Report for the year 2023 and future activities

SOLAS ‘Germany’
compiled by: ‘Manuela van Pinxteren and Leonie Esters’

This report has two parts:

- **Part 1**: reporting of activities in the period of January 2023 - Jan/Feb 2024
- **Part 2**: reporting on planned activities for 2024 and 2025.

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;
6. Integrated studies of high sensitivity systems;
7. Environmental impacts of geoengineering;

**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 2023 to Jan/Feb 2024**

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:

Virus-like particles accumulate in the sea-surface microlayer (SML) and sea foams at the air-sea boundary. From here, viruses are selectively aerosolized to the atmosphere and eventually end up in rainwater. About ~6% of the marine viral population could be found in rainwater. Microbial hosts from the sea surface show adaptive immunity towards viruses from rainwater.

Within the SML of natural slicks, viruses and bacteria form distinct communities compared to SML from non-slick areas and underlying water. Bacterial genomes from isolates and metagenome-assembled genomes indicate different carbon usage profiles of slick-dwelling bacteria, which probably allow for bacterial co-existence in the slick. Viruses infected the most abundant bacteria in the slick. Virus-host interactions in the slick SML uncoupled from remaining waters and non-slick SML.

Figure: Virus-like particles (VLP) as measured from flow cytometry in sea foam (b), surface microlayer (c) and underlying water (d). Figure taken from Rahlff et al. 2023a.

Reference:


Highlight 2:

To understand the connection of marine aerosol particles to processes in the ocean as well as subsequent atmospheric processing, it is crucial to unravel the chemical composition of the organic aerosol content. In a recent study important marine organic compounds, namely amino acids, carbohydrates and lipids, were identified in the Atlantic Ocean, specifically in the aerosol particles and in the upper layer of the ocean. These compounds were strongly enriched in the atmosphere. Their enrichment was, however, not solely explained with sea-to-air transfer via physical processes (bubble bursting) but also via atmospheric in situ formation. The identified compounds constituted about 50% of the organic carbon on the aerosol particles and suggested a pronounced coupling between ocean and atmosphere for oligotrophic regions.
Figure: Concentration of amino acids, lipids and carbohydrates in the seawater, in detail sea surface microlayer (SML) and bulk water (a), and in the submicron aerosol particles (b) together with their calculated enrichment factor in the atmosphere (blue bars) as well as a schematic representing the bubble-bursting-generated transfer of the compounds from the seawater to the atmosphere (c).


Highlight 3:

Carbohydrates, originating from marine microorganisms, enter the atmosphere as part of sea spray aerosol (SSA) and can influence fog and cloud microphysics as cloud condensation nuclei (CCN) or icenucleating particles (INP). Particularly in the remote Arctic region, significant knowledge gaps persist about the sources, the sea-to-air transfer mechanisms, atmospheric concentrations, and processing of this substantial organic group. In this ship-based field study conducted from May to July 2017 in the Fram Strait, Barents Sea, and central Arctic Ocean, we investigated the sea-to-air transfer of marine combined carbohydrates (CCHO) from concerted measurements of the bulk seawater, the sea surface microlayer (SML), aerosol particles and fog. Our results reveal a wide range of CCHO concentrations in seawater, with notable variations among different sea-ice-related sea surface compartments. Enrichment factors in the sea surface microlayer (SML) relative to bulk water exhibited variability in both dissolved (0.4–16) and particulate (0.4–49) phases, with the highest values in the marginal ice zone (MIZ) and aged melt ponds. In the atmosphere, CCHO was detected in super- and submicron aerosol particles and fog water. Enrichment factors for sea–air transfer varied based on assumed oceanic emission sources. Furthermore, we observed rapid atmospheric aging of CCHO, indicating both biological/enzymatic processes and abiotic degradation. This study highlights the diverse marine emission sources in the Arctic Ocean and the atmospheric processes shaping the chemical composition of aerosol particles and fog.
Highlight 4:

The global water cycle is primarily driven by two processes: rain and evaporation. These processes either add or remove freshwater from the upper ocean, which in turn affects the sea surface's salinity. We present the results on the salinity ($\Delta S$) and temperature ($\Delta T$) anomalies in the sea surface microlayer (SML) in relation to the underlying mixed bulk water. Precipitation and evaporation drive freshwater fluxes across the sea surface, making them the most essential processes of the hydrologic cycle. Measurements of the SML during precipitation are rare, but necessary to fully understand freshwater exchange at the air-sea interface. The fact is that a changes in salinity due to evaporation and precipitation occurs spontaneously in the SML. Our research involved recording several light to moderate rain events in the southern Pacific near Fiji while observing the temperature and salinity in the SML and bulk water. Our findings show that freshwater can mix rapidly with the bulk water through wind-induced mixing, as $\Delta S$ and $\Delta T$ exhibit a clear dependence on wind speed. At high wind speeds (5.1–11.6 m s$^{-1}$), anomalies approach zero ($\Delta S = -0.02 \pm 0.49$ g kg$^{-1}$, $\Delta T = -0.09 \pm 0.46^\circ$C), but they can reach $\Delta S = 1.00 \pm 0.20$ g kg$^{-1}$ and $\Delta T = -0.37 \pm 0.09^\circ$C at lower wind speeds (0–2 m s$^{-1}$). We discovered shallow freshwater lenses and fronts, likely caused by past rainfall, with $\Delta S$ and $\Delta T$ of up to $-1.11$ g kg$^{-1}$ and $1.77^\circ$C, respectively. Our observations suggest that freshwater lenses can be very shallow (<1 m depth) and missed by conventional measurements. Moreover, the temperature and salinity in the SML respond to
freshwater fluxes instantaneously, highlighting the role of the SML in a mechanistic understanding of the fate of freshwater over the ocean and, therefore, the global hydrologic cycle.

The graph shows the 3-minute average measurements taken at stations 03 and 24 over time. The measurements include salinity (a, e), temperature (b, f), and sigma-t densities of the sea surface microlayer (SML), 1-meter deep bulk water (catamaran), and 3-meter deep bulk water (research vessel) (c, g). Additionally, the graph shows rain rate (RR), wind speed (WS), evaporation (E), and solar radiation (SR) (d, h).


2. Activities/main accomplishments in 2023 (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).
The DFG research unit FOR5267 (Biogeochemical processes and Air-sea exchange in the Sea-Surface microlayer - BASS) conducted a multidisciplinary mesocosm experiment at the Sea-SURface Facility (SURF; ICBM, Wilhelmshaven) in spring 2023. BASS is coordinated by the group Marine Interfaces at ICBM. The primary purpose of the mesocosm study has been to create a natural algal bloom with the following objectives: (i) to track enrichment processes of surfactants and biomolecules, (ii) to monitor the dynamics of a bacterio-neuston community in the SML, including its diversity, specific adaptation, and activity in OM transformation, (iii) to determine the molecular composition, reactivity, and photochemical transformation of OM, (iv) to investigate the dynamics of the (re-)formation and thickness of the SML, and (v) to determine the influence of SML properties on the exchange of trace gases. The campaign was successful with an observed diatom bloom over a period of 5 weeks. Throughout this period, a comprehensive array of in-situ measurements was conducted, alongside daily sampling of both the sea surface microlayer (SML) and bulk water. Analysis encompassing multiple disciplines including chemistry, biology, and physics has been successfully completed.

A field campaign in the Southern Ocean based at the Chilean Research station Professor Julio Escudero Base on King George Island was conducted. An 8 week sampling campaign on the sea-surface microlayer and its role in the exchange of trace gases has been completed between December 2023 and January 2024. Hydrodynamics and atmospheric measurements were also made.

Further activities:
- SSS in Cabo Verde
- ORIGAMY field campaign in Cabo Verde
- BELS campaign
- Transdisciplinary ocean research
- Interaction with freelance journalist Philip Hunter, who wrote an article about the neuston:
  Hunter, P. (2023). Scratching the ocean surface: Researchers want to better understand the nature and dynamics of the abundant life living on and in the ocean's surface layers. *EMBO reports*, 24(9), e57928.
  [https://doi.org/10.15252/embr.202357928](https://doi.org/10.15252/embr.202357928)

3. List SOLAS-related publications published in 2023 (only PUBLISHED articles) and if any, web links to models, datasets, products, etc.


Datasets:


Sequencing data projects on NCBI:

- Bioproject PRJNA811790: Microbial and viral dispersal along the natural water cycle https://www.ncbi.nlm.nih.gov/bioproject/?term=PRJNA811790

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2023? If yes, who? How did you engage?

ShipTRASE stakeholder meeting (7 Feb 2023, online) - The objective is primarily to evaluate the likelihood of each of the potential scenarios on future shipping selected through the ShipTRASE project analyses and, on a secondary basis, to evaluate some hypotheses elaborated by the ShipTRASE team.

<table>
<thead>
<tr>
<th>PART 2 - Planned activities for 2024 and 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Planned major national and international field studies and collaborative laboratory and modelling studies (incl. all information possible, dates, locations, teams, work, etc.).</td>
</tr>
</tbody>
</table>
### 2024

**What:** International BASS field campaign: Multidisciplinary field study on microlayer. Autonomous vehicles, shipboard instruments, moorings, research aircraft, satellite obs.

**When:** June-July 2024

**Where:** German Bight (Helgoland)

**What:** Multidisciplinary field study on microlayer. Autonomous vehicles, shipboard instruments, moorings, research aircraft, satellite obs.

**Abstract:** The existence of the sea-surface microlayer (SML) is a global phenomenon, and due to its unique position, exchange of material and energy between the ocean and the atmosphere must occur through this boundary layer. The primary goal of the proposed cruises BASS-2024, as part of the BASS research unit (FOR 5267), is to explore the importance of the SML as a biogeochemical and photochemical reactor and how its reactivity affects ocean-atmosphere interactions. We have a solid understanding that the SML is carbon rich and a biofilm-like environment, but our knowledge of its reactivity in relation to carbon cycling is limited. In addition, the dynamic interaction of the SML with both the atmosphere and the ocean is largely unknown and does not currently allow us to assess the extent to which the SML affects biogeochemical cycling in the upper ocean and chemical-physical processes in the lower atmosphere. These knowledge gaps exist because quantifying processes on the required small spatial scales and integrating an interdisciplinary approach is difficult to achieve. Within the BASS research group, the appropriate framework has been established for this purpose, and the proposed cruises BASS-2024 brings together interdisciplinary expertise, advanced technologies for observations at millimeter scales or below, and core infrastructures of advanced analytical facilities at the molecular and cellular levels.

**Others:**
- **BIOCAT** – April to May 2024, R/V Sonne in Bay of Bengal
- Yuanxu Dong received the Humboldt postdoctoral fellowship with Christa Marandino and Bernd Jähne to investigate lab vs field observations of bubble effects from 1 March 2025-28 February 2026
- **ICEBERG** – EU proposal to study pollution in the Arctic from 1 January 2024 to 31 December 2026; will focus on pollution effects on biogeochemical cycling
- Cloud water and aerosol sampling for virus investigations around Puy de Dôme, France with Pierre Amato, Sept. 2024

### 2025

**What:** FreshOcean project (DFG funded)

**When:** June-July 2025

**Where:** Central Atlantic

**What:** International field study on skin layer (microlayer) and meteorology. Autonomous vehicles, shipboard instruments, ARGO floats, research drones, satellite obs.

**Abstract:** Alterations to the global water cycle due to climate change have intensified droughts and floods. This has a significant societal impact, especially in areas affected by water scarcity. On the global scale, 85% of evaporation (E) and 77% of precipitation (P) occurs over oceans, clearly demonstrating that the oceanic water cycle is a key element of the global water cycle. However, observational challenges of the freshwater flux (i.e., evaporation rates minus precipitation rates, or E-P) limit the current understanding of the oceanic water cycle. We propose using the skin salinity as a tracer to mechanistically understand freshwater fluxes in the central Atlantic dominated by evaporation. Despite its thickness of less than 1 mm, the skin layer is known to control air-sea exchange of gases and heat, but its detailed role in governing the freshwater flux remains unknown. We hypothesize that skin salinity is a suitable tracer for freshwater fluxes because evaporation increases skin salinity through water loss and precipitation decreases skin salinity.
through freshwater input, resulting in an instant response. Other atmospheric and oceanic forces will be investigated, such as advection and vertical mixing. We will use state-of-the-art technology (autonomous catamaran, drifters) to measure temperature and salinity in the skin layer and underlying near-surface layer. Meteorological measurements (including evaporation and precipitation) are carried out from the research vessel and by means of ascents from weather balloons and drones.

<table>
<thead>
<tr>
<th>2. Events like conferences, workshops, meetings, summer schools, capacity building etc. (incl. all information possible).</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGU24: 14th-29th April, Vienna, Austria</td>
</tr>
<tr>
<td>OASIS Face-to-face meeting before OSM in New Orleans, USA (17-18 Feb 2024)</td>
</tr>
<tr>
<td>International Virus Bioinformatics Meeting (ViBioM) 2024, 28-30th May 2024, Leuven, Belgium</td>
</tr>
<tr>
<td>VAAM2024: Annual Meeting of the Association for General and Applied Microbiology (VAAM), 2-5th June 2024, Würzburg, Germany</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Funded national and international projects/activities underway.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• BASS</td>
</tr>
<tr>
<td>• ICEBERG</td>
</tr>
<tr>
<td>• ORIGAMY</td>
</tr>
<tr>
<td>• Biocat</td>
</tr>
<tr>
<td>• FORMAS Mobility grant (Leonie Esters)</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>4. Plans / ideas for future national or international projects, programmes, proposals, etc. (please indicate the funding agencies and potential submission dates).</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUTURO: year long upwelling field campaign led by GEOMAR – should be an international effort</td>
</tr>
<tr>
<td>Second phase of BASS in planning stage</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Engagements with other international projects, organisations, programmes, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint SOLAS-OASIS side event at the UN Ocean Conference in Barcelona (April 2024)</td>
</tr>
</tbody>
</table>

**Comments**