SPACE AND TIME VARIABILITY OF TOTAL INORGANIC CARBON AND AIR-SEA FLUX OF CO_2 IN THE NORTH-EAST ATLANTIC OCEAN DURING THE POMME EXPERIMENT (2001): A STUDY FROM THE DIURNAL TO THE MONTHLY TIME SCALE ALONG LAGRANGIAN BUOYS' TRAJECTORY

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ABSTRACT

Four CARIOCA Lagrangian buoys drifted in the North-East Atlantic Ocean between 38° and 45°N between February and August 2001. Daily cycles of pCO_2, SST and DIC are observed even in winter. Biological rates of carbon consumption, gross and net primary production,are determined in situ from the amplitude of the diel cycles and the time evolution of surface dissolved inorganic carbon. Over the 6 months period, February-August, the ocean in the studied area is a sink for atmospheric CO_2.The mean absorbed flux is equal to 3.8 mmoles/ m^2/ day.

INTRODUCTION

Four CARIOCA drifters were deployed in February 2001 during the POMME project conducted in the Northeast Atlantic (20W-15W, 38N-45N). A complete time series of hourly measurements, over a 6 months period has been analysed with a twofold objective:

- identify and interpret the processes responsible for the observed variability at the ocean surface of the carbon compounds, the partial pressure of CO_2 , pCO_2 , and the dissolved inorganic carbon, DIC.
- estimate the CO_2 flux exchanged at the air-sea interface over the POMME area.

EXPERIMENTAL SET UP

On the water side, hourly measurements of pCO_2, sea surface temperature (SST), salinity and fluorescence are made by CARIOCA buoys on samples pumped at 2 meters depth. Wind speed and atmospheric pressure are measured at a height of 2 meters in the atmosphere.The dissolved inorganic carbon, DIC, is derived from the distribution of pCO_2 and salinity, knowing the relationship which links alkalinity and salinity in the studied area [*Gonzalez-Davila et al*, 2005].

PROCESSES WHICH CONTROL THE HIGH FREQUENCY VARIABILITY OF DIC

From the temporal evolution of DIC of two buoys, characteristic major events are identified :

1-a large increase over a 3 days period in early February.

A comparison between the temperature–salinity data measured either by the drifter or a close-by instrumented deep mooring over a time interval of 7 days shows the presence at the surface of a water parcel which originates from a level deeper than 200 meters .This is confirmed when we compare the maximum recorded value of DIC measured by the buoy, 2123 µmoles.kg^{-1},with a vertical section of DIC [*Gonzalez-Davila et al.*,2005]. The surface DIC value recorded by the buoy corresponds to the value observed at 300 meters depth in the water column. The clear signature of the presence at the surface of water with a deep origin is interpreted either as the result of an intense vertical mixing at a few days time scale or the crossing of the trajectory of the buoy with a deep homogeneous eddy.

2- diurnal cycles of DIC which are also observed for SST and pCO_2

Mixing due to either nocturnal convection or wind action and biological processes are the likely candidates to interpret the observations. An estimate of the diurnal cycle of the mixed layer depth and SST along the CARIOCA drifter trajectories has been computed by using a one dimensional model forced with hourly heat, salt and wind fluxes [*Caniaux et al.*, 2005].

A clear drawdown of DIC between dawn and dusk is observed (Fig. 1).

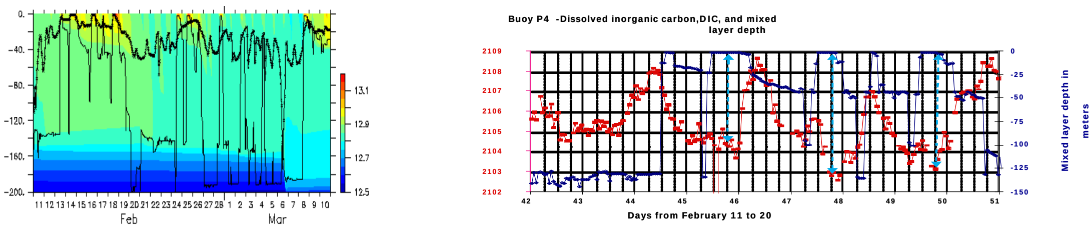

Fig.1: left) Section of the temperature computed by the lagrangian model for the upper 200 meters of the water column along the trajectory of one of the buoys between February11 and March 11.The thin line indicates the mixed layer depth (MLD). right) Modeled MLD (blue) and the measured DIC (red) variability from February 11 to 20.

A minimum value of DIC is associated with a minimum of MLD. As an exemple, at the end of March, over a time period of up to 5 consecutive days, regular daily cycles of DIC are observed as well as a regular decrease with time of the mean DIC measured at 2m depth. From the daily mean values of the amplitude of the cycle (3.2 μmoles.kg^{-1}) and the decrease (1.3μmoles.kg^{-1}), taking into account the contribution of the air-sea flux, we can calculate a gross primary production equal to 5.1μmoles.kg^{-1}d^{-1}, a net community production equal to 1.4 μmoles.kg^{-1}d^{-1} and then a f ratio equal to 0.27 .A high resolution biogeochemical model [*Levy et al.*,2005] has been coupled off line with the Lagrangian physical model described above. A comparison between the high frequency data either measured by the buoy or predicted by the model will be presented

AIR-SEA CO_2 EXCHANGED FLUX

Hourly values of the air-sea flux are computed along the trajectory of the buoys as all the needed quantities are measured, mainly SST, pCO_2 in the water and the wind speed. pCO_2 in the atmosphere is calculated taking into account the molar fraction of pCO_2 (atmosphere global monitoring network) and the atmospheric pressure measured by the buoys. We observe that the Atlantic Ocean in the POMME area is a sink for atmospheric CO_2 from February to the end of June. It is followed by an outgassing phase due to the thermal heating at the ocean surface.

The next step is to extrapolate the buoy's observations to the whole area besides the observations made only along the Lagrangian trajectories. For this purpose,we have established monthly empirical relationships between pCO_2 and SST. These relationships have subsequently been used to compute the fluxes using satellite measurements of SST (AVHRR) and wind speed (Quicksat) at 1° by 1°, one week resolution. The absorbing flux is maximum mid April, when the biological drawdown of DIC is large and before the start of the rise of the temperature.Over the February-August period, the ocean is a sink for atmospheric CO_2.The mean absorbed CO_2 flux is equal to–3.8 mmoles/ m^2/ day. Another approach is given by the 3D model's outputs [*Levy et al*., 2005] as the integrated flux over the zone is computed.The results of the 2 approaches will be compared and discussed.

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