Simultaneous satellite observations of IO and BrO over the Antarctic

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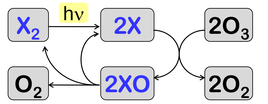
1) Motivation – halogens in the Polar troposphere

Importance of iodine and bromine for the Polar troposphere

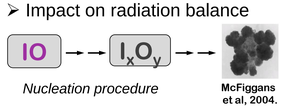


Scheme of catalytic O_3 depletion (X=I,Br)

- Reaction of atomic halogens with O_3
- Ozone depletion events (ODEs) recognized in the 80's
- Change of oxidation pathways in the troposphere

Iodine: Formation of particles

➢ Impact on radiation balance

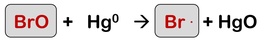


Nucleation procedure

McFiggans et al, 2004.

Bromine: Oxidation of gas-phase Hg

➢ Enhances the bioavailability of mercury



Release pathways: not fully understood

Iodine — possibly biogenic release by macroalgae/phytoplankton

CH_2I_2, CHICl, I_2, etc $\xrightarrow{h\nu}$ **I**

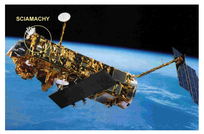
Bromine — inorganic bromine explosion **$H^+ + Br^- + HO_2 + O_3 \rightarrow Br\cdot + H_2O + 2\,O_2$**

organic release not relevant for sudden BrO events

2) The SCIAMACHY instrument

SCanning **I**maging **A**bsorption spectro**M**eter
for **A**tmospheric **CH**artograph**Y**

- UV-Vis-NIR spectrometer onboard ENVISAT
- spectral range: 214 – 2400 nm
- orbit: sun-synchronous, 800 km altitude
- geometries: nadir, limb, occultation
- ground pixel: typically 30 x 60 km²



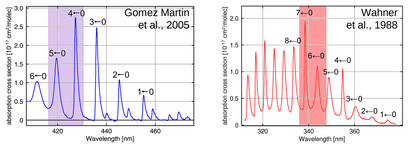
SCIAMACHY onboard ENVISAT, Monitoring the Changing Earth's Atmosphere, published by DLR, 2006. (ESA, artist's impression)

3) The DOAS trace gas retrievals

Retrieval settings	IO	BrO
Fitting window:	416 to 430 nm	336 to 347 nm
Trace gases:	NO_2 (223K)	NO_2 (223 K)
	O_3 (221K)	O_3 (223 K, 273 K)
	IO (298K)	BrO (228 K)
Other features:	- - - Ring effect, stray light, polynomial - - -	

Retrieval method:
DOAS
Differential
Optical
Absorption
Spectroscopy

The absorption cross sections:



4) IO and BrO observations over the Antarctic

Figures below: Time series of simultaneous observations of IO and BrO from SCIAMACHY – 6 year averages

Averaging procedure: Monthly means are averaged over six years of data

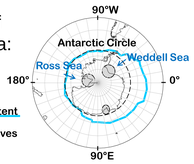
Each following map is shifted by a period of half a month.

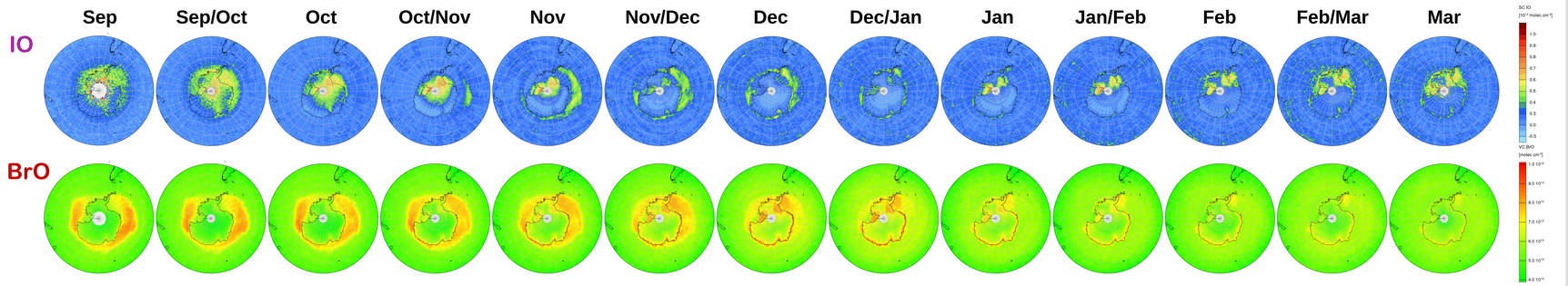
Time period: 2004-2009

The IO amounts are shown as slant columns, while BrO amounts are vertical columns using a stratospheric AMF (mainly depending on the solar zenith angle).

Therefore the distribution patterns remain comparable.

Sketch of Antarctica:





5) Comparison of IO and BrO distributions

Similarities:

- Both species appear in Antarctic Spring above sea ice and coastal regions
- Occurrence on the shelf ice regions - transport/recycling in both cases?

→ aerosols/particulate iodine might permit transport and later re-emission

Differences:

- Spatial and temporal distributions differ quite strongly
- IO above sea ice much later in the year than BrO
- Occurrence of IO and BrO above ice shelves during different times
- IO amounts above the continent during some periods, but no BrO
- BrO equivalent on both Hemispheres, IO not wide spread in Arctic (not shown)

→ Different release pathways for both molecules

→ Do these observations argue for mainly organic pathways for IO release?

6) Discussion of observations

Arguments for biogenic sources of iodine – explaining the observations

- Biogenic iodine release by certain types of macroalgae/phytoplankton has been observed before
- Antarctic waters show high biological productivity (Fig. 3) – e.g. cold water diatoms produce organic iodine species
- Sea ice more porous towards late spring (Fig. 2): iodine release from ice algae/phytoplankton might be facilitated
- Different biospheres in Arctic/Antarctic might produce different amounts and/or different species of organic iodine

Possibilities of inorganic release, e.g. via surface reactions of O_3 with I^-, and/or yet unknown pathways.

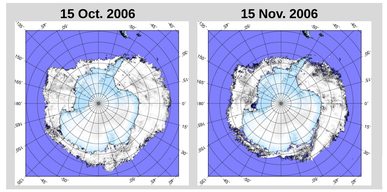


Figure 2: Maps of sea ice concentrations from AMSR-E measurements, provided by G. Spreen and L. Kaleschke, Institute of Oceanography, University of Hamburg, Germany. ftp-projects.zmaw.de/seaice/ In November, ice concentrations tend to be lower and exhibit more open leads.

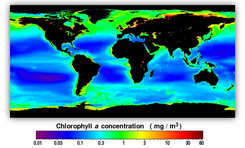


Figure 3: Chlorophyll-a concentrations from the SeaWIFS mission composite; provided by NASA. High biological productivity is detected, e.g. in the Weddell Sea.

7) Summary and conclusions

- Column amounts of IO and BrO are retrieved from SCIAMACHY nadir measurements.
- Simultaneous observations of the two reactive halogen species over the South Polar Region are compared for a long-term period of six consecutive years.
- Although IO and BrO are basically similar molecules, spatial and temporal distributions differ significantly.
- Different underlying release pathways must exist. BrO release is mainly inorganic. Supported by the observational results above, IO may be mainly biogenic.
- For a better understanding of the release and recycling pathways especially of IO, further research on the relation between iodine amounts and present biospheric species is needed.

Acknowledgements

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- We thank Prof. L. Kaleschke and Dr. G. Spreen, University of Hamburg, for providing the ice concentration maps.

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