A satellite based view of halogen oxides in the Arctic troposphere in a changing climate

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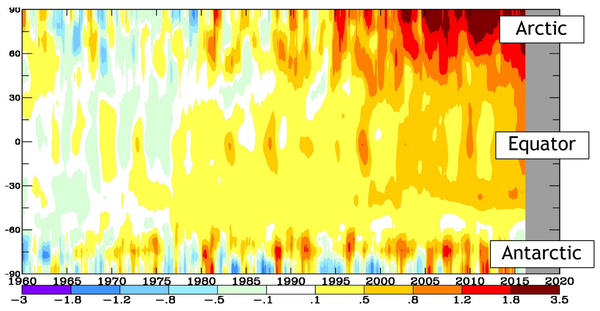
1 Motivation

Over the last 25 years, the near surface temperature of the Arctic atmosphere increased by more than a factor of two compared to other parts of the globe. This is known as Arctic amplification.



Time series of zonally and yearly mean near surface temperature anomaly [K] relative to the 1951-1980 mean (NASA GISTEMP, http://data.giss.nasa.gov/gistemp)

This temperature increase changes sea ice and weather conditions which influence:

-organohalogen release by phytoplankton and CDOM

-inorganic halogen release by bromine explosion

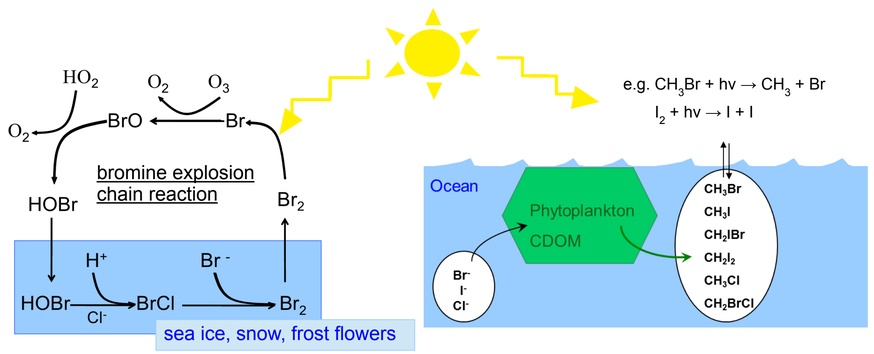


Illustration showing release mechanisms of bromine and iodine halogens to the atmosphere (Figure on bromine explosion adapted from Jones et al., 2009)

In the atmosphere, halogens are photolyzed by sunlight to halogen radicals which deplete the major greenhouse gas O_3 and are also involved in formation of cloud condensation nuclei.

Hence, changes in halogen abundance potentially impact on radiation properties, temperature and regional climate of the Arctic atmosphere. As O_3 is a precursor of OH, they may also change the oxidising capacity of the troposphere.

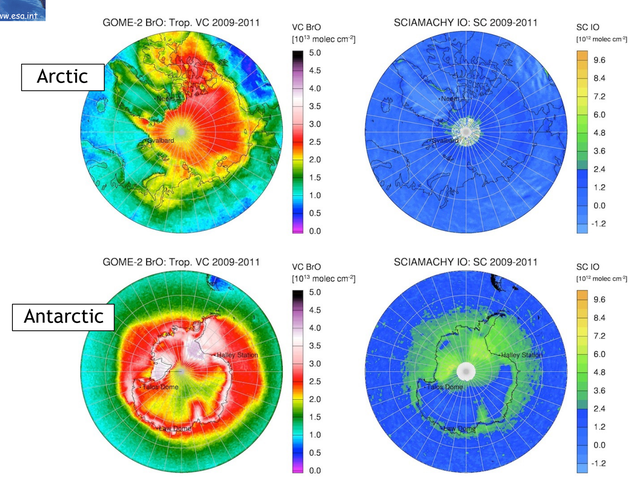
Within the framework of the German research project $(AC)^3$ (ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes and Feedback Mechanisms, http://www.ac3-tr.de/), this study is aimed to assess changes and links of surface ocean biogeochemistry and halogens in the Arctic due to climate change by satellite remote sensing.

2 BrO and IO satellite retrievals

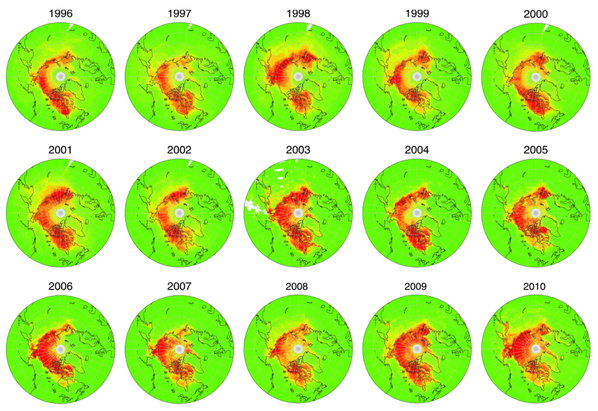
- UV/vis nadir-viewing spectrometers
- Sun-synchronous orbits, morning equator crossing times
- Slant column densities derived by Differential Optical Absorption Spectroscopy (DOAS; Platt, 1994) method
- 336-347 nm and 416-430 nm fitting window for BrO and IO, respectively

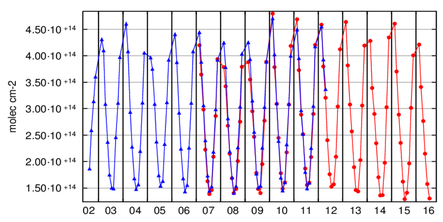
Instrument	Platform	Time period	Footprint	Equator crossing time
GOME	ERS-2	1996-2003	40x320 km²	10:30 am
SCIAMACHY	Envisat	2002-2012	30x60 km²	10:00 am
GOME-2	MetOp-A MetOp-B	2007-present	40x80 km²	09:30 am

Overview of satellite sensors routinely used for halogen retrievals by Uni Bremen

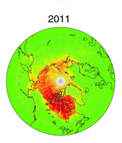


Mean atmospheric column amounts of BrO and IO in the Arctic and Antarctic between 2009 and 2011





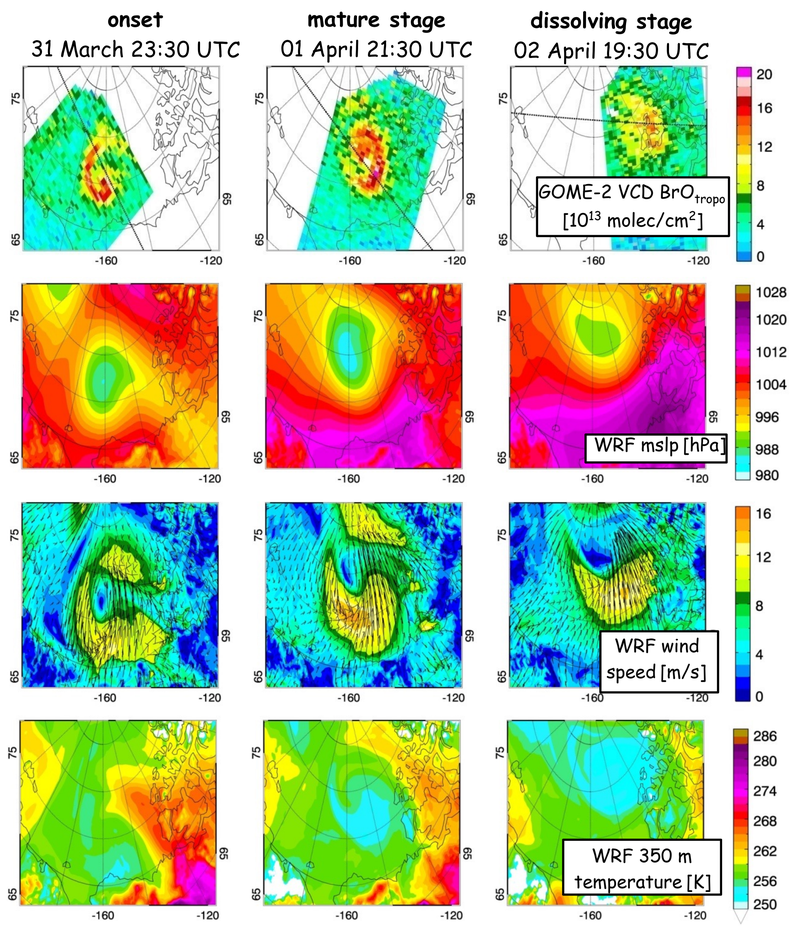
Time series of BrO SCDs averaged over the Arctic region (north of 70°N) and over months for (blue) SCIAMACHY and (red) GOME-2



Average BrO total columns for April derived from GOME (1996-2002) and SCIAMACHY (2003-2011)

- More than 20 years of satellite observations of BrO and IO
- Great basis to study individual halogen enhancement events and spatial distribution of halogens
- Within $(AC)^3$ the retrievals will be homogenized and improved in order to study possible changes of halogens in the Arctic in time due to climate change

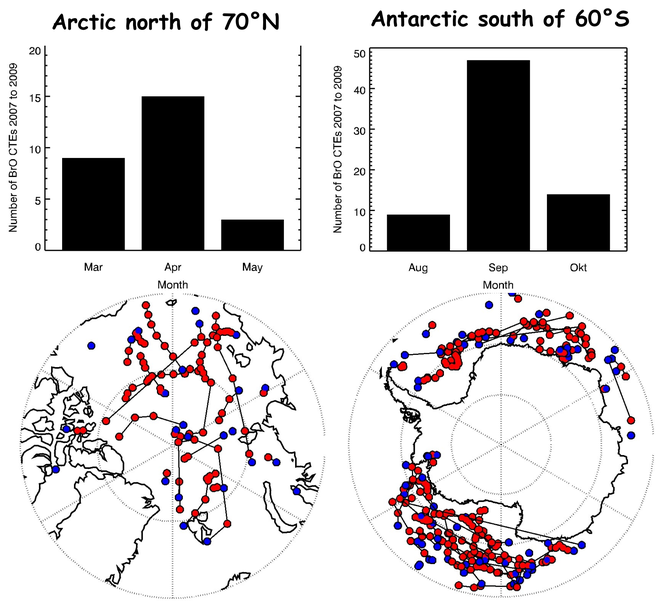
3 BrO Cyclone Transport Event



GOME-2 satellite observations and WRF regional model simulations of a BCTE over the Beaufort Sea near Canada in April 2011 (Blechschmidt et al., 2016)

- BCTE observed lifetime ~ 4 days despite short atmospheric lifetime of BrO
- BrO plume coincided with regions of frontal lifting, high wind speeds and colder temperatures
- These weather conditions favored blowing brine coated snow production and recycling of BrO on aerosol surfaces in the troposphere

4 Climatology of BCTEs



(Top) Frequency distributions and (bottom) tracks of BCTEs between 2007 and 2009 based on combining GOME-2 tropospheric BrO satellite retrievals with cyclone tracks from NCEP-CFSR mean sea level pressure model data. (Cyclone tracks provided by K.I. Hodges, Uni Reading)

- About twice as many cases in Antarctic (70) compared to Arctic (27)
- All events occurred over sea ice during polar spring

5 Future work

- Extend, combine, improve, homogenize existing BrO and IO retrievals from GOME, GOME-2, SCIAMACHY
- Evaluate potential of including OMI and S5P
- Link temporal evolution of BrO to meteorological drivers (sea ice coverage, surface temperature, blowing snow, polar cyclones)
- Link halogen oxide observations to phytoplankton satellite observations by Astrid Bracher's research group (IUP Bremen, AWI Bremerhaven)
- Study potential changes of BrO and IO amounts as well as frequency and intensity of BCTEs in the Arctic atmosphere due to Arctic amplification

6 References

Blechschmidt et al. (2016): An exemplary case of a bromine explosion event linked to cyclone development in the Arctic, Atmos. Chem. Phys., 16, 1773-1788, doi:10.5194/acp-16-1773-2016

Jones et al. (2009): BrO, blizzards, and drivers of polar tropospheric ozone depletion events, Atmos. Chem. Phys., 9, 4639–4652, doi:10.5194/acp-9-4639-2009

Schönhardt et al. (2008): Observations of iodine monoxide columns from satellite, Atmos. Chem. Phys., 8, 637-653

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