BREDOM - GROUND-BASED UV/VIS OBSERVATIONS OF ATMOSPHERIC TRACE GASES ABOVE DIFFERENT LATITUDES

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BREDOM

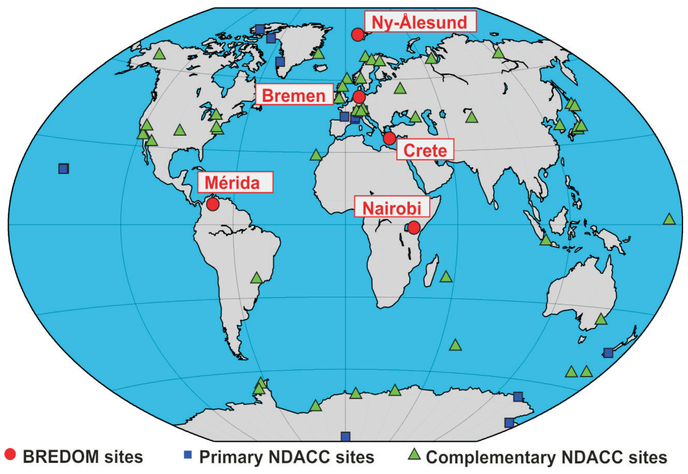

Figure 1: *Map of the Bremian DOAS network for atmospheric measurements (BREDOM) and NDACC sites*

Permanent Stations:

Ny-Ålesund (79°N)	: since 1995
Bremen (53°N)	: since 1993
Heraklion (35°N)	: since August 2007
Mérida (8°N)	: since March 2004
Nairobi (1°S)	: since July 2002

Campaigns and temporary stations:

OHP (France)	: 06. – 07. 1996 (**NDACC intercomparison**)
Kaashidhoo (Maledive)	: 02. – 03.1998 (**INDOEX**)
Po valley (Italy)	: 07. – 08.2002 and 08. – 09.2003 (**FORMAT**)
Andoya (Norway)	: 02. – 03.2003 (**NDACC intercomparison**)
Zugspitze (Germany)	: 02.2003 – 07.2003
Summit (Greenland)	: 08.2003 – 03.2005
Sylt (Germany)	: 03. – 09.2004
Cabauw (Netherlands)	: 06. – 07.2005 and 09.2006 (**DANDELIONS**)
Finokalia (Crete)	: 06.2007 – 08.2007

fully NDACC qualified instruments

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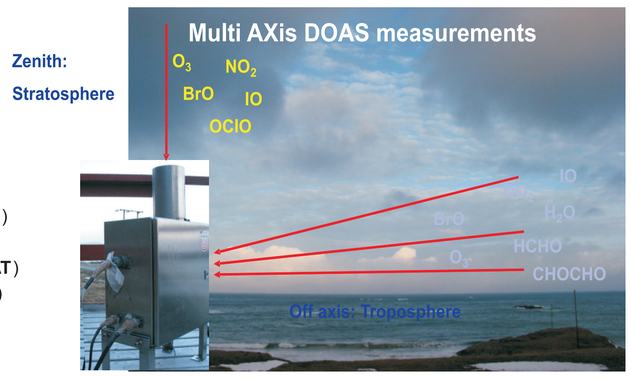
all stations equipped with MAX-DOAS

Instruments and Retrieval



Figures 2 and 3: *Sketches of the MAX-DOAS viewing geometry (above) and the instrumental setup (right). All stations of the BREDOM network are equipped with Multi Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) instruments. These instruments are basically UV/visible spectrometers observing scattered light in different viewing directions.*

Hardware:

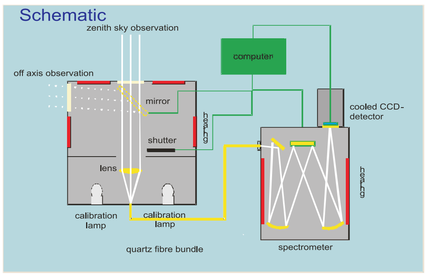
- UV / Visible grating spectrometers with CCD detectors
- temperature stabilized, daily calibration, fully automated, operated from Bremen via Internet
- zenith-sky and horizon (off-axis) viewing mode

Retrieval:

- Differential Optical Absorption Spectroscopy – DOAS
- Correction for vertical sensitivity (airmass factors) depending on several meteorological parameters (e.g. albedo, aerosol)
- Optimal Estimation for profile retrieval from ground(BREAM)

Target Quantities:

- stratospheric columns of O_3, NO_2, BrO and OClO (under certain conditions)
- tropospheric columns and profiles of NO_2, HCHO, CHOCHO and of BrO, IO, H_2O under certain conditions



Ny-Ålesund (79°N, 12°E)

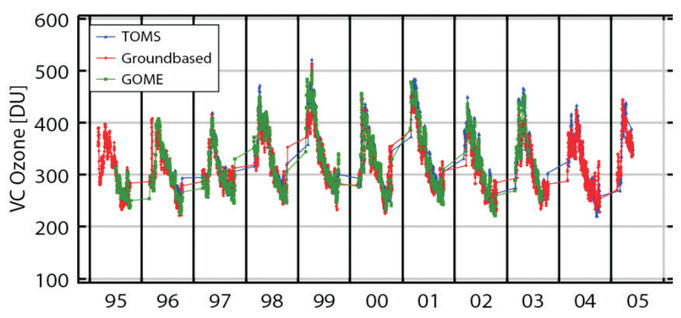


Figure 4: *Vertical Columns of ozone compared with the measurements of the satellite instruments GOME and TOMS above Ny-Ålesund. The BREDOM instrument is installed inside the building of the Alfred-Wegener-Institute for Polar and Marine Research as part of the primary Arctic NDACC station. Since February 1995 the instrument is running continuesly with the exception of polar night.*

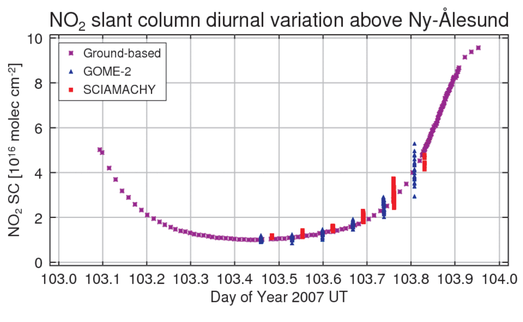


Figure 5: *Slant Columns of NO_2 compared with measurements of the satellite instruments SCIAMACHY and GOME-2 on one selected day in 2007. In high latitudes, satellites provide up to 12 measurements per day which facilitates observation of diurnal variation of e.g. NO_2 and new possibilities for validation.*

Bremen (53°N, 9°E)

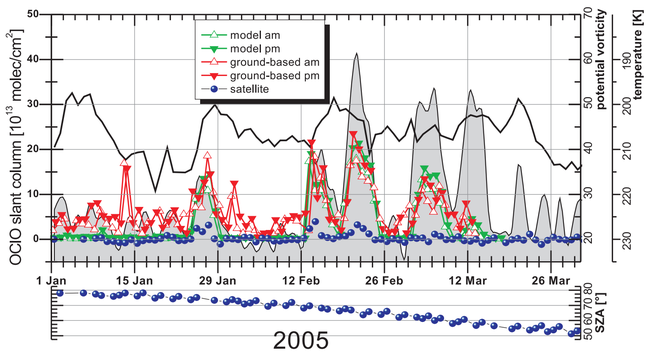
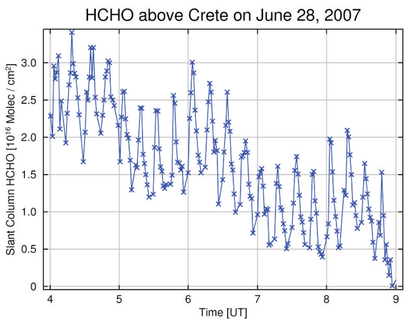


Figure 6: *In winter 2005 high levels of OClO were observed above Bremen during overpasses of the polar vortex. Comparison between model calculations, ground-based and satellite measurements show reasonable agreement for high and mid-latitudes for SZA < 90° but the model underpredicts OClO for strong chlorine activation at high SZA (H. Oetjen et al., manuscript in preparation).*

Figure 7: *Photo of the MAX-DOAS telescope on top of the iup building in Bremen. The Bremen DOAS instrument provides a continuous time series of atmospheric trace gases like ozone and NO_2 as well as BrO since 1993.*

Heraklion, Crete (35°N, 25°E)

The instrument has been installed quite recently on the roof of the Department of Chemistry, University of Crete. The main purpose of this station is to fill a gap in the latitudinal coverage of BREDOM between mid-latitudes and the equatorial regions. In addition, it should provide valuable information on the seasonal variation of tropospheric trace gases namely formaldehyde and glyoxal in the Mediterranean.



Figures 8 and 9: *HCHO slant columns (left) show clearly elevated levels due to a biomass burning plume observed over the Finokalia station (right photo) which is located about 70 km east of Heraklion. This was the first of a series of disastrous forest fires on Greek mainland in summer 2007.*

Merida (8°N, 71°W)

The Merida instrument has been installed inside the MARS (**M**erida **A**tmospheric **R**esearch **S**tation) building at Pico Espejo in April 2004. With 4765 m above sea level this station is the highest throughout the world.

The measurements are well-suited for observations of the free troposphere and the stratosphere in the tropics. However, it is possible to detect biogenic and pyrogenic emissions (see Fig 10) of the savannah and rain forest regions in Venezuela.

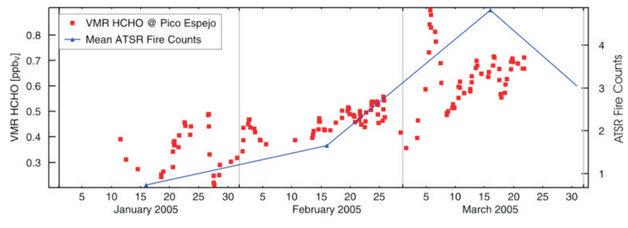


Figure 10: *VMR of HCHO at 4.8 km asl derived from MAX-DOAS observations with mean ATSR fire counts above Llanos in Venezuela.*

Figure 11: *The MARS building on top of the Pico Espejo.*

Summary

- Five permanent stations within BREDOM, two of them providing more than one decade of trace gas measurements
- Intercomparison campaigns have shown good agreement to other instruments and/or measurement techniques
- The latitudinal coverage of BREDOM is well-suited for satellite validation.
- The MAX-DOAS technique provides valuable information on tropospheric constituents.
  - ↔ Both stratospheric and tropospheric products can be monitored and therefore validated.

Nairobi (1°S, 37°E)

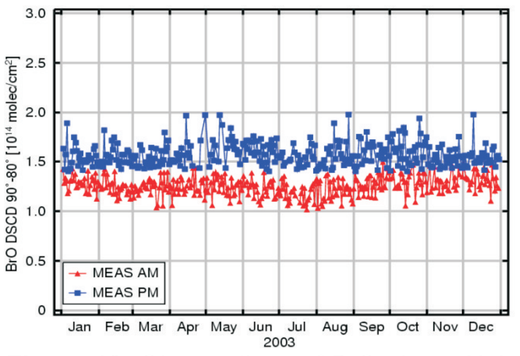


Figure 12: *(right) Comparison of ground-based and satellite data of ozone for the second tropical station Nairobi illustrating the good agreement between both instruments.*

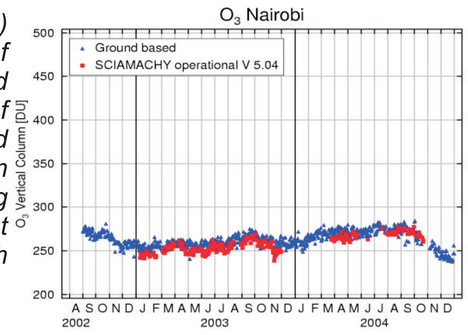


Figure 13: *Observations of BrO above Nairobi, 2003. Shown are differential slant columns between solar zenith angles of 90° and 80°. It can be seen that the afternoon values are slightly higher than the morning values which implies that BrO is released from $BrONO_2$ during the day and during the night the BrO is stored in its reservoir HOBr. The seasonal variation of BrO is most likely controlled by the seasonal variation of NO_2 and the following formation of the reservoir $BrONO_2$ (Fietkau et al., 2007).*

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