surface ocean solas lower atmosphere study

Report for the year 2018 and future activities

SOLAS Canada
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This report has two parts:

***- Part 1:** reporting of activities in the period of January 2018 – Jan-Feb 2019*
***- Part 2:** reporting on planned activities for 2019/2020 and 2021.*

The information provided will be used for reporting, fundraising, networking, strategic development and updating of the live web-based implementation plan. As much as possible, please indicate the specific SOLAS 2015-2025 Science Plan Themes addressed by each activity **or specify an overlap between Themes or Cross-Cutting Themes.**

1 Greenhouse gases and the oceans;
2 Air-sea interfaces and fluxes of mass and energy;
3 Atmospheric deposition and ocean biogeochemistry;
4 Interconnections between aerosols, clouds, and marine ecosystems;
5 Ocean biogeochemical control on atmospheric chemistry;
Integrated studies;
Environmental impacts of geoengineering;
Science and society**.**

***IMPORTANT**: This report should reflect the efforts of the SOLAS community in the **entire country** you are representing (all universities, institutes, lab, units, groups, cities).*

PART 1 - Activities from January 2018 to Jan/Feb 2019

1. Scientific highlight

Describe one scientific highlight with a title, text (max. 200 words), a figure with legend and full references. Please focus on a result that would not have happened without SOLAS, and we are most interested in results of international collaborations. (If you wish to include more than one highlight, feel free to do so).

Highlight 1

The Tortell group has continued to make progress towards documenting the distribution and cycling of climate active trace gases in marine surface waters. The paper by Jarnikova et al. presents a new data set of dimethylsulfide, and the related compound DMSP in the Canadian Arctic Ocean. Our new observations, conducted with much higher spatial resolution than any previous measurements, highlight the influence of hydrographic frontal zones driving DMS/P variability in this region. Our observations also help fill in critical gaps in the existing PMEL DMS data, leading to more robust estimates of the Arctic Ocean DMS emissions to the atmosphere.

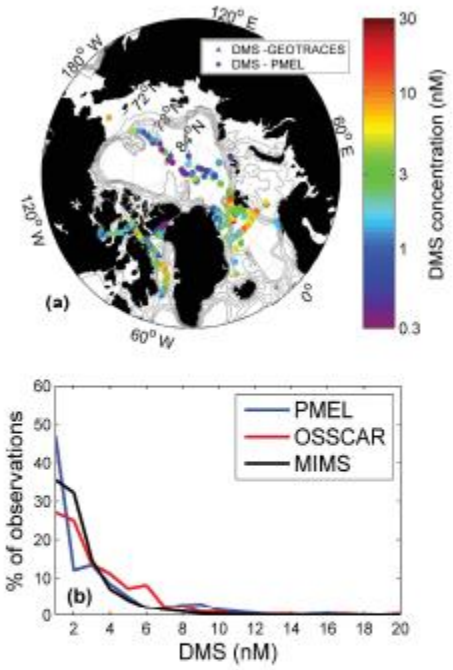

Figure 6. Comparison of OSSCAR- and MIMS-measured DMS from this study with existing summertime data in the PMEL database. Panel **(a)** shows the geographic distribution of DMS measurements in the PMEL database and those obtained by this study (using OSSCAR), while panel **(b)** shows a histogram of DMS concentrations in three datasets – the MIMS dataset (33 250 data points), the OSSCAR dataset (344 points) and the PMEL dataset (415 points).

Jarnikova T., Dacey J., Lizotte M., Levasseur, M. and P. Tortell. 2018. The distribution of methylated sulfur compounds, DMS and DMSP, in Canadian Subarctic and Arctic waters during summer, 2015. Biogeoscience. 15, 2449–2465, doi.org/10.5194

The group also published the results of a three year study of CH_4 and N_2O measurements in the Subarctic Pacific, examining spatial trends along the coastal-oceanic gradient of the Line P time-series transect, and temporal variability associated with environmental variability including the 2015 warm anomaly ('The Blob'). Our results highlighted the strong mid-water N_2O maximum associated with the large oxygen deficient zone, and the presence of CH_4 hot-spots along the continental shelf. Examination of ancillary data (nutrients etc.), provided some insight into the role of various microbial processes driving N_2O cycling.

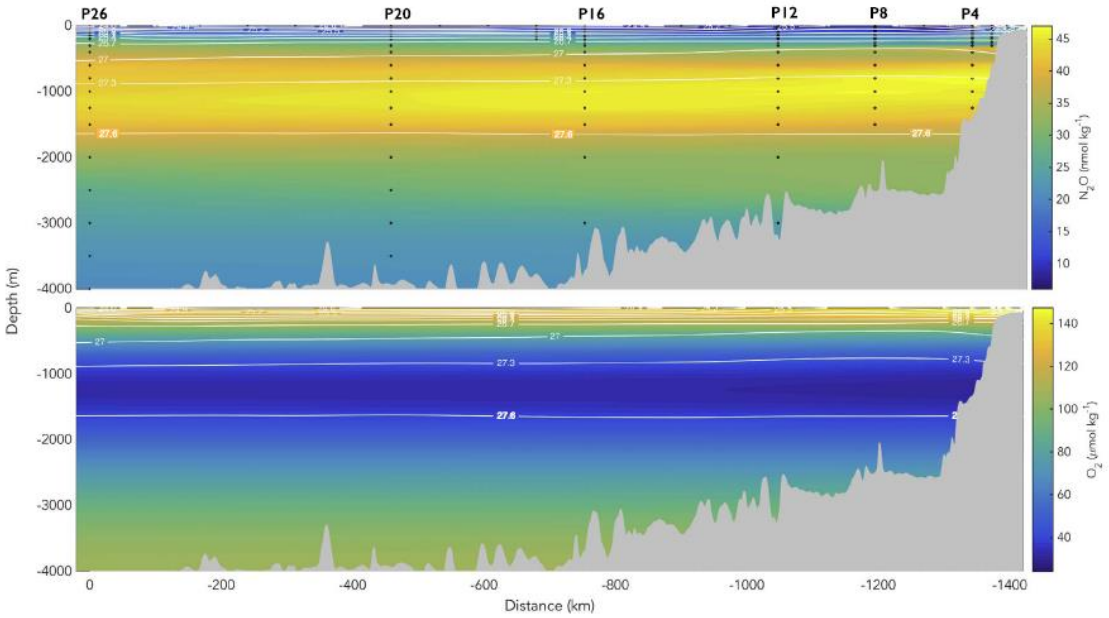

Fig. 7. Longitudinal – depth section of N_2O and O_2 distributions, averaged across all six cruises. The white lines denote density surfaces (σ_t).

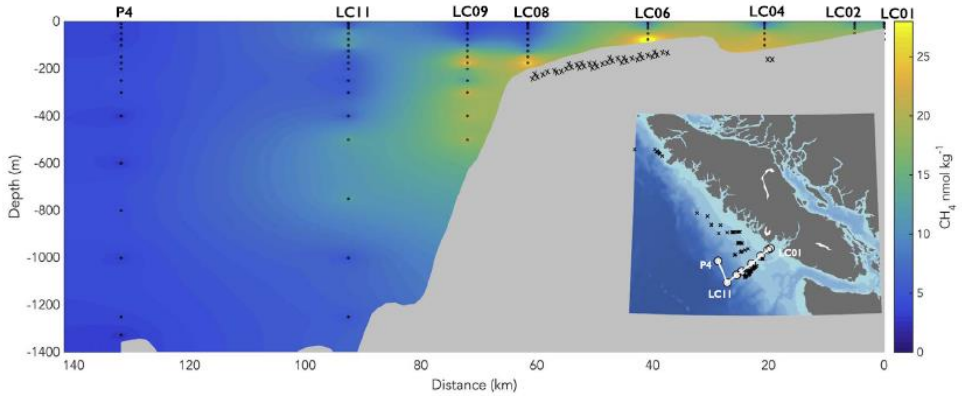

Fig. 5. Methane distribution off the coast of Vancouver Island during spring 2015. On the map inset in panel b, the white symbols denote the stations, while the black x's denote the locations of previously observed gas seeps (Vaughn J. Barrie, personal communication).

Fenwick, L. and P. Tortell. 2018. Methane and nitrous oxide distributions in coastal and open waters of the Northeast Subarctic Pacific during 2015-2016. Marine Chemistry, volume 200 (20) Pages 45-56.

Highlight 2

Ice nucleating particles in the marine boundary layer in the Canadian Arctic during summer 2014

Ice nucleating particles (INPs) in the Arctic can influence climate and precipitation in the region; yet our understanding of the concentrations and sources of INPs in this region remain uncertain. In the following we 1) measured concentrations of INPs in the immersion mode in the Canadian Arctic marine boundary layer during summer 2014 on board the CCGS *Amundsen*, 2) determined ratios of surface areas of mineral dust aerosol to sea spray aerosol, and 3) investigated the source region of the INPs using particle dispersion modelling. Average concentrations of INPs at -15, -20 and -25 °C were 0.005, 0.044, and 0.154 L^{-1}, respectively. These concentrations fall within the range of INP concentrations measured in other marine environments. For the samples investigated the ratio of mineral dust surface area to sea spray surface area ranged from 0.03 to 0.09. Based on these ratios and the ice active surface site densities of mineral dust and sea spray aerosol determined in previous laboratory studies, our results suggest that mineral dust is a more important contributor to the INP population than sea spray aerosol for the samples analysed. Based on particle dispersion modelling,

the highest concentrations of INPs were often associated with lower latitude source regions such as the Hudson Bay area, eastern Greenland, or northwestern continental Canada. On the other hand, the lowest concentrations were often associated with regions further north of the sampling sites and over Baffin Bay. A weak correlation was observed between INP concentrations and the time the air mass spent over bare land, and a weak negative correlation was observed between INP concentrations and the time the air mass spent over ice and open water. These combined results suggest that mineral dust from local sources is an important contributor to the INP population in the Canadian Arctic marine boundary layer during summer 2014.

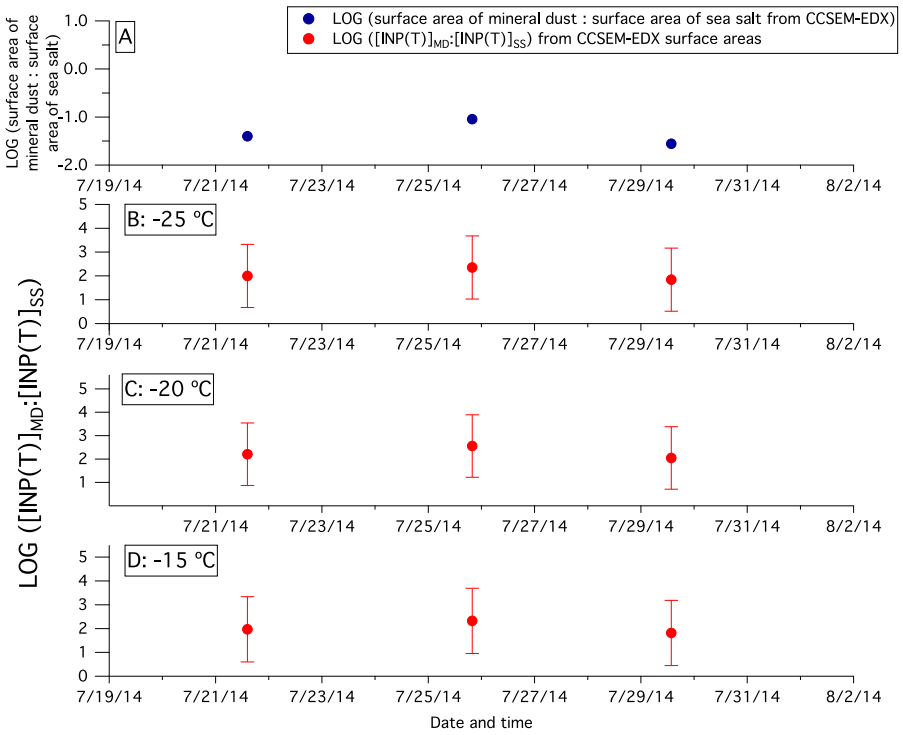

Figure: A) Ratios of the surface area of mineral dust particles to the surface area of sea salt particles measured by CCSEM-EDX (blue circles). Ratios of predicted concentrations of ice nucleating particles from mineral dust, $[INP(T)]_{MD}$, to the predicted concentrations of ice nucleating particles from sea spray aerosol, $[INP(T)]_{SS}$, calculated using CCSEM-EDX measurements (red circles) at B) -25 °C, C) -20 °C, and D) -15 °C.

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, 2019, Ice nucleating particles in the marine boundary layer in the Canadian Arctic during summer 2014, *Atmospheric Chemistry and Physics*, 19, 1027-1039, DOI: 10.5194/acp-19-1027-2019.

Highlight 3

A Swiss-Canadian collaboration involving laboratory experiments on carbon export from freezing sea ice was recently published . We found that when ice forms more quickly at lower temperatures (as opposed to more slowly at higher temperatures), less CO2 is injected into the underlying water, but it is injected in more intense plumes that sink deeper into the water. This has future climate implications, wherein a thinner, warmer solid ice cover would sequester less carbon in deep waters, but a broken, mobile ice cover resulting in more open water and ice formation in winter could foster more carbon sequestration (see figure 8 in the paper). This was published in a BEPSII-related special issue in Frontiers in Earth Science.

D. Konig, L.A. Miller, K.G. Simpson, S. Vagle, Carbon Dynamics During theFormation of Sea Ice at Different Growth Rates, Frontiers in Earth Science, 6, doi: 10.3389/feart.2018.00234, 2018.

2. Activities/main accomplishments in 2018 (projects, field campaigns, events, model and data intercomparisons, capacity building, international collaborations, contributions to int. assessments such as IPCC, interactions with policy makers or socio-economics circles, social sciences, and media).

Coastal Fog Project (CFOG) – research cruise on the R/V Hugh R. Sharp headed by University of Notre Dame Aug 31 – Oct 9, 2018 to study marine fog including air-sea interactions in the NW Atlantic Ocean off the coast of NS and NL (Theme 2)

Fog and Visibility Experiment in Tuktoyaktuk (FAVET) – coastal fog and aerosol project in Tuktoyaktuk (NWT) that aims to link ocean and sea-ice effects on atmospheric observations, July – Sep 2018 (Theme 2)

Microbiology-Ocean-Cloud-Coupling in the High Arctic (MOCCHA) – research cruise on the I/B Oden headed by Stockholm University Jul 31 – Sep 23, 2018 in the Central Arctic Ocean to study contributions of biological ocean emissions on atmospheric particles and cloud condensation nuclei (Themes 4 & 5)

Halifax Harbour Air Quality Study – preliminary study in Halifax harbour to study emissions in the harbour from anthropogenic and biogenic sources (Aug – Oct 2018). (Themes 1 & 5)

2017-2020 BOND (Beacons Of Northern Dynamics: developing light-based sensing technologies to monitor climate active gases in a mutating Arctic), a Sentinel North project (Canada First Research Excellence Fund). Relevant to SOLAS 2015-2025 Science Plan Core Themes 1 and 4. Goal: Deploy an Automated Cryogenic Trap Membrane-Inlet Mass Spectrometer (ACT-MIMS) in the Canadian Arctic Archipelago for continuous underway DMS measurements during the Sentinel North expedition aboard the icebreaker CCGS Amundsen in July 2018.

Laboratory studies of the VOCs emitted from cultured phytoplankton in axenic conditions. Investigation of the potential for these emissions to form aerosol. (Theme 4)

3. Top 5 publications in 2018 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

Gourdal M, Lizotte M, Massé G, Gosselin M, Scarratt M, Levasseur M (2018). Dimethylsulfide dynamics in first-year sea ice melt ponds in the Canadian Arctic Archipelago. *Biogeosciences*, 15, 3169–3188. https://doi.org/10.5194/bg-15-3169-2018

Galí M, Levasseur M, Devred E, Simó R, Babin M (2018). Sea-surface dimethylsulfide (DMS) concentration from satellite data at global and regional scales. *Biogeosciences*, 15, 34973519. https://doi.org/10.5194/bg-15-3497-2018, 2018

Jarnikova T., Dacey J., Lizotte M., Levasseur, M. and P. Tortell. 2018. The distribution of methylated sulfur compounds, DMS and DMSP, in Canadian Subarctic and Arctic waters during summer, 2015. Biogeoscience. 15, 2449–2465, doi.org/10.5194

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D. Konig, L.A. Miller, K.G. Simpson, S. Vagle, Carbon Dynamics During theFormation of Sea Ice at Different Growth Rates, Frontiers in Earth Science, doi: 10.3389/feart.2018.00234, 2018.

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2018? If yes, who? How did you engage?

Several of the publications are co-authored with researchers at Environment and Climate Change Canada.

Tortell groups has worked with communities in the high Canadian Arctic, helping to develop a new social media platform, SIKU, which facilitates the use of remote sensing observations to support local environmental stewardship - https://arcticeider.com/en/about.

PART 2 - Planned activities for 2019/2020 and 2021

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

Tortell group has many cruises (> 6) planned this year

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

3. Funded national and international projects / activities underway.

Ocean Frontier Institute at Dalhousie University and Memorial University, module funded to study marine atmospheric composition and visibility.

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

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

Comments