U.S. EFFORTS FOR THE DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT - MOBILIZING NOAA ACTIONS IN PREPARATION FOR THE OCEAN DECADE

Project Proposal Submission: Game-changing increase in air-sea CO_2 observations

Problem statement

The ocean plays a critical role in the global carbon cycle, absorbing approximately a quarter of CO_2 emissions every year. Uncertainties in the global carbon budget hinder both research seeking to better understand the global carbon cycle and efforts to independently verify reported CO_2 emissions and terrestrial sinks. Improved constraint on the budget is possible through better quantifying the ocean CO_2 sink from observations. Of the three main budget components (atmosphere, ocean, and land), the accounting of CO_2 in the atmosphere and ocean rely most on global observing networks, but the ocean sink estimate has a much larger uncertainty (≈0.6 GtC yr^{-1}) than the atmosphere (≈0.02 GtC yr^{-1}). This uncertainty is largely due to persistent gaps in a ship-dependent observing system that leaves large regions, especially in the Southern Hemisphere, with very few observations. Increased CO_2 and ocean acidification observations in the Global South is also a capacity building priority of the UN Decade of Ocean Science for Sustainable Development and the Global Ocean Acidification Observing Network (GOA-ON).

The international ocean carbon modeling community has called for a "game-changing increase in high-quality pCO_2 observations" (Hauck et al. 2020). Air-sea CO_2 observing technology developed at NOAA and proven over the past decade on long-range, long-duration Uncrewed Surface Vehicles (USVs) now makes it possible to fill persistent gaps in the observing system (Sabine et al. 2020). Estimates of decorrelation length scales compared to total area in open ocean waters suggest the need for 200±100 platforms to constrain surface ocean CO_2 in the Southern Hemisphere (Jones et al. 2012). Although there is large uncertainty in this estimate, it demonstrates the scope of the problem and provides a baseline for developing sampling strategies. We propose to demonstrate the utility of incorporating basin-scale USV observing into the global surface ocean CO_2 observing network and lay the groundwork for efforts to reduce ocean CO_2 flux uncertainty by building out 10% of the estimated network by deploying an initial fleet of 20 USVs equipped with sensors required for measuring air-sea CO_2 flux and ocean acidification. Based on the range of decorrelation length scales in basins more dominated by major ocean currents and gyres (e.g. S. Atlantic) versus those where waters are more heterogeneous (e.g., Southern Ocean), we propose to deploy and maintain three USVs in the S. Atlantic, six in the Indian Ocean, six in the S. Pacific, and five in the Southern Ocean. The Saildrone USV is the proposed platform for this demonstration project because of its basin-scale observing capacity, proven success in Southern Ocean conditions, integrated and proven air-sea CO_2 technology, and its lack of dependence on ships for deployment or recovery.

The main outcome within the first three years will be new CO_2 flux observations from data-poor regions incorporated into the Surface Ocean CO_2 Atlas (SOCAT). Data-based estimates of annual global ocean CO_2 flux with and without Southern Hemisphere data from the USV fleet will be compared. PMEL's role will be validating the Autonomous Surface Vehicle CO_2 sensors ($ASVCO_2^{TM}$) and analyzing the CO_2 data, requiring approximately $450K/year (in addition to USV days at sea). Recent technology transfer of the $ASVCO_2^{TM}$ make it possible to bring on additional international partners and scale up this effort as the new USV data are incorporated into SOCAT and data synthesis products show utility in the expanded observations.

Collaborators

- The >100 ocean carbon observationalists involved in SOCAT: providing community-level data quality control and continued evaluation of USV data in comparison to existing ship- and buoy-based data.
- International Ocean Carbon Coordination Project (IOCCP), its subgroup the Surface Ocean CO_2 NETwork (SOCONET), and GOA-ON: providing global perspective on this activity in the context of all current observations and future directions.
- Observing Air-Sea Interactions Strategy (OASIS): another proposed UN Decade project with the potential to share observing assets for multidisciplinary air-sea interaction observations that also address OASIS objectives (e.g., air-sea heat exchange).
- Integrated Ocean Carbon Research (IOC-R) Working Group: working on new and integrated directions in ocean carbon research under the auspices of Intergovernmental Oceanographic Commission. Activities supporting this work are:
    - The Ocean Carbon and Biogeochemistry working group on Filling the gaps in observation-based estimates of air–sea carbon fluxes, which is assessing critical uncertainties in existing model- and observation-based estimates of CO_2 flux.
    - Integrated Ocean Carbon Observing System (IOCOS) that plans to bring together the community of ocean carbon technologists, observers, and data synthesizers to every year estimate in near real time ocean carbon uptake based on data from multiple platforms and to report this to inform policy making.

Relevance to objectives

This project supports research and observations that improve understanding of effective responses to changes in the ocean system and the Administration's objective to build, strengthen, and expand strategic multisector partnerships as defined by the annual Joint OMB/OSTP Administration Research and Development Budget Priorities memo of 2019. It also addresses the following priorities laid out in the Science and Technology for America's Oceans report of 2018:

- integrate new monitoring technologies into existing and emerging ocean observation systems, while ensuring quality assurance and data comparability;
- encourage opportunities for public-private partnerships, particularly to leverage knowledge and resources, ensure the successful application of ocean research, avoid duplication of efforts, and improve communication between ocean researchers and ocean users;
- continue quantitatively monitoring coastal and open ocean biogeochemical trends to characterize changes in ocean acidification; and
- share resources to support surveys and uncrewed system operations, allowing operators from multiple agencies' oceanographic fleets to identify best practices and apply lessons learned through joint cooperation.

Finally, this project addresses several objectives in the UN Decade Implementation Plan draft relating to expanded ocean observing, technologies, and data access to support society's ability to respond to changing ocean conditions, including the following: (challenge 5) enhance understanding of the ocean-climate nexus and use this understanding to generate solutions to mitigate and adapt to the effects of climate change, and to improve services including predictions and forecasts; (challenge 7) ensure a sustainable ocean observations system that delivers timely data and information to end-users on the state of the ocean across all ocean basins; and (challenge 9) ensure comprehensive capacity development and equitable access to data, information, knowledge and technology across all aspects of ocean science and for all stakeholders regardless of geography, gender, or age.

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