CO_2 and associated parameters variability in the Southern Ocean: CARIOCA and ARGO drifters

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In the frame of the EU-FP6 CARBOOCEAN project, 19 months of CARIOCA data have been acquired by four CARIOCA buoys deployed in the Southern Atlantic Ocean in 2005, 2006 and 2007.
In this poster, we analyse the variability of pCO_2 with respect to 1) Takahashi (2002) climatology, 2) the location of the drifters relative to the subantarctic front and 3) the biological activity.

CARIOCA MEASUREMENTS IN THE SOUTHERN ATLANTIC OCEAN SINCE 2005

CARIOCA drifters measure each hour, at 2 meters depth, ocean CO_2 partial pressure, pCO_2, sea surface temperature, SST, salinity, SSS, fluorescence, and in the atmosphere surface wind speed, atmospheric pressure and air temperature.

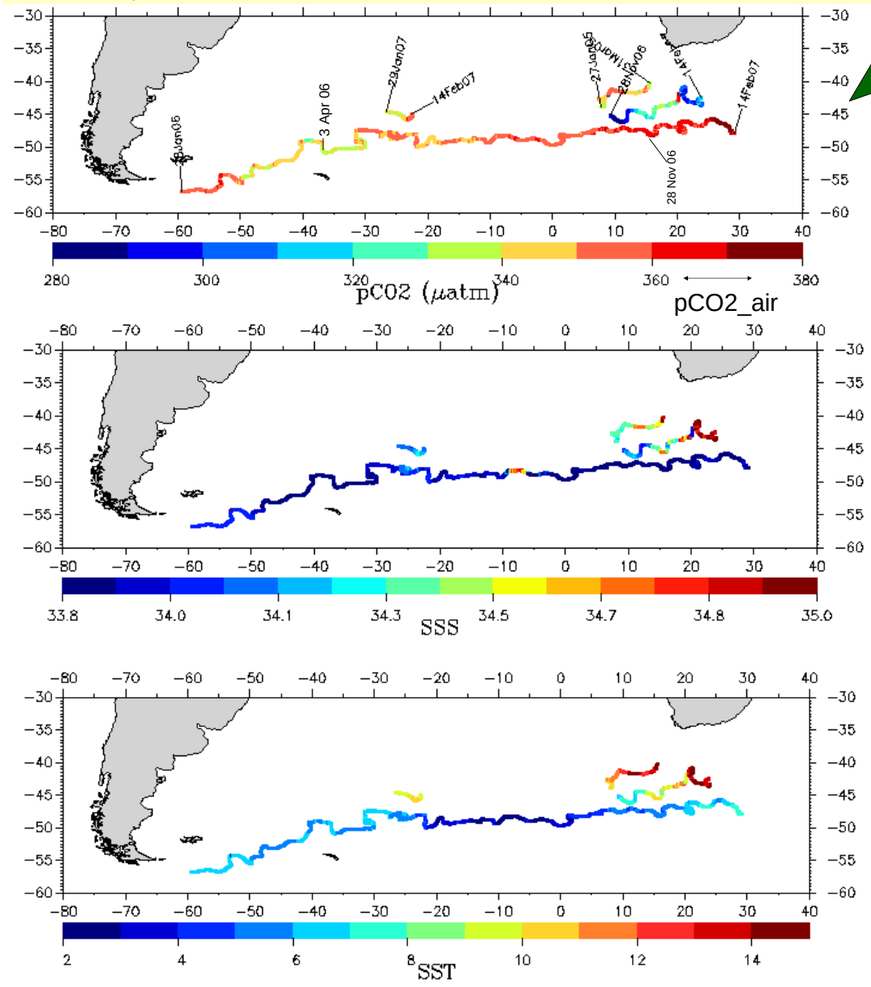


Fig 1:2005, 2006 and 2007 CARIOCA measurements.From top to bottom: pCO2, SSS and SST.

COMPARISON WITH TAKAHASHI (2002) CLIMATOLOGY

Takahashi et al. (2002) derived a pCO_2 climatology **referred to 1995 year,** from ship measurements. We extract pCO_2 values from this climatology corresponding to location and months of CARIOCA measurements.

pCO_2 is always undersaturated wrt atmospheric pCO_2 (370 ±5µatm over that period). It exhibits a large variability; pCO2 as low as 280µatm are observed.

On average over 3 CARIOCA tracks, pCO_2 from Takahashi climatology is 24 to 31µatm lower than pCO_2 measured by CARIOCA drifters. This difference is significant (well above the standard deviation of the differences): this is consistent with an increase of pCO_2 in surface waters that follows the atmospheric trend (20µatm between 1995 and 2006; N.B. Takahashi (2002) did not correct data south of 50°S for atmospheric trend so that the difference may be larger than 20µatm).
The difference with the 2006-2007 North-East buoy is much weaker and much more variable because of strong biological activity (see below)

Table: Difference between pCO_2 from Takahashi (2002) referred to 1995 year and pCO_2 measured by CARIOCA drifters. Standard deviation of the differences are also indicated.

	pCO_{2Taka}-$pCO_{2Carioca}$ (µatm)
2005-North East	-24 ±12
2006-2007 South	-31 ±10
2006-2007 North-East	-9 ±23
2007 North-Mid Atlantic	-26 ±8

Once the atmospheric trend is taken into account, the east-west gradient observed on the Southern buoy with lower pCO_2 in Summer-Fall between 50W and 30W is similar to Takahashi (2002) climatology.
On another hand, the strong difference between 2006 north-east and south buoys between 10E and 25E is not observed on the climatology

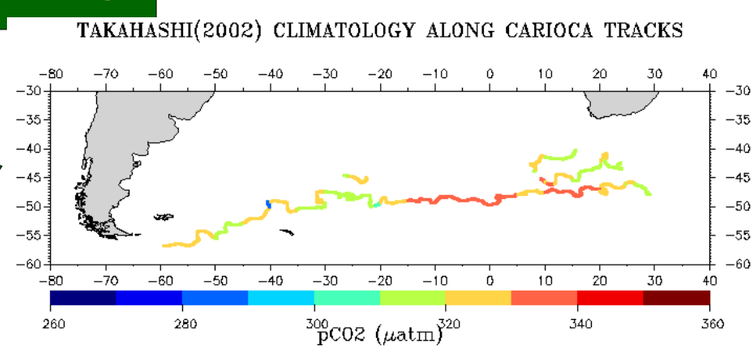


Fig 2: Takahashi (2002) pCO2 colocated in space and months with CARIOCA measurements. Color scale has been shifted by 20µatm wrt CARIOCA pCO2 figure in order to take into account oceanic trend.

LOCATION OF CARIOCA MEASUREMENTS RELATIVE TO SUBANTARCTIC FRONT

2006 CARIOCA remains south of the Subantarctic zone, in polar zone, as indicated by its low SSS (SSS < 34) and SST. Climatological fronts (Orsi et al., 1995; Belkin and Gordon 1996) were found too approximative to precisely locate CARIOCA with respect to Subantarctic front, SAF. We detect SAF from Microwave Optimally Interpolated (OI) Sea Surface Temperature (SST) maps (available on www.ssmi.com/SST/microwave_oi_sst_browse.html) as the maximum SST gradient within 5°C and 9°C (as proposed by Moore et al. (1999) and Burls and Reason (2006)).

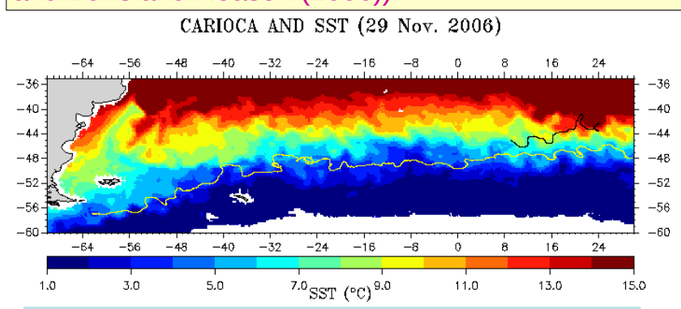


Fig 3: South and North-East CARIOCA trajectories superimposed on AMSR SST map (29/11/06: CARIOCA north-east deployment)

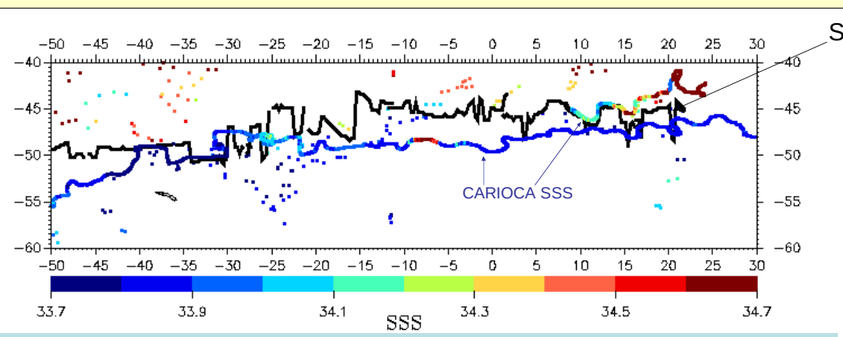


Fig 4: SSS recorded by CARIOCA 2006 South and North-East and by ARGO profilers (color points) superimposed on SAF detected from maximum SST gradient (black).

Both CARIOCA SSS, ARGO SSS (Salinity gradient around 34.1, indicative of SAF) and SST gradient criteria indicate that:
-2006 South buoy was south of SAF (Fig4)
-2006-2007 North East buoy was deployed on the SAF(Fig4)
-2005 and 2007 buoys were deployed in the SAZ (Fig1)

BIOLOGICAL ACTIVITY ALONG CARIOCA TRAJECTORIES

The low pCO_2 observed by the 2006 north-east buoy (Fig 1) are associated with very large fluorescence values (Fig 5). They correspond to a chlorophyll filament observed onto the SAF at the time of the buoy deployment (Fig 6, left) and to large chlorophyll contents at the edge of an eddy when the buoy drifts northwards (Fig. 6, right).

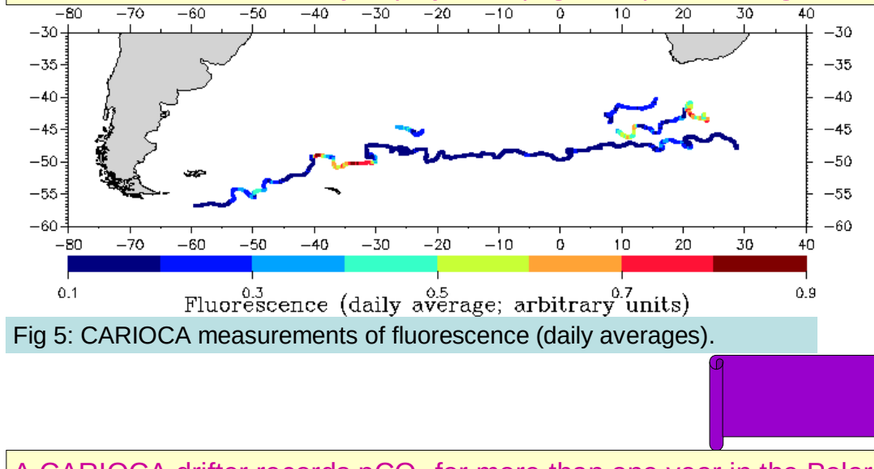
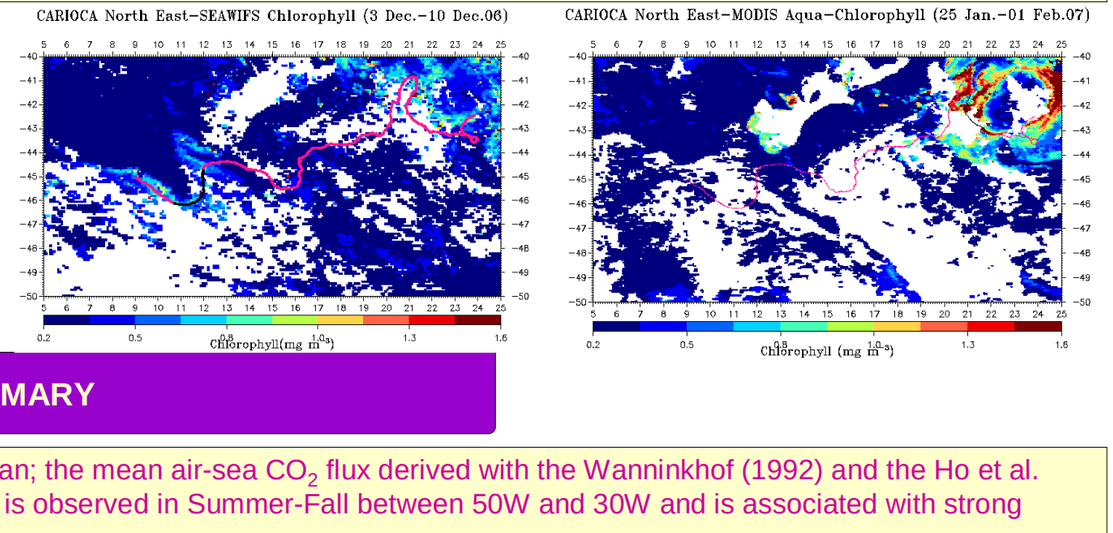


Fig 5: CARIOCA measurements of fluorescence (daily averages).

Fig 6: CARIOCA trajectory superimposed on (left) SEAWIFS chlorophyll image just after the buoy deployment, (right) MODIS chlorophyll image when the buoy was in the north east of the image



SUMMARY

A CARIOCA drifter records pCO_2 for more than one year in the Polar Zone of the Atlantic Ocean; the mean air-sea CO_2 flux derived with the Wanninkhof (1992) and the Ho et al. (2006) k-U relationship is 1.2 mol m^{-2} yr^{-1} and 1. mol m^{-2} yr^{-1} respectively; the minimum pCO_2 is observed in Summer-Fall between 50W and 30W and is associated with strong fluorescence values.
The 3 other buoys drift north of the SAF. The minimum pCO_2 (down to 280µatm) is observed in November 06 when the 2006 North-East buoy was on the SAF and in January-February 2007: during both periods, the buoy follows thin chlorophyll filaments. This strengthens the small scale variability of pCO_2 in the open ocean associated with strong chlorophyll variability linked to ocean dynamics.
CARIOCA pCO_2 is on average larger than Takahashi(2002) climatology by a value close to the atmospheric trend between 1995 and 2006, confirming that the surface ocean, even at high latitudes, follows the atmospheric trend (Takahahshi, 2006).

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