MAX-DOAS measurements in Ny-Ålesund and during the Andøya Campaign in 2003

H. Oetjen, S. Fietkau, T. Medeke, A. Richter,
A. Rozanov, F. Wittrock and J. P. Burrows

Institute of Environmental Physics,
University of Bremen, Germany
hilkeo@uni-bremen.de

Ny-Ålesund (79° N, 12° E)

Introduction

The Institute of Environmental Physics of the University of Bremen has been operating a DOAS instrument in Ny-Ålesund since 1995. After a successful test of the multi-axis (MAX) viewing geometry in April 1998 the instrument was equipped with a multi-axis telescope in spring 1999 which was able to automatically scan two lines of sight. In 2002 a new telescope was installed. In the automated measurement mode this new telescope is scanning five viewing directions.
Comparing the slant columns of the off-axis measurements with the slant column of the zenith it is possible to locate the absorber in the atmosphere and for clear sky conditions even determine the profiles of absorbers.
In this section a tropospheric profile of strong pollution, i.e. enhanced NO_2 caused by a cruise ship, will be retrieved. Also an example of a BrO-event will be shown.

Instrument

- 2 Czerny -Turner Spectrographs:
  - UV (323-411 nm), focal length 500 mm
  - vis (397-566 nm), focal length 260 mm
- CCD 2048 x 512 pixel resp. 1024 x 256 pixel
- Spectral resolution: ~0.5 nm resp. ~0.7 nm
- 1 telescope for both instruments with 5 lines of sight: 3°, 6°, 10° and 18° elevation angle and zenith
- Temporal resolution: 5 min for a complete cycle.
- Daily calibration measuremnts

Retrieval

- IUP Bremen DOAS algorithm to derive slant columns of trace gases
- Radiative transport model SCIATRAN for Air Mass Factor (AMF) calculations to convert slant columns (SC) to vertical columns (VC)
  - CDIPI: combined differential-integral approach involving the Picard iterative approximation
  - full spherical, refraction and full multiple scattering
- Combining different viewing directions to obtain the correct profiles of absorbers

NO_2

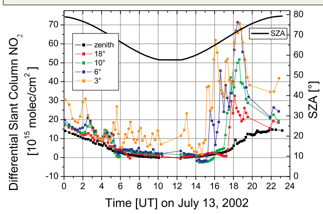

Figure 1.1 Slant Columns of NO_2

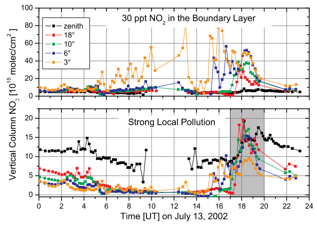

Figure 1.2 Vertical Columns of NO_2 for different viewing directions calculated with 2 different AMF sets.

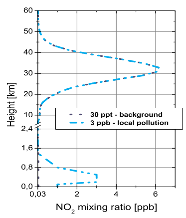

Figure 1.3 NO_2 profiles for the AMFs used for Fig. 1.2

In the afternoon of July 13, 2002 a big cruise ship was sailing into the harbour of Ny-Ålesund. When the sea is freed of ice in the summer ships often visit Ny-Ålesund.

The slant columns of NO_2 for all lines of sight increase in the afternoon and peak between 6 and 7 PM (see Fig. 1.1).

On this day were clear sky conditions.

Calculating vertical columns using AMFs with only a tropospheric Background of 30 ppt (see profile in Fig. 1.3) results in a good agreement for all viewing directions in the early morning (see Fig. 1.2 top).
→ vertical column:
~ 5×10^{15} molec/cm^2

A profile with a maximum amount of 3 ppb between 100 and 500 m (see Fig. 1.3) brings the vertical columns between 6:30 and 7 pm together (see Fig. 1.2 bottom).
→ vertical column:
~ 15×10^{15} molec/cm^2

Due to the local pollution caused by the exhaust fumes of the ship the vertical column is tripled.

Problems with the 3° direction (see Fig. 1.2 bottom) possibly due to the assumption of a homogeneous layer in the model calculations.

BrO

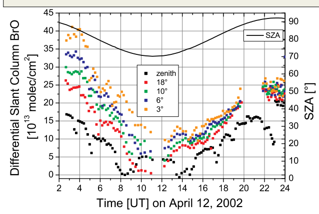

Figure 1.4 Slant Columns of BrO

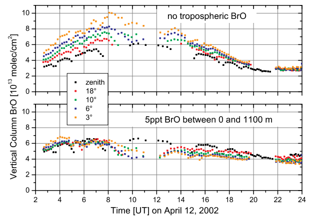

Figure 1.5 Vertical Columns of BrO for different viewing directions calculated with 2 different AMF sets.

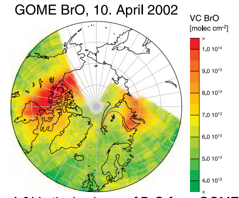

Figure 1.6 Vertical column of BrO from GOME on April 10, 2002 including backward trajectories (60 hours) from April 12, 2002 for 100, 500 and 1000 m.

On April 11 and 12, 2002 a small BrO-event could be observed in Ny-Ålesund.

Fig 1.4 shows the increased slant columns in the morning of April 12 compared to the afternoon values of this day.

The stratospheric profile of BrO for the AMF calculations is shown in Fig 2.3 d.

In the morning the mixing ratio was about 5 ppt in the boundary layer.
→ vertical column:
~ 6×10^{13} molec/cm^2
(see Fig. 1.5 bottom)

At about 10 pm the BrO-event was over (see Fig 1.5 top)
→ vertical column:
~ 3×10^{13} molec/cm^2

This results in a tropospheric BrO column of about 3×10^{13} molec/cm^2 during the BrO-event

This BrO-event was also seen by GOME.

The increased BrO was transported to and not produced at Svalbard (see Fig. 1.6)

Andøya (69° N, 16° E)

Introduction

The Institute of Environmental Physics of the University of Bremen participated in the NDSC intercomparison campaign of ground-based UV-vis measurements that took place at the Andøya Rocket Range, Norway from February 14 to March 7, 2003. The weather conditions were not suitable for a quantitative evaluation of the off-axis measurements for almost the whole time period of the campaign. So this section will only present the results for March 1, 2003 as an example.

Instrument

- 2 Czerny -Turner Spectrographs:
  - UV (324-408 nm), focal length 500 mm
  - UV/vis (336-504 nm), focal length 260 mm
- CCD 1340 x 400 pixel resp. 1024 x 256 pixel
- Spectral resolution: ~0.5 nm resp. ~1.0 nm
- 1 telescope for both instruments with 4 lines of sights: 3°, 7.5° and 12.5° elevation angle and zenith
- Temporal resolution: 2 min for the zenith and 1 min per off-axis giving a total of 5 min for a complete cycle.
- Daily calibration measurements

Oxygen Dimer O_4

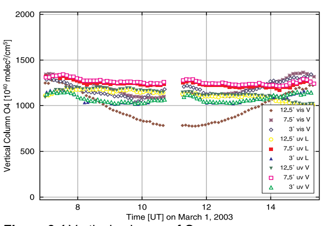

Figure 2.1 Vertical columns of O_4

O_4 slant columns retrieved for 3 off-axis directions
- with 2 instruments: V and L
- with 2 fits: UV and vis

AMF calculation with the correct aerosol scenario.
Good agreement between different line of sights.
Deviation in the vis (see Fig. 2.1), possibly due to incorrect scattering phase function.

O_4 vertical column out of pressure profile from 02/26/03:
1396.08×10^{40} molec^2/cm^5

NO_2

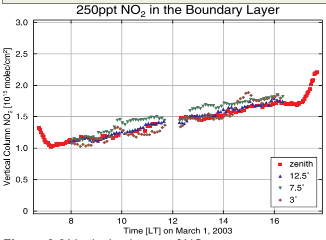

Figure 2.2 Vertical columns of NO_2

In general very clean, only little tropospheric NO_2 in Andøya during the campaign.

Vertical columns of NO_2 for all 4 viewing directions derived by the method of the Langley Plot (see Fig. 2.2) for March 1. Profile for AMF with 250 ppt NO_2 in the boundary layer.

SCIAMACHY:
1.13×10^{15} molec/cm^2
Overflight short before 11AM.
Only stratospheric AMF.

BrO

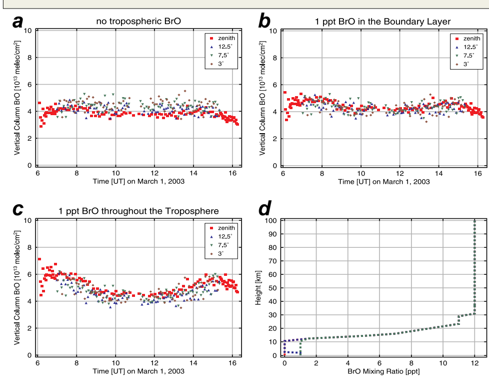

Figure 2.3 a - c Vertical columns of BrO for different viewing directions calculated with 3 different sets of AMFs.
Figure 2.3 d BrO profiles for the AMFs used for Fig 2.3 a - c

Clear indication of tropospheric BrO. Better agreement of the different lines of sight in Fig. 2.3 b and c than in a.

The run of the curves differ in the 2 scenarios including troposheric BrO (Fig 2.3 b and c): The correct profile of BrO in the troposphere cannot be clearly determined since a change in the vertical column during the day could also be caused by chemistry.

References

- Rozanov, A., V. Rozanov, and J. Burrows, A radiative transfer model for a spherical planetary atmosphere: combined differential-integral approach involving the Picard iterative approximation, Journal of Quantitative Spectroscopy & Radiative Transfer, 69, 491, 2001.
- Wittrock, F., H. Oetjen, A. Richter, A. Rozanov, and J. Burrows, MAX-DOAS measurements of atmospheric Trace Gases, submitted to Applied Optics, 2003.

Acknowledgements

- This work has been funded in parts by the German Federal Ministry of Education and Research (BMBF), the German Aerospace Agency (DLR), the European Union, the University of Bremen and the State of Bremen.
- We would like to thank the staff of the Alfred-Wegener-Institut and in particular all station leaders and engineers of the Koldewey-Station for their support in Ny-Ålesund through all these years.
- Also a big thank you goes to the Andøya Rocket Range and specially to the staff of the ALOMAR for their great assistance during our stay.

Universität Bremen

www.doas-bremen.de