

Meeting title	Sea-ice biogeochemistry and interactions with the atmosphere			
Working Group	COST Action 735 workshop Sea-ice Biogeochemistry			
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Meeting dates	12, 13, 14 March 2011			
Meeting location	Institute	Royal Netherlands Academy of Arts and Sciences		
	City	Amsterdam		
	Country	The Netherlands		

Meeting background and aims

Climate change already has a strong impact in Polar Regions due to direct changes in surface area of polar oceans and ice sheets and to subsequent feedback processes. Our understanding of these processes and the accuracy of dedicated models is still very limited. Sea-ice biogeochemistry is an emerging topic, of which the scientific community is small, not organized and spread all over the world.

The aim of the workshop was to bring together sea-ice specialists from multiple disciplines and modelers of sea-ice systems at the different scales, in order to:

- Share existing knowledge on the role of sea ice in influencing climate-relevant elemental fluxes,
- Discuss and formulate the relevant biogeochemical processes and specify gaps in our knowledge,
- Stimulate integrated model development.
- Produce recommendations for future collaboration.

Summary of discussions

The workshop was attended by 23 representatives from 10 countries, including representatives from the US, Canada and Australia. All participants are experts in their field of research and covered both experimental sea-ice research and sea-ice modelling. A broad range of disciplines was discussed in the course of three days (see attached programme). During the first 1.5 day, each participant presented her/his personal project. In addition several major ongoing science projects were presented and the possibilities for future cooperation were discussed during the second part of the workshop.



A brief summary of the major scientific findings as they were presented:

1. Sea ice has a major impact on the budgets of climate-active and biogenic gases. High pulses of DMS and bromocarbons are associated with ice melt. It is yet unclear whether sea ice is a source or a sink for CO₂. In addition, sea ice is a major source of sea-salt aerosols and involved in bromine explosions that impact on ozone and mercury chemistry.
2. Physicochemical processes largely control sea-ice biology. But biology also feeds back onto the physicochemical properties of sea ice. Many of these processes are still poorly understood, due to a lack of data and inadequate methodology.
3. Surface processes and exchange of biochemical components with the atmosphere are not well described.
4. Sea ice is a heterogeneous medium, including solid ice, brines, gas bubbles, and solid salt precipitates, and it exhibits substantial variability on all spatial and temporal scales. While standard analytical methods exist for the parameters of interest, the phase combinations and difficult sampling conditions that characterize sea-ice studies limit the application of existing methods.
5. The lack of data constrains model development. Sea-ice models are still poorly developed on temporal and spatial scales. Small-scale models cannot properly distinguish between the different ice phases. The larger Earth System Models only consider sea ice as a “cap” on the ocean surface and entirely lack a biochemical compartment.
6. Given the potential impact of climate change on sea ice (biogeochemistry) and subsequent effects on the global climate system, upgrading of modelling and methodology is urgently needed.

Several **major science projects** operational in both the Arctic and the Antarctic were presented:

OASIS – Ocean - Atmosphere - Sea Ice - Snowpack (USA, Canada, France):

An IPY programme that focussed largely on atmospheric chemistry and interactions at the snow-atmosphere interface. A major achievement of the programme is the ongoing deployment of autonomous O-buoys around the Arctic that continuously measure a.o. Ozone, BrO and CO₂. In future, OASIS aims at expansion towards marine and cryosphere sciences. A workshop to discuss future directions is planned in Telluride, CO, in June 2011.

Polarstern Antarctic winter cruise 2013 (Germany):

Expedition with the German research vessel, with a major focus on sea-ice biogeochemistry. A preparatory workshop will be organised later this year, to discuss various scientific approaches.

YROSIAE – Year-round ocean-sea-ice-atmosphere exchanges (Belgium):

The project involves long-term measurements at Scott Base, including year round atmospheric measurements. The project focuses on sea-ice dynamics near the coast. Comparison between landfast and pack ice dynamics, with respect to sea-ice biology and geochemistry are envisioned.

DEFROST – (initiative by Denmark, Finland, Iceland, Norway, Sweden, Greenland):

This network initiative focuses on ecosystem-climate feedbacks as they are affected by permafrost, snow and ice in the Arctic. The project relates to two other Nordic Centres of Excellence, all funded by the ICCG (on the interaction between climate change and the cryosphere):

SVALI: on the Stability and Variations of Land Ice

CRAICC: Cryosphere-atmosphere interactions in a changing Arctic

IAOOS - Ice Atmosphere Ocean Observing System (France):

The project involves the deployment of 15 autonomous platforms, drifting in the Arctic Ocean. The platforms make a real-time station, from which the upper ocean and the lower atmosphere in the vicinity of arctic sea-ice will be studied. The platforms operate complementary with satellite observations.



On the second day, opportunities for future cooperation were discussed in two separate working groups:

Working group 1 discussed strategies for continuation of the sea-ice network and set the outline for a grant proposal for a SCOR-working group. The rationale for such a WG is that emerging views indicate the importance of biogeochemical processes in and associated with sea ice for physical properties and exchange processes at the interfaces. In order to understand this system it is a prerequisite that the main processes and feedbacks at each and every scale are examined from an integrated perspective. This will be accomplished by active interaction between experimentalists and modellers. The experimentalists will need to assess the quality of the data that have been assembled and translate these in order to make them useful for modellers. The modellers will need to find ways to improve the flexibility of their models in order to translate processes from one scale to the other. Together they will identify, evaluate and parameterize the main biogeochemical and

physical properties at the different scales, with the ultimate goal of realistically implementing polar biogeochemical processes in both ocean biogeochemistry and Earth System Models.

Working group 2 focussed on the ins and outs of sea-ice methodology. Over the last 10-15 years, research on sea ice biogeochemistry has expanded dramatically, with many new parameters required and a variety of methods developed for application within the challenging medium of sea ice. However, to date, there has not been a comprehensive review of sea-ice biogeochemical methods equivalent to those that have been published for sea water (JGOFS & Repeat Hydrography manuals).

The need for a thorough evaluation of currents methods was discussed. This team has described the outlines of a review paper, which will be finished in the course of summer. The group has defined various theme's that need to be addressed in this review, like the challenge of the separation of brines and gas bubbles from the sea ice without introducing artefacts. In addition, recovering and handling organisms living within the sea ice while maintaining community structure and without stressing them is still problematic.

Numerous methods are currently being applied to a number of important parameters in sea ice, requiring comprehensive intercalibration exercises to assess their relative strengths, weaknesses, and develop recommendations. There is a strong feeling within the sea-ice biogeochemical community that a dedicated field effort is required to achieve this goal of intercomparison and identification of optimum methods for a variety of conditions and parameters.

Meeting Outcomes

The meeting was very successful. It was considered a first step towards combining expertise and effort in this complex area. A genuine sea-ice community will be established.

To this end, bi-annual meetings will be organised, most likely as a satellite meeting at one of the larger scientific meetings such as AGU, EGU, ASLO and an IGS-sea ice conference. Funding to facilitate these meeting will be sought.

A website will be constructed to facilitate data exchange, to provide a discussion platform and to share general information.

A white paper will be prepared for EOS; to describe the state-of-the-art and to improve awareness on the importance of sea ice, in order to promote additional research efforts into this vast, yet poorly explored territory.

A review paper describing the current-state-of-the-art on sea-ice methodology will be prepared in the course of the year.

Goals and plans for future activities (please include details of further meetings, publications research proposals and a timeline for these activities)

A proposal for a SCOR-working group ('Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII)') has been submitted on April 17th. Such a working group, which should bring together experimentalists and modelers, would be an excellent mechanism to assemble current expertise around this interdisciplinary topic.

A COST-action proposal will be drafted later this year (deadline Sept 2011).

Collaboration will be sought with the existing OASIS network in order to join forces (June 2011).

An EOS paper will be drafted for publication by the end of 2011.

Program COST Action 735 workshop Sea-ice Biogeochemistry
Royal Netherlands Academy of Arts and Sciences
Kloveniersburgwal 29, 1011 JV Amsterdam
12-14 April 2011

Tuesday 12 April:

- 9:00 Welcome at the Royal Academy
- 9:15 **Small scale processes:**
Jean-Louis Tison: Modelling Biogenic Gases Concentrations and Fluxes in sea ice...wishful thinking?
JiaYun Zhou: O₂/Ar and CH₄ measurements in sea ice : insight for modeling gas exchanges through sea ice
Agneta Fransson: Biogeochemical description of Antarctic summer sea ice and Arctic winter sea ice
- 10:45 Coffee
- 11:15 **Small-to-medium scale processes:**
Clara Deal: From 1-D Modeling of Primary Production and Dimethylsulfide within Sea Ice to the Pan-Arctic Scale
Jacqueline Stefels: Dynamics of DMS, DMSP and DMSO in Weddell Sea sea-ice
Claire Hughes: The impact of an alteration in sea-ice dynamics on the seawater concentrations of biogenic bromocarbons in coastal waters of the western Antarctic peninsula
Eric Wolff: The role of the sea ice surface on sea salt aerosol and bromine chemistry
- 13:00 Lunch
- 14:15 **Medium scale processes:**
Michel Gosselin: Modeling ice algal production in the Hudson Bay system
Paty Matrai: Marine gels and cloud formation over Arctic pack ice
Delphine Lannuzel: Distribution of trace elements in Antarctic sea ice
Veronique Schoemann: Sea ice as a source of bioavailable Fe
- 15:45 Tea
- 16:15 **New programmes and initiatives:**
Jan Bottenheim: OASIS - past and future
Gerhard Dieckmann: Antarctic winter cruise 2013
Bruno DeLille: New long-term measurements at Scott Base
Lise-Lotte Soerensen: Sea-ice in DEFROST, a new Nordic Centre of Excellence
Christine Provost: Ice Atmosphere Ocean Observing System (IAOOS)
- 17:30 Decision on themes for next days' parallel working-groups.
- 18:00 End day 1
- 19:00 Diner in "De Waag": Nieuwmarkt 4, 1012 CR Amsterdam

Wednesday 13 April:

- 9:00 *Martin Vancoppenolle*: Advanced coupled 1D ice biogeochemistry model
Medium-to-large scale processes:
Gerhard Dieckmann: What is the significance of CaCO₃ precipitation in sea ice?
Bruno DeLille: Overview of CO₂ dynamics within sea ice
Lisa Miller: Patterns amid the confusion in the sea-ice inorganic carbon system
- 10:45 Coffee
- 11:15 **Large scale processes:**
Scott Elliot: Development of Ice Biogeochemistry in a U.S. Earth System Model
Nadja Steiner: Modelling high latitude biogeochemistry in Earth System Models: Benefits, Limits and Constraints
Francois Fripiat: Nitrogen and silicon isotopic signatures in the sea ice and surface waters of polar oceans: implications for modern and past biogeochemical cycles
Christoph Garbe: Estimating transport processes of trace gases from satellite remote sensing in the polar regions
- 13:00 Lunch
- 14:00 **Parallel working groups**
- 18:00 End day 2
- 19:00 Diner in "De Jaren": Nieuwe Doelenstraat 20, 1012 CP Amsterdam

Thursday 14 April:

- 9:00 Continuation working groups: writing of a 2-page report
- 10:45 Coffee
- 11:15 Plenary presentation of working group results
Rapping up
- 13:00 Closure