MAX-DOAS Measurements of BrO during the Antarctic Polarstern Cruise in September 2006

P4-10

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Introduction

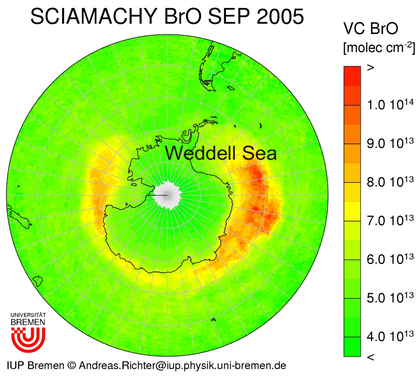


Figure 1: *Monthly average of BrO in the Antarctic seen by SCIAMACHY in September 2005*

Regularly, during springtime a strong increase of BrO-Concentrations in the polar regions, so called Bromine explosions, are observed by GOME and SCIAMACHY, respectively. Bromine explosions as single events have also been measured on the ground in the Arctic for several times [Tuckermann, Oetjen, Hönninger] and Antarctic [Kreher]. As BrO is a radical, it has an impact to the oxiditivy capacity of the atmosphere and its abundance in the polar troposhere is correlated with two further phenomenons: The sudden depletion of ozone (ODE) and of mercury (AMDE) in the boundary layer.Till now, the mechanism of BrO release is not understood in detail, but the conditions, where such events are observed, coincide with those, where frost flowers grow (on fresh sea ice at very low temperatures) and additionally sunlight is available. This knowledge leads to the concept of the “Potential Frost Flowers” (PFF) [Kaleschke, Roscoe], which models the probability of BrO liberation events in a certain area at a certain time. Due to their high concentration of sea salt, the frost flowers itself - or aerosols originating from frost flower erosion - are a good candidate to be the source of the BrO, released in an autocatalytic cycle [Sander]. During the Polarstern cruise ANTXXIII\7, taking place in the antarctic spring from Aug., 19 - Oct., 20 2006, we will perform continuous shipborne MAX-DOAS measurements in the Wedell Sea with the main task to detect specific bromine releasing areas.

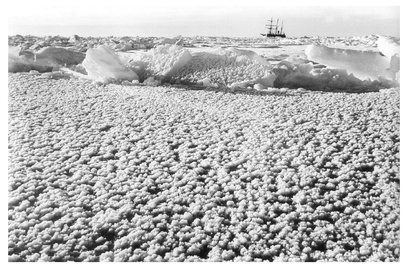


Figure 2: *A Frost Flower Field, Shackleton Expedition.*

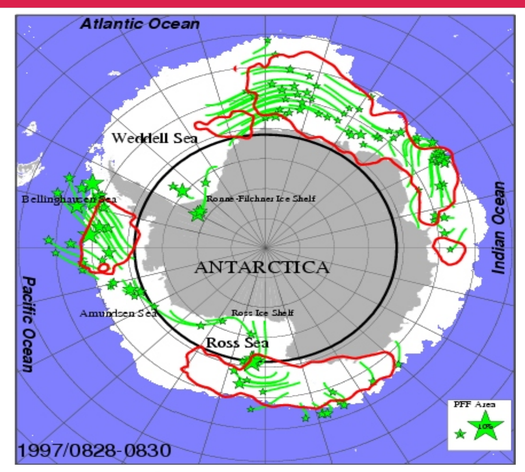


Figure 3: *A PFF coverage (green stars) compared to regions of enhanced BrO amounts (red isolines).*

The Cruise

The Polarstern cruise ANTXXIII\7 will start on August, 19 in Cape Town, South Africa at 33°41’ S 18°28’E and will reach the Wedell Sea (~ 72°S 45°W), Antarctica around the begining of September. During the whole of September, where the maximum of BrO events is to be expected, the Polarstern will cruise the Wedell Sea. In the begining of October, the route leads back to Cape Town, where arrival will be on October, 20.

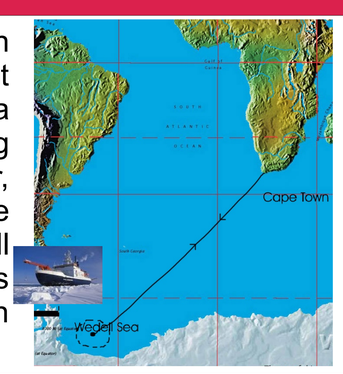


Figure 4: *The planned route of the Polarstern on ANTXXIII\7. The exact route in the Wedell Sea is not decided, yet, but will depend on local conditions and the needs of all researcher teams.*

Cooperative Measurements

Simultaneosly to the MAX-DOAS instruments, further devices, shipborne as well as mobile, go into action:

1) Ozone is not only depleted by the released bromine, but is also an indispensable component of the autotocatalytic cycle of a bromine explosion as it is modeled at present (s. fig.7). To determine this correlation, the local ozone concentration will be analyzed permanently by H.-W. Jacobi from AWI, Bremerhaven, using photometric ozone monitors.

2) Possibly, also reactive bromine compounds are involved in the mercury depostion, which may cause an important flux of this environmental pollutant to the polar and marine ecological systems [Ebinghaus]. Fig. 8 illustrates the modeled mechanism.
Therefore, K. Aspmo from the GKSS, Geesthacht will probe air and ice for mercury during the cruise. Also involved in this part is C. Ferrari, LGGE Grenoble.

3) Additionally, frost flowers will be probed and collected, and the local aerosol composition studied.

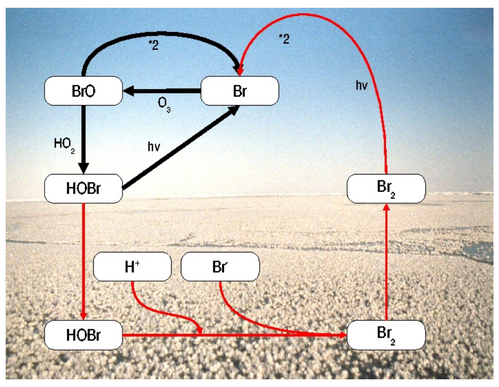


Figure 7: *The major steps of the modeled bromine explosion / ozone depletion cycle.*

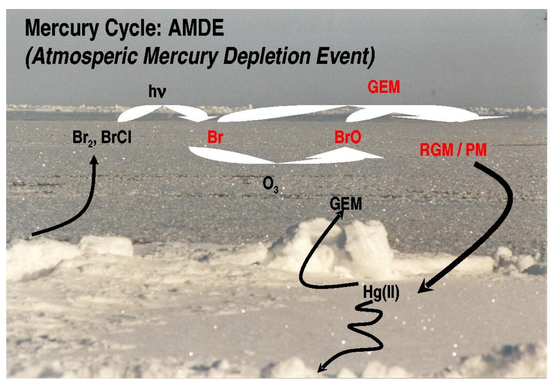
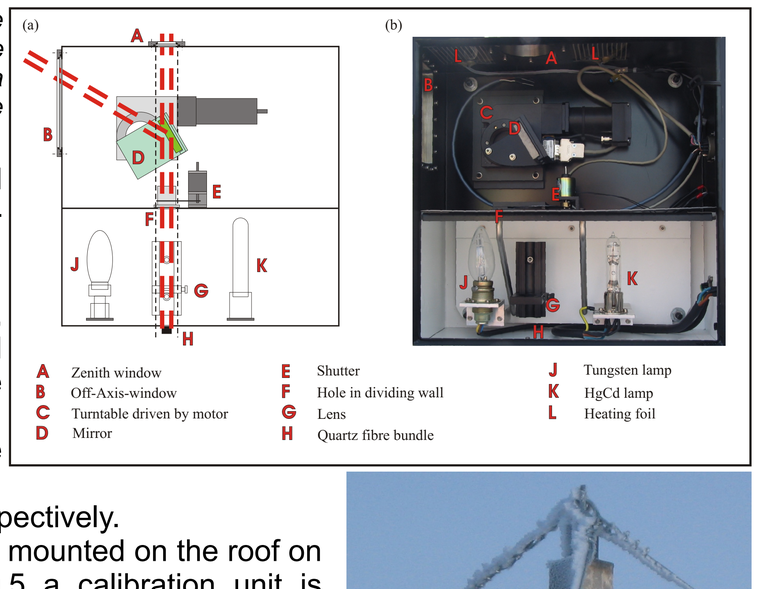


Figure 8: *The suggested mechanism leading to mercury deposition in sea ice.*

Experimental Setup

Figure 5: *Skech and interior view of the realization of the telescope. A rotatable mirror is selecting the line of sight, a broadband- and a line lamp are included for calibration issues.*



The campaign will be equipped with two MAX-DOAS-Instruments:

1) The shipborne Instrument, situated in a container, which will be placed on the deck above the bridge of the Polarstern.
It includes two temperature stabilized spectrometers,
measuring in the UV and VIS, respectively.
The associated telescope will be mounted on the roof on the container. As shown in fig.5 a calibration unit is integrated.
In contrast to former campaigns, there are no devices trying to compensate the ship motion, but instead of this the ship motion data will be logged and coupled with the LOS data of the instrument to reconstruct the real lines of sight. To avoid a bluring effect, the exposure times of the CCD will be choosen sufficently short.

Figure 6: *The telescope like it will be mounted on the roof of the container 25m above sea level.*

2) A mobile Instrument (under construction). It will use the same type of telescope, but all the other components, including CCD and spectrometer (UV) will be integrated in the telescope box. Its application is to be set up on various ice areas of interest and measure independently for at least one day.

Both instruments successively measure the following lines of sight: Zenith (90°), 30° and 15° - 1° in 1° steps. By means of the DOAS-technique, particularly, the target species BrO, IO and O_3 will be detected. The O_4 distribution will be used for correction issues Additionally, a DOAS instrument of the IUP, University of Heidelberg, is taking part in the cruise and is pointed in a different direction, providing additianoal information on the spatial distribution..

Expected Results

The data obtained will be processed to provide information on the following aspects:

1) As it is most likely to detect bromine explosion events during the abidance in the Wedell Sea, in particular this data will be evaluated in correlation with the measurements of the concentrations of ozone and mercury in the boundary layer (see cooperative measurements). In combination with temperature, wind trajectories and ice conditions this data promises progress in understanding the described chemical phenomenons.

2) The data of the low off-axis directions will allow retrievals of tropospheric profiles of the target species (BrO, IO and O_3) by means of BREAM [Wittrock].

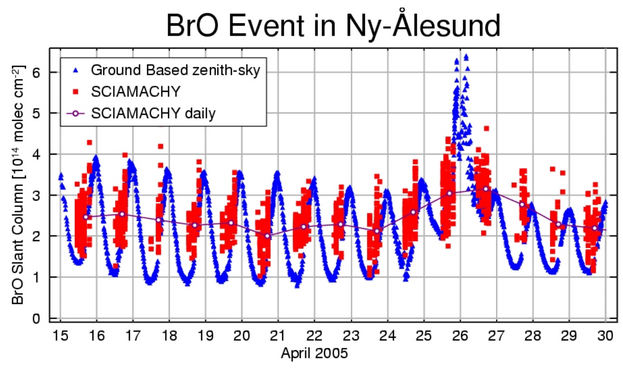


Figure 9: *Example: A bromine explosion at Ny Ålesund - seen by the DOAS instrument, which is part of BREDOM - and its comparison to satellite data.*

3) The data of the whole period will be analyzed and compared to the corresponding results of the SCIAMACHY measurements to provide local validation of the satellite data in the southern hemisphere.

References

[1] Tuckermann, M. et al . *DOAS-observation of halogen radical-catalysed arctic boundary layer ozone destruction during the ARCTOC-campaigns 1995 and 1996 In Ny Alesund*, Tellus, 49B, 533-555 (1997).
[2] Hönninger, G. et al. *Observations of BrO and ist vertical distribution during surface ozone depletion at Alert,* Atmos. Environ. 36, 2481-2489 (2002).
[3] Kreher, K., *Spectroscopic measurements of atmospheric OClO, BrO and No_2 and their relation to antarctic ozone depletion*. Ph.D Thesis, University of Heidelberg (1996).
[4] Kaleschke, L. et al. *Frost flowers on sea ice as a source of sea salt and their influence on tropospheric halogen chemistry.* Geophys. Res. Lett., 31, L16114 doi:1029/2004GL020655 (2004).
[5] Roscoe, H. K. et al. *Ozone loss episodes in the free Antarctic troposphere, suggesting a possible climate feedback,* Geophys. Res. Lett., 28(15), 2911-2914, 10.1029/2000GL012583, 2001.
[6] R. Sander, R. et al. *Modeling the chemistry of ozone, halogen compounds, and hydrocarbons in the arctic troposphere during spring. Tellus*, 49B, 522-532 (1997).
[7] Ebinghaus, R. et al. *Antarctic springtime depletion of atmospheric mercury*. Environ. Sci & Techno., 36, 1238-1244 (2002).

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