Photosynthesis and carbon dioxide uptake in the Southern Ocean: The Southern Ocean Gas Exchange Experiment (SO GasEX). Dr. Robert Vaillancourt (co-I, J. Marra, P.I., Brooklyn College of NY, and V. Lance, post-doctoral research scientist, LDEO). Funding provided by NASA.

Carbon Dioxide (CO_2) while a minor constituent of Earth's atmosphere (~0.03%) plays a disproportionally large role in regulating Earth's surface temperature. For the previous 200 years, humans have been increasing the atmospheric concentration of CO_2, and thus its effect on climate, through the burning of fossil fuels oil, coal, and natural gas. The world ocean has absorbed a large portion of this 'anthropogenic CO_2', but the exact rate of uptake is not certain. Dr. Robert Vaillancourt and colleagues recently participated in a multi-investigator program, The Southern Ocean Gas Exchange Experiment (SO GasEx) to study the rate at which CO_2 from the atmosphere enters the ocean. Our study site was at the boundary between the southern Atlantic Ocean and the Southern Ocean, east of the southern tip of South America, aboard the NOAA Research Vessel, the *Ronald H. Brown* (Figure 1). The contribution of our team was to determine the amount of CO_2 drawn down by phytoplankton through the process of photosynthesis. A patch of water was infused with tracer (SF_6 & ^3H) and its biogeochemical properties were analyzed for a 15-day period. We performed daily measurements of CO_2 uptake by phytoplankton using a combination of simulated *in-situ* incubations (Figure 3) and photosynthesis-irradiance experiments (Figure 4), using radioactive carbon dioxide (^{14}C-CO_2) as a tracer. Greater than 95% of the plant biomass and CO_2 uptake by phytoplankton was observed in the surface layer (Figure 2). We observed 3-to-4-fold variations in daily CO_2 draw-down during the 15-day period. Total CO_2 removal by plant photosynthesis is estimated at 439 mmol C m^{-2} and was confined to the surface mixed layer during the 15-day period. A portion of this 'fixed' CO_2 was likely exported to the deep ocean water and lost from the upper ocean/atmosphere reservoir, a process known as the "biological pump", although the exact rate of loss of this 'export CO_2' is not well understood.

FIGURES

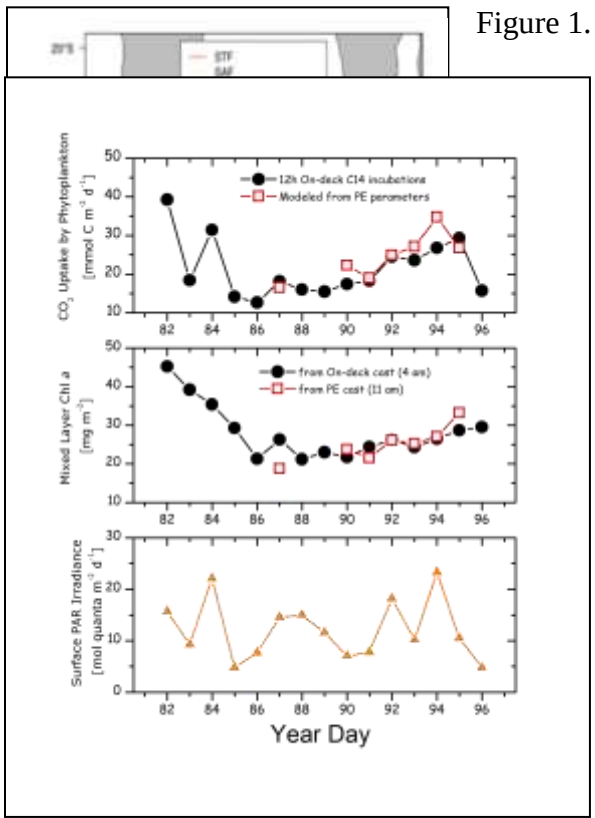

Figure 1. SO GasEx study site was located at approx 51.7ºS, 37ºW. The research vessel was the *NOAA ship Ronald H. Brown*. The solid colored lines show the approximate positions of the various ocean fronts in this region.

Figure 2. Daily (12-hr) mixed layer (50 m) CO_2 uptake (a) and Chlorophyll *a* (b) and surface PAR irradiance (400 – 700 nm) (c) during the 15-day period of patch occupation. Solid symbols are from 12-hour incubation data, and open symbols are modeled values based on photosynthesis-irradiance (PE) experiments. The two independent measures give very similar results. The change in CO_2 uptake over time probably indicates natural variability in addition to horizontal mixing and entrainment of patch water with water masses outside of the patch.

Figure 3. The NOAA research Ship *Ronald H. Brown*, in port in Punta Arenas, Chile prior to departure to Southern Ocean GasEx study site. February, 2008.

Figure 4. Scientists Dr. Veronica Lance (Lamont-Doherty Earth Observatory) and Dr. Pete Strutton (Oregon State University) arrange samples in on-deck incubator for 12-hour CO_2 uptake experiment on the back deck of the *Ron Brown*. The light source is natural sunlight, and temperature is maintained by flowing seawater pumped from the ship's side. The sample tubes are sheathed in blue filters to simulate the color of underwater light field.

Figure 5. The radial photosynthetron, shown here in the radiation lab aboard the *Ron H. Brown*, measures the rate of CO_2 uptake in multiple samples from up to 10 depths simultaneously using a central light source. Ambient temperature (~ 5°

C) is maintained by means of circulating water/propylene glycol mixture through the incubation chambers. The photosynthetron can measure CO_2 uptake rate in one hour in 120 samples simultaneously.