National and Regional Reports by Country 2023

Belgium
Brazil
Canada
Chile
China
China-Taipei
Denmark
Finland
France
Germany
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Norway
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Portugal
South Africa
Spain
Sweden
United Arab Emirates
Southeast Asia Regional Panel
Report for the year 2023 and future activities

SOLAS ‘Belgium’
compiled by: ‘Gypens Nathalie’

This report has two parts:

- **Part 1**: reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

- **Core Theme 1**: Greenhouse gases and the oceans;
- **Core Theme 2**: Air-sea interfaces and fluxes of mass and energy;
- **Core Theme 3**: Atmospheric deposition and ocean biogeochemistry;
- **Core Theme 4**: Interconnections between aerosols, clouds, and marine ecosystems;
- **Core Theme 5**: Ocean biogeochemical control on atmospheric chemistry;
- **Cross-Cutting Theme**: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
- **Cross-Cutting Theme**: Climate intervention;
- **Cross-Cutting Theme**: Science and society.

**IMPORTANT**: This report should reflect the efforts of the SOLAS community in the entire country or region 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 Feb/Mar 2024

1. Scientific highlight

1.1. Declaration on Operationalising the Surface Ocean Carbon Value Chain

Flanders Marine Institute (VLIZ) has been instrumental in the writing of the 2023 Oostende declaration on Operationalising the Surface Ocean Carbon Value Chain (https://www.ioccp.org/index.php/more/962-declaration-on-operationalising-the-surface-ocean-carbon-value-chain)

“We, the 100+ ocean experts and stakeholders specialising in surface ocean carbon measurements and quantification of ocean carbon uptake, representing Europe, Australia, Asia, North America, South America and Africa, assembled at the Flanders Marine Institute (VLIZ) in Oostende, Belgium and online (6-9 November 2023) to assess the status of the multi-component community effort capable of measuring, storing, synthesising and mapping of the surface ocean carbon information, call for concerted international and intergovernmental efforts to create a robust, resilient and sustainable surface ocean carbon observing system. We envisage and expect that such a system, the so-called surface ocean carbon value chain, will meet the ever-increasing demands for ocean carbon data and information needed to inform national and intergovernmental policies on climate change and mitigation efforts, with the Paris Agreement being the most pressing commitment”

1.2. A novel sea surface pCO$_2$-product for the global coastal ocean resolving trends over 1982–2020

In recent years, advancements in machine learning based interpolation methods have enabled the production of high-resolution maps of sea surface partial pressure of CO$_2$ (pCO$_2$) derived from observations extracted from databases such as the Surface Ocean CO$_2$ Atlas (SOCAT). These pCO$_2$-products now allow quantifying the oceanic air–sea CO$_2$ exchange based on observations. However, most of them do not yet explicitly include the coastal ocean. Instead, they simply extend the open ocean values onto the nearshore shallow waters, or their spatial resolution is simply so coarse that they do not accurately capture the highly heterogeneous spatiotemporal pCO$_2$ dynamics of coastal zones. Until today, only one global pCO$_2$-product has been specifically designed for the coastal ocean (https://doi: 10.5194/bg-14-4545-2017; Laruelle et al., 2017). This product, however, has shortcomings because it only provides a climatology covering a relatively short period (1998–2015), thus hindering its application to the evaluation of the interannual variability, decadal changes and the long-term trends of the coastal air–sea CO$_2$ exchange, a temporal evolution that is still poorly understood and highly debated. Here we aim at closing this knowledge gap and update the coastal product of Laruelle et al. (2017) to investigate the longest global monthly time series available for the coastal ocean from 1982 to 2020. The method remains based on a two-step Self-Organizing Maps and Feed-Forward Network method adapted for coastal regions, but we include additional environmental predictors and use a larger pool of training and validation data with ~18 million direct observations extracted from the latest release of the SOCAT database. Our study reveals that the coastal ocean has been acting as an atmospheric CO$_2$ sink of −0.40 Pg C yr$^{-1}$ (~−0.18 Pg C yr$^{-1}$ with a narrower coastal domain) on average since 1982, and the intensity of this sink has increased at a rate of 0.06 Pg C yr$^{-1}$ decade$^{-1}$ (0.02 Pg C yr$^{-1}$ decade$^{-1}$ with a narrower coastal domain) over time. Our results also show that the temporal changes in the air–sea pCO$_2$ gradient plays a significant role in the long-term evolution of the coastal CO$_2$ sink, along with wind speed and sea-ice coverage changes that can also play an important role in some regions, particularly at high latitudes. This new reconstructed coastal pCO$_2$-product (https://doi.org/10.25921/4sde-p068; Roobaert et al., 2023) allows us to establish regional carbon budgets requiring high-resolution coastal flux estimates and provides new constraints for closing the global carbon cycle.
1.3. A Synthesis of Global Coastal Ocean Greenhouse Gas Fluxes

The coastal ocean contributes to regulating atmospheric greenhouse gas concentrations by taking up carbon dioxide (CO₂) and releasing nitrous oxide (N₂O) and methane (CH₄). In this second phase of the Regional Carbon Cycle Assessment and Processes (RECCAP2), we quantify global coastal ocean fluxes of CO₂, N₂O and CH₄ using an ensemble of global gap-filled observation-based products and ocean biogeochemical models. The global coastal ocean is a net sink of CO₂ in both observational products and models, but the magnitude of the median net global coastal uptake is ~60% larger in models (−0.72 vs. −0.44 PgC year⁻¹, 1998–2018, coastal ocean extending to 300 km offshore or 1,000 m isobath with area of 77 million km²). We attribute most of this model-product difference to the seasonality in sea surface CO₂ partial pressure at mid- and high-latitudes, where models simulate stronger winter CO₂ uptake. The coastal ocean CO₂ sink has increased in the past decades but the available time-resolving observation-based products and models show large discrepancies in the magnitude of this increase. The global coastal ocean is a major source of N₂O (+0.70 PgCO₂-e year⁻¹ in observational product and +0.54 PgCO₂-e year⁻¹ in model median) and CH₄ (+0.21 PgCO₂-e year⁻¹ in observational product), which offsets a substantial proportion of the coastal CO₂ uptake in the net radiative balance (30%–60% in CO₂-equivalents), highlighting the importance of considering the three greenhouse gases when examining the influence of the coastal ocean on climate.
Figure 2: Net globally-integrated coastal fluxes of (a) $\text{CO}_2$ [Pg C year$^{-1}$], (b) $\text{N}_2\text{O}$ [Tg N year$^{-1}$] and (c) $\text{CH}_4$ [Tg CH4 year$^{-1}$] over the wide and narrow coastal oceans. Figure shows individual products and models (symbols) and their median and interquartile ranges. Models are shown for the full ensemble available (11 models for $\text{CO}_2$ and 4 for $\text{N}_2\text{O}$) and a subset of higher resolution models (4 models for $\text{CO}_2$ and 2 for $\text{N}_2\text{O}$, see Methods and Table 2 for details). Previous estimates available for the narrow coastal ocean are shown on the right of panel a (see list in Table S2 in Supporting Information S1). Coastal-SOM-FFN-kw, which is a second version of Coastal-SOM-FFN computed using different wind speed and kw formulation (filled diamond, see Methods), is not used in the calculation of the $p\text{CO}_2$ product median. Weber-$\text{CH}_4$ total flux (diffusive + ebullitive) and diffusive contribution (comparable to MARCATS-$\text{CH}_4$ flux) are shown in panel (c).


1.4. Unravelling the physical and biological controls of the global coastal $\text{CO}_2$ sink

The drivers governing the air-sea $\text{CO}_2$ exchange and its variability in the coastal ocean are poorly understood. Using a global ocean biogeochemical model, this study quantifies the influences of thermal changes, oceanic transport, freshwater fluxes, and biological activity on the spatial and seasonal variability of $\text{CO}_2$ sources/sinks in the global coastal ocean. We identify five typical coastal behaviors (dominated by biological drawdown, vertical transport, land imprint, intracoastal alongshore currents, and weak $\text{CO}_2$ sources and sinks coastal regions) and propose a new processed-based delineation of the coastal ocean based on the quantification of these controlling processes. We find that the spatiotemporal variability of $\text{CO}_2$ sources/sinks is dominated by strong exchanges with the open ocean and intracoastal processes, while continental influences are restricted to hotspot regions. In addition, where thermal changes appear to drive the seasonal $\text{CO}_2$ variability, it often results from compensating effects between individual non-thermal terms, especially biological drawdown and vertical transport.
Figure 3: Processes controlling the annual average coastal ocean CO₂ response in the mixed layer depth (CResponse, which includes all pCO₂ changes whether they are equilibrated by the air-sea CO₂ flux or not) in (a) the global coastal ocean and (b-f) in the five coastal systems identified in this study. Specifically, in (b) regions under imprint of land, (c) strong CO₂ sources dominated by the vertical biophysical dynamics, (d) strong CO₂ sinks dominated by the vertical biophysical dynamics, (e) strong CO₂ sinks dominated by the freshwater and lateral transport and (f) weak coastal CO₂ sources and sinks. Colors indicate the relative contributions from vertical biophysical dynamics (vert. biophysical dyn., in blue, balance between biological activity and vertical transport of chemical species), and the freshwater and lateral transport (FW and lateral trans., in purple, sum of dilution/concentration effects and lateral transport of chemical species). The thermal effect is not represented since its contribution to the annual average is near-zero. Results on all panels are averaged at 1° spatial resolutions for visibility. Black circles show the 20 largest annual average river runoffs.

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).

- Workshop on surface ocean pCO₂ observations, synthesis and data products – 6-9 November 2023, Oostende, Belgium, hosted by the Flanders Marine Institute (VLIZ) under the umbrella of ICOS https://www.icos-otc.org/node/222
- Tango1 survey on the West Antarctic Peninsula onboard the Sailboat Australis, in the frame of the project TANGO funded by BELSPO and led by Bruno Danis

![Image: TANGO1 survey on the West Antarctic Peninsula onboard the Sailboat Australis](image.png)

**Figure 4:** Tango1 survey on the West Antarctic Peninsula onboard the Sailboat Australis

We have just released the TANGO1 expedition report. The report will give you an overview of the activities of the TANGO1 team in the West Antarctic Peninsula, onboard RV Australis.

The TANGO1 expedition ventured to accumulate new data on the responses of marine ecosystems to shifts in ice regimes in the West Antarctic Peninsula (WAP), taking full advantage of a nimble sampling platform, the R/V Australis, a steel hulled, fully rigged motor sailor. TANGO1 took place between February and March 2023, sampling two main locations at different spatial scales. Deploying 14 different types of gear (both traditional and modern), the TANGO1 team gathered over 4000 samples that will be brought back to Belgium for further analysis. The team focused on synchronized, transdisciplinary sampling to understand the linkages between realms (atmosphere, sea-ice, water column, seafloor) and there potential responses to changes in climate-changed linked ice regime at various spatial scales.

The use of R/V Australis for coastal studies deemed to be extremely efficient, in terms of environmental impact (ca. 40 times less CO₂ emissions than a Polar class icebreaker) and reactivity, allowing the team to adapt the sampling efforts in function of the weather or anchoring conditions. Fully devoted to the expedition, the ship allowed the B121 team to sample in shallow areas, not accessible to icebreaker and too far away from research stations, and which have been under sampled.
During that cruise, we collected samples for CH₄ and N₂O in surface waters and observed an obvious supply of CH₄ from subglacial discharge in surface waters that will be presented at the next EGU conference by Axelle Brusselman [https://meetingorganizer.copernicus.org/EGU24/EGU24-18144.html](https://meetingorganizer.copernicus.org/EGU24/EGU24-18144.html).

- Greenfeedback cruise on the RV Belgica (RV BELGICA CRUISE 2023/14b)

Greenfeedback European funded Research and Innovation Action ([https://eu-greenfeedback.com/](https://eu-greenfeedback.com/)) is aiming, among other objectives, to enhance understanding of air-sea exchange of GHGs in ocean and coastal areas affected by sea ice and glacier runoff, riverine inputs and biogeochemical surface processes. The objective will be addressed by: (1) improving parameterizations of air-sea and air-ice gas exchange to provide a robust quantification of the Arctic Ocean (AO) CO₂ sink, and potential source and sinks of CH₄ and N₂O, (2) understanding C cycling in coastal-shelf areas and improve the description of exchange processes from coastal and shelf areas to the open ocean in Earth System Models, (3) evaluate the feedbacks of the AO CO₂ sink to ongoing climate change and assess the future Arctic CO₂ sink.
For that particular cruise, one of the first Arctic survey of the new Belgian Oceanographic vessel RV Belgica, we focused on greenhouse gases (GHGs) sampling along Tunulliarfik Fjord in Southwest Greenland (Figure 7). To do so, a hydrographic transect from the fjord's head to the adjacent continental shelf was performed. Along this transect, we used underway GHGs systems that was connected to the vessel's non-toxic seawater supply for underway (UW) measurements. We also performed vertical CTD casts at selected locations (see red markers in Figure 1 and exact locations in Table 1) combined with water sampling through Niskin bottles for DIC, TA, pH, CH4, and N2O analysis. In addition, the velocity field was monitored through both vessel-mounted shallow- (600 kHz) and deep-water (75 kHz) ADCPs that were runned constantly and simultaneously. Altogether, this will allow us to characterize GHG-related processes, as well as the water mass distribution and circulation within the fjord and respective connections with the continental shelf.

Preliminary results will be presented at the next EGU conference by Coraline Lesseure
https://doi.org/10.5194/egusphere-egu24-7427
Figure 7: Region of study with vessel’s transect along Tunulliarfik Fjord (green line) and CTD stations (red markers).

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


Nomura D., Y. Kawaguchi, A.L. Webb, Y. Li, M. Dall’osto, K. Schmidt, E.S. Droste, E.J. Chamberlain,


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?

Flanders Marine Institute (VLIZ) has been instrumental in the writing of the 2023 Oostende declaration on Operationalising the Surface Ocean Carbon Value Chain (https://www.ioccp.org/index.php/more/962-declaration-on-operationalising-the-surface-ocean-carbon-value-chain)
### PART 2 - Planned activities for 2024 and 2025

<table>
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<tr>
<th>1. Planned major national and international field studies and collaborative laboratory and modelling studies (incl. all information possible, dates, locations, teams, work, etc.).</th>
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<tbody>
<tr>
<td>- February- March 2024 – Second TANGO survey in the West Antarctica Peninsula. <a href="https://belgica120.be/">https://belgica120.be/</a></td>
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<tr>
<td>- March 2024 - Workshop with stakeholder on the impact on human activities on marine arctic systems in the frame of Greenfeedback EU-funded research and innovation action <a href="https://eu-greenfeedback.com/">https://eu-greenfeedback.com/</a></td>
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<th>2. Events like conferences, workshops, meetings, summer schools, capacity building etc. (incl. all information possible).</th>
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<tr>
<td>- BEPSII Field School co-ordinated by Daiki Nomura, Bruno Delille, Odile Crabeck et al... in Saroma-Ko in February 2026</td>
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<th>3. Funded national and international projects/activities underway.</th>
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<tr>
<td>- Estimating Tipping points in habitability of ANtarctic benthic ecosystems under GIObal future climate change scenarios (TANGO, Brain, 2021-2025) funded by the Belgian Science Policy</td>
</tr>
<tr>
<td>- Greenhouse gas fluxes and Earth system feedbacks (Greenfeedback, 2022-2026, HORIZON-CL5-2021-D1-01, Project: 101056921 — GreenFeedBack) EU funded Horizon Research and Innovation Action</td>
</tr>
<tr>
<td>- Sea Ice to sea Spray aerosol (SIP, 2023-2024) Research Project funded by the F.R.S.-FNRS, coordinator</td>
</tr>
<tr>
<td>- Arctic ocEan Greenhouse gases blogeochemiStry (AEGIS, CDR, J.0057.24, 2024-2025) Research Credit funded by the F.R.S.-FNRS</td>
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<th>4. Plans / ideas for future national or international projects, programmes, proposals, etc. (please indicate the funding agencies and potential submission dates).</th>
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<th>5. Engagements with other international projects, organisations, programmes, etc.</th>
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Comments
Report for the year 2023 and future activities

SOLAS Brazil
compiled by: Raquel Renó de Oliveira

This report has two parts:

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

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- **Cross-Cutting Theme**: Climate intervention;
- **Cross-Cutting Theme**: Science and society.

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

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

This is only the second report I have produced as a national representative, so I may need to be patient, but I have the impression that the reports are biased towards greenhouse gases, mass and heat fluxes between the ocean and the atmosphere themes. Therefore, it may be interesting to discuss the need to have another national representative in Brazil to ensure a more representative vision for topics involving aerosols, atmospheric deposition or atmospheric chemistry.
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).

**Multiple controls on carbon dioxide sequestration in the Beagle channel (Southern Patagonia) in early fall**

Subpolar coastal waters are key hotspots in the global carbon cycle. However, the small-scale distribution of partial pressure of carbon dioxide (pCO$_2$) in these environments and the physical and biological controls underlying this variability are still poorly understood. Here, we examine simultaneous high-resolution spatial measurements of wind speed and pCO$_2$, temperature, salinity, and in-vivo chlorophyll-a fluorescence (chl-a fluo, a proxy of phytoplankton biomass) in surface waters that were obtained during an oceanographic survey in the Argentinian Beagle Channel (subantarctic Atlantic Patagonian) in early fall 2017. The 240 km study transect (centered at 55°S – 67°W) was divided into two zones: (A1) The Beagle Channel innermost portion, semi-enclosed and subject to strong continental influence and (A2) its eastern outlet towards the open Southwest Atlantic. Discrete seawater samples were also collected for apparent oxygen utilization (AOU), nutrients and pH measurements. High-resolution spatial measurements revealed the persistence of pCO$_2$ below atmospheric equilibrium, increasing in median (interquartile range 25–75%) from 314 μatm in the inner Beagle Channel (A1) to 348 μatm towards the adjacent open sea (A2). A decrease in atmospheric CO$_2$ sequestration was associated with an increase in water temperature from 9.5 °C to 10.7 °C, salinity from 30.8 to 32.5, and chl-a fluo from 2.24 to 2.91 mg m$^{-3}$ along the coastal-offshore gradient. Low AOU and nutrient levels were found in regions inside the channel. Indeed, the relationships between CO$_2$ and temperature or salinity were significantly different from those expected from the theoretical solubility effect, indicating a dominance of metabolic over physicochemical controls on this gas. Moreover, physical factors such as vertical stratification contributed to the variable surface pCO$_2$ values. These findings reveal the existence of short-scale spatial variability of CO$_2$ in the Beagle Channel, improving our understanding of the multiple controls on atmospheric carbon sequestration in extensive subpolar continental shelves.
Figure: Spatial distribution of (A) temperature (°C), (B) salinity, (C) chl-a fluo (mg m⁻³), and (D) pCO₂ (μatm) in surface waters from the inner part of the Beagle Channel to the adjacent coastal sea, in fall 2017. The A1 and A2 zones are delimited by the meridian along 66°50’ W. Images were created in Ocean Data View software (Schlitzer, 2021).


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).

Projects underway:

- C-SCOPE 2.0 - Towards Marine Carbon Observations 2.0: Socializing, COnnecting, Perfecting and Expanding

- Impacts of extratropical cyclones on wind and precipitation extremes in southeastern South America: current climate and future projections using regional climate models (CORDEX) and high-resolution global climate models (HighResMIP) - CNPq/FAPESP.


- ATMOS 2.0: The study of the Antarctic Climate, the Southern Ocean and their
relations with the Brazilian and South American environment.
- ReNOMO - National Ocean Observation and Monitoring Network.
- SOAC-MULTIESCALE: Multiscale study of the coupled ocean-atmosphere-cryosphere system.
- COAWSTMaranhão - Development of a coupled ocean-atmosphere-wave modeling system to analyze the impacts of climate change and areas vulnerable to flooding and sea storms in the Itaqui Port Complex – in partnership with Empresa Maranhense de Administração Portuária – Emap.
- Cryosphere-atmosphere interaction between Antarctic sea ice and the South Atlantic Subtropical High.
- CALMAR - Climate change in the Amazonia Azul: impacts of MARINE HEAT waves and acidification.
- PRO-SAMBA - Oceanographic Processes and Mesoscale Structures in Climate Hotspots: Synergies and Advances in Physical and Biogeochemical Monitoring around the Antarctic Peninsula.
- Rio de Janeiro Sea Sentinel: independent monitoring of ocean-atmosphere CO2 fluxes in the southeast of the Brazilian Amazonia Azul – SENTINELA.
- PROVOCCAR - Ocean ventilation processes and the carbon cycle in the north of the Antarctic peninsula.
- PIRATA - Prediction and Moored Array in the Tropical Atlantic.
- SiMCosta - Brazilian Coastal Monitoring System.

Field campaigns:
- OPERANTAR XLII - 2023/2024, Antártica.
- C-SCOPE – Santos port, São Paulo.
- SiMCosta - Tide gauge in São José de Ribamar, Maranhão.
- PROTRINDADE – Cadeia Vitória-Trindade, Trindade Island.

International Collaboration with:
- Kevin Hodges (University of Reading).
- Ted Shepherd (University of Reading).
- Arne Körtzinger (GEOMAR)
- Tobias Steinhoff (GEOMAR)
- Denis Pierrot (NOAA)
- Ernesto Caetano Neto (Universidade Nacional Autônoma do México)

Collaboartion with companies:
- Empresa Maranhense de Administração Portuária – EMAP.
- Aliança, an Maersk company.
Scientific events:
- EPGMET - Meeting of postgraduate students in meteorology at INPE.
- OMARSAT - Symposium on waves, tides, ocean engineering and satellite oceanography.
- 11th Workshop on the Theory and Use of Regional Climate Models
- International Conference on Regional Climate (ICRC-CORDEX 2023).
- Sensitivity of an unusual cyclone in southeast South America to convective parameterization schemes in the new ICTP RCM (RegCM5).
- SOLAS Summer School 2023.
- Workshops on surface ocean pCO2 observations, synthesis and data products.
- III Simpósio do Programa de Pós-Graduação em Oceanografia da UERJ.

Media:
- Carbon Team News, www.carbonteam.furg.br
- @inpe_oceanography
- https://blog.ufes.br/iurygoncalves/author/iury-goncalves/

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.
the summer's warmest SST's impact on South American climate. International Journal of Climatology, 43(12), 5604-5619.

https://doi.org/10.1002/joc.8163


https://doi.org/10.1590/0001-3765202320220591


https://doi.org/10.1590/2675-2824072.22057

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?
   - Empresa Maranhense de Administração Portuária – EMAP.
   - Aliança, an Maersk company.

PART 2 - Planned activities for 2024 and 2025

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

   - OPERANTAR XLII - 2023/2024, Antártica.
   - OPERANTAR XLII - 2024/2025, Antártica.
   - C-SCOPE – Santos port, São Paulo.
   - SiMCosta - Tide gauge in São José de Ribamar, Maranhão.

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

   - Western Boudary Currents Workshop, 2024.
   - 11th International Carbon Dioxide Conference.
   - SOLAS Open Science Conference 2024.
   - 1° Workshop on Oceanography and Polar Climate, 2024.
3. Funded national and international projects/activities underway.
- CALMAR - Climate change in the Amazonia Azul: impacts of marine heat waves and acidification.
- C-SCOPE 2.0 - Towards Marine Carbon Observations 2.0: Socializing, COnnecting, Perfecting and Expanding
- PROVOCCAR - Ocean ventilation processes and the carbon cycle in the north of the Antarctic peninsula.
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4. Plans / ideas for future national or international projects, programmes, proposals, etc. (please indicate the funding agencies and potential submission dates).

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

Comments
Report for the year 2023 and future activities

SOLAS Canada
compiled by: Rachel Chang

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

The Canadian community thanks the members of the SOLAS IPO for their continued efforts in serving the SSC and the SOLAS community at large as well as in communicating SOLAS-related research.

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**PART 1 - Activities from January 2023 to Feb/Mar 2024**

1. **Scientific highlight**

Distinguishing Physical and Biological Controls on the Carbon Dynamics in a High-Arctic Outlet Strait
The water mass assembly of Nares Strait is variable, owing to fluctuating wind forcings over the central Arctic Basin, and irregular northward flows from the West Greenland Current (WGC) in Baffin Bay. Here we characterize the physico-chemical properties of the water masses entering Nares Strait in August 2014. We employ an extended optimum multi-parameter (OMP) analysis to estimate the mixing fractions of predefined source water masses, and to distinguish the role of physical and biological processes in governing the distribution of dissolved inorganic carbon (DIC) in Nares Strait. We show the first documented evidence of Siberian shelf waters arriving in Nares Strait, along with a diluted upper halocline layer of partial Pacific-origin. These mixed-origin water masses appear to play an important role in driving a modest phytoplankton bloom in Kane Basin, leading to decreased surface $p$CO$_2$ concentrations in Nares Strait. Although inorganic nitrogen was already limited near the surface in northern Nares Strait, the rather shallow upper halocline layer and the shoaling bathymetry in Kane Basin facilitated upwelling of nutrients to the surface. Our observations suggest that the positioning of the Transpolar Drift, and hence the balance of Atlantic and Pacific water delivered to Nares Strait, may play an important role in regional biological productivity and carbon uptake from the atmosphere. We also observed water masses from the WGC transported as far north as Kane Basin, contributing to relatively high $p$CO$_2$ and low pH in the intermediate and deep water column of southern Nares Strait and northern Baffin Bay.

Caption: Calculated source water mass fractions along the Nares Strait transect (transect location shown in bottom left map). Freshwater sources are sea-ice melt (SIM) and river runoff (RR), note the depth scale is reduced to the upper 60 m for freshwater panels. Source water masses are: Baffin Bay Polar water (BBPW), Subpolar Mode water (SPMW), Polar Mode water (PMW), Upper Halocline water (UHW), and Canada Basin Atlantic water (CBAW). Note the different color scales on all panels. Figure was created using Ocean Data View software (Schlitzer, 2020) with bathymetry contours from IBCAO version 3 (Jakobsson et al., 2012).
Arctic warming by abundant fine sea salt aerosol from blowing snow

The Arctic warms nearly four times faster than the global average, and aerosols play an increasingly important role in Arctic climate change. In the Arctic, sea salt is a major aerosol component in terms of mass concentration during winter and spring. However, the mechanisms of sea salt aerosol production remain unclear. Sea salt aerosols are typically thought to be relatively large in size but low in number concentration, implying that their influence on cloud condensation nuclei population and cloud properties is generally minor. Here we present observational evidence of abundant sea salt aerosol production from blowing snow in the central Arctic. Blowing snow was observed more than 20% of the time from November to April. The sublimation of blowing snow generates high concentrations of fine-mode sea salt aerosol (diameter below 300 nm), enhancing cloud condensation nuclei concentrations up to tenfold above background levels. Using a global chemical transport model, we estimate that from November to April north of 70° N, sea salt aerosol produced from blowing snow accounts for about 27.6% of the total particle number, and the sea salt aerosol increases the longwave emissivity of clouds, leading to a calculated surface warming of +2.30 W m⁻² under cloudy sky conditions.

Iodine emission from the reactive uptake of ozone to simulated seawater

The heterogeneous reaction of ozone and iodide is both an important source of atmospheric iodine and dry deposition pathway of ozone in marine environments. While the iodine generated from this reaction is primarily in the form of HOI and I₂, there is also evidence of volatile organoiodide compound emissions in the presence of organics without biological activity occurring. In this study, we evaluate our fundamental understanding of the ozonolysis of iodide which leads to gas-phase iodine emissions. To do this, we compare experimental measurements of ozone-driven gas-phase I₂ formation in a flow tube to predictions made with the kinetic multilayer model for surface and bulk chemistry (KM-SUB). The KM-SUB model uses literature rate coefficients used in current atmospheric chemistry models to predict I₂ formation in pH-buffered solutions of marine
composition containing chloride, bromide, and iodide compared to solutions containing only iodide. Experimentally, \( I_2(g) \) formation was found to be suppressed in solutions containing seawater levels of chloride compared to solutions containing only iodide, but the model does not predict this effect using literature rate constants. However, the model is able to predict this trend upon adjustment of two specific reaction rate constants. To more closely represent true oceanic conditions, we add an organic component to the proxy seawater solutions using material generated from Thalassiosira pseudonana phytoplankton cultures. Whereas the rate of ozone deposition is unaffected, the formation rate of \( I_2(g) \) is strongly suppressed in the presence of biological organic material, indicative of a sink or reduction of reactive iodine formed during the oxidation process.


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).

- Co-chair BEPSII meeting in La Jolla California: updates on sea-ice bgc work, discussions on polar components of the SOLAS science plan, SOLAS seminar organization as part of the BEPSII meeting
- Co-chair CiCe2Clouds meeting in Grenoble, active work on the development of 3 synthesis papers and one tutorial paper, discussion on missing ice-ocean-atmosphere processes in
ESMs
- Model evaluations of the Canadian carbon sink (Laenger et al., in prep.)
- Model evaluations of the evolution of sea-ice algae in a future climate, including a set of diagnostics (Haddon et al. 2024, accepted)
- Model evaluations of the evolution of DMS emissions in a future climate, including a set of diagnostics (Haddon et al., in prep)
- Contributions to the H2020 CRICES project – sea-ice gas exchange workshop, model advancements
- Ice Algae Model Intercomparison Project (IAMIP2) – regular meetings and discussions, publication in preparation
- Evaluation of CMIP6 models for climate-related stressors on ecosystems, including acidification an, sea ice, oxygen (Steiner et al, submitted)
- Fog and turbulence interactions in the marine atmosphere (FATIMA) research cruise in the Yellow Sea
- Observations to estimate marine sector greenhouse gas emissions (with a focus on N2O) in Halifax harbour (a port city) from anthropogenic sources as well as harbour waters impacted by human activity and climate change
- Characterizing changes in oceanwater properties during a multi-year ocean alkalinity experiment in Halifax harbour

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

[https://doi.org/10.1029/2022JC019393](https://doi.org/10.1029/2022JC019393)

[https://doi.org/10.1029/2023JD039159](https://doi.org/10.1029/2023JD039159)

[https://doi.org/10.1038/s41561-023-01254-8](https://doi.org/10.1038/s41561-023-01254-8)


[https://doi.org/10.1029/2023GL107777](https://doi.org/10.1029/2023GL107777)

[https://doi.org/10.1039/d2em00111j](https://doi.org/10.1039/d2em00111j)


Li Zhao, Xie Tao, W. Perrie, J.S. Yang (2023) *Deep-Learning-Based Sea Ice Classification With Sentinel-1 and AMSR-2 Data*, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (JSTARS)* DOI: 10.1109/JSTARS.2023.3285857

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?

Contribution to Arctic Monitoring and Assessment Program – climate change updates: ocean acidification section

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**PART 2 - Planned activities for 2024 and 2025**

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

   Continuation of the Ice Algae Model Intercomparison (IAMIP2)

2. Events like conferences, workshops, meetings, summer schools, capacity building etc. (incl. all information possible).
   - BEPSII meeting – online development of new science plan
   - Cice2Clouds meeting November 2024, Goa (in connection with SOLAS OSC) – progress on synthesis papers and campaign planning
   - IPY planning meeting, November 2024 France – development of white paper on SOLAS science in the polar regions in preparation for IPY2032

3. Funded national and international projects/activities underway.

   Contribution to CRICES Climate Relevant interactions and feedbacks: the key role of sea ice and Snow in the polar and global climate system through NSERC-NFRF (Else, Miller, Steiner)

   Transforming Climate Action – a collaborative project between Université Laval, Université de Québec à Rimouski, Dalhousie University, and Memorial University studying carbon transfer between the atmosphere, terrestrial, ocean, sea-ice, and sediment systems

4. Plans / ideas for future national or international projects, programmes, proposals, etc. (please indicate the funding agencies and potential submission dates).
Potential contributions to NorgeForce - through NSERC-NSRF

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

<table>
<thead>
<tr>
<th>Project</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEPSII (Biogeochemical Exchange Processes at Sea-Ice Interfaces)</td>
<td>SC members</td>
</tr>
<tr>
<td>Clce2Clouds (SCOR WG)</td>
<td>co-chair &amp; associate members</td>
</tr>
</tbody>
</table>

### Comments
Report for the year 2023 and future activities

SOLAS Chile
compiled by: Alexander Galán

This report has two parts:

- Part 1: reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

  Core Theme 1: Greenhouse gases and the oceans;
  Core Theme 2: Air-sea interfaces and fluxes of mass and energy;
  Core Theme 3: Atmospheric deposition and ocean biogeochemistry;
  Core Theme 4: Interconnections between aerosols, clouds, and marine ecosystems;
  Core Theme 5: Ocean biogeochemical control on atmospheric chemistry;
  Cross-Cutting Theme: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
  Cross-Cutting Theme: Climate intervention;
  Cross-Cutting Theme: Science and society.

IMPORTANT: This report should reflect the efforts of the SOLAS community in the entire country or region 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. ?

The IPO could support us to consolidate the Latin American network on Marine Biogeochemistry (see details below), created to generate a space for regional collaboration under common scientific interests that contribute to reduce spatial and temporal knowledge gaps, to achieve a better understanding of biogeochemical variability, the processes that control the greenhouse gases cycling, and the system's response to environmental stressors on a regional scale.

PART 1 - Activities from January 2023 to Feb/Mar 2024

1. Scientific highlight

GHG Cycling in coastal upwelling systems: uncertainties and implications in a warming world
This work provides a synthesis of the current knowledge on the surface ocean-lower atmosphere biogeochemistry and its role on GHG cycling in major coastal upwelling systems and its uncertainties and implications under a warmer climate. This synthesis is a contribution to the study of GHG in upwelling systems, a core theme in a key environment of the Science Plan and Organization of the Surface Ocean-Lower Atmosphere Study (SOLAS) project 2015-2025. The main results of this review is that (although with variations within and among upwelling systems), in general, low-latitude systems act as a net source of carbon to the atmosphere, while those at higher latitudes are weak sinks or remain neutral with respect to atmospheric CO₂. These systems also contribute significantly to oceanic emissions of N₂O and CH₄, although the magnitudes remain uncertain. Despite coastal warming is projected for all major coastal upwelling systems in the near future, the implications for the GHG cycling due to wind-modulating upwelling intensification and its implications in the context of global oxygen loss (see negative values in the Figure) and increased stratification are uncertain.

![Projected future O₂ changes in the thermocline](image)

Projected future O₂ changes in the thermocline. Effect of climate change on oxygen concentration (in µmol kg⁻¹) in the depth range of 200–600 m in the CESM (community Earth system model) Large Ensemble (Kay et al., 2015) using 34 members: difference in mean conditions between the present (1950–2005, “historical” scenario) and the future (2050–2100, RCP8.5 scenario) for dissolved oxygen (positive values indicate an increase of O₂ in the future). The blue and red contour lines show the isolines of 20 µmol kg⁻¹ for the present and future climates, respectively. The orange dots (stippling) correspond to the locations where the change in oxygen concentration is not significant at the 99% level according to a Wilcoxon rank sum test.

There are still important uncertainties regarding the ongoing and future impacts of climate change on the upwelling systems, mainly because their highly spatiotemporal variability, due to the occurrence, on different timescales, of local and remote atmospheric and oceanic drivers. Furthermore, both the scientific interest (e.g., monitoring, functioning, structure) and the quality of the data (amount and resolution) are neither the same nor comparable. For instance, different datasets suggest different trends, both across and within upwelling systems.

Authors finally addresses some recommendations for future research:

1. **Enable and improve the detectability of long-term changes in major upwelling systems.** An improvement in the length and resolution of the main observational data sets is required, especially in the less studied systems (Canary Islands, Arabian Sea and Humboldt). To this end, appropriate observational strategies should be designed that include regular monitoring of key physical and biogeochemical variables.

2. **Assess the vulnerability of major upwelling systems to climate change.** Improve understanding of the factors that control sensitivity to global change and explain their differences from the main upwelling systems.


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
2.1. Research Program for Climate Action Planning (CLAP)

The CLAP program is an initiative developed by Center for Advanced Studies in Arid Zones (CEAZA) and funded by National Agency for Research and Development of Chile – ANID, through the Competition for Strengthening the Scientific Development of Regional Centers (R20F0008-2021-2025), whose main objectives are:

**Overarching goal:** Improve predictions of the response of interconnected biosphere components to climate change and variability at multiple scales in north-central Chile to support effective climate planning.

**Specific goals:**

- Generate mesoscale to local predictions of future climate change effects in north-central Chile (ocean-atmosphere-biota) using a regional Earth System Model including key processes at a local scale (e.g. ocean-biogeochemical coupled processes, river run-off, air-sea-land interactions).
- Enhance the coastal meteorological and oceanographic observing network by incorporating an array of multidisciplinary sensors and co-building observational strategies with local stakeholders.
- Characterize and project the physiological tolerance of key marine species to climate variability and extreme events to estimate the evolution and resilience of ecosystem services

As the Principal Investigator of the Biogeochemical Research Line (RL2), a coupled ocean-atmosphere model is being built as part of the Earth System Model (Specific goal 1). Since 2022 to date, seven oceanographic campaigns have been conducted to obtain the necessary data to feed the nitrogen-based biogeochemical model (Coastal and Regional Ocean COmmunity model - CROCO, [https://www.croco-ocean.org/](https://www.croco-ocean.org/)), specifically developed for upwelling systems (Gutknecht et al., 2013). These comprehensive surveys were carried out along the marine water column associated with the Minimum Oxygen Minimal Zone off Coquimbo region (Guanaqueros system). Sampling included measurements, at high vertical resolution, of in situ physical, chemical, and biological parameters, and collection of water from discrete depths, characterized as representing the greatest biogeochemical vertical variability in the system (i.e., surface, oxycline, OMZ upper boundary, and OMZ core), to assess C and N pools, the presence and abundance of key planktonic species (using traditional and molecular tools), and for laboratory experiments using 15N tracers (i.e., $^{15}$NO$_3$, $^{15}$NO$_2$, and $^{15}$NH$_4$) to assess fundamental microbial processes related to the nitrogen cycle (i.e., nitrification, denitrification, DNRA, anammox) (Galán et al., 2009; 2014).

Part of this information has been processed already (see Figure and table), but due the complexity of the analysis required, some samples (e.g., molecular, isotopic, and tracers experiments) are still in progress.

![Typical CTD profile off Guanaqueros Bay, Region of Coquimbo, Chile, showing the depth distribution of Temperature, Oxygen, Fluorescence and the Photosynthetically Active Radiation (PAR).](image-url)
Under the CLAP umbrella, ANID has awarded two international collaborative networks. These two projects will focus on strengthening local capacities related to isotope-based analysis of C and N cycles in marine systems. These projects are led by myself and by Dr. Víctor Aguilera. The International biogeochemical network for understanding climate change impacts on coastal upwelling ecosystems, focused on the N cycle, has the collaboration of Dr. Bo Thaumdrup from the University of Southern Denmark and International Alliance for the generation of knowledge and capacities to detect remote and local processes of Ocean Acidification in the coasts of Chile, focused on the C cycle, has the collaboration of Dra. Babette Hoogakker from Heriot-Watt University. Both awarded projects contributed to the training of advanced human capital directly related to the objectives of the Project, as both include workshops and e-learning activities related to the C and N cycles, in line with the specific objectives of RL2.

2.2. Second International GO₂NE Summer Course GOOD-OARS-CLAP-COPAS


2.3. SOLAS Latin American Workshop. Marine biogeochemistry research on Latin American coastal zones

Organized together with Dra. Marcela Cornejo (Chile and former SOLAS Scientific Steering Committee) and Dra. Constanza Ricaurte (Colombia), this international workshop took place on May 26, 2023.

The aims of this activity supported by SOLAS was to learn about current research on coastal marine biogeochemistry in Latin America, focusing on, but not restricted to, the key biogeochemical-physical interactions and feedbacks between the ocean and the atmosphere of upwelling zones, and create a Latin American community network to start collaborations under common scientific interests that contribute to reducing spatial and temporal knowledge gaps, to achieve a better understanding of biogeochemical variability, the processes that control the greenhouse gases cycling, and the system’s response to environmental stressors on a regional scale. Likewise, with the creation of this network, it is intended to understand how this coupled ocean-atmosphere system affects and is affected by climate and environmental change, in order to find new ways to further contribute toward constructive solutions to the concerns of the society.

This activity was attended by 10 speakers from 8 countries in the region. 117 people from 16 different countries attended the event, of which 94% were from Latin America. The event was broadcasted.
online with the support of SOLAS. To date, the YouTube channel has 154 views (https://www.youtube.com/watch?v=gP3XaAw5MKY).

### 3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


- **Bustos-Espinoza, L., Torres-Ramírez, P., Figueroa, S. ...Galán, A.** (2024). Biogeochemical response of the water column of Concepción Bay, Chile, to a new regime of atmospheric and oceanographic variability. Geosciences (Accepted).

### 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?

As a part of the project “International biogeochemical network for understanding climate change impacts on coastal upwelling ecosystems - InBioNet”, led by myself and funded by the National Agency for Research and Development of Chile – ANID, through the call to promote international links for regional research institutions (FOVI21005 - 2022-2023), and whose main objective was generate and strengthen a scientific-technological network between regional institutions in Chile and Denmark to understand, from an interdisciplinary perspective, the impacts of climate change/climate crisis on the biogeochemistry of the coastal upwelling ecosystem of the eastern South Pacific, allowed the support of Dr. Bo Thaumdrup, from the University of Southern Denmark, who is also an international collaborator of the CLAP project, was consolidating.

As a part of the project “Omics and Nitrogen BiOgeochemistry Applied foR moDeling in Chile - ONBOARD”, in which I participate as a research associate and funded by the National Agency for Research and Development of Chile – ANID, through the call scientific cooperation ECOS/ANID (ECOS220026 - 2023-2024), and whose main objective is improve our understanding of the biogeochemical cycles along the coast of Chile, through combining different modeling approaches, and analyzing existing and new data, the support of Dra. Veronique Garcon, from LEGOS, France, who is also an international collaborator of the CLAP project, was improving.

### PART 2 - Planned activities for 2024 and 2025

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


**Omics and Nitrogen BiOgeochemistry Applied foR moDeling in Chile – ONBOARD.** ECOS/ANID 2023-2024.

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

Postulation as expositor of the Congreso Latinoamericano de Ciencias del Mar, COLACMAR (https://colacmar2024.com/es/), with the work Biogeochemical response of the water column of Concepción Bay, Chile, to a new regime of atmospheric and oceanographic variability.

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

Postulation of a project to the ANID 2024 call to promote international links for research institutions to consolidate a regional network on marine biogeochemistry study in Latin American (July 2024).

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

Comments
Report for the year 2023 and future activities

SOLAS China
compiled by: Huiwang Gao, Xianghui Guo, Yujue Wang, Yan Yang, Chao Zhang

This report has two parts:

- **Part 1**: reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

- **Core Theme 1**: Greenhouse gases and the oceans;
- **Core Theme 2**: Air-sea interfaces and fluxes of mass and energy;
- **Core Theme 3**: Atmospheric deposition and ocean biogeochemistry;
- **Core Theme 4**: Interconnections between aerosols, clouds, and marine ecosystems;
- **Core Theme 5**: Ocean biogeochemical control on atmospheric chemistry;
- **Cross-Cutting Theme**: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
- **Cross-Cutting Theme**: Climate intervention;
- **Cross-Cutting Theme**: Science and society.

**IMPORTANT**: This report should reflect the efforts of the SOLAS community in the entire country or region 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.

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**PART 1 - Activities from January 2023 to Feb/Mar 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).
Title: Upper Ocean Biogeochemistry of the Oligotrophic North Pacific Subtropical Gyre: From Nutrient Sources to Carbon Export (Theme 3)

Subtropical gyres cover 26%–29% of the world's surface ocean and are conventionally regarded as ocean deserts due to their permanent stratification, depleted surface nutrients, and low biological productivity. Despite tremendous advances over the past three decades, particularly through the Hawaii Ocean Timeseries and the Bermuda Atlantic Time-series Study, which have revolutionized our understanding of the biogeochemistry in oligotrophic marine ecosystems, the gyres remain understudied. We review current understanding of upper ocean biogeochemistry in the North Pacific Subtropical Gyre, considering other subtropical gyres for comparison. We focus our synthesis on spatial variability, which shows larger than expected dynamic ranges of properties such as nutrient concentrations, rates of N$_2$ fixation, and biological production. This review provides new insights into how nutrient sources drive community structure and export in upper subtropical gyres. We examine the euphotic zone (EZ) in subtropical gyres as a two-layered vertically structured system: a nutrient-depleted layer above the top of the nutricline in the well-lit upper ocean and a nutrient-replete layer below in the dimly lit waters. These layers vary in nutrient supply and stoichiometries and physical forcing, promoting differences in community structure and food webs, with direct impacts on the magnitude and composition of export production. We evaluate long-term variations in key biogeochemical parameters in both of these EZ layers. Finally, we identify major knowledge gaps and research challenges in these vast and unique systems that offer opportunities for future studies.

Figure: Illustration of vertical nutrient and organic carbon profiles within the oligotrophic North Pacific Subtropical Ocean, elucidating the interplay of various nutrient sources including diazotroph-derived nitrogen that govern the intricate process of carbon sequestration in this expansive oceanic domain. Credit: Hong Zhou


Title: Atmospheric deposition and river runoff stimulate the utilization of dissolved organic phosphorus in coastal seas (Theme 3)

In coastal seas, the role of atmospheric deposition and river runoff in dissolved organic phosphorus (DOP) utilization is not well understood. Here, we address this knowledge gap by combining microcosm experiments with a global approach considering the relationship between the activity of alkaline phosphatases and changes in phytoplankton biomass in relation to the concentration of dissolved inorganic phosphorus (DIP). Our results suggest that the addition of aerosols and riverine water stimulate the biological utilization of DOP in coastal seas primarily by depleting DIP due to increasing nitrogen concentrations, which enhances phytoplankton growth. This “Anthropogenic
Nitrogen Pump" was therefore identified to make DOP an important source of phosphorus for phytoplankton in coastal seas but only when the ratio of chlorophyll a to DIP $[\log_{10} (\text{Chl} \ a/\text{DIP})]$ is larger than 1.20. Our study therefore suggests that anthropogenic nitrogen input might contribute to the phosphorus cycle in coastal seas.

Figure: In coastal seas, atmospheric deposition and river runoff are mainly contributing dissolved inorganic nitrogen (DIN) whereas in the surface open ocean, atmospheric deposition is mainly contributing essential trace metals for enhancing the activity of the alkaline phosphatase (APA). DIN therefore increases in surface waters of the coastal seas leading to higher N:P ratios, enhanced phytoplankton growth, and the uptake of dissolved inorganic phosphorus (DIP). Once DIP is below a certain threshold, the APA significantly increases. This process leads to an increase in the utilization of dissolved organic phosphorus (DOP).


Title: Important roles and formation of atmospheric organosulfates in marine organic aerosols: Influence of phytoplankton emissions and anthropogenic pollutants (Theme 5)

Organic aerosols in marine atmospheres currently are rarely identified or quantified at the molecular level. Organosulfates (OSs) could be potentially important compounds in marine organic aerosols, while their formation in marine atmospheres is far from clear due to lack of cruise observations. In this work, shipboard atmospheric observations were conducted over the Yellow Sea and Bohai Sea to investigate the abundance and formation of biogenic isoprene/monoterpene-OSs in marine aerosols. The quantified OSs and NOSs accounted for 0.04%–6.9% of marine organic aerosols and were 0.07%–2.2% of the nss-sulfate in terms of sulfur content. Isoprene-related (nitrooxy-)OSs occupied 27%–87% of the total quantified OSs, following the abundance order of summer>autumn>spring or winter. This order was driven by the marine phytoplankton biomass and sea surface temperature (SST), which controlled the seawater and atmospheric isoprene concentration levels. Under the severe impacts of anthropogenic pollutants from the East Asia continent in winter, monoterpene nitrooxy-OSs, generated with NOx involved in, elevated to 34.4±35.5 ng/m³ and contributed 68% of the quantified (nitrooxy-)OSs. Our results highlight the notable roles of biogenic OSs in marine organic aerosols over regions with high biological activity and high SST. The formation of biogenic OSs and their roles in altering marine aerosol properties calls for elaboration through cruise observations in different marine environments.
Coupling of carbon and oxygen in the Pearl River plume in summer: upwelling, hypoxia, reoxygenation and enhanced acidification (Theme 3)

Acidification and hypoxia are universal environmental issues in coastal seas, especially in large river estuaries such as the Pearl River estuary. In July and August of 2015, two legs of a field survey were conducted in the Pearl River plume. Leg 1 was sampled during the influence of upwelling favorable winds, while Leg 2 was during downwelling favorable winds. During both legs, instead of the typically observed dissolved inorganic carbon (DIC) consumption and dissolved oxygen (DO) over-saturation, upwelling-induced high DIC (>2000 μmol kg⁻¹), low pH (7.7-7.8) and low DO (140-150 μmol kg⁻¹) values were observed in surface waters at the estuary mouth and the area off Hong Kong. In the bottom waters, hypoxia, acidification (pH 7.6-7.8) and DIC accumulation (DIC addition of ~ 100-180 μmol kg⁻¹) were observed. Hypoxia was less severe during Leg 2 compared to Leg 1. The stoichiometry of oxygen depletion to DIC addition was 0.89 for bottom water, suggesting remineralization was dominated by marine sourced organic matter. However, a comparison of data from the two legs showed that the stoichiometry of oxygen consumption to DIC accumulation was significantly higher during Leg 2 (0.73±0.03 for Leg 1 vs. 0.80±0.05 for Leg 2), although N/P ratios were the same (13.54±1.93 for Leg 1 vs. 13.51±2.04 for Leg 2). This phenomenon was attributed mainly to enhanced ventilation (reoxygenation) under the influence of the downwelling favorable winds during Leg 2. Although ventilation relieves hypoxia, it might enhance acidification in bottom waters after a short-term ventilation event. The enhanced acidification after short-term ventilation is worthy of further study considering that most hypoxia and acidification are found in shallow coastal seas.

Figure: Conceptual model of the enhanced ocean acidification process in shallow estuaries or coasts. (A) status before ventilation; (B) the ventilation process; (C) enhanced acidification after the re-
establishment of the stratification following short-term ventilation. N/P indicates nutrients and OM is organic matter. The yellow symbols and black dots denote phytoplankton and particulate OM in the water column, respectively. The thick and thin dashed lines represent strong stratification and weak stratification, respectively.


Title: Mixed Archaeal Production and Nitrifier Denitrification Dominate N₂O Production in the East China Sea: Insights From Isotopocule and Hydroxylamine Analyses (Theme 1)

Oceans are identified as potent sources of atmospheric nitrous oxide (N₂O), while the magnitude of its flux and microbial production mechanisms remain uncertain in highly perturbed coastal zones. Here, the first analyses of N₂O isotopocule signatures in the East China Sea (ECS) are presented, along with hydroxylamine (NH₂OH) and N₂O concentrations, to clarify the dominant N₂O production processes in coastal water. In the ECS in October 2015, N₂O ranged from 6.3 to 33.1 nmol L⁻¹, equivalent to 99%–251% saturation, leading to air-sea fluxes of 1.6–10.5 μmol m⁻² d⁻¹ (4.8 ± 2.5 μmol m⁻² d⁻¹) using the W2014 formula. The coexistence of high levels of NH₄⁺, NH₂OH, and NO₂⁻ indicated the potential for nitrification and/or hybrid N₂O formation. In the shallow water (<300 m), the concentration (∼9.3 nmol L⁻¹), δ¹⁵Nbulk–N₂O (∼−6.8‰), δ¹⁸O–N₂O (∼−45.1‰), and ¹⁵N site preference (SP, ∼14.8‰) of N₂O were close to the isotopic signatures in atmospheric N₂O, whereas values in the deep water increased with depth, with N₂O reaching maxima of 33.1 nmol L⁻¹, 8.6‰, 54.7‰, and 18.7‰, respectively. From the dual N₂O isotopocule mapping approach, almost equal contributions of archaeal N₂O production (archaeal nitrification and/or hybrid mechanism, ∼47%) and nitrifier denitrification (or denitrification) (∼53%) to total in situ N₂O production were identified for the shallow water, but archaeal nitrification was responsible for ∼83% of the deeper N₂O production. Moreover, the far-field lateral advection from other areas served as a potential physical supply of deeper N₂O.

Our findings enhance the understanding of N₂O dynamics in coastal waters.


Title: Signature of Mesoscale Eddies on Air-Sea Heat Fluxes in the North Indian Ocean (Theme 2)

Using a combination of 20-year (1999-2018) remotely-sensed air-sea heat flux products and altimeter-based eddy atlas, we investigate the signature of mesoscale eddies on sea surface temperature (SST) and air-sea turbulent latent and sensible fluxes, or simply, turbulent heat fluxes (THFs), in the North Indian Ocean. On average, eddy-induced THF feedback can approach ∼40 W m⁻² k⁻¹ for warm-core anticyclones (AEs) and ∼28 W m⁻² k⁻¹ for cold-core cyclones (CEs) at their extreme values. In addition to these conventional sea surface height (SSH)-SST coherent eddies and their imprints as
monopoles in heat fluxes, a comparable proportion of SSH-SST incoherent eddies (cold-AEs and warm-CEs) are surprisingly active in this region, which offset the monopolar paradigm of coherent eddy-induced THF anomalies or develop a dipole structure when combined with these conventional eddies. In terms of seasonality, the aggregation of SSH-SST coherent and incoherent eddies in the Arabian Sea develops concentrated monopoles within eddy contours in both summer and winter, with a damped THF located farther away from the eddy core in winter. In the Bay of Bengal, a strong compensation between SSH-SST coherent and incoherent eddies is observed in summer that leads to null net fluxes, while the winter-time THF composite of these two eddy types displays a dipolar structure which was described as eddy-stirring effect in the literature.

Figure: Schematic of anticyclonic and cyclonic eddies in depth. Panel (a) illustrates an example of SSH - SST coherent eddies, and (b) shows a possible vertical structure of SSH-SST incoherent eddies.


Title: Assessing the Intensity of Marine Biogenic Influence on the Lower Atmosphere: An Insight into the Distribution of Marine Biogenic Aerosols over the Eastern China Seas (Theme 4)

Marine biological activities make a non-negligible contribution to atmospheric aerosols, leading to potential impacts on the regional atmospheric environment and climate. The eastern China seas are highly productive with significant emissions of biogenic substances, but the spatiotemporal variations of marine biogenic aerosols are not well known. Air mass exposure to chlorophyll $a$ (AEC) can be used to indicate the influence of biogenic sources on the atmosphere to a certain degree. In this study, the 12 year (2009–2020) daily AEC were calculated over the eastern China seas, showing the spatial and seasonal patterns of marine biogenic influence intensity which were co-controlled by surface phytoplankton biomass and boundary layer height. By combining the AEC values, relevant
meteorological parameters, and extensive observations of a typical biogenic secondary aerosol component, methanesulfonate (MSA), a parameterization scheme for MSA simulation was successfully constructed. This AEC-based approach with observation constraints provides a new insight into the distribution of marine biogenic aerosols. Meanwhile, the wintertime air mass retention over land exhibited a significant decrease, showing a decadal weakening trend of terrestrial transport, which is probably related to the weakening of the East Asian winter monsoon. Thus, marine biogenic aerosols may play an increasingly important role in the studied region.

Figure: The 12 year (2009–2020) daily AEC were calculated over the eastern China seas, showing the spatial and seasonal patterns of marine biogenic influence intensity which were co-controlled by surface phytoplankton biomass and boundary layer height.


Title: Isoprene Production and Its Driving Factors in the Northwest Pacific Ocean (Theme 5)

Marine isoprene plays a crucial role in the formation of secondary organic aerosol within the remote marine boundary layer. Due to scarce field measurements of oceanic isoprene and limited laboratory-based studies of isoprene production, assessing the importance of marine isoprene on atmospheric chemistry and climate is challenging. Calculating in-field isoprene production rates is a crucial step to predict marine isoprene concentrations and the subsequent emissions to the atmosphere. The distribution, sources, and dominant environmental factors of isoprene were determined in the Northwest Pacific Ocean in 2019. The nutrient enrichment in the Kuroshio Oyashio Extension (KOE) surface seawater, driven by the upwelling and atmospheric deposition, promoted the growth of phytoplankton and elevated the isoprene concentration. This was confirmed by observed responses of isoprene to nutrients and aerosol dust additions in a ship-based incubation experiment, where the isoprene concentrations increased by 70% (t = 4.417, p < 0.001) and 35% (t = 2.387, p < 0.05), respectively. Biogenic isoprene production rates in the deck incubation experiments were positively related to chlorophyll a, temperature, and solar radiation, with an average production of 7.33 ± 4.27 pmol L⁻¹ day⁻¹. Photochemical degradation of dissolved organic matter was likely an abiotic source of isoprene, contributing to approximately 14% of the total production. Driven by high isoprene production and extreme physical disturbance, the KOE showed very high emissions of isoprene of 46.0 ± 13.0 nmol m⁻² day⁻¹, which led to a significant influence on the oxidative capacity of the local atmosphere.
Figure: Modeled production rate of isoprene in the mixed layer in the Kuroshio Oyashio Extension (KOE) (P01, and P05) and the subtropical Northwest Pacific Ocean (NWPO) (P24). Blue lines are photochemical production rates, red lines are biological production rates, and orange lines are the observed isoprene concentrations. Green points are the Chl-a concentration of seawater at sampling depth. Purple and green lines show the temperature and Chl-a used in model rate calculation.


Title: Ambiguous Variations in Tropical Latent Heat Flux since the Years around 1998 (Theme 2)

The tropical latent heat flux (LHF) has experienced a significant increase under the background of global warming in the past four decades. However, since the years around 1998, the long-term LHF variations in the tropics have been found to be quite different in various flux products. Three different trends in the LHF, climbing, near zero, and declining, are suggested by five widely used flux products, which hinders our knowledge of the actual LHF variations. Although there are buoy observations in the tropics, these observations are hard to use to evaluate flux products as they have been assimilated and/or used as benchmarks in the flux data production. This study aims to identify credible long-term LHF variations since 1998. A linear model decomposing the LHF variations into contributions from sea surface wind (U) and air-sea humidity differences (ΔQ) is first applied. The linear model results show that the LHF variations have been more positively connected to U variations since 1998. Evidence from in situ and remote sensing observations is subsequently employed to identify how U has varied recently. Both Global Tropical Moored Buoy Array (GT MBA) buoy observations (from 82 buoys) and a multi-sensor merged satellite product support a slightly downward trend in U in the last two decades. Such a weakening of U is not conducive to oceanic evaporation and leads to a reduced LHF. Consequently, a declining LHF under a weakening U since the emergence of the global warming “hiatus” in approximately 1998 might be more convincing in the sense of data accuracy and physical consistency.
Figure: Time series of the anomalous (a) LHF, (b) $U$, and (c) $\Delta Q$ over tropical oceans ($30^\circ$S-$30^\circ$N, 0-360$^\circ$). The thin and thick straight lines denote the linear trends in 1979 to 1998 and 1999 to 2018, respectively. The anomalies in each flux product are computed by removing their climatology mean values from 1979 to 2018. The two values in parentheses denote the linear trends before and after 1998, respectively. The bold italics indicate that the value passes the 95% confidence level. The units for the linear trends in (a), (b), and (c) are W m$^{-2}$ yr$^{-1}$, m s$^{-1}$ 10yr$^{-1}$, and g kg$^{-1}$ 10yr$^{-1}$, respectively. The green filled area denotes the period from 1979 to 1998. During this period, all the products show consistent signs of long-term trends in the LHF, $U$, and $\Delta Q$.


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).

- Cruises and field experiments

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Activities</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jul.-Aug., 2023</td>
<td>South China Sea</td>
<td>Parameters investigated include carbonate system in water column and surface water partial pressure of CO$_2$.</td>
<td>1</td>
</tr>
</tbody>
</table>
Investigate carbon cycling in selected seagrass ecosystems involves multiple interfaces (water-gas, water-soil, soil-gas, vegetation-water) and multiple parameters (CO$_2$, CH$_4$, N$_2$O, etc.)

Parameters investigated include chemical compositions of aerosols, alkaline phosphatase activities, marine phytoplankton, and multiple parameters (CO$_2$, CH$_4$, N$_2$O, etc.)

### - Selected Projects

NSFC Basic Science Center Program: Research Center for Marine Carbon Sequestration and Biogeochemical Processes (2022-2027), Leading PI: Nianzhi Jiao at Xiamen University. The center will focus on the international frontier of marine carbon sequestration processes and their control mechanisms. The center is also a platform for collaborations with intellects both domestic and international, creating a plateau of scientific innovation and development. (Theme 1 & 3)

Tencent BLUE-CARE Project or “Blue Carbon Ecosystem Assessment, Restoration and Accounting Project” (2022-2024), Leading PI: Minhan Dai at Xiamen University. (Theme 1)

Project supported by the Major Research Plan of NSFC: Integrative Study of Multi-scale Cycling at the Air-sea Interface in the Western Pacific Ocean (2023-2025), Leading PI: Zhimian Cao at Xiamen University. (Theme 1, 2, 3)

National Key Research and Development Project: Refined Air-Sea Interface Observation Technology and Flux Process Cognition (2022-2027), Leading PI: Xin Zhang at South China Sea Institute of Oceanography, Chinese Academy of Sciences (Theme 1)

NSFC Major Project: CARBON Fixation and Export in the Oligotrophic Ocean (Carbon-FE) (2019-2023), Leading PI: Minhan Dai at Xiamen University. (Theme 1, 3 & Environmental impacts of geoengineering). This is a SOLAS endorsed project.

NSFC Special Project: Air-sea Carbon Fluxes, Budget and Uncertainties in China Seas (2022-2025), Leading PI: Xianghui Guo at Xiamen University. (Theme 2)

NSFC Innovative Research Group: Nitrogen Cycle under Global Change (2018-2023), Leading PI: Shuh-Ji Kao at Xiamen University. (Theme 1)

NSFC-Shandong Joint Fund Project: Impacts of Atmospheric Deposition on Water Quality and Ecosystem in the Coastal Waters of Shandong Province (2020-2023), Leading PI: Huiwang Gao at Ocean University of China. (Theme 3)

NSFC Key Project: Source and Flux of N$_2$O in the Euphotic Zone of the Northwestern Pacific (2021-2024), Leading PI: Shuh-Ji Kao at Xiamen University. (Theme 1)

NSFC Key Project: Identification, Transport, and Impact on Oceanic New Production of Anthropogenic Iron and Nitrate Sources in the Northwest Pacific (2021-2025), Leading PI: Mei Zheng at Peking
University. (Theme 3)

NSFC Key Project: Source-Sink Patterns, Regulatory Mechanisms, and Climate Impacts of Carbon Monoxide in the Northwest Pacific (2024-2028), Leading PI: Guipeng Yang at Ocean University of China. (Theme 5)

NSFC General Project: Spatial and Temporal Patterns and Regulatory Mechanisms of Dimethyl Sulphide (DMS) Production, Distribution, and Release in the Kuroshio Extension Region of the Northwest Pacific (2023-2026), Leading PI: Honghai Zhang at Ocean University of China. (Theme 5)


NSFC General Project: The Impact of East Asian Aerosol Deposition on the Structure, Metabolic Function, and Up-Down Regulation of Bacterial Communities in the South China Sea (2022-2025), Leading PI: Cui Guo at Ocean University of China. (Theme 3)

NSFC General Project: Physicochemical Characterization and Depositional Ice Nucleation Efficiency of Atmospheric Particles over South China Sea (2021-2024), Leading PI: Bingbing Wang at Xiamen University. (Theme 3)

NSFC General Project: Influences of Hydrodynamics on the Spatial Distribution and Long-term Variations of Persistent Halogenated Hydrocarbons in the Bohai, Yellow, and East China Seas (2020-2023), Leading PI: Xinyu Guo at Ocean University of China. (Theme 1)

NSFC General Project: Study on the Transport and Transformation Processes of Nutrients from Different Sources in the Yellow Sea and Their Contribution to Primary Productivity (2022-2025), Leading PI: Jie Shi at Ocean University of China. (Theme 2&3)

NSFC General Project: Chemical compositions and formation pathways of atmospheric organosulfates in marine aerosols (2023-2025), Leading PI: Yujue Wang at Ocean University of China. (Theme 5)

NSFC General Project: Investigation on abnormal fluctuations of amines in concentration and composition in marine atmospheres (2023-2026), Leading PI: Xiaohong Yao at Ocean University of China. (Theme 4)

NSFC General Project: Study on sinking rate and its parameterization of atmospheric particulates in seawater (2024-2027), Leading PI: Huiwang Gao at Ocean University of China. (Theme 3)

- International interactions and collaborations

1) Conference presentations

Minhan Dai. Upper ocean biogeochemistry of the oligotrophic North Pacific Subtropical Gyre: from nutrient sources to carbon export. The second Hong Kong-Macau Ocean Forum. 6 July, 2023. Hong Kong, China. (Oral)


Xianghui Guo, Surface water pCO₂ and air-sea CO₂ fluxes in the northwestern Pacific, Ocean Science Meeting. 18-23 February, 2024. New Orleans, USA. (Oral)


2) Conference & meetings organized

● SOLAS Session and Town Hall at XMAS-VI

Organized by the State Key Laboratory of Marine Environmental Science, Xiamen University (MEL), Sixth Xiamen Symposium on Marine Environmental Sciences (XMAS-VI) was held in Xiamen, China and online from 9-12 January 2023 with the theme focusing on Multidisciplinary and Solution Sciences for a Sustainable and Healthy Ocean.

SOLAS session on Surface Ocean - Lower Atmosphere Study: Air-Sea interaction and its climatic and environmental impacts was convened by Guiling Zhang, Bingbing Wang, Lin Du, and Zhijun Wu.
This session provided opportunities for the scientific community to exchange new ideas and discuss the latest achievements in our understanding of the key biogeochemical-physical interactions and feedbacks between the ocean and the atmosphere, and of how this coupled system affects and is affected by climate and environmental change.

SOLAS Town Hall on SOLAS in the new era: harnessing partnership and transforming science into solutions was convened by Cécile Guieu, Erik van Doorn, Mohd Talib Latif, Li Li, Anoop Mahajan, Christa Marandino, Lisa Miller, Arvind Singh, and Guiling Zhang.

This town hall allowed XMAS-VI attendees to provide direct input and contribute new ideas for SOLAS in planning our future activities, notably on how SOLAS can most usefully facilitate scientific research in understudied regions, identifying the research priorities of underrepresented communities, and discussing how SOLAS science can be transformed to societal solutions.

- **International Digital Twins of the Ocean Summit 2023**
  Initiated by the United Nations Decade of Ocean Science endorsed programme Digital Twins of the Ocean (DITTO) and co-hosted by the Fujian Ocean Innovation Center and MEL, the International DITTO Summit 2023 took place in conjunction with the 2023 World Ocean Week in Xiamen, China on 9-12 November 2023, attracting 450 renowned experts, scholars and industry representatives from 19 countries and regions. The Summit enabled sharing of the latest advances on digital twins of the ocean and discussion of future joint actions.

- **SOLAS Scoping Workshop**
  The SOLAS Scoping Workshop was held in Xiamen and online on 25-28 September 2023. The workshop gathered 40 leading oceanographers and atmospheric scientists from 18 countries to discuss SOLAS future beyond 2025 and draft the SOLAS 2026-2035 science plan and organization.

- **8th OUC-UEA Symposium on Integrative Ocean Sciences**
  On September 12th, the 8th UEA-OUC Symposium was held at the University of East Anglia (UEA). More than 40 scholars participated in the symposium and had in-depth discussions on topics such as climate change, biogeochemical cycling, marine microbial ecology, and sea ice dynamics. President David Maguire attended the opening ceremony and delivered a speech. President Maguire expressed his sincere gratitude to Ocean University of China (OUC) for joining in the celebration of the 60th anniversary of UEA. He reviewed the latest developments in personnel exchange, student development, and research cooperation between the two universities, and expressed hopes for exploring more possibilities for future cooperation.

3) **Contribution to international initiatives**

Xianghui Guo serves as Associate Editor of Frontiers in Marine Science (section Global Change and Future Ocean).

Minhan Dai is engaged in REgional Carbon Cycle Assessment and Processes-2 (RECCAP2) which is an activity of the Global Carbon Project with a number of partners.

Minhan Dai is a member of IOC working group on Integrated Ocean Carbon Research (IOC-R). Established in 2018, this group aims at filling knowledge gaps in relation to ocean carbon by designing and promoting the implementation of a new generation of integrated ocean carbon research. The working group fosters active collaboration and synergies amongst IOC, IOCCP, SOLAS, IMBeR, GCP, CLICAR, WCRP and relevant international efforts on carbon research.

Minhan Dai is a member of GOOS Task Team ocean indicator framework which is an activity support the GOOS Expert Panels (lead: GOOS Physics and Climate Panel) to develop a global ocean monitoring indicator framework to serve as a standardized means of monitoring global ocean changes and trends, identifying knowledge gaps and observations needs, and facilitating communication on the state of the ocean.

3. **Publications in 2023** (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


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?

Blue carbon ecosystems – mangroves, seagrasses, and salt marshes– are highly productive coastal ecosystems that are particularly important for their carbon sequestration capacity, and are thereby considered a key component of nature-based solutions to climate change. Based on this, Xiamen University and Tencent co-initiated the BLUE-CARE project entitled “Blue Carbon Ecosystem Assessment, Restoration and Accounting Project” partnering with leading research institutes and nongovernmental organizations. The first 107.33 ha of salt marshes restoration project in the Jiangsu Yancheng Wetland & Rare Birds National Nature Reserve has generated about 1926 tCO$_2$e net carbon credit. The net carbon credit accounting is based on the salt marshes methodology. On 26 September 2023, this salt marshes carbon credit has been registered in the Ecological Product Value Realization Platform of Guangzhou Emissions Exchange, and has been subscribed by Tencent Company. It will open a new chapter for salt marshes blue carbon trading in China.

Led by MEL, the COASTAL-SOS, or “Coastal Zones Under Intensifying Human Activities and Changing Climate: A Regional Programme Integrating Science, Management and Society to Support Ocean Sustainability,” partners cross-sectoral stakeholders, including leading academic institutions, industrial enterprises, non-profit foundations, and nongovernmental/intergovernmental organizations (NGO/IGOs) from East Asian countries to advance scientific understanding of critical coastal ocean health issues. In 2023, multiple research funds for COASTAL-SOS were granted. Implementation plans are progressing in an orderly manner. In July, COASTAL-SOS co-organized the interdisciplinary panel “Coastal Issues: Support Ocean Sustainability” at the 20th Annual Meeting of the Asia Oceania Geosciences Society in Singapore, to jointly promote healthy and sustainable development of the oceans and coastal zones.
The Global Ocean Negative Carbon Emissions (Global-ONCE) Program was approved by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational Scientific and Cultural Organization (UNESCO). It is in the framework of the United Nations Decade of Ocean Science for Sustainable Development. The program aims to promote ONCE’s “public products” to the international community and governments through official channels, disseminating knowledge, promoting exchanges, and enhancing mutual trust. On November 8th, the opening ceremony of the ONCE Open Science Conference was held in Xiamen. The ONCE Program’s series of achievements were released. After the opening ceremony, Dr. Xiankang Dou and Mr. Peter Thomson delivered keynote speeches during the ninth session of the Xiamen University Qunxian Lecture, focusing on the development and transformation of the NSFC and ocean health issues and sustainable development goals.

### PART 2 - Planned activities for 2024 and 2025

<table>
<thead>
<tr>
<th>1. Planned major national and international field studies and collaborative laboratory and modelling studies (incl. all information possible, dates, locations, teams, work, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There will be a summer cruise to Pearl River Estuary in 2024 which is closely related to themes 1 of SOLAS.</td>
</tr>
<tr>
<td>2. There will be a cruise to Yangtze River Estuary in July 2024 which is closely related to themes 1 of SOLAS.</td>
</tr>
<tr>
<td>3. There will be two cruises to the West Pacific in 2024, which is closely related to themes 1, 2, 3, 4 of SOLAS.</td>
</tr>
<tr>
<td>4. There will be a cruise to the Yellow Sea in April 2024 which is closely related to themes 3, 4, 5 of SOLAS.</td>
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<th>2. Events like conferences, workshops, meetings, summer schools, capacity building etc. (incl. all information possible).</th>
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<tr>
<td>The 7th Xiamen Symposium on Marine Environmental Sciences (XMAS-VII) will be held in Xiamen from January 14 to 17, 2025. It will focus on interdisciplinary cutting-edge sessions covering physical oceanography, chemical oceanography, biological oceanography, and marine ecotoxicology along with workshops for emerging topics in marine environmental sciences such as ocean-based carbon removal, ocean governance and sustainability, and marine economy.</td>
</tr>
</tbody>
</table>

"Training Workshop on Marine Radioactivity" is scheduled to take place from 19-23 August 2025 at Xiamen University Malaysia, Selangor Darul Ehsan, Malaysia. This workshop is being organized by MEL, in collaboration with Center for Marine and Environmental Radioactivity of Woods Hole Oceanographic Institution (CMER), Xiamen University Malaysia (XMUM), and China-ASEAN College of Marine Sciences (CAMS).

The workshop on "Formation, Ageing and Heterogeneous Chemistry of Marine Aerosols" will be held in September 2024. This workshop is being organized by Ocean University of China, University of Gothenburg and University of Helsinki.

The 9th OUC-UEA Symposium on Integrative Ocean Sciences will be held at Ocean University of China, which is also for celebrating the 100th anniversary of OUC.

<table>
<thead>
<tr>
<th>3. Funded national and international projects/activities underway.</th>
</tr>
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<tbody>
<tr>
<td>NSFC Key Project: Source and Flux of N2O in the Euphotic Zone of the Northwestern Pacific (2021-2024), Leading PI: Shuh-Ji Kao at Xiamen University. (Theme 1)</td>
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Project supported by the Major Research Plan of NSFC: Integrative Study of Multi-scale Cycling at the Air-sea Interface in the Western Pacific Ocean (2023-2025), Leading PI: Zhimian Cao at Xiamen University. (Theme 1, 2, 3)

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

The proposal of integrated research on sustainability of the coastal ocean is to be submitted to NSFC for Major Project in 2024. The prospective proposal aims to address how land-sea-ocean-atmosphere/ecosystem-resource-environment-social economic system is coupled in the coastal ocean under dual stresses of climate change and human activities.

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

Xianghui Guo serves as Associate Editor of Frontiers in Marine Science (section Global Change and Future Ocean).

Minhan Dai is engaged in REgional Carbon Cycle Assessment and Processes-2 (RECCAP2) which is an activity of the Global Carbon Project with a number of partners.

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Comments
Report for the year 2023 and future activities

SOLAS Taiwan
compiled by: Hon-Kit Lui

This report has two parts:

- **Part 1:** reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

- **Core Theme 1:** Greenhouse gases and the oceans;
- **Core Theme 2:** Air-sea interfaces and fluxes of mass and energy;
- **Core Theme 3:** Atmospheric deposition and ocean biogeochemistry;
- **Core Theme 4:** Interconnections between aerosols, clouds, and marine ecosystems;
- **Core Theme 5:** Ocean biogeochemical control on atmospheric chemistry;
- **Cross-Cutting Theme:** Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
- **Cross-Cutting Theme:** Climate intervention;
- **Cross-Cutting Theme:** Science and society.

**IMPORTANT:** This report should reflect the efforts of the SOLAS community in the entire country or region 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 Feb/Mar 2024**

1. **Scientific highlight**
The wind-driven meridional overturning circulation between the tropical and subtropical oceans is critical for regulating temperature in the Pacific Ocean and globally. Strengthening of the circulation helps reducing global surface temperature. The equatorward low-latitude western boundary current is a critical component of the meridional circulation cell in the Pacific. It is also a major source of water mass for the Equatorial Undercurrent. Yet, long-term observations of its transport are scarce. To fill this gap, this study uses a 94-year coral record from the Solomon Sea. The authors demonstrated that the
15N/14N ratio recorded by *Porites* spp. corals in the western tropical South Pacific is sensitive to the exchanges of water masses driven by the western boundary transport. The isotopic records suggest that the South Pacific western boundary current has strengthened in the past century and may have contributed to the reported strengthening of the Equatorial Undercurrent. Additionally, the 15N/14N record shows decadal solid variability, indicative of weaker equatorial Pacific upwelling and stronger western boundary transport when the eastern equatorial Pacific is in the warm stage of the Pacific Decadal Oscillation. The results also indicate that the isotopic records of coral have the potential to constrain the low-latitude western boundary current transport in the Solomon Sea.

Figure: Schematic representation of the atmospheric and oceanic processes for different large-scale climate conditions that affect low-latitude western boundary current (LLWBC) transport. a) The subtropical-tropical cells (STCs, blue arrows), Walker circulation (black arrows), Hadley circulation (orange arrows), and the LLWBC in the South Pacific (red arrow) are coupled processes. Green shadings represent the amount of nutrient upwelled and remaining at the surface of the central equator Pacific (CEP) and eastern equatorial Pacific (EEP). b) The positive phase of the Pacific Decadal Oscillation (PDO) is associated with a weaker Walker circulation, reduced equatorial winds and accompanied by weaker oceanic overturning circulation, flattened thermocline tilt, and weaker upwelling in the CEP and EEP. If not accompanied by changes in the subtropics, the weaker trade winds generate negative wind stress curl in the South Pacific, strengthening the LLWBC by Sverdrup transport. c) Schematic representation of projected changes associated with anthropogenic warming.


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 Ocean Acidification, Deoxygenation and Freshening Research Center has submitted a multi-year proposal to the Ministry of Education. The proposal aims to gain the understanding of the influences of the increased atmospheric CO₂ and seawater warming on ocean acidification, deoxygenation, coastal water freshening, and the marine ecosystems in the marginal seas around Taiwan.
In response to the 2050 Net-Zero mission, different organizations have successively hosted relevant meetings or conferences to discuss the possibility of using blue carbon as one of the carbon credits. Artificial wetlands, seagrass and algae farming, and ocean alkalization have been widely discussed and considered.

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


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?
### PART 2 - Planned activities for 2024 and 2025

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

In response to the 2050 Net-Zero mission, extra funds are provided by the government to develop certain strategies and technologies, as well as research in both the green and blue carbons. Additional efforts and collaborations within the discipline are expected to participate in the Core Theme 1 of the SOLAS: Greenhouse gases and the oceans.

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

The Fisheries Agency of the Ministry of Agriculture, the National Academy of Marine Research, the Taiwan Ocean Union, and other organizations initiated workshops related to blue carbon and carbon credit several times in 2023. Several related integrated projects are running. It is expected that similar conferences or workshops will be initiated by the mentioned units in 2024.

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

Several multi-year integrated projects related to Core Themes 1 and 2, funded by the National Science and Technology Council and the Fisheries Agency of the Ministry of Agriculture, are running. Cores of the projects are to understand the carbon and energy flows between the atmosphere and the ocean, and how the processes can be enhanced artificially to meet the need of reducing greenhouse gases from the atmosphere.

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

Several multi-year integrated projects related to Core Themes 1 and 2 have been running. The National Science and Technology Council and the Fisheries Agency of the Ministry of Agriculture are the main funders. The National Academy of Marine Research would be a potential funder. Collaborations within the discipline are strong in Taiwan. Further international collaboration would be made between some South Asia counties. Research topics would be focused on carbon flux and algae farming.

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

In 2023, exchange visits were made with the University of Delaware and Hokkaido University. Further collaborates and works will be discussed and proposed.

### Comments
Report for the year 2023 and future activities

SOLAS ‘Denmark’
compiled by: ‘Carolin Löscher’

This report has two parts:

- **Part 1**: reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

- **Core Theme 1**: Greenhouse gases and the oceans;
- **Core Theme 2**: Air-sea interfaces and fluxes of mass and energy;
- **Core Theme 3**: Atmospheric deposition and ocean biogeochemistry;
- **Core Theme 4**: Interconnections between aerosols, clouds, and marine ecosystems;
- **Core Theme 5**: Ocean biogeochemical control on atmospheric chemistry;
- **Cross-Cutting Theme**: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
- **Cross-Cutting Theme**: Climate intervention;
- **Cross-Cutting Theme**: Science and society.

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

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

It turns out that in Denmark, the response and also the willingness to interact internationally is limited to very few individuals, mostly foreigners in DK, therefore the report is likely not representative. There might be similar experiences in other countries, from which we could benefit.

There might also be some material to be send out to institutes, which can be used to broadcast the SOLAS mission?

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**PART 1** - Activities from January 2023 to Feb/Mar 2024

1. **Scientific highlight**

   Novel pathway of N2O formation: Abiotic N2O formation driven by sunlight in fresh and marine waters
Nitrous oxide (N\textsubscript{2}O) is the main stratospheric ozone depleting agent, and the strongest greenhouse gas in the atmosphere. Classically, microbially-mediated processes, such as ammonia oxidation and denitrification are assumed to control the N\textsubscript{2}O budget in aquatic systems. Recent studies suggest that our understanding of N\textsubscript{2}O production is incomplete. Specifically, abiotic reactions like chemodenitrification may contribute significantly to N\textsubscript{2}O production, but their importance is uncertain, particularly in surface waters. Here, we experimentally demonstrate a significant and consistent production of N\textsubscript{2}O induced by sunlight under oxic abiotic conditions in two fresh and two marine waters, a novel process not considered for greenhouse gas budgets. N\textsubscript{2}O production was strongly correlated to the radiation dose. Nitrite is the main substrate, and the nitrate can also contribute after being photoreduced to nitrite. The authors defined this abiotic N\textsubscript{2}O photoproduction as photochemodenitrification. Photochemodenitrification exceeded biological production of N\textsubscript{2}O by ammonia oxidation in surface waters. We demonstrate that photochemodenitrification may be an essential and overlooked process occurring in fresh and marine surface waters across the globe, with particular importance in areas of high solar radiation and nitrite availability. Because it occurs in surface waters in direct contact with the atmosphere, photochemodenitrification may be responsible for a significant fraction of N\textsubscript{2}O emissions globally.

![Fig. 1: Photoproduction of N\textsubscript{2}O as function of UVB and PAR dose. Linear increases in the concentrations of N\textsubscript{2}O (N\textsubscript{2}O excess, nmol-N L\textsuperscript{-1}) in experiments](image)


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).

Field campaigns:

Greenland Sea campaign: Survey of Disko Bay (July 23), Time series measurements Qaanaaq fjord

Mediterranean Sea campaign: Time series measurements (4 times/yr) on Elba for N\textsubscript{2} fixation, CO\textsubscript{2} flux, trace gases.

International collaborations:

University of Gothenburg (SE), B. Thamdrup/ L. Bristow: N2O cycling

GEOMAR (DE), Princeton U. (USA), C. Löscher/ H. Bange/ E. Palmero: N2O cycling

Baltic Sea Network on N cycling (Malin Olofsson (SE), C. Löscher (DK), B. Szymczycha (PL), D. Hellemann (FI), M. Zilius (LA), G. Vali/ P. Laas (EST), H. Farnelid (SE), H. Bange (DE), L. Ruokanen (Helcom, FI): N turnover in the Baltic Sea

Collaborations across fields:
In-house collaboration on sea level rise and human health in India and Guinea-Bissau (collaborators within the Danish center of advanced study at the University of Southern Denmark, C. Løscher, A. Chang, C. Stabel-Benn), with a focus on salination of groundwater.

Collaboration on climate change and war around the Arctic. The project centers around the possibility of wars caused by altered ice-coverage of the sea and continental shelf, where territories might develop or get lost and power constellations will therefore shift (collaborators at the University of Southern Denmark, C. Løscher, at Cornell University J. Rogers).

Interdisciplinary activities:

Connections exhibition (https://www.sdu.dk/en/forskning/dias/news-new/news/20210819-thorarinsdottir-and-james-rogers-presents-connections-exhibition): A total of 18 life-size, androgynous, figurative sculptures created by the Icelandic artist Steinunn Thórarinsdóttir were arranged on the ground around the Danish Institute for Advanced Study, Center for War Studies, the SDU campus, Nordatlantisk Hus, in Odense city and outside the Icelandic Embassy in Copenhagen. They remind us of the frailty of the human condition, and how we battle the challenges and insecurities, such as COVID, climate change, and our divided politics, in today’s world. The sculptures raise questions about our perception of everyday life, and how we relate to each other.

We generally foster a strong collaboration with Nordatlantisk Hus in Odense, a cultural center of the Nordic countries (Greenland, Iceland, Farø islands), which represents Inuk art, politics, and culture. Providing a platform, involvement and inclusion to Inuk is integral to our Arctic research in the ocean and elsewhere.

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

**Strauss, J., Choi, C.J., Grone, J., Wittmers, F., Jimenez, V., Makareviciute-Fichtner, K. et al. (2023)**
The Bay of Bengal exposes abundant photosynthetic picoplankton and newfound diversity along salinity-driven gradients. Environmental Microbiology, 25(11), 2118–2141. Available from: https://doi.org/10.1111/1462-2920.16431


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?

No

PART 2 - Planned activities for 2024 and 2025

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

Bay of Bengal cruise, RV Sonne, April- May 2024 (SDU Thamdrup, Löschler), collaboration with GEOMAR (DE)

Greenland cruise summer 2024 (SDU, Löschler)

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

Aquatic Microbial and Molecular Ecology (AMME) summer school at SDU, regularly hosted in summer

3. Funded national and international projects/activities underway.

N2 fixation in Danish coastal waters (Rieman, Löschler, Markager, Danish Research Council)

N2O sinks in the Ocean (Löschler, Danish Research Council)

N2O in Danish waters (Thamdrup, Danish Research Council)

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

N2O in Greenlandic waters

Greenlandic Sea: N cycle assessment

Discerning mesoscale variability from decadal trends in Greenhouse gas turnover

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

Global ONCE CDRmare (DE)

HELCOM

ICES

Comments
Report for the year 2023 and future activities

SOLAS Finland
compiled by: Heidi Pettersson, Finnish Meteorological Institute (FMI)

with the input from Jukka-Pekka Jalkanen and Martti Honkanen (FMI), Joonas Virtasalo Geological Survey of Finland (GTK), Jukka Seppälä Finnish Environment Institute (SYKE) and Joanna Norkko University of Helsinki (UH).

This report has two parts:

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

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Core Theme 1: Greenhouse gases and the oceans;
Core Theme 2: Air-sea interfaces and fluxes of mass and energy;
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Core Theme 4: Interconnections between aerosols, clouds, and marine ecosystems;
Core Theme 5: Ocean biogeochemical control on atmospheric chemistry;
Cross-Cutting Theme: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
Cross-Cutting Theme: Climate intervention;
Cross-Cutting Theme: Science and society.

IMPORTANT: This report should reflect the efforts of the SOLAS community in the entire country or region 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. ?

A need has arisen to link air quality studies with those of water quality. However, emission inventories for air emissions do not necessarily contain relevant pollutant species especially for the contaminants. For air, it is relevant to model NOx, SOx, PM, and few metals (Cd, Pb) etc, but contaminants are not usually covered since these are not listed in the LRTAP convention as monitored species. PAHs, their alkylated forms and many more metals are relevant from water point of view, but emission/discharge inventories for these do not exist or they are for individual
sites. Therefore, it would be useful to develop a similar service of water discharge inventories as exists within Copernicus Atmospheric Monitoring Services for air emissions. This could be done under Copernicus marine, and it would enable studies of water quality everywhere in Europe. The need to understand the contaminants is very visible in the HELCOM HOLAS3 (Baltic Marine Environment Protection Commission/Holistic Assessment 3) report, which listed contaminants as the primary environmental concern over eutrophication.

PART 1 - Activities from January 2023 to Feb/Mar 2024

1. Scientific highlight

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).

Projects

- Kristian Spilling from SYKE coordinate an Academy of Finland funded PHYTOTRANS-project which will unravel the interplay between the phytoplankton community composition vertical and lateral particle transport on the organic matter remineralization in coastal seas, to better understand the coastal carbon sink. Themes #1, #5
- SYKE is participating in SapHTies (Metrology for standardized seawater pHT measurements) and MINKE (Metrology for integrated marine management and knowledge transfer network) EU-projects addressing metrological challenges for the measurement of seawater acidity. Projects have included interlaboratory comparisons and sensor comparisons for pH measurements. Theme #1
- In the EU-project NAUTILOS (New approach to underwater technologies for innovative, low-cost ocean observation) SYKE is testing low-cost pH sensor for FerryBox applications. Theme #1
- Project “Baltic Carbon” coordinated by Jukka Seppälä from SYKE and funded by Finnish Ministry of Environment, provided a list of recommendations how to organize a high resolution and impactful carbonate system monitoring of the Finnish waters in the Baltic Sea. Themes #1, #5
- Jukka-Pekka Jalkanen from FMI is the coordinator of the H2020/EMERGE project on the environmental impacts of shipping emissions. Themes #3, Science and Society

Field campaigns

- At Utö Marine station, joint continuous and high-frequency measurements with FMI and SYKE were ongoing approx. 60% of the year, including in-water pCO2 and pH, as well as relevant physical, chemical, and biological measurements to understand their impact on carbonate system variability. Themes #1, #2.
- Joonas Virtasalo from GTK participated in the Science Party of IODP Expedition 386 Japan Trench Paleoseismology. Theme #5
Workshops and conferences

- Sami Kielosto and Lari Kaukonen from SYKE participated in MINKE “pHT Interlaboratory Comparison on buffered artificial seawater and natural seawater “at MIO – AMU, Marseille, from the 13th to the 17th of November 2023. Theme #1.
- Martti Honkanen from FMI participated with a poster in the 14th Baltic Sea Science Congress (BSSC) in Helsinki, Finland. Theme #1.
- Martti Honkanen from FMI had an oral presentation in the FINMARI (Finnish Marine Research Infrastructure) Researcher Day 2023 in Helsinki, Finland. Theme #1.
- Scientists from FMI participated in the Joint Transport and Air Pollution & Shipping and Environment conference in Gothenburg. FMI was included in 16 conference abstracts of TAP&SEAAssistance for EMSA/EEA with the 2nd European Maritime Transport Environmental Report through EMERGE and CAMS2-61 project data deliveries. Themes #3, Sciences and Society.

Working group and committees

- Jukka-Pekka Jalkanen from FMI participated in the ICES WGSHIP (ICES Working Group on Shipping Impacts in the Marine Environment) work. Themes #3, Science and society.
- Aarno Kotilainen from GTK is a member, Joonas Virtasalo from GTK and Petteri Uotila from HU are deputy members in the committee for the planning of the Finnish national Implementation Plan for the UN Decade of Ocean Science. All themes.
- Petteri Uotila from University of Helsinki is the Chair and Heidi Pettersson from FMI the vice chair of the Finnish National Committee of SCOR. Themes 1-5
- Heidi Pettersson from FMI is the Finnish National Correspondent of IAPSO/IUGG. Themes 1,2, Cross-cutting themes
- Joonas Virtasalo from GTK is the Finnish national delegate in ESSAC (Science committee of ECORD, European Consortium for Ocean Research Drilling), the European branch of IODP. Themes Climate intervention, Science and society.

Reports, assessments, etc

- Jukka-Pekka Jalkanen from FMI produced two IMO submissions from EMERGE project (MEPC 81/INF.21 and PPR 11/INF.11), to support the Finnish delegation on the issue of exhaust gas cleaning systems. These were accompanied with a large report published in Jan 2024. Themes #3, Science and society.
- Jukka-Pekka Jalkanen from FMI produced three reports to HELCOM IG Maritime 2023 (air emissions, discharges, noise from Baltic Sea shipping) and Heidi Pettersson from FMI a report on the Baltic Sea wave climate to HELCOM BSEFS 2023. Themes #2, #3, Science and society.

Data

- Atmospheric GHG measurements at Tvärminne Zoological Station of HU were approved with an ICOS (Integrated Carbon Observation System) station label for Associated Ecosystem station (https://meta.icos-cp.eu/resources/stations/ES_FI-Tvm), Currently the ocean station is under development. Theme #1
- The ICOS OTC (Integrated Carbon Observation System/Ocean Thematic Center) labelling process of the pCO2 measurement on M/S Silja Serenade ferrybox
travelling between Helsinki and Stockholm is progressing and new equipment will be acquired. **Theme #1.**

- FMI continued delivery of ship emissions products for Copernicus Atmosphere Monitoring Systems (CAMS2-61) for global and regional emissions. **Themes #3, Science and society.**

**International collaborations**

- Jukka Seppälä from SYKE has been collaborating with Hellenic Centre for Marine Research (Greece) on their high-frequency observations of carbonate system. **Themes #1, #5**
- Lumi Haraguchi from SYKE has been collaborating with University of Cape Town (South Africa) on Atlantic Southern Ocean productivity and carbon export. **Themes #1, #5**

**3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.**


• Jalkanen, J.-P., Johansson, L., Heikkilä, M., Majamäki, E. (2023) "Discharges to the sea from Baltic Sea shipping in 2022", Submission from Finland to HELCOM Maritime 2023 (Oct 2023). **Themes #3, Science and society.**

• Jalkanen, J.-P., Johansson, L., Majamäki, E. (2023) "Underwater noise emissions from Baltic Sea shipping in 2022", Submission from Finland to HELCOM Maritime 2023 (Oct 2023). **Themes #3, Science and society.**


• Manshausen, P., Watson-Parris, D., Christensen, M. W., Jalkanen, J.-P., Stier Ph. (2023) Rapid saturation of cloud water adjustments to shipping emissions, Atmos. Chem. Phys., 23, 12545–12555, [https://doi.org/10.5194/acp-23-12545-2023](https://doi.org/10.5194/acp-23-12545-2023). **Themes #3, Science and society.**


• Russo, M., Carvalho, D., Jalkanen J.-P., Monteiro, A., (2023) Future impact of shipping emissions on air quality in Europe under climate change, Atmosphere, 14 (7), 1126. [https://doi.org/10.3390/atmos14071126](https://doi.org/10.3390/atmos14071126). **Themes #3, Science and society.**

• Solonen, A., Maraila, R., Springer, S., Haario, H., Laine, M., Räty, O., Jalkanen, J.-P., Antola, M., (2023) Hierarchical Bayesian propulsion power models for marine vessels, Ocean...
Themes #3, Science and society.


**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?**

**PART 2 - Planned activities for 2024 and 2025**

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

- FMI is taking part in an onboard measurement campaign of GREEN RAY to determine methane slip from LNG vessel in spring 2024 (organized by Technical Research Centre of Finland VTT). **Themes #1, Science and society.**

- At FMI, there will be various modeling studies of air emissions, discharges, and underwater noise in 2024-2025. **Themes #3, Science and society**

- SYKE will continue the tests with a low-cost pH sensor throughout spring in FerryBox (H2020/NAUTILO). **Theme #1**

- SYKE will report the developments in improving metrology of pH measurements in the SapHTies (EMPIR/H2020/EURAMET) project. **Theme #1.**

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

- Jukka-Pekka Jalkanen from FMI will (mainly **themes #3 and Science and society**)  
  o Will be part of the organizing team in UH and FMI of the conference “Air-Quality – from science to applications 2024” in Helsinki, Finland, May 2024.
  o Will be co-convener in one EGU2024 session.
  o Will participate in IMO PPR11 and IMO MEPC81 meetings in London, UK

- GTK will be the main organizer of the FINMARI Researcher Day 7.3. 2024 in Espoo, Finland. **All themes.**

- The 12th FerryBox Workshop will be organized in October 2024 in Helsinki, Finland.
3. Funded national and international projects/activities underway.

- Jukka-Pekka Jalkanen from FMI is the coordinator of H2020/EMERGE (Evaluating, control and Mitigation of the Environmental impacts of shipping Emissions). *Themes #3, Science and Society.*
- Jukka-Pekka Jalkanen is the FMI PI of the Horizon Europe/GREEN RAY project aiming to assess and mitigate methane slip from shipping. *Themes #3, Science and Society.*
- Jukka-Pekka Jalkanen is the FMI PI of CAMS2-61 (Global and European emission inventories/ Coperinic Atmosphere Monitoring Service). *Themes #3, Science and Society.*
- Jukka-Pekka Jalkanen is the FMI PI ShipNOEm project (national funding) on NOx emissions from shipping. *Themes #3, Science and Society.*
- Jukka-Pekka Jalkanen is the FMI PI of the Horizon Europe/GREEN RAY project aiming to assess and mitigate methane slip from shipping. *Themes #3, Science and Society.*
- Kristian Spilling from SYKE coordinates project “The Impacts of Phytoplankton Community Composition and Particle Transport Pathways on the Biological Carbon Pump in Coastal Seas Under the Changing Climate – PHYTOTRANS” funded by Academy of Finland. *Themes #1, #5.*
- Joonas Virtasalo from GTK is the PI of an Academy of Finland Project called FERMAID - Ferromanganese Concretion-Archives of Ecosystem Variability, Climate Forcing and Anthropogenic Impact on the Baltic Sea. *Theme #5.*
- Joonas Virtasalo from GTK is the PI of an Academy of Finland Project called GEOMEASURE - Foundations for green offshore energy production in Finland: from marine investigations to the numerical estimation of undrained shear strength of the seabed deposit layers under cycling loading. *Theme #5.*
- Joonas Virtasalo from GTK is the PI of a Foundation for Research of Natural Resources in Finland Project: FeCoVERY - Recovery and sustainable use of Baltic Sea ferromanganese concretions as a resource of hi-tech metals. *Theme #5.*

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

- FMI is preparing applications at least to following funding instruments (mainly *themes #3, Science and society*):
  - Strategic Research Council, Water call (National funding).
  - Nordforsk Arctic call (Nordic Council of Ministers)
  - Business Finland (national funding) – underwater noise

5. Engagements with other international projects, organisations, programmes, etc.
• FMI is engaged or cooperating in the following organisations:
  o Planned cooperation with WWF Canada. *Themes #3, Science and Society.*
  o Cooperation with the UK project Atmospheric Composition and Radiative forcing changes due to UN International Ship Emissions regulations ACRUISE. *Themes #3, Science and Society.*
  o Cooperation with Portuguese national shipping project. *Themes #3, Science and Society.*
  o Cooperation with Irish national project on alternative fuels for shipping. *Themes #3, Science and Society.*
  o Cooperation with Statistics Finland. *Themes #3, Science and Society.*

**Comments**

• The research related to shipping at FMI deals with environmental topics of the IMO MEPC (International Maritime Organization/Marine Environment Protection Committee), whether these relate to air emissions, discharges, or underwater noise. This facilitates wide cooperation in a range of topics.
Report for the year 2023 and future activities

SOLAS France
compiled by: Marie Boye, Karine Sellegri, Rémi Losno

This report has two parts:

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

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Core Theme 2: Air-sea interfaces and fluxes of mass and energy;
Core Theme 3: Atmospheric deposition and ocean biogeochemistry;
Core Theme 4: Interconnections between aerosols, clouds, and marine ecosystems;
Core Theme 5: Ocean biogeochemical control on atmospheric chemistry;
Cross-Cutting Theme: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
Cross-Cutting Theme: Climate intervention;
Cross-Cutting Theme: Science and society.

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

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**PART 1 - Activities from January 2023 to Feb/Mar 2024**

1. **Scientific highlight**

C. Panagiotopoulos ([christos.panagiotopoulos@mio.osupytheas.fr](mailto:christos.panagiotopoulos@mio.osupytheas.fr)), K. Violaki, J. Castro-Jimenez, A. Nenes, R. Sempéré, Institut Méditerranéen d’Océanologie

**Spatial and temporal patterns of organophosphate Esters flame retardants and plasticizers in airborne particles over the Mediterranean sea**

Organophosphate esters flame retardants (OPEs) were measured in total suspended particles at the two edges of the Mediterranean Sea (semi-rural areas at Heraklion/Crete and Marseille/France) under the influence of the transport of polluted air from Europe and dust from the Sahara. In NW Mediterranean total average $\Sigma_6$OPEs concentration was $2103 \pm 2020$ pg m$^{-3}$ ($n = 23$) with 2-ethylhexyl
diphenyl phosphate (EHDPP) and tris(1-chloro-2-propyl) phosphate (TCPP) to be the predominant OPEs, accounting on average for 46% and 37% of the total ΣOPEs concentrations, respectively. On the other hand, the average concentration of ΣOPEs in East Mediterranean was 156.4 ± 170.3 pg m⁻³ (n = 67) with TCPP showing the highest concentration (116.1 ± 92.8 pg m⁻³), followed by Tris-(2-chloroethyl) phosphate (TCEP) with an average concentration of 67.5 ± 55.8 pg m⁻³. The highest concentrations were recorded during the summer period in the East Med. while in the NW Med. was recorded during spring. The latter is justified from the presence of EHDPP with higher concentrations during Saharan dust transportation, which happens more often in the spring. In both areas, OPEs were mostly associated with fossil fuel combustion and road traffic, while the air masses from Saharan desert influenced the concentration of EHDPP, TCEP in NW Mediterranean and the TCEP concentration levels in the East Mediterranean. The total concentration of OPEs in NW Med. was 57 times higher than the East area, while the total annual deposition of OPEs to the Mediterranean basin was estimated to 584 tonnes, accounting for about 8.5% of the total deposited anthropogenic phosphorus. The implications of the increased OPE-induced compounds of anthropogenic origin will likely affect the extremely low P pool in the Mediterranean Sea and therefore should be one of the research priorities in the future due do the massive global used of these plastic additives with the lack of a sound regulatory framework.

Reference
Violaki et al. (2024). Chemosphere 348, 140746, DOI:10.1016/j.chemosphere.2023.140746

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H. Angot (helene.angot@univ-grenoble-alpes.fr), IGE, University of Grenoble Alpes

Multidisciplinary drifting Observatory for the Study of Arctic Climate

During Arctic summers, rapid snow and sea ice melt release low-salinity meltwater into the surface ocean, forming thin layers on and under sea ice floes (see Photos). Recent observations from the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) expedition highlight the persistence and impact of these meltwater layers, which act as barriers for nutrient and gas exchange, influencing ecosystem dynamics (Smith et al., 2023). Additionally, these layers affect atmospheric mercury (Hg) concentrations in the Arctic (Yue et al., 2023). Analysis from MOSAiC, coupled with modeling suggests that over 50% of the explained variability in atmospheric Hg concentrations is due to oceanic evasion. Notably, this process occurs predominantly in the Marginal Ice Zone rather than the central Arctic Ocean. These findings suggest that meltwater layers may contribute to the lack of Hg
evasion from the central Arctic by buffering gas exchange processes. This underscores the complex relationship between Arctic sea ice changes and lower atmospheric composition.

References

R. Lapere (remy.lapere@univ-grenoble-alpes.fr), IGE, University of Grenoble Alpes

The Representation of Sea Salt Aerosols and Their Role in Polar Climate Within CMIP6

The ocean is a major source of aerosols and aerosol precursors. These aerosols then impact the climate through their interaction with sunlight (direct effect) and their role in cloud formation (indirect effect). We evaluated how sea salt aerosols are represented in polar regions in CMIP6 models and found a large diversity across models, and an inadequate representation of seasonality compared to observations at high latitudes (Lapere et al., 2023). The misrepresentation at high-latitude, which
implies a large uncertainty on the radiative budget, can be attributed to the absence of representation of the sources of sea salt in sea ice regions (blowing snow, leads) in the CMIP6 climate models. This finding motivated the development of the first parameterization for the representation of sea spray fluxes emitted from leads (Lapere et al., in prep). Computations with a conceptual model and sensitivity analyses with the WRF-Chem regional atmospheric chemistry model indicate that sea salt aerosols from leads in the Arctic could be as important for the aerosol budget as the sea salt aerosols transported from open ocean regions. The ocean also releases gases such as DMS that can lead to the formation of secondary aerosols highly relevant for cloud formation. We are currently working with the University of Victoria on improving the oceanic DMS used as a boundary condition in WRF-Chem and the representation of its chemistry.

Schematic of the ocean-atmosphere interactions in polar regions through sea spray aerosols. Created by R. Lapere.

References
Lapere, R., Thomas, J. L., Marelle, L., et al. Bounding the contribution of leads to sea spray aerosol emissions in the high Arctic, in prep.

A. Shaddy (shaddy.ahmed@univ-grenoble-alpes.fr), J.L. Thomas (jennie.thomas@univ-grenoble-alpes.fr), IGE, University of Grenoble Alpes

Coupled chemical cycling between sea-ice, snow, and the atmosphere during Arctic spring

Near-surface mercury and ozone depletion events occur in the lowest part of the atmosphere during Arctic spring. Mercury depletion is the first step in a process that transforms long-lived elemental mercury to more reactive forms within the Arctic that are deposited to the cryosphere, ocean, and other surfaces, which can ultimately get integrated into the Arctic food web. Depletion of both mercury and ozone occur due to the presence of reactive halogen radicals that are released from snow, ice, and aerosols. In this work, we added a detailed description of the Arctic atmospheric mercury cycle to our
recently published version of the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem 4.3.3) that includes Arctic bromine and chlorine chemistry and activation/recycling on snow and aerosols. The major advantage of our modelling approach is the online calculation of bromine concentrations and emission/recycling that is required to simulate the hourly and daily variability of Arctic mercury depletion. We used this model to study coupling between reactive cycling of mercury, ozone, and bromine during the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) spring season in 2020 and evaluated results compared to land-based, ship-based, and remote sensing observations. The model predicts that elemental mercury oxidation is driven largely by bromine chemistry and that particulate mercury is the major form of oxidized mercury. The model predicts that the majority (74%) of oxidized mercury deposited to land-based snow is re-emitted to the atmosphere as gaseous elemental mercury, while a minor fraction (4%) of oxidized mercury that is deposited to sea ice is re-emitted during spring. Our work demonstrates that hourly differences in bromine/ozone chemistry in the atmosphere must be considered to capture the springtime Arctic mercury cycle, including its integration into the cryosphere and ocean.

Simulated mean surface ozone concentration. Surface ozone concentration is averaged for the full simulation period (March 14 to April 14, 2020). Observational averages for the same period are shown by markers with the same colour scale.

Reference

J.L. Thomas (jennie.thomas@univ-grenoble-alpes.fr) and H. Angot (helene.angot@univ-grenoble-alpes.fr), IGE, University of Grenoble Alpes

Polar oceans and sea ice in a changing climate

Polar oceans and sea ice cover 15% of the Earth’s ocean surface, and the environment is changing rapidly at both poles. Improving knowledge on the interactions between the atmospheric and oceanic realms in the polar regions, a Surface Ocean-Lower Atmosphere Study (SOLAS) project key focus, is essential to understanding the Earth system in the context of climate change. However, our ability to monitor the pace and magnitude of changes in the polar regions and evaluate their impacts for the rest of the globe is limited by both remoteness and sea-ice coverage. Sea ice not only supports biological activity and mediates gas and aerosol exchange but can also hinder some in-situ and remote sensing observations. While satellite remote sensing provides the baseline climate record for sea-ice
properties and extent, these techniques cannot provide key variables within and below sea ice. Recent robotics, modeling, and in-situ measurement advances have opened new possibilities for understanding the ocean–sea ice–atmosphere system, but critical knowledge gaps remain. Seasonal and long-term observations are clearly lacking across all variables and phases. Observational and modeling efforts across the sea-ice, ocean, and atmospheric domains must be better linked to achieve a system-level understanding of polar ocean and sea-ice environments. As polar oceans are warming and sea ice is becoming thinner and more ephemeral than before, dramatic changes over a suite of physicochemical and biogeochemical processes are expected, if not already underway. These changes in sea-ice and ocean conditions will affect atmospheric processes by modifying the production of aerosols, aerosol precursors, reactive halogens and oxidants, and the exchange of greenhouse gases. Quantifying which processes will be enhanced or reduced by climate change calls for tailored monitoring programs for high-latitude ocean environments. Open questions in this coupled system will be best resolved by leveraging ongoing international and multidisciplinary programs, such as efforts led by SOLAS, to link research across the ocean-sea ice-atmosphere interface.

Reference

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Emma Moreau (emoreau@ipgp.fr) and Marie Boye (boye@ipgp.fr), IPGP

Tropical island mass-effect on coastal biogeochemistry and phytoplankton assemblage: the case of Guadeloupe (French West Indies)

Tropical islands are often located in oligotrophic gyres, where nitrogen is the most limiting macronutrient for phytoplankton development. Those oceanic provinces can also be co-limited by low inputs of nutritive metals such as iron. However, phytoplankton production can be very intense around islands, as shown by satellite observations. It is due to the various inputs originating from the island (rivers, runoff water, groundwater) and to processes occurring around it (upwelling, vertical mixing, resuspension of sediment, atmospheric Saharan dust deposition, wet deposition) as represented in the Guadeloupe island where no study is existing (Fig. 1). Topography and exposition to the wind also play...
a major role in the nutrient distribution. In order to quantify these inputs and determine the impact on the phytoplankton assemblage, we did two field campaigns at sea and on land in Basse-Terre (Guadeloupe) during the wet season (June 2023) and dry season (January 2024) to capture the seasonality effect.

Preliminary results obtained during the wet season suggested that the island mass effect is different depending on the coast and it is not exported offshore. Indeed, on the Atlantic coast, atmospheric dust deposition and rivers (weathering) are sources of particulate iron and the coastal sediment dissolution is a major source of dissolved iron. Human activities are a major source of nitrate. These high nutrient concentrations explain the relatively high chlorophyll-a concentration and the dominance of diatoms on the shelf. By contrast, on the Caribbean coast, dissolved iron is coming from hydrothermal activity but there are low nitrate concentrations corresponding to oligotrophic waters. This amount of nutrients can explain a much lower chlorophyll-a concentration and the predominance of cyanobacteria (Moreau et al., in prep.).

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Clément Demasy (demasy@sun.ac.za) and Marie Boye (boye@ipgp.fr)

Highlight 1- Iron dissolution from Patagonian dust in the Southern Ocean: under present and future conditions

Although the input of desert dust as a key source of trace metals in the Southern Ocean (SO) has been previously studied, the dissolution process of metals in surface waters, particularly iron (Fe), remain poorly understood. Given the crucial role of Fe in primary production and the biological carbon pump in the SO, we focused on experimental estimations of Fe dissolution from Patagonian dust, the primary natural dust source in the SO. There, we aimed to diagnose the effects of increased dust deposition and other predicted changes on the solubility of Fe and other trace metals in Patagonian dust. Our study considered both current and projected future conditions, encompassing sea-surface warming, acidification, increased photosynthetically active radiation, and doubled dust inputs. Through controlled laboratory experiments using filtered SO seawater, conducted over 7 days, we assessed changes in particulate Fe (pFe) concentrations, Fe redox speciation (Fe(II)/Fe(III)), and in the mineralogy of Fe-bearing dust in abiotic condition.

The predominant minerals in the dust included quartz and aluminosilicates, with silicon (Si), aluminum (Al), and Fe as the major elements. No significant alterations in the mineralogy and the elemental composition of the dust were recorded during the dissolution experiments, neither under present nor
under projected future conditions. The particulate Fe(II)/Fe(III) ratio remained consistently at 0.25 during the experiments, unaffected by changed conditions. Consequently, changes in environmental conditions in the SO would therefore not significantly alter the mineralogy and redox speciation of pFe in the Patagonian dust. On the contrary, pFe exhibited a dissolution rate of 3.8% and 1.6% per day under present and future conditions, respectively. The environmental changes anticipated for 2100 in the SO will likely result in a decrease in the dissolution rate of pFe. Consequently, the future intensification of Patagonian dust inputs may not alleviate the Fe limitation in the SO (Demasy et al., in press).

Highlight 2 - Impact of Patagonian dust and future environmental changes on the natural phytoplankton community in the Polar Frontal Zone and the HNLC area of the Southern Ocean (Indian sector)

The Southern Ocean (SO) plays a major role in the global sequestration of atmospheric carbon dioxide, driven by its biological carbon pump. Atmospheric inputs from Patagonia are dominant in the SO and contribute to fertilize surface waters by providing iron and other nutrients to phytoplankton. Projections suggest an increase in these inputs alongside other anticipated environmental shifts like warming and acidification of waters by 2100. Yet, the cumulative effects of these changes and the intensification of Patagonian inputs on phytoplankton dynamics remain uncertain, potentially reshaping the intensity of the primary production.

We aimed to diagnose the net effect of these multifaceted changes on phytoplankton communities, assessing their individual and interactive effects. This study aimed to estimate the impacts of these changes on the growth, composition and productivity of phytoplankton assemblages in the Polar Frontal Zone (PFZ) and the HNLC region of the Indian sector of the SO during the austral 2022 summer aboard R/V Marion Dufresne. Natural phytoplankton communities underwent a 5-day incubation under 4 scenarios (actual and future environmental conditions, alongside 2 intermediate scenarios). In the PFZ, warming and acidification stimulated phytoplankton growth, mainly cyanobacteria, while intensified dust inputs alone didn’t exhibit significant impacts. Conversely, in HNLC waters, the addition of Fe-dust increased the biomass of diatoms (mainly *F. kerguelensis*) under current temperature and pH conditions, whereas the negative effect of acidification and warming in the future conditions.
counteracted the positive impact of Fe-dust input on the diatoms. The phytoplankton assemblage was not modified by future conditions in the PFZ and the HNLC area, where, respectively, picophytoplankton remained the predominant species at this season and diatoms persisted as the dominant biomass. The particulate organic carbon production by photosynthesis was also not altered by future conditions, suggesting that primary production may not change in the future SO. But the increase in the length and the number of long-chain diatoms under future conditions in the HNLC area may indicate that particulate organic carbon export may intensify in the future (Demasy et al., in prep.).

References

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K. Sellegri (K.Sellegri@opgc.univ-bpclermont.fr) and co-workers, LaMP

Highlight 1 (Theme 5). In Peltola et al. (2023), we report on the chemical precursors to nucleation in air masses originating from the open South Western Pacific Ocean. Measurements of natural ion clusters composition were conducted over 7 months at Baring Head, coastal New Zealand and showed that while over land new particle formation is likely driven by sulfuric acid and organic species, in clean marine air of this area iodine oxoacids and sulfur species are likely important drivers of particle
formation processes. Bisulfate anions displayed a clear daytime maximum whereas iodine oxoacids had morning and evening maxima.

Highlight 2 (Themes 4). A french contribution to the international effort to gather the state of knowledge on aerosol-cloud interactions in the Southern Ocean. In Sellegri et al. (2023), we investigate the influence of surface seawater biogeochemical composition on the temperature dependence of number-based sea spray emission fluxes. The dependence of sea spray fluxes was investigated in different water masses (i.e., subantarctic, subtropical and frontal bloom) with contrasting biogeochemical properties across a temperature range from ambient (13-18°C) to 2°C using seawater circulating in a plunging jet sea spray generator. Sea spray total concentration was found to increase by an average 4-fold at 2°C compared to ambient temperatures, with the highest impact of temperature in subtropical seawaters. The temperature dependence of the sea spray flux was found to be inversely proportional to the abundance of the cyanobacterium *Synechococcus* in seawater.
Highlight 3 (Theme 5). Using measurements collected in ship-borne air-sea interface tanks deployed in the Southwestern Pacific Ocean, Chamba et al. (2023) identified new particle formation during nighttime that was related to plankton community composition. They show that nitrate ions are the only species for which abundance could support new particle formation rates in the semi-controlled experiments. Nitrate ions also prevailed in the natural pristine marine atmosphere and were elevated under higher sub-10 nm particle concentrations. The hypothesis for the nitrate-based emissions that are complex, short-term biogeochemical cycling involving the microbial loop.

References

V. Garçon (garcon@ipgp.fr) and co-workers, IPGP & LEGOS

Research work over the last year has been carried out under the SOLAS cross-cutting theme Integrated topics: Upwelling systems, looking at the impact of multi-stressors (warming, ocean acidification, deoxygenation) on marine ecosystems.

Highlight 1. Major coastal upwelling systems are among the most productive marine ecosystems in the world. They contribute disproportionately to the cycling of carbon and nutrients in the ocean and influence marine biogeochemistry beyond their productive regions. Characterized by intense microbial respiration (both aerobic and anaerobic), major coastal upwelling systems are also hotspots for the production and outgassing of potent greenhouse gases (GHG) such as CO₂, N₂O, and CH₄. Quantifying and understanding these roles in the context of a changing climate is therefore a subject of great interest. Here we provide a short synthesis of the current knowledge of the contributions of major coastal upwelling systems to the cycling of GHG. Despite variations within and among different systems, low-latitude coastal upwelling systems typically act as a net carbon source to the atmosphere, while those at higher latitudes function as weak sinks or remain neutral regarding atmospheric CO₂. These systems also significantly contribute to oceanic N₂O and CH₄ emissions, although the extent of their contribution to the latter remains poorly constrained. We also overview recent and future changes to upwelling systems in the context of a warmer climate and discuss uncertainties and implications for GHG production. Although rapid coastal warming is anticipated in all major coastal upwelling systems, the future changes in upwelling-favorable winds and their implications within the context of increased stratification are uncertain. Finally, we examine the major challenges that impede our ability to accurately predict how major coastal upwelling systems will respond to future climate change, and present recommendations for future research to better capture ongoing changes and disentangle natural and forced variability.
Highlight 2. On-going climate change is now recognized to yield physiological stresses on marine species, with potentially detrimental effects on ecosystems. Here, we evaluate the prospect of using climate velocities (CV) of the metabolic index ($\Phi$) for assessing changes in habitat in the South East Pacific. Methods: Our approach is based on a species with mean ecophysiotype (i.e. model species) and the use of a global Earth System Model simulation (CESM-LE) under RCP 8.5 scenario. The SEP is chosen as a case study as it hosts an Oxygen Minimum Zone and seamounts systems sustaining local communities through artisanal fisheries. Our results indicate that CV$_\Phi$ pattern is mainly constrained by the oxygen distribution and that its sign is affected by contrasting oxygen trends (including a re-oxygenation in the upper OMZ) and warming. We further show that CV$_\Phi$ is weakly dependent on physiological traits composing $\Phi$, which conveys to this metrics some value for inferring the projected mean displacement and potential changes in viability of metabolic habitat in a region where physiological data are scarce. Based on sensitivity experiments to physiological traits and natural variability, we propose a general method for inferring broad areas of climate change exposure regardless of species-specific $\Phi$. We show in particular that for the model used here, the upper OMZ region can be considered a “safe” area for the species with ecophysiotype close to that of 71 species used to derive the model species. Limitations of the approach and perspectives of this work are also discussed.

Highlight 3. The South East Pacific (SEP) is characterized by the presence of an oxygen minimum zone (OMZ) embedded in the subsurface waters of the very productive upwelling system along the coast of Peru and Chile. This OMZ is currently diversely simulated by state-of-the-art Earth System Models (ESM) hampering a reliable projection of ocean deoxygenation on marine ecosystem services in these regions. We showed that, despite the low consensus among ESM long-term projections of oxygen levels, the sensitivity of the depth of the upper margin (oxycline) of the SEP OMZ to El Niño events in an ensemble of ESMs can be used as a predictor of its long-term trend, which establishes an emergent
constraint for the SEP OMZ. Because the oxycline along the coast of Peru and Chile deepens during El Niño events, the upper bound of the SEP OMZ is thus likely to deepen in the future climate, therefore oxygenating the SEP OMZ.

**Highlight 4.** While mechanisms are being established to strengthen ocean mitigation and adaptation measures across relevant UN and international conventions, capacity for generating tailored information for local management, policy response and preparedness remains a significant barrier to advancing necessary adaptation efforts to help break down this barrier, OARS Outcome 3 will contribute to co-design and implement observation strategies in collaboration with data/information producers and end-users, supported by capacity building, to ensure vulnerable areas are adequately monitored and baseline information for newly developed carbon removal strategies is provided. To have the capability to effectively co-design activities, all interested stakeholders involved in that co-building of observing systems need an effective knowledge to engage more effectively. Stakeholders need to understand how the natural and human systems work and how they interact. Without this key understanding, there will not be any willingness for action. We witness a current plethora of individual monitoring activities operating over different spatial and temporal scales, all with different objectives and approaches. Only targeted co-built observation strategies will guide successful coral reef restoration, fisheries and aquaculture resilience strategies, innovative nature-based projects, carbon removal strategies, land-based pollution controls and climate responsive marine spatial planning and conservation effort.

**References**


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C. Guieu (cecile.guieu@imev-mer.fr), LOV, and E. Ortega-Retuerta (eva.ortega-retuerta@obs-banyuls.fr), LOMIC

**How biomass combustion aerosols affect the chemical composition of seawater and what is its impact on marine micro-organisms?**

The overall aim of PYROPLANKTON (PI J. Llort, funded by ESA) and PYROPLANKTON-LEFE (PIs C. Guieu, LOV et E. Ortega-Retuerta LOMIC, funded by LEFE of French CNRS-INSU in 2023-2024) is to provide a detailed mechanical understanding of how biomass combustion aerosols affect the chemical composition of seawater and its impact on marine micro-organisms. A combination of experimental approach (know-how at LOV) and modeling of the parameters obtained (know-how of Joan Llort, Computer Center, Barcelona), will enable us to better represent this source of nutrients for the water column. In July 2022, for the first time at LOV, we conducted a ground-breaking experiment using ash collected after a real forest fire (collaboration Cristina Santin, Spain), to gain a detailed mechanical understanding of how biomass combustion aerosols (BBA) disrupt the chemical composition of seawater and their impact on marine micro-organisms. To do this, we used our cleanroom container in "sedentary" mode in the laboratory, pumping water from the Bay of Villefranche during the oligotrophic summer season. These experiments enabled us to quantify, for the 1st time, the
adsorption/desorption kinetics of nutrients and metals (with a strong focus on iron) provided by BBa in seawater, the pattern of dissolved organic matter, as well as their impact on biota (bacteria and phytoplankton). Results have been presented at several occasion by C. Guieu (XMAS-VI 2023) and J. Llort (ASLO Aquatic Sciences Meeting 2023) and are currently under publication.

The experiment lasted 14 days. Among the 9 tanks: 4 were filled with 0.2 µm filtered seawater to remove phytoplankton (1 control with no addition and 3 with the same atmospheric flux) (those tanks are covered with black plastic bags on the left picture); 5 tanks were filled with unfiltered seawater (=natural assemblage) (1 control with no addition and 5 tanks representing a gradient of atmospheric deposition). We chose to represent wet deposition and designed a rotating device that correctly imitated the rain droplets containing the BBa particles deposited on the surface of each tank.

Reference
Guieu C., et al.: Biogeochemical response in surface ocean after wildfire ash deposition: results from minicosms experiment. Sixth Xiamen Symposium on Marine Environmental Sciences (XMAS-VI), Jan 9-12, 2023 (EST Time) in Xiamen, China. Invited Speech
Llort J., et al.: Biogeochemical impacts of wildfire ash deposition on the surface ocean: results from minicosms experiment, ASLO Aquatic Sciences Meeting 2023, 4-9 June 2023 · Palma de Mallorca, Spain

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<th>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).</th>
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**POLAR-Change**
The POLAR-CHANGE ship campaign, led by the Institut de Ciencies del Mar in Barcelona, took place on board on the Hesperides, in the Weddell Sea (Antarctica) during Feb-March 2023 with the goal of investigating how sea ice melting is impacting primary and secondary marine emissions. CNRS-LaMP contributed to this ship campaign with shipborne mesocosms for characterizing gaz-phase precursors to nucleation and with temperature-controlled sea spray generation.

**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/).
The Arctic and Antarctic regions are experiencing rapid and unprecedented changes due to polar and global climate change, clearly caused by anthropogenic activities. 21st century projections show substantial decrease of sea ice in both Arctic and Antarctic, which are expected to impact people in the Arctic and also society beyond polar regions. The CRIceS project focuses on improving model predictions of the role of polar processes in the climate system that consists of the oceans, ice and...
snow cover, and the atmosphere. It is crucial to understand the role of the polar processes, such as feedback loops, in polar and global climate. One of the main ways scientists can improve our understanding of environmental change is to combine knowledge from different disciplines in a coordinated way. The CRiceS project brings together 20 international research teams, from Europe, Canada, South Africa, and India, at the forefront of polar and global climate research. The CRiceS research project aims to enhance the modelling of the impacts that these regions have for the global climate.


CERTAINTY

Cloud-aERosol inTeractions & their impActs IN The earth sYstem (https://certainty-aci.eu/). The recent decade has seen an unprecedented acceleration in climate change and related weather extremes. Significant questions remain regarding how aerosol-cloud-radiation interactions control and modify these events. CERTAINTY aims to deliver the knowledge and models that provide improved confidence and representation of the role of cloud-aerosol-radiation interactions in climate and weather. This translates to better understanding and predictions of extreme events and facilitates planning climate mitigation and adaptation strategies for the good of the society.

ISLE

The project ISLE aimed to evaluate the island mass-effect on marine biogeochemistry and the phytoplankton assemblage in the tropical island of Guadeloupe (French West Indies). Two field campaigns at sea and on land were carried out by an IPGP team in collaboration with the University of Antilles (Pierre-Yves Pascal) and ObsERA (Observatory of Water and Erosion in the Antilles, Céline Dessert, IPGP) in June 2023 and January 2024 to examine this island mass-effect.

Selected communications at International Conferences


Demasy C., Boye M., Burckel P., Monna F., Losno R.: Solubility of trace metals from Patagonian dust in the future Southern Ocean. Oral presentation, SOLAS France meeting, 29/03/2021, visioconference.

Demasy C., Boye M., Lai B., Burckel P., Feng Y., Losno R., Borensztajn S., Besson P.: Iron dissolution from Patagonian dust in the Southern Ocean: under present and future conditions. 27/03/2024, Department of Earth Sciences, Stellenbosch University, Stellenbosch, South Africa.

Demasy C.: Solubility and bioavailability of Patagonian dust in the future Southern Ocean. 16/03/2023, Laboratoire des sciences du climat et de l’environnement, Gif sur Yvette, France.

multidisciplinary community of practice for the study of methylated sulfur compounds in the ocean: SCOR working group DMS-PRO. *ASLO Aquatic Sciences meeting*, June 4-9, Palmas de Mallorca, Spain.

Guieu C., Llort J, Bressac M, Gazeau F, Urruti P, Montanes M, Uher E, Santin C, Santiso M, Djaoudi K, Pulido E, Ortega-Retuerta E, Marie B, Biogeochemical response in surface ocean after wildfire ash deposition: results from minicosms experiment. Sixth Xiamen Symposium on Marine Environmental Sciences (XMAS-VI), Jan 9-12, 2023 (EST Time) in Xiamen, China. *Invited Speech*


3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

**Contributions of French community to international collaborative works:**


**Core theme 1:**

Core theme 3:
Violaki et al. (2024). Chemosphere 348, 140746, DOI:10.1016/j.chemosphere.2023.140746


Core theme 4:

Core theme 5:


Cross-Cutting Theme: polar oceans and sea ice


Lapere R. et al.: The Representation of Sea Salt Aerosols and Their Role in Polar Climate Within CMIP6, JGR Atmospheres, 2023. doi.org/10.1029/2022JD038235


Cross-Cutting Theme: Science and society


Cross-Cutting Theme: upwelling systems

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?

PART 2 - Planned activities for 2024 and 2025

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

SOPHYAC-Light
Ship campaign on board the Marion Dufresne during Jan-Feb 2025 to the Terres Australes et Antarctiques Françaises (TAAF) from La Réunion. The main objective is to investigate the impact of UV light on marine microorganisms of the Southern Ocean and the subsequent release of precursor gases to nucleation in the atmosphere.

Contact: karine.sellegr@uca.fr and boye@ipgp.fr

Model intercomparison between LAMTOS and IGE, which is a CATCH (IGAC and SOLAS) effort: https://github.com/jenniethomas/arctic-bromine-model-intercomp

Contact: jennie.thomas@univ-grenoble-alpes.fr

Amsterdam Island: Installation of a new station for aerosol measurements
Researcher from LaMP and IGE will initiate aerosol measurements (number size distribution 2 nm-10 microns; submicron aerosol chemical composition, fluorescence, scattering properties) at Amsterdam Island. Installation planned April 2024.

Contact: karine.sellegri@uca.fr and aurelien.dommergue@univ-grenoble-alpes.fr
MAP-IO
The R/V Marion Dufresne has been equipped with atmospheric and oceanic sensors that operate on a continuous basis since 2022, and will continue to be tested as a mobile measurement station for 2024. Atmospheric sensors relevant for SOLAS comprise SMPS, CPC, CCNC, OPC, ozone and NOx analysers, picarro for GHG, sunphotometer and miniSAOZ, while oceanic sensors comprise an on-line flow cytometer.

Contact: pierre.tulet@aero.obs-mip.fr

REFUGE-ARCTIC campaign aboard the Amundsen this summer (early August to early October 2024). The objective is to study the Nares Strait and the Lincoln Sea. The campaign is organized by Mr. Ardyna from Takuvik. Hélène Angot will have an atmospheric mercury instrument on board and Lars-Eric Heimburger-Boavida is in charge of Hg measurements in the water column. They will try to calculate exchange flows at the ocean-sea ice-atmosphere interface in different types of ice (multi-year or first-year sea ice) from these measurements.

Contact: helene.angot@univ-grenoble-alpes.fr and lars-eric.heimburger@mio.osupytheas.fr

CaledoNia
A field campaign on land and at sea will be carried out by an IPGP team in collaboration with IRD at Nouméa in June-July 2024 to study the island mass effect of New Caledonia on marine biogeochemistry and phytoplankton assemblages.

Contact: boye@ipgp.fr

Polar POD program
The Polar POD program really starts after more than a decade of preparation (https://www.polarpod.fr/). The “Plateforme Océanique Dérivante Polaire”, known as the “Polar POD”, has been primarily conceived to support an exploration of the Southern Ocean, with the explorer mindset of Jean-Louis Etienne, who is known for having dedicated his life to exploration of our planet. The expedition goal is to undertake two circumnavigations of the Southern Ocean, wandering in the turbulent waters of the Antarctic Circumpolar Current, one of the main physical features of this ocean of global importance that also drives ecosystem dynamics in the sub-Antarctic domain. The Southern Ocean is the only ocean whose waters circulate around the globe without meeting continental masses, generating specific large-scale physical and biological processes. Known as a major sink for atmospheric CO₂, its water masses also play an important role in biogeochemical cycles and in the regulation of the Earth’s climate. This region is also home of extreme meteorological conditions, with strong winds and waves. Only very few people are living in the area but anthropogenic perturbation is present and imported here from long range transport. The Polar POD will provide an unprecedented means of collecting continuously and simultaneously a wide range of physical, biogeochemical, and biological observations of the upper layers of the ocean and of the overlying atmosphere that will allow us to answer these climatically related important questions in the current global change context.

More than 100 researchers of 43 research institutions are involved in the Polar POD scientific program. It will be an essential contribution to the program of the United Nations Decade of Ocean Science for Sustainable Development (2021-2030). All data will be available to the entire scientific community as well as the general public.

Contacts: David Antoine (david.antoine@curtin.edu.au), Peter Sutherland (peter.sutherland@ifremer.fr), Karine Leblanc (karine.leblanc@mio.osupytheas.fr), Cédric Cotte (cedric.cotte@locean.ipsl.fr), Rémi Losno (losno@ipgp.fr)
The Polar POD project includes five major components: Ocean-Atmosphere exchanges of momentum, energy and mass, Bio-optics, ocean colour and phytoplankton, permanent residents (biodiversity), anthropogenic influence and impacts, passive and active acoustics.
2. Events like conferences, workshops, meetings, summer schools, capacity building etc. (incl. all information possible).

A **SOLAS-France workshop** will be organized at IPGP (Paris) in spring/summer 2024.

A **new SOLAS-France website** hosted at IPGP will be lunched.

3. Funded national and international projects/activities underway.

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
<th>Funding Agency</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>PYROPLANKTON-LEFE</td>
<td>PI C. Guieu, LOV et E. Ortega-Retuerta LOMIC, funded by LEFE of French CNRS-INSU, 2023-2024.</td>
<td>LEFE of French CNRS-INSU</td>
<td>2023-2024</td>
</tr>
<tr>
<td>SOPHYAC-Light</td>
<td>PI K. Selligri, funded by LEFE of French CNRS-INSU, 2024-2025.</td>
<td>LEFE of French CNRS-INSU</td>
<td>2024-2025</td>
</tr>
<tr>
<td>CaledoNia</td>
<td>PI M. Boye, funded by LEFE-EC2CO of French CNRS-INSU, 2024-2025.</td>
<td>LEFE-EC2CO of French CNRS-INSU</td>
<td>2024-2025</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
<th>Potential Submission Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>OABI-one</td>
<td>Merging new emission schemes with new ocean satellite products in mesoscale transport models, evaluated using in situ and remote sensing satellite products. To be submitted to the French spatial agency CNES in September 2024. Collaboration LaMP-LOA-LAERO-LOV-MIO</td>
<td>September 2024</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Description</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCOR 166 - DMS-PRO (2023-2027)</td>
<td>Developing resources for the study of Methylated Sulfur compound cycling PROcesses in the ocean</td>
<td><a href="https://scor-int.org/group/developing-resources-for-the-study-of-methylated-sulfur-compound-cycling-processes-in-the-ocean-dms-pro/">https://scor-int.org/group/developing-resources-for-the-study-of-methylated-sulfur-compound-cycling-processes-in-the-ocean-dms-pro/</a></td>
</tr>
<tr>
<td>Contact: <a href="mailto:Eva.Bucciarelli@univ-brest.fr">Eva.Bucciarelli@univ-brest.fr</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Nations Decade of Ocean Science for Sustainable Development</td>
<td><a href="https://oceandecade.org/">https://oceandecade.org/</a></td>
<td></td>
</tr>
<tr>
<td>IOCCP (International Ocean Carbon Cooperation Program)</td>
<td><a href="https://www.ioccp.org/">https://www.ioccp.org/</a></td>
<td></td>
</tr>
<tr>
<td>GOOS (Global Ocean Observing System)</td>
<td><a href="https://goosocean.org/">https://goosocean.org/</a></td>
<td></td>
</tr>
<tr>
<td>BioGeoSCAPES (Ocean metabolism and nutrient cycles on a changing planet)</td>
<td><a href="https://biogeoscapes.org/">https://biogeoscapes.org/</a></td>
<td></td>
</tr>
<tr>
<td>Futureearth</td>
<td><a href="https://futureearth.org/">https://futureearth.org/</a></td>
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</tbody>
</table>

**Comments**
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;
   - 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).

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

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**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.

![Image](image-url)

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.
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 und 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

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


Datasets:


• Zeppenfeld, S., Bracher, A., Wiegmann, S., Zeising, M., Fuchs, S., van Pinxteren, M., and Herrmann, H.: Dissolved and particulate combined carbohydrates, pH, inorganic ions, CDOM and particulate absorption of SML and bulk water in Arctic surface seawater and melt ponds, PANGAEA [data set], https://doi.org/10.1594/PANGAEA.961004, 2023c.

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.
**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.

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

- **EGU24**: 14th - 29th April, Vienna, Austria
- **OASIS Face-to-face meeting** before OSM in New Orleans, USA (17-18 Feb 2024)
- **International Virus Bioinformatics Meeting (ViBioM)** 2024, 28-30th May 2024, Leuven, Belgium
- **VAAM2024**: Annual Meeting of the Association for General and Applied Microbiology (VAAM), 2-5th June 2024, Würzburg, Germany

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

- BASS
- ICEBERG
- ORIGAMY
- Biocat
- FORMAS Mobility grant (Leonie Esters)


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

- **FUTURO**: year long upwelling field campaign led by GEOMAR – should be an international effort
- Second phase of BASS in planning stage

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

Joint SOLAS-OASIS side event at the UN Ocean Conference in Barcelona (April 2024)

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**Comments**
Report for the year 2023 and future activities

SOLAS ‘India’
compiled by: ‘Sheryl Oliveira Fernandes’

This report has two parts:

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- **Core Theme 1:** Greenhouse gases and the oceans;
- **Core Theme 2:** Air-sea interfaces and fluxes of mass and energy;
- **Core Theme 3:** Atmospheric deposition and ocean biogeochemistry;
- **Core Theme 4:** Interconnections between aerosols, clouds, and marine ecosystems;
- **Core Theme 5:** Ocean biogeochemical control on atmospheric chemistry;
- **Cross-Cutting Theme:** Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
- **Cross-Cutting Theme:** Climate intervention;
- **Cross-Cutting Theme:** Science and society.

**IMPORTANT:** This report should reflect the efforts of the SOLAS community in the *entire country or region* 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 Feb/Mar 2024**

1. **Scientific highlight**
   Title: Response of surface ocean pCO₂ to tropical cyclones in two contrasting basins of the northern Indian Ocean

   The impact of two very severe tropical cyclonic events, Phailin (over the Bay of Bengal) and Ockhi (over the Arabian Sea) was examined on surface ocean pCO₂ and the associated changes in the
upper ocean using a coupled biogeochemical ROMS model. Primary productivity averaged over the mixed layer increased from 6.9 to 12.0 (7.2–45.6) mg C m$^{-3}$d$^{-1}$ in response to Phailin (Ockhi). Decomposition analysis revealed that the mean contribution of temperature-driven changes in inducing pCO$_2$ variability in response to pre- and post-cyclonic conditions, in case of Phailin (Ockhi), were $5.4$ (–$8.8$) and $–7.6$ (–$58.8$) μatm whereas dissolved inorganic carbon (DIC) driven changes were $23.6$ (19.5) and $27.8$ (78.0) μatm. The enhancement of DIC was more in the near-surface waters than its removal by net biological processes. This caused the dominance of cyclone-induced upwelling and associated vertical mixing driven changes over enhanced biology-driven changes in controlling pCO$_2$ variability during both cyclones.

![Fig. 1. Spatial plot of (a) pCO$_2$ (μatm) and (b) surface chl-a (mg/m$^3$) during Phailin. Spatial plot of (c) pCO$_2$ (μatm) and (d) surface chl-a (mg/m$^3$) during Ockhi.](image)

Relatively large ratio of DIC to total alkalinity in the upper layers of Arabian Sea facilitated a higher pCO$_2$ response during cyclones. Proportion of variance explained by ocean pCO$_2$ on air-sea CO$_2$ flux was 53% (69%) whereas wind speed explained 57% (62%) for Phailin (Ockhi). Despite comparable magnitudes of environmental forcing during both cyclones, the oceanic response to Phailin was comparatively short-lived and subdued due to strong salinity stratification in the Bay of Bengal. A relatively large ratio of DIC to total alkalinity in the upper layers of Arabian Sea facilitated a higher pCO$_2$ response to Ockhi. These findings suggest that the Arabian Sea (Ockhi) acts as a greater source of CO$_2$ to the atmosphere in comparison to the Bay of Bengal (Phailin) during tropical cyclones.


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).
1. The 6th meeting of the IIOE-2 Steering Committee was held at Perth, Australia during 06-09 February, 2023. Integrated meetings reviewed the progress and scientific knowledge gained due to the concerted efforts of regional bodies. Discussions were held to draw an action plans to address the issues leading to the UN Decade of Ocean Science for Sustainable Development (2021-2030).

2. The third meeting of the KUDOS community (KUDOS-III) took place at the Indian Ocean Marine Research Center at the University of Western Australia (UWA) in Perth on 10 February 2023. The meeting was part of an integrated package of meetings during 6-10 February 2023 under the banner of the International Indian Ocean Science Conference (IIOSC) 2023, which included annual meetings of IOOE-2, Indian Ocean GOOS (IOGOOS), the Indian Ocean Regional Panel (IORP), the Sustained Indian Ocean Biogeochemistry and Ecosystem Research Program (SIBER) and the IndOOS Resource Forum (IRF).

3. National Science Workshop on Indian Ocean Biogeochemistry (NSWIO-BGC) was held at the Center for Marine Living Resources and Ecology (CMLRE), Kochi from 26th to 28th April 2023.

4. From May 15 to June 11, 2023, the Korea Institute of Ocean Science and Technology (KIOST) research vessel ISABU, the KIOS 2023 expedition covered a meridional transect from 65° E and 25° S to 5° N, stretching between Port Louis, Mauritius, and Malé, Maldives. This cruise was a part of the KIOS (KIOST Indian Ocean Study), which received endorsement from IIOE-2 (IIOE2-EP51: Korea-US Joint Observation Study of the Indian Ocean led by Dr. Dong-Jin Kang, PI/Chief Scientist, KIOST, and funded by the Ministry of Oceans and Fisheries, the Republic of Korea). The primary goal of the KIOS scientific cruise was to gain insights into the physical, biogeochemical, and ecological characteristics of the Seychelles-Chagos Thermocline Ridge (SCTR) region, which is a significant open ocean upwelling region in the tropical Indian Ocean. The findings would contribute to enhancing the predictability of global climate patterns.

5. Three RAMA moored buoys were successfully deployed at 12°S-65°E, 8°S-65°E, and 4°S-65°E, alongside one subsurface ADCP mooring and eight Lagrangian drifter buoys. Additionally, the RAMA mooring that had gone adrift at 8°S, 67°E on 18th September 2022, was successfully recovered.

6. The "RAMA-K study site" was established around 8°S, 65°E, where KIOST plans to relocate additional subsurface moorings in 2024.

7. The 8th edition of the Biennial National Conference of the Ocean Society of India (OSICON-23), was held at Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, India from August 23 - 25, 2023. The focal theme for OSICON-23 was 'Operational Oceanography - Science to Services'. The conference hosted two special sessions i.e. of the Indian Meteorological Society (IMS) and Federation of Indian Geosciences Associations (FIGA).

8. The UN Ocean Decade Collaborative Centre for the Indian Ocean Region was also launched during OSICON-23.

9. Invited Early Career Ocean Professional (ECOP) talks were held at OSICON-23. ECOPs from premiere oceanographic institutions of India explained the latest advancements in the Indian oceanographic realm through their path breaking research and elucidated how their work aligned with the sustainable goals of the UN Ocean decade.

10. The 'Decade Collaborative Centre for Indian Ocean Region (DCC-IOR)' organized the 'Indian Ocean Regional Decade Conference 2024: Bridging Billions to Barcelona' from 1-3 February, 2024 at INCOIS. It was organized under the ambit of UN Ocean Decade (2021-30). Technical sessions were held on ten ocean decade challenges, National Decade Collaborative Committees, Early career ocean professionals (ECOPS) and other stakeholders including industry.

11. A joint research initiative was formulated between India and the United States of America, titled Enhancing Knowledge of the Arabian Sea Marine Environment through Science and Advanced Training" (EKAMSAT). ESSO-Indian National Centre for Ocean Information Services
conducted a month-long scientific cruise in the Arabian Sea from June 29 to July 24, 2023, onboard research vessel *Sagar Nidhi*, immediately following the field campaign by a US-India team onboard *Roger Revelle* during June 10-25, 2023. Fine-scale oceanographic and atmospheric measurements carried out during the expedition aimed to improve our understanding of the small-scale mixing processes in the ocean surface boundary layer, Interior Ocean, and air-sea interaction processes.

12. The IIOE-2 Project Office at INCOIS hosted a brainstorming session from 28-30th November, 2023 to discuss and deliberate upon the ways to sustain the 2nd International Indian Ocean Expedition (IIOE-2) beyond 2025. It brought together several distinguished researchers, leaders and policymakers across the globe active in Indian Ocean-focused forums such as the Indian Ocean Global Ocean Observing System (IOGOOS), Indian Ocean Region Panel of CLIVAR/IOC-GOOS (IORP), Indian Ocean Observing System Resources Forum of IOGOOS (IRF), Sustained Indian Ocean Biogeochemistry and Ecosystem Research of IMBeR/IOGOOS (SIBER), IOC Regional Committee for the Central Indian Ocean (IOCINDIO) and the Scientific Committee on Oceanic Research (SCOR).

13. During the Prydz Bay Air-Sea-Ice Experiment (PRAISE) field survey, which is a part of one of the newly initiated research observatory projects of National Centre for Polar and Ocean Research (NCPOR), researchers have successfully retrieved essential data from the ice-tethered mooring system at the Bharati Station at Prydz Bay in Antarctica. The main aim of the observatory is to study the Air–Ice–Sea interactions by measuring various environmental variables from these three spheres.

14. Revised version of the manuscript has been submitted for consideration in SOLAS special issue to be published in *Elementa: Science of the Anthropocene*:


3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


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?
   - As part of the Ocean Decade framework, INCOIS has proposed ‘Decade Collaborative Centre for Indian Ocean Region’ (DCC-IOR) which has been endorsed by Intergovernmental Oceanographic Commission (IOC).
   - Ministry of Earth Sciences (MoES), Govt. of India has constituted the National Decade Coordination Committee (NDCC) to address Ocean Decade Actions at the national level by providing scientific coordination and planning, identifying collaboration opportunities, awareness raising and stakeholder engagement apart from interacting with the Decade Coordination Unit at IOC.

PART 2 - Planned activities for 2024 and 2025
1. Planned major national and international field studies and collaborative laboratory and modelling studies (incl. all information possible, dates, locations, teams, work, etc.).
   - The 44th Indian Scientific Expedition to Antarctica has been proposed to be held in October-November 2024 for field data collection and conducting laboratory-based experiments.

2. Events like conferences, workshops, meetings, summer schools, capacity building etc. (incl. all information possible).
   1. Second International Indian Ocean Expedition (IIOE-2) IIOE-2 Steering Committee Meeting No. 7 (IIOE-2 SC7), March 04 – 08, 2024, Lombok, Indonesia.
   2. SOLAS Open Science Conference 2024, Hosted by CSIR - National Institute of Oceanography, Goa, India. 10-14 November, 2024.
   3. SOLAS India side meeting in hybrid mode during SOLAS Open Science Conference 2024.
   4. SOLAS Science and Society Workshop during SOLAS Open Science Conference 2024.

3. Funded national and international projects/activities underway.
   - The IIOE-2 committee has endorsed the KIOST Indian Ocean Study (KIOS): Korea-US Joint Observation Study of the Indian Ocean led by Dr. Dong-Jin Kang (PI/Chief Scientist, KIOST, djocean@kiost.ac.kr), funded by the Ministry of Oceans and Fisheries, the Republic of Korea. The KIOS program aims to understand the physical, biogeochemical, and ecological characteristics of the open ocean upwelling region in the Indian Ocean in order to improve the predictability of global climate change, which is well linked to the scientific themes of IIOE-2 (ST-2; Boundary current dynamics, upwelling variability and ecosystem impacts, and ST-4; Circulation, climate variability, and change). The KIOS Program will be conducting a research cruise by R/V Isabu every year until 2026.
   - “Polar Science and Cryosphere Research (PACER)” scheme is being implemented by MoES, Govt. of India through NCPOR, Goa. Scientific projects under four sub-schemes viz., the Antarctic Program, Indian Arctic Program, Indian Southern Ocean Program and Cryosphere and Climate Program are underway.
   - Climate Relevant Interactions and feedback studies (CRiceS) involving scientists from NCPOR, Goa are underway to understand the key role of sea ice and snow in the polar and global
climate system.

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

The Second International Indian Ocean Expedition (IIOE-2), a major global scientific program which will engage the international scientific community in collaborative oceanographic and atmospheric research from coastal environments to the deep sea will continue until 2025.

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

• The Global Ocean Biogeochemistry Array (GO-BGC; https://go-bgc.org) project funded by the US National Science Foundation will deploy 500 BGC profiling floats as half of the planned 1000 float BGC-Argo array in the Indian Ocean. Over the past year, 17 floats have been deployed equipped with oxygen, nitrate, pH, chlorophyll fluorescence and optical backscatter sensors throughout the basin north of 30 °S. Eight more floats will be deployed on the GO-SHIP I05 cruise.

• The Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM; https://soccom.princeton.edu) project funded by the US NSF Office of Polar Programs has deployed 44 BGC-Argo floats in the Indian Ocean sector of the Southern Ocean (25 °E to 120 °E) since 2014. These floats have collected over 5000 vertical profiles from 30 °S, through the seasonal ice zone, to the Antarctic margin. Twenty-one of these floats are currently operating and the remainder has exhausted their batteries. Data from these floats is available with automated and delayed quality control through the Argo data system and at the GO-BGC and SOCCOM websites.

Comments
Report for the year 2023 and future activities

SOLAS ‘Ireland
compiled by: ‘Peter Croot’

This report has two parts:

- Part 1: reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

Core Theme 1: Greenhouse gases and the oceans;
Core Theme 2: Air-sea interfaces and fluxes of mass and energy;
Core Theme 3: Atmospheric deposition and ocean biogeochemistry;
Core Theme 4: Interconnections between aerosols, clouds, and marine ecosystems;
Core Theme 5: Ocean biogeochemical control on atmospheric chemistry;
Cross-Cutting Theme: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
Cross-Cutting Theme: Climate intervention;
Cross-Cutting Theme: Science and society.

IMPORTANT: This report should reflect the efforts of the SOLAS community in the entire country or region 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. ?

Activity in the IPO based at the University of Galway was greatly reduced this year as Jesscia Gier left the IPO to return to Germany and the position has not yet been replaced as funding for the position was put on hold by the University due to financial constraints. Alternative funding sources are being looked at and it is hoped to fill this position sometime in late 2024 or early 2025. The SOLAS themed MSc programme still continues at the University of Galway and is looking to attract more students for the next academic year beginning in Sept 2024.

Previously we had sought the IPO support for developing links with Future Earth, while this is still a goal, there is no longer a Future Earth Ireland committee. This committee had been run by the Royal Irish Academy (RIA) but it was wound up in late 2023.
PART 1 - Activities from January 2023 to Feb/Mar 2024

1. Scientific highlight

As the most ubiquitous natural source of sulfur in the atmosphere, dimethylsulfide (DMS) promotes aerosol formation in marine environments, impacting cloud radiative forcing and precipitation, eventually influencing regional and global climate. In this study, we propose a machine learning predictive algorithm based on Gaussian process regression (GPR) to model the distribution of daily DMS concentrations in the North Atlantic waters over 24 years (1998–2021) at 0.25° × 0.25° spatial resolution. The model was built using DMS observations from cruises, combined with satellite derived oceanographic data and Copernicus-modelled data. Further comparison was made with the previously employed machine learning methods (i.e., artificial neural network and random forest regression) and the existing empirical DMS algorithms. The proposed GPR outperforms the other methods for predicting DMS, displaying the highest coefficient of determination (R2) value of 0.71 and the least root mean square error (RMSE) of 0.21. Notably, DMS regional patterns are associated with the spatial distribution of phytoplankton biomass and the thickness of the ocean mixed layer, displaying high DMS concentrations above 50°N from June to August. The amplitude, onset, and duration of the DMS annual cycle vary significantly across different regions, as revealed by the k-means++ clustering. Based on the GPR model output, the sea-to-air flux in the North Atlantic from March to September is estimated to be 3.04 Tg S, roughly 44% lower than the estimates based on extrapolations of in-situ data. The present study demonstrates the effectiveness of a novel method for estimating seawater DMS surface concentration at unprecedented space and time resolutions. As a result, we are able to capture high-frequency spatial and temporal patterns in DMS variability. Better predictions of DMS concentration and derived sea-to-air flux will improve the modeling of biogenic sulfur aerosol concentrations in the atmosphere and reduce aerosol-cloud interaction uncertainties in climate models.

Figure: Conceptual diagram of application of machine learning to North Atlantic DMS fluxes.

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).

iCRAG (Irish Centre for Research in Applied Geoscience) researchers participated in an international research expedition CE23011 SiTrAc (Signal Tracking to unveil Arctic Climate variability to the Arctic) onboard the Celtic Explorer. Chief Scientist, Dr Audrey Morley (iCRAG@UG), a follow up expedition to the 2020 expedition CIAAN (Constraining the Impact of Arctic Amplification in the Nordic Sea: A biogeochemical approach). FI Dr Brian Ward (iCRAG@UG) participated on the expedition along with scientists from Norway, Germany, the UK and the USA.

Prof. Croot was a member of the European Marine Board’s working group on Ocean Oxygen, which released their scientific report in June 2023 at the ASLO meeting in Mallorca. At the ASLO meeting in Mallorca, he was also able to participate in the meeting of SCOR WG167 “Reducing Uncertainty in Soluble aerosol Trace Element Deposition (RUSTED)”.

Prof. Croot also attended the annual SCOR meeting, held in Guayaquil, Ecuador in his role as Secretary of the SCOR Executive Committee.

Prof Croot is an inaugural member of Ireland’s National committee for the United Nations Decade for Ocean Science which was formed in late 2023. More details can be found at https://undecadeocean.ie

PhD students Celine Burin (UG) and Kevin McGraw (UG) attended the recent Ocean Sciences Meeting in New Orleans (USA) and presented posters (OB44F-1015 and A134B-2408 respectively) on their graduate work.

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


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?

In January 2024, Prof. Peter Croot (UG) hosted a workshop entitled “Sustainability of Marine Transitional Zones in Ireland”. This workshop involved 35 (in person) participants from diverse backgrounds, including physical and social scientists, local government agencies, and community groups from around Ireland. This event was coordinated by the EPA/MI funded project NUTS&BOLTS, and provided a platform to present the final results on a project examining multi-stressors on ecosystems in Irish Marine Transitional Zones. NUTS&BOLTS is an IMBER endorsed project, which includes many SOLAS relevant components, most notably looking at air/sea gas exchange of important gases for climate research (e.g. O2, CO2 and Ar).

PART 2 - Planned activities for 2024 and 2025

1. Planned major national and international field studies and collaborative laboratory and modelling studies (incl. all information possible, dates, locations, teams, work, etc.).
Dr Brian Ward is the chief scientist for expeditions to the Labrador Sea to study the Biological Carbon Pump. The BELAS (Biological Carbon Export in the Labrador Sea) expedition will take place on the RV Celtic Explorer (CE24007) from May 1st to June 7, 2024. The expedition's planned track is shown below.

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

It is anticipated that several Irish researchers will attend the SOLAS open Science conference in Goa, India in Nov 2024.

The 2nd annual Mary Robinson Climate Conference will be held in Ballina, Co, Mayo, Ireland from June 5-7, 2024. Prof. Peter Croot (UG) is acting as a co-chair for this meeting and there are plans

Dr Brian Ward (UG) and Prof. Peter Croot (UG) are members of the European mCDR node of the SOLAS mCDR global network.

There are preliminary plans to make the NUTS&BOLTS workshop (see above) into an annual event, though at the time of writing it is not known when the 2nd workshop would be held.

3. Funded national and international projects/activities underway.

Jurgita Ovadnevaite (UG) is a PI in 2 new EPA funded projects, “Sources of PM2.5 in the Air of Irish Towns” (as lead PI) and “Solid-fuel emissions to air in Ireland” (PI: William Smith, UCD).

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

At the time of writing this report, a pre-proposal had been submitted (Dec 2023) to SFI for a new SFI centre focused on the Marine Environment (FORCE – Future Ocean Research CEntre). Dr Brian Ward (UG) is a co-applicant in this proposal, and the lead for the Changing Ocean theme. SOLAS Ireland Dr Jurgita Ovadnevaite and Prof. Peter Croot are also included in this proposal as Funded Investigators. A decision is expected in late May 2024 as to if a full proposal will be submitted for FORCE, with a final decision on the funding scheduled in late 2024.
Prof. Croot is in an international consortia working on a proposal to a current JPI-Oceans joint call on Changing Marine Lightscapes, the call closes at the end of May 2024.

5. Engagements with other international projects, organisations, programmes, etc.
As mentioned above, Prof Croot is currently the secretary to the SCOR executive committee and a member of the SCOR WG167 Reducing Uncertainty in Soluble aerosol Trace Element Deposition (RUSTED).

Comments
The SOLAS Ireland community continues to work towards obtaining funding to support the hiring of a new officer for the SOLAS IPO in Ireland and to promote the work of SOLAS nationally and internationally.
Report for the year 2022 and 2023 and future activities

SOLAS Italy
compiled by: Luisa Galgani

This report has two parts:
- **Part 1:** reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

- **Core Theme 1:** Greenhouse gases and the oceans;
- **Core Theme 2:** Air-sea interfaces and fluxes of mass and energy;
- **Core Theme 3:** Atmospheric deposition and ocean biogeochemistry;
- **Core Theme 4:** Interconnections between aerosols, clouds, and marine ecosystems;
- **Core Theme 5:** Ocean biogeochemical control on atmospheric chemistry;
- **Cross-Cutting Theme:** Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
- **Cross-Cutting Theme:** Climate intervention;
- **Cross-Cutting Theme:** Science and society.

**IMPORTANT:** This report should reflect the efforts of the SOLAS community in the entire country or region 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.**

I have a list of previous SOLAS-related projects and research groups in Italy that the previous NCP, Dr. Santinelli, forwarded me. However, I did not have any feedback to the introductory email I wrote as new Italy NCP, nor last year, not this year. The only group who wrote back reporting its activity for 2022 and 2023 is CNR-ISAC (Dr. Rinaldi and colleagues). I would need the help of SOLAS IPO to re-establish the Italian network. I am starting with some activities planned for next year but they only involve my research group at the University of Siena (Environmental Spectroscopy Group) where I am back since September 2023.
PART 1 - Activities from January 2023 to Feb/Mar 2024

1. Scientific highlight

CNR-ISAC 2023:
Dimethylsulfide (DMS), the most ubiquitous natural source of sulfur in the atmosphere, is responsible for aerosol formation over the global ocean, impacting cloud radiative forcing and precipitations, eventually influencing the climate system. Using machine learning predictive algorithms, we reconstruct the distribution of daily DMS concentrations in the North Atlantic waters over 24 years (1998–2021) at 0.25° x 0.25° spatial resolution. The proposed model outperforms any other methods for predicting seawater DMS concentrations deployed so far, achieving an unprecedented space and time resolution, and revealing that DMS concentration is strongly driven by regional and mesoscale patterns in phytoplankton biomass and seawater vertical mixing dynamics.

We extend machine learning algorithms, to model the sea-level atmospheric concentrations of marine biogenic aerosol MSA and nss-SO4 over the North Atlantic Ocean utilizing the constructed daily sea-to-air DMS emission flux (F_DMS) (Mansour et al., 2023). The in situ long-term sulfur aerosol observations at Mace Head research station, on the west coast of Ireland, and from the recent NAAMES cruises were combined with F_DMS, and the meteorological parameters to act as predictors for MSA and nss-SO4. The model's output has a spatial resolution of 0.25° x 0.25°, a daily time resolution, and, most importantly, covers 25 years (1998–2022), far exceeding what observations alone could achieve both space and time-wise.

CNR-ISAC 2022:
Investigation of the marine biota impact on atmospheric aerosol over the North Atlantic Ocean from satellite data [Matteo Rinaldi, Karam Mansour (CNR)]. A machine learning predictive algorithm based on Gaussian process regression (GPR) was used to model the distribution of daily DMS concentrations in the North Atlantic waters over 24 years (1998–2021) at 0.25° x 0.25° spatial resolution. The model was built using DMS observations from cruises, combined with satellite-derived oceanographic data and Copernicus-modelled data. Further application of the same approach to model sulfur aerosol concentration data is ongoing.

Studying aerosol physico-chemical properties over the Southern Ocean and Antarctica [Matteo Rinaldi, Marco Paglione, Stefano Decesari (CNR)]. Aerosol samples have been collected during two Antarctic cruises: the R/V Laura Bassi (Italy) cruise on the Ross Sea and the R/V Hesperides (Spain) cruise on the Weddel Sea. Aerosol characterization is in progress through a multi-technique analytic approach, comprising Ion Chromatography, C and N quantification and Nuclear Magnetic Resonance Spectrometry.

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).

CRUISES
CNR-ISAC participated to two cruises between the end of 2022 and the first months of 2023:
- R/V Laura Bassi (Italy) cruise on the Ross Sea (within the 39th PNRA summer campaign) in the framework of the PNRA project CAIAC.
- R/V Hesperides (Spain) cruise on the Weddel Sea, in the framework of the Spanish funded project PI-ICE (external participant).

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


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?

University of Siena – Env. Spectroscopy Group (Dr. Galgani) – cross cutting theme science and society: citizen science project on surface microplastics sampling and DNA analysis with the help of volunteers on board of an eco-friendly vessel (sailing boat), July 2023, SeaPaCS project (EU funded) https://crowdusg.net/seapacs/. Follow up with sailing school kids who will sample sea-surface microplastics with a diy assembled manta net (starting April 2024). Plastic samples will be analyzed at the University of Siena.

PART 2 - Planned activities for 2024 and 2025

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

CNR-ISAC plans to adapt the machine learning developed models to predict DMS concentration, DMS flux and sulfur aerosol atmospheric concentrations over the Mediterranean Sea.

2. Events like conferences, workshops, meetings, summer schools, capacity building etc. (incl. all information possible).
- EGU 2024 – L. Galgani et al. *Plastics Affect the Ocean's Uptake of Atmospheric CO₂ across the Marine Boundary Layer* (talk, session OS1.7 *The ocean surface layer: multi-scale dynamics, atmosphere-ocean interactions and impacts on biogeochemistry*)

- 2025: (Funding granted, being organized) *ESA-Future Earth Joint Programme* funding for the development and uptake of Earth observation data by Future Earth’s research networks – grant for the workshop “SPARSE”: Sea-surface microPIAstic fRom SpacE: optical signals of organic compounds at the sea-surface and lower atmosphere as a proxy for plastic and microplastic detection. Lead: Dr. L. Galgani, Dr. L. Tinel (IMT Nord Europe, France) € 19,831. The workshop will be hosted at the University of Siena in 2025.

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

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

### 5. Engagements with other international projects, organisations, programmes, etc.
University of Siena – L. Galgani collaboration with GEOMAR Kiel and Dr. Anja Engel group on previous projects and data analysis.

**Comments**
Report for the year 2023 and future activities

SOLAS JAPAN
compiled by: Yuzo Miyazaki

This report has two parts:
- **Part 1**: reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

**Core Theme 1**: Greenhouse gases and the oceans;
**Core Theme 2**: Air-sea interfaces and fluxes of mass and energy;
**Core Theme 3**: Atmospheric deposition and ocean biogeochemistry;
**Core Theme 4**: Interconnections between aerosols, clouds, and marine ecosystems;
**Core Theme 5**: Ocean biogeochemical control on atmospheric chemistry;
**Cross-Cutting Theme**: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
**Cross-Cutting Theme**: Climate intervention;
**Cross-Cutting Theme**: Science and society.

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

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**PART 1 - Activities from January 2023 to Feb/Mar 2024**

1. **Scientific highlight**

**Asian dust-deposition flux to the subarctic Pacific**
Iron availability limits marine ecosystem activities in large areas of the ocean. However, the sources and seasonal supply of iron, critically important for controlling surface ocean biogeochemistry and carbon cycling, are poorly understood. The western subarctic Pacific is a high-nutrient and low chlorophyll region. Despite high concentrations of macronutrients, iron limits...
phytoplankton production in that oceanic region in summer. Nagashima et al. (2023) determined the seasonal deposition flux of Asian dust using scanning electron microscope–cathodoluminescence analysis of single quartz particles derived from the western subarctic Pacific during 2003–2022 to trace provenance. They found a high deposition flux (up to 6.9 mg m\(^{-2}\) day\(^{-1}\)) of Asian dust in May, June, and early July, with an annual average of 1.0 ± 0.2 mg m\(^{-2}\) day\(^{-1}\). The supply of dissolved-iron flux calculated from Asian dust was 0.9 ± 0.3 μg m\(^{-2}\) day\(^{-1}\) during the high productivity season (April–July), which is approximately half that from the deeper part of the ocean, calculated from vertical profiles of dissolved iron. Nagashima et al. (2023) provides a reliable approach for estimating iron supply from dust to the surface ocean that may be critical for sustaining biological productivity under future ocean stratification, which suppresses nutrient supply from the subsurface ocean.

![Western Subarctic Pacific](image)

Figure: Schematic of seasonality of the iron supply from Asian dust and other potential sources, phytoplankton production, and other oceanic environments revealed by Nagashima et al. (2023). This schematic denotes the seasonality of phytoplankton production and its relation to the depth of mixed layer, ocean temperature, insolation, and dissolved iron supply from Asian dust, anthropogenic aerosol, and the intermediate water. This figure is adopted from Nagashima et al. (2023).

Citation: Nagashima, K. et al. (2023) Asian dust-deposition flux to the subarctic Pacific estimated using single quartz particles, Sci. Rep., 13, 15424, https://doi.org/10.1038/s41598-023-41201-6.

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).
**Core Theme:**
- Regional Carbon Cycle Assessment & Processes-2 (RECCAP-2; JAMSTEC, MRI)
- Photoproduction of oxygenated VOCs from bacteria-derived organic matter, (PI: Y. Omori), 2022-2023
- Quantitative evaluation of VOCs emitted from microlayer, (PI: Y. Omori), 1 April 2023—31 March 2024
- Atmospheric GHG and oceanic CO2 monitoring in the Pacific Ocean using 2 cargo ships (NIES).
- Seisui-maru (Mie University) cruise at Ise Bay and coastal area of western North Pacific (chief scientist: Urumu Tsunogai) (from April 26 to 28, 2023).
- Ground-based continuous aerosol sampling in Siorapalku, Greenland: since Mar 2021- (PI: Y. Miyazaki; S. Matoba)
- Ground-based continuous aerosol sampling at a coastal site in the Sea of Okhotsk, Japan: since August 2023- (PI: Y. Miyazaki)

**Cross-Cutting Theme:**
- Air-sea ice CO2 flux measurement over sea ice in the Cambridge Bay, Canada, May 2023
- Effect of Glacier meltwater on CO2 concentration and flux with atmosphere in the fjord of Patagonia, January 2024
- CO2 dynamics at surface water of the Arctic Ocean by T/S Oshoro-maru, June-August 2023

**Meetings/international conferences/workshop/siminar contributions to int. assessments**
- SOLAS-related IGAC activity: Oceans WG of TOAR-II (Tropospheric Ozone Assessment Report Phase II) led by Roberto Sommariva and Alfonso SaizRoberto Sommariva with Yugo Kanaya as SC Liaison, and Takashi Sekiya, Hisahiro Takashima, and Yuzo Miyazaki as WG members from Japan.
- A session of Biogeochemical linkages between the surface ocean and atmosphere (A-CG45) (Convener: S. Kameyama, Y. Iwamoto, M. N. Alta, N. Kosugi), JpGU Meeting 2023, May 21 2023, Chiba, Japan
- AS2.6: Air-sea Chemical Fluxes: Impacts on Biogeochemistry and Climate (Convener: Maria Kanakidou; Co-conveners: Parvadha Suntharalingam, Akinori Ito, Robert Duce, Cécile Guieu)
- The Oceanographic Society of Japan, 2023 Fall Meeting, Kyoto, Japan, Multidisciplinary Study of Biogeochemistry in the Northwestern Pacific(23F-05), Sep 27, 2023, Conveners: Aita Noguchi M., Fujiki T., Honda M., Iwamoto Y., Tada Y.
3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc. (No specific order)

Core Theme 1: Greenhouse gases and the oceans;


Core Theme 2: Atmospheric deposition and ocean biogeochemistry;
Miyakawa, T., Ito, A., Zhu, C., Shimizu, A., Matsumoto, E., Mizuno, Y., and Kanaya, Y.: Trace elements in PM2.5 aerosols in East Asian outflow in the spring of 2018: Emission, transport, and


Core Theme 4: Interconnections between aerosols, clouds, and marine ecosystems;

Core Theme 5: Ocean biogeochemical control on atmospheric chemistry;

Cross-Cutting Theme:
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?

PART 2 - Planned activities for 2024 and 2025

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

(No specific order)

- Sea ice CO₂ dynamics in the Utqiagvik (Barrow), Alaska, May 2024
- CO₂ dynamics at surface water of the Arctic Ocean by R/V Minai, August-September 2024
- Methane emission from the east coastal area in south Vietnam, Ganh Rai Bay, Vietnam, June-July 2024, Hokkaido University (S. Kameyama) and Vietnam National University Ho Chi Minh-University of Science (O. T. N. Bui).
- SCOR Working Group: #166 "Developing resources for the study of Methylated Sulfur compound cycling PROcesses in the ocean (DMS-PRO)", Hakase Hayashida (JAMSTEC, Full member), Sohiko Kameyama (Hokkaido Univ, Associate member)
- NIES VOS program and Global Environmental Research Coordination System from Ministry of the Environment of Japan support the atmospheric GHG and oceanic CO₂ monitoring in the Pacific Ocean from FY2021 to FY2025.
- R/V Toyoshio Maru cruise targeting sea surface microlayer and photo-chemistry at the sea surface in the Seto Inland Sea, Japan, 29 June to 3 July 2024 (PI: K. Takeda and Y. Iwamoto)
- R/V Shinsei Maru cruise targeting methane and iodine biogeochemistry in the off coast of southern Kanto area, 10 to 14 July 2024 (PI: Y. Iwamoto)
- Atmospheric observation in R/V Hakuho Maru KH-24-3 Leg2 cruise over the Indian Ocean, 25 Aug to 22 Sep 2024 (PI: Y. Masumoto and H. Saito)
- Seisui-maru (Mie University) cruise at Ise Bay and coastal area of western North Pacific (chief scientist: Urumu Tsunogai) (from September 2 to 5, 2024).
- R/V Toyoshio Maru cruise targeting sea surface microlayer and photo-chemistry at the sea surface in the Seto Inland Sea, Japan, 10 to 14 March 2025 (PI: K. Takeda and Y. Iwamoto)

- R/V Mirai cruises in the western North Pacific: June 2024 (PI: S. Yokoi)

- R/V Mirai cruises from the western North Pacific to Arctic Ocean: Aug. 2024 (PI: M. Ito)

- R/V Mirai cruises in the western North Pacific: Sep. 2024 (PI: K. Kimoto)


- R/V Mirai cruises in the equatorial western Pacific: Jan. 2025 (PI: A. Nagano)

- Ground-based continuous aerosol sampling in Siorapalku, Greenland: since Mar 2021- (PI: Y. Miyazaki; S. Matoba)

- Ground-based continuous aerosol sampling at a coastal site in the Sea of Okhotsk, Japan: since August 2023- (PI: Y. Miyazaki)

- Ground-based observation at Ogasawara-island, Japan: Autumn 2024- (PI: F. Taketani)

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

(No specific order)

- A session of “Biogeochemical linkages between the surface ocean and atmosphere (A-CG41)” in JpGU Meeting in May 28, 2024 (Conveners: S. Kameyama, Y. Iwamoto, M. N. Aita, N. Kosugi)


3. Funded national and international projects/activities underway.

(No specific order)

- The Arctic Challenge for Sustainability II (ArCS II)

- Global Environmental Research Coordination System from Ministry of the Environment of Japan is planned to support a part of NIES VOS program to investigate the role of biological activity to ocean carbon cycle since 2022 for 5 years.

- Grant-in-Aid for Scientific Research (A), granted by the Japan Society for the Promotion of Science (JSPS), PI: Yugo Kanaya, FY2021-2024, Tropospheric ozone hole and iodine chemistry over the ocean: Focus analysis in the western Pacific low-latitude region and global assessment.

- Grant-in-Aid for Scientific Research (A), granted by the Japan Society for the Promotion of Science (JSPS), PI: Urumu Tsunogai, FY2022-2025, High-sensitivity tracer assay for oxygen consumption rate in seawater and freshwater.

- Grant-in-Aid for Scientific Research (A), granted by the Japan Society for the Promotion of Science (JSPS), PI: Koji Hamasaki, FY2022-2026, Microbiology of the atmosphere-ocean boundary: its linkage with enrichment in ocean bubbles and cloud nuclei.

- Grant-in-Aid for Scientific Research (B), granted by the Japan Society for the Promotion of Science (JSPS), PI: Yuzo Miyazaki, FY2023-2025, Elucidation of microbial factors that control the amount and physicochemical properties of atmospheric organic nitrogen aerosols in the subarctic ocean.
- Grant-in-Aid for Scientific Research (B), granted by the Japan Society for the Promotion of Science (JSPS), PI: Fumikazu Taketani, FY2024-2026, Impacts of atmospheric deposition on marine ecosystems: integration of observation, laboratory experiment and model analysis

- Grant-in-Aid for Scientific Research (C), granted by the Japan Society for the Promotion of Science (JSPS), PI: Yuko Omori, FY2024-2026, The impact of marine plastic as a source of volatile organic compounds emissions.

- Grant-in-Aid for Early-Career Scientists, granted by the Japan Society for the Promotion of Science (JSPS), PI: Minako Kurisu, FY2024-2026, Source identification of Fe supplied in the western subarctic North Pacific ~Quantitative evaluation using Fe stable isotope ratios.


- NIES VOS Program (Atmosphere/Ocean Greenhouse Gas Observation: Japan-North America, Japan-Oceania)

- Global Environmental Research Coordination System from Ministry of the Environment of Japan, Comprehensive observations of marine ecosystem and carbonate system for accurate evaluation of oceanic CO2 uptake


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

(No specific order)


5. Engagements with other international projects, organisations, programmes, etc.
Report for the year 2023 and future activities

SOLAS Aotearoa New Zealand
compiled by: Holly Winton

This report has two parts:

- **Part 1:** reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

- **Core Theme 1:** Greenhouse gases and the oceans;
- **Core Theme 2:** Air-sea interfaces and fluxes of mass and energy;
- **Core Theme 3:** Atmospheric deposition and ocean biogeochemistry;
- **Core Theme 4:** Interconnections between aerosols, clouds, and marine ecosystems;
- **Core Theme 5:** Ocean biogeochemical control on atmospheric chemistry;
- **Cross-Cutting Theme:** Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
- **Cross-Cutting Theme:** Climate intervention;
- **Cross-Cutting Theme:** Science and society.

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

<table>
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<tr>
<th>First things first...Please tell us what the IPO may do to help you in your current and future SOLAS activities.?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ongoing support (promotion, facilitation) for the development of the Aus/NZ mCDR node.</td>
</tr>
<tr>
<td>2. International collaboration - New Zealand has become an Associate Member of Horizon Europe. This is a positive step forward for potentially supporting SOLAS related-research in the New Zealand/South-west Pacific region given that the research outlook in this space is highly uncertain in NZ. A number of NZ researchers were involved in the Deep South National Science Challenge, which ends in June, and NIWA, a Crown Research Institute, has also cut its ocean aerosol programme, both of which contributed to SOLAS research, particularly in Theme 4 (Interconnections between aerosols, clouds, and marine ecosystems). SOLAS would be an ideal platform to support and facilitate future Horizon Europe funding bids as NZ researchers have the international connections but little experience in this scheme.</td>
</tr>
</tbody>
</table>
PART 1 - Activities from January 2023 to Feb/Mar 2024

1. Scientific highlight

Exploring the links between biological processes in the surface ocean with aerosol production and transformation in the marine boundary layer is complex. Past missions including SAGE (2006), PreSOAP (2011) and SOAP (2012) [Law et al, 2017] have provided a foundation for establishing the influence of regional ocean biogeochemistry on atmospheric CO₂ and aerosols in the Southern Ocean south of Aotearoa New Zealand, which was built upon by Sea2Cloud (2021) which further investigated how surface ocean biogeochemistry influences primary aerosol production across different water masses [Sellegri et al., 2023; Chamba et al, 2023].

The successful sampling mission conducted by the RV Tangaroa over the biologically rich waters of the Ross Sea in early 2023 provided data that will help to advance our understanding of marine ecosystems and their potential influence on atmospheric processes. Seawater and aerosol filter samples and real-time aerosol measurements were collected over the 6-week voyage from Wellington to the Ross Sea and back to quantify biogenic aerosol sources using trace elements, soluble ions and fatty acid biomarkers. Relatively high-resolution (6 hourly) trace element and black carbon aerosol concentrations were determined in fine (PM2.5) and coarse (PM10) mode aerosol by ion beam analysis techniques, and soluble ions and fatty acid biomarkers were measured on high volume PM10 aerosols collected every 5 days. Analysis of additional fatty acid biomarker samples is ongoing. Present data indicates that episodic increases in sea salt, non sea salt (nss)-sulphate and mineral dust aerosol corresponds to higher wind speed events (Figure 1). Within the Ross Sea, nss-sulphate and methanesulfonic acid (MSA) concentrations increased to peak concentrations at the beginning of February 2023 and then declined to low values just before the cruise left the Ross Sea. Aerosol measurements were obtained using a GRIMM Mini Laser Aerosol Spectrometer (Mini-LAS, GRIMM) and revealed significant particle formation in the sub-micron range (Figure 2). However, instrument issues resulted in a substantial loss of data for much of the journey. No nucleation events were observed during this period. Future work will investigate the relationship between sulphur and fatty acid biomarker aerosols, chlorophyll-a data derived from satellites and onboard observations of diatoms and Phaeocystis antarctica to understand the role of phytoplankton bloom composition on Ross Sea aerosols.

Figure 1: Time series of latitude, wind speed, mineral dust aerosol (coarse fraction), sea salt (coarse fraction), and nss-sulphate (coarse fraction) data collected on the RV Tangaroa. The shaded area signified time in the Ross Sea.
Figure 2: Time series aerosol data from the aerosol instrument (Grimm Mini-Las E11) collected from RV Tangaroa during 15 January to 23 February 2023 in the Ross Sea. Top: Aerosol concentration (dN/dlogDp) for diameters between (260<d<1200 nm). Bottom: Same as top but plotted as contours. Data gaps are due to instrument issues.

References


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).

Field campaigns

TAN2302 RV Tangaroa voyage to Ross Sea (January-February 2023) – clouds, aerosols, microplastics, dissolved gases, seawater biogeochemistry and productivity.

Munida transect (NIWA) – continuation of marine carbonate system time series, with five sampling events (bimonthly) in coastal, modified subtropical water and subantarctic water (parameters surface pCO2, vertical and discrete carbonate system, biogeochemistry)

NZOAON (NZ Ocean Acidification Observing Network) - samples collected bimonthly and analysed at 20+ coastal stations

Investigating relationships between DMS and grazers in the Hauraki Gulf (University Auckland NIWA) - October 2023

We continue our ships of opportunity programme, collecting air flask samples for 14CO2 analysis. In this programme, volunteers on a variety of ships travelling between New Zealand and the Ross Sea fill air flasks for us on transects across the Southern Ocean. The 14CO2 measurements are intended to provide new information on the strength and variability of deep water upwelling.

Contributions to international assessments

Coordination of SOLAS Special Feature The Air-Sea Interface in a Changing Climate: Research advances and directions in Elementa

Coordination of SOLAS Post-Doctoral Programme on Marine Carbon Dioxide Removal

Guest Editor for Sea2Cloud Special Issue in Atmospheric Chemistry & Physics/Ocean Sciences

Scientists’ Coalition for an Effective Plastics Treaty, which is informing UNEP plastics pollution treaty negotiations

UNEP Environmental Effects Assessment Panel, which assesses the environmental effects of ozone layer depletion

UN Ocean Decade Programme OARS (Ocean Acidification Research for Sustainability) Outcome #2 (OA Information for Decision making) White Paper

Workshops and conferences


NZ Ocean Acidification Annual workshop, Nelson, September 2023, presentations on monitoring and mCDR.

Initiation and coordination of the Aotearoa Marine Carbon Forum (AMCF).


Law CS, Miller L. New Challenges in Transcending the Boundary: directions for SOLAS. Invited Keynote Presentation. SOLAS Session, AGU, San Francisco, USA 14/12/23, online


Media

International collaboration

New Zealand - France Antarctic sea ice biomarker collaboration – MSc student, Emma de Jong, visited University of Bordeaux for two months working on project titled 'Pinpointing diatom specific species of biomarkers in the Southwestern Ross Sea sediments to advance paleoclimate reconstructions of phytoplankton.'

New-Zealand - Australia Southern Ocean aerosol collaboration – Sharing infrastructure and voyage opportunities for Southern Ocean aerosol research.

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


and Southern Ocean life on clouds. Elementa: Science of the Anthropocene, 11(1)


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?

Presentation on coastal and marine ecosystem impacts of climate change at NZ Regional Council Coastal Special Interest Group (CSIG) annual workshop.

Interaction with organisations investigating mCDR in New Zealand waters.
**PART 2 - Planned activities for 2024 and 2025**

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

   2024 (January) Laura Bassi voyage to Ross Sea – seawater biomarkers, seafloor seeps.

   2024 (November- December) land-based fieldwork for “Antarctic seafloor seeps: A driver of coastal change?” Marsden project.

   2025 (January) *RV Tangaroa* voyage to Ross Sea – clouds, aerosols, microplastics.

   2024 and 2025 (January) Antarctic fieldwork near Priestley Glacier, Victoria Land – ocean-air-snow transfer of biogenic aerosols.

   2025 (November- December) land-based fieldwork for “Antarctic seafloor seeps: A driver of coastal change?” Marsden project.

   2025 “Go South 2 – Finding the missing Southern Ocean aerosol and cloud processes” funded by a RSNZ Catalyst award. TROPOS and University of Hannover have received funds from German funders to come to Aotearoa in 2025 to carry out ground and air measurements of Southern Ocean marine aerosol-cloud interactions. Our funding will allow us to 1) plan joint activities with TROPOS and University of Hannover in NZ in 2025 and 2) discuss potential long-term collaboration with teams in Germany and France on Southern Ocean aerosol and cloud processes. In 2024, a site selection study will take place with German visitors.

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

   NZ Ocean Acidification Annual workshop

3. Funded national and international projects/activities underway.

   Deep South National Science Challenge (ends June 2024), Marine organic aerosol as freezing and cloud-condensation nuclei: Improving the realism of cloud-aerosol coupling (Laura Revell, UC and Olaf Morgenstern, NIWA)

   Rutherford Discovery Fellowship (2023-2028), Airborne microplastics in a changing climate (Laura Revell, UC)

   Rutherford Discovery Fellowship (2023-2028), Southern Ocean phytoplankton and climate: understanding the ability of phytoplankton to modulate climate in a warmer world (Holly Winton, VUW)

   Marsden Fund (2023-2026), Constraining the longevity of microplastic-climate forcing, Laura Revell (UC), Karin Kvale (GNS) and Nikolaos Evangelion (Norwegian Institute for Air Research)

   Marsden Fund (2023-2026), How did changing sea ice conditions impact primary production in the Ross Sea over the past 200 years? (Holly Winton, VUW, Adam Hartland, University of Waikato, Alison Ming, University of Cambridge, Caroline Holmes, John Turner, British Antarctic Survey, Manul Dall'Osto, Spanish Institute of Marine Science)

   Marsden Fund (2024-2027) Antarctic seafloor seeps: A driver of coastal change? (Sarah Seabrook, Cliff Law, NIWA).

   RSNZ Catalyst award (2024-2025) Go South 2 – Finding the missing Southern Ocean aerosol and cloud processes (Guy Colson, NIWA, Adrian McDonald, UC, Patrick Seifert, TROPOS).
4. Plans / ideas for future national or international projects, programmes, proposals, etc. (please indicate the funding agencies and potential submission dates).

A new German-New Zealand collaboration is scheduled to investigate aerosol-cloud-radiation processes over the Southern Ocean south of New Zealand in 2025 using aircraft, ship and land-based observations.

Aircraft: Halo-South “The interplay of Clouds, Aerosols and Radiation above the Southern Ocean” is funded which utilises the is funded German HALO aircraft in June – October 2025 based out of Wellington. [https://halo-research.de/sience/future-missions/halo-south/](https://halo-research.de/sience/future-missions/halo-south/)

Ship: Sonne-South “Atmospheric Clouds, Aerosol, and Radiation in the Southern Ocean around Aotearoa” GPF Cruise Proposal for SO 9/2025 is currently under review which proposed to bring the Sonne to waters surrounding lower New Zealand.

Land-based: “Better Climate Forecasting: Finding the Missing Southern Ocean Aerosol and Cloud Processes” Marsden Fund proposal is currently under review for a 12-month land based campaign in conjunction with the Sonne and Halo.

This builds upon a current Catalyst Fund grant which enables new collaboration through travel between NZ and Germany and scoping of potential land-based sites for atmospheric campaigns. In 2024, a site selection study will take place with German visitors.

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

Comments
Report for the year 2023 and future activities

SOLAS ‘Norway’
compiled by: ‘Siv Kari Lauvset’

This report has two parts:

- Part 1: reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

Core Theme 1: Greenhouse gases and the oceans;
Core Theme 2: Air-sea interfaces and fluxes of mass and energy;
Core Theme 3: Atmospheric deposition and ocean biogeochemistry;
Core Theme 4: Interconnections between aerosols, clouds, and marine ecosystems;
Core Theme 5: Ocean biogeochemical control on atmospheric chemistry;
Cross-Cutting Theme: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
Cross-Cutting Theme: Climate intervention;
Cross-Cutting Theme: Science and society.

IMPORTANT: This report should reflect the efforts of the SOLAS community in the entire country or region 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. ?
The Early Career Scientists have made this comment:

SOLAS has been very active in organizing conferences and Summer Schools for early careers. We find the continuation of these kind of events very helpful to maintain and enhance the network community in ocean-atmospheric biogeochemical and physical interactions.

Perhaps organizing some sort of “alumni” network or regional meetings/workshops would also be helpful for the community to grow, but specially for early career scientist for making new and keeping old contacts.

PART 1 - Activities from January 2023 to Feb/Mar 2024
1. Scientific highlight
Old weather station evidences warming and acidification of the Norwegian Sea

The Ocean Weather Station M, or Station M in short, is situated in the Norwegian Sea and started its observations already in 1948, as one of 13 weather stations in the North Atlantic.

In addition to meteorological observations at Station M, also ocean observations have been performed since the very beginning, which has resulted in one of the world’s longest time series of deep-water temperature and salinity. The time series show that the water at 2000 m depth in the Norwegian Sea has warmed by more than 0.2°C degrees over nearly 40 years. The warming started in the 80-ties and is still going on. The warming is connected to a reduced deep-water formation, which has resulted in a change in the water exchange between the deep basins in the Arctic Mediterranean. Now, more Arctic water is flowing into the Norwegian Sea compared to previously, which is evidenced by increasing temperature and decreasing dissolved oxygen.

Time series of inorganic carbon over nearly 3 decades from Station M show that the sea surface pCO2 increases slightly faster than that of the atmosphere, which indicates that the area is a decreasing sink for atmospheric CO2. Surface water pH, on the contrary, is decreasing over time, and over nearly 30 years, the surface pH has decreased by nearly 0.1 pH units, which is comparable to the global pH decrease since the onset of industrial revolution. These surface water changes are primarily due to uptake of anthropogenic CO2 from the atmosphere.

Changes are not only seen in surface water. At all depths, the pCO2 is increasing and pH and saturation concentration of aragonite are decreasing over time. Currently, the water at 2000 m is corrosive for aragonite, and this corrosive water has shoaled by approximately 7 m/yr over the last decades, which means that eventually, the corrosive water will reach and degrade the rich amounts of deep-water corals off the Norwegian coast.

Reference:
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).

- WMO-GGGW meeting March
- ICOS/SOCAT/GCB workshop 6-10 November, Oostende, Belgium.
- Participation in the RECCAP2 synthesis. Norwegian scientists contributed to the Global, Antarctic, Atlantic Ocean, Seasonal Cycle, and Coastal synthesis papers.
- Several students took part in the SOLAS Summer School 2023 in Cape Verde

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Journal</th>
<th>DOI</th>
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<tbody>
<tr>
<td>Ericson et al.</td>
<td>Rapid fCO₂ rise in the northern Barents Sea and Nansen Basin</td>
<td>Prog. in Oceanogr.</td>
<td>10.1016/j.pocean.2023.103079</td>
</tr>
<tr>
<td>Koseki, S., J. Tjiputra, F. Fransner, L. R. Crespo, and N. S. Keenlyside</td>
<td>Disentangling the impact of Atlantic Nino on sea-air CO₂ fluxes</td>
<td>Nature Communications</td>
<td>10.1038/s41467-023-38718-9</td>
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<tr>
<td>ICOS workshop, 7-10 October, Villefranche, France</td>
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<tr>
<td>3. Funded national and international projects/activities underway.</td>
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<tr>
<td>ICOS Norway and OTC (2021-2024), funded by Research Council of Norway.</td>
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<tr>
<td>Norwegian Ocean Acidification Monitoring program (2021-2025), funded by Norwegian Environment Agency.</td>
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<tr>
<td>NorEMSO (2020-2025), funded by the Research Council of Norway.</td>
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<tr>
<td>KADI (2022-2025), funded by EU (HORIZON-INFRA-2021-DEV-01).</td>
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<tr>
<td>NUBICOS (2023-2027), funded by EU (HORIZON-INFRA-2023-DEV-01).</td>
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<td>4. Plans / ideas for future national or international projects, programmes, proposals, etc. (please indicate the funding agencies and potential submission dates).</td>
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<tr>
<td>5. Engagements with other international projects, organisations, programmes, etc.</td>
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Report for the year 2023 and future activities

SOLAS ‘Peru
compiled by: ‘Ivonne Montes

This report has two parts:

- **Part 1:** reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

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- **Cross-Cutting Theme:** Science and society.

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

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

There is a diverse academic community, ranging from young to seasoned scholars, particularly at the university level, that needs to take a step forward in the advancement of Peruvian science, as well as increase the number of people involved in the high-level science. In this regard, SOLAS IPO can play a significant role in facilitating collaboration. For instance, it can help connect researchers, scientists and organizations within the SOLAS community to organize conferences, workshops, networking meetings, as well as summer schools, among other activities. Additionally, it can provide technical advice by linking individuals with experts in specific areas related to SOLAS, such as ocean chemistry, marine biogeochemistry, and ocean dynamics. Furthermore, it can offer valuable information and resources, including up-to-date technical documents, research reports, oceanographic and meteorological data, and other relevant materials.

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**PART 1 - Activities from January 2023 to Feb/Mar 2024**

1. **Scientific highlight**
El Niño Southern Oscillation (ENSO) is one of the most important modes of climate variability in the Pacific Ocean, which has a strong influence on global and regional precipitation. In Peru, during the cold phase of ENSO, La Niña in the central Pacific Ocean increases precipitation in the southern highlands as well as in the northeastern region of the highlands-Puno. On the other hand, El Niño in the eastern Pacific Ocean is the one that causes the greatest impacts through increased precipitation and heat waves on the northern coast, while El Niño in the central Pacific Ocean can result in droughts in the Andes and the Amazon. This widely affects the socioeconomic sphere since it causes damage to infrastructure, agriculture, fishing, among others.

Peru, as part of the public management strategy to confront ENSO, especially with respect to El Niño, establishes the Results-Based Budget Program (PPR) 068 “Vulnerability reduction and disaster emergency response.” The Geophysical Institute of Peru (IGP), like other institutions that make up the Multisector Commission in charge of the National Study of the “El Niño” Phenomenon, participates in this PPR with the product called “Studies for disaster risk estimation.” This product consists of the timely delivery of scientific information on the monitoring and forecasts of this natural oceanic-atmospheric event, through monthly technical reports, which allow decision-making by authorities at the national and regional level.

The IGP, a pioneer in numerical modeling in Peru and as part of the aforementioned product, has implemented the IGP Regional Earth System Model CROCO-OASIS-WRF v.1 (IGP RESM-COWv1); whose ultimate purpose is its use as a forecasting tool. The IGP RESM-COW v1, with a resolution of 12 km for the ocean and 30 km for the atmosphere, covering the entire Peruvian territory and part of the eastern Pacific Ocean, providing 7-month forecasts for both the ocean and atmosphere. Regarding the realism of the simulation, the preliminary validation of the implementation in forecast mode for the period January-July 2023 shows that the coupled model can reproduce the dynamics of the study region. This is seen in Figure 1, where the simulated sea surface temperature (SST) in the Niño 1+2 region is compared with the observed SST extracted from the OISST AVHRR product (i.e., the satellite/sensor daily optimal interpolation SST [NOAA/AVHRR: Advanced Very High-Resolution Radiometer]) with a resolution of 25 km. In the medium term, the aim is to use other global models to improve the model's boundary conditions. Likewise, it is expected to integrate other components of the Earth system, such as the biological component, which could include changes in the type of vegetation cover on the continent, the carbon cycle or the contribution of microorganisms in the ocean to nutrient stocks and concentration of gases (mainly oxygen).

Figure 1. (Left panel) Monthly average precipitation, surface winds and SST contours (27°C, 28°C and 29°C, yellow, red and purple line, respectively) calculated from the outputs of the IGP RESM-COW v1 in forecast mode during April 2023 with initial condition January 2023. (Right panel) Time series of the monthly average of sea surface temperature in the Niño 1+2 region compared with the observed SST extracted from the OISST AVHRR product (i.e., the satellite/sensor daily optimal interpolation SST [NOAA/AVHRR: Advanced Very High-Resolution Radiometer]) with a resolution of 25 km. In the medium term, the aim is to use other global models to improve the model's boundary conditions. Likewise, it is expected to integrate other components of the Earth system, such as the biological component, which could include changes in the type of vegetation cover on the continent, the carbon cycle or the contribution of microorganisms in the ocean to nutrient stocks and concentration of gases (mainly oxygen).

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 phase 2 of SEPICAF (South Eastern Pacific Circulation from ARGO floats) project was accepted. The project is aimed at making a breakthrough in our understanding of the physical forcing of the Oxygen Minimum Zone (OMZ) in the Southeastern Pacific (SEP) through the consideration of processes not well accounted for in current generation global coupled models (i.e., upwelling dynamics, turbulent flow, oceanic teleconnection), which will provide material for interpreting historical data sets and guide model improvement. It will yield a conceptual understanding of the non-linear response of the OMZ to ENSO forcing in the SEP. The project is lead by France having national partners from Ecuador, Peru and Chile to implement the first step, i.e., the release of ARGO floats along Ecuador, Peru and Chile between 2024-2026.

- Implementation of the observatory of scientific knowledge on climate change of Peru ‘cienci aclimática’ (https://cienci aclimática.igp.gob.pe), which allows users, such as change authority, researchers and students, to easily access interpreted scientific knowledge ("interpretations") for the comprehensive management of climate change and research. It is a living space that allow interaction between members of the academic/scientific community and users and will take full advantage of artificial and human intelligence.

- Participation in the SOLAS Latin-American Workshop ‘Marine biogeochemistry research on Latin American coastal zones’, 26/05/2023, https://www.youtube.com/watch?v=gP3XaAw5MKY).

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


- Linford, P., Pérez-Santos, I., Montes, I., Dewitte, B., Buchan, S., Narváez, D., ... & Altamirano, R. (2023). Recent deoxygenation of Patagonian fjord subsurface waters connected to the Peru–Chile undercurrent and equatorial subsurface water variability. Global Biogeochemical Cycles, 37(6), e2022GB007688


### 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?

### PART 2 - Planned activities for 2024 and 2025

1. **Planned major national and international field studies and collaborative laboratory and modelling studies (incl. all information possible, dates, locations, teams, work, etc.).**
   - To incorporate the ocean biogeochemical component on the IGP RESM-COW v1.
   - To involve more scientist around the world to contribute with [https://cienciaclimatica.igp.gob.pe](https://cienciaclimatica.igp.gob.pe)

2. **Events like conferences, workshops, meetings, summer schools, capacity building etc. (incl. all information possible).**
   - The 45th session of WCRP’s Joint Scientific Committee (JSC-45) in parallel with the 2nd Meeting of ANDEX, 27-30 May 2024, Peru. [https://www.wcrp-climate.org/jsc45](https://www.wcrp-climate.org/jsc45)
   - APEC activity ‘Developing best practices to address coastal marine deoxygenation in APEC economies for improving the management of marine living resources’, September 2024.

3. **Funded national and international projects/activities underway.**
   - [https://cienciaclimatica.igp.gob.pe](https://cienciaclimatica.igp.gob.pe)

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

5. **Engagements with other international projects, organisations, programmes, etc.**
   - GO2NE (Global Ocean Oxygen Network)
   - WRCP (World Climate Research Programme)
   - CLIVAR (Climate and Ocean -Variability, Predictability and Change) Pacific Regional Panel
   - SCOR WG 155 – EBUS
   - ANDEX: A regional Hydroclimate Initiative for the Andes ([https://www.gewex.org/project/andex/](https://www.gewex.org/project/andex/))

### Comments
Report for the year 2023 and future activities

SOLAS ‘Portugal’
compiled by: ‘Catarina V. Guerreiro’

This report has two parts:
- Part 1: reporting of activities in the period of January 2023 - Jan/Feb 2024
- Part 2: reporting on ongoing/concluded/planned activities for 2024.

Introduction
The present document reports on the second assessment of science-related activities by Portuguese researchers working in Themes and Cross-Cutting Themes within the SOLAS 2015-2025 Science Plan, less than one year since Portugal was invited to join the SOLAS international community. The SOLAS-Portugal introduced here is composed by a multidisciplinary group of researchers from various universities, institutes, and research centres from all over the country, including MARE/ARNET-University of Lisbon, CIIMAR/LOAI-University of Porto, IPMA (Marine Geology and Geo-resources Division), LNEG, IH, CESAM-University of Aveiro, CIMA/ARNET-University of Algarve, IDL/ARDITI-University of Madeira, IDL-University of Lisbon, IDL-University of Coimbra, and IMS-University of Azores (affiliations provided in the “Comments” section). The alphabetical list of SOLAS-relevant projects (n=19) in which Portuguese researchers participate as PI's, co-PI's and/or research collaborators, as well as the list of publications (n=25) and conference presentations (n=20) for the period of January 2023 – February 2024 with Portuguese and/or Portugal-based authors/co-authors, are based on researchers’ voluntary input. SOLAS-relevant activities developed in Portugal were/are mostly focused on: investigating the biogeochemical effects of atmospheric deposition; studying air-sea interfaces and fluxes of mass and energy; using Earth Observations and modelling approaches to explore climate-related environmental variability; paleo-reconstructions; integrated studies of high sensitivity systems, with focus on polar regions; outreach activities linking science, education, and society.

PART 1 - Activities from January 2023 to Jan/Feb 2024

1. Scientific highlight
The year 2023 was marked by the occurrence of numerous relevant SOLAS-related publications and initiatives, of which the following are highlighted:

(1) Gorodetskaya, I. (LOAI/CIIMAR-University of Porto) and colleagues have reported on a new extreme warm event and record-high surface melt in February 2022 in the Antarctic Peninsula (AP), reportedly rivaling the recent temperature records from 2015 and 2020 and contributing to the alarming series of extreme warm events over this region showing stronger warming compared to the rest of Antarctica (npj Climate and Atmospheric Science 6, 2023). According to this study, the northern/northwestern AP was directly impacted by an intense atmospheric river (AR) attaining category 3 on the AR scale, which brought anomalous heat and rainfall, while the AR-enhanced foehn effect further warmed its northeastern side. The event was triggered by multiple large-scale atmospheric circulation patterns linking the AR formation to tropical convection anomalies and stationary Rossby waves, with an anomalous Amundsen Sea Low and a record-breaking high-pressure system east of the AP. This multivariate and spatial compound event culminated in widespread and intense surface melt across the AP. Circulation analog analysis shows that global warming played a role in the amplification and increased probability of the event. Increasing frequency of such events can undermine the stability of the AP ice shelves, with multiple local to global impacts, including acceleration of the AP ice mass loss and changes in sensitive ecosystems.
Figure: Map of AP with geographic names. Location of the weather stations (black circles with bold dark blue names), ice shelves (names in black italic) and other geographical features used in this study. The topography is from the 1-km Reference Elevation Model of Antarctica (REMA) used in Polar WRF75. The ice shelves are delimited by the 1:10 million Antarctic Ice Shelf Edges. Red line delineates the land and ice shelf extent corresponding to the Antarctic Peninsula used in the MAR (Modèle Atmosphérique Régional) analysis. In Gorodetskaya, I.V. et al. (2023). Record-high Antarctic Peninsula temperatures and surface melt in February 2022: a compound event with an intense atmospheric river. npj Clim Atmos Sci 6, 202 (2023).

(2) Brotas, V., and colleagues (MARE/ARNET-University of Lisbon) have published the results from a cross-Atlantic (50°N–50°S) assessment of the phytoplankton community composition (Frontiers in Marine Science 10, 2023) during which several Saharan dust plumes were seen across the tropical North Atlantic (10–22°N). This study, based on in-situ observations collected during the Atlantic Meridional Transect in synergy with satellite time-series data, represents the first attempt in the literature to match satellite size classes with in-situ data derived from cell abundance, and in relation to environmental drivers across the Atlantic Ocean. Results showed a dominance of picoplanktonic Cyanobacteria in oceanic gyres, an increase in all size-class phytoplankton groups in the equatorial upwelling region, and higher biomass of microphytoplankton in the higher latitude regions. The comparison of community structure between recent cruises (2019, 2018, 2015) and earlier ones (1995–1998) indicates a decrease in the number of diatom-bloom forming species, and an increase in dinoflagellates, whereas nitrogen-fixing Trichodesmium abundance in tropical Atlantic remained constant. The presence of diazotrophic Cyanobacteria species and of diazotrophic diatom Hemiaulus hauckii offshore NW Africa during both AMT28 and 29 was likely related to iron and phosphate supplied by Saharan dust deposition in the region, resulting in enhanced N2-fixation rates (see also: Guerreiro et al., 2023). Results also revealed a relative increase in the median values of picoplankton fraction in the South Atlantic Gyre (SATL) in recent years, counterbalanced by a decrease in both nano- and microplankton fractions.
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).

PROJECTS (n=19)

1. **(AC)3** (Arctic Amplification: Climate Relevant Atmospheric and Surface Processes and Feedback Mechanisms). TR172 Trans-regional German project funded by DFG (Germany). LOAI/CIIMAR participates as Mercator fellow and external collaborator, student co-supervisor (2017-current).

2. **APMAR2** (Antarctic Peninsula precipitation and surface Mass and energy balance: what is the role of Atmospheric Rivers?). Fieldwork project in Antarctica funded by FCT-PROPOLAR (in collaboration with Korea Polar Research Institute). Radiosonde profiling, precipitation remote sensing, precipitation sampling at King Sejong station, King George Island. PI LOAI/CIIMAR (2022-2023).

3. **ARCA** (Atmospheric rivers climatology in Antarctica), funded by ANR (France). LOAI/CIIMAR participates as external collaborator (2020-2023).

4. **ATLACE** (ATLantic interactions via atmospheric water cycle: exploiting a unique dataset from the Antarctic Circumnavigation Expedition for better understanding of clouds and precipitation), funded by FCT (Portugal), PI LOAI/CIIMAR (2020-2023).

5. **ATLANTIDA** (Platform for the monitoring of the North Atlantic Ocean and tools for the sustainable exploitation of the marine resource), funded by CCDR-N (Portugal). Researchers and task leaders LOAI/CIIMAR (2020-2023).

6. **CHASE** (CHASing the environmental Effects of dust deposition across the Atlantic and Southern Ocean: a coccolithophore perspective), funded by CEECIND-FCT (Portugal). PI MARE/ARNET (2020-current).

7. **GPD4CCI** (GPD + Wet Tropospheric Corrections for use in the Sea level), CCI project funded by ESA. LOAI/CIIMAR participates as researcher (2022-2023).

8. **GPD4CRYOSAT** (Wet Tropospheric Correction), funded by ESA. Task leader LOAI/CIIMAR (2016-2024).
9. **GPD4S3** (S3 Altimetry GPD + Wet Tropospheric Correction), funded by EUMETSAT. Task leader LOAI/CIIMAR (2021-2024).
10. **HALO-(AC)3** (Arctic Air-Mass Transformations During Warm Air Intrusions and Marine Cold Air Outbreaks), funded by DFG (Germany). LOAI/CIIMAR participates as external collaborator and co-PI (2020-2023).
11. **HYDROCOASTAL** (Sentinel-3 and Cryosat SAR/Sarin Radar Altimetry for Coastal Zone and Inland Water), funded by ESA. Researcher LOAI/CIIMAR (2019-2023).
14. **Magal Constellation** (Setting the cornerstone of a future ocean and climate change monitoring constellation, based on radar altimeter data combined with gravity and ocean temperature and salinity), funded by Programme UT Austin Portugal. PI LOAI/CIIMAR (2020-2023).
16. **MODELRISK** (Ecosystem models to support Environmental Risk Assessment of marine ecosystems under HNS spills), funded by ITOPF (UK). Researchers and task leaders LOAI/CIIMAR (2021-2023).
17. **Ocean3R** (Reduce pressures, restore, and regenerate the NW-Portuguese ocean and waters), funded by CCDR-N (Portugal). Researchers LOAI/CIIMAR (2021-2023).
18. **PRIMUS** (PRIMary-productivity in Upwelling Systems). Earth Science Case “Comparison of sediment trap data in the Canary upwelling system using standard and Lagrangian approaches to primary production”, funded by ESA. PI Plymouth Marine Laboratory, WP lead MARE/ARNET (2021-2023).

**MAJOR INTERNATIONAL INITIATIVES (n=5)**

1. **ARTMIP** – Atmospheric Rivers Tracking methods Intercomparison Project (2017-ongoing):
   - Gorodetskaya, I. (LOAI/CIIMAR): active member contributing with her AR own algorithm
   - [https://www.cgd.ucar.edu/projects/artmip](https://www.cgd.ucar.edu/projects/artmip)

2. **SCAR** – Scientific Committee on Antarctic Research (2020-2028):
   - Scientific Research Programme AntClimNow - Near Term Variability and Prediction of the Antarctic Climate System; Gorodetskaya, I. (LOAI/CIIMAR): Member of the Scientific Steering Committee
   - [https://www.scar.org/science/antclimnow/members/](https://www.scar.org/science/antclimnow/members/)


5. **JETZON** – Joint Exploration of the Twilight Zone Ocean Network (2023-ongoing), funded by the NERC – National Environmental Research Council; NASA; OBC Project – Ocean Carbon & Biogeochemistry; and SCOR – Scientific Committee on Oceanic Research. Endorsed by the UN Ocean Decade. Guerreiro C.V. (MARE/ARNET): member of WG5 of the JETZON BCP (Biological Carbon Pump) initiative (lead by Ghent University).

**ORGANIZATION OF CONFERENCES/EVENTS (n=6)**

**SOLAS Session at the Ocean Sciences Meeting (OSM):** “The Biogeochemistry of Air-Sea Exchange Processes”, February 2024, New Orleans, Louisiana, USA. Primary chair: Guerreiro C.V.
Discussions on Research Topics developed by LOAI and MEMO graduate and undergraduate students, CIIMAR, Matosinhos, Portugal, 13 July 2023. International workshop organized by LOAI/CIIMAR.


EDUCOAST Summer School 2023 on “Coastal Geosystem Services - the Ria Formosa case study”, led by IPMA during 10–16 September, Tavira, Portugal.


Winterschool on Arctic amplification – the role of clouds (in feedback mechanisms), Hyytiälä, Finnland (2023/03/12 - 2023/03/18), led by Gorodetskaya, I. (LOAI, CIIMAR).

SCIENTIFIC CONFERENCES (n=20)


Gorodetskaya, I. V. et al. (2023). YOPPsiteMIIP applications over the Antarctic Peninsula. Paper presented in Workshop on Model Intercomparison and Improvement Projects for the polar regions and beyond, Stockholm University, Sweden, 17-20 April.


changes during key glacial terminations in the North Atlantic Region; IJUP 23 (Encontro de Jovens Investigadores da Universidade do Porto); 10 e 12 May, Porto, Portugal (Best Oral Presentation Award).


Rodrigues T., Toucanne S., Naughton F., Casado M., Gonzalez Y., Hodell D., Abrantes F., Grimalt J.O. (2023). Comparing two similar extreme SST cooling events under different boundary conditions within MIS 8 and MIS 34 in the Iberian Margin. XXI INQUA Congress, Rome (Italy), 13-20th July.

Stuut, J-B., Guerreiro C.V., van der Does, M. (2023). Monitoring present-day Saharan dust above and below the ocean surface. XXI INQUA Congress 2023, Session 35 - Dust dynamics through the Quaternary: terrestrial records of climatic and environmental impacts, 13-20 July, Rome, Italy.


OUTREACH ACTIVITIES & PARTICIPATION AT MAJOR EVENTS:

Webinar “Ocean Changes: a plankton story, from open waters to the lab” organized by HIPÁCIA (Association of Portugal-residing Italian Researchers), in collaboration with the Embassy of Italy in Lisbon, SCIAENA, and Italian Culture Institute, 14 April 2023 (online). Invited speaker: Guerreiro, C.V. (MARE/ARNET) “Chasing the effects of dust across the Atlantic Ocean: a coccolithophore perspective”.

Conference “An ocean of opportunities” organized by the City Hall of Torres Vedras (Portugal) in celebration of the Ocean’s International Day at the Environmental Interpretation Center of the Local Nature Reserve Foz Azul, 8 June 2023. Invited speaker: Guerreiro, C.V. (MARE/ARNET) “How marine phytoplankton contributes to sequester atmospheric CO2”.

17 media articles – national and international – featuring FMS paper by Guerreiro et al. (2023), incl.: Público (online and paper), Visão Online, Sábado Online, Phys Org, EurekAlert!, Creative News Online, Atlas da Saúde Online, Correio de Lagos Online, Medjournor Online, PT Jornal Online, Terras do Homem Online, Tv Online Centro TV, Ambiente Magazine Online, Funchal Notícias Online, Green Savers Online, Alvorada Online, Environment Coastal & Offshore (ECO), BNNBreaking, Ciências-ULisboa Newsletter, ULisboa Newsletter.

Lecture: “Exemplo de um trabalho desenvolvido por um investigador que estudava variações climáticas lecture to students of the “Escola básica D. Fernando; Sintra”, May 2023. Invited speaker: Naughton, F.

Lecture: “Climate change of the last 1Myr: linking ocean, land and ice records”. PhD students of the PhD programme in Geology, FCUL, Portugal, 2023. Invited speaker: Naughton, F.

Seminar: “Climate change across the last 1Myr: linking ocean, land and ice records”. Presentation to bachelor and master students from Aveiro University at IPMA. Invited speaker: Naughton, F.

Website/interactive blogs of projects CHASE (www.chase-dust.com) and PRIMUS (www.primus-atlantic.org) (creation and coordination MARE/ARNET).
EDITORIAL ACTIVITIES:


FIELDWORK:

DUST 2023 EXPEDITION (64PE514): took place from 6–27 March 2023 on board RV Pelagia, sailing from Mindelo (Cape Verde) to Malaga (Spain), led by the Royal NIOZ, and including MARE/ARNET participant Guerreiro, C.V. The goal was to investigate the biogeochemical effects of Saharan dust deposition on the biological carbon pump, focusing on the calcifying phytoplankton communities. [Stuut J.-B., Guerreiro C.V., and participants (2023). Cruise report and preliminary results (64PE514) DUST2023, 6–27 March 2023 (Mindelo, Cabo Verde – Malaga, Spain), 51 pp.]

ATLANTIC MERIDIONAL TRANSECT (AMT30–DY157): took place from 21 February to 30 March 2023 on board RRS Discovery, sailing from the Falkland Islands to Southampton (UK), led by PML and including MARE/ARNET participants (Tracana, A., Lenna, F.). The goal was to collect material for the study of the phytoplankton communities across the Atlantic in relation to carbon chemistry, nutrient distribution, nitrogen fixation, optical properties, oxygen status, air-sea gas exchange, atmospheric deposition, and particle export. Outcomes from this international collaboration will contribute to ongoing collaborations between MARE/ARNET and PML, in the context of the AMT program. [Rees A.P. and participants (2023). AMT 30 Cruise Report, RRS Discovery (DY157), 162 pp.]

3. List SOLAS-related publications published between Jan 2023 and Jan/Feb 2024 (only PUBLISHED articles) and if any, web links to models, datasets, products, etc. (n=25)


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?

N/A

PART 2 - Planned activities for 2024

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

   Earth Systems Summer School 2024 on "Land-Atmosphere-Ocean interactions in a changing planet", led by IDL during July, Aveiro, Portugal.

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

   CONFERENCE PRESENTATIONS:
   Guerreiro, C.V., Invited Speaker for a plenary keynote on 'Atmospheric deposition and ocean biogeochemistry' at the 9th SOLAS Open Science Conference, 10–14 November 2024, Goa, India.

   SUBMITTED PAPERS:

3. Funded national and international projects/activities underway.

   In addition to most of the Projects and Major International Initiatives indicated in PART 1.2:

   2023-2024: MAPS (Measurements and modelling of the atmospheric and oceanic boundary layers at the northern Antarctic Peninsula during the Year of Polar Prediction Special observing periods). Funded by FCT (Portugal). PI and co-PI LOAI/CIIMAR.

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

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

   MARE/ARNET application to participate on the Ocean Alkalinity Enhancement Pelagic Impact Intercomparison Project (OAEIP) led by Lennart Bach, Institute for Marine and Antarctic Studies, University of Tasmania (Australia), funded by the Carbon to Sea Initiative.
The Portuguese SOLAS community reported here is very active on a personal/research group basis and/or by being involved in SOLAS-related studies in the context of national/international projects, but without being organised as SOLAS-Portugal. This second report is part of the ongoing assessment and recognition of the SOLAS-related activity developed in Portugal, aimed at disclosing it to both the national and the international SOLAS communities. The goal is to contribute to stimulate scientific networks both inside of Portugal and within the international SOLAS community, likely to result in more interdisciplinary, robust, and evidence-based SOLAS-related science.

ARDITI - Regional Agency for the Development of Research, Technology, and Innovation
ARNET – Aquatic Research Network
CIIMAR - Interdisciplinary Centre of Marine and Environmental Research
CIMA – Marine and Environmental Research Center
IDL – Instituto Dom Luiz
IPMA - Portuguese Institute for Sea and Atmosphere
LOAI - Land Ocean and Atmosphere Interactions
MARE – Marine and Environmental Sciences Center
LNEG – National Laboratory of Energy and Geology
IH – Hydrographic Institute
IMS – Institute of Marine Sciences
Report for the year 2023 and future activities

SOLAS ‘South Africa’
compiled by: ‘Brett Kuyper’

This report has two parts:

- **Part 1**: reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

**Core Theme 1**: Greenhouse gases and the oceans;
**Core Theme 2**: Air-sea interfaces and fluxes of mass and energy;
**Core Theme 3**: Atmospheric deposition and ocean biogeochemistry;
**Core Theme 4**: Interconnections between aerosols, clouds, and marine ecosystems;
**Core Theme 5**: Ocean biogeochemical control on atmospheric chemistry;
**Cross-Cutting Theme**: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);
**Cross-Cutting Theme**: Climate intervention;
**Cross-Cutting Theme**: Science and society.

**IMPORTANT**: This report should reflect the efforts of the SOLAS community in the **entire country or region** 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?  

Thank you for the great work and on-going support.
## PART 1 - Activities from January 2023 to Feb/Mar 2024

### 1. Scientific highlight

Dr Sandy Thomalla\(^1\), Dr Thomas Ryan-Keogh\(^1\), Dr Sarah Nicholson\(^1\), Dr Marie Smith\(^2\), Prof Alessandro Tagliabue\(^3\), Prof Pedro Monteiro\(^4\)

\(^1\)Southern Ocean Carbon-Climate Observatory (SOCCO), CSIR, Cape Town, South Africa  
\(^2\)Coastal Systems and Earth Observation Research Group, CSIR, Cape Town, South Africa  
\(^3\)Department of Earth, Ocean and Ecological Sciences, School of Environmental Sciences, University of Liverpool, Liverpool L69 3GP, UK.  
\(^4\)School for Climate Studies, Stellenbosch University, Stellenbosch, South Africa

Climate change is eliciting widespread adjustments to the physical and chemical environment of the oceans, which affects the distribution and seasonal cycle of phytoplankton primary production (NPP). This in turn impacts ecosystem function and the transfer of carbon, energy and nutrients through food webs with complex feedbacks on ocean biogeochemistry and climate. By applying a number of NPP algorithms to 26 years of remote sensing data we show that almost two thirds of the Southern Ocean is typified by significant negative trends in production. Moreover, we provide evidence of a significant multi-decadal increase in phytoplankton iron stress (from in situ BGC-Argo and ship-based platforms) that could potentially be a cause (Ryan-Keogh et al., 2023). Concomitant with these declines in NPP are significant shifts in the amplitude, timing, duration and characteristics of variability of phytoplankton seasonal blooms (Thomalla et al., 2023). Investigating relationships between observed trends and prominent climate drivers highlights regional sensitivities and the complexities of multiple interacting aspects of a changing climate. The majority of these trends differ to those currently being predicted by earth system models, suggesting that they may be underestimating ongoing change in the Southern Ocean, a region where the biological carbon pump is considered to be particularly important. Adjustments of this magnitude at the base of the food web can de-synchronise energy transfer to higher trophic levels, threatening ecosystem services and impacting global climate by altering natural CO2 uptake.

### 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).

**South African Polar Research Infrastructure (SAPRI)**

The South African Polar Research Infrastructure is a consortium and was established in 2021. The ultimate goal of SAPRI is enable broadscale research growth across the polar disciplines and further expand the world class datasets already established. The Implementation Phase is being finalised between the Department of Science and Innovation (DSI) and the National Research...
Foundation (NRF) of South Africa. SAPRI is currently hosted by the South African Earth Observing Network (SAEON) under Dr Juliette Hermes. SAPRI aims to close the gap between existing infrastructure (logistics) and ongoing and upcoming research in the South Africa marine and polar regions.

Part of the SAPRI umbrella includes facilitating research cruises on the R/V SA Agulhas II. These include SEAmester and the Winter Cruise. SAPRI is also heavily involved in establishing a Polar Laboratory, which will be hosted at UCT. One of the Polar Laboratory’s missions is to make research in the polar regions accessible for universities and students who would otherwise not have the opportunity.

**SEAmester**

Annual training of approximately 40 students along the ASCA line off Port St Johns, South Africa. See more details below.

**South African Weather Service**

Testing the new TEKRAN Total Gaseous Mercury Instrument for semi-autonomous measurement during voyages. The instrument will be loaded on the *SA Agulhas II* for future voyages in the Southern Ocean. This is a SA-France collaboration to facilitate transfer of skills but while doing so, also to understand the distribution, sources and pathways of total mercury and (toxic) methylmercury in the Atlantic Southern Ocean. In 2023, Rob Mason, USA, joined the team and supported sampling and training efforts on board.

**Southern Ocean Carbon & Climate Observatory (SOCCO) Cruise participation:**

**DY172 nPOP cruise**

The DY172 nPOP cruise ran from 20/12/2023 to 26/01/2024, which included 1 South African participant co-PI Thomas Ryan-Keogh. The research focus of the cruise was to examine the role of nutrient limitation in constraining phytoplankton primary production. The specific focus of the team was to examine how nutrient limitation impacts phytoplankton photophysiology, specifically how it impacts fluorescence quantum yield.

**UN/GESAMP Working group 38**

A number of South African scientists including members of the UCT Marine Biogeochemistry Laboratory, North-West University, Nelson Mandela University, and Rhodes University (perhaps others) took part in the UN/GESAMP WG38 project in Gqeberha, South Africa and focused on atmospheric deposition to the South Indian Ocean.
3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


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?

International:

National (non university)

Collaborations included shared field work (specifically):

Research cruises – Relief Voyage of the R/V SA Agulhas II along the ‘Goodhope Transect’ between Cape Town and Antarctica.

Ongoing collaboration between the South African Weather Service and University of Cape Town. Resulting in research at the Cape Point Global Atmospheric Watch Tower.

South African Polar Research Infrastructure (SAPRI) – See above.

PART 2 - Planned activities for 2024 and 2025

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

SAPRI –

SEAmester

The SEAmester recommenced in 2022. This programme offers postgraduate students from South Africa a hands-on learning opportunity aboard the SA Agulhas II. The cruise lasts around 10 days and is comprised of lectures and practical demonstration and activities. Introducing students to various facets of ocean and atmospheric dynamics. This includes physical, chemical and biological oceanography, atmospheric chemistry and meteorology, data analysis and measurement techniques. The cruise involves running a transect across the core of the Agulhas Current off Port St Johns, known as the ASCA line.

SEAmester is an ongoing training platform for young students. The SEAmester cruise aims to provide a learning opportunity for postgraduate students, who might not have otherwise had such a chance. There is also the opportunity for the training of early career scientists, by becoming involved in the teaching aspects of the course. Approximately 40 students from 22 institutions
across South Africa are involved in the cruise every year.

**Winter Cruise**

The *R/V SA Agulhas II* embarks on a cruise each year departing from Cape Town to the marginal ice zone. This cruise closes a seasonal gap / bias in the knowledge in physical oceanography and in better understanding the processes affecting the sea ice formation and the Southern Ocean during winter months. The cruise follows the same transect as in summer, known as the ‘Goodhope Transect’.

**Susanne Fietz** (University of Stellenbosch) is heading up a new NRF SANAP grant 2024-2026, focusing on Micronutrient and pollutant trace elements at the air-sea interface of the Southern Ocean.

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

16th International Conference On Mercury as a Global Pollutant (ICMGP 2024) will be held in Cape Town in July 2024. The conference is being organised by the South African Weather Service – Global Atmospheric Watch Division, Western Cape Government – Air Quality Division and the Cape Peninsula University of Technology. This meeting will seek to assess implementation of solutions to reduce the emissions and exposure to mercury as a global environmental pollutant and test the efficiency of implementation of the Minamata Convention in various parts of the world. The conference will bring together representatives from industry, government, research institutions, non-governmental organizations (NGOs) and academia to discuss, inter alia, options for low-mercury energy and industrial technologies and the concept of low-mercury society. The event will also showcase new equipment to measure mercury in various environmental samples, and technology to reduce mercury emissions and exposure.

Planned local SOLAS conference and or communal screening of the OSC at a venue at UCT.

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

**BIOGRIP –**

The Biogeochemistry Research Infrastructure Platform (BIOGRIP) is a South African research initiative. The multidisciplinary initiative aims to broaden research capacity and discovery biological, geological, chemical and physical process. To explore how these processes interact and shape natural environments over time and space.

**South African National Antarctic Programme (SANAP) –**

The South African National Antarctic Programme is funded by the Department of Forestry, Fisheries and the Environment (DFFE) and the National Research Foundation (NRF). The DFFE remain responsible for logistics and infrastructure with the SANAP programme. The NRF is the
agency responsible for grant allocation for the scientific community to continue research in the
polar regions, utilising SANAP infrastructure. Large infrastructure includes the manned station on
Antarctica as well as on Marion and Gough Islands, the SA Agulhas II and a number of smaller
research vessels.

**South African Polar Research Institute (SAPRI) –**

Part of the goal of SAPRI is to bridge this disconnect between research being funded in the polar
regions and access to the infrastructure. There are proposed upgrades to the SA Agulhas II to
create capacity for underway atmospheric chemistry measurements in the Southern Ocean.

**4. Plans / ideas for future national or international projects, programmes, proposals, etc.**

*(please indicate the funding agencies and potential submission dates) *

**Joint venture**

A joint measurement campaign between the Department of Oceanography and Mayis Universitesi
Department of Physics Turkey / Samsun is being examined. The venture aims to place underway
atmospheric instrumentation onboard the SA Agulhas II. Proposed measurements include CO, O3,
NOx and FTIR. Dates for the start of the project are still being determined.

**5. Engagements with other international projects, organisations, programmes, etc.**
Report for the year 2023 and future activities

SOLAS ‘Spain’
compiled by: ‘Jordi Dachs’

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**Cross-Cutting Theme**: Climate intervention;
**Cross-Cutting Theme**: Science and society.

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

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<th>First things first…Please tell us what the IPO may do to help you in your current and future SOLAS activities. ?</th>
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<tr>
<td>It would be good to be able to get the SOLAS endorsement to proposals, and maybe to other activities, in a fast way. So far, the endorsement of SOLAS takes too long, usually longer than the times available for submitting within the framework of Spanish's calls of proposals.</td>
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</tbody>
</table>
### 1. Scientific highlight

Ocean halogen emissions cool climate, but do not offset warming.

The climatic importance of the exchange of gases between the ocean and the atmosphere has focused mainly on the exchange of greenhouse gases, such as carbon dioxide, methane and nitrous oxide. Less attention has been paid to ocean emissions of reactive gases into the atmosphere, where they initiate chemical reactions that can indirectly affect Earth’s radiative balance and climate.

One such group of reactive gases are the so-called short-lived halogen compounds (SLHs), compounds of chlorine, bromine and iodine which last for no longer than six months in the atmosphere. These molecules are naturally emitted from oceans, polar ice, and the biosphere. Measurements over the past two decades measurements have shown their ubiquitous presence in the global atmosphere.

This study uses a state-of-the-art Earth system model to quantify the contribution of SLHs to the global energy balance in pre-industrial, present and future climates. The results show that the SLHs emitted by the ocean exerts an indirect cooling effect on the climate system, arising from complex chemical reactions that modify the energy balance in the atmosphere. This work highlights the net indirect cooling caused by SLH as the result of a trade-off between various cooling and warming effects of halogens, mainly on ozone and methane, with a minor contribution from aerosols and stratospheric water vapor. The study demonstrates that ocean-initiated atmospheric chemistry plays a role in partially mitigating anthropogenic warming.

This cooling mechanism has been amplified since the beginning of the industrial age, as a result of human emissions which, in turn, have increased ocean emissions of halogens. This hitherto unrecognized interaction between SLH and Earth’s radiative budget is nonlinear across past, present, and future climates, and is determined by a combination of natural and anthropogenic emissions, climate variability, and atmospheric chemistry.

Finally, the work shows that this natural cooling effect does not compensate for global warming induced by human action since pre-industrial times, although it must be included in climate models to more accurately reproduce the observed increase in global temperature and improve projections of future scenarios.
Figure: Conceptual representation of the SLH influence on atmospheric composition and radiative feedbacks within the climate system.


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).
Projects:


ACID- The Rías Baixas (NW Iberian Upwelling System) as experimental sites for studying the impact of marine environment acidification on coastal ecosystems (ACID) PI. C. Sobrino. University of Vigo (Ref PID2021-127092OB-I00 . 2021-2025).

PANTOC – Persistent anthropogenic organic carbon in the oceans and Antarctica (PID2021-127769NB-I00). Funded by Spanish ministry of Science. PIs Jordi Dachs (IDAEA-CSIC) and Begoña Jiménez (IQOG-CSIC). 306.000 euros. 2021-2025.

REWITE: Rewilding European Shorelines and Beyond, funded by the European Commission (Horizon Europe) (https://rewriteproject.eu/), PI: Gabriel Navarro (ICMAN-CSIC) (CT5)

COMFORT: Our common future ocean –quantifying coupled cycles of carbon, oxygen, and nutrients for determining and achieving safe operating spaces with respect to tipping points, funded by the European Commission (H2020) (https://comfort.w.uib.no/) PI: Emma Huertas (ICMAN-CSIC) (CT1)

EURO-Sea: Improving and Integrating European Ocean Observing and Forecasting Systems for Sustainable use of the Ocean, funded by the European Commission (H2020) (https://eurosea.eu/), PI: Gabriel Navarro (ICMAN-CSIC) (CT5)

DICHOSO: Contribution of Water Masses of Deception Island to biogeochemical inventories of the Southern Ocean: current budgets and future trends (PID2021-125783OB-I00) funded by the Spanish Ministry of Science and Innovation (https://www.dichoso.csic.es/) PIs: Emma Huertas y Antonio Tovar (ICMAN-CSIC) (CT1, CT2 and CT5)

Cruises and other campaigns:

POLAR-CHANGE, Antarctica, R/V Hespérides, 16/2-16/3/2023. Chief Scientist: M. Dall’Osto; PIs of the project: R. Simó, M. Dall’Osto (ICM-CSIC, Barcelona). 23 participants from ICM-CSIC (Spain), Aerodyne (USA), TROPOS and GEOMAR (Germany), Univ. Birmingham and Univ. Manchester (UK), KOPRI (Korea), Univ. Helsinki (Finland), Univ. Clermont Auvergne (France), Univ. Liége (Blegium), Univ. Cape Town (South Africa). Aerosols, volatiles, and surface ocean biogeochemistry.

ACID-Monthly sampling campaigns since April 2023 following a transect from freshwater stations to open water stations in Ría de Vigo (higher anthropogenic impact) y Ría Muros-Noia (lower anthropogenic impact).
PANTOC-1. Antarctic Sampling campaign at coastal Livingston and Deception islands (South Shetlands, Antarctica). February-march 2023. 8 participants from IDAEA-CSIC and IQOG-CSIC.

"DICHOSO1": oceanographic cruise throughout the South Shetland Islands (Southern Ocean) to measure CO2, CH4 and N2O and related biogeochemical variables in the water column on board RV Hesperides (March 12-March 22, 2024), Chief Scientists: Emma Huertas y Antonio Tovar (ICMAN-CSIC) (CT1, CT2 and CT5)

GIFT0523 oceanographic cruise throughout the Strait of Gibraltar to measure CO2, CH4 and N2O and related biogeochemical variables in the water column on board RV Angeles Alvarino to sustain the marine time series GIFT (May 21-May 25, 2023) CS: Emma Huertas (CT1 and CT5)

GIFT1123: oceanographic cruise throughout the Strait of Gibraltar to measure CO2, CH4 and N2O and related biogeochemical variables in the water column on board RV Angeles Alvarino to sustain the marine time series GIFT (November 27-Dec 4, 2023) CS: Emma Huertas (ICMAN-CSIC) (CT1 and CT5)

International collaborations:

Data intercomparisons and networking between the ICMAN (CSIC) group and an international consortium of different partners managing fixed ocean time series to provide a pilot (SPOTS) on biogeochemical Essential Ocean Variables and complement relevant products for the global interior ocean carbon data (GOlah Ocean Data Analysis Project), global surface ocean carbon data (Surface Ocean CO2 Atlas; SOCAT), and global interior and surface methane and nitrous oxide data (MarinE MethanE and NiTrous Oxide product). N. Lange et al., (2024) Synthesis Product for Ocean Time Series (SPOTS) – a ship-based biogeochemical pilot. Earth Syst. Sci. Data, 16, 1901–1931, https://doi.org/10.5194/essd-16-1901-2024. (CT1 and CT5)

Collaboration between the ICMAN (CSIC) group, with Alina Blume from the European Space Agency and Dimos Traganos from the German Aerospace Center to generate a cloud-native Earth Observation approach to map blue carbon in coastal areas. (CT5)

Collaboration between the ICMAN (CSIC) group and Bruno Delille (University of Liege) to coordinate CH4 measurements in the Southern Ocean and provide data in complementary regions. (CT1)

Collaboration between the ICMAN (CSIC) group and the consortium of the REWRITE project (CT1 and CT5)

International Conferences

### 3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


J. Belyaev et al. (2023) The contribution of penguin guano to the Southern Ocean iron pool. Nature Communications https://doi.org/10.1038/s41467-023-37132-5 (CT5)


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?

PART 2 - Planned activities for 2024 and 2025

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

Field studies:

“DICHOSO2”: oceanographic cruise throughout the South Shetland Islands (Southern Ocean) to measure CO2, CH4 and N2O and related biogeochemical variables in the water column on board de RV Hesperides, leaded by the ICMAN (CSIC) group (Dates to be decided yet) (CT1, CT2 and CT5)

GIFT campaigns: oceanographic cruises throughout the Strait of Gibraltar to measure CO2, CH4 and N2O and related biogeochemical variables in the water column leaded by the ICMAN (CSIC) group (Dates to be decided yet) (CT1 and CT5).

Collaborative laboratory:

Collaboration between the ICMAN (CSIC) group and Bruno Delille’s laboratory (University of Liege) for the assessment of air-sea GHGs fluxes in the South Shetland Islands (SO) region.

Collaboration with Smithsonian Environmental Research Center (Smithsonian Institution, MD, EEUU). PI Whitman Miller and Patrick J. Neale. (Project: Using natural CO2 sources to assess Phytoplankton response to climate change: THE Rhode River estuary as experimental site for studying the regulation of phytoplankton metabolism by CO2 (Smithsonian Institution).

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

<table>
<thead>
<tr>
<th>Event</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendance to SOLAS Open Science Conference 2024 by the ICMAN (CSIC) group</td>
<td>Goa, India, 10-14 November 2024 (CT1 and CT5)</td>
</tr>
<tr>
<td>Organization of the XX Spanish Congress of Remote Science and Global Change leaded by the ICMAN (CSIC) group</td>
<td>Cadiz, Spain, 4-7 June 2024 <a href="http://eo.csic.es/aet2024">http://eo.csic.es/aet2024</a> (All CTs)</td>
</tr>
</tbody>
</table>

3. Funded national and international projects/activities underway.

<table>
<thead>
<tr>
<th>Project</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Integrated Research Infrastructure Services for Climate Change (IRISCC)</td>
<td>Horizon Europe INFRASERV (2023-2025)</td>
</tr>
<tr>
<td>- Blue Mission: Marine Research and Climate Change. Ministerio de Ciencia e Innovación-FECYT (2020-2023)</td>
<td>(Fomento de la cultura científica, tecnológica y de la innovación)</td>
</tr>
<tr>
<td>DICHOSO: Contribution of Water Masses of Deception Island to biogeochemical inventories of the Southern Ocean: current budgets and future trends</td>
<td>PID2021-125783OB-I00 funded by the Spanish Ministry of Science and Innovation (2022-2026) PIs: Emma Huertas y Antonio Tovar (ICMAN-CSIC) (CT1, CT2 and CT5)</td>
</tr>
<tr>
<td>REWRITE: Rewilding European Shorelines and Beyond, funded by the European Commission (Horizon Europe) (2023-2026), PI: Gabriel Navarro (ICMAN-CSIC)</td>
<td>(CT1 and CT5)</td>
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<td>PID2021-127769NB-I00. Funded by Spanish ministry of Science. PIs Jordi Dachs (IDAEA-CSIC) and Begoña Jiménez (IQOG-CSIC). 306.000 euros. 2021-2025.</td>
</tr>
</tbody>
</table>

4. Plans / ideas for future national or international projects, programmes, proposals, etc. (please indicate the funding agencies and potential submission dates).
- Assessment of Green House Gases emission and controlling processes in wetlands of Doñana National Park (to be submitted in May 2024 by the ICMAN-CSIC group to the call launched by the Spanish Ministry for Ecological Transition and Demographic Challenge)

- Anthropogenic organic compounds and their interactions with the nutrient and carbon cycles (lead by J. Dachs and M. Vila-Costa, IDAEA-CSIC)

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

**GEOTRACES**

### Comments

The interactions between the surface ocean and lower atmosphere are key to understand the transport, cycle and fate of all pollutants, but SOLAS is only covering a narrow section of this anthropogenic pollution. Several scientists from SOLAS-Spain think that these topics should be emphasized more within SOLAS, not only by endorsing proposals, but also in the Open Science conference, or the SOLAS summer class.
Report for the year 2023 and future activities

SOLAS Sweden  
compiled by: Paul Zieger

This report has two parts:

- **Part 1**: reporting of activities in the period of January 2023 - Feb/Mar 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 Core Themes or Cross-Cutting Themes.

- **Core Theme 1**: Greenhouse gases and the oceans;  
- **Core Theme 2**: Air-sea interfaces and fluxes of mass and energy;  
- **Core Theme 3**: Atmospheric deposition and ocean biogeochemistry;  
- **Core Theme 4**: Interconnections between aerosols, clouds, and marine ecosystems;  
- **Core Theme 5**: Ocean biogeochemical control on atmospheric chemistry;  
- **Cross-Cutting Theme**: Integrated studies of high sensitivity systems (upwelling systems, Indian Ocean, polar oceans and sea ice);  
- **Cross-Cutting Theme**: Climate intervention;  
- **Cross-Cutting Theme**: Science and society.

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

<table>
<thead>
<tr>
<th>First things first...Please tell us what the IPO may do to help you in your current and future SOLAS activities. ?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide email and contacts from Sweden that are in your email list.</td>
</tr>
</tbody>
</table>

**PART 1 - Activities from January 2023 to Feb/Mar 2024**

1. **Scientific highlight**
   
   One highlight was the work by Julika Zinke and co-workers working on emission fluxes and bacterial enrichment in sea spray aerosols (PhD thesis “Factors influencing emission fluxes and bacterial enrichment in sea spray aerosols: Insights from laboratory and field studies”, defended in October 2023 at Stockholm University, [http://su.diva-portal.org/smash/record.jsf?pid=diva2:1793569](http://su.diva-portal.org/smash/record.jsf?pid=diva2:1793569)).
Zinke et al. (2024) conducted two research campaigns on the Baltic Sea, during which they combined laboratory-based sea spray simulation experiments with flux measurements on a nearby island (see Fig. 1). To combine the two methods, the sea spray simulation experiments were scaled to the flux measurements using three different approaches. As a result, Zinke et al. (2024) derived a parameterization that is dependent on wind speed and wave state for particles with diameters between 0.015–10 μm which is applicable to low-salinity waters. The parametrization and its comparison to previous reported studies is shown in Fig. 2.

Figure 1: Study site where in-situ and laboratory derived fluxes of sea spray aerosol production were combined (taken from Zinke et al., 2024).

Figure 2: Comparison of the wind-speed- and wave-state-dependent parameterizations derived by Zinke et al. (2024) with previous studies. Panel (a) shows emission estimates at U_{10m} = 10 m s^{-1}, while panel (b) shows the estimated mass emission flux for particles with dry diameters between 0.02 < D_p < 2.8 μm.

Reference:

Further highlight from 2023 were
• the successful conducted expedition ARTofMELT2023 (Atmospheric rivers and the onset of Arctic melt) in May and June 2023 on board the Swedish ice breaker Oden (www.su.se/artofmelt) (M. Tjernström and P. Zieger, Stockholm University)
• the evaluation of data from five research expeditions to the inner Arctic in the summer/fall of 1991, 1996, 2001, 2008, and 2018 (C. Leck, Stockholm University)
• the successful conduction of field campaign in the Baltic Sea to study the effect of cyanobacterial blooms on marine VOC emissions (S. Aggarwal and M. Salter, Stockholm University).
• Analysis of Arctic sea water at the European X-Ray Free-Electron Laser Facility XFEL (nanoaerosol project, M. Patanen, Uni Oulu Finland and P. Zieger, Stockholm University).
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 ARTofMELT field expedition ("Atmospheric rivers and the onset of Arctic melt", see www.su.se/artofmelt) aimed and documenting and characterizing the late winter and early spring transition from freezing to the initial melt in the Arctic Ocean. The expedition took place from 8 May to 14 June in the pack ice in Fram Strait and took detailed measurement in the upper ocean, sea ice and atmosphere of physical biogeochemical and atmospheric processes (M. Tjernström and P. Zieger, Stockholm University)

- Interaction with journalist for an article in EMBO Press "Scratching the ocean surface": https://doi.org/10.15252/embr.202357928 (J. Rahlf, Linnaeus University & Friedrich Schiller University)

- The 4th Arctic Ocean 2018 - MOCCHA, ACAS, ICE workshop hosted by the Swedish International Meteorological Institute (C. Leck, Stockholm University)

3. Publications in 2023 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.


### 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?


- Organization of departmental day “How science can serve society” (~200 participants), Department of Environmental Science, Stockholm University with inspirational talks from various partners and stakeholders, poster session and photo booth for scientists to engage with the topic (P. Zieger, Stockholm University)

### PART 2 - Planned activities for 2024 and 2025

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

- Arctic Climate Across Scales (ACAS) observation platform on the icebreaker Oden during the GEOEO expedition to northern Greenland late summer 2024 (M. Tjernström and J. Prytherch, Stockholm University)

- Measurements of cloud and aerosols in the marine environment at Mado Observatory, La Reunion from October 2023 to April 2024 (P. Zieger, Stockholm University)

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

- EGU General Assembly 2024, Vienna: Session: AS4.6 – The atmospheric microbiome – characterization, processes, and connections with Earth’s surface

- EGU General Assembly 2024, Vienna: Session: AS4.2 - As spring arrives: Processes leading up to annual Arctic sea-ice melt

- 1st ARTofMELT Open Science Conference, 22-24 April 2024, Stockholm University, Sweden (www.su.se/artofmelt)

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

- Viral Transmission in the Dynamic Environment of Surface Microlayers and Rainwater (VIRTIDE), funded by the Swedish Research Council, start April 2024 (J. Rahlf, Linnaeus University & Friedrich Schiller University)

- Icebreaker Oden as a National Infrastructure (M. Tjernström, Stockholm University)

- H2020 CleanCloud [https://projects.au.dk/cleancloud/](https://projects.au.dk/cleancloud/) (P. Zieger, Stockholm University)

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

- Planned expedition 2026/2027 “Pulse of the Weddell Sea” ([https://www.polar.se/en/research-support/polar-research-process/theme-antarctica/theme-pulse-of-the-weddell-sea/](https://www.polar.se/en/research-support/polar-research-process/theme-antarctica/theme-pulse-of-the-weddell-sea/)) where various member are currently preparing proposal from research funding (e.g. on gas exchange or marine biological aerosol particles). (J. Prytherch & P. Zieger, Stockholm University)

- SERC Synergy Grant 2024, Swedish Research Council (C. Leck, Stockholm University)
## 5. Engagements with other international projects, organisations, programmes, etc.

- Continuous engagement within IASC/ICARP ([https://iasc.info/our-work/icarp](https://iasc.info/our-work/icarp)) (M. Tjernström, Stockholm University)


- Plan to write a larger research grant for Southern Ocean aerosol-cloud observations (P. Zieger, Stockholm University)

## Comments
Report for the year 2023 and future activities

SOLAS UAE
compiled by: ‘Dr. Diana Francis’

This report has two parts:

- **Part 1:** reporting of activities in the period of January 2023 - Jan 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;
   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?

It would be good to organize a SOLAS conference or meeting so we get to know each other and engage in more productive discussions. It would be good to have this conference in a relatively new country to the network to boost participation and engagement.

**PART 1 - Activities from January 2023 to Jan 2024**

1. **Scientific highlights**
   ENGEOS, Khalifa University:
   - Investigating the drivers and impacts of tropical cyclones making landfall in southeast Arabian Peninsula.
   - Investigation dust storms drivers and impacts.
ACCESS center NYUAD:
- Investigated hypoxia in the Gulf, both in shallow coastal reefs and in the deepest part of the Gulf.
- Modeled decadal-scale changes in acidification, oxygenation and warming in the Arabian Gulf, and their link with the atmospheric forcing.

2. Activities/main accomplishments in 2023 (e.g., projects; field campaigns; workshops and conferences; model and data intercomparision; 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).

ENGEOS, Khalifa University:
Monitoring of atmospheric parameters including greenhouse gases, aerosols, radionuclides and meteorology.
Earth Observations for weather and climate.
Atmospheric and climate modelling at regional scale.
Study of polar ice; its melt and link to the atmospheric conditions (Antarctica).

ACCESS, NYUAD:
- Performing monthly transects from the Abu Dhabi coastline up to 40 miles offshore (CTD, Chla, Turbidity, Dissolved O2)
- Has dataloggers at 6 coastal stations continuously collecting data at the bottom of the water column (CTD, Chla, Turbidity, Dissolved O2)
- Developed a ROMS model of the Gulf with 1/2 arcminute resolution.
- Developed a ROMS model of the Arabian Sea (including the Red Sea and the Arabian Gulf) that includes a biogeochemical module that includes, among other things, dissolved oxygen, dissolved inorganic carbon and total alkalinity.
- Participation to webinar series: https://www.youtube.com/watch?v=QZVhHWPnrLM
- ACCESS organized the conference: "The Gulf Environment and Beyond: Global Change, Regional Impacts and Solutions", November 1-3, 2023, NYUAD Campus, Abu Dhabi.
- ACCESS organized the Second CCRN Conference on May 25-26 2023, NYUAD Campus, Abu Dhabi.

3. Top 5 publications in 2023 (only PUBLISHED articles) and if any, web links to models, datasets, products, etc.

ENGEOS – KU:


ACCESS- NYUAD:
### 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?

Engaged with the Climate Change Research Network (CCRN), an academic society sponsored by the UAE's Ministry of Climate Change and Environment.

### PART 2 - Planned activities for 2024 and 2025

1. **Planned major national and international field studies and collaborative laboratory and modelling studies (incl. all information possible, dates, locations, teams, work, etc.).**
   - Will deploy (by June) an oceanography buoy with near-real time meteo and subsurface measurements.
   - Will begin (by June) water samples along the transect for nutrient measurements and phytoplankton classification.
   - Expand the high resolution ROMS Gulf model with a biogeochemical module based on observations.
   - Register as an early user of the PACE satellite to provide ground truth measurements.

2. **Events like conferences, workshops, meetings, summer schools, capacity building etc. (incl. all information possible).**
   A third conference in the series “The Gulf Environment” is possible.

3. **Funded national and international projects/activities underway.**
   - ACCESS was funded until 2026 by a Tamkeen grant.
   - ACCESS received a 5-years grant (2024-2028) by Mubadala in order to investigate Gulf deoxygenation and its impact on coral reefs and other Gulf ecosystems, as well as on fisheries.

4. **Plans / ideas for future national or international projects, programmes, proposals, etc. (please indicate the funding agencies and potential submission dates).**
- Collaborate with NASA's PACE team in order to develop a better understanding of the Gulf's planktonic ecosystems.

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

**Comments**
Report for the year 2023 and future activities

SOLAS Southeast Asia
compiled by: ‘Mohd Talib Latif (Malaysia) and Iskhaq Iskandar (Indonesia)

This report has two parts:
- **Part 1**: reporting of activities in the period of January 2023 - Feb/Mar 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;
   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 Southeast Asia you are representing (all universities, institutes, lab, units, groups, cities).

<table>
<thead>
<tr>
<th>First things first...Please tell us what the IPO may do to help you in your current and future SOLAS activities. ?</th>
</tr>
</thead>
<tbody>
<tr>
<td>We would appreciate it if IPO could help the Southeast Asia Regional Panel organise a Regional Workshop on SOLAS-related research every two years and help us apply for a research grant that focuses on research related to sea-atmosphere interaction in Southeast Asia.</td>
</tr>
</tbody>
</table>
### 1. Scientific highlight

In this study, atmospheric deposition was collected at three sites in Malaysia, two urban and one pristine, covering the Northeast and Southwest monsoons to quantify the role of this pathway in Southeast Asia. Air mass back trajectories showed long-range atmospheric transport of microplastics to all sites with atmospheric deposition varying from 114 to 689 MP/m²/day. For the east coast of Peninsular Malaysia, the monsoonal season influenced microplastic transport and deposition rate with peak microplastic deposition during the Northeast monsoon due to higher wind speed. MP morphology combined with size fractionation and plastic-type at the coastal sites indicated a role for long-range marine transport of MPs that subsequently provided a local marine source to the atmosphere at the coastal sites.

### 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).


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


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?

We engaged the Asia Pacific Network for Global Change Research (APN-GCR) and applied for a research grant to monitor air quality using satellites and determine microplastics in the atmosphere near the coastal environment (under review for the second phase).

We also work with the International Global Atmospheric Chemistry—Monsoon Asia and Oceania Networking Group (IGAC-MANGO) via several related projects and grants.

PART 2 - Planned activities for 2024 and 2025

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

Microplastic samples will be collected in selected Southeast Asian countries (Malaysia, Thailand, and Vietnam) and sent to Waseda University in Japan for microplastic analysis.

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

Every six-month webinar from an expert in Southeast Asia

3. Funded national and international projects/activities underway.

APN Project among researchers in Asian Monsoon Region countries on monitoring air quality using satellite images.

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

We are working together with researchers in related fields including the International Global for Atmospheric Chemistry (IGAC)