

Towards Joint SOLAS-CliC Activities on Sea-Ice Biogeochemistry

Report on a discussion held at the 2015 SOLAS Open Science Conference
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Following on their successes, SCOR working group 140 on “Biogeochemical Exchange Processes at Sea-Ice Interfaces” (BEPSII) identified a need to sustain the community studying sea-ice biogeochemistry beyond the lifetime of the SCOR working group, in order to develop consistent methodologies, establish effective sea-ice data archiving approaches and databases, integrate observational and modelling efforts, and foster technological developments. While sea-ice biogeochemistry has been a mid-term strategy of SOLAS, which has endorsed BEPSII, the WCRP Climate and Cryosphere (CliC) project has Arctic and Antarctic sea ice working groups and a Sea Ice and Climate Modelling Forum that are also working towards similar goals from a more physical perspective. Therefore, we held a discussion at the SOLAS Open Science Conference to explore ways SOLAS and CliC can jointly promote activities in sea-ice biogeochemistry.

The goal of the discussion was to develop a draft proposal to the CliC and SOLAS steering committees for a joint framework to support continuing developments in sea-ice biogeochemical research. We were largely successful in achieving that goal, in that a CliC Forum application is being prepared for their November 15th deadline, and we will also submit a modified version of that proposal to SOLAS. However, the requirements for that application are very brief and general, and much of the discussion pursued more detailed ideas for long-term BEPSII activities.

We started the session with a presentation by BEPSII co-chair Jacqueline Stefels on BEPSII history, starting with the SOLAS mid-term strategy and an initial COST-SOLAS workshop in Amsterdam in 2011, followed by provisional acceptance as a SCOR working group later that year and their first (unofficial) meeting at the 2012 SOLAS Open Science Conference. The final BEPSII meeting under the auspices of the SCOR working group will be held in Paris during March 2016.

The initial aim of BEPSII was ambitious: *To improve our understanding of the role of sea ice in global biogeochemistry by bringing together sea-ice modelers and observationalists.* This goal was approached through four activities:

1. Standardisation of methods for data inter-comparison;
2. Summarizing existing knowledge in order to prioritise processes and model parameterizations;
3. Up-scaling of processes from 1D models to earth system models; and
4. Analysing the role of sea ice biogeochemistry in climate simulations.

Despite substantial successes, much of this work still remains incomplete, and the need for additional activities has become apparent.

Martin Vancoppenolle then presented the general goals and structure of CliC (www.climate-cryosphere.org), including their ‘Fora’ which provide a framework for long-term association of communities addressing specific issues in cryospheric science. Support provided for a forum includes 5000 CHF/year to support a workshop, travel bookings, and hosting a website. Lisa Miller then described the activity structures and resources available from SOLAS, noting that their structures are in no way incompatible with those of CliC.

The open discussion was then set up with a list of ideas for future BEPSII activities identified at the last BEPSII meeting (in Barga, Italy, March 2015) and through a survey of the BEPSII mailing list in late summer. The discussion was framed by 4 themes: networking mechanics and funding; scientific topics and issues; membership, including entraining more atmospheric scientists; and boundaries.

Other ideas for networking mechanics (money)?

- Roll of BEPSII in helping coordinate activities and raise funding.
- Each topic/task will require leaders.
- Suggestion to propose a COST action in March 2016.
- IMBER: Connections to higher trophic levels. Help maintain strength of the Antarctic in BEPSII.
- European Space Agency (ESA): CLiC and SOLAS both have contacts.
- International Arctic Science Commission (IASC): coordinator of Arctic research funding agencies. Contact: Volker Rachold, IASC secretary.
- UK is putting money into ship plume emissions.

Additional topics/issues?

- Stakeholder engagement: Arctic researchers have a lot of experience. Future Earth ArcticSTAR cluster. Ocean acidification community. Issues are locally defined.
- Higher trophic levels: links with IMBER.
- Anthropogenic impacts on sea ice: warming-induced changes in sea-ice structure, as well as distribution; ship plumes; ocean acidification; invasive species; modifications of riverine freshwater discharges.
- Upwelling: shelf-basin interactions; primary production.
- Snow & melt ponds.
- Paleoclimate: sea-ice proxies.

New members (atmospheric sciences)?

- Need to better link with IGAC and AICI (Air-Ice Chemical Interactions), as well as OASIS.
- People working on snow.
- SCOR working group on sea-ice proxies.

Boundaries?

- Effects of sea ice on the environment around sea ice, such as the marginal ice zone, under ice blooms, etc.
- Open waters influenced by ice melt.

Appendix: Complete minutes of the discussion

Lisa Miller (LM), Martin Vancoppenolle (MV), and Jacqueline Stefels (JS) presented the Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII) SCOR working group, its objectives and main achievements. They pointed out the strong will of the former members of the BEPSII group to renew this network. They presented potential funding of a future network by CLiC, the envisaged specific activities of the network and most glaring scientific questions related to sea ice biogeochemistry.

Emily Brévière (EB) SOLAS IPO pointed out that resources from CLiC were low.

It has been pointed out that there are some relationships between CLiC and ESA, and they have some interests in the sea ice. It might be of interest for BEPSII to deal also with remote sensing. By doing that BEPSII may catch attention of ESA, and then ESA may support BEPSII in some ways. The issue, is that remote sensing currently addresses mostly sea ice physics, rather than biogeochemistry. CLiC has already this remote sensing component, but BEPSII is focusing on biogeochemistry instead.

Eric Saltzman (ES) pointed out that most of the funders of Arctic research are gathered and coordinated within the International Arctic Science Commission (IASC). ES asked about the relationships between BEPSII and IASC. LM/JS: unfortunately, BEPSII does not have so many connections with IASC. LM asked the appropriate channel to reach IASC. ES reply that BEPSII should contact IASC secretary Volker Rachold. JS pointed out that IASC as a top-down approach. ES replied that it's true and that IASC is good at setting the research priorities. However IASC has difficulties to entrain new young enthusiastic people. LM argue that money can help to attract young scientist, but ES pointed out that IASC have no money for projects.

ES pointed out that most of Arctic projects pay attention to the stakeholders and that he could not imagine that they are not paying attention to sea ice, that is crucial for the subsistence of Arctic communities. LM replied that, for the time being, BEPSII has not focused on such issues but BEPSII could. JS asked if it must be done through Future Earth programs, or can that be avoided ? ES suggested to focus on water quality for instance, even if people are most interested in higher trophic levels. LM agreed that every single projects in the Arctic pays attention to stakeholder needs and that we can set up a task group that focuses on the connections with stakeholders, even if Antarctic people are not used to doing that.

Véronique Graçon (VG), SOLAS chair, stressed that within Future Earth, ArcticSTAR is focusing on the Arctic. Does BEPSII have relationships with ArcticSTAR. BEPSII contacted Faye McNeill, and her response was "yes it's interesting, keep me posted".

Maurice Levasseur (ML) asked some question about boundaries of BEPSII, and if BEPSII looks at the effects of sea ice on the surrounding environment, like the marginal ice zone, under ice blooms... LM thinks that these processes are of interest for BEPSII, and even a summer ice-free Arctic Ocean covered by a thin ice layer in winter, is still related to sea ice. However, it's not up to her to decide what are the boundaries of BEPSII, and that will depend of the will of the communities. ML stress that there will be more interest from stakeholders in the processes related to sea ice. LM argues that there are enthusiastic people to do that. ML stress that then the title of the network should reflect this interest in the processes in the surroundings of sea ice. JS insisted that BEPSII is oriented to exchanges at the interface, and in that way we are interested in exchange with the surroundings, and for instance with the pelagic. If BEPSII would like to investigate the role of sea ice at large scales, BEPSII definitely has to look at the effect of sea ice on the surrounding habitats.

Laurent Bopp (LB) raised the question of the interest of BEPSII on higher trophic levels in the surrounding ecosystems. JS said that it's up to people to step up to do that, and at some point BEPSII needs a connection with IMBER. It's just a matter of having someone who will step up to make the link between BEPSII and IMBER. VG pointed out that SOLAS produced a list of topics for integration of marine projects within Future Earth, and the Arctic was one of the topics. So SOLAS is pushing for an emphasis on the Arctic with subjects related to the ocean within Future Earth. LM stated that one of our concerns, however, is that BEPSII will be pushed towards the Arctic, while BEPSII wants to keep a strong Antarctic component. A connection with IMBER will help to maintain a strong link with the Antarctic, as there is a strong interest in the Antarctic within IMBER. It appears that BEPSII should definitely have a link with IMBER.

What about SOOS ? We have also good connections with SOOS, through Klaus Meiners, Steve Ackley, and Bruno Delille, who will participate in a meeting with SOOS in 2 weeks. We are well involved in ASPECT (from SCAR) through Steve Ackley.

LM raised the question of links with AICI. EB noted that Fade McNeill is in charge.

VG: BEPSII should be inserted in Future Earth. Because numerous projects are already there (SOLAS, IMBER). There is a need to put science in Future Earth. According to JS, BEPSII is still a new community. Obviously, the future step is to develop the link with the pelagic. And then, BEPSII can have an interest for the stakeholders. We have the impression that BEPSII is too fundamental in understanding what is happening. , since we are not focusing on the pelagic food web, which is of interest to stakeholders and thereby Future Earth. Lisa pointed out that Arctic communities have a subsistence way of live and are very concerned about environmental changes overall, and we have already some topics of interest such as ocean acidification and interactions with climatically active gases.

Emily suggested to pay attention to ocean acidification people, because they have good connections with stakeholders.

BEPSII should pay attention not to have too much overlaps with atmospheric people (IGAT, OASIS). LM do not see so much issue there.

Katerina Abrahamson (KA) pointed out that there is also strong anthropogenic pressure on sea ice coming from the atmosphere (for instance, ship plumes, ocean acidification). There are numerous other pressures, like invasive species, water discharges that affect biogeochemistry.

ML: One of the big changes in the Arctic is the change in the quantity and quality of the ice that will impact the whole food web of the Arctic through the ice algae bloom. There are big changes to come. For instance, a comparison between under-ice and open water phytoplankton blooms will be crucial. So there are a lot of things to do there. All communities in the Arctic are working at local level, and BEPSII should approach this local level, if BEPSII wants to interact with stakeholders. LM agrees.

JS stressed that one of the big questions is practically how to organize the suite of BEPSII. How many meetings, how frequent, how structure them, and BEPSII needs task leaders to coordinate specific meetings. LM said that BEPSII definitely needs some leaders to run tasks, and this is an issue. So we are expecting to have people step up to lead some task/questions.

JS. Regarding to science, BEPSII circulated a small questionnaire to identify the scientific questions to be addressed regarding sea ice biogeochemistry, and how to carry out intercalibrations. JS asked the audience what are the most glaring issues for sea ice biogeochemistry? She pointed out that BEPSII could be used to organize things or get money, like EU COST Actions, among others. BEPSII is willing to help to coordinate things.

Lise Lotte Sørensen (LS) pointed out that the deadline for COST Action proposals just passed, so that we have a year to propose a new COST Action. There are one or two calls per year, and the answer comes during the following 6 months. LM asked about the framework of COST actions. LS thinks that BEPSII may submit a cost action similar to the previous SOLAS cost action. BEPSII will discuss that issue specifically among European partners, but BEPSII could aim to submit a proposal by March 2016.

Tom Bell (TB) said that the UK is putting some money in addressing trace gases emission and gas exchanges, and ship emissions of sulfur compounds. TB is wondering if it may be relevant to BEPSII. He pointed out that there are now some attempts to regulate these emissions. One way for the shipping industry to regulate these emissions is to inject these sulfur compounds directly into the water. This raises the question of the fate of these sulfur compounds in the water, and re-emission to the atmosphere. JS replied that Brice Loose is investigating the effect of sea ice on air-sea exchanges. However, as LM pointed out, the issue of ship traffic was not specifically addressed, even if BEPSII is putting a lot of effort in studying air-ice exchanges of gases. For instance, as part of our intercomparison of methodologies, some BEPSII members are working on comparison between fluxes measurements carried out by eddy covariance techniques and chambers. BD pointed out that there is still a lot to do in this field. LM stressed that it's a complex issue, since there is also the role of snow on these exchanges, the exchanges in the leads, and so on.

It was asked about interest in issue of the snow. BD acknowledged that it's a big issue and quite complex for us to address. LM stressed that is due to under-representation of atmospheric people in BEPSII. Atmospheric scientists are working on snow, but they are stopping at the snow-ice interface, while obviously there are connections between the ice and the snow above, that are poorly addressed. This is a key issue that should be addressed by the OASIS group. LM is unsure about their progress but stressed that OASIS has made pretty good progress by building buoys with analyzers that can travel through the Arctic.

KA propose to look at the fluxes of other trace gases by eddy-covariance.

Mario Hoppema (MH) is interested in the Southern Ocean. He is wondering about the role of upwelling in the Southern Ocean on sea ice. We acknowledged that we haven't done anything in that direction.

In the Arctic, there are people interested in the interaction between the Arctic shelf and the sea ice. MH is thinking about the fluxes of energy, fluxes of salinity, etc. ML pointed out that the under-ice bloom observed by Arrigo was fueled by upwelling, so it should be of interest.

On the N-ICE camp cruise, spatial heterogeneity was a key issue, and it should be addressed. BEPSII is paying attention to spatial heterogeneity and has taken this issue as far as we could. We finished up with some recommendations about how to tackle this question.

ML suggested to pay attention to melt ponds. ML stress that little is known about the transfer from snow to melt ponds, and to the underlying layer, and their impact. ML underlined that sea ice is a very complicated and specific medium, and BEPSII has really found their position among the community working in the Arctic by dealing with sea ice together with SOLAS questions.

Alfonso Saiz-López (ASL) asked about the connection between BEPSII and paleo studies. For example, there are strong connections between sea ice extent and the level of bromine in the atmosphere, and bromine level can be a proxy of sea ice extent. There is a direct link between sea ice and the level of halogens. By looking at the bromine record, we may explore ice extent changes in the past. LM pointed out that there are also some materials exported from sea ice to the sediment that can be used as tracers of sea ice extent, but there are no BEPSII members who are investigating these questions. MV pointed out that there is already a community interested in sea ice proxies, gathered in a SCOR working group.

LM said that we should have better connections. MV suggest that we should remain open to some connections in this respect.

LM pointed out that the meeting was quite interesting, that we will prepare a summary of the meeting, and based on the discussion, we will submit a formal proposal to SOLAS.