surface ocean solas lower atmosphere study

# Report for the year 2021 and future activities

## SOLAS *Norway*
## *compiled by: Siv K. Lauvset*

*This report has two parts:*

***- Part 1:** reporting of activities in the period of January 2021 - Jan/Feb 2022*
***- Part 2:** reporting on planned activities for 2022 and 2023.*

*The information provided will be used for reporting, fundraising, networking, strategic development and updating of the live web-based implementation plan. As much as possible, please indicate the specific SOLAS 2015-2025 Science Plan Themes addressed by each activity* **or specify an overlap between Themes or Cross-Cutting Themes.**

1 Greenhouse gases and the oceans;
2 Air-sea interfaces and fluxes of mass and energy;
3 Atmospheric deposition and ocean biogeochemistry;
4 Interconnections between aerosols, clouds, and marine ecosystems;
5 Ocean biogeochemical control on atmospheric chemistry;
Integrated studies of high sensitivity systems;
Environmental impacts of geoengineering;
Science and society**.**

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

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

| **PART 1 - Activities from January 2021 to Jan/Feb 2022** |
|---|
| **1. Scientific highlight** |
| *Describe one scientific highlight with a title, text (**max. 300 words**), a figure with legend and full references. Please focus on a result that would not have happened without SOLAS, and we are most interested in results of international collaborations. (If you wish to include more than one highlight, feel free to do so).* |

Stratification constrains future heat and carbon uptake in the Southern Ocean between 30°S and 55°S

The Southern Ocean between 30°S and 55°S is a major sink of excess heat ($H_{excess}$) and anthropogenic carbon ($C_{ant}$), but model projections of these sinks remain highly uncertain. Reducing such uncertainties is required to effectively guide the development of climate mitigation policies for meeting the ambitious climate targets of the Paris Agreement. Here, we show that the large spread in the projections of future $H_{excess}$ uptake efficiency and cumulative $C_{ant}$ uptake in this region are strongly linked to the models' contemporary stratification. This relationship is robust across two generations of Earth system models and is used to reduce the uncertainty of future estimates of the cumulative $C_{ant}$ uptake by up to 53% and the $H_{excess}$ uptake efficiency by 28%. Our results highlight that, for this region, an improved representation of stratification in Earth system models is key to constrain future carbon budgets and climate change projections.

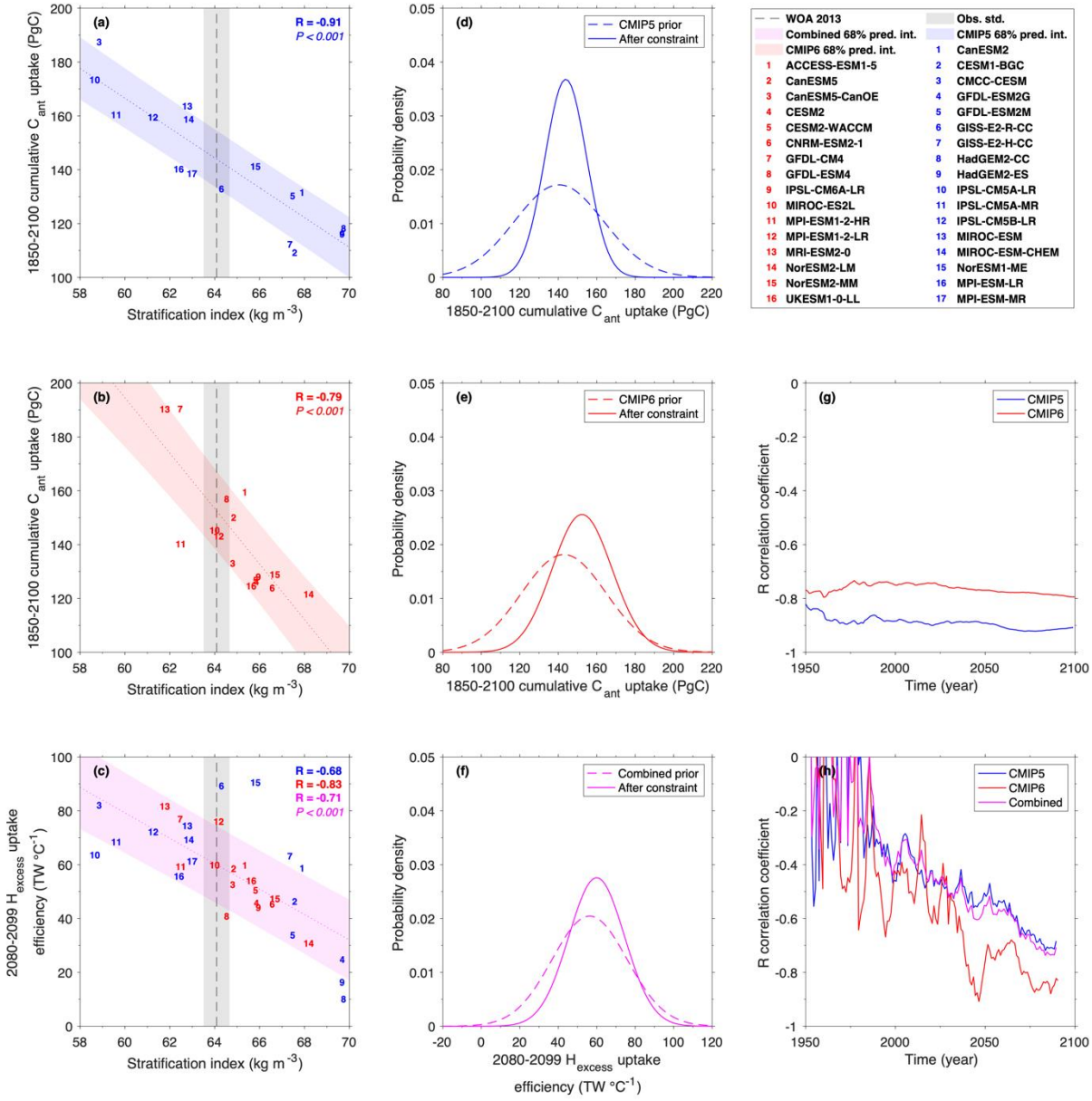


**Figure:** Emergent constraints on the sensitivity of projected carbon and heat uptake to stratification. **a, b** cumulative future $C_{ant}$ uptake between 30°S and 55°S and **c** future ocean $H_{excess}$ uptake efficiency and their emergent relation to the contemporary stratification. CMIP5, CMIP6 and combined CMIP5/6 ensembles are denoted in blue, red and magenta, respectively. Emergent constraints include a linear regression fit (dotted line), its 68% prediction interval (abbreviated pred. int., coloured shaded area according to the ensemble), the observational constraint (vertical black dots) and its uncertainty (grey shaded area). All emergent constraints are accompanied by **d–f** prior- and after-constraint probability density functions and **g, h** correlation timeseries obtained by sliding the predictand over time while leaving the predictor fixed.

Bourgeois, T., Goris, N., Schwinger, J. and Tjiputra J. Stratification constrains future heat and carbon uptake in the Southern Ocean between 30°S and 55°S. Nat Commun 13, 340 (January 2022). https://doi.org/10.1038/s41467-022-27979-5

**2. Activities/main accomplishments in 2021 (e.g., projects; field campaigns; workshops and conferences; model and data intercomparisons; capacity building; international collaborations; contributions to int. assessments such as IPCC; collaborations with social sciences, humanities, medicine, economics and/or arts; interactions with policy makers, companies, and/or journalists and media).**

EGU General Assembly 2021

We have obtained the first year of surface ocean pCO2 observations from our new ship Tukuma Arctica (submitted to SOCAT 2021: 30 datasets).

We have installed a new pCO2 observation system on the Norwegian tall ship Statsraad Lehmkuhl, which is sailing around the world between summer 2021 and Spring 2023. Data from the 3 first legs (August to December) was submitted to SOCAT).

Keynote presentation at 2nd Conference on Climate Justice, Italy, Oct 2021.

Presentation of surface ocean CO2 measurements and the ICOS network to the US Ambassy and the Norwegian minister for Climate, Akvariet, Bergen

We have contributed to RECCAP 2, a global initiative of the ocean carbon cycle community to better quantify and understand the CO2 fluxes into and out of the ocean and the associated changes in ocean carbon storage beneath the sea surface.

Meike Becker was elected as Co-Chair of the ICOS ocean MSA in October 2021

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

Bourgeois, T., Goris, N., Schwinger, J. and Tjiputra J. Stratification constrains future heat and carbon uptake in the Southern Ocean between 30°S and 55°S. Nat Commun 13, 340 (2022). https://doi.org/10.1038/s41467-022-27979-5

Terhaar, J., Torres, O., Bourgeois, T., and Kwiatkowski, L. Arctic Ocean acidification over the 21st century co-driven by anthropogenic carbon increases and freshening in the CMIP6 model ensemble, Biogeosciences. 18, 2221–2240 (2021). https://doi.org/10.5194/bg-18-2221-2021

*Fransner et al., Acidification of the Nordic Seas, https://doi.org/10.5194/bg-19-979-2022.*

*Ali et al., Sea surface pCO2 variability and air sea CO2 exchange in the coastal Sudanese Red Sea, https://doi.org/10.1016/j.rsma.2021.101796, 2021.*

*Becker et al., The northern European shelf as increasing net sink for $CO_2$, https://doi.org/10.5194/bg-18-1127-2021, 2021.*

Bock, J., Michou, M., Nabat, P., Abe, M., Mulcahy, J. P., Olivié, D. J. L., Schwinger, J., Suntharalingam, P., Tjiputra, J., van Hulten, M., Watanabe, M., Yool, A., and Séférian, R.: Evaluation of ocean dimethylsulfide concentration and emission in CMIP6 models, Biogeosciences, 18, 3823–3860, https://doi.org/10.5194/bg-18-3823-2021, 2021.

Liddicoat, S. K., Wiltshire, A. J., Jones, C. D., Arora, V. K., Brovkin, V., Cadule, P., Hajima, T., Lawrence, D. M., Pongratz, J., Schwinger, J., Séférian, R., Tjiputra, J. F., and Ziehn, T.,

Compatible Fossil Fuel CO2 emissions in the CMIP6 Earth System Models' Historical and Shared Socioeconomic Pathway experiments of the 21st Century, Journal of Climate, doi:10.1175/JCLI-D-19-0991.1, 2021.

**Becker, M.,** Olsen, A., Landschützer, P., Omar, A., Rehder, G., Rödenbeck, C., Skjelvan, I., 2021, The northern European shelf as increasing net sink for $CO_2$, Biogeosciences.

**Becker, M.,** Olsen, A., Reverdin, G., In-air on-point calibration of oxygen optodes in underway systems, 2021, L&O Methods.

Macovei, V.A., Voynova, Y.G**.,** **Becker, M**., Triest, J. and Petersen, W. (2021) Long-term intercomparison of two pCO2 instruments based on ship-of-opportunity measurements in a dynamic shelf sea environment. Limnology and Oceanography: Methods, 19, pp.37-50.

**4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2021? If yes, who? How did you engage?**

## PART 2 - Planned activities for 2022 and 2023

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

Cruise on R/V Johan Hjort in May-June 2022 along several monitoring sections and the GO-SHIP line at 75N

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

EGU General Assembly 2022

ICOS science conference in Utrecht on 13-15 September 2022

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

EU infrastructure project: ICOS (2021-2024) on measuring CO2 fluxes between ocean, atmosphere, and land

**Verfiy**

**Havforsuringsprogrammet**

**The Nansen Lecacy**

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

**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

EU proposal to the programme HORIZON-INFRA-2022-TECH-01 (**GEORGE**), submitted April 2022.

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

Ocean Acidification expert member of OSPAR commission (the mechanism by which 15 Governments & the EU cooperate to protect the marine environment of the North-East Atlantic).

Deliveries towards UN's SDG on Ocean Acidification.

Delivery towards SOCAT (Surface Ocean CO2 Atlas)

**Comments**