

Report for the year 2019 and future activities

SOLAS 'Canada'

compiled by: 'Martine Lizotte'

First things first...Please tell us what the IPO may do to help you in your current and future SOLAS activities. ?

The Canadian SOLAS community had nothing to report here for this year.

PART 1 - Activities from January 2019 to Jan/Feb 2020

1. Scientific highlight

1.1 Revisiting properties and concentrations of ice-nucleating particles in the sea surface microlayer and bulk seawater in the Canadian Arctic during summer.

This scientific highlight addresses SOLAS Theme #4. Interconnections between aerosols, clouds, and marine ecosystems

The ocean is an important source of ice nucleating particles (INPs) to the atmosphere, yet our understanding of the properties and concentrations of INPs in ocean surface waters remains limited. We investigated ice nucleating particles (INPs) in sea surface microlayer and bulk seawater samples collected in the Canadian Arctic during the summer of 2016. Unique in the current study, we showed that the concentrations of INPs were strongly correlated with meteoric water (terrestrial runoff plus precipitation). These results suggest that meteoric water may be a major source of INPs in the sea surface microlayer and bulk seawater in this region. Future modelling studies of clouds and climate in the Arctic should consider this possible source of INPs.

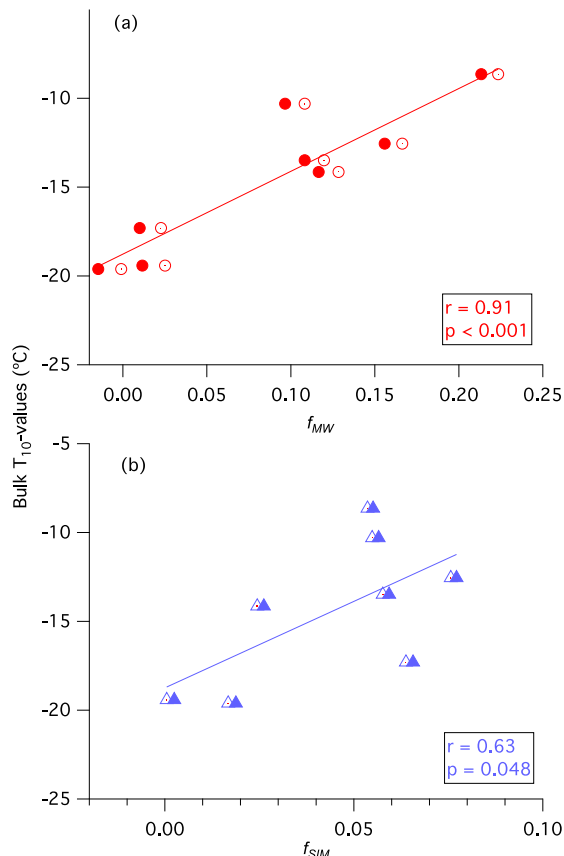


Figure 1. Relationships between T_{10} -values (indicator of freezing temperature of the INPs) for bulk seawater and (a) the water volume fractions for meteoric water, f_{MW} , and (b) the water volume fractions for sea-ice melt, f_{SIM} . The x-error bars are due to the uncertainties in seawater salinities and seawater $\delta^{18}O$ values used when calculating f_{MW} and f_{SIM} .

Citation: Irish, V. E., S. Hanna, Y. Xi, M. Boyer, E. Polishchuk, J. Chen, J. P. D. Abbatt, M. Gosselin, R. Chang, L. Miller, and A. K. Bertram, *Revisiting properties and concentrations of ice nucleating particles in the sea surface microlayer and bulk seawater in the Canadian Arctic during summer*, Atmospheric Chemistry and Physics, 2019, 19 (11), p. 7775-7787.

1.2 Overview paper: New insights into aerosol and climate in the Arctic

This scientific highlight integrates, to different degrees, all of the major SOLAS Themes (1-2-3-4-5)

Motivated by the need to predict how the Arctic atmosphere will change in a warming world, results from this overview paper summarize key discoveries that have been made in climate-related Arctic aerosol research by the NETCARE (Network on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments) research network. Formed in 2013, NETCARE consisted of Canadian academic and government researchers along with international collaborators. Given the highly diverse nature of inter-related earth system processes that couple within the Arctic environment, the network was interdisciplinary, consisting of climate and air quality modellers, atmospheric chemists, aerosol and cloud physicists, biological and chemical oceanographers, biogeochemists, and remote sensing experts. Over the past 6 years, the network conducted a set of field campaigns and modelling projects focused on the sources and loss mechanisms of atmospheric particles, their chemical and optical characteristics, and their role in climate. By studying the nature of fundamental biogeochemical and physical processes that connect aerosol to climate in environments that vary from pristine to polluted, such as those found in the Arctic, the results gathered will strengthen the accuracy of different modelling approaches used to simulate climate in these environments.

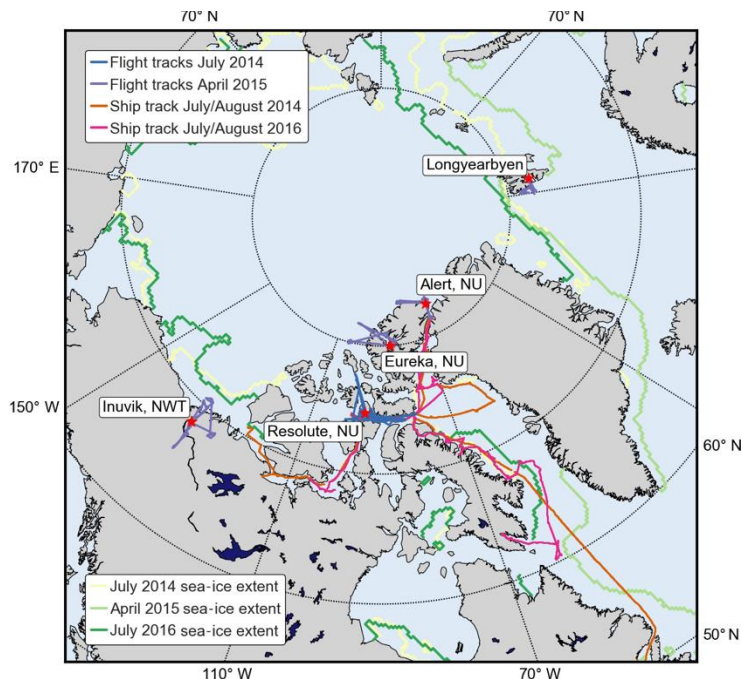


Figure 2. Map of the Arctic indicating NETCARE field work locations, including the ground station (Alert), CCGS Amundsen ship tracks in the summers of 2014 and 2016, and *Polar 6* aircraft flights in summer 2014 (based out of Resolute Bay) and in spring 2015 (based out of Longyearbyen, Alert, Eureka, and Inuvik)

Citation: Abbatt, J. P. D., Leaitch, W. R., Aliabadi, A. A., Bertram, A. K., Blanchet, J.-P., Boivin-Rioux, A., Bozem, H., Burkart, J., Chang, R. Y. W., Charette, J., Chaubey, J. P., Christensen, R. J., Cirisan, A., Collins, D. B., Croft, B., Dionne, J., Evans, G. J., Fletcher, C. G., Galí, M., Ghahremaninezhad, R., Girard, E., Gong, W., Gosselin, M., Gourdal, M., Hanna, S. J., Hayashida, H., Herber, A. B., Hesarak, S., Hoor, P., Huang, L., Hussherr, R., Irish, V. E., Keita, S. A., Kodros, J. K., Köllner, F., Kolonjari, F., Kunkel, D., Ladino, L. A., Law, K., Lefebvre, M., Libois, Q., Liggio, J., Lizotte, M., Macdonald, K. M., Mahmood, R., Martin, R. V., Mason, R. H., Miller, L. A., Moravek, A., Mortenson, E., Mungall, E. L., Murphy, J. G., Namazi, M., Norman, A.-L., O'Neill, N. T., Pierce, J. R., Russell, L. M., Schneider, J., Schulz, H., Sharma, S., Si, M., Staebler, R. M., Steiner, N. S., Thomas, J. L., von Salzen, K., Wentzell, J. J. B., Willis, M. D., Wentworth, G. R., Xu, J.-W., and Yakobi-Hancock, J. D.: Overview paper: New insights into aerosol and climate in the Arctic, *Atmos. Chem. Phys.*, 19, 2527–2560, <https://doi.org/10.5194/acp-19-2527-2019>, 2019.

2. Activities/main accomplishments in 2019 (e.g., projects; field campaigns; workshops and conferences; model and data intercomparisons; capacity building; international collaborations; contributions to int. assessments such as IPCC; collaborations with social sciences, humanities, medicine, economics and/or arts; interactions with policy makers, companies, and/or journalists and media).

2.1 International Collaborations

International collaboration, including Canadian participation, to the Scientific Committee on Oceanic Research (SCOR) activities within the Working Group (WG) #143 “Dissolved N₂O and CH₄ measurements: Working towards a global network of ocean time series measurements of N₂O and CH₄”. Activities carried out in this WG led to the following publication: Bange, Hermann W., Arévalo-Martínez, Damian L., De La Paz, Mercedes, Farías, Laura, Kaiser, Jan, Kock, Annette, Law, Cliff S., Rees, Andrew P., Rehder, Gregor, Tortell, Philippe D., Upstill-Goddard, Robert C. and Wilson, Samuel T. (2019) *A Harmonized Nitrous Oxide (N₂O) Ocean Observation Network for the 21st Century*. *Frontiers in Marine Science*, 6. ISSN 2296-7745. This paper is part of the MEMENTO joint initiative between SOLAS and COST Action 735.

This activity addresses SOLAS Theme #1 Greenhouse Gases and the Oceans

An international collaborative activity, including Canadian participation, within the Scientific Committee on Oceanic Research (SCOR) Working Group (WG) #152 “Essential Climate Variables in Sea Ice (ECV-Ice) intercalibration experiment on gases in sea ice” was conducted at the Roland von Glasow sea-ice chamber at the University of East Anglia in January 2020.

This activity addresses the SOLAS cross-cutting theme on Integrated Topics and Theme #2

Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), Working Group (WG) #38 – Atmospheric Input of Chemicals to the Ocean. International collaboration, including a Canadian representative, towards a review article “Unravelling the impacts of ocean acidification on marine trace gases and the implications for atmospheric chemistry and climate”, Proceedings of the Royal Society A, in press. Co-authors: Frances E. Hopkins, Parvatha Suntharalingam, Marion Gehlen, Oliver Andrews, Stephen D. Archer, Laurent Bopp, Erik Buitenhuis, Isabelle Dadou, Robert Duce, Nadine Goris, Tim Jickells, Martin Johnson, Fiona Keng, Cliff S. Law, Kitack Lee, Peter S. Liss, Martine Lizotte, Gillian Malin, J. Colin Murrell, Hema Naik, Andrew P. Rees, Jörg Schwinger, Philip Williamson

This activity addresses several SOLAS Themes including #1-4-5

A compilation of Arctic sea-ice $\delta^{18}\text{O}$ data was initiated under Canadian leadership, in parallel to and in collaboration with an Antarctic effort lead by a US group. This was a joint activity of the Expert Group on Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII) and the Expert Group on Antarctic Sea ice Processes and Climate (ASPeCT)

This activity addresses the SOLAS cross-cutting theme on Integrated Topics and Theme #2

A BEPSII-led position analysis on future Arctic sea-ice biogeochemistry and ice-associated ecosystems has been submitted to Nature Climate change.

This activity addresses the SOLAS cross-cutting theme on Integrated Topics and Theme #2

A group review of the the United Nations' (UN) Intergovernmental Panel on Climate Change's (IPCC) Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC), was conducted by several members of the Association of Polar Early Career Scientists (APECS), including Canadian representatives. The paper “The benefits to climate science of including Early Career Scientists as reviewers”, Geoscience Communication, <https://doi.org/10.5194/gc-2019-20>, is under review. Co-authors: Mathieu Casado, Gwenaëlle Gremion, Paul Rosenbaum, Jilda Alicia Caccavo, Kelsey Aho, Nicolas Champollion, Sarah L. Connors, Adrian Dahood, Alfonso Fernandez, Martine Lizotte, Katja Mintenbeck, Elvira Poloczanska, Gerlis Fugmann

This activity addresses the SOLAS cross-cutting theme on Science and Society and recognizes the importance of including of early career scientist in the climate science dialogue.

2.2 Completed papers based on field measurements carried out as part of NETCARE

(Network on Aerosols and Climate: Addressing Key Uncertainties in Remote Canadian Environments)

Abbatt, J.P.D., Leaitch, W.R., Aliabadi, A.A., Bertram, A.K., Blanchet, J.-P., Boivin-Rioux, A., Bozem, H., Burkart, J., Chang, R.Y.W., Charette, J., Chaubey, J.P., Christensen, R.J., Cirisan, A., Collins, D.B., Croft, B., Dionne, J., Evans, G.J., Fletcher, C.G., Galí, M., Ghahremaninezhad, R., Girard, E., Gong, W., Gosselin, M., Gourdal, M., Hanna, S.J., Hayashida, H., Herber, A.B., Hesaraki, S., Hoor, P., Huang, L., Hussherr, R., Irish, V.E., Keita, S.A., Kodros, J.K., Köllner, F., Kolonjari, F., Kunkel, D., Ladino, L.A., Law, K., Levasseur, M., Libois, Q., Liggio, J., Lizotte, M., Macdonald, K.M., Mahmood, R., Martin, R.V., Mason, R.H., Miller, L.A., Moravek, A., Mortenson, E., Mungall, E. L., Murphy, J. G., Namazi, M., Norman, A.-L., O'Neill, N. T., Pierce, J.R., Russell, L.M., Schneider, J., Schulz, H., Sharma, S., Si, M., Staebler, R.M., Steiner, N.S., Thomas, J.L., von Salzen, K., Wentz, J.J.B., Willis, M.D., Wentworth, G.R., Xu, J.-W., and Yakobi-Hancock, J.D.: Overview paper: New insights into aerosol and climate in the Arctic. *Atmos. Chem. Phys.*, 19, 2527-2560, doi:10.5194/acp-19-2527-2019, 2019.

Galí, M., Devred, E., Babin M., Levasseur, M.: Decadal increase in Arctic dimethylsulfide emission Proceedings of the National Academy of Sciences, 116 (39) 19311-19317, doi.org/10.1073/pnas.1904378116, 2019.

Ghahremaninezhad, R., Gong, W., Galí, M., Norman, A.-L., Beagley, S. R., Akingunola, A., Zheng, Q., Lupu, A., Lizotte, M., Levasseur, M., and Leaitch, W. R.: Dimethyl sulfide and its role in aerosol

formation and growth in the Arctic summer – a modelling study, *Atmos. Chem. Phys.*, 19, 14455–14476, <https://doi.org/10.5194/acp-19-14455-2019>, 2019.

Gourdal, M., Crabeck, O., Lizotte, M., Galindo, V., Gosselin, M., Babin, M., Scarratt, M. and Levasseur, M.: Upward transport of bottom-ice dimethyl sulfide during advanced melting of arctic first-year sea ice, *Elem. Sci. Anth.*, 7(1), p.33, doi:10.1525/elementa.370, 2019.

Hayashida, H., Christian, J., Holdsworth, A., Hu, X., Monahan, A., Mortenson, E., Myers, P., Riche, O., Sou, T., Steiner, M.: CSIB v1: a sea-ice biogeochemical model for the NEMO community ocean modelling framework, *Geoscientific Model Development (GMD)*, *Geosci. Model Dev.*, 12, 1965-1990, 2019, doi:10.5194/gmd-12-1965-2019, 2019.

Irish, V. E., S. Hanna, Y. Xi, M. Boyer, E. Polishchuk, J. Chen, J. P. D. Abbatt, M. Gosselin, R. Chang, L. Miller, and A. K. Bertram, Revisiting properties and concentrations of ice nucleating particles in the sea surface microlayer and bulk seawater in the Canadian Arctic during summer, *Atmospheric Chemistry and Physics*, 2019, 19(11), p. 7775-7787.

Irish, V.E., S.J. Hanna, M.D. Willis, S. China, J.L. Thomas, J.J.B. Wentzell, A. Cirisan, M. Si, W.R. Leaitch, J.G. Murphy, J.P.D. Abbatt, A. Laskin, E. Girard, and A.K. Bertram, Ice nucleating particles in the marine boundary layer in the Canadian Arctic during summer 2014, *Atmospheric Chemistry and Physics*, 2019, 19(2): p. 1027-1039.

Lizotte, M., Levasseur, M., Galindo, V., Gourdal, M., Gosselin, M., Tremblay, J.-É., Blais, M., Charette, J., and Hussherr, R.: Phytoplankton and dimethylsulfide dynamics at two contrasting Arctic ice edges, *Biogeosciences Discuss.*, <https://doi.org/10.5194/bg-2019-422>, accepted, 2019.

Mahmood, R., von Salzen, K., Norman, A.L., Gali, M., and Levasseur, M. Sensitivity of Arctic sulfate aerosol and clouds to changes in future surface seawater dimethylsulfide concentrations. *Atmospheric Chemistry and Physics*, 2019, 19(5), 6419-6435.

Si, M., E. Evoy, J. Yun, Y. Xi, S. J. Hanna, A. Chivulescu, K. Rawlings, D. Veber, A. Platt, D. Kunkel, P. Hoor, S. Sharma, W. R. Leaitch, and A. K. Bertram, Concentrations, composition, and sources of ice-nucleating particles in the Canadian High Arctic during spring 2016, *Atmospheric Chemistry and Physics*, 2019, 19(5): p. 3007-3024.

2.3 Meetings, conferences and workshops

The Expert Group on Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII) hosted a successful annual meeting in Winnipeg (Canada) this year in connection with the International Sea-Ice Symposium. BEPSII also hosted a well-attended session during the symposium.

Several members of the Canadian SOLAS community took part in the SOLAS Open Science Conference (OSC) held in Sapporo, Japan, April 21-25 2019, as well as participated in the organization of plenary talk sessions, parallel discussion and poster sessions, and the Early Career Scientist Day (ECSD) during this event.

2.4 Fieldwork and laboratory activities

A laboratory study exposing phytoplankton cultures to ozone and measuring VOCs and the formation of aerosol particles formed was completed (Schneider et al., 2019). Results show that older cultures (3-weeks-old) are more prolific in the formation of both gases and particles than younger cultures (1-week-old). The particles formed were shown to be largely organic in nature, with only a small amount of sulfate present. Schneider, S. R., Collins, D. B., Lim, C. Y., Zhu, L., Abbatt, J. P. D.: Formation of Secondary Organic Aerosol from the Heterogeneous Oxidation by Ozone of a Phytoplankton Culture, *ACS Earth Space Chem.*, 3, 2298-2306, 2019.

3. Top 5 publications in 2019 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

Abbatt, J.P.D., Leaitch, W.R., Aliabadi, A.A., Bertram, A.K., Blanchet, J.-P., Boivin-Rioux, A., Bozem, H., Burkart, J., Chang, R.Y.W., Charette, J., Chaubey, J.P., Christensen, R.J., Cirisan, A., Collins, D.B., Croft, B., Dionne, J., Evans, G.J., Fletcher, C.G., Galí, M., Ghahremaninezhad, R., Girard, E.†, Gong, W., Gosselin, M., Gourdal, M., Hanna, S.J., Hayashida, H., Herber, A.B., Hesarakı, S., Hoor, P., Huang, L., Hussherr, R., Irish, V.E., Keita, S.A., Kodros, J.K., Köllner, F., Kolonjari, F., Kunkel, D., Ladino, L.A., Law, K., Levasseur, M., Libois, Q., Liggio, J., Lizotte, M., Macdonald, K.M., Mahmood, R., Martin, R.V., Mason, R.H., Miller, L.A., Moravek, A., Mortenson, E., Mungall, E. L., Murphy, J. G., Namazi, M., Norman, A.-L., O'Neill, N. T., Pierce, J.R., Russell, L.M., Schneider, J., Schulz, H., Sharma, S., Si, M., Staebler, R.M., Steiner, N.S., Thomas, J.L., von Salzen, K., Wentz, J.J.B., Willis, M.D., Wentworth, G.R., Xu, J.-W., and Yakobi-Hancock, J.D.: Overview paper: New insights into aerosol and climate in the Arctic. *Atmos. Chem. Phys.*, 19, 2527-2560, 2019, <https://doi.org/10.5194/acp-19-2527-2019>.

Bénard, R. Levasseur, M., Scarratt, M., Michaud, S., Starr, M., Mucci, A., Ferreyra, G., Gosselin, M., Tremblay, J.-É., Lizotte, M., Yang, G.-P.: Contrasting effects of acidification and warming on dimethylsulfide concentrations during a temperate estuarine fall bloom mesocosm experiment. *Biogeosciences*, 16, 1167-1185, 2019, <https://doi.org/10.5194/bg-16-1167-2019>.

Miller, L. A., Burgers, T., Burt, W.J., Granskog, M.A., Papakyriakou, T. N.: Air-Sea CO₂ Flux Estimates in Stratified Arctic Coastal Waters: How Wrong Can We Be? *Geophys. Res. Lett.* 46: 235-43, doi:10.1029/2018GL080099, 2019.

Sastri, A.R., Christian, J.R., Achterberg, E.P., Atamanchuk, D., Buck, J.J.H., Bresnahan, P., Duke, P.J., Evans, W., Gonski, S.F., Johnson, B., Juniper, S.K., Mihaly, S., Miller, L.A., Morley, M., Murphy, D., Nakaoka, S., Ono, T., Parker, G., Simpson, K., Tsunoda, T.: Perspectives on in situ sensors for ocean acidification research. *Frontiers in Marine Science* 6:653, doi:10.3389/fmars.2019.00653, 2019.

Watanabe, E., Jin, M., Hayashida, H., Zhang, J., Steiner, N.: Multi-model intercomparison of the pan-Arctic ice-algal productivity on seasonal, interannual, and decadal timescales, *JGR Oceans*, doi:10.1029/2019JC015100, 2019.

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2019? If yes, who? How did you engage?

Steiner, N. (Fisheries and Oceans Canada) and collaborators engaged with Inuit communities in the Inuvialuit Settlement Region with respect to the impacts of ocean acidification and sea-ice retreat on forage fish through regular interactions during Inuvialuit Game Council (IGC) meetings and the Fisheries Joint Management Committee.

Several NETCARE publications (described in Part 1 – Section 2.2) have been co-authored with researchers and scientists from government entities such as Environment and Climate Change Canada (ECCC) and Department of Fisheries and Oceans (DFO) Canada which represents a significant mechanism for knowledge mobilization.

PART 2 - Planned activities for 2019/2020 and 2021

1. Planned major national and international field studies and collaborative laboratory and modelling studies (incl. all information possible, dates, locations, teams, work, etc.).

The launch of the second “Sea-ice algae Model Intercomparison Project” is planned for 2019/2020.

Field experiments, as part of the “Essential Climate Variables in Sea Ice (ECV-Ice) intercalibration experiment on gases in sea ice”, are planned for Cambridge Bay in Spring of 2021, with initial deployments in Fall 2020. These experiments will focus on methods for measuring gases and primary production.

2. Events like conferences, workshops, meetings, summer schools, capacity building etc. (incl. all information possible).

EGU, Vienna, 3-8 May 2020. "Diversity and strength of ice-related dimethyl sulfide sources in the Arctic" by M. Levasseur, M. Lizotte, V. Galindo, M. Gourdal, M. Gosselin has been accepted for presentation in the Session CR7.1 – Cryosphere change impacts on marine ecosystems and biogeochemical cycling.

Preparations for the Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII) Sea Ice Winter Field School, that will be held in Cambridge Bay in April 2021, are underway.

3. Funded national and international projects/activities underway.

3.1 Projects underway

A Co-operative Observation Network to Address Community Research Priorities While Studying Marine Biogeochemistry, PI Brent Else. ArcticNET

Quantifying and Predicting Canada's Marine Carbon Sink, PI Roberta Hamme. NSERC

University of Toronto researchers (J. Abbatt team) are pursuing laboratory studies of the interactions of oxidants (such as ozone) with seawater, specifically studying the inorganic system. In the near future, using phytoplankton cultures, the team will examine the mechanisms for new particle formation as a result of light and oxidant exposure.

3.2 Papers underway

Several papers relating to the following SOLAS-relevant scientific activities are underway:

- Sea-ice ecosystem services (BEPSII community).
- Impacts of ocean acidification on dimethylsulfide cycling with a focus into the microbial processes involved.
- Dimethylsulfide hotspots linked to hydrographic frontal structures and sea ice in the Canadian Arctic
- Essential Climate Variables in Sea Ice (ECV-Ice) intercalibration experiment on gases in sea ice

4. Plans / ideas for future national or international projects, programmes, proposals, etc. (please indicate the funding agencies and potential submission dates).

The Canadian SOLAS community had nothing to report here for this year.

5. Engagements with other international projects, organisations, programmes, etc.

Canadian co-leadership of BEPSII (Co-Chair Nadja Steiner, Lisa Miller and Brent Else are members of the Steering Committee).

Canadian co-leadership of SCOR WG 152 - ECV-Ice (Co-Chair Brent Else)

Lisa Miller is a member of the International Commission for Atmospheric Chemistry and Global Pollution (iCACGP).

Comments

The Canadian SOLAS community wishes to express its gratitude to the SOLAS IPO staff for their continued efforts in facilitating the communication of SOLAS activities.