surface ocean solas lower atmosphere study

Report for the year 2023 and future activities

SOLAS *'Norway'*
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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

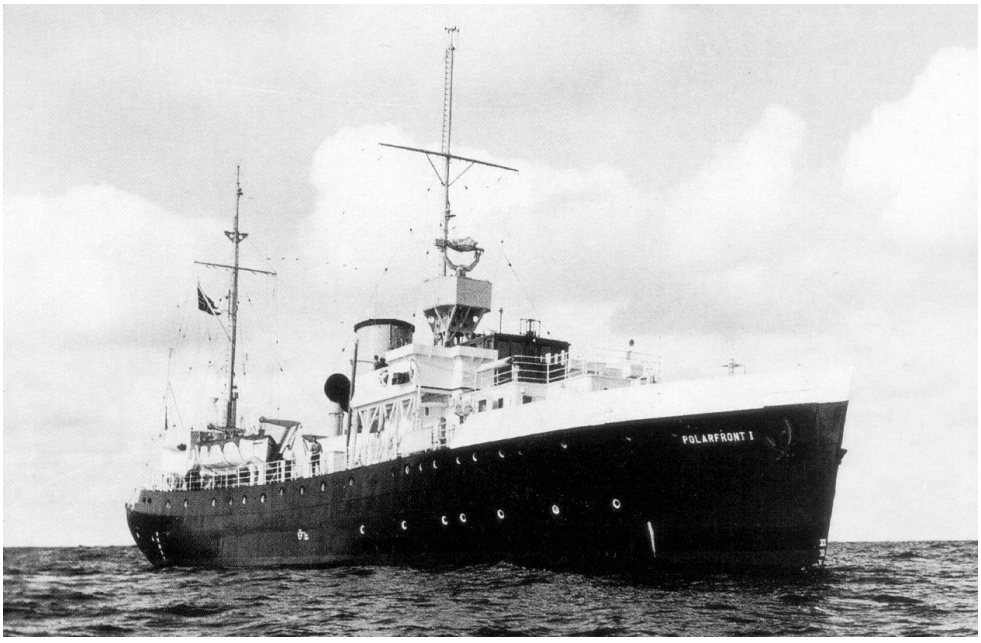
The Ocean Weather Station M, or Station M in short, is situated in the Norwegian Sea and started its observations already in 1948, as one of 13 weather stations in the North Atlantic.

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:
Skjelvan et al., Decadal trends in ocean acidification from the Ocean Weather Station M in the Norwegian Sea, J Marine Systems, 234, https://doi.org/10.1016/j.jmarsys.2022.103775**, 2022.**



The first weather ship operation Station M.

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.

ICOS Nordic conference 21-22 November, Bergen, Norway.

Participation in the RECCAP2 synthesis. Norwegian scientists contributed to the Global, Antarctic, Atlantic Ocean, Seasonal Cycle, and Costal 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.

Ericson et al., Rapid fCO_2 rise in the northern Barents Sea and Nansen Basin, Prog. in Oceanogr., 217, https://doi.org/10.1016/j.pocean.2023.103079, 2023.

Friedlingstein et al., Global Carbon Budget 2023, Earth Syst. Sci. Data, 15, 5301–5369, https://doi.org/10.5194/essd-15-5301-2023, 2023.

Skjelvan et al., Decadal trends in ocean acidification from the Ocean Weather Station M in the Norwegian Sea, J Marine Systems, 234, https://doi.org/10.1016/j.jmarsys.2022.103775, 2022.

Friedlingstein, P., et al. (2023): Global Carbon Budget 2023, Earth Syst. Sci. Data, 15, 5301–5369, doi:10.5194/essd-15-5301-2023

DeVries, T., Yamamoto, K., Wanninkhof, R., Gruber, N., Hauck, J., Müller, J. D., et al. (2023): Magnitude, trends, and variability of the global ocean carbon sink from 1985 to 2018, Global Biogeochemical Cycles, 37, e2023GB007780, doi:10.1029/2023GB007780

Rodgers, K. B., Schwinger, J., Fassbender, A. J., Landschützer, P., Yamaguchi, R., Frenzel, H., et al. (2023): Seasonal variability of the surface ocean carbon cycle: A synthesis, Global Biogeochemical Cycles, 37, e2023GB007798, doi:10.1029/2023GB007798

Jiang, L.-Q., Dunne, J., Carter, B. R., Tjiputra, J. F., Terhaar, J., Sharp, J. D., et al. (2023): Global surface ocean acidification indicators from 1750 to 2100, Journal of Advances in Modeling Earth Systems, 15, e2022MS003563, doi:10.1029/2022MS003563

Koseki, S., J. Tjiputra, F. Fransner, L. R. Crespo, and N. S. Keenlyside (2023), Disentangling the impact of Atlantic Nino on sea-air CO_2 fluxes, Nature Communications, 14, 3649, https://doi.org/10.1038/s41467-023-38718-9.

Couespel, D. and J. Tjiputra (2024), What goes in must come out: the oceanic outgassing of anthropogenic carbon, Environ. Res. Lett., 19, https://doi.org/10.1088/1748-9326/ad16e0.

Couespel, D., J. Tjiputra, K. Johannsen, P. Vaittinada Ayar, and B. Jensen (2024), Machine learning reveals regime shifts in future ocean carbon dioxide fluxes inter-annual variability, Communications Earth & Environment, https://doi.org/10.1038/s43247-024-01257-2.

Goris, N., K. Johannsen, and J. Tjiputra (2023), The emergence of the Gulf Stream and interior western boundary as key regions to constrain the future North Atlantic carbon uptake, Geosci. Model Dev., 16, 2095–2117, https://doi.org/10.5194/gmd-16-2095-2023.

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.).

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

ICOS workshop,7-10 October, Villefranche, France

3. Funded national and international projects/activities underway.

ICOS Norway and OTC (2021-2024), funded by Research Council of Norway.

Norwegian Ocean Acidification Monitoring program (2021-2025), funded by Norwegian Environment Agency.

NorEMSO (2020-2025), funded by the Research Council of Norway.

KADI (2022-2025), funded by EU (HORIZON-INFRA-2021-DEV-01).

GEORGE (2022-2025), funded by EU (HORIZON-INFRA-2022-TECH-01-01).

NUBICOS (2023-2027), funded by EU (HORIZON-INFRA-2023-DEV-01).

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