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Chemical Sensors for a Global Observing System

K. Johnson
MBARI, Moss Landing, CA, United States (johnson@mbari.org)

Observing the response of biogeochemical processes to climate forcing at the global scale and with seasonal and interannual resolution is one of the grand challenges of oceanography. There are simply not enough ships or scientists to make the required measurements using conventional approaches. In situ observing systems are likely the only means to achieve this goal. Such systems will require both low cost platforms and chemical sensors with long-term (years) stability, low power requirements and which are scaleable to large numbers (low cost, simplicity in manufacture, operation and calibration). The Argo observing system, with >3000 profiling floats now operating, demonstrates the feasibility of establishing global scale observing systems. Our challenge is now to develop the chemical sensors that can be deployed in such large arrays. Ten years ago there were essentially no chemical sensors that would be available for such large observing systems. Today, sensors for oxygen, nitrate, pCO_2, and pH have many of the properties needed for observing systems that can be scaled to large numbers. Here, I will review the work that the Chemical Sensor Laboratory at MBARI is doing to develop chemical sensors for global scale systems. I will present examples of oxygen and nitrate data collected by profiling floats that are now operating throughout the global ocean and which have run for multiple years with no intervention. This includes observations in the Southern Ocean, Arctic Ocean, and oxygen minimum of the Arabian Sea, as well as the Pacific and Atlantic subtropical oligotrophic gyres. The measurements are used to derive rates of nutrient supply, net community production in surface waters, and respiration of carbon exported into deeper waters. I will also review the status of pH sensor development for these systems. While challenges still remain, in particular the development of chemical standards that allow globally consistent data to be obtained, we are rapidly approaching the point where climate quality, chemical measurements can be made by in situ, autonomous systems at the global scale.