NEW VIEWS OF THE OCEANIC CARBON CYCLE FROM AUTONOMOUS EXPLORERS

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ABSTRACT

A new paradigm for ocean carbon observations is emerging with the rapid advances in autonomous measurements of carbon systems with the success of robotic ocean profiling Carbon Explorers, autonomous sensors for particulate organic and inorganic carbon (POC and PIC), and new instruments which will measure year-long high frequency records of POC and PIC sedimentation in the very observation-poor but biologically-active upper kilometers of the ocean. The new observing capability described here is critical for improved prediction of the substantial biotic carbon flows in the ocean. There are excellent prospects for an enhanced ocean carbon observing system fully capable of autonomous real time monitoring, measurement, and verification of ocean carbon sequestration.

INTRODUCTION

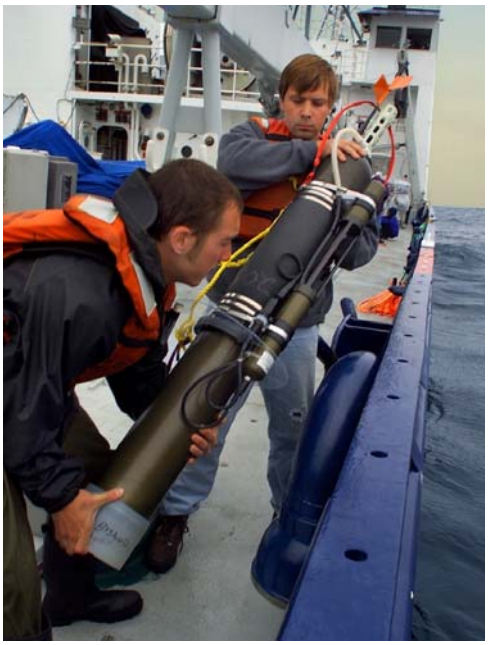

Fig. 1. Carbon Explorer with 25 cm pathlength transmissometer used to measure Particulate Organic Carbon (POC). The instrument shown has been modified to follow systematics of carbon sedimentation by measuring transmission loss due to the accumulation of particles on the upward looking optic of the POC sensor while the float is drifting at depth between profiles.

Carbon Explorers are telemetry and sensor enhanced ocean-profiling floats similar to the thousands now being widely deployed to study ocean climate and mid depth motions as part of the international study called Argo (CLIVAR, 1999). The Explorers further differ from Argo floats in they are specifically designed and programmed to capture the fast processes of the ocean's biological carbon pump.

Carbon Explorers (Fig. 1) operating in remote and stormy seas, have returned real-time year-long high-frequency records of particulate organic carbon (POC) biomass variability and sedimentation to kilometer depths. We captured first records of the transient but distinct biotic response to iron delivered to high nutrient – low chlorophyll (HNLC) waters of the North Pacific by a storm carrying Gobi Desert dust [*Bishop et al.*, 2002].

During the Southern Ocean Iron Experiment (SOFeX, *Coale et al.*, [2004]) our Carbon Explorers recorded a strong -- but unexpected -- enhancement of carbon biomass and carbon sedimentation in response to purposeful iron addition to low-silicate HNLC subpolar waters of the Southern Ocean [*Bishop et al.*, 2004].

In all a total of 12 Explorers have been deployed to date and have returned approximately 8 float years of POC data. The optical systems have outlived the floats.

PARTICULATE ORGANIC CARBON CONCENTRATION AND FLUX VARIABILITY IN THE SOUTHERN OCEAN

Three Carbon Explorers deployed during SOFeX carried optical POC sensors which were modified and programmed to follow the systematics of carbon sedimentation at depth between profiles. Two CE's (Fig. 2) were deployed at 55S and remained north of the Antarctic Polar Front. One (data not shown) was deployed south of the front and survived two Antarctic winters in the seasonal ice edge zone.

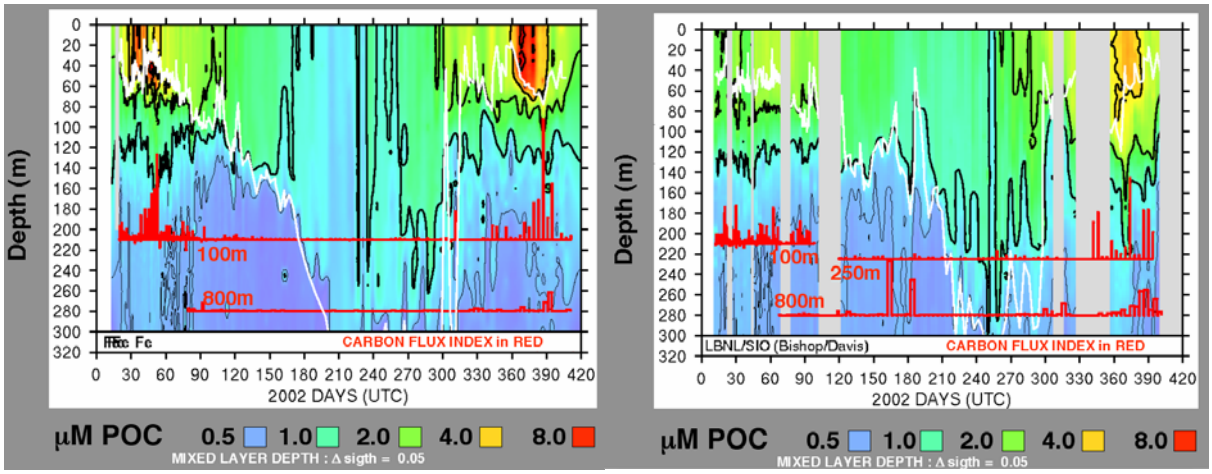

Fig. 2. Year long records from Carbon Explorers deployed at 55S 172W during SOFeX. (Left) record from the "in-patch" Explorer. Effects of Iron addition to HNLC waters are seen during the first 60 days of record. (Right) records of POC from "Control" Carbon Explorer. Both Explorers were remotely reprogrammed to determine carbon sedimentation systematics at multiple depths at the end of SOFeX. Carbon Flux Index systematics are shown in red, (Instrumental CFI artifacts are present in 800 m data (right) near day 165 and 185).

The two records from the two 55S Explorers depict POC concentration and flux variability as as they advected and separated within the flowing Antarctic Circumpolar current. There is a clear coherence between depth of wintertime mixing and POC concentration. Surprisingly, one year after deployment, the 'in the patch' Explorer recorded a spring bloom and 100 m carbon sedimentation that was the same magnitude as seen in iron stimulated waters one year earlier. Yet only 5 to 10% of POC exiting 100 m penetrated to 800 m. More efficient export is depicted in the record of the "control" Explorer. The results indicate that magnitude of carbon export through 800 m is not predictable from simple optical assessment of overlying POC. Understanding of food web structure (e.g. role of calcareous plankton in providing ballast for sinking particles) will be important to solving this puzzle.

SUMMARY

The Carbon Explorers and POC sensors are mature and useful. New sensors for particulate inorganic carbon (PIC) concentration have been extensively deployed from CTD's during the NOAA repeat hydrography program (A16N A16S). Instruments for particulate organic and inorganic carbon flux are rapidly maturing. Both will ride on Carbon Explorers within the next year. A "Carbon" Argo is possible.

REFERENCES

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