Atmospheric composition and ocean colour of the Arctic retrieved from satellite measurements

C03

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1 Summary

Coupling between **air composition, cryosphere, and oceanic biomass**

Research Foci address marine biogeochemistry and atmospheric chemistry. C03 delivers

- **validated data sets** of **halogen oxides** from all relevant satellite measurements 1995-2020;
- decadal changes in amounts and composition of Arctic atmospheric compounds and oceanic **phytoplankton functional types, PFT,** and coloured dissolved organic matter, **CDOM**;
- investigate links and feedback between both and the physical environment during **Arctic Amplification**

Hypothesis

Arctic Amplification impacts significantly on and is influenced by oceanic phytoplankton, the chemical composition of the Arctic atmospheric boundary layer, and their interactions.

2 Research rationale

Changes in sea ice, and thus the amount of **open ocean water**, impact the **inorganic production of halogen oxides** and **productivity of oceanic biomass (see Fig.1).**

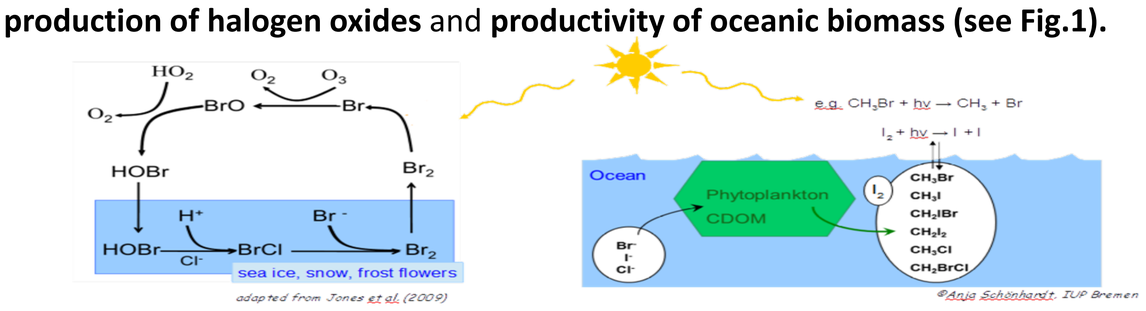


Fig. 1: "inorganic" bromine explosion and the biogenic release of oceanic organohalogen compounds

- **What** is the **impact** of **changes in sea ice, rising temperatures, increased CDOM** on **phytoplankton** abundance and composition, and on **organohalogen** emissions?
- **What** is the **impact** of changes during **Arctic Amplification** on atmospheric **composition**?

Shift in phytoplankton type?

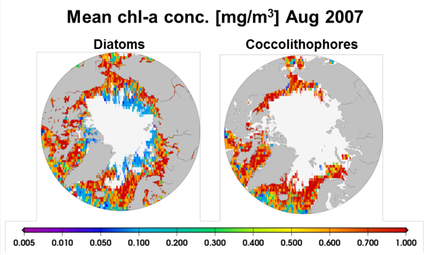


Fig. 2: SCIAMACHY phytoplankton data using PhytoDOAS (Bracher et al. 2009, Sadeghi et al. 2012)

Feedback on heat budget?

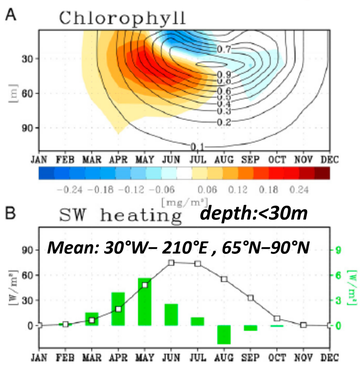


Fig. 3: A) Future phytoplankton change and B) its impact (green) on ocean radiant heating (grey) using ocean-ecosystem model, estimated +20% (Park et al. 2015)

Link to meteorology?

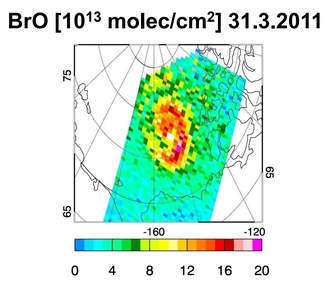


Fig. 4: GOME-2 observed tropospheric BrO event on 31 March 2011, showing link between BrO activation and a cyclone (Blechschmidt et al. ACPD)

- **Satellite observations** yield **long-term variability and trend**s in phytoplankton functional type (PFT) and CDOM
- **Ocean colour radiometry (OCR) data** are complemented by **coupled ecosystem-ocean-ice modellin**g to retrieve vertical profiles and annual cycle
- **Halogen oxide time series** from different satellites need to be homogenized to **assess past and current changes in response to Arctic Amplification**
- **Biological and inorganic halogen sources** need to be better understood
- **Multi-disciplinary approach** (atmosphere-ocean; biology-chemistry-physics; remote sensing-modelling) to elucidate **biochemistry** during Arctic Amplification

3 Research plan

WP1 Optimization of **Arctic ocean colour data**

Adaptation of OCR retrievals to high latitude peculiarities (improved corrections for low sun, clouds, ice, photo-adaptation) to reduce errors and obtain long-term data

a) unique retrieval deriving concentrations of various phytoplankton groups (PFT)
b) amount and source of CDOM
c) merged data set by synergistically applying algorithms to all available hyper- and multispectral satellite data sets to improve coverage (1997-today)

WP2 Accommodation of coupled **ecosystem-ocean model**

- Extension of REcoM-MITgcm to predict composition of phytoplankton and CDOM
- Accommodation of parameterization to Arctic with evaluation by satellite data

WP3 Feedback of **Arctic Amplification** on **PFT & CDOM**

- Study of variability and trend in PFT and CDOM over the last 20+x years
- Identification of drivers of PFT specific phenology

WP4 Optimization of **Arctic BrO** satellite **retrievals**

- Extension and harmonisation between satellite instruments
- Improvement of stratospheric correction and light path estimates

WP5 Optimization of **Arctic IO** satellite retrievals

- Extension to other instruments (GOME-2, OMI, S5P), use of high spatial resolution, optimisation of fitting window

WP6 Evaluation of changes in **BrO and IO**

- Link to sea-ice coverage, first year ice fraction, meteorology (T, cyclones, radiation)
- Link to changes in PFT amounts and composition

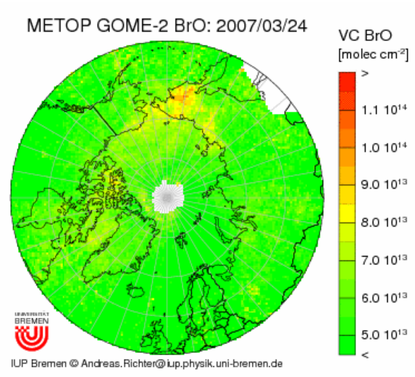
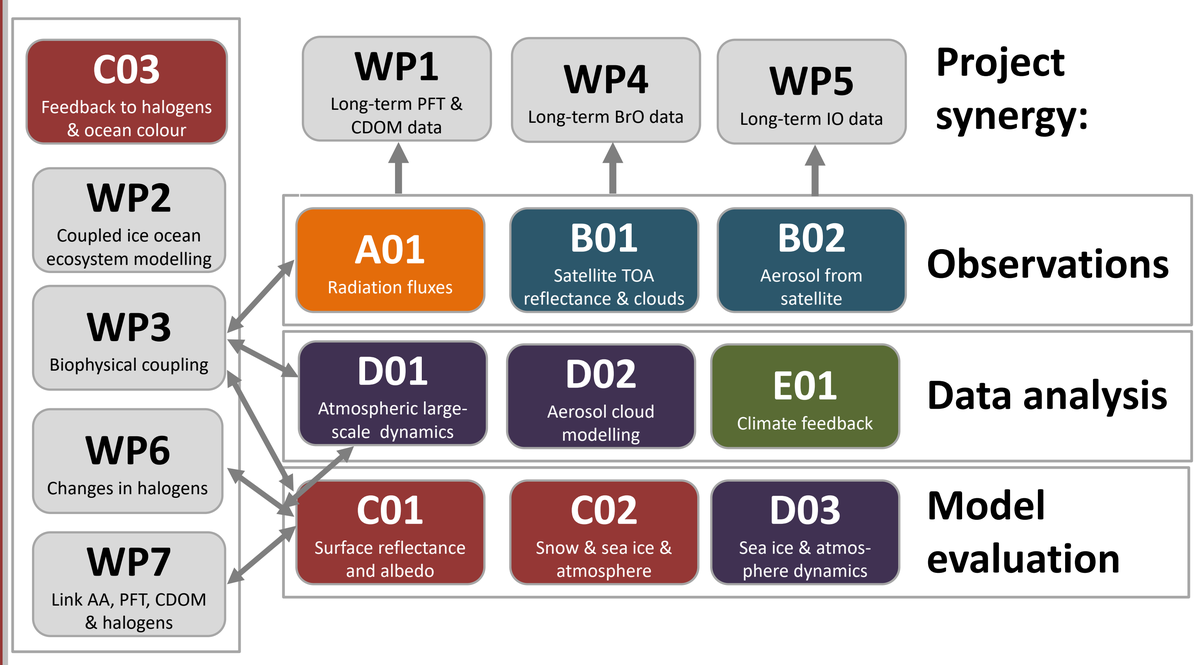


Fig. 5: Elevated BrO columns

WP7 Feedback between **sea ice, phytoplankton and halogens**

- Link of halogen oxides to composition and amount of phytoplankton and CDOM?
- Assessing satellite observations and compare to ground-based data

4 Role within (AC)³ & perspectives



Collaboration within (AC)³

- Key atmospheric constituents in the ABL and absorbers of radiation in the surface ocean, and their interactions to be used as input for Cluster D and E modelling studies
- Surface properties and radiative forcing needed to improve retrievals and models, respectively

Perspectives

- **Extension** of **ecosystem-ice-ocean model** by improving radiative transfer to **quantify radiative feedback** of Arctic Ocean and compare with output from coupled ice-atmosphere models in **Cluster D** and **Cluster E**
- After establishment **of past changes in halogen oxides** and changes in **oxidative capacity** and **metal composition**, improvement of spatial knowledge using new hyperspectral data products (coming available 2017 and 2020)
- Addition of CO_2, methane, CH_4 to analyses as data from new active and passive remote sensing instrumentation are rolled out

External Collaborations

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