MAX-DOAS OBSERVATIONS OF IODINE MONOXIDE AT DIFFERENT COASTAL MEASUREMENT SITES

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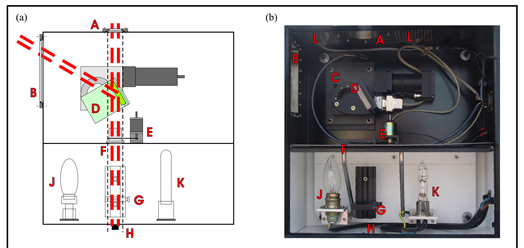
Introduction

This study presents ground-based measurements of iodine monoxide IO by means of UV/visible spectroscopy at different coastal stations. The measurement sites range from northern high latitudes (Ny-Ålesund, 79°N, 12°E and Andøya, 69°N, 16°E) to mid-latitudes (List, 55°N, 8°E).
In addition to the zenith viewing direction four different lines of sight close to the horizon have been used. With this MAX-DOAS (multi-axis Differential Optical Absorption Spectroscopy) technique it is possible to derive profile information for the retrieved absorbers using an adequate radiation transport model (Wittrock et al., 2004).

Experimental Setup

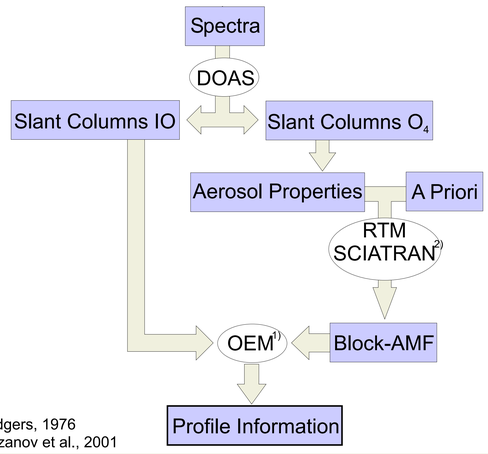


A Zenith window
B Off-Axis-window
C Turntable driven by motor
D Mirror
E Shutter
F Hole in dividing wall
G Lens
H Quartz fibre bundle
J Tungsten lamp
K HgCd lamp
L Heating foil

Figure 1: Setup of the telescope.

The telescope shown in figure 1 is able to switch between zenith and any elevation angle between 0° and 30°. In the standard measurement mode light from 4 off-axis directions plus the zenith sky direction is integrated over 1 minute consecutively.

Data Analysis Overview



1) Rodgers, 1976
2) Rozanov et al., 2001

Iodine Monoxide in the tropospheric Boundary Layer

List (55°N, 8°E)

Measurement site:

- List is located on the island Sylt at the coast of the North Sea (see Fig. 2.)
- viewing direction towards the Danish coast overseeing the wadden sea (distance: ~ 15 km).
- measurement period: March to September 2004 with
  68 days of measurement and
  26 days with few or no clouds.

Figure 2: On the right the Coastline of the North Sea with the wadden sea (shaded area). The red arrow indicates the location and the viewing direction of the telescope.

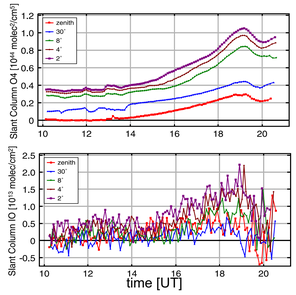


Figure 3: Slant columns for O_4 and IO (1st June 2004).

Example 1st June 2004:

- Typical weather conditions for Sylt: Almost no clouds but very hazy. The mainland is just about visible (15 - 20 km).
- Slant columns for O_4 and IO for the afternoon of this day are shown in Figure 3.
- The slant columns for IO are clearly distinguishable (Fig. 3).

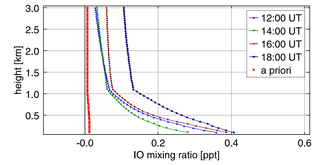


Figure 4: Retrieved IO profile

Discussion of the retrieved profile:

- Figure 4 shows the retrieved profile of IO for 4 times of the given day.
- Only information for the lowest km can be retrieved due to the high extinction.
- Mixing ratio at the ground is about 0.35 ppt.
- The shape of the profile varies with changes in boundary layer height. However the value at the ground varies by about 0.1 ppt.

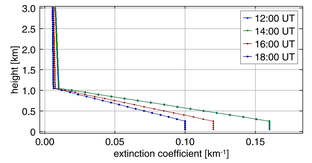


Figure5: Extinction coefficient retrieved from the O_4 slant columns of 1st June.

Extinction:

- An extinction coefficient of 0.1 to 0.16 km^{-1} was obtained at the ground (see Fig. 5).
- That corresponds to a visibility of 18 to 30 km.

Summary:

- All days have been analysed for tropospheric IO.
- A roughly constant mixing ratio of about 0.3 to 0.4 ppt has been found on clear days.
- A possible dependency on tidal cycles in the mixing ratio could be masked by a change of boundary layer height. However the changes would be very small.

Ny-Ålesund (79°N, 12°E)

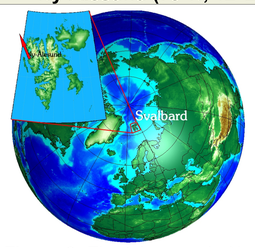


Figure 6: The telescope in Ny-Ålesund is overlooking the fjord

Measurement site:

- The DOAS instrument is installed in the NDSC building in Ny-Ålesund on Svalbard.
- Automated MAX-DOAS measurements since spring 1999.
- Off-axis directions towards the entrance of the fjord (see Fig. 6: red arrow) .

Outlook:

- Analysis is ongoing.
- First results: Mixing ratios of up to 1 ppt have been found.

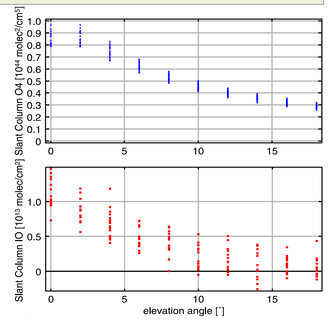


Figure 7: Slant columns for O_4 and IO versus the elevation angle for 14th April 2005 from 12:00 to 16:00 UT

Example 14th April 2005:

- In the afternoon between 12:00 and 16:00 UT the measurements were switched to scanning the horizon.
- Slant columns as a function of elevation angles (0° to 18° with a step of 2°).
- The scatter in the slant columns is due to the changing SZA and relative azimuth (Figure 7).

Andøya (69°N, 16°E)

Measurement site:

- Andøya is one of the Vesterålen islands on the coast of Norway north of the Arctic Circle (see Fig. 8).
- Measurements from 13th February to 5th March 2003 in the frame of an NDSC intercomparison of UV/vis zenith-sky instruments.
- 2 cloudless days.
- Off-axis directions to the sea.
- Only 3 off-axis directions have been used.

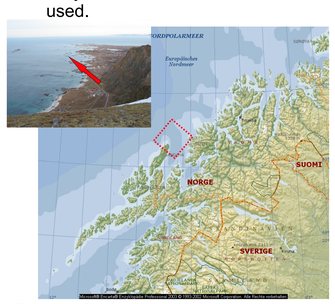


Figure 8: Location of the telescope, pointing to the north

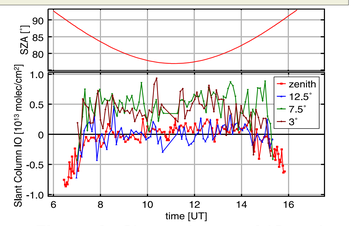


Figure 9: Slant columns of IO and SZA on 1st March 2003

Example 1st March 2003:

- The retrieved profiles (Figure 10) suffer from insufficient independent information in the slant columns (Figure 9).

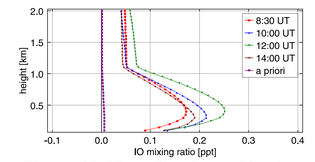


Figure 10: IO profiles for 1st March

Summary:

The limited length of the currently available dataset prohibits any definitive conclusion on tropospheric IO in Andøya.

Summary & Outlook

- Clear signal of Boundary Layer IO of about (0.4 0.2) ppt during the day is observed at List and Andøya. In Ny-Ålesund larger mixing ratios of about 1 ppt can be found.
- The time series in Andøya and List are not long enough to find an annual (i.e. a biological) cycle. Analysis for Ny-Ålesund is ongoing work
- For a promising profile retrieval up to a height of a few kilometers
  very good visibility
  and more than 4 off-axis directions
  are needed.
  → From January 2005 on not only 4 off-axis directions are used but the horizon is scanned in 1° to 2° steps when there is good visibility.

Selected References

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