Comparison of BrO Diurnal Variations as Measured by Ground Based Long-Path DOAS and Remotely by Satellite (GOME-2)

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I would like to thank Leif Vogel at the IUP who conducted the LP-measurements during Period A. Thierry Marbach and Cornelia Mies working at the MPI are furthermore acknowledged.
EUMETSAT provided the GOME-2 spectra, and the Hysplit4-software by ARL(NOAA) was used to compute the backward trajectories.

Abstract

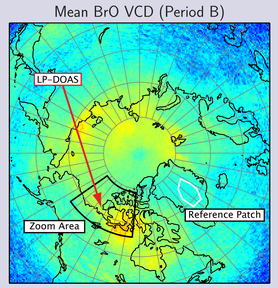
Reactive bromine is known to play an important role in the chemistry of the springtime polar troposphere. Its release by halogen activation processes leads to the almost complete destruction of near-surface ozone during ozone depletion events (ODEs) which may cover areas of up to several thousand square kilometers.
The mechanisms leading to halogen activation from saline surfaces, such as frost flowers and brine, are not well understood yet and may occur on much smaller spatial scales than covered by satellite measurements. It is therefore necessary to combine measurements of the spatial distribution of BrO radicals from satellite with in situ measurements in order to improve our understanding of the nature of halogen activation processes.
We compare ground-based LP-DOAS measurements of BrO with BrO vertical column densities (VCDs) measured by the GOME-2 instrument. Both measurements clearly reveal high BrO concentrations in the air above the sea ice surface during daylight and during periods of low ozone mixing ratios.

Conclusion

- Bromine explosion/ozone depletion events were observed with very good temporal resolution and accuracy by an active LP-DOAS instrument in spring 2008.
- These measurements were compared to satellite measurements by the GOME-2 instrument. With this instrument, ground-based measurements could be interpreted in the context of mesoscale BrO distribution.
- In order to remove stratospheric background signal from the vertical column, a reference patch on inner Greenland was chosen.
- In conjunction with Hysplit-data for the height of the boundary layer, both measurements showed a reasonable agreement.

LP-DOAS Measurements at the OASIS-Amundsen Campaign

Mean BrO VCD (Period B)



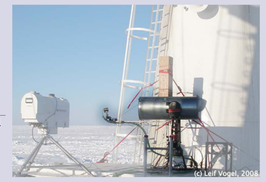
Active long-path differential optical absorption spectroscopy (LP-DOAS) measurements were performed out on board the Amundsen research vessel in the Beaufort Sea in March and April 2008. These measurements were carried out within the OASIS framework in the scope of the International Polar Year (IPY).

LP-DOAS is a very sensitive technique for measurements of molecular absorption along a well defined light-path. It's remote sensing nature allows to measure atmospheric radical species like BrO directly without potential systematic errors due to chemical conversion.

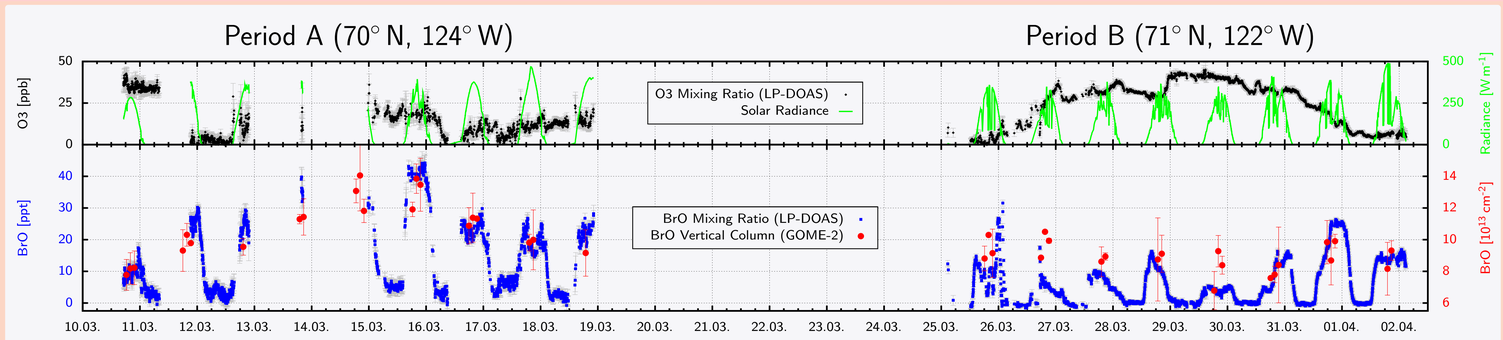
The Instrument was mounted on top the ice-breaker Amundsen at a height of 20 m ASL. The telescope (30 cm diameter, 150 cm focal length) aimed at a retro-reflector array installed close to the sea ice surface at a distance of several kilometers. The light of the XE-arc light-source was transmitted by optical fibers and analyzed in a spectrograph applying a CCD sensor-array. The minimal detection limit for BrO averaged to 1 ppt.

During the cruise, LP-DOAS measurements could only be conducted when the ship did not move for a longer period. Presented here are results from two periods A and B.

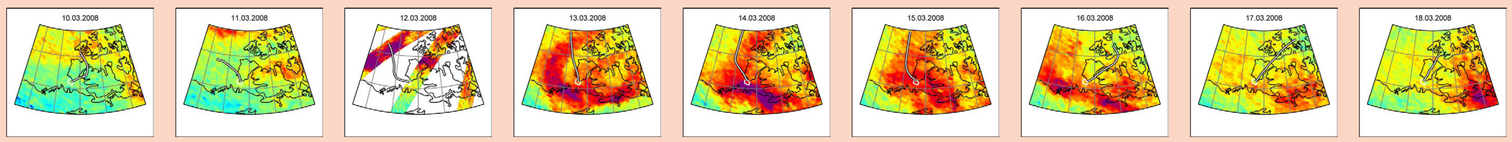
Period	A	B
Time	10/03 - 18/03	25/03 - 02/04
Positions	70° N 124° W	71° N 122° W
Path Lengths	3258 m	7360 m



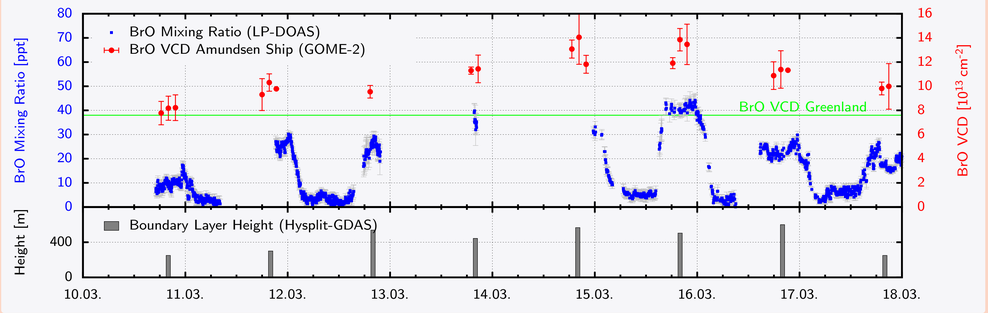
Time Series



Satellite Images of Period A



BrO Mixing-Ratio vs. Tropospheric Column



Estimation of BrO Mixing Ratio as measured by GOME-2 for March 15th

- GOME-2: VCD = 13.8×10^{13} cm^{-2}
- Stratospheric reference: $VCD_{ref} = 7.6\times10^{13}$ cm^{-2}
- Assume tropospheric BrO only within boundary layer
- $\Rightarrow VCD_{BL}$ = VCD -$VCD_{ref} = 6.2\times10^{13}$ cm^{-2}
- BL height: 503 m, Std. Atmosphere: 2.5×10^{19} cm^{-3}

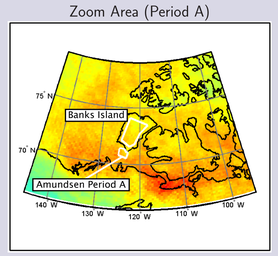
$\Rightarrow$ BrO concentration in our GOME-2 evaluation: 49 ppt

Taking the measurement error into account, this result agrees very well with the 44 ppt of BrO as measured by the ground-based instrument.

BrO VCD

GOME-2 Measurements and Evaluation

Zoom Area (Period A)



The GOME-2 instrument is a versatile scanning spectrometer on board the MetOp-A satellite. Compared to its predecessor, GOME on ERS-2, it delivers a 4 times higher spatial resolution (typical 80×40 km^2) and a doubled swatch width of now 1920 km. Its polar orbit makes it a very suitable tool to observe bromine explosion events, as it passes locations at high latitudes multiple times a day.

The map of the area surrounding the location of the Amundsen vessel shows BrO columns averaged over the entire first period.

Evaluation steps:

- DOAS-fit in the wavelength range between 334.7 and 348.5 nm
- Normalization of slant column densities (SCDs) to a constant value 4.5×10^{13} cm^{-2}at the Equator
- Calculate vertical columns (VCDs) assuming a vertical BrO profile in the stratosphere based on SCIAMCHY limb-measurements.

This scheme was used for all maps shown on this poster.

Local VCDs are averages of satellite pixels whose center lays within a predefined area.

1. $\approx$ 40 km diameter around the LP-DOAS
2. Reference Patch at similar latitude but covering the remote interior of Greenland $\Rightarrow VCD_{ref} = 7.6 \pm 1.1\times10^{13}$ cm^{-2}
3. VCDs on Banks Island for validation

In order to normalize the total VCD with respect to the stratospheric offset from our measurements, the Reference Patch on Greenland was used. This method also compensates the potential influence of systematic errors of our evaluation, which contains some free parameters.

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