# MAPCO$_2$ Buoy Metadata Report

**Project Title:**

Autonomous Multi-parameter Measurements from a Drifting Buoy During the SO GasEx Experiment

**Funding Agency:**

NOAA Global Carbon Cycle program

**PI(s):**

Christopher L. Sabine (NOAA Pacific Marine Environmental Laboratory),

Michael DeGrandpre (University of Montana),

Wade McGillis (LDEO/Columbia University)

**Contact Info for Project Coordinator:**

Christopher Sabine, NOAA/PMEL, 7600 Sand Point Way NE, Seattle, WA 98115; Phone: 206-526-4809, Fax: 206-526-6744, Email: chris.sabine@noaa.gov

**Project Goals:**

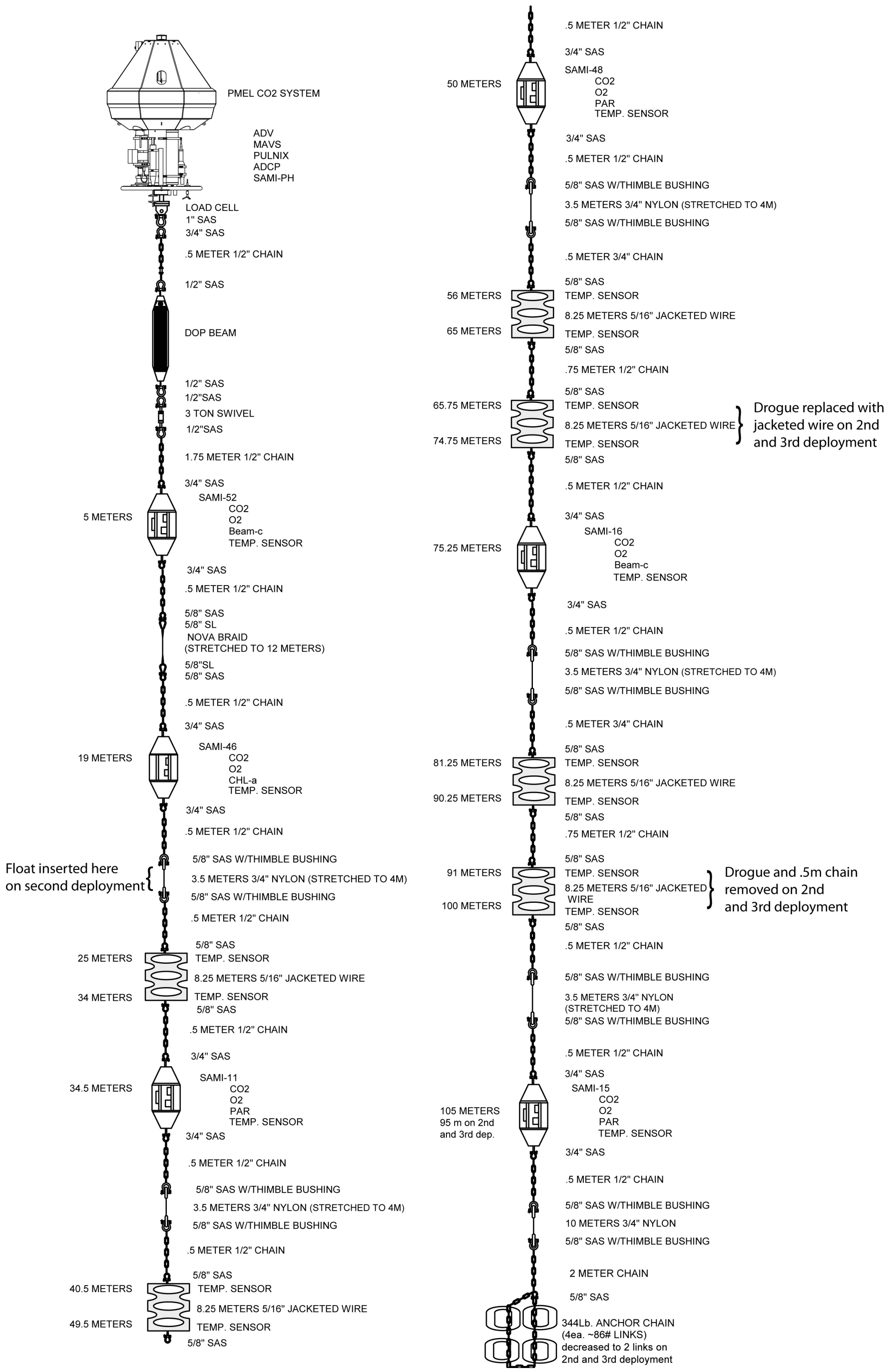
Our specific objectives for the 3-years of this project are to 1) modify a recently developed low profile, high payload buoy to act as a drogued drifter for the SO GasEx Experiment; 2) instrument the drifter with a variety of autonomous instruments capable of making a coordinated set of physical, geochemical, and biological measurements at high temporal resolutions to provide a key component in the study of processes controlling air-sea $CO_2$ exchange; 3) Integrate the multi-parameter measurements into a mass balance study of the surface ocean carbon system (in conjunction with shipboard water column studies) to provide an independent assessment of air-sea gas exchange; 4) evaluate the physical and biogeochemical mechanisms leading to short-term variability in air-sea gas exchange; and 5) evaluate potential biases in $CO_2$ flux estimates from high resolution data sets (e.g. $CO_2$ moorings) arising from the use of traditional gas exchange parameterizations. The basic hypothesis driving this study is that short-term variability in carbon system and physical parameters has a significant impact on gas exchange and the estimation of carbon mass balances on time scales of days to weeks.

**Shipboard Personnel Involved in Project:**

Chris Sabine, Chris Zappa, Geoff Lebon

**Shipboard Operations:**

A drifting autonomous buoy was designed by NOAA/PMEL to make high frequency physical and biogeochemical measurements in the tracer patch during the experiment. The buoy was approximately 1.5m in diameter and 2m high (half above the water and half below the water). Below the buoy was a 118m sting of instruments and 6 tubular canvas drogues that were 10m long by 1m diameter (see figure). At the bottom of the string was 350 pounds of weight.




The buoy contained a $MAPCO_2$ non-dispersive infrared analyzer based system for measuring the $CO_2$ concentrations of the surface water and atmosphere every 30 minutes. A Gill sonic anemometer measured the wind speed and direction at approximately 0.9m above the water surface. A 10 minute average reading was recorded every 30 minutes. The wind sensor was damaged half way through the second deployment and was replaced with a spare for the third deployment. A SeaBird 37 Microcat sensor measured the temperature and conductivity of the water at approximately 1m depth every 15 minutes. All of these data, together with the GPS location of the buoy, were transmitted via Iridium satellite to NOAA/PMEL four times per day. These data were automatically processed and posted to a web site that could be accessed from the Ron Brown to get near real time information about the waters being sampled by the $MAPCO_2$ buoy. The buoy also had a second, independent Iridium/GPS system that transmitted GPS fixes and information from a load cell located immediately below the buoy back to NOAA/PMEL once per hour. These data were also posted to the web. The hourly GPS fixes were also emailed to Chris Sabine and several of the ship's officers so the ship would know where to find the buoy at any time.

There were several instruments mounted to the buoy at approximately 1m depth to determine near surface turbulence, relative currents and bubble characteristics. The MAVS (Modular Acoustic Velocity Sensor) measures 3-axis velocity at a single point (1000 $cm^3$). The technology is time-of-flight. However, battery problems prevented the instrument from operating properly so no data was recovered from this instrument. The Sontek 10 MHz ADV (Acoustic Doppler Velocimeter) measures 3-axis velocity at a single point (1 $cm^3$). This instrument uses backscatter from particles in the water to make its measurement. The measurement was made at a sampling frequency of 25 Hz for 10 minutes every 30 minutes. The RDI 1200 KHz ADCP measures vertical profiles of 3-axis velocity over 15 m of water column with a blanking distance of 1-2 m. There are roughly 75 bins of 25 cm each. A profile was sampled every 2.5 seconds throughout the deployments. There was also an underwater camera that took photos every 90 minutes. These photos will be analyzed to characterize the bubble dynamics under different wind and wave conditions.

Just below the buoy at 2m depth was a Nortek 2 MHz Aquadopp HR which measures along-beam velocity over a profile of 1 m with 1.7 cm bins. This allowed us to determine the wave-number spectra for velocity which allowed us to estimate the turbulent kinetic energy dissipation rate. A profile was sampled at 4 Hz for roughly 3 minutes every hour.

A SAMI-pH sensor was mounted on the buoy at 1m depth. Six SAMI-$CO_2$ sensors were deployed below the buoy at 5, 19, 34.5, 50, 75, and 105m. The SAMI instruments used a colorimetric dye to measure pH or $pCO_2$ every half hour. All of the SAMI instruments also had dissolved oxygen sensors. Beam-C instruments were mounted to the 5 and 75m SAMIs. PAR sensors were located on the 34.5, 50, and 105m SAMIs. A fluorometer was mounted on the 19m SAMI. All instruments were programmed to sample every 30 minutes.

Onset water temperature PRO V2 sensors were located below the buoy at 5, 19, 25, 34, 34.5, 40.5, 49.5, 50, 56, 65, 65.75, 74.75, 75.25, 81.25, 90.25, 91, 100, and 105m. They sampled every 30 minutes with an accuracy of 0.1°C and precision of 0.02°C.

The first $MAPCO_2$ buoy deployment was on 8 March, immediately after the tracer injection was completed. The buoy was deployed adjacent to the GPS drifter used for the patch creation. When the buoy was released from the ship we noticed that it was sitting lower in the water than expected. When large waves would pass, the waves would ride over the buoy instead of the buoy riding over the waves. Unfortunately, the buoy could not be recovered until 12 March to fix the situation.

On 13 March the buoy was redeployed in the patch with four drogues instead of six. We also removed half the weight at the bottom of the drifter string and added a cylindrical float from the ASIS buoy at a depth of about 20m. The only instrument affected by these changes was the 105m SAMI which was 10m shallower on the second deployment. The buoy rode much better with this configuration and was not getting topped by the waves nearly as often. The load cell readings on the bottom of the buoy were also lower and, more importantly, did not show the large spikes observed in the first deployment. A few hours after the buoy was redeployed the ship left the study area for South Georgia Island because of approaching heavy weather. Based on the load cell data, it appears that the 20m float was compromised sometime between 14 and 15 March. The maximum loads on the load cell got significantly higher and the frequency of large spikes increased.

The MAP$CO_2$ buoy was recovered the morning of 18 March, after returning to the study site from South Georgia Island. The buoy was sitting a little lower in the water than when it was deployed, but not as bad as the first deployment. When the ASIS float we added was lifted out of the water it had clearly been crushed and was full of water. Because the float was filled with foam, we believe that it still had a small net positive buoyancy but not the original 250 pounds of flotation.

The MAP$CO_2$ buoy was deployed in the patch for the third and final time on 21 March, immediately after the second tracer injection. The configuration was the same as the second deployment except without the float at 20m. A piece of nylon rope was inserted in place of the float so the instrument depths were not affected.

Although the drogues made the drifter difficult to deploy and retrieve, the MAP$CO_2$ buoy did an excellent job of staying with tracer patch. During the first two deployments and the first week of the third deployment the buoy was providing a useful navigation tool for mapping the patch and recording its movements. Suddenly around 27 march the tracer completely stopped moving while the buoy continued on its southeasterly course. Each day as the ship stayed with the patch the buoy got farther and farther away. Unfortunately, we were not able to go retrieve the buoy because the ship's propulsion systems repeatedly failed throughout the weekend and it was all we could do to keep track of the patch. On 31 March we decided that we must make the 50 km trek to retrieve the buoy before it got too far away. As we approached the buoy, however, we discovered that there were significant concentrations of tracer moving with the buoy. Apparently the patch had sheared in two. The portion of the patch near the buoy continued moving to the southeast while the core of the patch got caught up in a small stable eddy. Because the ship's propulsion systems were failing so often and we were concerned about having to make a sudden early departure from the study site, we chose not to redeploy the buoy again.

The surface $CO_2$, temperature, salinity and wind data will be processed at NOAA/PMEL. The

SAMI data will be processed at the University of Montana. The remaining data will be processed at LDEO. All data collected from the MAP$CO_2$ drifter will be made available to the GASEX community by early October 2008.