VARIABILITY OF OCEAN CO2 PARTIAL PRESSURE AND AIR-SEA CO2 FLUXES IN THE SUBANTARCTIC ZONE OF THE SOUTHERN OCEAN

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ABSTRACT

Seven CARIOCA lagrangian buoys drifted in the Subantarctic Zone, SAZ, of the Indian and Pacific Ocean between 2001 and 2005. Measurements indicate that pCO_2 in sea water is undersaturated with respect to the atmospheric value and consequently the subantartic zone of the Southern Ocean acts as a sink for atmospheric CO_2 during all seasons. Large observed pCO_2 variability is associated with mixing close to the subantarctic front, with biological activity and local warming. These variabilities are higher than the seasonal cycle in the studied areas.

INTRODUCTION

The Southern Ocean is expected to act as a significant sink for atmospheric CO_2; however the estimates of the magnitude of this sink significantly vary depending on the methods used to infer it (see for instance [*Gloor et al.*, 2002]). In order to better quantify the air-sea flux in the Subantarctic zone of the Southern Ocean, CARIOCA drifters were deployed in this area. In this paper, we present seasonal fluxes deduced from CARIOCA measurements, with a thorough analysis of the origin of the sea surface CO_2 partial pressure, pCO_2, variability in the Pacific sector in 2004-2005.

DATA AND METHODS

Seven CARIOCA lagrangian buoys were deployed in the SAZ successively in November 2001, January 2002 and 2003 and in March-April 2004 during the SAGE experiment south of New-Zealand. Hourly pCO_2, sea surface temperature, SST, salinity, SSS, fluorescence, surface wind speed, U, atmospheric pressure, Pa, and air temperature were recorded during 50 months. Comparisons of CARIOCA pCO_2 with ship measurements indicate an accuracy of about 3μatm. The trajectories of the buoys are superimposed on Longhurst provinces on Fig. 1.

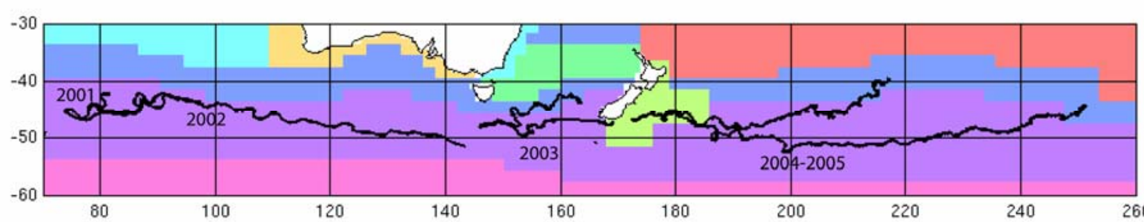

Fig.1: Trajectories of CARIOCA drifters, deployed in the central Indian Ocean (2001, 2002), south of Tasmania (2003) and south of New Zealand (2004), and superimposed on biogeochemical provinces defined by [*Longhurst,* 1998]; they mostly drift in Subantarctic Water Ring province (SAWR, purple) except 2 drifters deployed in New-Zealand coastal province (green) in Fall 2004 and 3 drifters that escape towards the south subtropical convergence province (SSTC, blue) (one in Fall and Winter 2003 and 2 in Fall 2005).

Air-sea CO_2 fluxes are computed using the Wanninkhof [1992] K-U relationship and the difference between ocean and atmospheric pCO_2, ΔP. Dissolved inorganic carbon content, DIC, is derived from measured pCO_2 and alkalinity estimated from measured SSS according to the SSS-Alk relationship [*Jabaud-Jan et al.,* 2004].

RESULTS

The buoys recorded very variable pCO_2 and fluxes from one region to another one (Fig. 2) although they went mostly in the same hydrological area (SAZ). The flux variability appears to be primarily driven by ΔP. No clear seasonal cycle was identified.

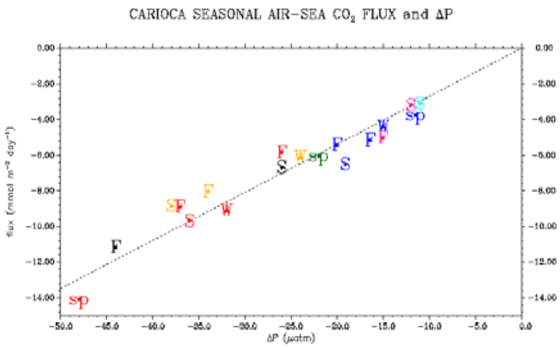

Fig. 2: Mean seasonal air-sea CO_2 fluxes versus ΔPas deduced from 7 CARIOCA drifters measurements, in 2001 (green), 2002 (light blue: northern drifter; black: southern drifter), 2003 (orange: northern drifter; pink: southern drifter), 2004-2005 (red: northern drifter; blue: southern drifter). Austral seasons are indicated as S for summer, sp for spring, F for fall and W for winter. Dotted line is adjusted to the mean values (2001-2005) of ΔP and flux. The slope of the line corresponds to U close to 10m s^{-1}. Data points above this line are mostly associated with very negative ΔP and lower wind speeds.

Most of the largest absorbing fluxes occur for the buoys that went north of the SAWR province, close to or inside the SSTC. This is particularly evident, in the Pacific Ocean (Fig. 3): pCO_2 close to 360µatm are recorded by the Southern buoy 1) between August and December when the buoy was in a jet close to the SAF caracterised by high DIC and 2) in April because of local warming (pCO_2 gradients are not associated with DIC gradients). In contrast, pCO_2 measured by the northern buoy are as low as 290µatm at the end of December because of the onset of a phytoplankton bloom as seen on MODIS images (not shown).

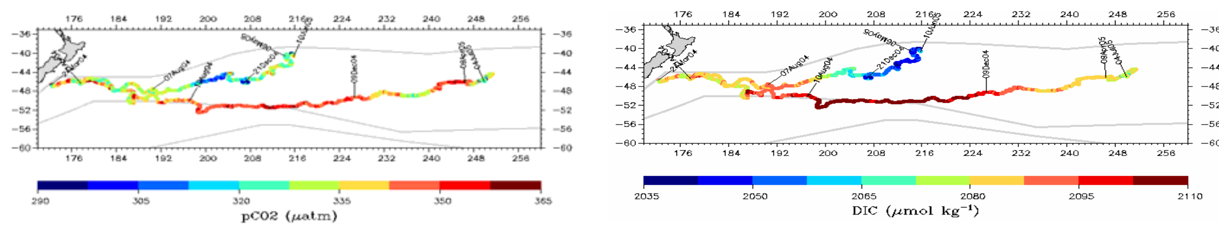

Fig. 3: pCO_2 (left) and DIC (right) color coded along the trajectories of the 2004-2005 CARIOCA buoys in the Pacific Ocean (from March 2004 to June 2005). Fronts (as defined by [*Belkin and Gordon*, 1996]) are reported in grey: from south to north: polar front, subantarctic front (SAF), south subtropical front (SSTF). SAZ is between SAF and SSTF.

CONCLUSION AND PERSPECTIVE

CO_2 fluxes in the SAZ are always towards the sea whatever the season. A large part of the variability appears at short (day to week) time scale and is associated with local biological and warming events. At large scale mixing close to the SAF is driving lower air-sea fluxes than north of the SAZ. Next step is to spatially and temporally extrapolate these measurements.

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