Nouvelles estimations in situ des flux de carbone biologiques, « Gross Community Production », GCP, et « Net Community Production », NCP, à partir des mesures de bouées Carioca dans l'Atlantique Nord Est et dans l'Océan Sud

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Outline of the presentation

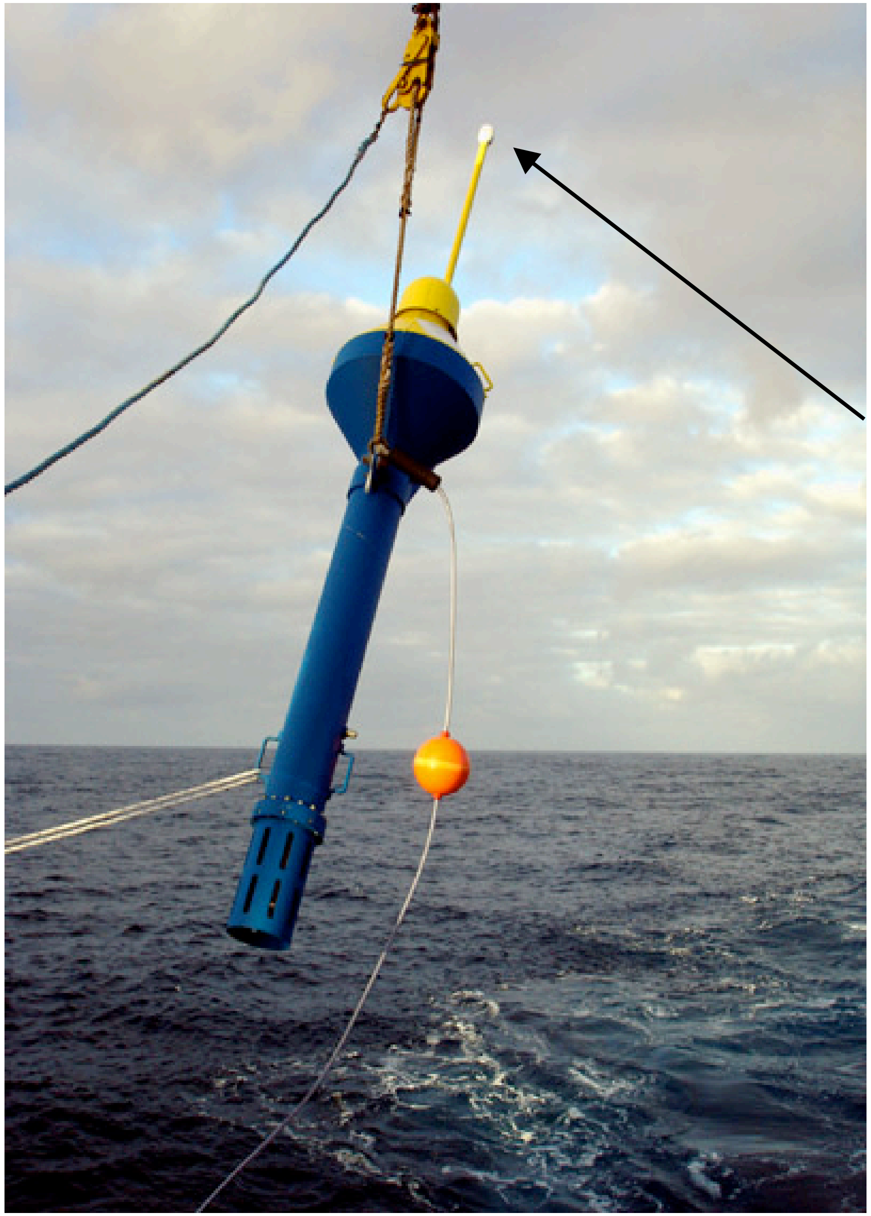
New direct in situ determination of biological rates at the ocean surface taking advantage of automatic high frequency acquisitions of hydro-biogeochemical variables by Carioca buoys at the ocean surface

- the set of parameters acquired with Carioca buoys

- how to estimate gross and net community production, GCP and NCP, from hourly measurements of dissolved inorganic carbon,DIC and CO_2 air-sea flux.
  - -model assumptions and validation with measurements made in 2001 during the POMME program in the north east Atlantic
  - - comparison with classical methods

- estimation of GCP and NCP in the polar zone of the Southern Atlantic Ocean in April and December 2006.

- Conclusion and Summary



A Carioca buoy launched from the Marion Dufresne on January, 29,2007 in the Southern Atlantic Ocean during the OISO 15 campaign.

Ocean measurements at 2m depth:

-SST, SSS, fCO_2, Fluorescence

Atm. measurements at 2m height:

-Wind speed, Atmospheric pressure

• *DIC deduced from fCO2, SSS, SST assuming Alk/SSS relationships (Gonzalez-Davila et al,2005, Lee et al,2006) .*

Scope of time scale 1 hour to 1 year, space scale from 1 meter to thousands of km.

➡ study of submeso and mesoscale to basin scale processes from diel to seasonal scale

Trajectory influenced by -15m depth currents.A drogue is attached to the buoy.

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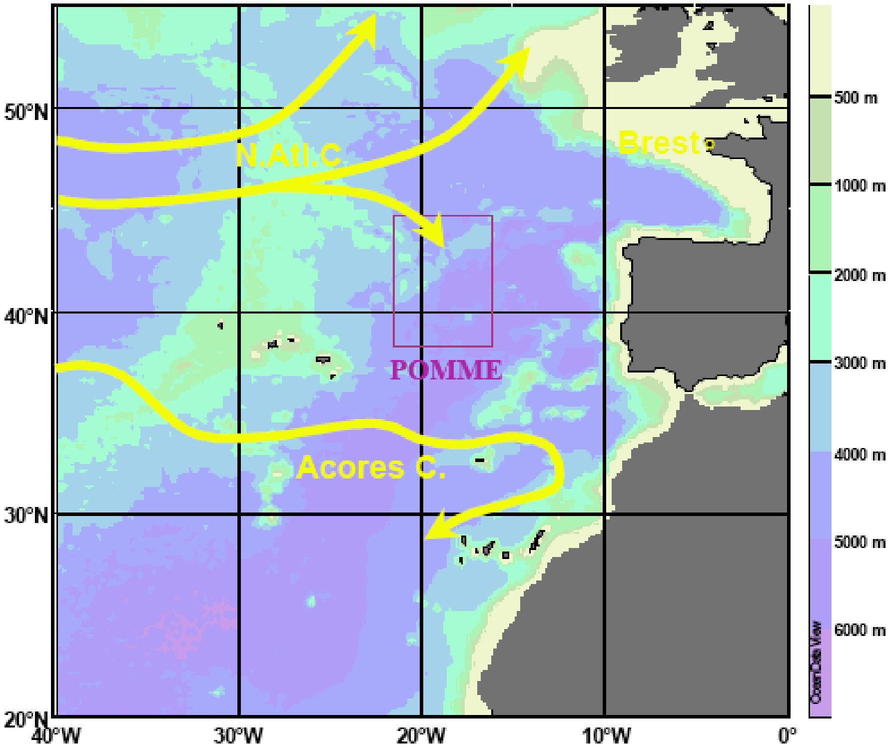
Trajectories of 4 Carioca buoys deployed during the POMME program between February 2001 and August 2001

a



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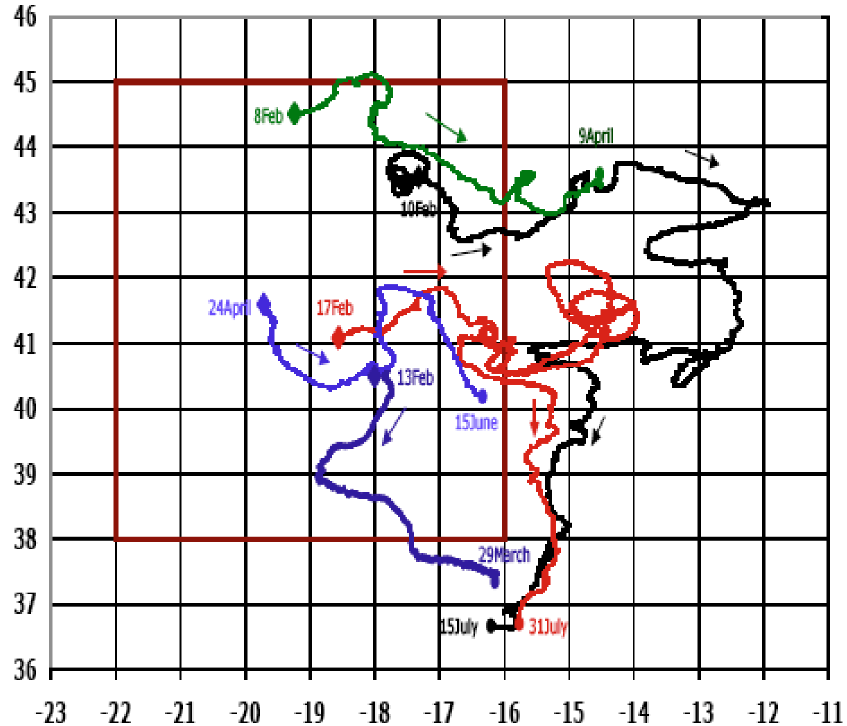
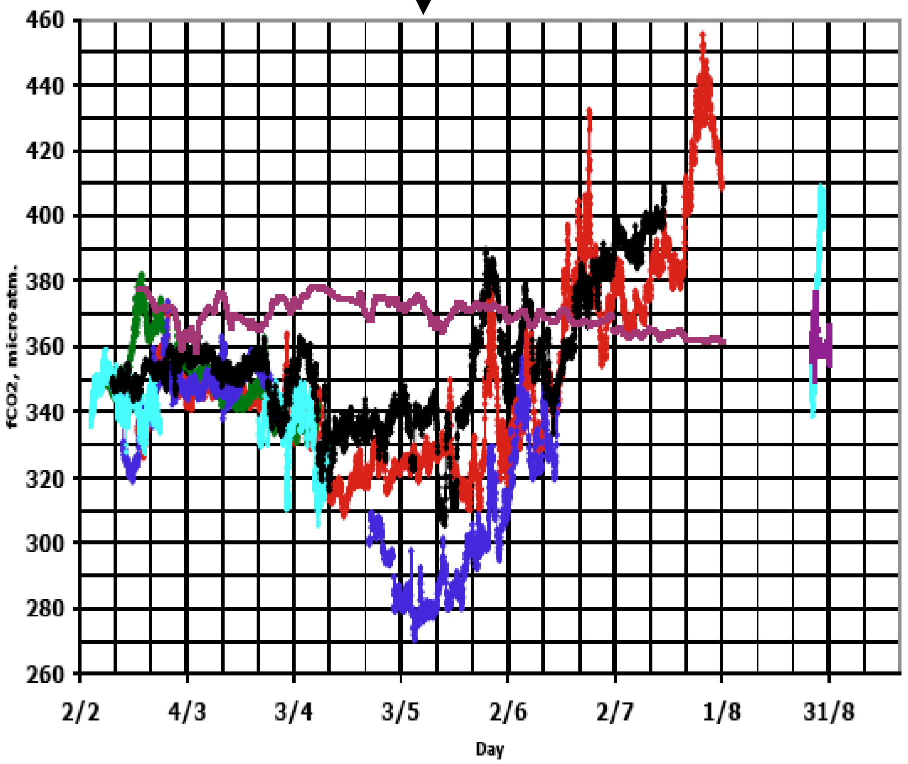
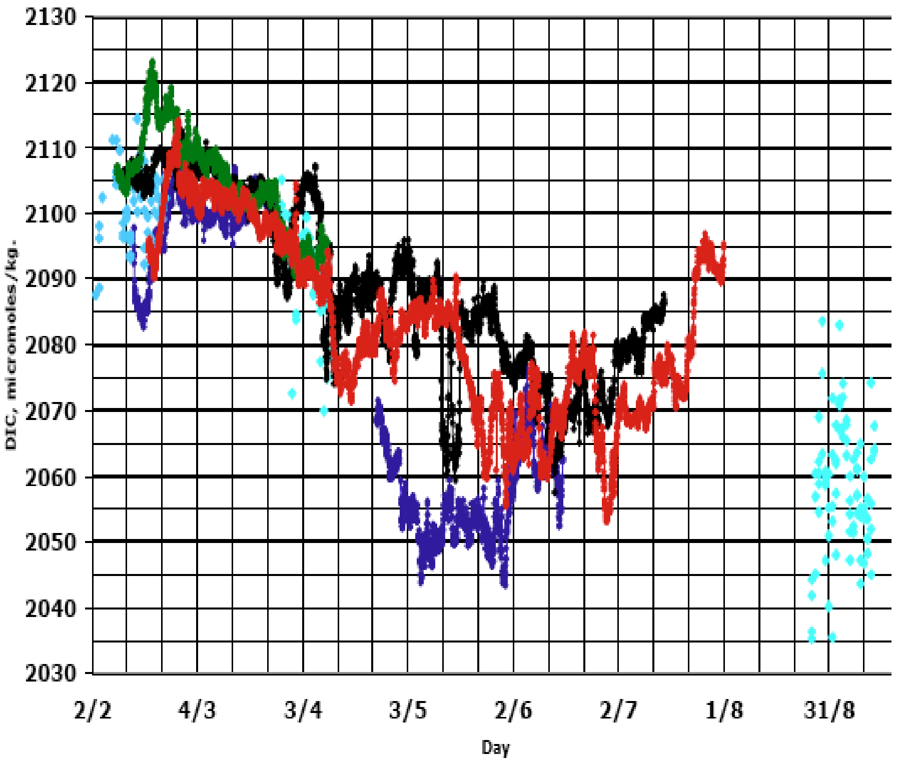


Merlivat et al.,*submitted to JGR, April 2007*,

Variability of fCO_2(µatm) and DIC (µmoles.kg^{-1}) measured by the buoys (green,blue, red, black) and the ship (cyan) during POMME from February to August 2001.

The purple line indicates the atmospheric fCO_2 value





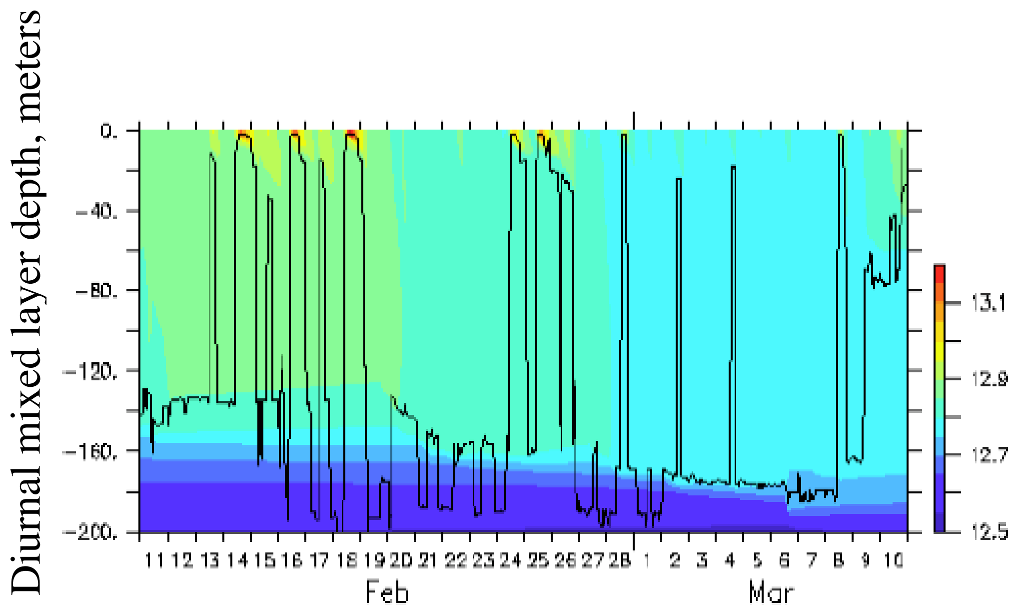
fCO_2

DIC

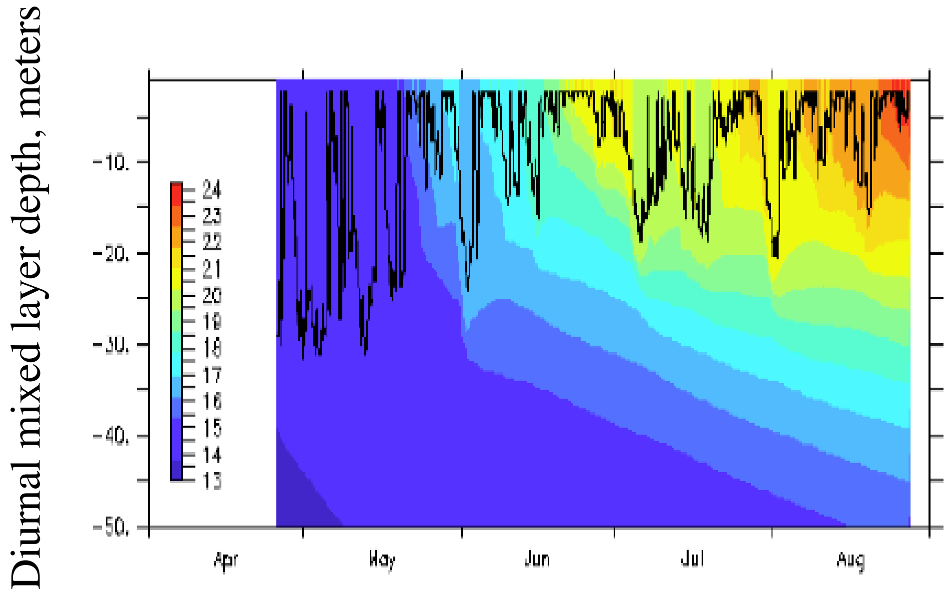
1D modeling of the mixed layer depth along a buoy trajectory forced with hourly surface atmospheric and radiative forcings:

-vertical resolution,1 meter

-time step:15 minutes (G.Caniaux)

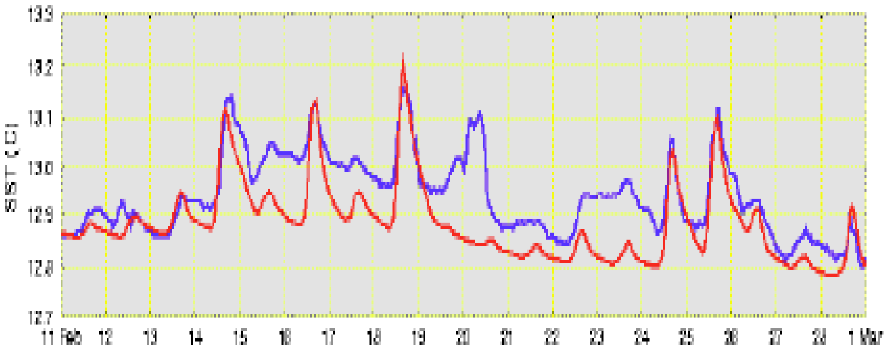


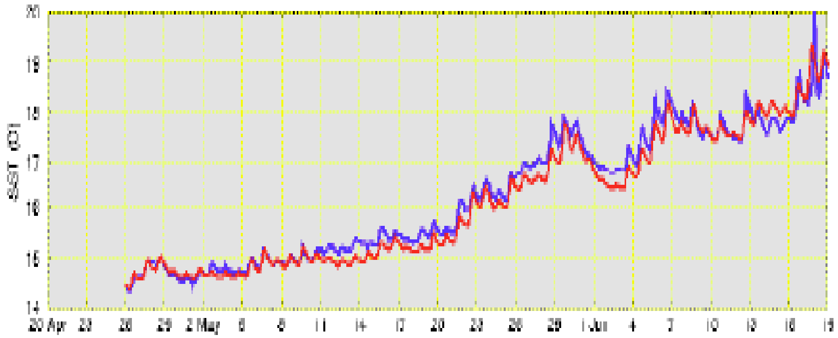
Temperature distribution and diurnal mixed layer variability In February-March (buoy P4) and May-August (buoy P2)



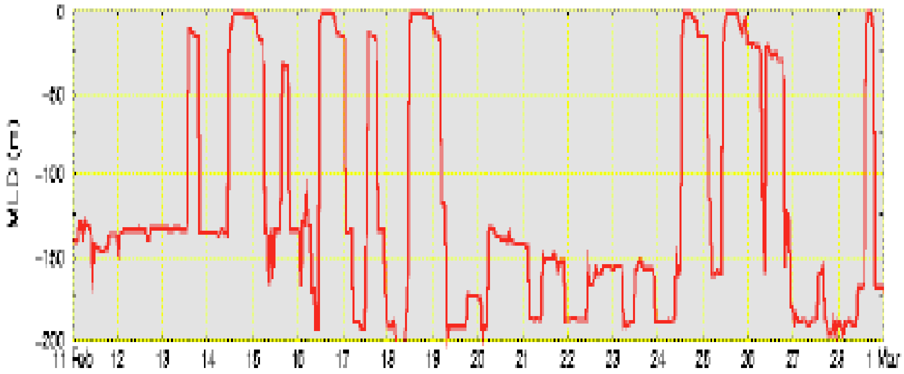
Modeled (red) and measured (blue) SSTalong the buoys trajectories

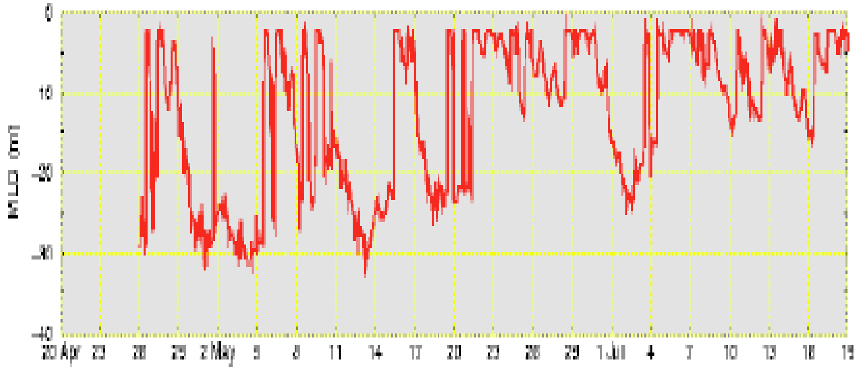
in winter in spring



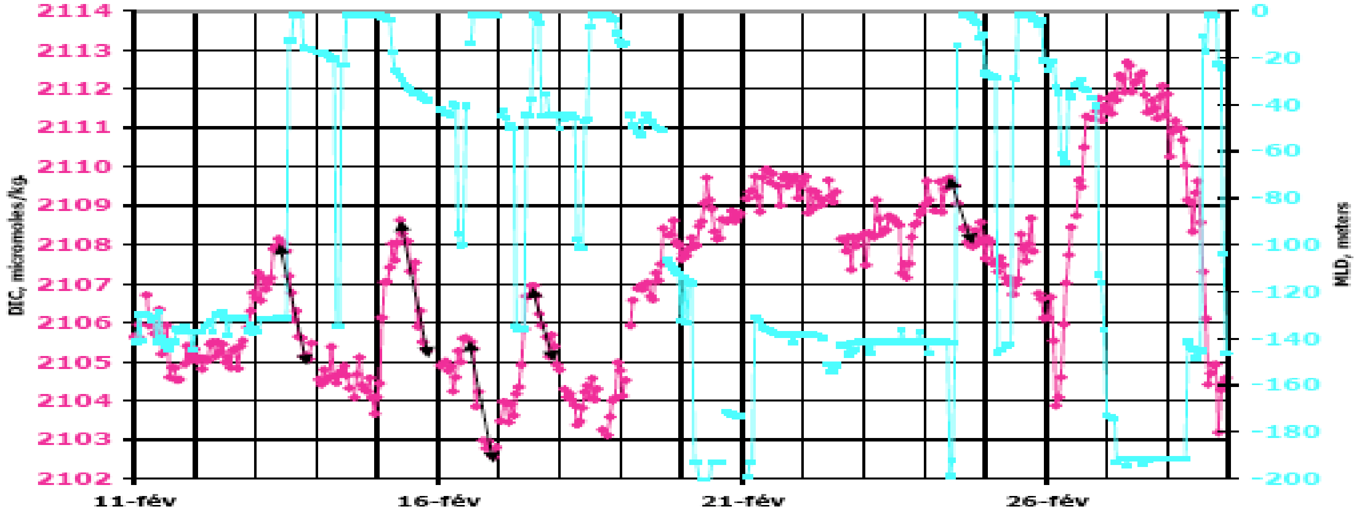


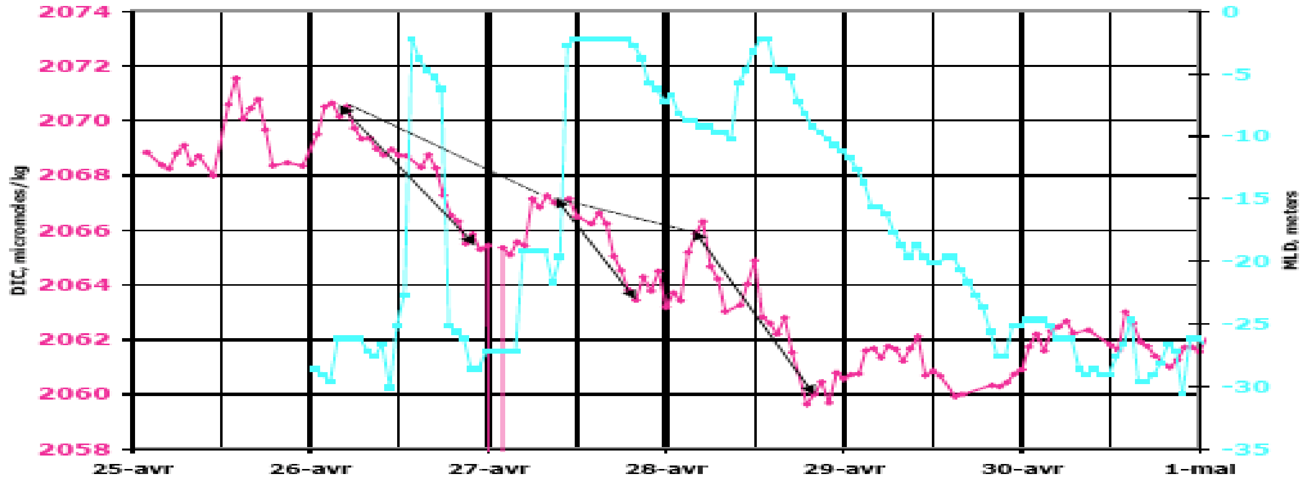
Modeled diurnal mixed layer depth in winter and in spring





DIC variability (µmoles.kg^{-1}) measured by buoys P1 and P2 (pink) and modeled MLD (cyan) in February and April.





In situ direct estimations of GCP and NCP from buoys measurements-1

DIC and SST changes over a 5 days (a) and 2 days period (b) between March 28 to April 2.

A maximum of DIC,C_M ,is observed close to sunrise and a minimum,C_m, close to sunset.

dC/dt,is the change of C_M between 2 consecutive days.

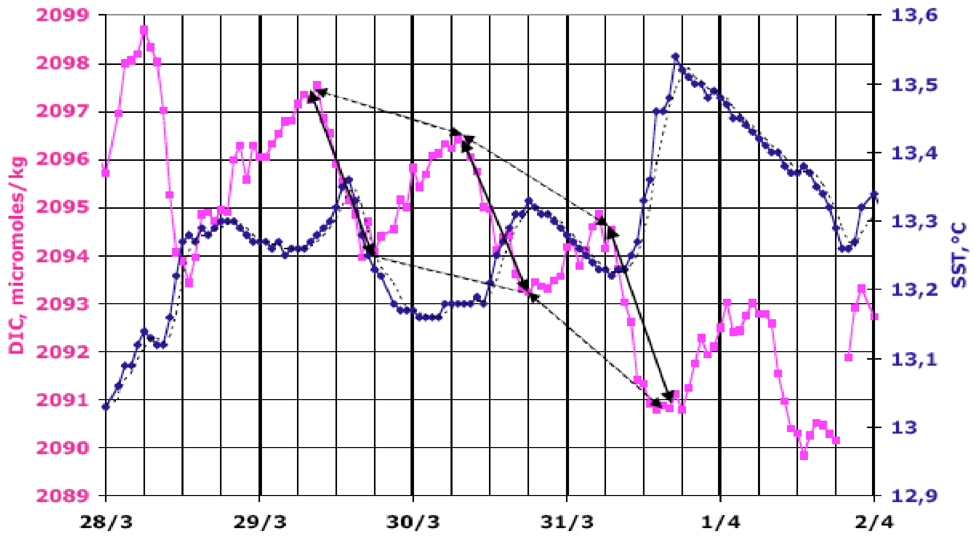
Under a 1D assumption (no lateral exchange and shallowing of the MLD during day time) :

-(C_M-C_m) is a measure of gross community production,**GCP**, respiration ,**R**, and air-sea flux, **F**, during day time.

-dC/dt represents the contribution of the net community production,**NCP** and the air-sea flux at the daily scale

-**F** is known from buoys measurements

a



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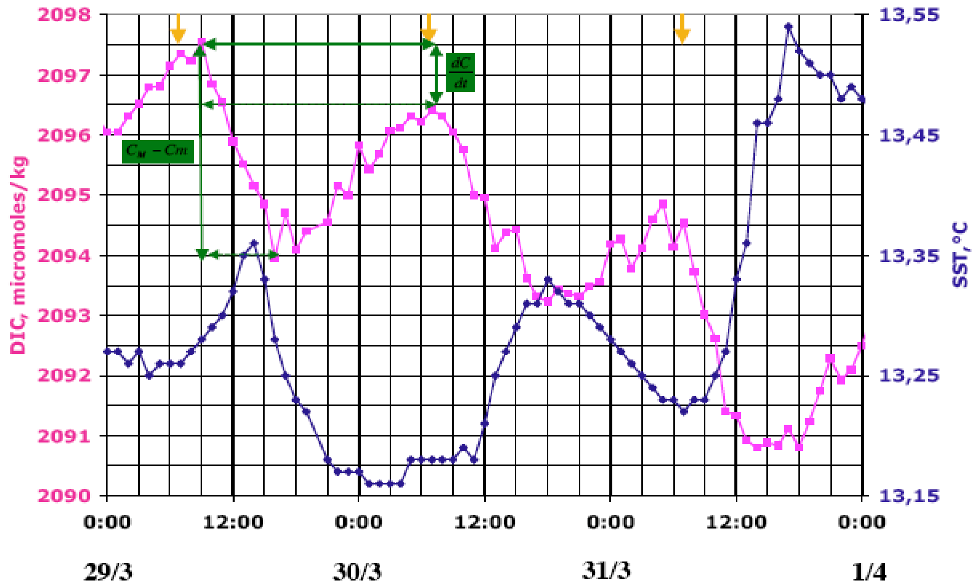


In situ direct estimations of GCP and NCP from buoys measurements--2 : quantitative approach

$$C_M - C_m = GCP - \frac{R}{2} - \frac{1}{\rho}\frac{F}{2h^*}$$

$$\frac{dC}{dt} = GCP - R - \frac{1}{\rho}\frac{F}{h}$$

$$NCP = GCP - R$$

● 2 assumptions:

-photosynthetic processes take place over a 12 hours period.

-the respiration rate is constant over a day.

● h* and h are the thicknesses of the minimum and maximum values of the MLD over a day- h/h*=a

Based on the measured quantities of **(C_M-C_m)**, **dC/dt and F,** we get:

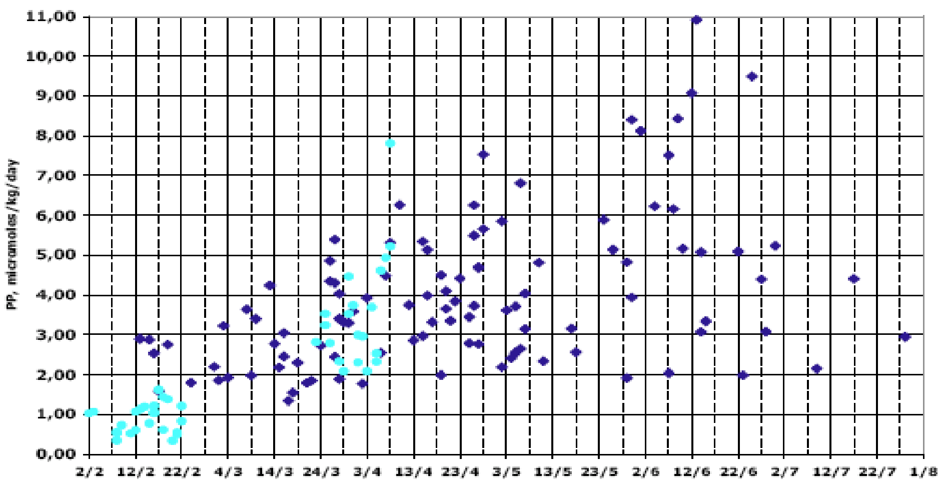
$$GCP = 2(C_M - C_m) - \frac{dC}{dt} + \frac{1}{\rho}\frac{F}{h^*}\left(1 - \frac{1}{a}\right)$$

$$NCP = \frac{dC}{dt} + \frac{1}{\rho}\frac{F}{ah^*}$$

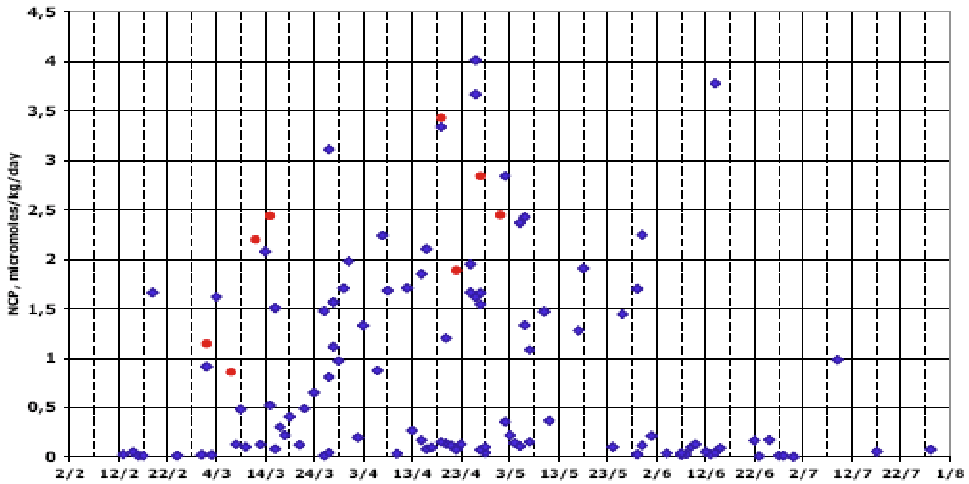
The contribution of the CO_2 air-sea flux (an intake in the case of POMME) is at maximum close to 10%of GCP. So the uncertainty on the values of h and h* , estimated from models or other measurements applies only on this part.

Comparisons with in vitro isotopic incubation measurements, C^{13} and C^{14}, made during POMME

$$PP = GCP - \frac{R}{2}$$



$$NCP = GCP - R$$



Blue,buoys data- Cyan,C^{13} incubation (*Fernandez et al.,2005*)-Red, C^{14} incubation (*Claustre et al.,2005)*

In summary, in situ autonomous instruments are best suited to capture and measure high frequency intermittency in biological production events, not necessarily observed by in vitro techniques which moreover are heavy to implement, costly and time consuming. But, it does not work in all situations .

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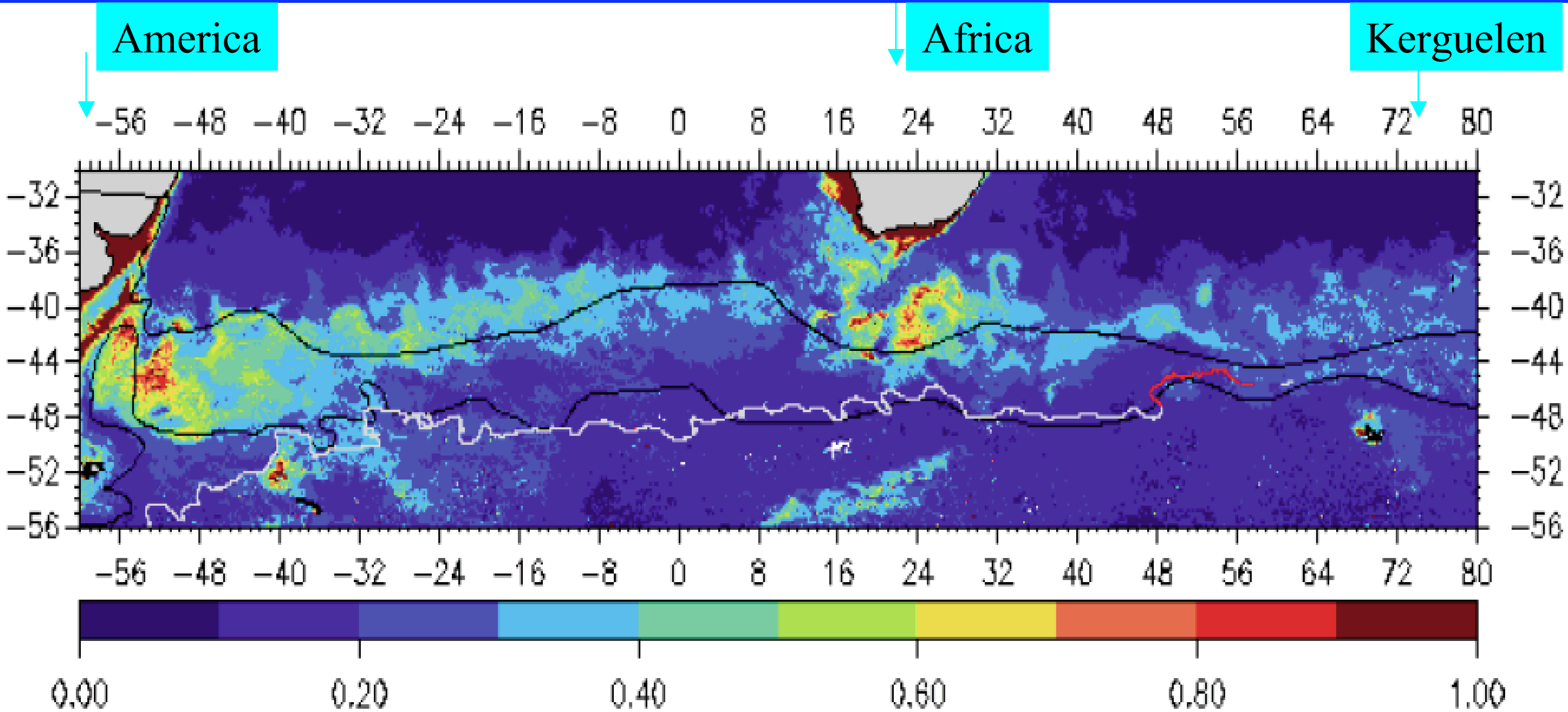
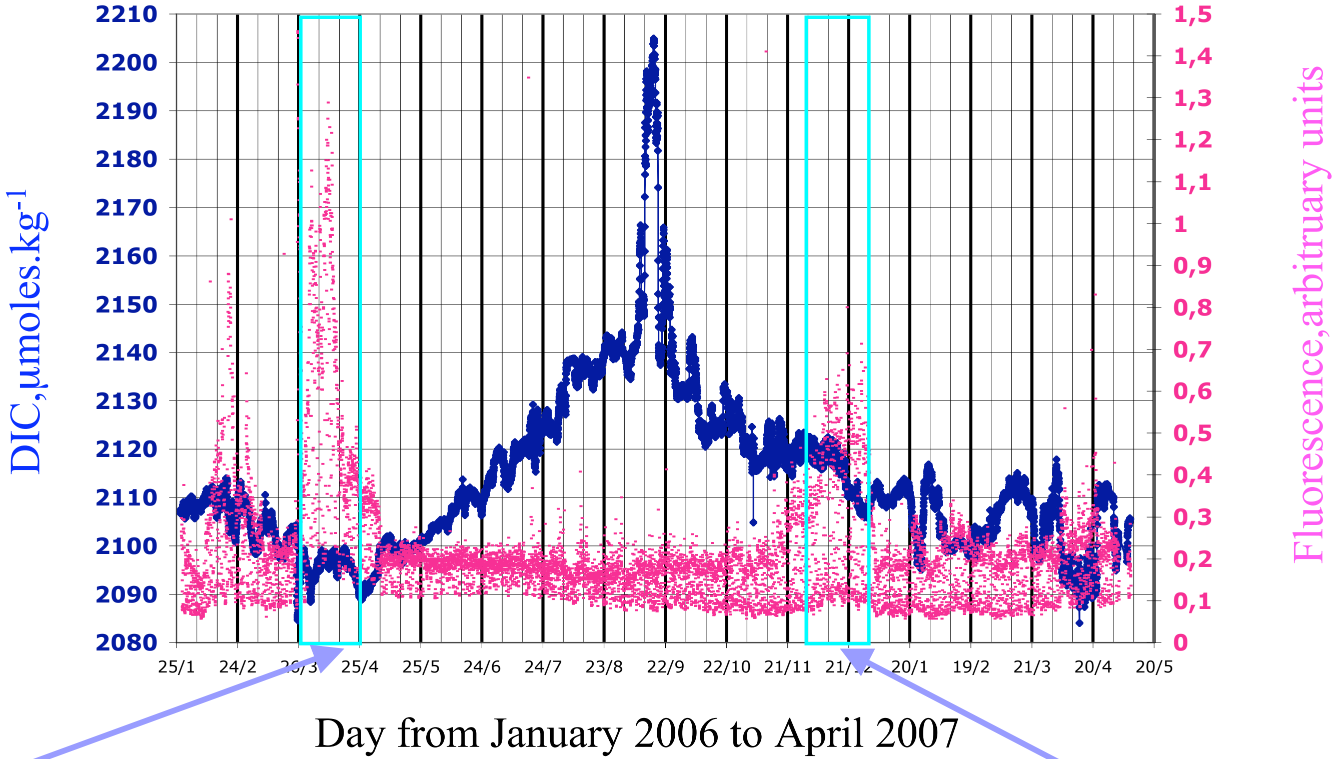
Trajectory of a Carioca buoy since its deployment during the DRAKE campaign in January 2006 in the Southern Atlantic and Indian ocean until April 2007

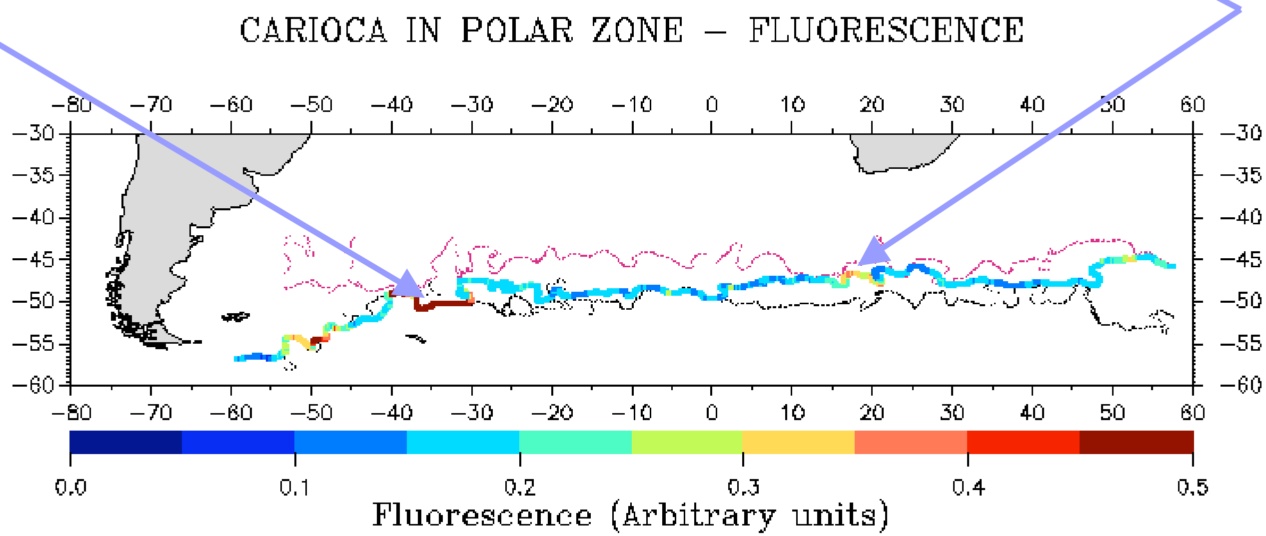


The white line indicates the trajectory followed by the buoy during its 15 months lifetime. The 2 black lines show the climatological Antarctic and Polar fronts (Orsi). *(Boutin and Merlivat, in preparation)*

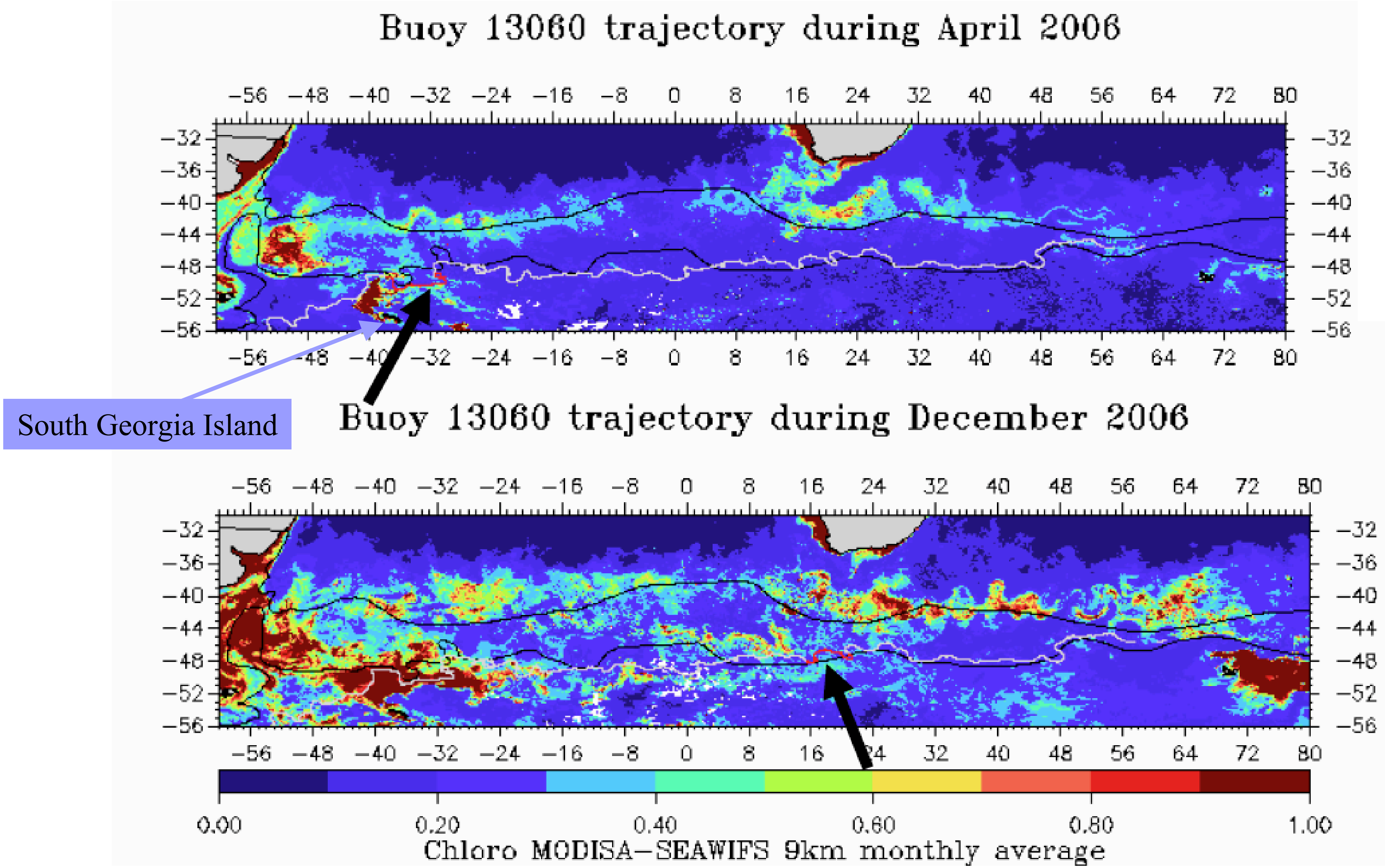
Overall variability of DIC and fluorescence measured by the buoy



High fluorescence signal



Trajectory of the buoy (white and red) superimposed on monthly Modis-Seawifs ocean color in April and December



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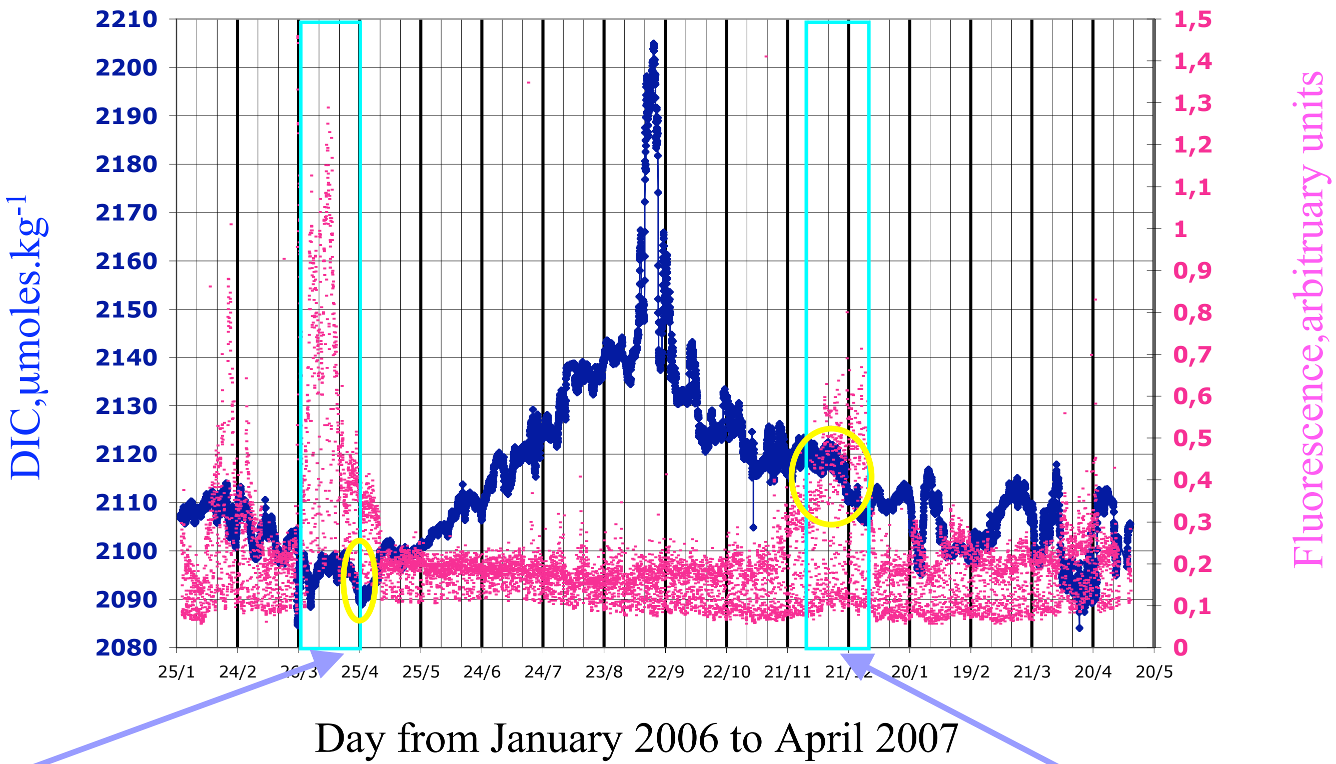

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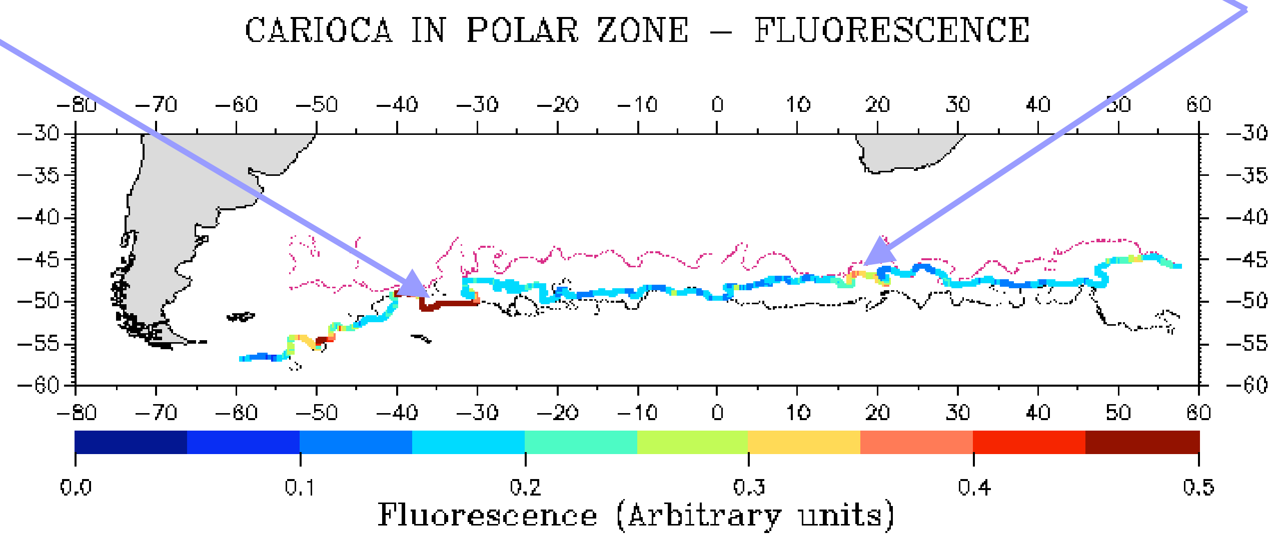
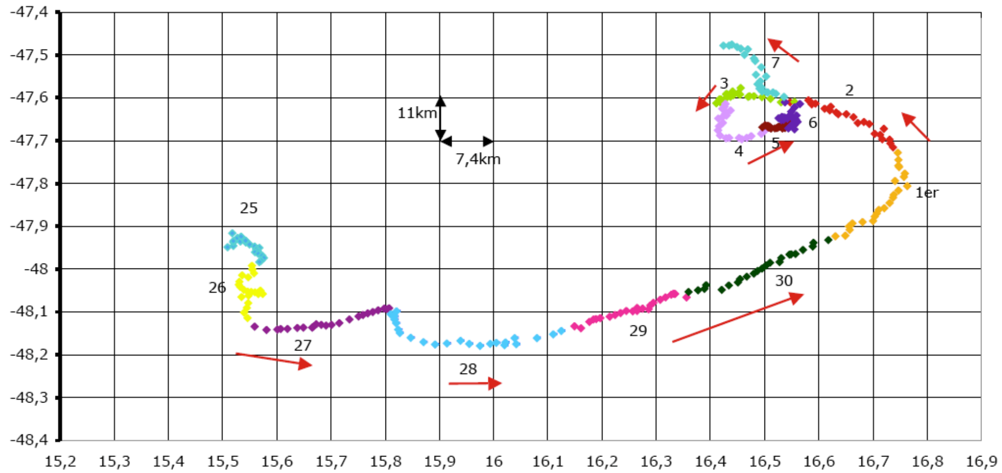
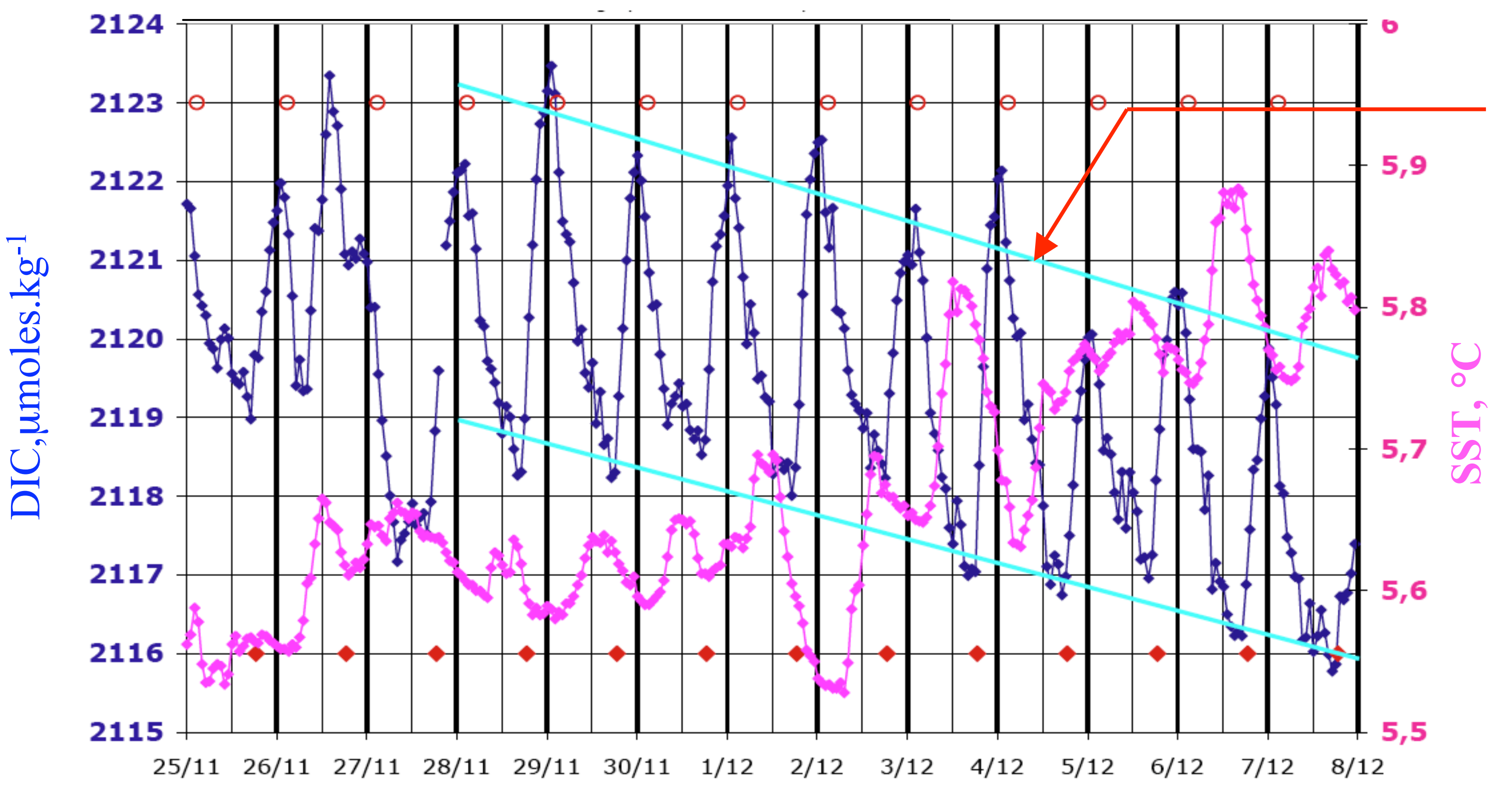


NCP and GCP measured over 10 consecutive days in spring in the Southern ocean.

1D assumption validated by the trajectory of the buoy (analysis of crossover points).





Day, from November 25 to December8, 2006

dC/dt=0.29+/-0.07 µmoles.kg^{-1}.d^{-1}

(C_M-C_m)=4.14+/-0.75 µmoles.kg^{-1}

The contribution of the air-sea flux is negligible

Summary of carbon biological rates computed from the measured diurnal cycle of DIC along the trajectory of the buoy in the Southern ocean in 2006.

	Time period Year 2006	Geographical area (mean)	Number of days	NCP μmoles.kg^{-1}d^{-1}	GCP μmoles.kg^{-1}d^{-1}	*Integrated NCP mmoles.m^{-2}d^{-1}*	*Integrated GCP mmoles.m^{-2}d^{-1}*
West Fall	April 19-24	49.3°S-30.3°E	5	1.10+/-0.19	2.3+/-1.0	*44*	*92*
	November28-December 8	47.8°S-16.4°W	10	0.27+/-0.07	7,9+/-1.5	*27*	*790*
East Spring	December 11-19	46.8°S-18°0W	8	0.34+/-0.24	7.1+/-2.0	*34*	*710*
	December 20-25	47.3°S-20.3°W	5	0.30+/-0.12	2,6+/-2,0	*30*	*260*
	December 26-30	47.7°S-21.2°W	4	0.22+/-0.17	2.3+/-2 .2	*22*	*230*

The values of the mixed layer depth necessary to compute the values of integrated NCP and GCP have been estimated from the temperature -salinity profiles measured by Argo floats colocated within +/- 10 days and +/- 100 km of the position of the buoys.

Comments on the Southern Ocean results

- 1-Contrasting situations between the east and the west:

-NCP , a quantity which informs on the export flux of carbon, is larger in the wake of South Georgia Island in the spring , 1.10+/-0.19 µmoles.kg^{-1}.d^{-1}, compare to measurements in the west during the fall, 0.27+/-0.05 µmoles.kg^{-1}.d^{-1} .

- The difference is smaller for integrated quantities .The respective numbers are 44mmoles.m^{-2}.d^{-1} and 27 mmoles.m^{-2}.d^{-1} as the MLD is deeper in spring.

- 2-In December, over consecutive periods of 5 to 10 days, large variations of GCP are observed from 2.5 to 7.5 µmoles.kg^{-1}.d^{-1} while no significant changes of NCP are observed.

NCP/GCP ≈0.5 in the west , NCP/GCP ≈0.1 in the east.

Difference of biological regimes? Autotrophy versus heterotrophy?

Conclusion and summary

- Automatic instruments are adapted tools to catch the high natural variability of biological processes at the ocean surface at the diel time scale.

- Combined measurements of unattended platforms as Carioca buoys and neighbour Argo floats form an in situ non intrusive method to estimate the biological drawdown flux of carbon from the surface towards the interior of the ocean. It works in difficult remote areas as the Southern Ocean.

- **Next step:**

-enlarge the field of observations in other oceanic areas.

-continue and develop the interactions with modelers.