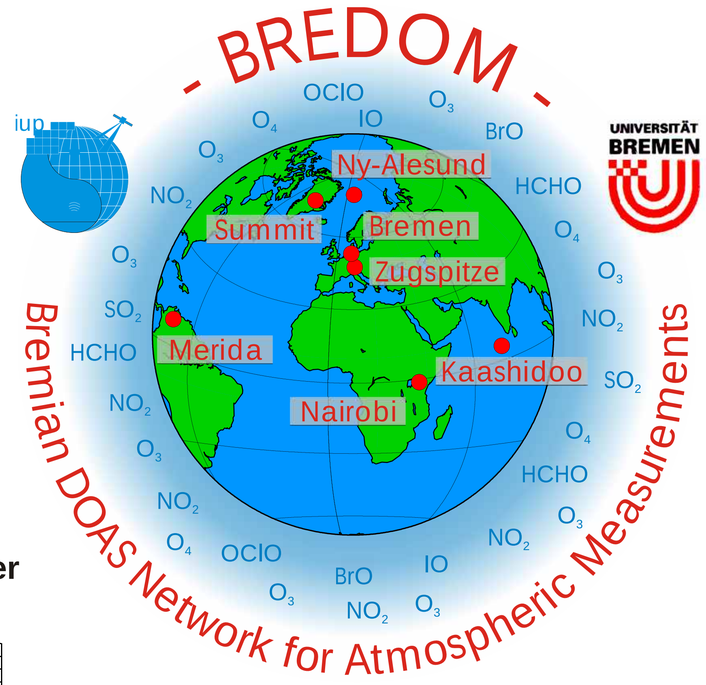
Multi-axis DOAS observations of atmospheric trace gases

H. Oetjen, D. Adukpo, S. Fietkau, A. Löwe, T. Medeke, A. Richter, A. Rozanov, F. Wittrock, and J.P. Burrows
Institute of Environmental Physics, University of Bremen, Germany
hilkeo@uni-bremen.de

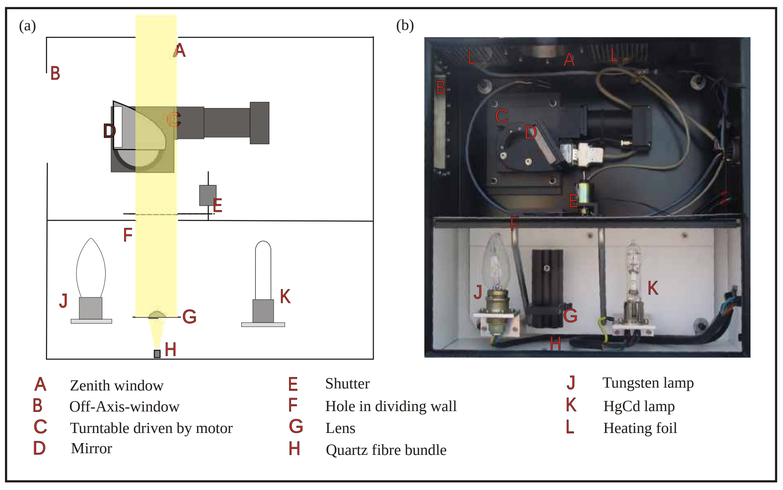


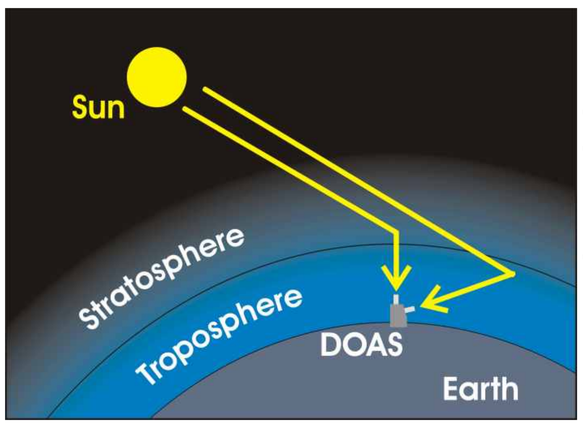
Abstract

A new approach to derive profile information for different atmospheric trace gases from ground-based UV/vis measurements is described. The instrument, referred to as the MAX-DOAS, is based on the well-known UV/vis instruments, which use the sunlight scattered in the zenith sky as the light source and the method of Differential Optical Absorption Spectroscopy (**DOAS**) to derive column amounts of absorbers like ozone and nitrogen dioxide. Substantial enhancement have been applied to this standard setup to use different line of sights near to the horizon as additional light sources (**MAX** - multi axis). Results from measurements at different latitudes within **BREDOM** (**Bre**men **DO**AS Network for Atmospheric **M**easurements) are presented and interpreted with the full-spherical radiation transport model SCIATRAN. Results demonstrate the capability to realize a long term UV/vis setup to derive not only column amounts of different trace gases but also some information about the location of these absorbers, which enables us to further investigate the consistency of trace column amounts derived from different platforms.

Experiment

- five viewing directions (4 off-axis between 0 and 30° above horizon, 1 zenith) with new telescope unit (see scheme)
- CCD detector (2048x512 pixel)
- spectrograph: focal length 257 mm, 1200 l/mm grid
- FWHM 0.6 nm
- time resolution for each direction: 5 min



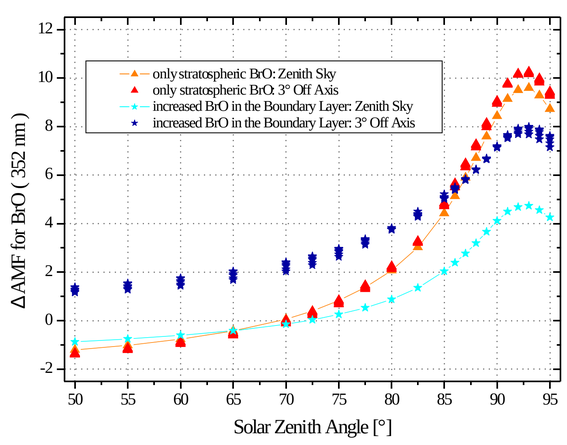


Features

- similar setups for all sites
- Zenith sky view:short path through troposphere, long path through stratosphere
- Horizontal view: long path through troposphere, similar path through stratosphere

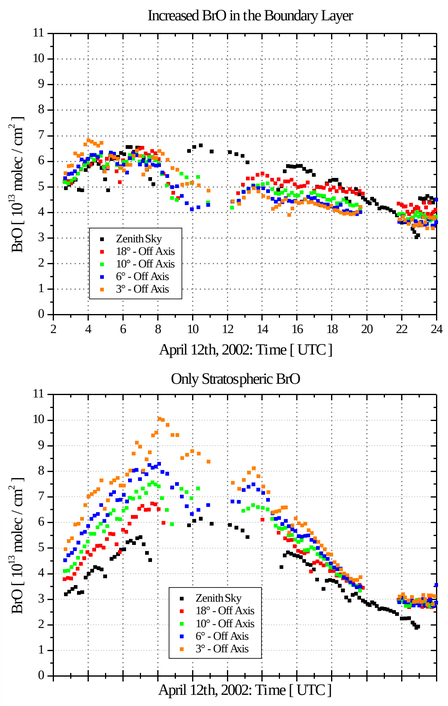
Retrieval

- iup DOAS algorithm to derive slant columns of trace gases
- Radiative transport model SCIATRAN to combine results from different viewing directions - calculation of air mass factors (AMF)
  - CDIPI approach: combined differential-integral approach involving the Picard iterative approximation
  - Full spherical
  - Refraction included
  - Full Multiple scattering
  - Example for AMF calculation is shown to the right (low aerosol scenario)
  - Interface to chemical model still under construction

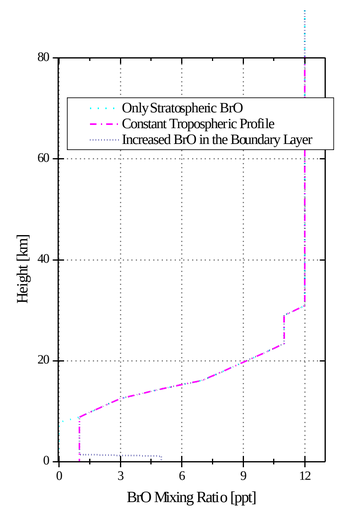


Results (Case studies)

1. Low ozone event - BrO in the boundary layer

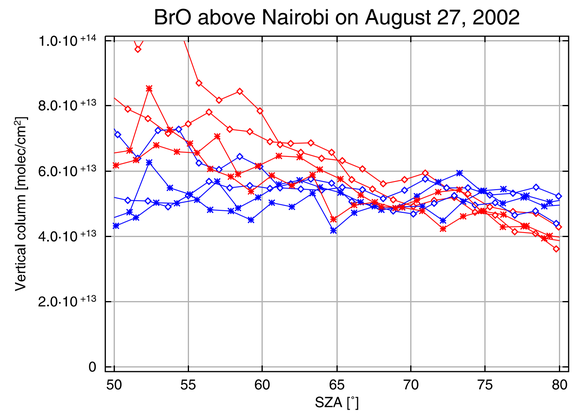


- BrO on April 12, 2002 above Ny-Ålesund
- low aerosol content in troposphere
- most consistent results with 5ppt BrO in the boundary layer



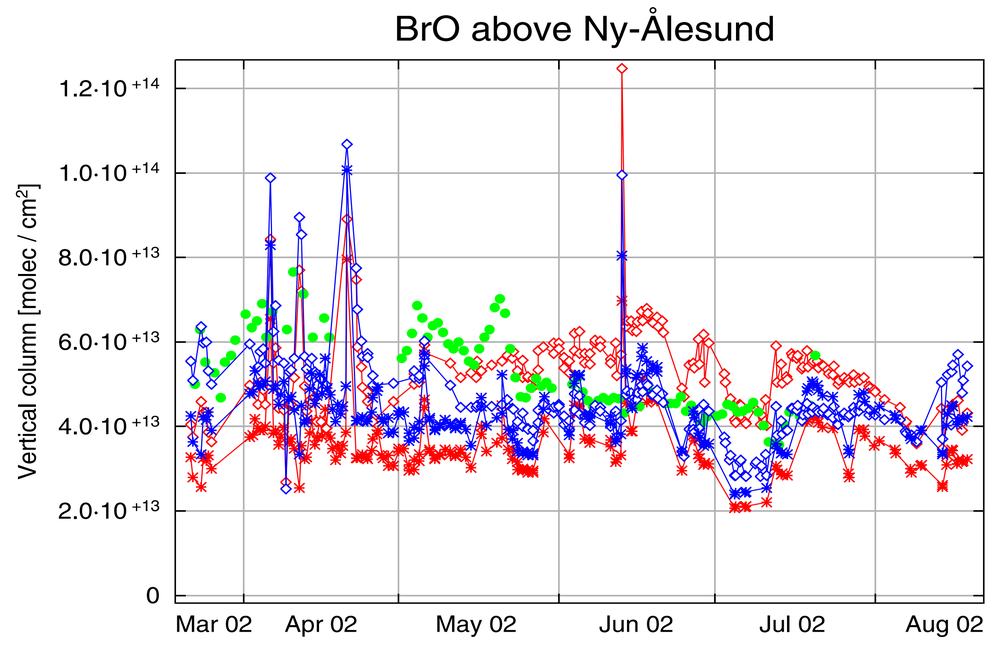
2. BrO near to the equator

- very preliminary!!
- similar amounts compared to mid-latitudes - in contrast to GOME observations
- red: no BrO in the troposphere, blue: 1 ppt in the trop.,diamonds: 4° above horizon, stars: 30° above horizon



3. BrO in the free troposphere?

- BrO seasonal variation in 2002
- red: no BrO in the trop., blue: 1 ppt uniformly distributed, stars: zenith sky, diamonds: 3° above horizon, green spheres: GOME VC with 1 ppt in trop.
- reasonable agreement with BrO in free troposphere
- remaining discrepancies partly due to diurnal variation (GOME overpass not at the same time as ground-based evaluation)
- further problems: for AMF calculations only cloud-free scenarios assumed
- at least in April and May often BrO events in the boundary layer



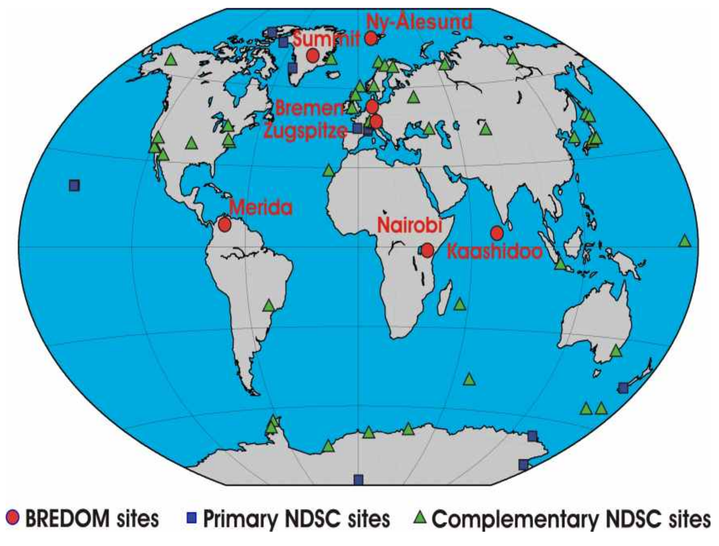
Outlook

MAX-DOAS systems

- Bremen (53°N, 9°E), Ny-Ålesund (79°N, 12° E) and Nairobi (1°S, 37°E) in operation with new setup, second detector-spectrometer system for Visible planned for 2003
- Setup of new sites:
  - Merida (8°N, 71°W) October 2002
  - Summit (72°N, 38°W) 2003 Summer 2003
  - Other sites (Zugspitze, Maledive) not before fall 2003

Radiation transport model

- Implementation of chemical box model into full spherical RTM will be finished in spring 2003



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