An optical sensor or autonomous detection of particulate inorganic carbon concentration in seawater

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The ocean's biological carbon pump (BCP) represents the flux of biogenic carbon from the surface to the deep ocean and exerts an important control on atmospheric CO_2 levels and global climate. This pump is fueled by processes of photosynthesis and calcification in the surface ocean, respectively generating particulate organic and inorganic carbon, POC and PIC. Part of these carbon particles will then sink to the deep ocean and ultimately to the seafloor, where it can be stored out of contact with the atmosphere on geological time scales. The differentiation between PIC and POC is crucial as the downward fluxes of POC and PIC have opposing effects on the ocean's capacity to remove CO_2 from the atmosphere.

Recent technological advances have enabled to observe the BCP from robotic ocean profilers equipped with bio-optical sensors. At present, around 500 of these so-called BioGeoChemical-Argo profilers operate between the surface ocean and the bottom of the twilight zone that is roughly 1000 m deep, providing biogeochemical observations at unprecedented time and space scales. However, no autonomous sensor currently exists to estimate PIC, hampering our understanding of and ability to estimate the magnitude of the biological carbon pump.

Here, we provide a proof-of-concept for the autonomous measurement of PIC with a cross-polarized beam transmissometer that measures the depolarization of forward-scattered light induced by the birefringence of PIC. We built a prototype PIC sensor in the lab and set up cultures for various types of calcifying phytoplankton. Our results demonstrate the relationship between light depolarization and the concentration of PIC in seawater over a large dynamic range. Next, PIC sensors will be integrated onto BioGeoChemical-Argo profiling floats for robotic monitoring of the BCP in various parts of the world's oceans.

Keywords
Biological Carbon Pump; Particulate Inorganic Carbon; Robotic Ocean Observations; Bio-Optics And Remote Sensing