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Estimation of Air-Sea CO_2 Flux at the Southwestern Atlantic Ocean using a circulation and biogeochemical model

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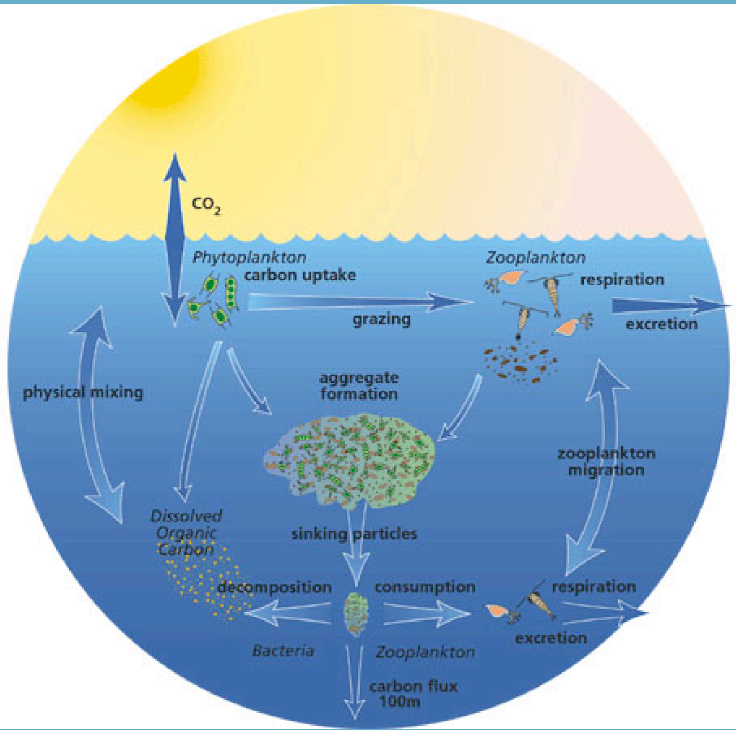
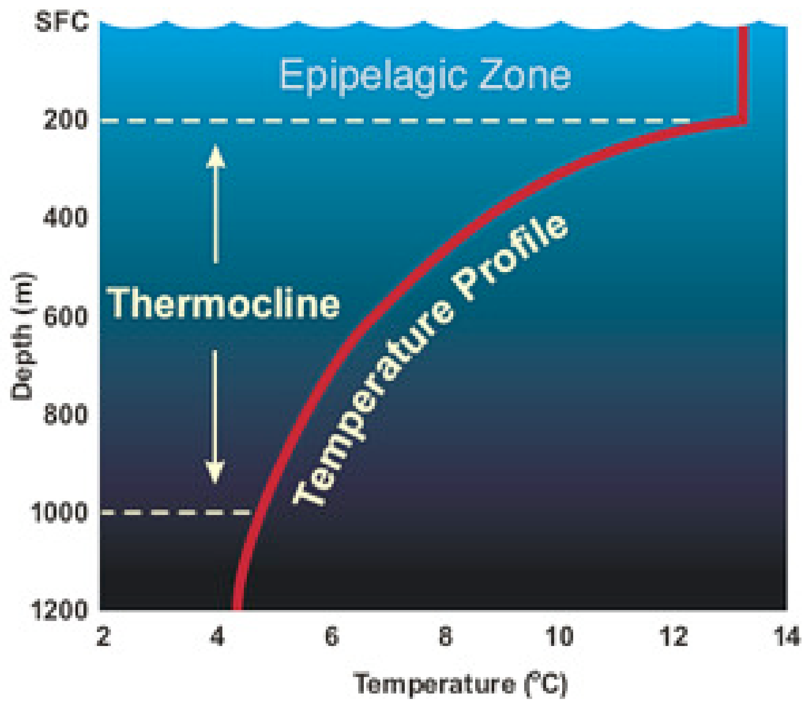
Luciano P. Pezzi

Introduction



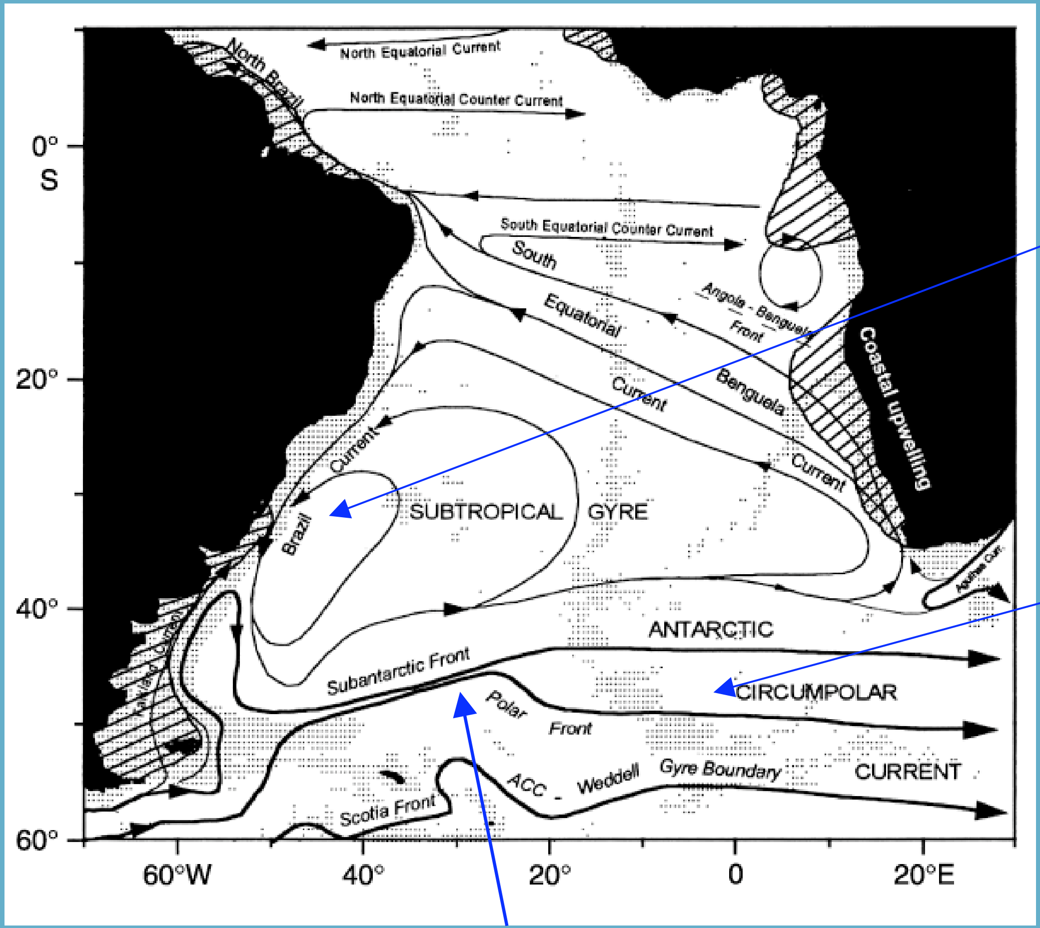
Source:http://www.learner.org/courses/envsci/visual/visual.php?shortname=biological_pump



Source: http://www.eoearth.org/article/Layers_of_the_ocean

- **Biological pump**
  - Atlantic Ocean: 23% of the total oceanic area, 41% of the annual ocean flux (-1.42 PgC/year);

Area of study



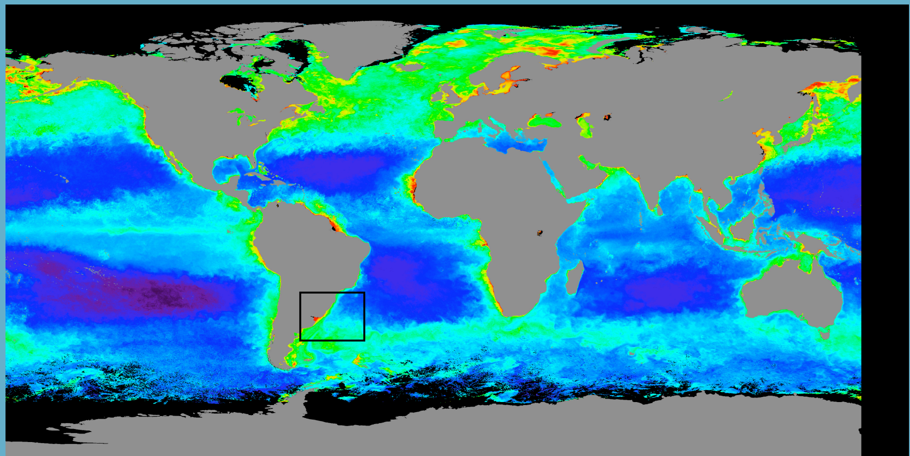
BMC

PF: sinking of ACC under subantarctic waters = AIW, moving north ~ 20-25°S

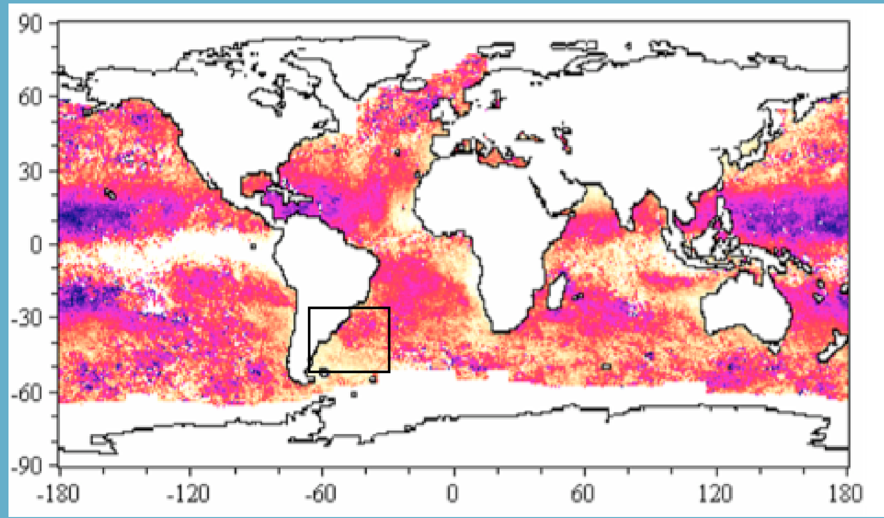
Subantarctic Front (SACW)

Source: Peterson & Stramma, 1991.

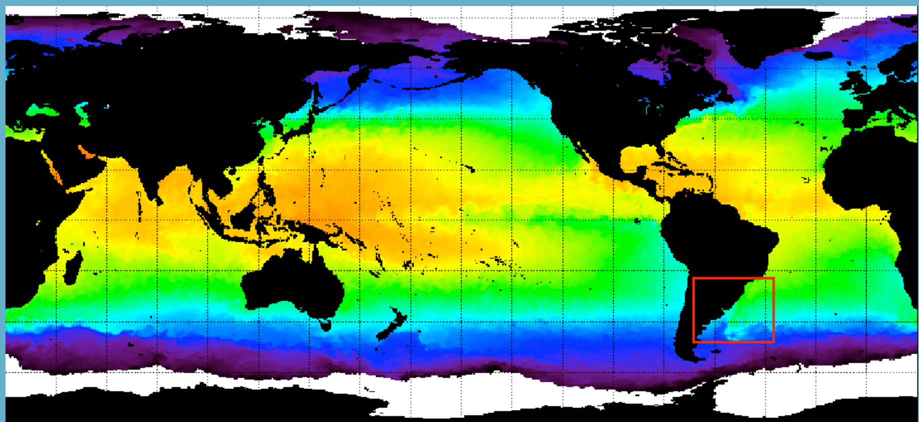
Very energetic area:



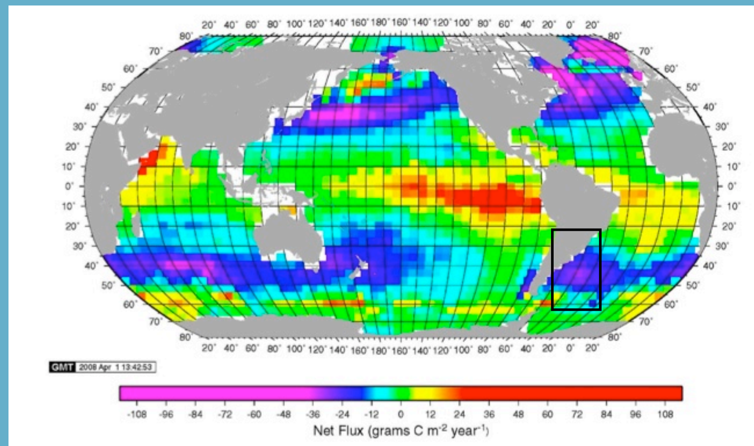
Global chlorophyll.
Source: earthobservatory.nasa.gov



White caps.
Source: Anguelova & Webster, 2006.

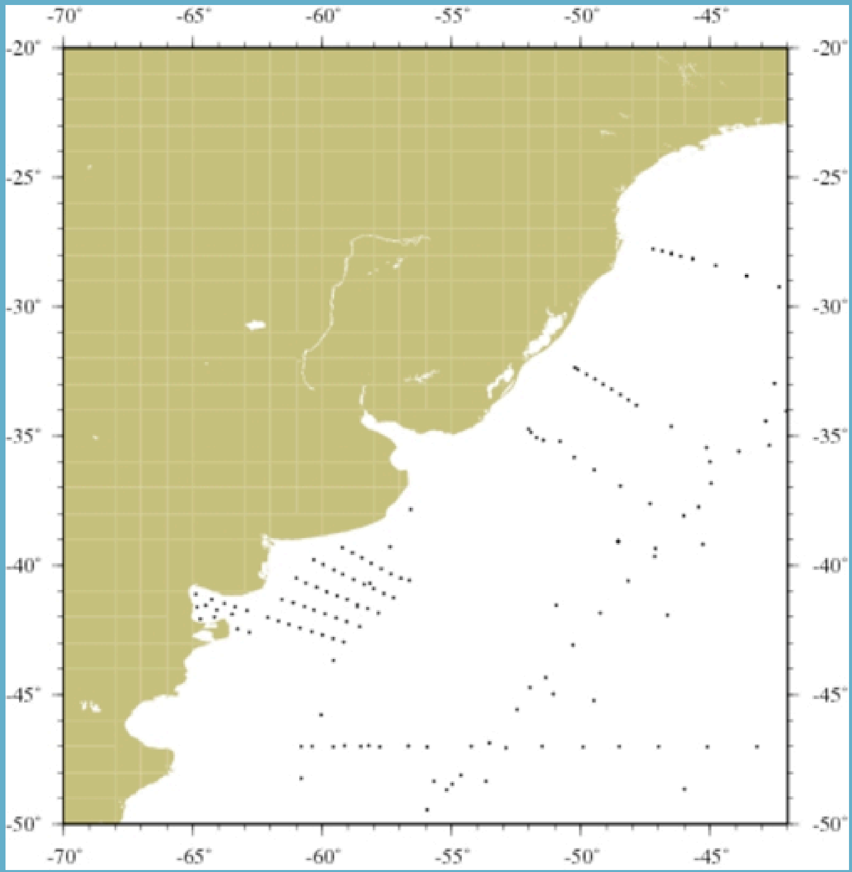


2007 SST. Source: www.ospo.noaa.gov

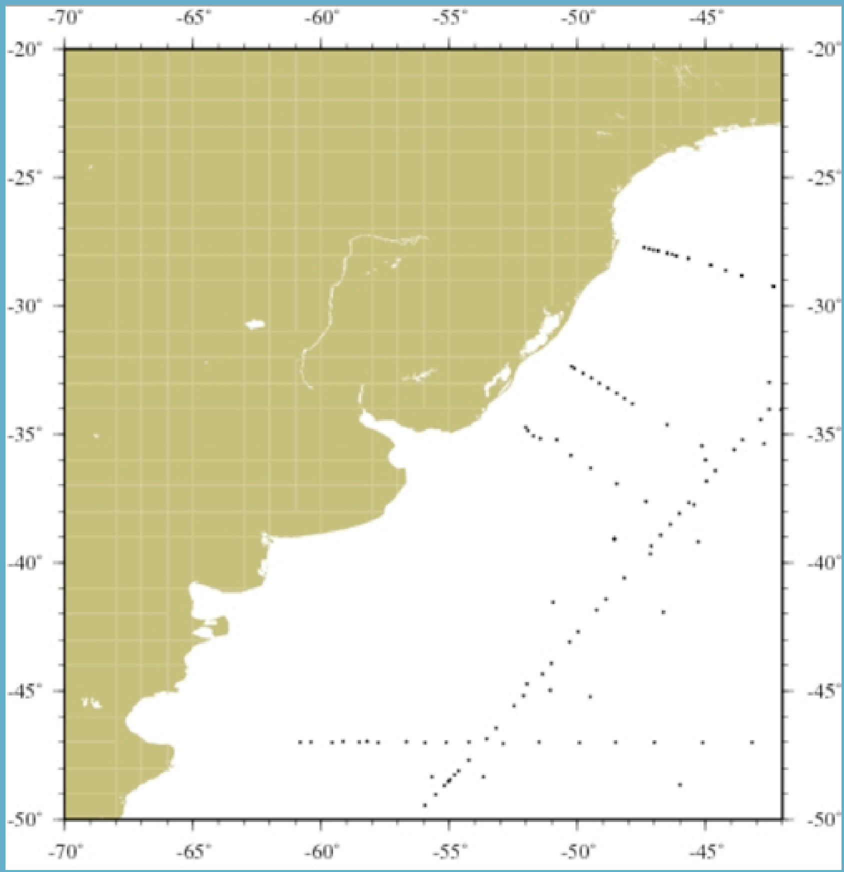


Climatological nnual CO_2 flux.
Source: Takahashi *et al*, 2009.

Problems, problems!



Total alkalinity stations, WOD09.



DIC stations, WOD09.

Regional Ocean Modeling System (ROMS)

- **Primitive equations;**
- **Hidrostatic and Boussinesq approximations;**
- **Free surface;**
- **Arakawa-C grid.**

Time evolution of tracers:

$$\frac{\partial C}{\partial t} + \vec{v}\cdot\nabla C = -\frac{\partial}{\partial z}\left(\overline{C'w'} - \nu_\theta \frac{\partial C}{\partial z}\right) + \mathcal{F}_C + \mathcal{D}_C.$$

Vertical momentum:

$$\frac{\partial \phi}{\partial z} = \frac{-\rho g}{\rho_o}$$

Horizontal momentum balance:

$$\frac{\partial u}{\partial t} + \vec{v}\cdot\nabla u - fv = -\frac{\partial \phi}{\partial x} - \frac{\partial}{\partial z}\left(\overline{u'w'} - \nu \frac{\partial u}{\partial z}\right) + \mathcal{F}_u + \mathcal{D}_u$$

$$\frac{\partial v}{\partial t} + \vec{v}\cdot\nabla v + fu = -\frac{\partial \phi}{\partial y} - \frac{\partial}{\partial z}\left(\overline{v'w'} - \nu \frac{\partial v}{\partial z}\right) + \mathcal{F}_v + \mathcal{D}_v$$

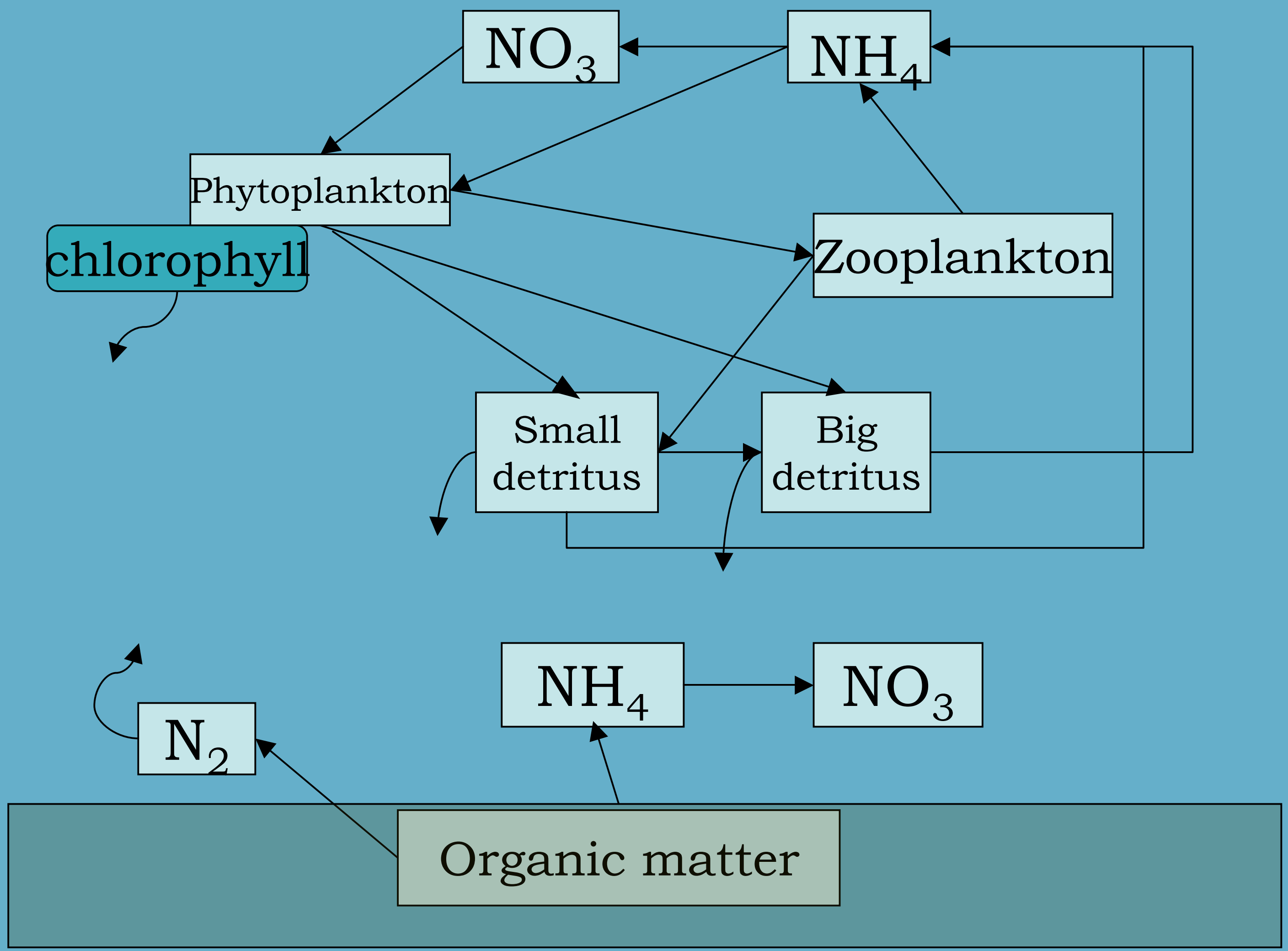
Horizontal diffusion

Sources/forcings

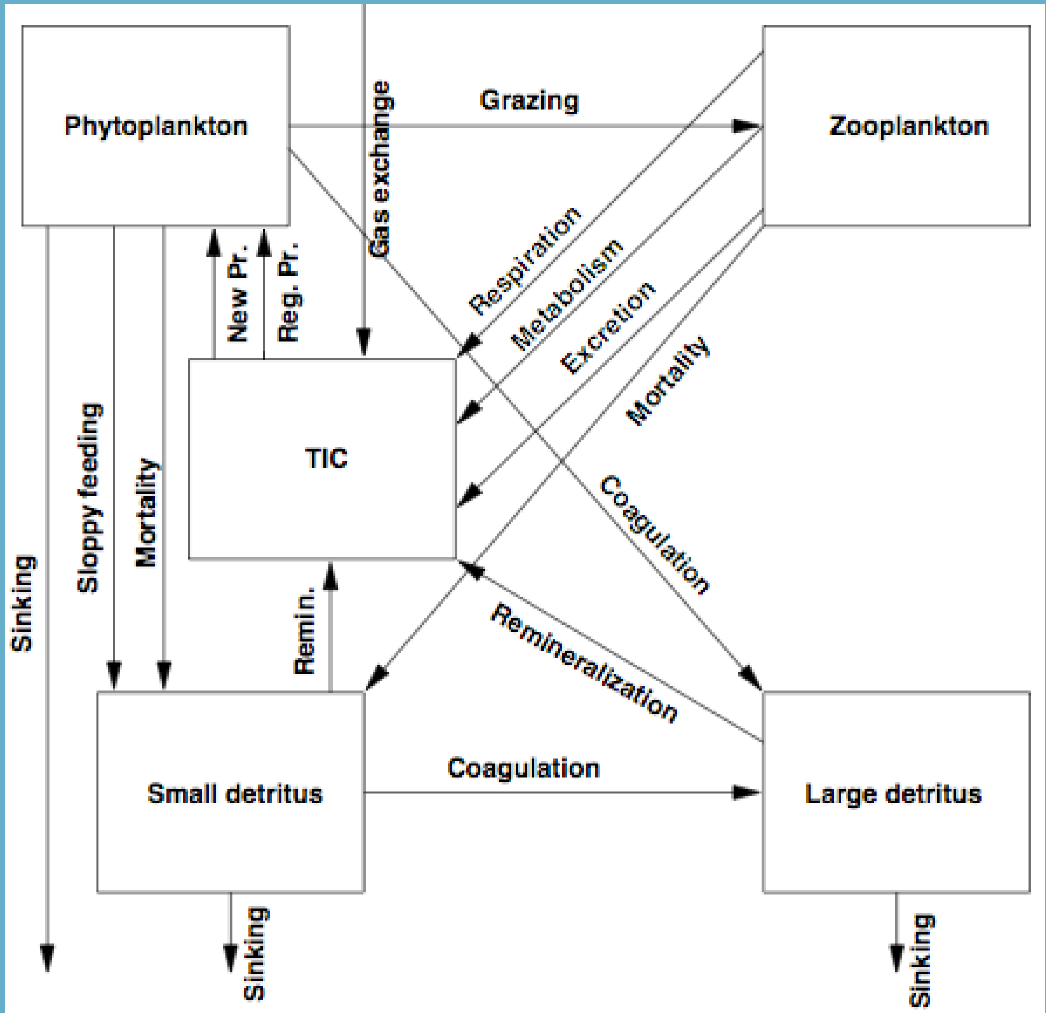
Continuity equation:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0.$$

Regional Ocean Modeling System (ROMS)



Regional Ocean Modeling System (ROMS)



- pCO2_water_RZ.h:
  - Ionic product ($k_w = [H^+][OH^-]$)
  - Determines p_{CO2}:

$$K_1 = [H^+].[HCO_3^-]/[H_2CO_3]$$

$$K_2 = [H^+].[CO_3^{-2}]/[HCO_3^-]$$

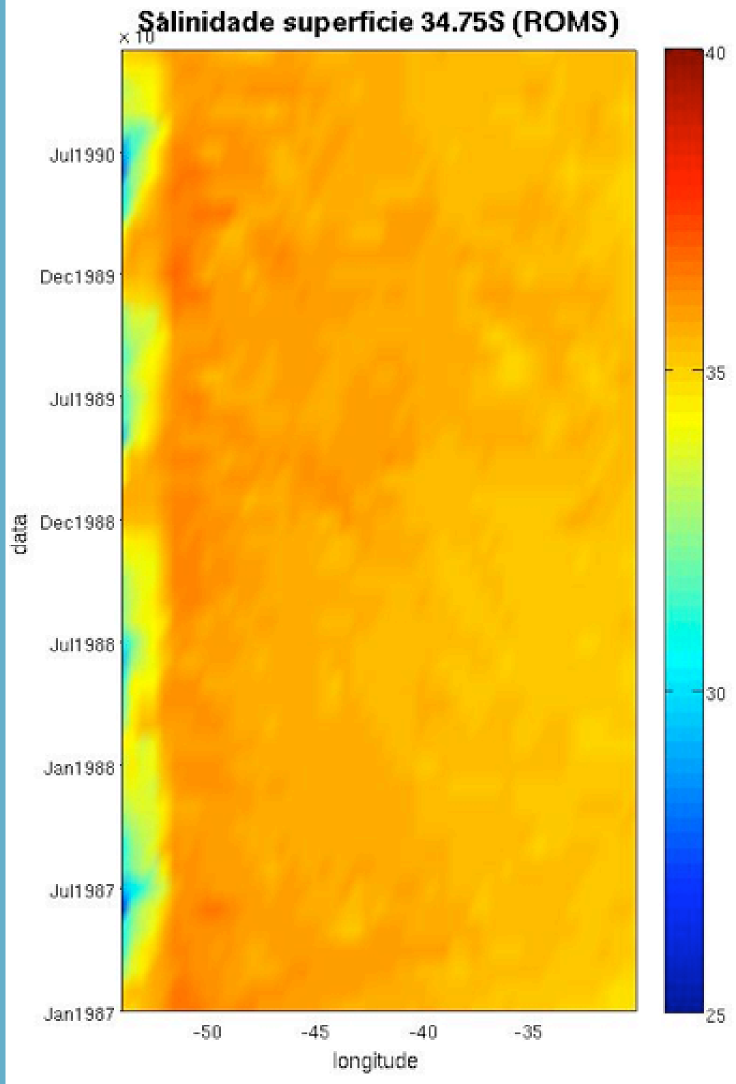
$$CO_2^* = CID.[H^+]^2 / ([H^+]^2+K_1.[H^+]+K_1.K_2]$$

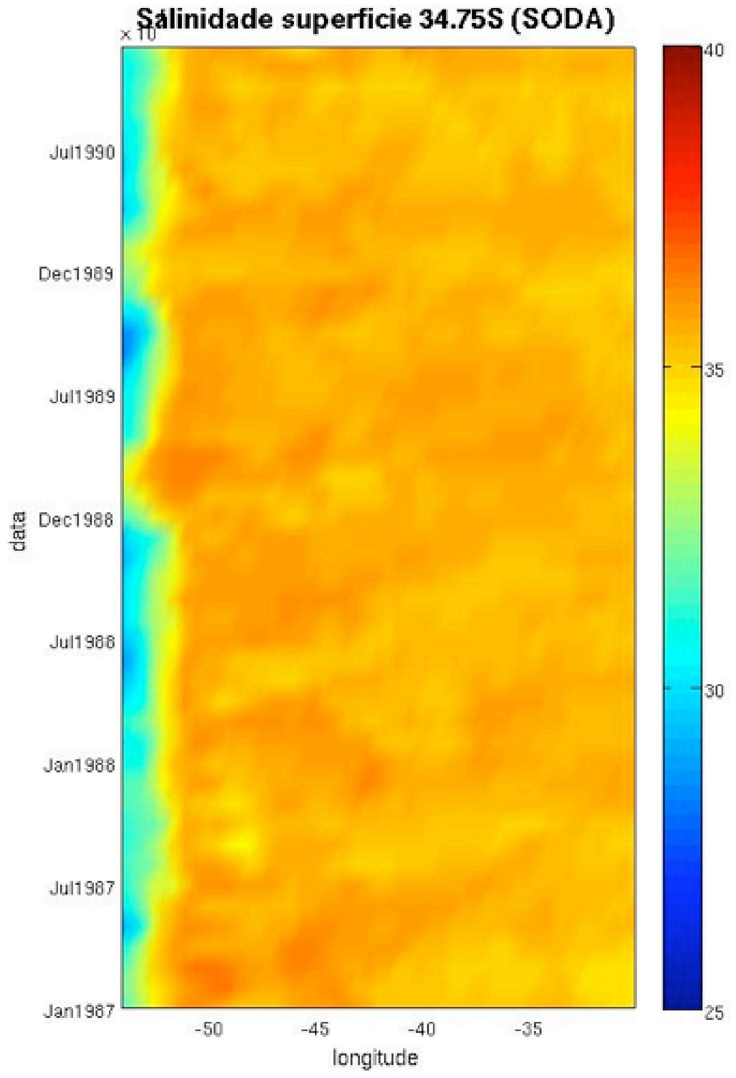
$$p_{CO2} = CO_2^*.1000000 / ff$$

ff(T,S) = "non-ideality" cte

$$K = 0{,}31.u^2(Sc/660)^2$$

Results





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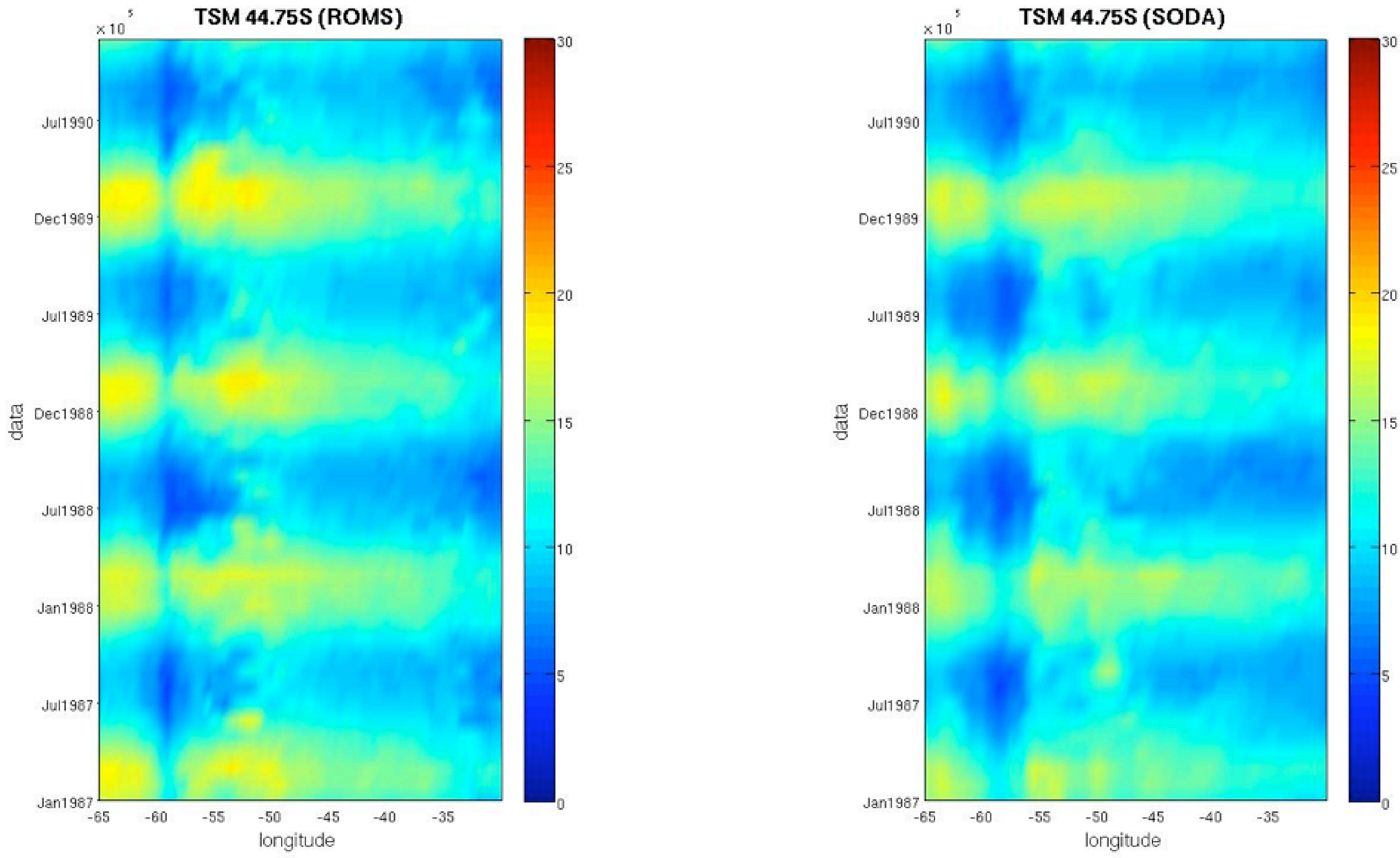
Results



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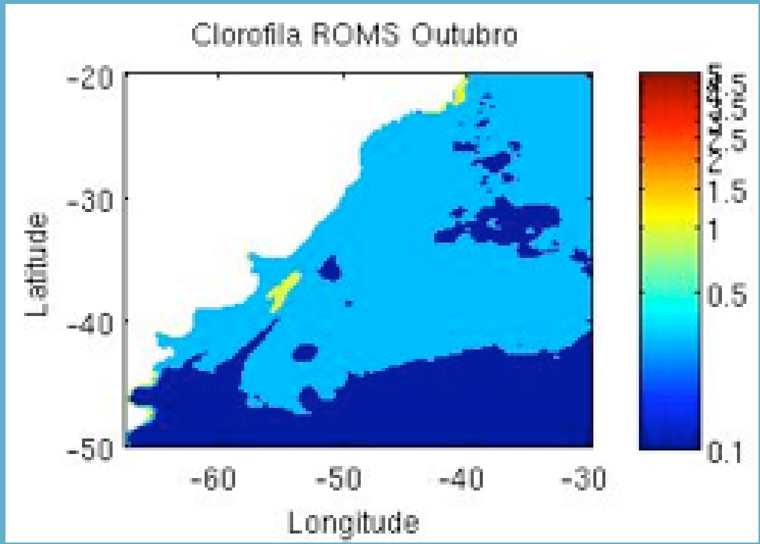
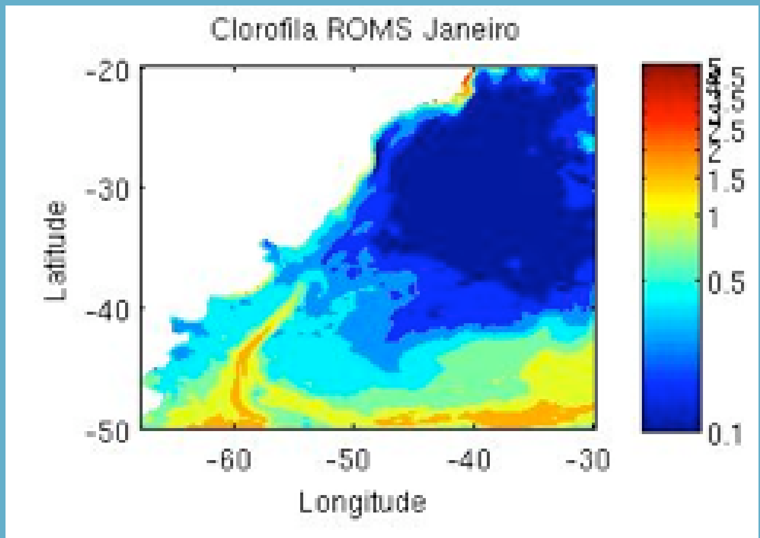
Results - Chlorophyll





- Higher chlorophyll during summer:
  - Delay in the spring bloom?
  - Ovesestimates light effect?
- Chlorophyll higher at the CS than open ocean
- La Plata influence
- Errors in spring:
  - Chlorophyll ~0 at the CS south os 45ºS in Sept-Oct;
  - Chlorophyll ~0.5 mg/m^3 on the northern part of the grid;
- Maximums at the CS south of the La Plata during November.

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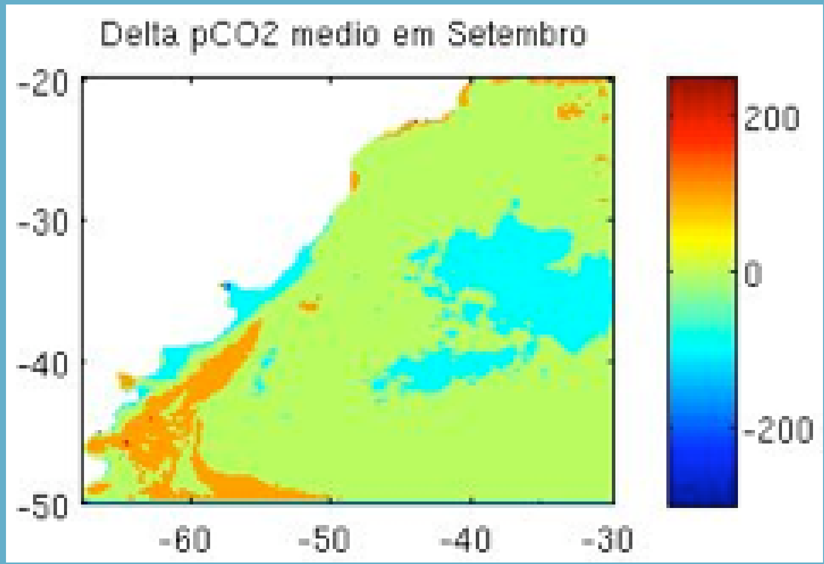
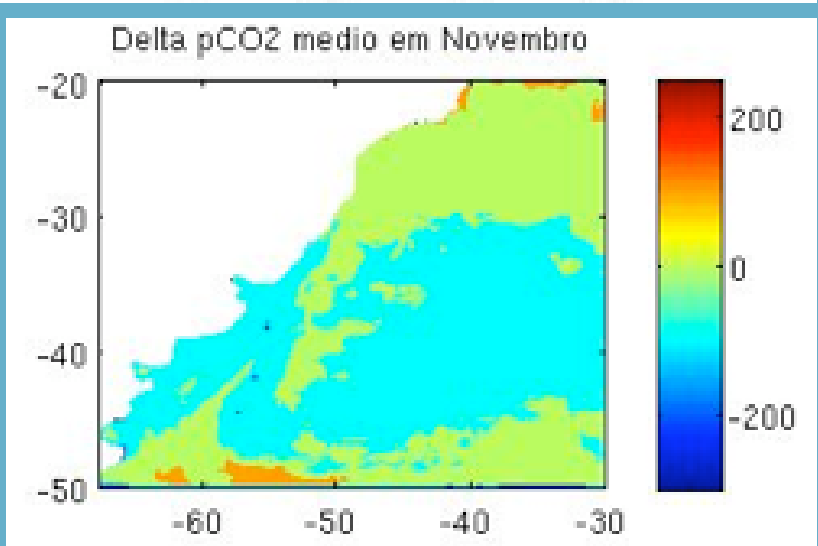
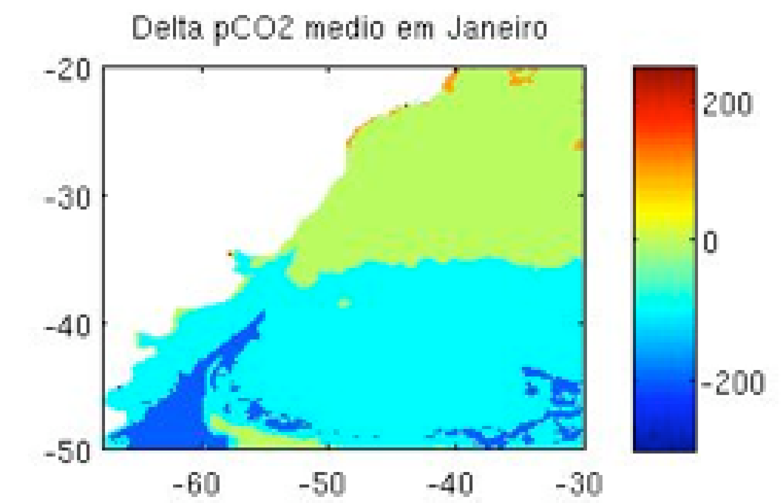
Results - Spring

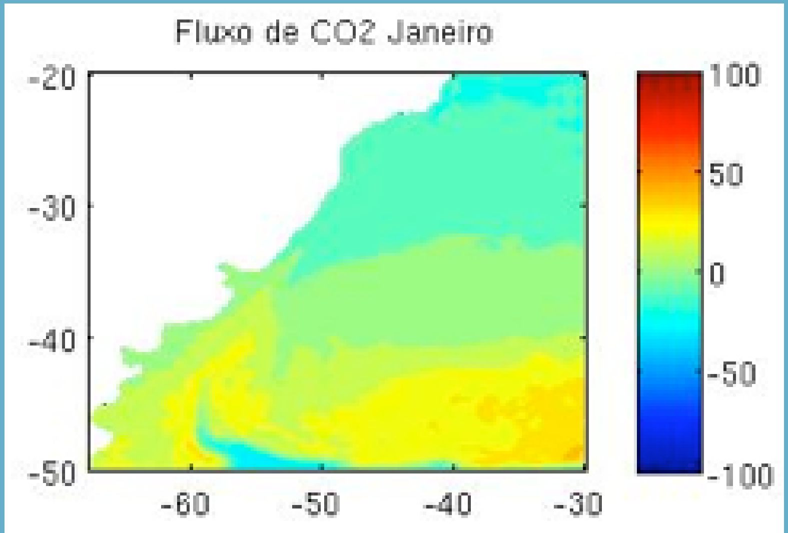




- Bianchi *et al* (2009):
  - 60% os the Patagonian CS has negative Δ_{pCO2};
  - Strong link with chlorophyll;
- Representation of the spring bloom was one of the errors discussed;
  - Impact on the C flux;
  - Where [chlorophyll]>1 mg/m3, Δ_{pCO2} ~ -60 μatm;
- North of 30ºS
  - Δ_{pCO2} ~ zero, in spite of the higher chlorophyll simulated.

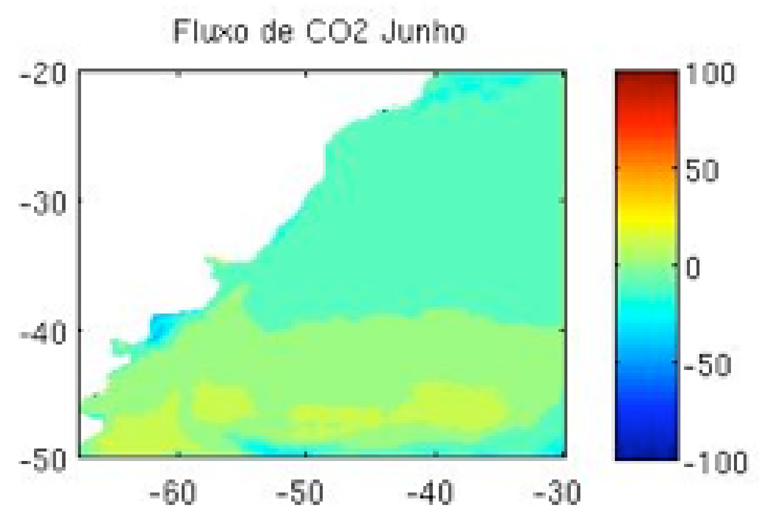
Results - Summer

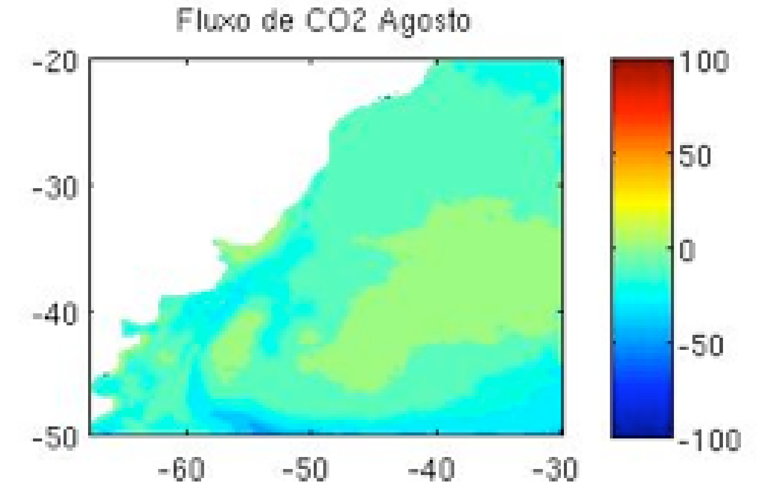




- Negative Δ_{pCO2} in almost all the grid through Dec/Jan:
  - Dec: ~ -200 µatm;
  - Jan: ~ -100 µatm;
  - ~0 north part;
- Area with positive Δ_{pCO2} close to the coast between 39-43ºS not found;
- Fluxes related to latitude
- No significant correlation with chlorophyll.

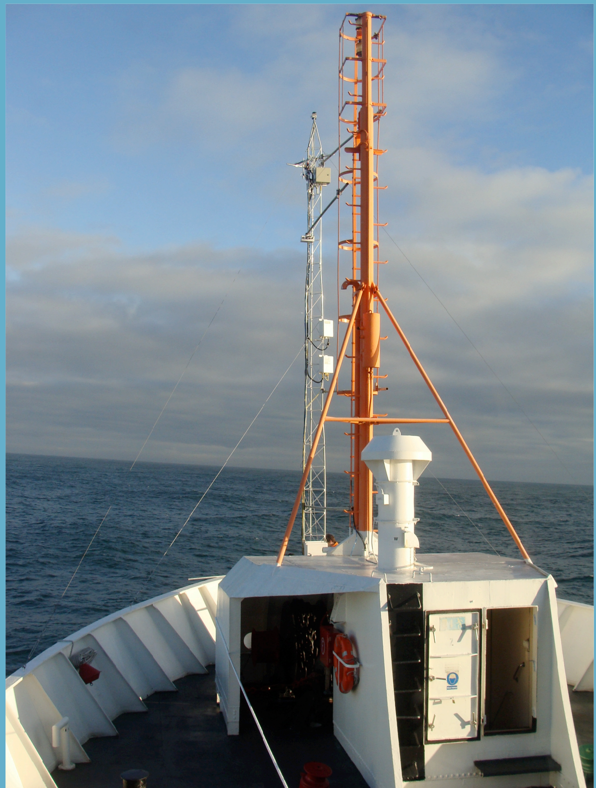
Results - Winter





- Alternates between slightly positive and negative Δ_{pCO2} at the Patagonian CS:
  - Negative: -200 µatm, migrates north;
- 34-49ºS: CO_2 sink in June, becomes a source at the end of the station;
- Measures of Bianchi *et al* (2009) done at the end of winter.

Projects



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Thank you very much!