

Reports to SCOR (2020)

1. Name of group

Working Group 152, Measuring Essential Climate Variables in Sea Ice (ECV-Ice)

2. Activities since previous report to SCOR (e.g., virtual or in-person meetings, email discussions, special sessions). Limit 1000 words

In-person meeting

#1: CO₂ flux compilation meeting at Alfred Wegener Institute, Germany, 18 Mar. 2019. Present: D. Nomura, B. Delille.

#2: CO₂ flux compilation meeting at Hokkaido University, Sapporo, Japan, 23 Apr. 2019. Present: D. Nomura, L. A. Miller.

#3: Planning meeting for Inter-comparison experiment for primary production and CO₂ flux at Cambridge Bay, Canada, 3 Jul. 2019. Present: D. Nomura, B. Else.

#4: 2019 ECV-Ice annual Meeting with BEPSII, Winnipeg, Canada, 16-18 Aug. 2019. Present: D. Nomura, F. Fripiat, B. Else, B. Delille, L. Miller, J. Bowman, A. Fransson, D. Lannuzel, K. Meiners, and J.-L. Tison.

#5: CO₂ flux compilation meeting at Tromsø, Norway, 19 Aug. 2019. Present: D. Nomura, B. Delille, S. Moreau.

#6: Planning meeting for Inter-comparison experiment for primary production at Toyama, Japan during SCOR annual meeting, 24 Aug. 2019. Present: D. Nomura, L. A. Miller, I. Peeken.

#7: CO₂ flux compilation meeting at California, USA during CATCH annual meeting, 7 Dec. 2019. Present: D. Nomura, B. Delille.

#8: Planning meeting for sea ice storage for sea ice tank experiment at University of East Anglia, UK, 20 Jan. 2020. Present: B. Delille, O. Crabeck, D. Nomura.

#9: Planning meeting for Inter-comparison experiment for primary production in Cambridge Bay, Canada at University of East Anglia, UK, 29 Jan. 2020: B. Delille, D. Nomura (skype: L. Miller, B. Else, F. Fripiat).

Inter-comparison Experiment

#1: Sea ice inter-comparison experiment for light measurement in Saroma-ko Lagoon, Hokkaido Japan, 23-28 Feb. 2019. Present: D. Nomura, P. Wongpan, T. Toyota, T. Tanikawa, Y. Kawaguchi, T. Ono, T. Ishino, M. Tozawa, T. P. Tamura, I. Yabe, E. Y. Son, F. Vivier, A. Lourenco, M. Lebrun, Y. Nosaka, and M. Vancoppenolle.

#2: Inter-comparison experiment for sea ice storage and gas flux in UEA ice-tank facility, UK, 18-29 Jan. 2020. Present: B. Delille, O. Crabeck, D. Nomura, Kyle Simpson.

#3: Inter-comparison experiment for eddy covariance CO₂ flux measurement in Tsukuba, Japan. 25-29 Feb. 2020. Present: D. Nomura, H. Ikawa, K. Ono, F. Kondo.

Virtual meeting

#1: CO₂ flux compilation meeting with skype, 25 Jan. 2019. Present: D. Nomura, S. Moreau.

#2: ECV-Ice co-chair meeting with skype, 19 Apr. 2019. Present: D. Nomura, F. Fripiat.

#3: ECV-Ice co-chair and full member meeting with skype, 24 Jan. 2020. Present: B. Else, D. Nomura, F. Fripiat, B. Delille, L. A. Miller, O. Crabeck.

3. Documents published since previous report to SCOR (e.g., peer-reviewed journal articles, reports, Web pages) and should be limited to publications that resulted directly from WG activities and which acknowledge SCOR support

Peer-reviewed journal articles

#1: Roukaerts, A., Nomura, D., Deman, F., Hattori, H., Dehairs, F., Fripiat, F.: The effect of melting treatments on the assessment of biomass and nutrients in sea ice (Saroma-ko lagoon, Hokkaido, Japan), *Polar Biology*, 42, 347–356, 2019.

#2: Campbell, K., Mundy, C. J., Juhl, A. R., Dalman, L. A., Michel, C., Galley, R. J., Else, B. E., Geilfus, N. X., and Rysgaard, S.: Melt Procedure Affects the Photosynthetic Response of Sea Ice Algae. *Front. Earth Sci.* 7:21. doi: 10.3389/feart.2019.00021, 2019.

#3: Nomura D, Wongpan P, Toyota T, Tanikawa T, Kawaguchi Y, Ono T, Ishino T, Tozawa M, Tamura T. P, Yabe I. S, Son E. Y, Vivier F, Lourenco A, Lebrun M, Nosaka Y, Hirawake T, Ooki A, Aoki S, Else B, Fripiat F, Inoue J, Vancoppenolle M. Saroma-ko Lagoon Observations for sea ice Physico-chemistry and Ecosystems 2019 (SLOPE2019). *Bulletin of Glaciological Research*, 38, 1-12, doi:10.5331/bgr.19R02, 2020.

Web pages: Updated by Daiki Nomura (<https://sites.google.com/view/ecv-ice/>).

4. Progress toward achieving group's terms of reference. List each term of reference separately and describe progress on each one. Limit 1000 words

This working group gathers international experts on chemical and biological measurements in sea ice to design and coordinate required inter-comparison and intercalibration experiments. The group is synthesizing the results of past experiments, identifying what types of new experiments are needed, and supporting the community in executing those experiments.

Term of reference (TR) #1: Publish synthetic reviews compiled from measurements demonstrating large, unresolved discrepancies.

We compiled published and unpublished datasets (raw data, methodologies and associated protocols for data correction, instruments, and sampling design) on sea ice-air CO₂ flux and *in situ* primary production from the sea-ice research communities.

(1) Published and unpublished datasets, using various methodologies, have been collated for primary production both in the Arctic and Antarctic sea ice: incubations (^{13}C , O_2 , ^{14}C), under-ice microelectrode, and biomass accumulation rates (F. Fripiat, C. J. Mundy, F. Deman, and K. Campbell). The different methods will be compared, and a mechanistic understanding of the observed discrepancies will be elaborated. Together, this dataset represents the largest compilation of primary production rates so far in sea ice.

(2) Published and unpublished datasets have been collated to compare gas flux measurements over sea ice using chamber techniques (D. Nomura, B. Else, F. Fripiat et al.). A preliminary draft of this paper has been almost completed, and it was discussed at the ECV-Ice annual meeting in Winnipeg, MB, Canada.

TR #2: Design and coordinate intercalibration experiments to evaluate different methods for key parameters.

Completed Inter-calibration Experiments:

(1) Sea ice light measurement: Saroma-Ko Lagoon, February 2019

Participants: D. Nomura, P. Wongpan, T. Toyota, T. Tanikawa, Y. Kawaguchi, T. Ono, T. Ishino, M. Tozawa, T. P. Tamura, I. Yabe, E. Y. Son, F. Vivier, A. Lourenco, M. Lebrun, Y. Nosaka, and M. Vancoppenolle.

Summary: An intercalibration experiment (one week; Lead: D. Nomura) was carried out at Saroma-ko lagoon (Japan) in February 2019 to evaluate different methodologies (sensors) assessing sea-ice over/under ice light measurement. The experiment was successful and a peer reviewed paper (Nomura et al., 2020) was published.

(2) Gases in sea ice and sea ice-air gas flux: Roland Von Glasgow Air-Sea-Ice Chamber (University of East Anglia), January 2020

Participants: B. Delille, D. Nomura, A. K. Simpson, O. Crabeck

Summary: Sea ice freezing experiments were carried out at Roland von Glasgow air-sea-ice chamber (University of East Anglia) for the sea ice storage inter-comparison experiments. We obtained warm and cold sea ice and stored them in the different kinds of bags over different time periods to inter-compare the storage of sea ice samples.

(3) Eddy covariance (EC) drying air comparison for air-sea ice CO_2 flux measurement: Tsukuba, Japan, February 2020

Participant: D. Nomura, H. Ikawa, K. Ono, F. Kondo

Summary: In order to check the moisture effect on the EC CO_2 flux on sea ice (very small magnitude of CO_2 flux), we have examined the drying air experiments in the National Agriculture and Food

Research Organization, Tsukuba, Japan. We prepared two CO₂/H₂O analyzers (enclosed, LI-7200) and compared with/without air drying systems (Drierite, Magnesium perchlorate, Perma pure dryer) for CO₂ signals to calculate the CO₂ flux. This EC system will be used for inter-comparison experiment in the Cambridge Bay, Canada, 2021 to compare with the other EC system and enclosure CO₂ chamber system for air-sea ice CO₂ flux.

Planned Inter-calibration Experiments:

Primary Production and Gas Fluxes: The Canadian High Arctic Research Station (CHARS), Cambridge Bay, Canada

Participants: B. Else (lead), F. Fripiat (co-lead), D. Nomura (co-lead), Bowman, C.J. Mundy, N. Kanna, B. Delille, L. Tedesco, N. Geilfus, N. Steiner, L.A. Miller etc.

Summary: We will attempt to do this experiment in 2021 (late April-middle of May), in order to target the sea-ice algal bloom in an ascending phase. During the Canada-Japan workshop 2019 at CHARS (July 2019), we discussed (science, logistics, funding) the possibility to perform a large-scale intercalibration experiment in Cambridge Bay. At the ECV-Ice meeting in Winnipeg (August 2019), we also discussed with ECV-Ice and BEPSII members.

TR #3: Design inter-comparison studies to facilitate validation and adoption of new technologies for assessing the complexity and heterogeneity of sea ice at various spatial and temporal scales.

We have tried to merge as much as possible the inter-calibration experiments (e.g. Roland Von Glasgow Air-Sea-Ice Chamber in University of East Anglia and eddy covariance experiment in Tsukuba) with emerging technologies.

TR #4: Create a guide of best practices for biological and biogeochemical studies in the sea-ice environment.

Based on the information available at this time, we will start to create a guide of best practices hosted on the ECV-Ice website as a living document. The first entry will be the Miller et al. (2015) methodological review from SCOR WG 140, and the results of additional methods evaluations and intercalibrations will be added, as they become available.

5. WG activities planned for the coming year. Limit 500 words

Virtual meetings: Expect to meet 2-3 times to discuss updates and working plans for the different TR. F. Fripiat, B. Else, and D. Nomura and other members. 2-3 meetings expected to discuss about each data collation related to TR1 (primary production and sea ice-air CO₂ exchange).

In-person meeting: We planned Aug. 2020, ECV-Ice annual meeting with BEPSII, Hobart, Australia. However, due to Covid-19, we have decided that we will cancel this meeting. Alternatively, we will discuss as virtual meetings for review progress on the Terms of reference (present the data-collations (TR2), pursue the elaboration of intercalibration experiments (TR #1 and #3)), including reviewing

results of UEA sea ice tank experiment and eddy covariance method in Tsukuba. For 2021 ECV-Ice annual meeting, we are planning at the Canadian High Arctic Research Station (CHARS), Cambridge Bay, Canada during following Inter-calibration experiment.

Inter-calibration experiment: We will attempt to do this experiment in 2021 (late April-middle of May) at CHARS, Cambridge Bay, Canada in order to target the sea-ice algal bloom in an ascending phase. Expected participants: B. Else (lead), F. Fripiat (co-lead), D. Nomura (co-lead), J. Bowman, C.J. Mundy, N. Kanna, B. Delille, L. Tedesco, N. Geilfus, N. Steiner, L.A. Miller etc.

6. Is the group having difficulties expected in achieving terms of reference or meeting original time schedule? If so, why, and what is being done to address the difficulties Limit 200 words

At this point, we appear to be on track, with a number of activities moving forward the terms of reference.

7. Any special comments or requests to SCOR. Limit 100 words.

We would like to express heartfelt thanks for financial and technical supports. Due to Covid-19, we have decided that we will cancel 2020 ECV-Ice annual meeting, Hobart, Australia. Therefore, we would like to use 8,000 USD for 2021 ECV-Ice annual meeting.

Additional information can be submitted and will be included in the background book for the SCOR meeting at the discretion of the SCOR Executive Committee Reporter for the WG and the SCOR Secretariat.

Please see attached minutes (Appendix A) from the 2019 ECV-Ice annual meeting in Winnipeg, Canada on August 2019.

APPENDIX A.

Summary of SCOR WG152 ECV-Ice (with BEPSII) annual meeting in Winnipeg, Canada (16-18 August 2019)

Participant from ECV-Ice member: D. Nomura, F. Fripiat, B. Else, B. Delille, L. Miller, J. Bowman, A. Fransson, D. Lannuzel, K. Meiners, and J.-L. Tison.

• Historical compilation of CO₂ fluxes over sea ice using chamber techniques

D. Nomura showed all CO₂ flux data on sea ice and indicated seasonal cycle and relationships between flux and air temperature. No discrepancies are reported for chamber-flux measurements. In the future, we will check the ice thickness data etc and compare CO₂ flux values with other parameters. The flux data compilation will be shared with the co-authors to allow further exploration of the data. In the future, D. Nomura will lead and write the paper.

• Historical compilation of primary production

F. Fripiat showed compiled data for sea ice primary production, to see if there are discrepancies between the different methods. The recommendation so far is to perform an incubation with filtered seawater as a buffer (to prevent stresses on the sympagic community, as well as to ensure a proper dispersion of the tracer). However, this compilation also suggests that sea-ice incubations likely underestimate primary production. In the future, K. Campbell will lead and try to write paper.

• Results SAROMA primary production (2018)

F. Fripiat compared each method for sea ice primary production and reported large discrepancies (one order of magnitude difference). The current hypothesis is that the methods with no tracer addition and/or requiring less processing (e.g., dark-light O₂ incubation and O₂:Ar method) are more reliable, as giving higher rates of primary production more in line with biomass accumulation. However, in order to provide stronger constraints, we need to repeat this experiment on a longer timeframe (2 weeks instead of 3 days), allowing to have more replicates, additional methods (e.g., ¹⁴C-tracer incubations) and a better sensitivity for some methods (e.g., biomass accumulation). This will be done in Cambridge bay (spring 2021).

• Results SAROMA light experiment (2019)

D. Nomura, P. Wongpan, M. Vancoppenolle showed preliminary results for sea ice core, light measurement above/under the sea ice, and inter-comparison for light measurement. These activities were summarized and submitted to peer reviewed report paper (Nomura et al., submitted).

• EUROCHAMPS: Intercalibration for sea ice carbonate chemistry parameters, as well as for the processing and storage of sea-ice samples for gas measurements

O. Crabeck introduced the UEA sea ice tank facility and B. Delille organized the discussion for the plan of experiment in January 2020. Participant for the experiment will be O. Crabeck, B. Delille, D. Nomura, L. Miller (or technician), B. Else, N. Geilfus and TBD etc.

• Cambridge Bay experiment: Intercalibration for sea-ice primary production and ocean-sea ice-atmosphere CO₂ flux

D. Nomura introduced the facility (lab and space of CHARS, accommodation etc) of Cambridge Bay based on the visiting at beginning of July for Canada-Japan Future Collaboration Workshop. B. Else organized the discussion for the plan of inter-comparison experiment in May 2021. Potential participant for inter-comparison experiment will B. Else, F. Fripiat, D. Nomura, K. Campbell, N. Kanna, L. Dalman, C.J. Mundy, N. Geilfus and TBD and students etc.

• Cambridge Bay field school

ECV-Ice representatives joined in discussions with BEPSII WG5 to design a sea ice summer school. ECV-Ice participants joining the Cambridge Bay intercalibration experiment will likely join the summer school as instructors, and summer school participants will visit the intercalibration experiment sites. However, in order to achieve the goals of ECV-Ice and because this experiment is requiring less funding and preparation than the summer school, the intercalibration experiment will be done in May 2021, independently of the funding status of the summer school.