

Report for the year 2021 and future activities

SOLAS Sweden

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This report has two parts:

- **Part 1:** reporting of activities in the period of January 2021 - Jan/Feb 2022
- **Part 2:** reporting on planned activities for 2022 and 2023.

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 of high sensitivity systems;
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).*

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

Maybe providing an email list of Swedish participants within SOLAS would be helpful. I am not sure that I reach everyone.

PART 1 - Activities from January 2021 to Jan/Feb 2022

1. Scientific highlight

*Describe one scientific highlight with a title, text (**max. 300 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).*

Swedish scientists involved within SOLAS were active in various fields ranging from gas-transfer to sea-air exchange of aerosol particles and many other fields. As such it was difficult to select just one highlight and thus I choose two.

Highlight I:

We measured the Hg^0 flux on the Baltic Sea coast using micrometeorological methods (gradient-based and relaxed eddy accumulation, REA) and also simulated the flux with a gas exchange model. The coastal waters were typically supersaturated with Hg^0 (mean $\pm 1\sigma = 13.5 \pm 3.5 \text{ ng m}^{-3}$; ca. 10% of total Hg) compared to the atmosphere ($1.3 \pm 0.2 \text{ ng m}^{-3}$). The Hg^0 flux calculated using the gas exchange model ranged from $0.1\text{--}1.3 \text{ ng m}^{-2} \text{ h}^{-1}$ (10th and 90th-percentile) over the course of the campaign (May 10–June 20, 2017) and showed a distinct diel fluctuation.

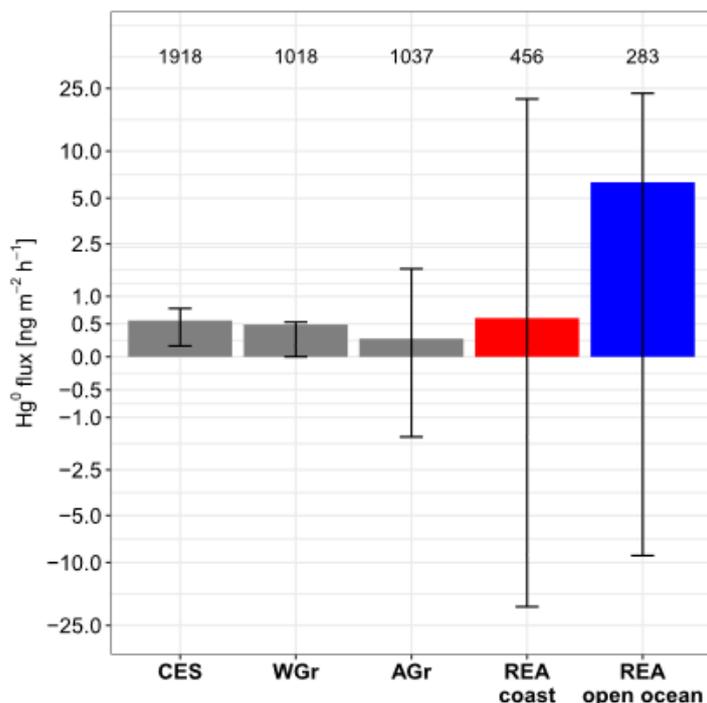


Figure 1: Overview of the average fluxes of Hg^0 at Östergarnsholm, Gotland. Figure taken from Osterwalder et al. (2021).

Reference: Osterwalder, S., Nerentorp, M., Zhu, W., Jiskra, M., Nilsson, E., Nilsson, M. B., et al. (2021). Critical observations of gaseous elemental mercury air-sea exchange. *Global Biogeochemical Cycles*, 35, e2020GB006742. <https://doi.org/10.1029/2020GB006742>

Highlight II:

In the perspective paper “Aerosols in current and future Arctic climate” by Schmale et al. (2021), we discuss the role of aerosols in the current Arctic climate change. The natural baseline of aerosols in the Arctic is changing fast and regional effects of aerosols are very diverse. To improve our understanding of current and future Arctic climate, more detailed knowledge on processes related to the emission, processing and formation of especially natural aerosol is needed (e.g. emitted from ocean or ice/snow, see Figure 2). The article summarizes current measurement gaps and modelling issues for Arctic processes, discusses various regional processes that will be impacted by Arctic warming, and also gives examples for important model issues when determining the climate effect aerosols in the Arctic.

Reference: Schmale, J., Zieger, P., Ekman, A. (2021): Aerosols in current and future Arctic climate, *Nat. Clim. Change*, 11, 95–105.

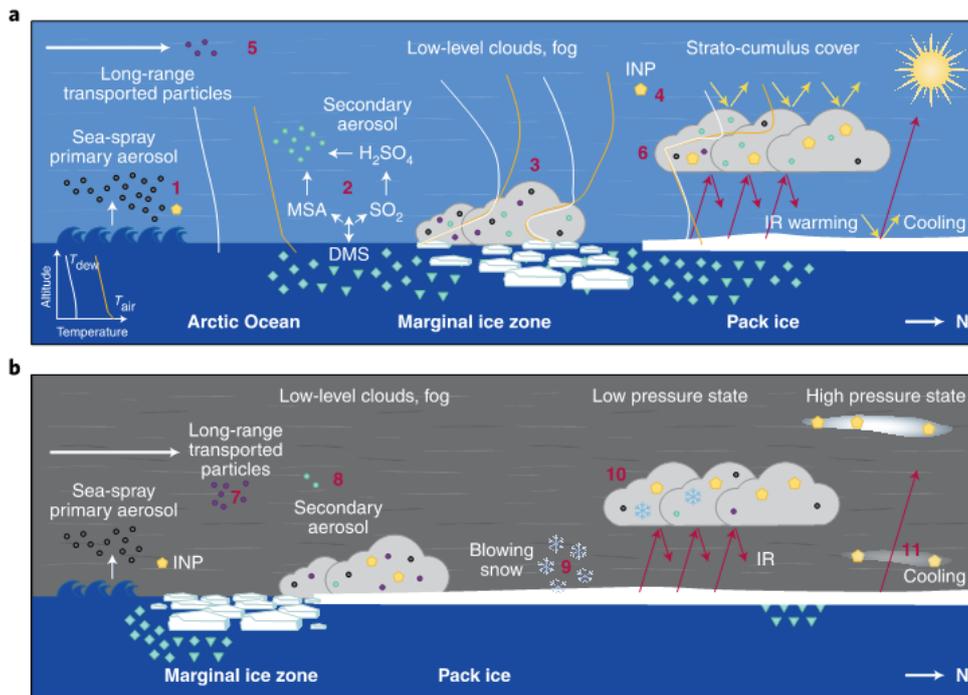


Figure 2: Overview of main Arctic aerosol processes during polar day (panel A) and night (panel B). Figure taken from Schmale et al. (2021).

2. Activities/main accomplishments in 2021 (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).

- ICOS pCO₂ intercomparison ongoing (Anna Rutgersson, Uppsala University).
- Co-location of ICOS and ACTRIS stations and received infrastructure funding for this (Anna Rutgersson, Uppsala University).
- Synoptic Arctic Survey 2021 expedition on icebreaker Oden to central Arctic Ocean: measurement of air-sea and air-ice exchange of CO₂ and CH₄ using eddy covariance and chamber flux systems (John Prytherch, Stockholm University).
- Field campaign at Askö laboratory (<https://www.su.se/stockholm-university-baltic-sea-centre/infrastructure/ask%C3%B6-laboratory>): Measuring coastal Baltic emissions of CH₄ using different techniques in order to develop upscaling methods (John Prytherch, Stockholm University).
- Sea-surface microlayer sampling during Arctic cruise Synoptic Arctic Survey 2021; Sampling of microlayer in surface slicks of the Baltic Sea for microbial and viral analysis; isolation of ~80 bacteriophages from sea-surface microlayer, surface slicks, sea foams and beach foams (Janina Rahlff, Linnaeus University).
- Measurement campaign related to cloud forming properties of ship emissions (Erik Thomson, University of Gothenburg).
- Field campaigns on R/V Electra (Sweden) and R/V Oceania (Poland) close to Östergarnsholm/Gotland to study the sea-air exchange of aerosol particles as part of the CROISSANT project (Douglas Nilsson, Matthew Salter and Paul Zieger, Stockholm University).
- SCOR working group “Coupling of ocean-ice-atmosphere processes: from sea-ice biogeochemistry to aerosols and Clouds (CIce2Clouds)” got started, <https://scor-int.org/group/coupling-of-ocean-ice-atmosphere-processes-from-sea-ice-biogeochemistry-to-aerosols-and-clouds-cice2clouds/> (Paul Zieger, Stockholm University).

- Preparation of ARTofMELT expedition 2023 (on I/B Oden, <https://www.polar.se/en/research-support/open-calls/open-call-expedition-artofmelt-2023/>) with the selection of the theme proposal and dedicated workshop (Michael Tjernström and Paul Zieger, Stockholm University).
- Successfully securing infrastructure funding to develop a new atmospheric science laboratory at the marine research laboratory Askö as part of the multidisciplinary Centre for Coastal Ecosystem and Climate Research (CoastClim, <https://www.coastclim.org/>) (Matthew Salter, Ilona Riipinen and Christoph Humborg, Stockholm University).

3. List SOLAS-related publications published in 2021 (only PUBLISHED articles). If any, please also list weblinks to models, datasets, products, etc.

- Kong X, Castare`de D, Thomson E S, Boucly A, Artiglia L, Ammann M, Gladich I & Pettersson J B C. (2021). A surface-promoted redox reaction occurs spontaneously on solvating inorganic aerosol surfaces. *Science*, 374:747–752.
- Zhao X, Allen R J, Thomson E S. An implicit air quality bias due to the state of pristine aerosol (2021). *Earth's Future*, 9:e2021EF001979.
- Gutiérrez-Loza, L., Wallin, M.B., Sahlée, E., Holding, T., Shutler, J.D., Rehder, G., Rutgersson, A. (2021). Air-sea CO₂ exchange in the Baltic Sea--A sensitivity analysis of the gas transfer velocity. *Journal of Marine Systems*, 103603.
- Rahlf, J., Stolle, C., Giebel, H. A., Mustaffa, N. I. H., Wurl, O., & PR Herlemann, D. (2021). Sea foams are ephemeral hotspots for distinctive bacterial communities contrasting sea-surface microlayer and underlying surface water. *FEMS microbiology ecology*, 97(4), fiab035.
- Osterwalder, S., Nerentorp, M., Zhu, W., Jiskra, M., Nilsson, E., Nilsson, M. B., et al. (2021). Critical observations of gaseous elemental mercury air-sea exchange. *Global Biogeochemical Cycles*, 35, e2020GB006742. <https://doi.org/10.1029/2020GB006742>
- Zhang, S.; Rutgersson, A.; Philipson, P.; Wallin, M.B. Remote Sensing Supported Sea Surface pCO₂ Estimation and Variable Analysis in the Baltic Sea. *Remote Sens* (2021). 13, 259. <https://doi.org/10.3390/rs13020259>.
- Elvidge, A. D., Renfrew, I. A., Brooks, I. M., Srivastava, P., Yelland, M. J., & Prytherch, J. (2021). Surface heat and moisture exchange in the marginal ice zone: Observations and a new parameterization scheme for weather and climate models. *Journal of Geophysical Research: Atmospheres*, 126, e2021JD034827. <https://doi.org/10.1029/2021JD034827>
- Prytherch, J., & Yelland, M. J. (2021). Wind, convection and fetch dependence of gas transfer velocity in an Arctic sea-ice lead determined from eddy covariance CO₂ flux measurements. *Global Biogeochemical Cycles*, 35, e2020GB006633. <https://doi.org/10.1029/2020GB006633>
- Nilsson, E.D.; Hultin, K.A.H.; Mårtensson, E.M.; Markuszewski, P.; Rosman, K.; Krejci, R. Baltic Sea Spray Emissions: In Situ Eddy Covariance Fluxes vs. Simulated Tank Sea Spray. *Atmosphere* (2021). 12, 274. <https://doi.org/10.3390/atmos12020274>
- Schmale, J., Zieger, P., Ekman, A. (2021). Aerosols in current and future Arctic climate, *Nat. Clim. Change*, 11, 95–105.
- Siegel, K., Karlsson, L., Zieger, P., Baccarini, A., Schmale, J., Lawler, M., Salter, M., Leck, C., Ekman, A.M. L., Riipinen, I., and Mohr, C. (2021). Insights into the molecular composition of semi-volatile aerosols in the summertime central Arctic Ocean using FIGAERO-CIMS, *Environ. Sci.: Atmos., RSC*, 1, 161-175
- Triesch, N., van Pinxteren, M., Salter, M., Stolle, C., Pereira, R., Zieger, P., and Herrmann, H. (2021). Sea Spray Aerosol Chamber Study on Selective Transfer and Enrichment of Free and Combined Amino Acids, *ACS Earth and Space Chemistry*, 5, 1564-1574

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2021? If yes, who? How did you engage?

- Shiptase Belmont forum project. Discussions on shipping scenarios with stakeholders (Anna Rutgersson, Uppsala University).
- Engagement in the Gothenburg Air and Climate Center (Erik Thomson, University of Gothenburg).

PART 2 - Planned activities for 2022 and 2023

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

- Summer 2022: ArcOP expedition to Arctic Ocean. Deep sea drilling program but will include opportunistic trace gas flux measurements (John Prytherch, Stockholm University).
- May 2023: ARTofMelt expedition to central Arctic Ocean. Planning extensive trace gas surface exchange measurements (John Prytherch, Stockholm University).
- Second Field campaign with University of Oldenburg (Leonie Esters, Uppsala University).
- 2022 - follow up ship engine emission campaign (Erik Thomson, University of Gothenburg).
- Sea-spray aging experiments in the laboratory and within an international field campaign on Graciosa, Azores, in summer 2022 as part of the AGENA campaign in collaboration with US partners (Claudia Mohr, Matthew Salter and Paul Zieger, Stockholm University).
- Planning and coordinating ARTofMELT expedition in 2023, conducting extensive atmospheric and oceanic observation to study the onset of sea ice melt within an international collaboration with participants from Sweden, US, UK, Switzerland, Finland, Denmark and others (Michael Tjernström and Paul Zieger, Stockholm University).

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

- Shiptrase Belmont forum project. Discussions on shipping scenarios with stakeholders.
- Gas-Transfer on Water Surfaces, Plymouth, UK, May 2022
- The 8th international symposium on gas transfer at water surfaces (Plymouth, UK, 17-20 May 2022)
- Baltic Earth Conference (Hel peninsula, Poland, 30 May-3 June, 2022)
- 3rd CATCH Open Science Workshop 9-13 May 2022 (<https://www.catchscience.org/OpenScienceWorkshop>)

3. Funded national and international projects/activities underway.

- Continued Integration of ICOS-ACTRIS (Anna Rutgersson, Uppsala University).
- Arctic Climate Across Scales (K&A Wallenberg Foundation, PI Michael Tjernström).
- Baltic Sea CH₄ upscaling (Bolin Centre for Climate Research Flagship Project funding, PI Volker Brüchert).
- FORMAS Mobility grant (Leonie Esters, Uppsala University).
- Viral-bacterial interactions between ocean and atmosphere (VIBOCAT) funded by the German Research Foundation (DFG), <https://gepris.dfg.de/gepris/projekt/446702140?language=en>, (Janina Rahlff, Linnaeus University).
- FORMAS ending, related to ship emissions in Arctic. VR ongoing related to molecular-level understanding of aerosol surfaces (Erik Thomson, University of Gothenburg).
- VR (Swedish Research council) project "Closing the gap between properties of fresh sea spray aerosol and aerosol observed in the marine boundary layer" (Claudia Mohr, Matthew Salter and Paul Zieger, Stockholm University).
- H2020 project CRiceS (Climate Relevant interactions and feedbacks: the key role of sea ice and Snow in the polar and global climate system, <https://www.crices-h2020.eu/>) which is dedicated to improve model predictions of the role of polar processes in the climate system of oceans, ice, snow and atmosphere, start 2021 (Paul Zieger and Annica Ekman, Stockholm University).
- VR (Swedish Research council) project "Characterizing properties of Climate Relevant Organic and Inorganic Sea-Spray-aerosols, Sources and Air-sea-exchange causing their

Net-emission (CROISSANT)” (Douglas Nilsson, Matthew Salter and Paul Zieger, Stockholm University).

- VR (Swedish Research council) project “Biogenic particles and their role in the formation of Arctic clouds” (Paul Zieger, Stockholm University).

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

- Arctic surface exchange observations (surface flux observations in the central Arctic, including trace gases - submitted to VR March 2022). Surface-atmosphere gas exchange in sea-ice regions project (submitted to Formas April 2022) (John Prytherch, Stockholm University).
- Peculiar transmission routes of novel and neustonic viruses along the natural water cycle (PATRONUS), German Research Foundation, Emmy Noether research group grant (submitted in January 22), (Janina Rahlff, Linnaeus University).
- Potentially joining ARTofMELT, (Erik Thomson, University of Gothenburg).
- Studying the properties of marine primary biological particles in pristine atmospheres (proposal submitted to VR, April 2022) (Paul Zieger, Stockholm University).

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

- Engagement within (Biogeochemical Exchange Processes at Sea Ice Interfaces, <https://sites.google.com/site/bepsiiwg140/home>) and CATCH (the Cryosphere and Atmospheric CHEmistry, <https://www.catchscience.org/>)
- New SCOR (Scientific Committee on Oceanic Research) working group: Coupling of ocean-ice-atmosphere processes: from sea-ice biogeochemistry to aerosols and Clouds (Cice2Clouds), <https://scor-int.org/group/coupling-of-ocean-ice-atmosphere-processes-from-sea-ice-biogeochemistry-to-aerosols-and-clouds-cice2clouds/>

Comments