surface ocean solas lower atmosphere study

Report for the year 2021 and future activities

SOLAS *UK*
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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. ?

- I would like to make sure that the SOLAS UK mailing list is up to date, so subject to GDPR, a cross-check with the IPO records would be very useful.
- Help in facilitating time and space for networking mixers of the SOLAS UK community at conferences (such as the upcoming SOLAS 2022 conference), to enable members of the UK community have continued opportunities to be introduced, and catch up, face to face. This would be particularly beneficial for ECRs.
- Support in organising a SOLAS UK seminar.

PART 1 - Activities from January 2021 to Jan/Feb 2022

1. Scientific highlight

Highlight
Satellite observations now recognised as a critical approach for studying and quantifying atmosphere-ocean exchange.

Following an invited contribution from Jamie Shutler (University of Exeter) to the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and International Oceanographic Commission (IOC) decadal vision for ocean carbon research (https://unesdoc.unesco.org/ark:/48223/pf0000376708), remote sensing approaches are now considered a key aspect of studying and quantifying atmosphere-ocean exchange of carbon, and identified as an area where research should be focussed.

Summary

The ocean, the second largest long-term store of carbon on Earth, annually absorbs more than a quarter of all carbon emissions, primarily across the atmosphere-ocean interface, and so the ocean is a fundamental component and powerful constraint within global carbon assessments used to guide action for reducing emissions. Assessments of the global ocean carbon sink rely heavily on remotely-sensed satellite observations for interpolating in situ data and as inputs for calculating the integrated net sink. The importance of satellite observations within these global assessments has been gradually increasing since the 1990s but their use is often invisible or opaque as they were generally considered as just another set of environmental observations. Whereas the electromagnetic response of the ocean surface encapsulates many atmosphere-ocean exchange processes and so these satellite sensing technologies can be used to probe the atmosphere-ocean interface in ways not possible in situ. To date the full potential of satellite observations to expand our scientific knowledge of the atmosphere-ocean exchange and movement of carbon, heat and energy remains largely unexplored and these methods will likely be critical for answering key open questions now facing the marine carbon communities (Shutler et al., 2020). This year, for the first time, these capabilities and potential have been recognised internationally by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and International Oceanographic Commission (IOC) within their decadal vision for ocean carbon research, where a dedicated section identifies the opportunities that remote sensing technologies can now provide to the marine carbon communities (Arico et al., 2021).

Figure 1 This view of the Pacific Ocean from International Space Station illustrates the synoptic-scale view uniquely provided by satellite observations, but advances over recent decades have identified that satellites offer more than just another set of ocean observations and this potential for gaining new knowledge of exchanges across the atmosphere-ocean interface remains mostly unexplored. Credit: European Space Agency.

Citations

Aricò, S., Arrieta, J. M., Bakker, D. C. E., Boyd, P. W., Cotrim da Cunha, L., Chai, F., Dai, M., Gruber, N., Isensee, K., Ishii, M., Jiao, N., Lauvset, S. K., McKinley, G. A., Monteiro, P., Robinson,

C., Sabine, C., Sanders, R., Schoo, K. L., Schuster, U., Shutler, J. D., Thomas, H., Wanninkhof, R., Watson, A. J., Bopp, L., Boss, E., Bracco, A., Cai, W., Fay, A., Feely, R. A., Gregor, L., Hauck, J., Heinze, C., Henson, S., Hwang, J., Post, J., Suntharalingam, P., Telszewski, M., Tilbrook, B., Valsala, V. and Rojas Aldana, A. 2021. Integrated Ocean Carbon Research: A Summary of Ocean Carbon Research, and Vision of Coordinated Ocean Carbon Research and Observations for the Next Decade. R. Wanninkhof, C. Sabine and S. Aricò (eds.). Paris, UNESCO. 46 pp. (IOC Technical Series, 158.) DOI: 10.25607/h0gj-pq41

Shutler J.D., Wanninkhof R., Nightingale P.D., Woolf D.K., Bakker D.C., Watson A., Ashton I.G., Holding T., Chapron B., Quilfen Y., Fairall C., (2020). Satellites will address critical science priorities for quantifying ocean carbon, Frontiers in Ecology and the Environment, doi: 10.1002/fee.2129

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).

Projects:

Mingxi Yang at Plymouth Marine Laboratory lead the Atmospheric Composition and Radiative forcing changes due to UN International Ship Emissions regulations (ACRUISE: https://www.pml.ac.uk/science/Projects/ACRUISE); PML collaborators Frances Hopkins, Tim Smyth and Tom Bell. Project duration: January 2019-2022. Endorsed by SOLAS.

Mingxi also:

- designed the novel gas transfer efficiency (GTE) method to quantify how gas exchange varies with surfactants; application of this at sea in combination with eddy covariance CO2 flux measurements shows that sea/air CO2 exchange depends not just on wind, but also on surfactants; this innovative work inspired 3SAGES (see citation 71).
- led the most definitive assessment yet on the uncertainties in sea/air CO2 exchange measurements by eddy covariance at sea, a foundational guide for processing, filtering, and interpreting existing/future data (see citation 18).

Fieldwork:

Ben Murray's team at the University of Leeds have recently (March 2022) completed the ACAO (Arctic cold air outbreaks) campaign where they used the FAAM aircraft to study boundary layer clouds and the aerosol that control their properties in the springtime Arctic. The project is a collaboration between the Met Office and the NERC funded M-Phase project (Resolving climate sensitivity associated with shallow mixed phase cloud in the oceanic mid- to high latitudes) https://cloudsense.ac.uk/m-phase/ (in turn this is part of NERC's CloudSense programme (https://cloudsense.ac.uk/about/).

Ryan Pereira's team at the Lyell Centre, Heriot-Watt University (Edinburgh) completed field campaigns on the Essequibo River (Guyana) in April-May 2022 and during the RAPID cruise February-March 2022. They also supported students on the WASCAL cruise from CVOO to Bremerhaven with GEOMAR (Germany).

Rob Upstill-Goddard's team (Newcastle University) completed two 21-day field campaigns between May-October 2021 (final campaign in spring 2022), at Lake Erken (Sweden), in collaboration with Uppsala University (Sweden) exploring surfactant control of air-water gas transfer in a freshwater lake.

Tom Bell's team at Plymouth Marine Laboratory had a successful aircraft campaign out of Exeter to measure ship emissions in the English Channel and NW European Shelf.

Conferences:

The Gas Transfer at Water Surfaces (GTWS) 8th International Symposium was postponed for a second time due to the ongoing COVID-19 pandemic, so the Plymouth Marine Laboratory organising committee hosted a 'bitesize' online event on 19th May 2021 with ~150 participants from 30+ countries spanning the entire range of time zones; the in person/hybrid conference was postponed until 17th-20th May 2022.

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

The following alphabetical list of SOLAS-relevant, peer-reviewed March 2021 – February 2022 publications (n = 73) with UK authors and/or co-authors is based on researchers' input and Web of Knowledge searches. There has been no attempt to formally rank the "top 5" in terms of scientific quality or importance.

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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.).

Field studies:

Helen Czerski (University College London) plans to participate in the CenBASE study (three weeks in the Baltic Sea) to study air-sea gas flux in the central Baltic (PI: Henry Bittig) during June/July 2022, and also has tentative plans (depending on grant proposal decision due in June/July 2022) to participate in the six-week BELS expedition to the Labrador Sea to study air-sea gas flux and how deep circulation affects gas export into the deep ocean (PI: Christa Maradino, GEOMAR).

Mingxi Yang (Plymouth Marine Laboratory) plans to participate in ACSIS/ACRUISE flights (Apr-May 2022): atmospheric sulphur cycling in SW UK and near Azores, and SEANA cruise - air-sea fluxes of CO2 and VOC (May-June 2022).

Ryan Pereira's team (Lyell Centre, Heriot-Watt University) will be participating in fieldwork on the Essequibo River (Guyana) and Cape Verde Islands, and are joining the AMT cruise in February-April 2023.

Tom Bell (Plymouth Marine Laboratory) will be participating in the AMT4CO2flux field campaign on *RRS* Discovery (https://amt4oceansatflux.org/).

Projects:

Jamie Shutler (University of Exeter) is leading a new project from April 2022 (with French and Swiss partners): European Space Agency (ESA): Ocean satellite datasets for acidification (OceanSODA: https://esa-oceansoda.org/), €550K, 2-year project. Scientific development of satellite observation-based datasets with co-designed early-adopter user cases (for policy makers, regional resource managers and small businesses).

Lucy Carpenter and Rosie Change at the University of York have a new NERC funded project starting September 2022: I-SEA: Iodine sea-air emissions and atmospheric impacts in a changing world (Carpenter, L. J., Chance, R., Evans, M.).

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

Conferences:

The 8th Gas Transfer at Water Surfaces (GTWS) Symposium (https://www.pml.ac.uk/Events/The-8th-International-Symposium-on-Gas-Transfer-at) is being held at Plymouth Marine Laboratory on 17th-20th May 2022 (originally postponed from May 2020 due to the COVID-19 pandemic).

The Challenger Society Conference (https://www.nhm.ac.uk/our-science/science-events/the-challenger-society-conference-2022-in-london.html) is being held at the Natural History Museum and Imperial College, London, on 5th-9th September 2022.

Summer schools:

Jamie Shutler (University of Exeter) is an invited Lecturer for ocean carbon and air-sea exchange within the 2022 European Space Agency (ESA) Remote Sensing Summer School (online over 3 months, with an at-sea fieldwork element in the Agulhas current).

3. Funded national and international projects/activities underway.

Projects:

Jamie Shutler (University of Exeter) is leading two ongoing projects:

- A two-year, £15K, UK Research and Innovation (UKRI) Globalink UK-Canada award (Canada lead: Brent Else): Remote sensing for understanding air-ice-sea gas exchange over land fast sea ice during spring melt season in the Canadian Archipelago (UK student recipient: Jenny Watts).
- A two-year, €500K, project with the European Space Agency (ESA) (with French and Swiss partners): Ocean satellite datasets for acidification (OceanSODA: https://esa-oceansoda.org/).

Jamie is also involved in a European Union (EU) Joint Baltic Sea Research and Development Programme (BONUS: https://www.bonusportal.org/) Integrated carbon and trace gas monitoring in the Baltic Sea (Integral), €3 million, four-year project led by Germany (Gregor Ryhder).

Karen Heywood (University of East Anglia) is leading the NERC funded Processes Influencing Carbon Cycling: Observations of the Lower limb of the Antarctic Overturning (PICCOLO) (https://roses.ac.uk/piccolo/.

Rob Upstill-Goddard (Newcastle University) is leading a three-year Leverhulme Trust funded project in collaboration with Erik Sahlée (Uppsala University, Sweden): Surfactant control of air-water gas exchange is freshwater systems. This project ends in July 2022.

Ryan Pereira (Lyell Centre, Heriot-Watt University) is leading a five-year, £1.6M, interdisciplinary research project, Breathing Oceans: Understanding the Organic Skin that Modulates the Exchange of Greenhouse Gases between the Atmosphere and the Ocean (BOOGIE: https://cordis.europa.eu/project/id/949495), funded by the European Research Commission.

Tom Bell's team (Plymouth Marine Laboratory) are involved with multiple ongoing projects:

- ASEauto, enabling the purchase of a range of SOLAS-relevant equipment in relation to the developments in marine autonomy: https://www.pml.ac.uk/News/Funding-award-will-facilitate-game-changing-advanc
- AMT4CO2flux (https://amt4oceansatflux.org/), funded by the European Space Agency (ESA), and led by Plymouth Marine Laboratory (UK) in cooperation with the University of Southampton (UK), the Institut Francais de Recherche pour l'Exploitation de la Mer (France); IFREMER) and the University of Exeter (UK), and endorsed by SOLAS. This project aims to develop a processing chain for satellite products and uncertainties for the air-sea flux of carbon dioxide and ocean acidification parameters.
- SeaCURE marine mediated anthropogenic carbon removal (Sea Carbon Unlocking and Removal) (£250K grant: https://www.pml.ac.uk/News/Champagne-technology-to-capture-carbon-dioxide-via) led by the University of Exeter, with support from Brunel University London and industrial partner tpgroup; NERC funded.

- PICCOLO (https://roses.ac.uk/piccolo/): PI Karen Heywood (see above).

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