surface ocean **solas** lower atmosphere study

Report for the year 2022 and future activities

SOLAS *Germany*
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This report has two parts:

- Part 1: *reporting of activities in the period of January 2022 - Jan/Feb 2023*
- Part 2: *reporting on planned activities for 2023 and 2024.*

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 2022 to Jan/Feb 2023
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:

Transparent exopolymer particles (TEP) that are gel-like particles ubiquitous found in oceans, may enter the atmosphere through sea spray aerosol. During the international MarParCloud campaign, we investigated TEP number concentrations in aerosol and cloud water samples from the tropical Atlantic Ocean, and in aerosol particles generated by a plunging waterfall tank filled with ambient seawater. We found that atmospheric TEP had a similar size distribution to TEP in the ocean, with increasing TEP number concentrations towards smaller particle sizes. Enrichment of TEP in tank-generated aerosol particles was in line with another study. However, ambient TEP enrichments were up to two orders of magnitude higher than in the tank study, potentially from enrichment during bubble-bursting transfer from the ocean and secondary atmospheric formation.
Based on these findings, we propose that similar (biotic and abiotic) formation mechanisms for TEP in seawater might take place in the atmosphere as well, given the required conditions such as high concentrations of dissolved TEP precursors like polysaccharides and the presence of bacteria in the cloud water. TEP concentrations in the atmosphere were two orders of magnitude higher than ice-nucleating particle (INP) concentrations in the aerosol particles and cloud water, with only a portion of the TEP population likely contributing to the INP population.
This study suggests that marine gel particles, their in-cloud formation, and their connection to bacteria in the atmosphere could be highly relevant for understanding marine cloud properties in oceanic locations. While dust may be the dominant INP source in the tropical Atlantic region near the Sahara, TEP and their formation mechanisms could be critical in other remote oceanic locations.

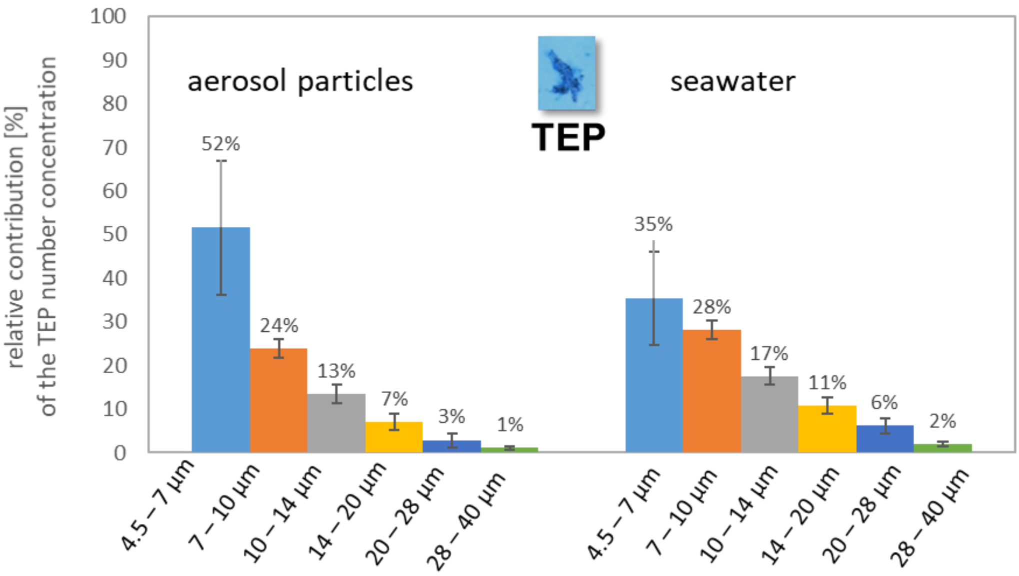

Figure: Relative contribution of the TEP number concentrations in the aerosol particles and in the ocean surface water within identical size bins.

Citation: van Pinxteren, M., Robinson, T.-B., Zeppenfeld, S., Gong, X., Bahlmann, E., Fomba, K. W., Triesch, N., Stratmann, F., Wurl, O., Engel, A., Wex, H., and Herrmann, H.: High number concentrations of transparent exopolymer particles in ambient aerosol particles and cloud water – a case study at the tropical Atlantic Ocean, Atmos. Chem. Phys., 22, 5725–5742, https://doi.org/10.5194/acp-22-5725-2022, 2022.

Highlight 2:

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.

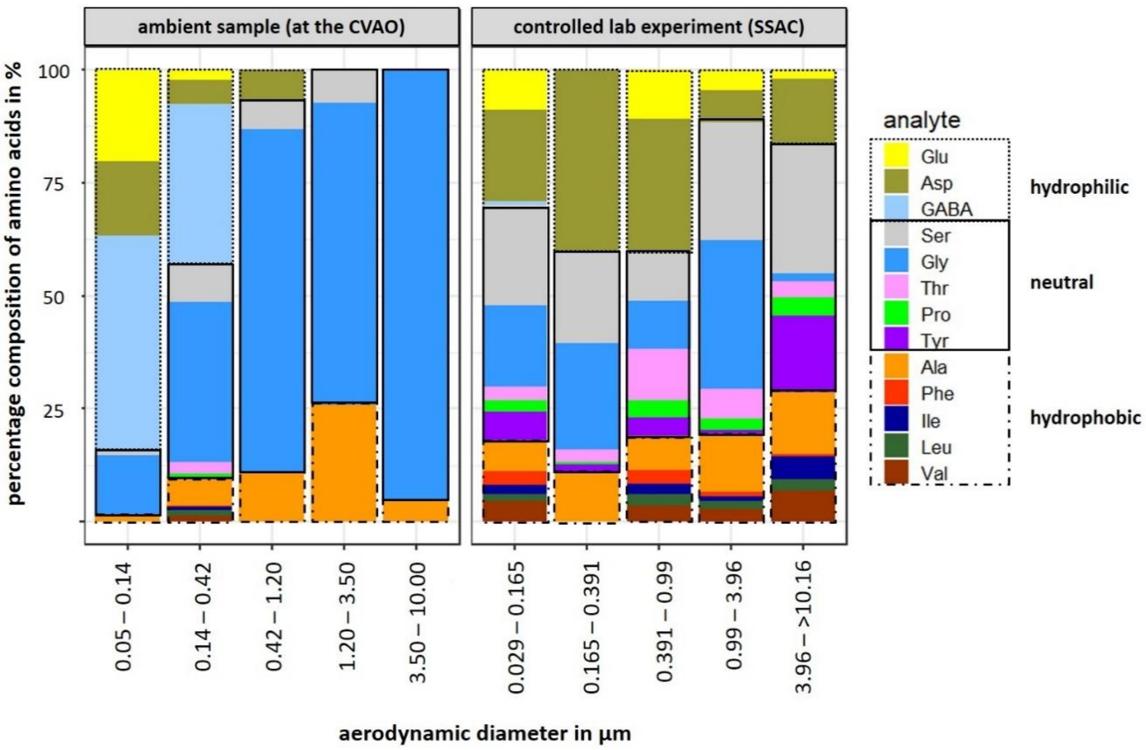

Figure: Relative composition of amino acids on the size-segregated aerosol particles of the laboratory experiment sea-spray simulation chamber (right) and ambient samples at the Cape Verde Atmospheric Observatory (left).

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 2022 (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).

Baltic and North Sea ship campaign to investigate the carbon budget (HE611), November-December 2022, Hereon

BASS pilot ship campaign in the North Sea to test joint investigation of the sea surface microlayer, November 2022, University of Oldenburg

Workshop on rectifying lab and field studies of air-sea exchange, 5-6 September 2022, University of Heidelberg

Baltic Sea ship campaign Central Baltic Air-Sea Exchange (CenBASE) June 2022, IOW

Balloon campaign in Ny Alesund: Oct/Nov. 2021 and March-May 2022, participants: TROPOS, University of Leipzig, AWI

3. List SOLAS-related publications published in 2022 (only PUBLISHED articles) and if any, web links to models, datasets, products, etc.

Bange, H. W. (2022) Non-CO2 greenhouse gases (N2O, CH4, CO) and the ocean. One Earth, 5 (12). pp. 1316-1318. DOI 10.1016/j.oneear.2022.11.011. . Item availability may be restricted.

Barthelmess, T. und Engel, A. (2022) How biogenic polymers control surfactant dynamics in the surface microlayer: Insights from a coastal Baltic Sea study. Biogeosciences (BG), 19 . pp. 4965-4992. DOI 10.5194/bg-19-4965-2022.

Campen, H. I. , Arevalo-Martinez, D. L. , Artioli, Y., Brown, I. J., Kitidis, V., Lessin, G., Rees, A. P. und Bange, H. W. (2022) The role of a changing Arctic Ocean and climate for the biogeochemical cycling of dimethyl sulphide and carbon monoxide. Ambio, 51 . pp. 411-422. DOI 10.1007/s13280-021-01612-z.

Carpenter, J., Buckley, M., Veron, F. (2022) Evidence of critical layer mechanism in growing wind waves. Journal of Fluid Mechanics, 948, A26. doi:10.1017/jfm.2022.714

Crisp, D., Dolman, H., Tanhua, T. , McKinley, G. A., Hauck, J., Bastos, A., Sitch, S., Eggleston, S. und Aich, V. (2022) How Well Do We Understand the Land-Ocean-Atmosphere Carbon Cycle?. Reviews of Geophysics, 60 (2). Art.Nr. e2021RG000736. DOI 10.1029/2021RG000736.

Friedlingstein, P., Körtzinger, A. und Tanhua, T. and et al (2022) Global Carbon Budget 2021. Earth System Science Data, 14 (4). pp. 1917-2005. DOI 10.5194/essd-14-1917-2022.

Galgani, L., Goßmann, I., Scholz-Böttcher, B., Jiang, X., Liu, Z., Scheidemann, L., Schlundt, C. und Engel, A. (2022) Hitchhiking into the Deep: How Microplastic Particles are Exported through the Biological Carbon Pump in the North Atlantic Ocean. Environmental Science & Technology, 56 . pp. 15638-15649. DOI 10.1021/acs.est.2c04712.

Gindorf, S., Bange, H. W., Booge, D. und Kock, A. (2022) Seasonal study of the small-scale variability in dissolved methane in the western Kiel Bight (Baltic Sea) during the European heatwave in 2018. Biogeosciences (BG), 19 . pp. 4993-5006. DOI 10.5194/bg-19-4993-2022.

Grote, M., Boudenne, J. L., Croué, J. P., Escher, B. I., von Gunten, U., Hahn, J., Höfer, T., Jenner, H., Jiang, J., Karanfil, T., Khalanski, M., Kim, D., Linders, J., Manasfi, T., Polman, H., Quack, B., Tegtmeier, S., Werschkun, B., Zhang, X. und Ziegler, G. (2022) Inputs of disinfection by-products to the marine environment from various industrial activities: Comparison to natural production. Water Research, 217 . Art.Nr. 118383. DOI 10.1016/j.watres.2022.118383.

Jia, Y., Quack, B., Kinley, R. D., Pisso, I. und Tegtmeier, S. (2022) Potential environmental impact of bromoform from Asparagopsis farming in Australia. Atmospheric Chemistry and Physics, 22 . pp. 7631-7646. DOI 10.5194/acp-22-7631-2022.

Jiang, L. Q., Pierrot, D., Wanninkhof, R., Feely, R. A., Tilbrook, B., Alin, S., Barbero, L., Byrne, R. H., Carter, B. R., Dickson, A. G., Gattuso, J. P., Greeley, D., Hoppema, M., Humphreys, M. P., Karstensen, J. , Lange, N., Lauvset, S. K., Lewis, E. R., Olsen, A., Pérez, F. F., Sabine, C., Sharp, J. D., Tanhua, T. , Trull, T. W., Velo, A., Allegra, A. J., Barker, P., Burger, E., Cai, W. J., Chen, C. T. A., Cross, J., Garcia, H., Hernandez-Ayon, J. M., Hu, X., Kozyr, A., Langdon, C., Lee, K., Salisbury, J., Wang, Z. A. und Xue, L. (2022) Best Practice Data Standards for Discrete Chemical Oceanographic Observations. Frontiers in Marine Science, 8 . Art.Nr. 705638. DOI 10.3389/fmars.2021.705638.

Lauvset, S. K., Lange, N., Tanhua, T. , Bittig, H. C., Olsen, A., Kozyr, A., Alin, S. R., Álvarez, M., Azetsu-Scott, K., Barbero, L., Becker, S., Brown, P. J., Carter, B. R., da Cunha, L. C., Feely, R. A., Hoppema, M., Humphreys, M. P., Ishii, M., Jeansson, E., Jiang, L. Q., Jones, S. D., Lo Monaco, C., Murata, A., Müller, J. D., Pérez, F. F., Pfeil, B., Schirnick, C. , Steinfeldt, R., Suzuki, T., Tilbrook, B., Ulfsbo, A., Velo, A., Woosley, R. J. und Key, R. M. (2022) GLODAPv2.2022: the latest version of the global interior ocean biogeochemical data product. Earth System Science Data, 14 (12). pp. 5543-5572. DOI 10.5194/essd-2022-293.

Perner, M. , Wallmann, K. , Adam-Beyer, N., Hepach, H. , Laufer-Meiser, K., Böhnke, S., Diercks, I., Bange, H. W. , Indenbirken, D., Nikeleit, V., Bryce, C., Kappler, A., Engel, A. und Scholz, F. (2022) Environmental changes affect the microbial release of hydrogen sulfide and methane from sediments at Boknis Eck (SW Baltic Sea). Frontiers in Microbiology, 13 . Art.Nr. 1096062. DOI 10.3389/fmicb.2022.1096062.

Rees, A. P. , Bange, H. W. , Arevalo-Martinez, D. L. , Artioli, Y., Ashby, D. M., Brown, I., Campen, H. I. , Clark, D. R., Kitidis, V., Lessin, G., Tarran, G. A. und Turley, C. (2022) Nitrous oxide and methane in a changing Arctic Ocean. Ambio, 51 . pp. 398-410. DOI 10.1007/s13280-021-01633-8.

Révelard, A., Tintoré, J., Verron, J., Bahurel, P., Barth, J. A., Belbéoch, M., Benveniste, J., Bonnefond, P., Chassignet, E. P., Cravatte, S., Davidson, F., deYoung, B., Heupel, M., Heslop, E., Hörstmann, C., Karstensen, J. , Le Traon, P. Y., Marques, M., McLean, C., Medina, R., Paluszkiewicz, T., Pascual, A., Pearlman, J., Petihakis, G., Pinardi, N., Pouliquen, S., Rayner, R., Shepherd, I., Sprintall, J., Tanhua, T. , Testor, P., Seppälä, J., Siddorn, J., Thomsen, S., Valdés, L., Visbeck, M. , Waite, A. M., Werner, F., Wilkin, J. und Williams, B. (2022) Ocean Integration: The Needs and Challenges of Effective Coordination Within the Ocean Observing System. Frontiers in Marine Science, 8 . Art.Nr. 737671. DOI 10.3389/fmars.2021.737671.

Santana-Casiano, J. M., González-Santana, D., Devresse, Q., Hepach, H. , Santana-González, C., Quack, B., Engel, A. und González-Dávila, M. (2022) Exploring the Effects of Organic Matter Characteristics on Fe(II) Oxidation Kinetics in Coastal Seawater. Environmental Science & Technology, 56 (4). pp. 2718-2728. DOI 10.1021/acs.est.1c04512.

Sutton, A. J., Battisti, R., Carter, B., Evans, W., Newton, J., Alin, S., Bates, N. R., Cai, W. J., Currie, K., Feely, R. A., Sabine, C., Tanhua, T. , Tilbrook, B. und Wanninkhof, R. (2022) Advancing best practices for assessing trends of ocean acidification time series. Frontiers in Marine Science, 9 . Art.Nr. 1045667. DOI 10.3389/fmars.2022.1045667.

Tegtmeier, S., Marandino, C. A., Jia, Y., Quack, B. und Mahajan, A. S. (2022) Atmospheric gas-phase composition over the Indian Ocean. Atmospheric Chemistry and Physics, 22 (10). pp. 6625-6676. DOI 10.5194/acp-22-6625-2022.

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Yang, M., Bell, T. G., Bidlot, J. R., Blomquist, B. W., Butterworth, B. J., Dong, Y., Fairall, C. W., Landwehr, S., Marandino, C. A., Miller, S. D., Saltzman, E. S. und Zavarsky, A. (2022) Global Synthesis of Air-Sea CO2 Transfer Velocity Estimates From Ship-Based Eddy Covariance Measurements. Frontiers in Marine Science, 9 . Art.Nr. 826421. DOI 10.3389/fmars.2022.826421.

Zhao, Y. , Booge, D., Marandino, C. A., Schlundt, C. , Bracher, A., Atlas, E. L., Williams, J. und Bange, H. W. (2022) Dimethylated sulfur compounds in the Peruvian upwelling system. Biogeosciences (BG), 19 . pp. 701-714. DOI 10.5194/bg-19-701-2022.

Zhou, L., Booge, D. , Zhang, M. und Marandino, C. A. (2022) Winter season Southern Ocean distributions of climate-relevant trace gases. Biogeosciences (BG), 19 . pp. 5021-5040. DOI 10.5194/bg-19-5021-2022. . Item availability may be restricted.

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2022? If yes, who? How did you engage?

PART 2 - Planned activities for 2023 and 2024

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

BASS (SML) mesocosm study at ICBM in Wilhelmshaven, May-June 2023 (German research unit with partners from multiple institutes in Germany and Austria)

Bubble (mediated) Exchange in the Labrador Sea (BELS) ship campaign, November-December 2023, GEOMAR (international collaborators)

Biocat Cruise in the Indian Ocean, spring 2024, GEOMAR (national and international collaborators)

BASS (SML) ship campaign off Helgoland in the North Sea, summer 2024

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

Eddy covariance best practices workshop, London, March 2023 – co-lead C. Marandino (GEOMAR)

SOLAS summer school, Mindelo, June 2023 – lead C. Marandino (GEOMAR)

SOLAS Science and Society workshop, Galway, October 2023 – leads E. van Doorn (CAU, Kiel), C. Marandino (GEOMAR)

3. Funded national and international projects/activities underway.

BASS German Research Foundation Research Unit to investigate the biogeochemistry and air-sea exchange of the sea surface microlayer

GEORGE EU Project to build multiplatform ocean observing technologies for research infrastructures

SOOP Helmholtz Project to outfit sailboats and other ships of opportunity to measure carbon parameters in the surface ocean

AIRSPACE- funded BMBF project: TROPOS (Germany) – FIO, SDU (China): Investigation of effects of air pollution from ship emissions and advection of anthropogenic air masses on the composition of the oceanic atmosphere and exchange processes at the ocean surface.

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

FUTURO year-long field campaign to investigate biogeochemical and physical processes in the upwelling regions off of the African coast – lead by GEOMAR 2027-2028

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

UN Ocean Decade
OASIS
IOCCP
GOOS
ICOS
SCOR
IIOE

Comments