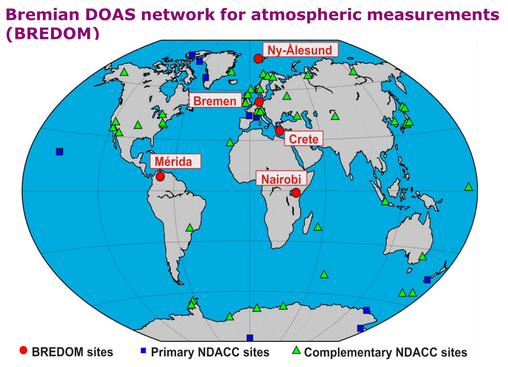
AIR POLLUTION MONITORING IN THE MEDITERRANEAN USING MAX-DOAS OBSERVATIONS

F. Wittrock (1), M. Vrekoussis (2), E. Peters (1), A. Richter (1), E. Gerasopoulos (3), N. Mihalopoulos (4), M. Kanakidou (4), J.P. Burrows (1)

(1) Institute of Environmental Physics, University of Bremen, Germany (2) Research Centre for Atmospheric Physics and Climatology, Academy of Athens, Greece
(3) Institute for Environmental Research and Sustainable Development, National Observatory of Athens, Greece (4) Department of Chemistry, University of Crete, Greece
Presenting author email: folkard.wittrock@iup.physik.uni-bremen.de

Introduction

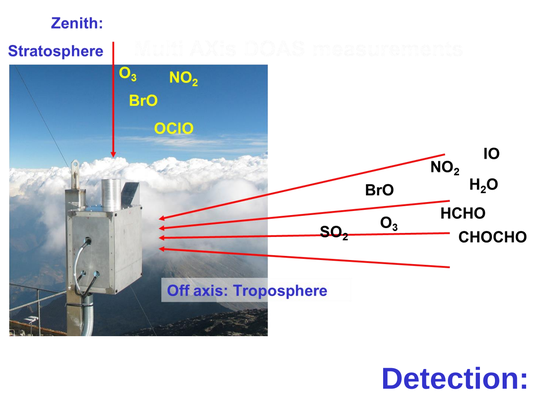
In the last years, Differential Optical Absorption Spectroscopy using observations from multiple elevation angles (MAX-DOAS) has evolved as a useful tool for measurements of tropospheric composition (e.g. Hönninger et al., 2004, Wittrock et al., 2004). With this technique, both integrated **tropospheric column** amounts and **vertically resolved concentration profiles** can be retrieved, providing a link between in-situ surface measurements from air quality networks and satellite observations. In addition aerosol properties like AOD and extinction profiles can be derived.
In 2007 a MAX-DOAS instrument has been installed as part of the Bremian DOAS network for atmospheric measurements (**BREDOM**) in Heraklion, which is the largest city and the administrative capital of the island of Crete, Greece. Before it was located for three months in Finokalia 70 km east of Heraklion. Until 2010 measurements of different atmospheric trace gases like nitrogen dioxide, ozone, and formaldehyde have been carried out.



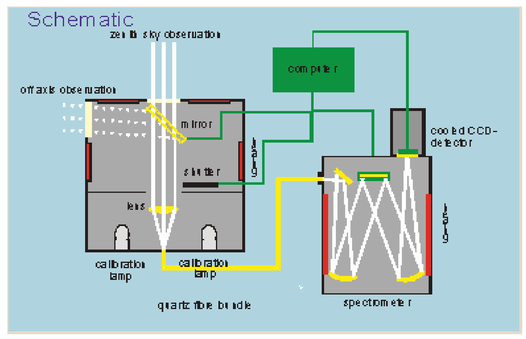
Permanent Stations:

Ny-Ålesund (79°N)	: since 1995
Bremen (53°N)	: since 1993
Heraklion (35°N)	: August 2007 to 2010, in 2012 Athens
Mérida (8°N)	: March 2004 to 2010, 2014? to …
Nairobi (1°S)	: since July 2002

Instrument and Retrieval



Sketches of the MAX-DOAS viewing geometry (above) and the instrumental setup (top 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 sunlight** in different viewing directions.



Detection:

- UV/vis measurement of scattered sunlight measured for different lines of sight
- Method: Differential Optical Absorption Spectroscopy - DOAS
- Result: averaged absorption along all contributing light paths -> Slant Column

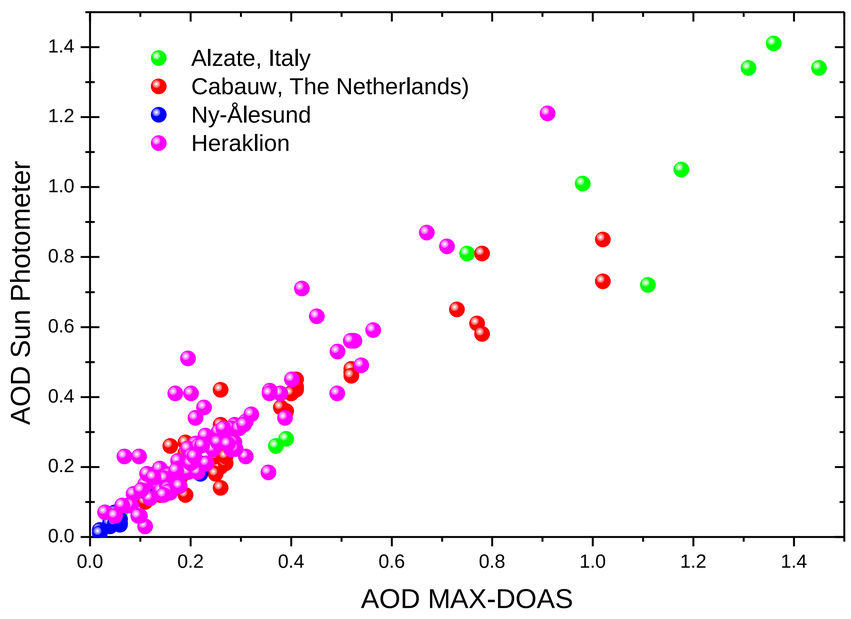
Retrieval:

- Total columns: Correction for vertical sensitivity (airmass factors) depending on several meteorological parameters (e.g. albedo, aerosol)
- **Standard algorithm for tropospheric products: Optimal Estimation for profile retrieval (BREAM)**

Results:

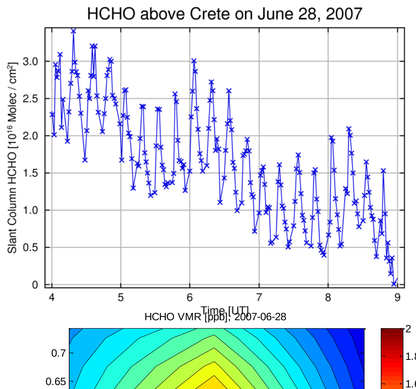
- Vertical columns and profile information for trace gases, aerosol information

Selected Results



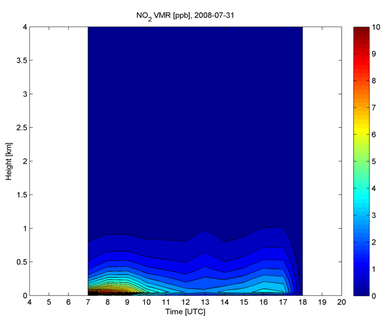
Correlation plot for AOD retrieved from MAX-DOAS measurements and from sun-photometer (data provided by AERONET, lv1) for different stations. In general a very good agreement was found. For all stations the correlation is better than 0.8 with slopes between 0.9 and 1.2 (Crete: r=0.84, m=1.13)

Biomass burning plume above Finokalia on June 28, 2007



The same time MAX-DOAS observations show elevated levels of formaldehyde.

Using radiative transfer calculations a profile has been inverted, indicating a HCHO plume with more than 1ppb in about 500 m altitude above Finokalia .

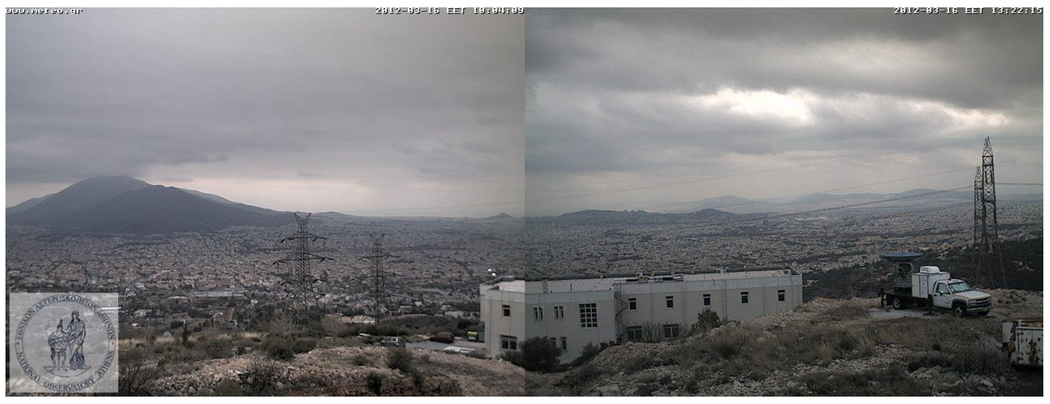


Typical diurnal variation of NO_2 above Heraklion with high values up to 10 ppb in the morning due to local traffic.

Time series of NO_2 columns (monthly bins) from 2007 to 2009. The summer maximum is probably due to higher traffic and power consumption (air condition) during these months. Bars for the standard deviation illustrate the high variability of NO_2.

MAX-DOAS observations in Athens

The Bremen MAX-DOAS instrument has been upgraded to derive three-dimensional fields of tropospheric absorbers (Wittrock et al., 2012). It will be installed in summer 2012 in Athens at Penteli hill, an ideal location providing open and wide horizon over Athens, thus being suitable for pollution scanning.



Conclusions

MAX-DOAS measurements of several trace gases have been succesfully carried out on Crete since early summer 2007. Data are available on www.doas-bremen.de

Future setup in Athens will help to investigate the spatial variation of reactive trace gases like NO_2 and HCHO in this area.

MAX-DOAS has been proven as an innovative method to derive information on aerosols and trace gases in the atmosphere, which are useful for several applications:

- Retrieval of aerosol properties, at least AOD
- Detection of oxygenated hydrocarbons (HCHO and CHOCHO) (which has been identified as a big gap in the GAW network, GAW report No. 171)
- Profile information for trace gases possible
- Validation of satellite products relatively straight-forward
- Long-term deployment, at unmanned remote locations possible

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see also: www.iup.uni-bremen.de/doas