Simultaneous observations of IO and BrO over the Antarctic from space

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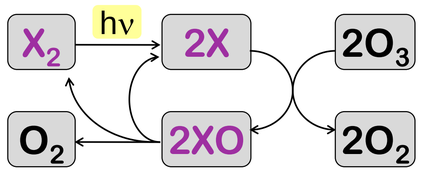
Iodine and bromine in the troposphere

Impact of iodine & bromine on tropospheric composition

- Strong ozone depletion potential via catalytic cycles
- Change of oxidation pathways of some atmospheric species

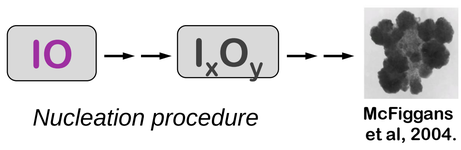


Example of catalytic O_3 depletion (X=I,Br)

Iodine specific: New Particle Formation

- Nucleation of higher iodine oxides I_xO_y (e.g. I_2O_5, I_2O_4)
- Possible growth to cloud condensation nuclei

→ Impact on the radiation balance



Nucleation procedure

McFiggans et al, 2004.

Bromine specific: Oxidation of gas-phase mercury $BrO + Hg^0 \rightarrow Br^{\cdot} + HgO$

→ Enhancement of the bioavailability of mercury

Release pathways of iodine & bromine

Iodine: Release pathways in Polar Regions not yet fully understood

Biogenic release by certain types of macroalgae/phytoplankton: CH_2I_2, CHICl, I_2, etc $\xrightarrow{h\nu}$ I

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

Bromine: Release mainly via the inorganic bromine explosion mechanism

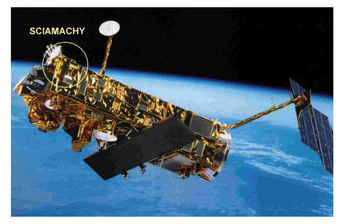
Net multi-phase reaction: $H^+ + Br^- + HO_2 + O_3 \rightarrow Br \cdot + H_2O + 2\,O_2$

Biogenic release (e.g., of CH_3Br) not directly important for sudden Polar BrO appearances

SCIAMACHY and the trace gas retrievals

SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY

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



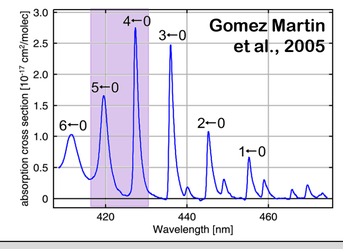
SCIAMACHY onboard ENVISAT, Monitoring the Changing Earth's Atmosphere, published by DLR, 2006. (ESA, artist's impression)

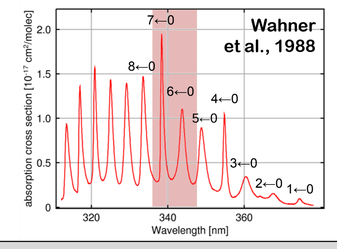
The trace gas retrievals

Method: Differential Optical Absorption Spectroscopy (DOAS)

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 ---	

The absorption cross sections:





IO and BrO maps over the Antarctic

The maps below show the time series of simultaneous observations of IO and BrO from SCIAMACHY

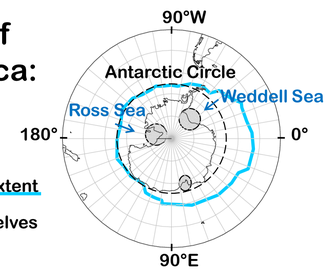
IO amounts are slant columns, BrO amounts are vertical columns using a stratospheric AMF. Therefore patterns remain comparable.

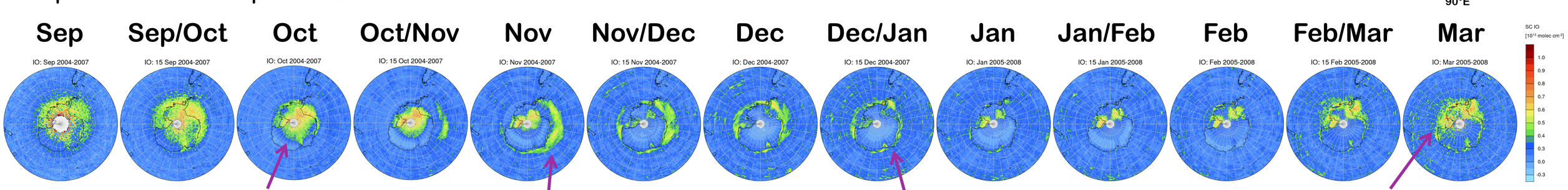
Averaging procedure: Monthly means are averaged over four years of data; periods start at the beginning or middle of the month

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

Time period covered: September 2004 – March 2008

Sketch of Antarctica:





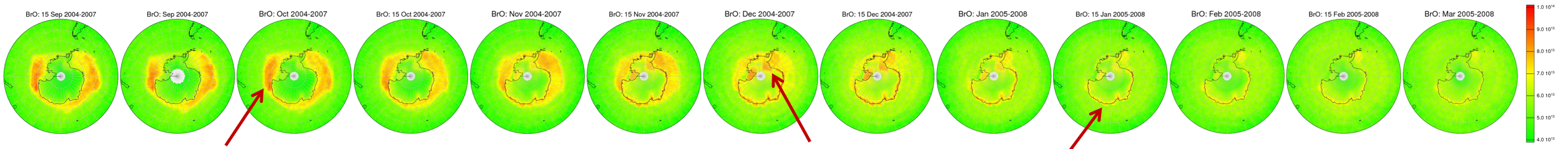
IO

on the continent/shelf ice

above sea ice in late Spring

along the coast lines

possibly increase towards Autumn



BrO

above sea ice throughout Spring

above the ice shelves

along the coast lines

vanishing towards Autumn

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?

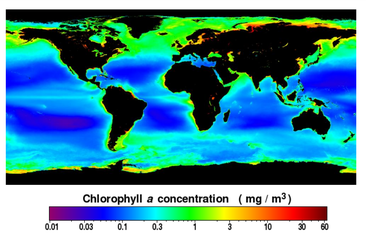
Discussion of sources and open questions

Organic sources for iodine … might explain the observations

- Antarctic waters show high biological productivity
- Cold water diatoms produce organic iodine species

(e.g. sea ice becomes more porous towards late spring: iodine release from phytoplankton might be facilitated)

- Different biospheres in Arctic/Antarctic might produce different amounts and/or different species of organic iodine



Chlorophyll-a concentrations from the SeaWIFS mission composite; provided by NASA.
High biological productivity is detected in the Weddell Sea.

Conclusion: 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 results above, IO may be mainly biogenic.

Selected References

- Wahner, A., et al., Chem. Phys. Lett. 152, 507, 1988.
- Alicke, B., et al., Nature, 397, 572, 1999.
- Afe, O. T., et al., Geophys. Res. Lett., 31, L24113, 2004.
- McFiggans, G., et al.,Atmos. Chem. Phys., 4, 701–713, 2004.
- Gómez Martín, J. C., et al., J. Photochem. Photobiol. A, 176, 15–38, 2005.
- Carpenter, L., et al., Marine Chemistry, 103, 227–236, 2007.
- Saiz-Lopez, A., et al., Science, 317, 348, 2007.
- Simpson, W. R., et al., Atmos. Chem. Phys., 7, 4375–4418, 2007.
- Schönhardt, A., et al., Atmos. Chem. Phys., 8, 637–653, 2008.

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