surface ocean **solas** lower atmosphere study

Report for the year 2021 and future activities

SOLAS *Germany*
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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. ?

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).*

Highlight 1:

Oceanic Transfer and Atmospheric Transformation of Marine Carbohydrates in the Western Antarctic Peninsula

Marine carbohydrates are released by microbial activities in the oceanic surface water and represent an important class of organic substances. They can enter the atmosphere as part of sea spray aerosol (SSA) through wind-driven processes. The emission processes of marine carbohydrates, their atmospheric aging and their contribution to the condensation of atmospheric water vapor and ice nucleation is not yet well understood. To this end, the primary transfer of carbohydrates from the ocean via the sea surface microlayer (SML) to the atmosphere and their secondary atmospheric modifications were studied in the western Antarctic Peninsula during the PI-ICE campaign (January - March 2019).
Marine carbohydrates were found in bulk seawater, SML and size-resolved aerosol particles and contributed 2-4% to organic carbon (OC). Air back-trajectories and strong correlations between the aerosolized carbohydrates, sodium and the wind speed suggest local and regional wave breaking and bubble bursting processes as the driving emission processes for the carbohydrates contained in the aerosol particles.
Sodium - a conservative tracer for marine emissions - was used to calculate carbohydrate to sodium ratios. The direct comparison of these ratios in the seawater and aerosol particles revealed a chemo-selective transfer of carbohydrates over sodium during the sea-air transfer. In contrast to very small enrichment factors within the SML (EF, median=1.4), very high enrichment factors for carbohydrates relative to the bulk seawater were found for supermicron (20-4000) and submicron (40-167 000) particles.
However, the monosaccharide composition of the carbohydrates detected in the aerosol and water samples showed quite different patterns. Detailed analyses gave strong evidence for a bacterial degradation and modification of the aerosolized carbohydrates in the atmosphere after their oceanic emission. Abiotic reactions and processes as an alternative explanation to the bacterial metabolism were considered possible, but eventually rated as less likely.

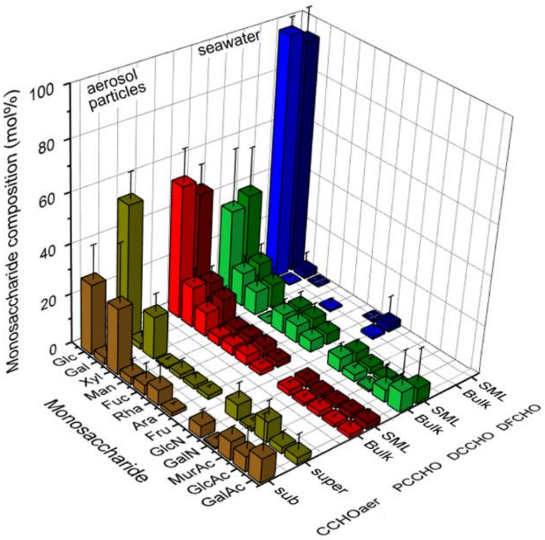

Figure: Three-dimensional (3D) bar graph showing the average and standard deviation of the relative monosaccharide composition of combined carbohydrates in sub-/supermicron aerosol particles ($CCHO_{aer}$), particulate combined carbohydrates (PCCHO), dissolved combined carbohydrates (DCCHO) and dissolved free carbohydrates (DFCHO) in seawater and SML samples.

Citation: Zeppenfeld, S., van Pinxteren, M., van Pinxteren, D., Wex, H., Berdalet, E., Vaqué, D., Dall'Osto, M., and Herrmann, H.: Aerosol Marine Primary Carbohydrates and Atmospheric Transformation in the Western Antarctic Peninsula, ACS Earth Space Chem., 5, 1032–1047, https://doi.org/10.1021/acsearthspacechem.0c00351, 2021.

Highlight 2:

Amino acids – complex patterns in nascent and ambient aerosol particles

There have been a number of studies focusing on amino acids in the surface, however little is known about the sources of amino acids found on marine aerosol particles. Here, we have generated nascent sea-spray aerosol (SSA) using a well-characterized laboratory chamber (SSAC) to investigate the transfer of amino acids from the ocean to the atmosphere under controlled conditions.

The highest enrichments of amino acids (enrichment factors up 10^7) were found on aerosol particles in the submicron size range with a tendency of increasing enrichments with decreasing aerosol particle size. A selectivity in the transfer of the individual amino acids was observed: The more polar the free amino acids are, the more they are enriched on the SSA particles. However, physico-chemical parameters alone are not sufficient to explain the amino acid transfer to the atmosphere.

Comparison of the amino acids present on nascent SSA to those present on ambient marine aerosol particles revealed a higher complexity of the amino acids of the nascent SSA, suggesting that atmospheric processes likely reduce the amino acid diversity. In addition, our results highlight that although almost all the amino acids studied are transferred to the atmosphere via bubble-bursting under controlled conditions, two amino acids, γ-aminobutyric acid (GABA) and glycine likely have additional sources to the atmosphere. GABA is likely formed on ambient marine submicron aerosol particles to a large extent (35-47 % of ∑amino acids). Glycine likely originates from long-range transport processes or photochemical reactions, as discussed in the literature, however our results highlight the potential for a direct oceanic source via bubble-bursting (~20 % of ∑amino acids).

The determined size-dependent transfer efficiencies and enrichments can be used to improve future modelling of oceanic amino acid transfer as a substantial fraction of OM in the marine ocean-atmosphere coupled environment.

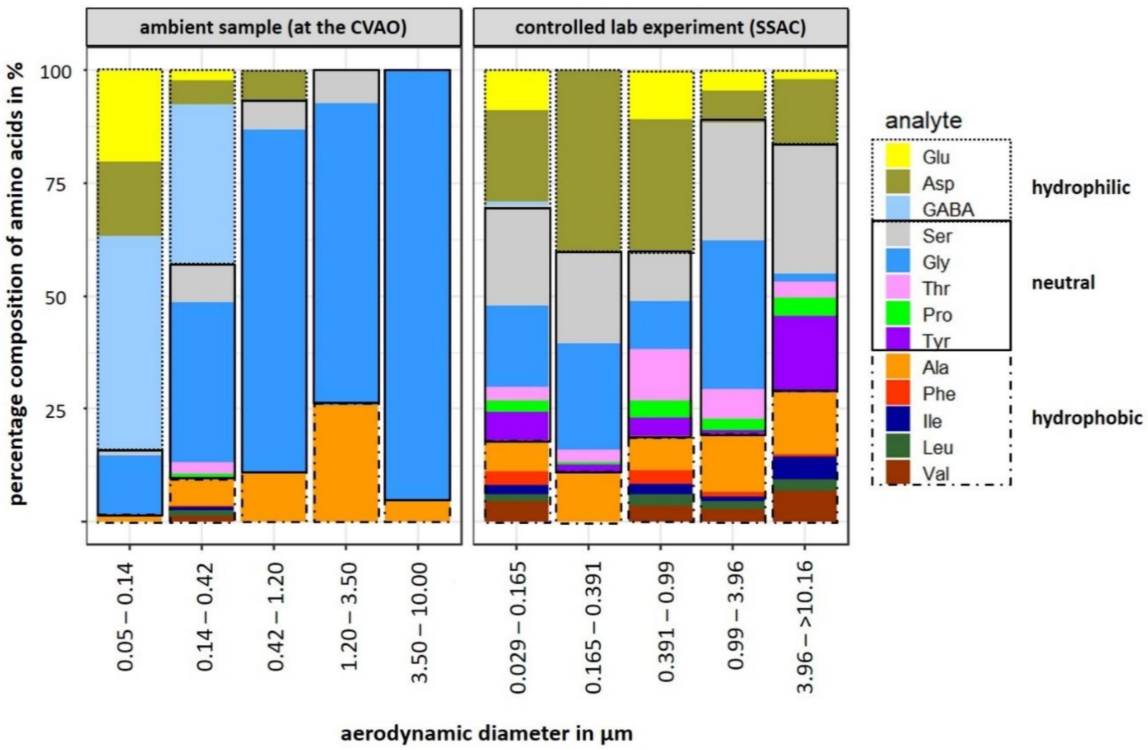

Figure: Relative composition of amino acids on the size-segregated aerosol particles of the laboratory experiment sea-spray simulation chamber (right) and ambient samples at the Cape Verde Atmospheric Observatory (left).

Citation: Triesch, N., van Pinxteren, M., Salter, M., Stolle, C., Pereira, R., Zieger, P., and Herrmann, H.: Sea Spray Aerosol Chamber Study on Selective Transfer and Enrichment of Free and Combined Amino Acids, ACS Earth Space Chem., 5, 1564-1574, 10.1021/acsearthspacechem.1c00080, 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).

- **Marandino, C. A.** Global shipping: Linking policy and economics to biogeochemical cycling and air-sea interaction (ShipTRASE) (*invited talk*), online – hosted in Guangzhou, China.
- **Marandino, C. A.** Eddy covariance measurements of DMS and CO_2 *Keynote speaker* for the 'Bite-size' Gas Transfer at Water Surfaces Symposium, online – hosted in Plymouth, United Kingdom.
- **Marandino, C. A.** The ocean cool skin and eddy covariance measurements (*invited short talk*), Global Carbon Budget Ocean Workshop, online – hosted in Bremerhaven, Germany.
- **Marandino, C. A.** *Forum co-convener* The apparent mismatch between science and policy at the air-sea interface, Sustainability Research & Innovation Congress, Brisbane, Australia
- **Uni Oldenburg, GEOMAR** (with Israeli cooperation) - A novel approach to quantify global oceanic emissions of carbonyl sulfide (COS), funded by VW Stiftung
- **GEOMAR, Uni Kiel** (with Swedish and French cooperation) – Global shipping: Linking policy and economics to biogeochemical cycling and air-sea interaction (ShipTRASE), funded by the BMBF (Belmont Forum)
- **Marandino, C. A.** *Lead organizer* of UN Ocean Decade Clean Ocean Laboratory Satellite Event – OASIS for a Clean Ocean/approx. 75 participants/online
- **Marandino, C. A.** *Lead organizer* of Open ocean eddy covariance best practices workshop series planning event – Ocean Best Practices System (OBPS) workshop/9 participants/online
- **Marandino, C. A.** *Organizer and moderator* for UN Ocean Decade Predicted Ocean Laboratory Satellite Event – OASIS for a Predicted Ocean/approx. 200 participants/online
- **Marandino, C. A.** *Scientific steering committee member* for 8th International Symposium on Gas Transfer at Water Surfaces/approx. 150 participants/United Kingdom

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

- Adenaya A, Haack M, Stolle C, Wurl O, Ribas-Ribas M. Effects of Natural and Artificial Surfactants on Diffusive Boundary Dynamics and Oxygen Exchanges across the Air–Water Interface. *Oceans*. 2021; 2(4):752-771. https://doi.org/10.3390/oceans2040043
- Lennartz, S. T., Gauss, M., von Hobe, M., and Marandino, C. A. (2021) Monthly resolved modelled oceanic emissions of carbonyl sulfide and carbon disulfide for the period 2000–

2019 Earth System Science Data, 13 (5). pp. 2095-2110. DOI: 10.5194/essd-13-2095-2021.

- Rahlff J, Khodami S, Voskuhl L, Humphreys MP and others (2021) Short-term responses to ocean acidification: effects on relative abundance of eukaryotic plankton from the tropical Timor Sea. Mar Ecol Prog Ser 658:59-74. https://doi.org/10.3354/meps13561
- Ribas-Ribas, M., C.J. Zappa, and O. Wurl. 2021. Technologies for observing the near sea surface. Pp. 88–89 in Frontiers in Ocean Observing: Documenting Ecosystems, Understanding Environmental Changes, Forecasting Hazards. E.S. Kappel, S.K. Juniper, S. Seeyave, E. Smith, and M. Visbeck, eds, A Supplement to Oceanography 34(4), https://doi.org/10.5670/oceanog.2021.supplement.02-32.
- Triesch, N., van Pinxteren, M., Salter, M., Stolle, C., Pereira, R., Zieger, P., and Herrmann, H.: Sea Spray Aerosol Chamber Study on Selective Transfer and Enrichment of Free and Combined Amino
- Zeppenfeld, S., van Pinxteren, M., van Pinxteren, D., Wex, H., Berdalet, E., Vaqué, D., Dall'Osto, M., and Herrmann, H.: Aerosol Marine Primary Carbohydrates and Atmospheric Transformation in the Western Antarctic Peninsula, ACS Earth Space Chem., 5, 1032–1047, https://doi.org/10.1021/acsearthspacechem.0c00351, 2021.
- Zhang, M., Marandino, C. A., Yan, J., Wu, Y., Park, K., Sun, H., et al. (2021) Unravelling surface seawater DMS concentration and sea-to-air flux changes after sea ice retreat in the western Arctic Ocean Global Biogeochemical Cycles, 35. e2020GB006796. https://doi.org/10.1029/2020GB006796.
- Zhang, M., Marandino, C. A., Yan, J. P., Park, K, Lin, Q., Park, K., Xu, G., Kim, T.-W., and Chen, L. (2021) DMS sea-to-air fluxes and their influence on sulfate aerosols over the Southern Ocean, southeast Indian Ocean, and northwest Pacific Ocean Environmental Chemistry, DOI: 10.1071/EN21003.

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?

- ✓ ShipTRASE conducted stakeholder surveys related to future shipping scenarios.
- ✓ OASIS regularly interacts with stakeholders during the UN Ocean Decade Labs and during Theme Team meetings.

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.).

- POLAR-CHANGE campaign: (*Aerosol emissions from POLAR-CHANGing Environments*) taking place in Jan./Feb. 2023, Antarctic peninsula PI: Manuel Dall'Osto, TROPOS contribution: Identifying atmospheric relevant organic matter (carbohydrates, amino acids) in Antarctic seawater, sea surface microlayers and aerosol particles, identification of formation and transfer pathways
- Nov./Dec. 2023 Bubble (mediated) Exchange in the Labrador Sea (BELS), Germany-Canada-USA-UK research cruise aboard the Maria S. Merian (German chief scientist)
- 2022-2026 German DFG Research Unit, Biogeochemical processes and Air–sea exchange in the Sea-Surface microlayer (BASS), lab based experiments in 2023
- Jun./Jul. 2022 Central Baltic Air-Sea Exchange (CenBASE) Germany-USA-UK research cruise aboard the Elisabeth Mann Borgese to study inland sea gas exchange (German chief scientist)

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

- Dec. 2022 German convener – Get Involved! Observing Air-Sea Interactions Strategy (OASIS) Theme Teams, hybrid Town Hall Meeting, AGU Fall Meeting, Chicago, USA
- Sep. 2022 German discussion session lead – Strengthening Partnerships between OASIS and the Global South, SOLAS Open Science Conference, Cape Town, Republic of South Africa.
- Sep. 2022 German discussion session co-lead - SOLAS Science & Society: building upon past achievements & future possibilities, SOLAS Open Science Conference, Cape Town, Republic of South Africa.
- Sep. 2022 German discussion session lead – SOLAS science and global ship emissions – common challenges and next steps, SOLAS Open Science Conference, Cape Town, Republic of South Africa.
- Sep. 2022 Organizer of hybrid workshop Cross-linking lab and field measurements and numerical modeling to identify and quantify the mechanisms of air-sea gas transfer/approx. 100 participants/Germany
- Jun. 2022 Organizer of UN Ocean Decade Productive Ocean Laboratory Satellite Event – OASIS for a Productive Ocean (offshore wind energy)/approx. 100 participants/online
- Jun. 2022 German director virtual SOLAS summer school, 1 week-long with 62 students, lectures, practicals and posters
- May 2022 German discussion session co-lead – How to cross-link lab and field measurements, Gas Transfer at Water Surfaces, Plymouth, UK.
- May 2022Organizer and note taker for UN Ocean Decade Accessible Ocean Laboratory Satellite Event – OASIS for an Accessible Ocean/approx. 100 participants/online
- Mar. 2022 German organizer for OASIS Panel Discussion/Webinar - Best Practices panel discussion on Essential Ocean Variables (EOVs) needed for air-sea CO2 fluxes/approx. 50 participants/online
- Feb. 2022 German convener – Get Involved! Observing Air-Sea Interactions Strategy (OASIS) Theme Teams, virtual Town Hall Meeting, Ocean Sciences Meeting

- 3. Funded national and international projects/activities underway.

- 2023 Bubble (mediated) Exchange in the Labrador Sea (BELS), Germany-Canada-USA-UK research cruise aboard the Maria S. Merian (German chief scientist)
- 2022-2026 German DFG Research Unit, Biogeochemical processes and Air–sea exchange in the Sea-Surface microlayer (BASS)
- 2020-2023 German VW Stiftung cooperation with Israel, A novel approach to quantify global oceanic emissions of carbonyl sulfide (COS)
- 2020-2023 Belmont Forum international project with German PI, Global shipping: Linking policy and economics to biogeochemical cycling and air-sea interaction (ShipTRASE)

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

GEOMAR has submitted two proposals to participate in consortium-based ship emissions and biogeochemistry in the Arctic proposals (within Germany and internationally)

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

Christa Marandino (GEOMAR) will continue to work closely within the international OASIS project (SCOR and UN Ocean Decade) as co-chair.

Comments