Atmospheric composition and ocean colour feedback to Arctic amplification

C03

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1. Summary

The **sea ice decline impacts** on ocean **b**io**g**eo**c**hemistry (**BGC**), organic and inorganic **halogen release** (Fig. 1). Phase II of C03 builds on the success of Phase I.

Research questions:

Q1 Will the net **observed increases of tropospheric BrO**, **p**hytoplankton **g**roups (**PG**s) and **c**oloured **d**issolved **o**rganic **m**atter (**CDOM**) **continue**?

Q2 What are the key **scales of changes and drivers** (cracks in sea ice, synoptic scale lows, sea surface temperature, oceanic radiation) **and how are they linked**?

Q3 What is the impact of **indirect effects of changing** surface **water BGC on radiative forcing via aerosol precursor emissions**?

Hypothesis

Changes in atmospheric trace gases/ particles and surface ocean constituents are influenced by and feed back to Arctic amplification on different spatial and temporal scales, through their impact on radiative forcing and oxidative capacity.

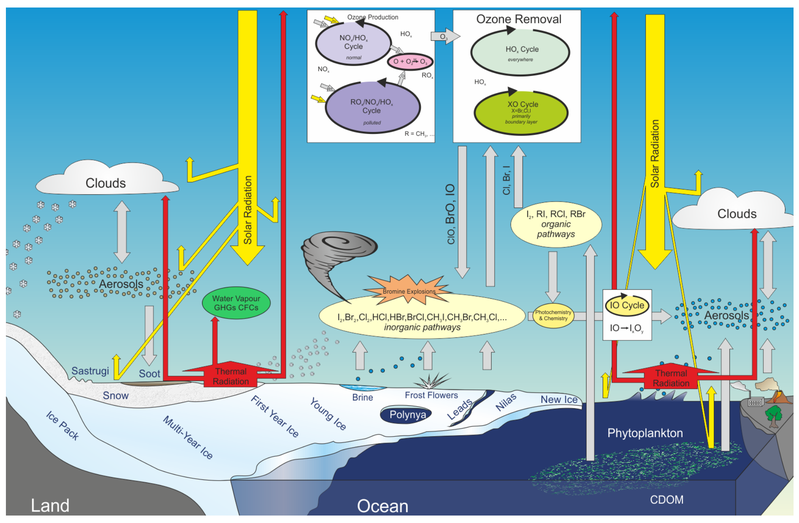
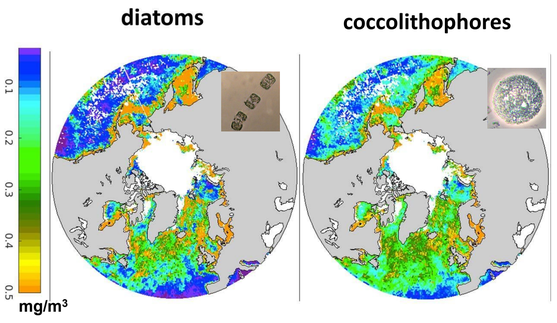


Fig. 1: Halogen and aerosol precursor release mechanisms and related feedbacks

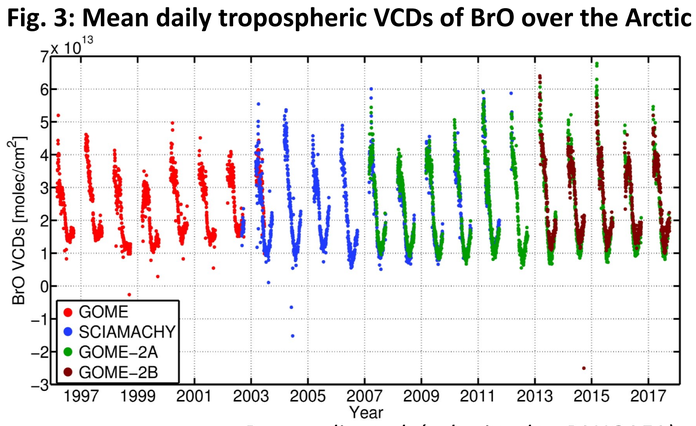
2. Achievements phase I

Fig. 2: Mean chlorophyll-a concentration, June 2010



Losa et al. (Front. Mar. Sci., 2017)

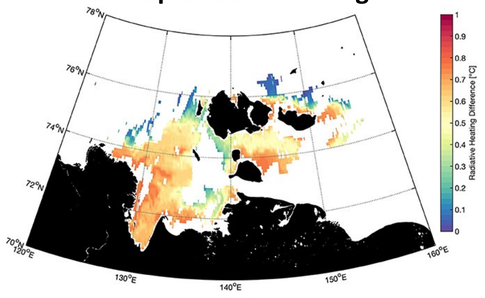
Fig. 3: Mean daily tropospheric VCDs of BrO over the Arctic



Bougoudis et al. (submitted to PANGAEA)

- **Long-term** consistent **multi-sensor data** of **oceanic light attenuation** *(Oelker et al., Opt. Express, 2019)*, **PGs** (Fig. 2), **BrO** (Fig. 3)

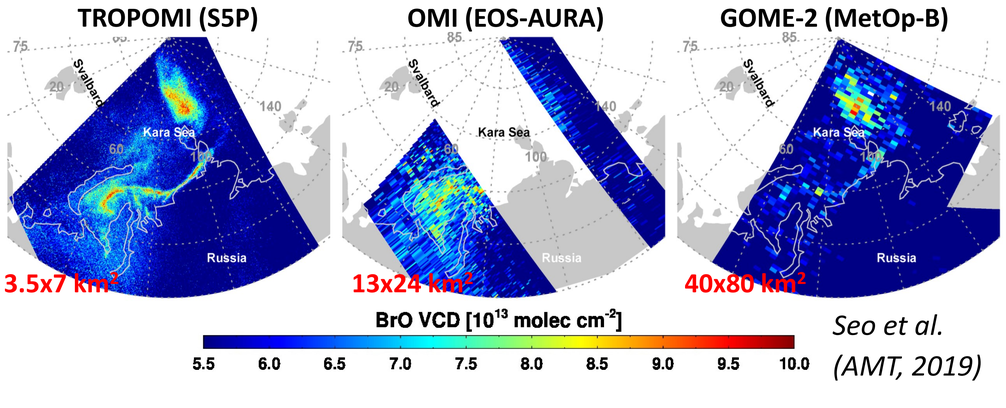
Fig. 4: Radiative heating difference (°C) of the Laptev Sea for 4 August 2010



Soppa et al. (Front. Mar. Sci., 2019)

- Identified strong **impact of surface BGC on radiative feedbacks** in the Laptev Sea (Fig. 4) and **increased growth of small PGs** in Fram Strait (*Engel et al., Front. Mar. Sci., 2019*)
- First observations of **IO** plume from **volcano** in Alaska (*Schönhardt et al., ACP, 2017*)
- Identified close **link between** a **bromine explosion and polar cyclone** development *(Blechschmidt et al., ACP, 2016)*

Fig. 5: Satellite retrievals of a bromine explosion event in April 2018 for three sensors



Seo et al. (AMT, 2019)

- The first **high spatial resolution retrievals** of **BrO** from S5P (Fig. 5)

3. Research plan phase II

WP1: Submesoscale ice-ocean-BGC modelling

- Downscale to better predict PGs, CDOM and the impact on spectral radiation
- Update, merge ocean colour datasets on PGs, kd, CDOM to cover last two decades

WP2: Diagnosis of marine aerosol tracers

- Include marine aerosol precursors in the BGC model
- Assess role of surface BGC for aerosol formation using PASCAL/MOSAIC data

WP3: Time series of oceanic emissions

- Run ice-ocean BGC model over last two decades and compare to observations
- Assess oceanic emissions, observed ocean and atmosphere variability and trends

WP4: Consistent retrievals of halogen oxides up to 2024

- Extend BrO dataset by OMI, GOME-2C, S5P and S5 (launch expected 2021)
- Evaluate potential of high resolution IO retrievals

WP5: High resolution case studies on halogen oxide plumes

- Lagrangian transport simulations driven by regional model weather simulations
- Identify sources and drivers using sea ice, lead, melt pond, frost flower data

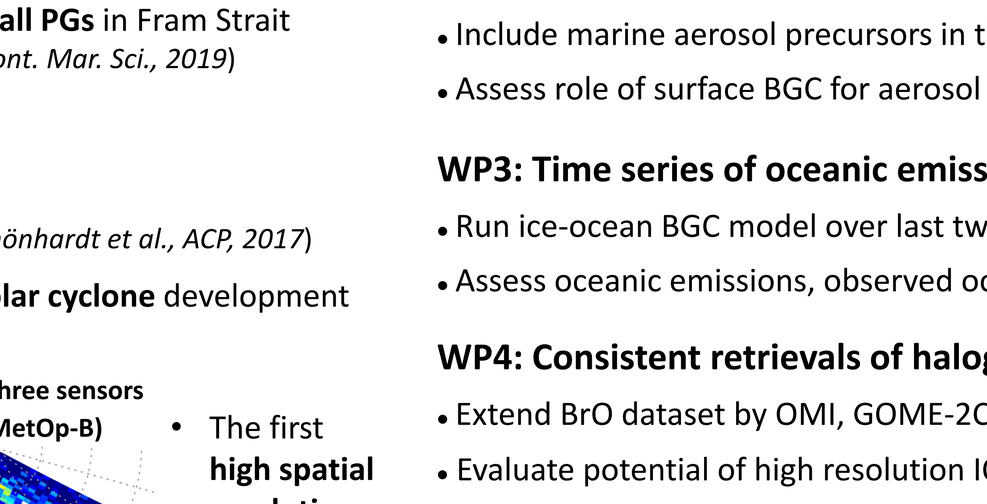
WP6: Long-term changes and drivers of halogens at different spatial scale

- Evaluate temporal and spatial changes of halogen oxides
- Compare to ocean colour, sea ice, lead, meteorological data and evaluate links

4. Role within (AC)³ & perspectives

Collaborations within (AC)³

- Marine aerosol **B04**, ocean physics **C04,** small scale ocean dynamics **D03/D04** data for BGC model evaluation
- **D02**, **E01** on aerosol precursors and radiative feedback
- **C01**, **B01**, **B02** clouds and surface properties for satellite retrievals
- Cyclone, sea ice **C01** and **D03** data on long-term changes
- **E03**, **E04** on Lagrangian transport simulations
- **E02** on ground-based ozone data



Perspectives

- Analysis of **feedbacks and trends** in ocean BGC and halogen oxides **using improved** and **high resolution data over more than 3 decades**
- **Synergistic use** of C03 and **cloud, aerosol, water vapour data** (cluster B) together with radiative transfer and **atmospheric chemistry modelling**

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