Resolving CO2 system seasonality in the West Antarctic Peninsula with Year-Round Autonomous Observations

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Project Description
The circumpolar Southern Ocean connects the major ocean basins returning carbon (and nutrients) to the surface ocean via the upwelling branch of the overturning circulation, and transporting heat and carbon to the ocean interior via the downwelling branch. Present day carbon fluxes reflect the balance between significant uptake and storage of anthropogenic carbon dioxide (CO2) and the uptake and release of natural CO2. Understanding the Southern Ocean response to both natural and anthropogenic changes is critical to understanding changing global biogoechemical cycles. However, major uncertainties persist in in our knowledge of the Southern Ocean carbon budget due in part to unresolved variability at the seasonal time scale, and in part to a particularly significant lack of observations in coastal regions. Seasonal, interannual and multi-annual variability in the CO2 system in Antarctic coastal regions is much larger than the signals of anthropogenic change, and our understanding of coastal systems is heavily biased by observations obtained in the summer season where primary production dominates CO2 system variability. Changes in the physical and biogeochemical state of coastal Antarctic waters are already underway: warming, freshening and variability in the onshore intrusion of carbon-rich circumpolar deep water, are all processes with associated feedbacks to the CO2 system that are expected to influence contemporary rates of CO2 system change in coastal regions. Resolving the dominant drivers of variability and predicting the evolution of these systems in the context of future change requires sustained observations; given the challenges of working in remote Antarctic coastal waters, acquiring observations outside of the summer season necessitates the use of autonomous platforms.

The proposed research will make an essential contribution to our understanding of coastal Southern Ocean CO2 system variability by delivering new autonomous observations that will allow the full CO2 system seasonality to be resolved. Using a moored observing system (to measure pH, CO2 partial pressure, temperature, salinity and dissolved oxygen with 6-hour frequency) on the West Antarctic Peninsula continental shelf, the proposed research will characterise diurnal and seasonal variability, identify the dominant physical and biological controls on the seasonal variations, and incorporate this observed natural variability into projections of West Antarctic Peninsula carbonate chemistry under various future scenarios. Given the rapid environmental change occurring in the West Antarctic Peninsula region, an improved understanding of natural CO2 system variability and feedbacks to the carbonate system will additionally provide insight for evolution of other coastal Antarctic systems not currently impacted by the same magnitude of change.

The proposed research is directly relevant to the SOOS Scientific Strategy as it aims to implement a sustained CO2 system observing platform in coastal Antarctic waters. Furthermore, the proposed research will investigate the drivers of seasonality and natural variability in the CO2 system, which is an essential first step in predicting the evolution of ecologically important coastal systems to anthropogenic change. The proposed research will thus contribute to SOOS Science Themes 4 and 6 through characterisation of natural ranges of the CO2 system, identification of the dominant physical and biological controls on seasonality and air-sea CO2 exchange, and the acquisition of rare observations of the system

outside of the open water season. The proposed research will yield high-resolution biogeochemical observations, which, after internal quality control, and in accordance with policies from US funding agencies, will be shared with the global carbon cycle research community and with interested parties within the SOOS data network.

Capacity building strategies include the training of a graduate student and the use of data in graduate courses in polar marine biogeochemistry. The proposed research will additionally support an early career scientist in building an observation-based high-latitude biogeochemistry research program.

Project Timeline
Sept 2016 – Aug 2019

Key deliverables
The observational component of the project will use moorings to obtain biogeochemical (pH, pCO_2, dissolved oxygen) and hydrographic (temperature, salinity, mixed-layer depth) data over a proposed deployment period covering 2 full annual cycles. These data will be high-frequency (6-hourly), and will represent rare coverage outside of the summer season. These data will form an essential component of a PhD project, and are expected to result in numerous presentations at US and international conferences as well as publications in peer-reviewed journals.

Funding
Proposed project is funded by the US National Science Foundation Antarctic Science Program on April 15, 2015.

Data Management
The sensor data will be calibrated with discrete samples collected from a ship at the mooring location, and QA/QC procedures will be undertaken in the Shadwick laboratory at VIMS following recently developed best practices formalized at a workshop that Shadwick attended at the University of California at San Diego (Aug. 2014). All sensor data, including date and time stamp, and deployment location, will be written out to ASCII format for archiving with US National Science Foundation Biological and Chemical Oceanography Data Management Office (BCO-DMO, http://www.bco-dmo.org/), as well as with the Carbon Dioxide Information Analysis Center (CDIAC, http://cdiac.ornl.gov), where they will be freely available to the international community.