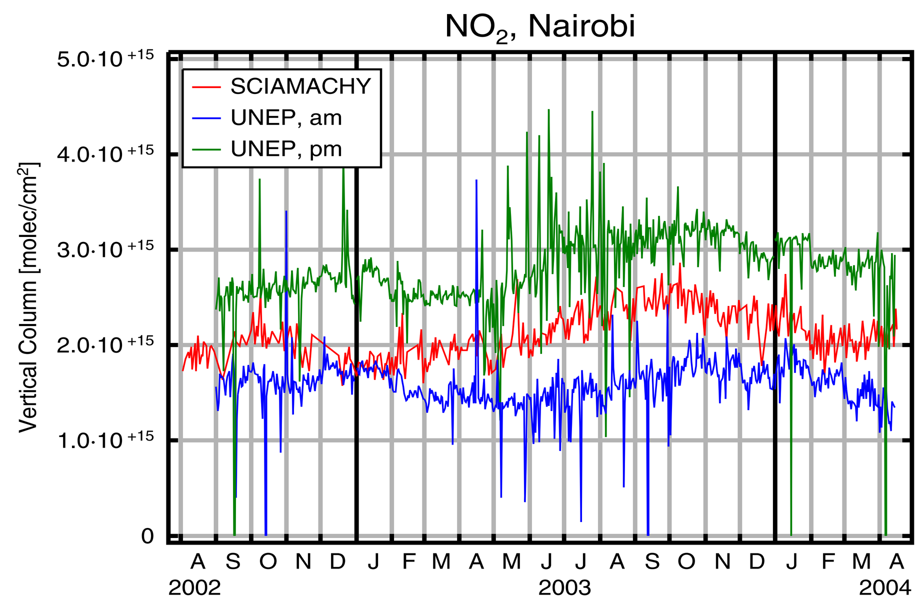

Figure 4: NO_2 vertical columns above Nairobi observed at solar zenith angles (SZA) around 90°. Morning and afternoon values are given.

Slant columns of BrO for the different lines of sight are shown in figure 5. There are clear indications for tropospheric BrO. But on most of the days the atmospheric situation is similar to that on the 16th of February 2004. The slant columns of the different viewing directions are close together, it would be difficult to analize tropospheric BrO. On some days of the year a difference in the slant columns can be seen. A calculation of the tropospheric amount of BrO should be possible. The investigation of these situations is one of the future tasks.

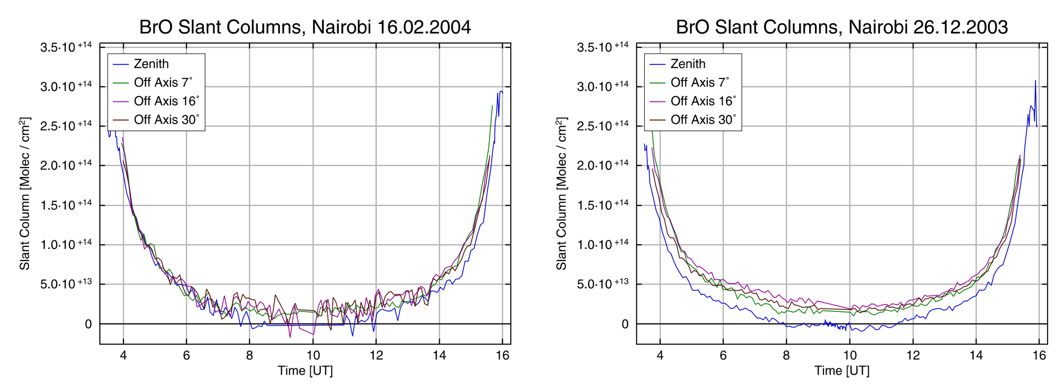

Figure 5: Slant columns of BrO for different lines of sight. For the 16th of February the values are very similar, the analisys of troposopheric BrO is very difficult (the normal situation in Nairobi). In contrast the slant columns of the 26th of December 2003 show that a tropospheric amount of BrO should be present and analizable.

Conclusions

First long-term measurements of BrO at the tropical site Nairobi are presented on the poster. As result of the small changes of NO_2 during the year there is also no significant seasonal variation of the BrO DSCD's. The amount of BrO of about $1{,}5 \cdot 10^{14}$ molec/cm^2 is comparable to the observations that were made in high and mid latitudes (e.g. Sinnhuber).
A look on the slant columns of different lines of sight show that on most of the days an analysis of tropospheric amounts of BrO is difficult in Nairobi.
For the near future a comparison of the measurements with SLIMCAT model data is in preparation.

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