surface ocean solas lower atmosphere study

Report for the year 2019 and future activities

SOLAS *USA*

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This report has two parts:

***- Part 1:** reporting of activities in the period of January 2019 - Jan/Feb 2020*
***- Part 2:** reporting on planned activities for 2020 and 2021.*

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).*

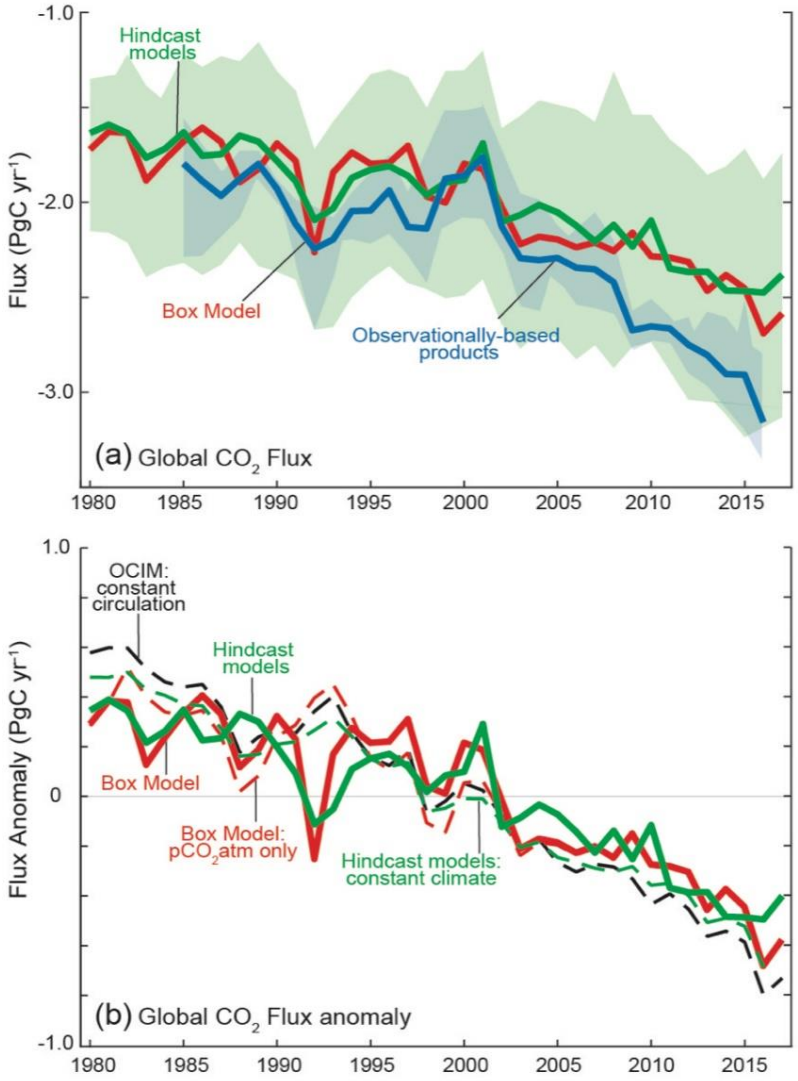
First things first…Please tell us what the IPO may do to help you in your current and future SOLAS activities. ?

PART 1 - Activities from January 2019 to Jan/Feb 2020

1. Scientific highlight

SOLAS THEME 1

The ocean has absorbed the equivalent of 39% of industrial-age fossil carbon emissions, significantly modulating the growth rate of atmospheric CO_2 and its associated impacts on climate. Despite the importance



of the ocean carbon sink to climate, our understanding of the causes of its interannual-to-decadal variability remains limited. This hinders our ability to attribute its past behavior and project its future.

A recent study by McKinley et al. (2020 – see full citation below) focuses on a key period of interest -- the 1990s, when the ocean carbon sink did not grow as expected. Previous explanations of this behavior have focused on variability internal to the ocean or associated with coupled atmosphere/ocean modes, but a clear mechanistic explanation does not yet exist. Here, we use an idealized upper ocean box model to illustrate that two external forcings are sufficient to explain the pattern and magnitude of the variability. In the Figure (panel a), this box model result (red) is compared to an ensemble of 6 ocean hindcast models (green) and 4 observationally-based products (blue). Correlations across the timeseries in panel (a) are 0.89 to 0.95, indicating that the box model captures the dominant mechanisms of our best estimate of the real-world variability.

First, the global-scale reduction in the decadal-average ocean carbon sink in the 1990s is attributable to the slowed growth rate of atmospheric pCO_2. Acceleration of atmospheric pCO_2 growth, particularly after 2001, drove recovery of the sink (panel b, red dash). Second, the 1991 eruption of Mt Pinatubo explains the timing of the global sink within the 1990s. Global sea surface cooling with the eruption led to an uptake anomaly. The subsequent rewarming and presence of excess surface carbon content slowed the sink for the rest of the decade (panel b, red). These results are consistent with previous experiments using ocean hindcast models with and without forcing from variable atmospheric pCO_2 and climate variability (panel b, green solid and dash, respectively). The fact that variability in the growth rate of atmospheric pCO_2 directly imprints on the ocean sink implies that there will be an immediate reduction in ocean carbon uptake as atmospheric pCO_2 responds to cuts in anthropogenic emissions.

McKinley, G.A., A.R. Fay, Y. Eddebbar, L. Gloege and N. Lovenduski, External forcing explains recent decadal variability of the ocean carbon sink, revised for AGU Advances, 2020. Read it on ESSOArchive

2. Activities/main accomplishments in 2019 (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).

Research Projects

GOHSNAP Oxygenation of the Labrador Sea Water prevents large-scale hypoxia from developing anywhere in the Atlantic, and anthropogenic CO_2 storage in the Labrador Sea is the highest in the global ocean. he assumption that, in the Atlantic, O_2 and CO_2 uptake and their variability are tied to the dynamics of heat loss and the overturning circulation pervades the literature but has never been evaluated on the basis of direct observations. Thus, *Gases in the Overturning and Horizontal circulation of the Subpolar North Atlantic (GOHSNAP)* addresses this gap and the urgent need to better understand interactions between gas uptake, transport, and the overturning circulation. Specifically, this program will provide a continuous 2-year record of the trans-basin, full water column transport of O_2 across the southern boundary of the Labrador Sea, leveraging the mooring infrastructure of the US-lead, international *Overturning in the Subpolar North Atlantic Program (OSNAP)*. The addition of O_2 sensors at various depths on this array, supplemented by observations collected by autonomous platforms will allow for the quantification of O_2 export from the Labrador Sea. SOLAS THEME 1 and 2

MOSAiC: US scientists are participating in the year-long international Arctic MOSAiC project in which the German research icebreaker Polarstern is trapped in ice for a year. One US project in MOSAiC focuses on surface ocean-sea-ice-atmosphere interactions. The project led by Blomquist, Helmig, Fairall, Archer and Ganzeveld directly observes of air-sea gas exchange and deposition for several climate-active compounds: carbon dioxide, methane, dimethylsulfide, and ozone. Modeling objectives include development of improved ocean to sea ice to atmosphere gas transfer parameterizations and local/regional scale atmospheric chemistry modeling to asses s the role of sea ice gas transfer on climate active trace gas budgets. SOLAS THEME 2 (other parts of MOSAiC are releveant to other SOLAS themes)

NAAMES: The North Atlantic Aerosol and Marine Ecosystem Study (NAAMES) has just finished. This was a 5 year NASA EVS mission focused on plankton blooms and ocean-aerosol-cloud interactions. There have been over 40 publications already from NAAMES. Details on the project are available at: https://naames.larc.nasa.gov/ SOLAS THEMES 3, 4, and 5

SeaSCAPE project: A large interdisciplinary project, led by CAICE at UC San Diego, in 2019 generated sea spray aerosol in a large wave flume, and characteristics were examined over the course of an algal bloom. The big new focus for these experiments was looking at oxidation impacts on emissions, including aged seaspray aerosol, secondary aerosol formation, and gas phase chemistry. https://scripps.ucsd.edu/news/research-highlight-scientists-bring-ocean-lab-study-human-impacts-ocean-and-climate SOLAS THEMES 3 and 4

Saildrones: Western Boundary Currents, like the Gulf Stream, and their neighboring subtropical mode water (STMW) formation regions are areas of intense ocean uptake of atmospheric CO_2. However, the observations used to quantify this uptake are extremely sparse. Jaimie Palter and others are using a Saildrone to complete an autonomous wintertime survey of ocean and atmospheric pCO_2 in the Gulf Stream region. The Saildrone completed five crossings of the Gulf Stream and traversed through part of the STMW formation region throughout the mission from 1/30-3/7/2019, as it experienced 3 major storms. SOLAS THEME 1

SPIROPA: The continental shelf break of the Middle Atlantic Bight supports a productive and diverse ecosystem. Current paradigms suggest that this productivity is driven by several upwelling mechanisms at the shelf break front. This upwelling supplies nutrients that stimulate primary production by phytoplankton, which in turn leads to enhanced production at higher trophic levels. Although local enhancement of phytoplankton biomass has been observed in some circumstances, such a feature is curiously absent from time-averaged measurements, both from satellites and shipboard sampling. Why would there not be a mean enhancement in phytoplankton biomass as a result of the upwelling? Dennis McGillicuddy is leading an interdisciplinary team designed to investigate these issues. The team conducted three cruises within the past two years, in spring of 2018 and spring and summer of 2019, each with repeated crossings of the shelf-break front. http://science.whoi.edu/users/olga/SPIROPA/SPIROPA.html SOLAS THEMES 1 and 2

Working Groups

Ocean Carbon Biogeochemistry (OCB) formed a working group to address critical gaps in understanding the ocean carbon sink and how it sits in the global carbon cycle. https://www.us-ocb.org/filling-the-gaps-in-observation-based-estimates-of-air-sea-carbon-fluxes-working-group/ SOLAS THEME 1

Workshops

The **Ocean Atmosphere Interaction** Committee (a subcomittee of OCB) held a workshop on October 1-3, 2019 to discuss priorities for research USA in the area of ocean atmosphere interactions and specifically to develop a US SOLAS science plan. The three day workshop was mostly discussion based, with participants sharing their ideas on exciting questions and directions of research. Currently the OAIC and interested participants from the workshop are working on the US SOLAS science plan, which should be ready for broader community input by June. SOLAS THEMES 1-5

Broecker Symposium: A symposium was held in 24-26 October, 2019 to honor the life and work of Wally Broecker. http://wallysymposium.ldeo.columbia.edu/.

The **ArcticOcean 2018**/ MOCCHA/ ACAS/ Ice science workshop was held in Stockholm, Sweden in March 2019. Four US projects (including 10 US PIs and 7 US institutions) were involved and presented results.

The **Ocean Sciences Meeting** co-sponsored by AGU, ASLO, and TOS was held in February in San Diego. Many SOLAS-relevant sessions were included in that meeting. SOLAS THEMES 1-5

3. Top 5 publications in 2019 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

Beaupre, S.R, D. Kieber, W.C. Keene, M. S. Long, J.R. Maben, X. Lu, Y. Zhu, A. A. Frossard, J.D. Kinsey, P. Duplessis, R.Y.W. Chang, and J. Bisgrove. Oceanic efflux of ancient marine dissolved organic carbon in primary marine aerosol. Science Advances. Vol 5. DOI: 10.1126/sciadv.aax6535. (2019)

Bourne, H. L., Bishop, J. K. B., Wood, T. J., Loew, T. J., and Liu, Y.: Carbon Flux Explorer optical assessment of C, N and P fluxes, Biogeosciences, 16, 1249–1264, https://doi.org/10.5194/bg-16-1249-2019, 2019.

Frossard, A.A., V. Gerard, P. Duplessis, J.D, Kinsey, X. Lu, Y. Zhu, J. Bisgroc, J.R> Maben, M.S. Long, R.Y.W. Chang, S.R. Beaupre, D.J. Kieber, W.C. Keene, B. Noziere, R.C. Cohen. Properties of Seawater Surfactants Associated with Primary Marine Aerosol Particles Produced by Bursting Bubbles at a Model Air–Sea Interface. Environ. Sci. Technol. 53, 16, 9407-9417. https://doi.org/10.1021/acs.est.9b02637 (2019)

Gassó, S., & Torres, O. Temporal characterization of dust activity in the Central Patagonia desert (years 1964–2017). *Journal of Geophysical Research: Atmospheres*, 124, 3417– 3434. https://doi.org/10.1029/2018JD030209 (2019)

Horowitz, H. C. Holmes, A. Wright, T. Sherwen, X. Wang, M. Evans, J. Huang, L. Jaegle, Q. Chen, S. Zhai and B. Alexander. Effects of Sea Salt Aerosol Emissions for Marine Cloud Brightening on Atmospheric Chemistry: Implications for Radiative Forcing. Geophysical Research Letters. doi.org/10.1029/2019GL085838 (2020)

Ji, B.Y, Z.O Sandwith, W.J. Williams, O. Diaconescu. R. Ji, Y. Li, E. Van Scoy, M. Yamamoto-Kawai, S. Zimmerman, and R.H.R. Stanley. Variations in Rates of Biological Production in the Beaufort Gyre as the Arctic Changes:Rates From 2011 to 2016. Journal of Geohpysical Research Oceans. Doi: 10.1029/2018JC014805. (2019)

Koenig, T.K., S. Baidar, P Campuzano-Jost, C.A. Cuevas, B. Dix, R.P. Fernandez, H. Guo, S.R. Hall, D. Kinnison, B.A. Nault, K. Ullmann, J.L. Jimenez, A. Saiz-Lopez, R. Volakmer. Quantitative detection

of iodine in the stratosphere. Proceedings of the National Academy of Sciences. doi/10.1073/pnas.1916828117. (2020)

Juranek, L.W., T. Takahashi, J.T. Mathis, and R. Pickart (2019), Significant biologically-mediated CO_2 uptake in the Pacific Arctic during the late open water season, *J. Geophysical Research – Oceans,* 124, doi:10.1029/2018JC014568.

Manfredi Manizza Dimitris Menemenlis Hong Zhang Charles E. Miller. Modeling the Recent Changes in the Arctic Ocean CO2 Sink (2006–2013). Global Biogeochemical Cycles. **https://doi.org/10.1029/2018GB006070**, 2019.

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2019? If yes, who? How did you engage?

PART 2 - Planned activities for 2019/2020 and 2021

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

The large scale EXPORTS project was going to have its second cruise in May, 2020. Due to the coronavirus pandemic, this cruise has been delayed.

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

Note: fewer workshops than usual are included b/c many workshops have been cancelled due to the coronavirus pandemic.

A symposium is being planned for May 4 to honor the life and work of Taro Takahashi at LDEO.

The American Meterological Society National Meeting will be Jan 10-14, 2021 in New Orleans.

The fall meeting of the American Geophysical Union will be from Dec 7-11 in San Francisco.

3. Funded national and international projects/activities underway.

Too many to report.

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

Too many to report.

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

Too many to report.

Comments