Bio-optical floats:

- Towards delayed mode for Chla and CDOM;
- Understanding the phytoplankton dynamics in sub-tropical regimes.
- High resolution measurements of bio-optical properties in the sub-equatorial Pacific

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#1 Towards delayed mode for Chla and CDOM; Context and Challenges

- Fluorometers (e.g. Chla and CDOM) => proxies of bio-geochemical or bio-optical quantities (concentration in Chla, CDOM absorption) => calibration required.
- Floats are lost => how "durably accurate" can be an initial calibration (either factory, either in situ) over a 2-3 years lifetime?
- Float network => different calibrations => dataset consistency => big issue if we want to build large database from which (climatic) trends can be extracted over the long term (like the Argo program).

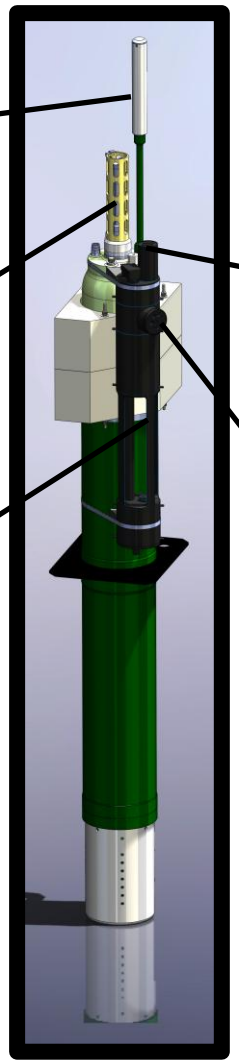
- ***Develop a method to "calibrate" fluorescence (Chla, CDOM) proxies in term of their biogeochemical counterparts over the float life-time***
- ***Evaluate the method through a comparison of multi-float***

Xing, X., Morel, A., Claustre, H., Antoine, D., D'Ortenzio, F., Poteau, A., Mignot, A. (2011). Combined processing and mutual interpretation of radiometry and fluorimetry from autonomous profiling Bio-Argo Floats. The retrieval of Chlorophyll a, *Journal of Geophysical Research*, 116, C06020, doi:10.1029/2010JC006899.

Xing, X., Morel, A., Claustre, H., D'Ortenzio, F., and A. Poteau (2012). Combined processing and mutual interpretation of radiometry and fluorimetry from autonomous profiling Bio-Argo Floats. II The retrieval of CDOM absorption, *Journal of Geophysical Research*, in press

The “Bio-Argo” floats

BASIS: NKE CTS3 « Argo » float

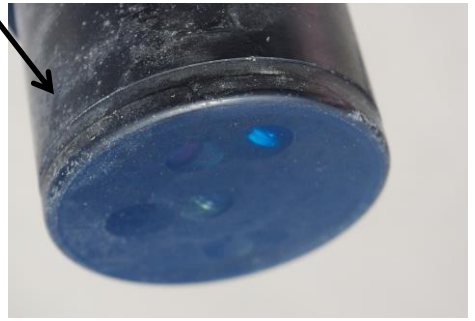


Iridium antena

Seabird CTD

Wetlabs transmissiometer

Satlantic radiometer
Ed(412), Ed(490), Ed(555)



Wetlabs puck
Fluo Chla
Fluo CDOM
b_b

See poster by Leymarie

Eight floats deployed in 2008-2010

- 2 in the Mediterranean Sea: Western and Eastern basins
- 2 in the North Atlantic sub-polar gyre: Irminger Sea, Icelandic basin
- 2 in the North Pacific Gyre (HOTS)
- 2 in the South Pacific Gyre (Eastern Island)

Representative of the range in trophic conditions for the open ocean :

ultra-oligotrophic (0.02 mg Chla m^{-3}) to bloom (~ 4 mg Chla m^{-3})

General principle of the method

- The diffuse attenuation coefficient is derived from the downwelling irradiance:

  $K_d(\lambda,z) = d[\ln E_d(\lambda,z)]/dz$

- Kd is relatively insensitive to fouling/drift (because a ratio).
- Kd at 490 is essentially influenced by Chla concentration, [Chla]

  $K_d(490) = 0.0166 + 0.0825\,[Chla]^{0.6259}$

  (*Morel et al.* 2007)

- Kd at 412 is influenced by CDOM absorption, $a_y(412)$ and by [Chla]

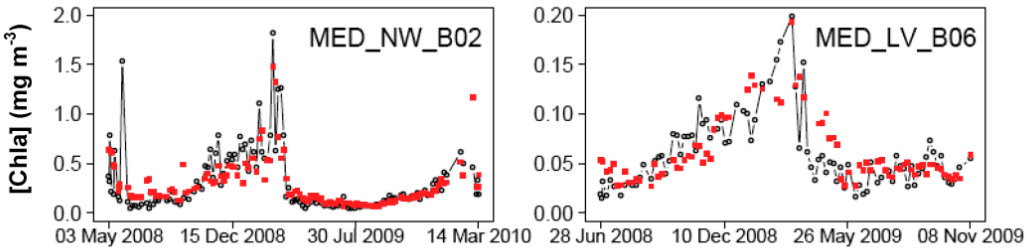
  $K_d(412) = 0.01 + 0.0676[Chla]^{0.686} + 1.3a_y(412)$

  (*Bricaud et al.* 1998); (*Gordon* 1989)

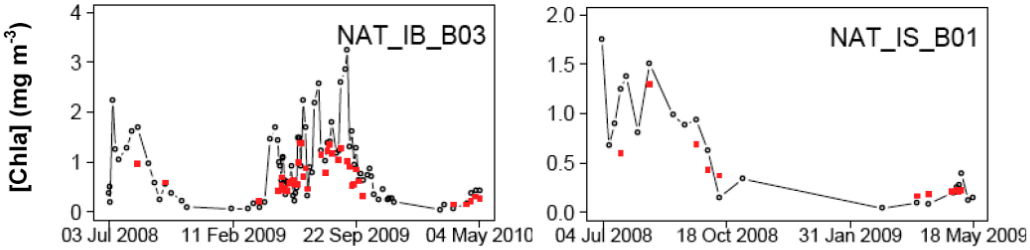
- Accurate retrieval of [Chla] and $a_y(412)$ based on the combined processing of Ed(λ) and Fluo.

[Chla] retrieval at surface: floats vs MODIS

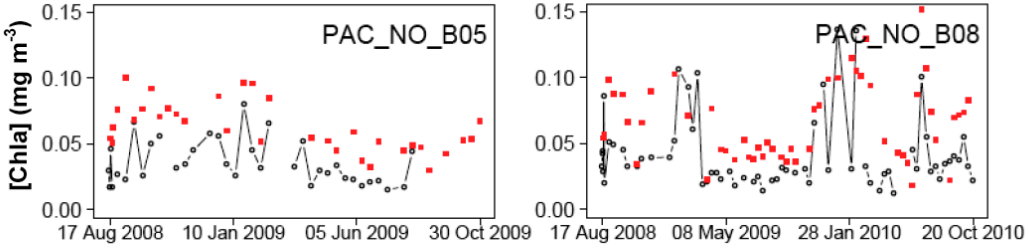
Med Sea



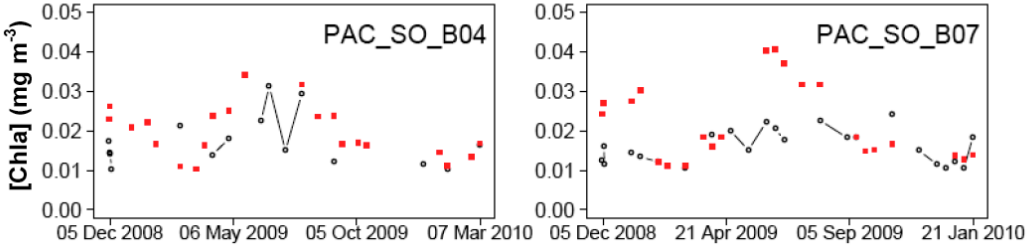
North Atlantic gyre

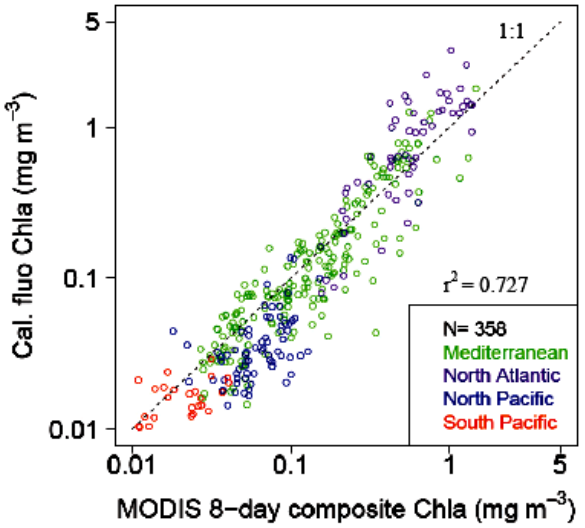


North Pacific gyre



South Pacific gyre





Float [Chla]
MODIS [Chla]

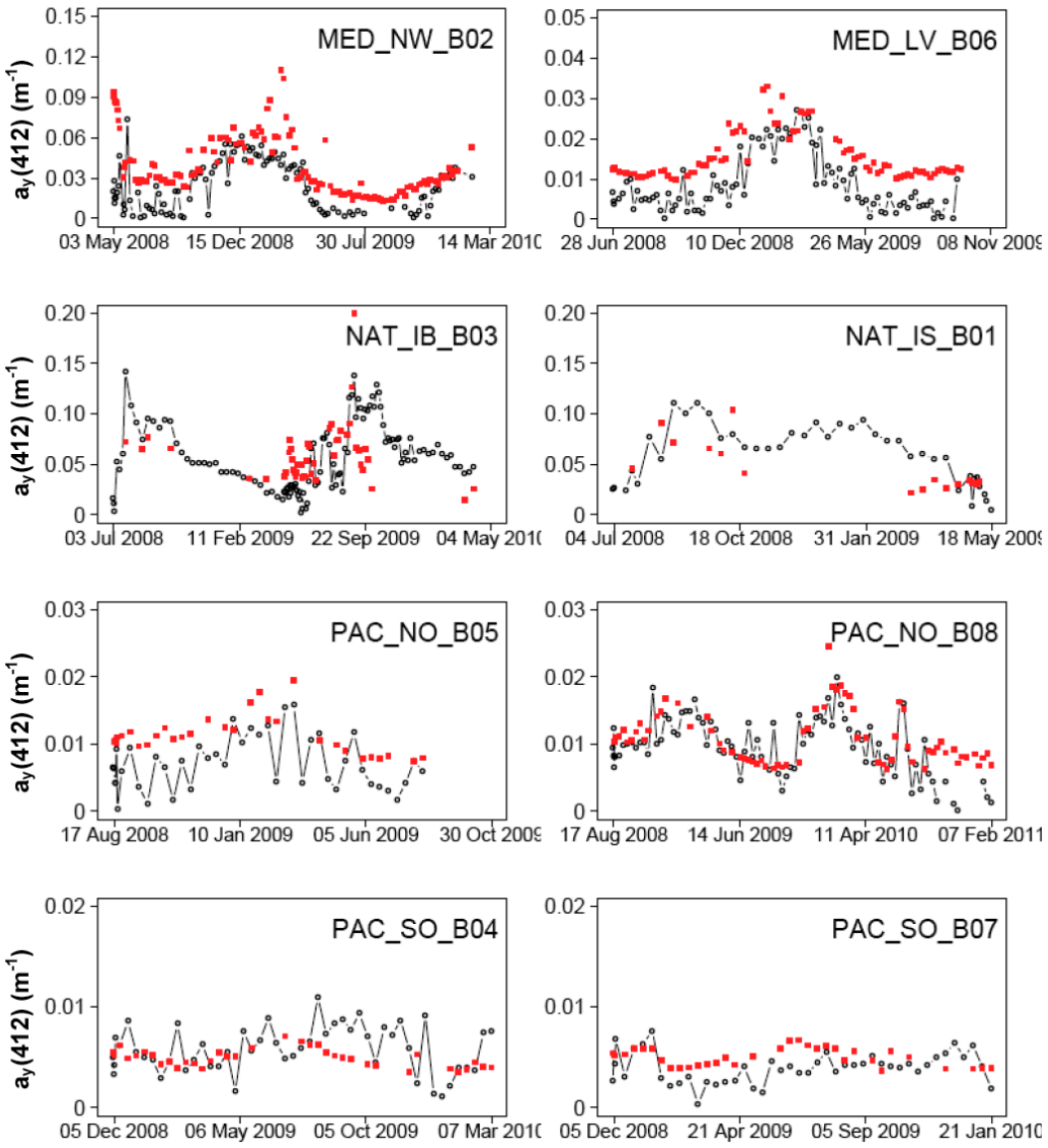
$a_y(412)$ retrieval at surface: floats vs MODIS

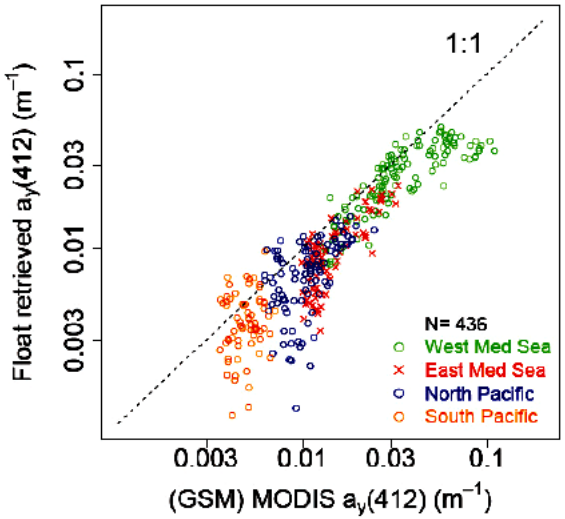
Med Sea

North Atlantic gyre

North Pacific gyre

South Pacific gyre

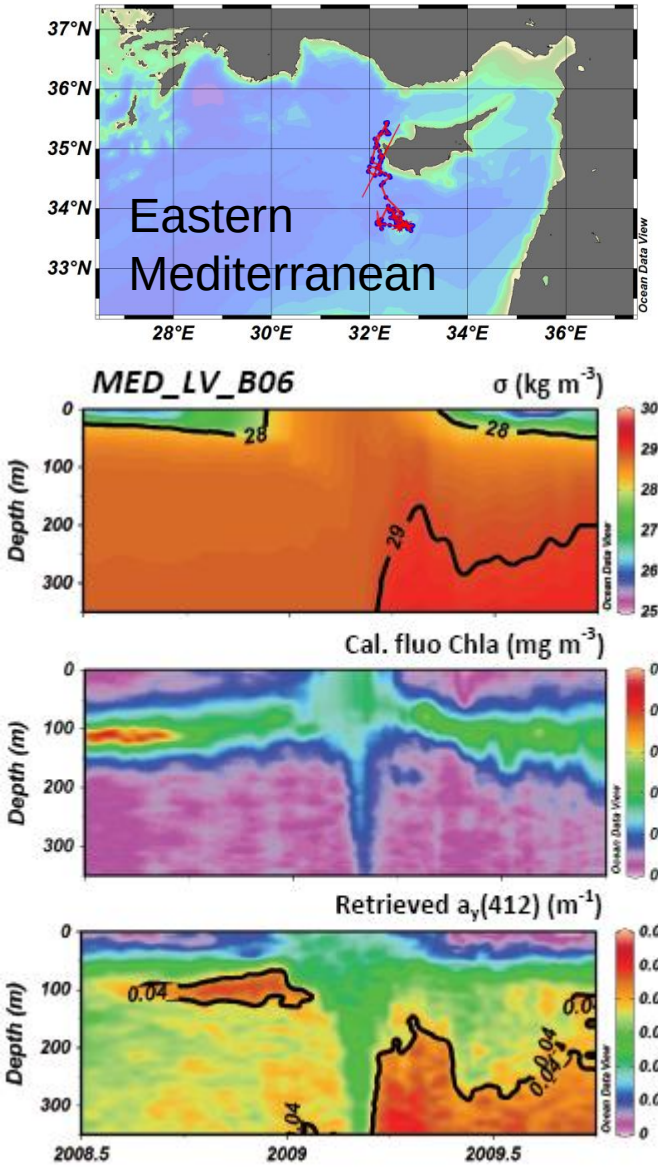


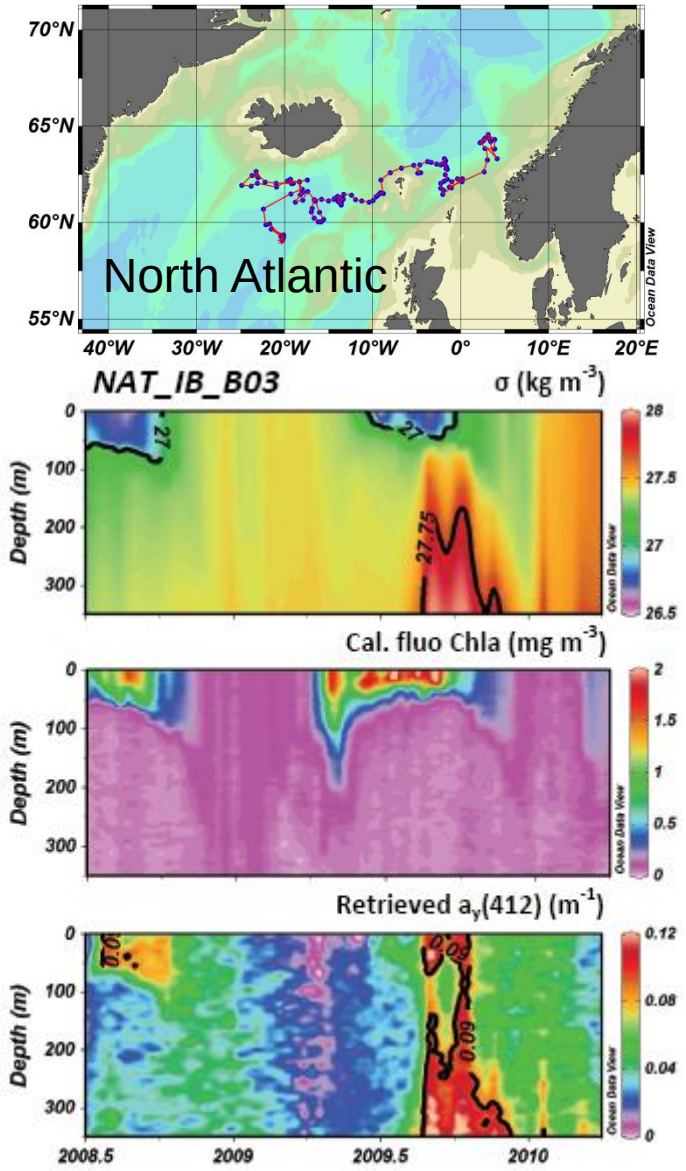


Float $a_y(412)$

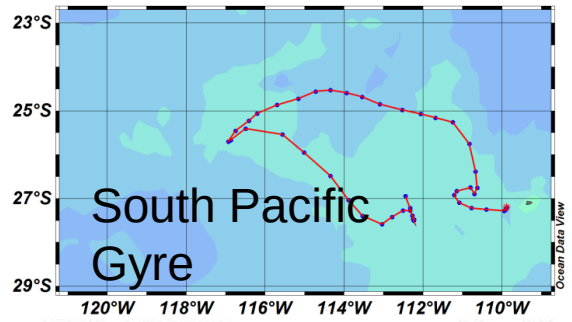
MODIS $a_y(412)$ via GSM $a_{dg}(443)$

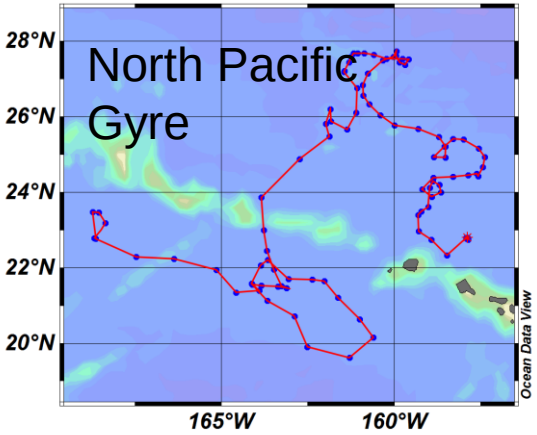
Vertical & seasonal distribution

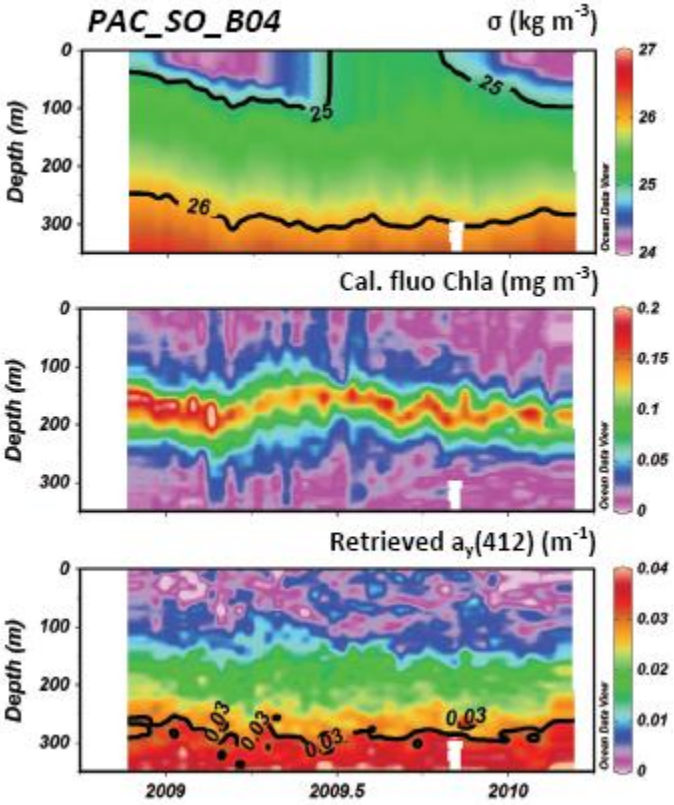


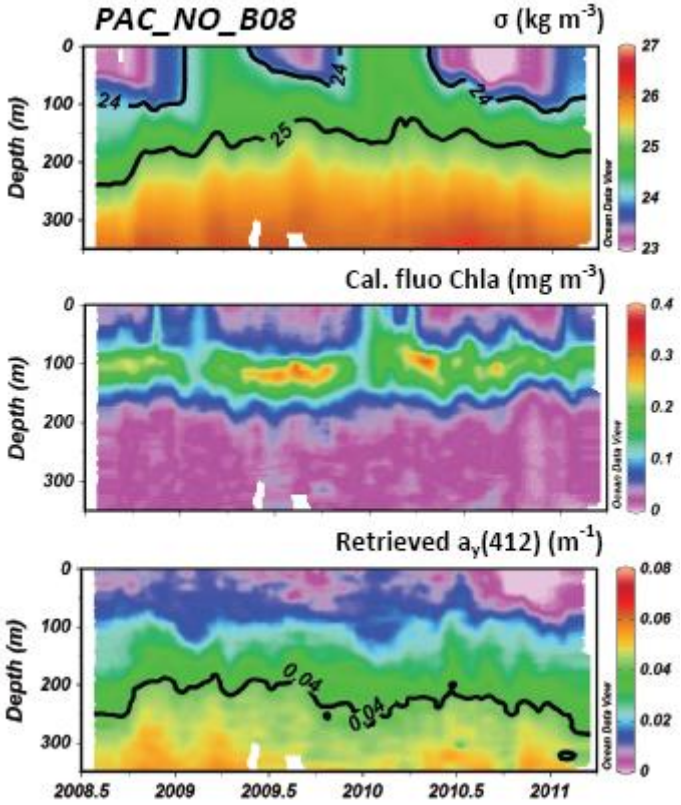


Vertical & seasonal distribution









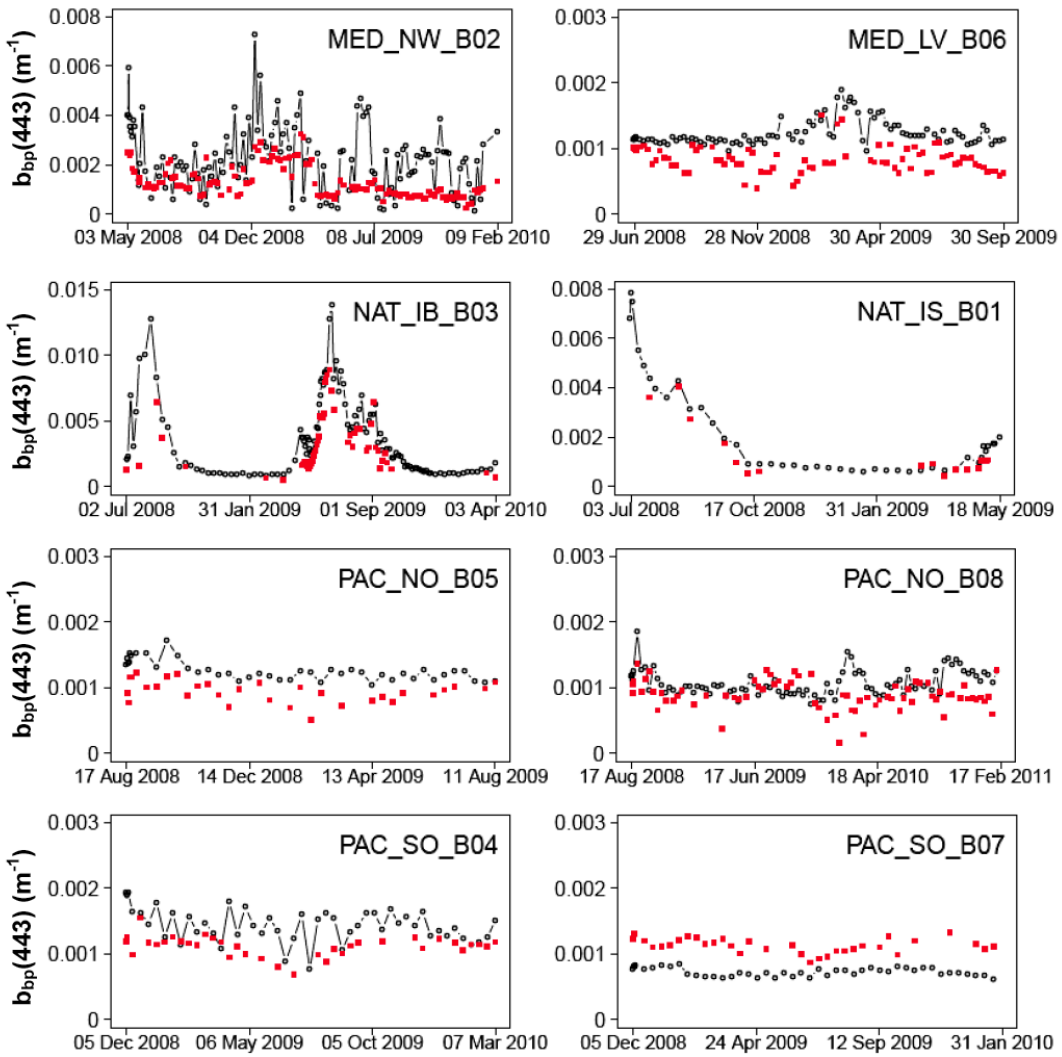
b_{bp} (POC proxy): floats vs MODIS

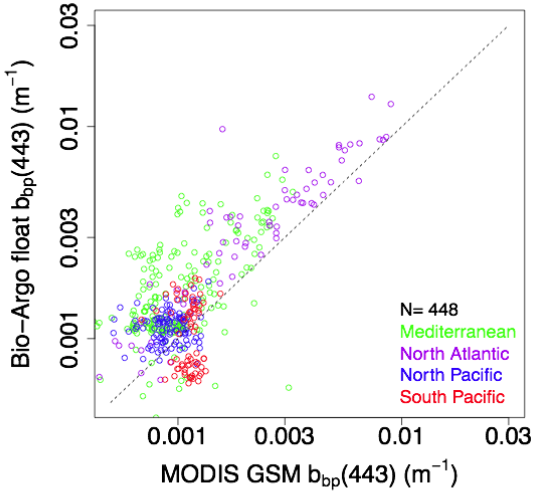
Med Sea

North Atlantic gyre

North Pacific gyre

South Pacific gyre



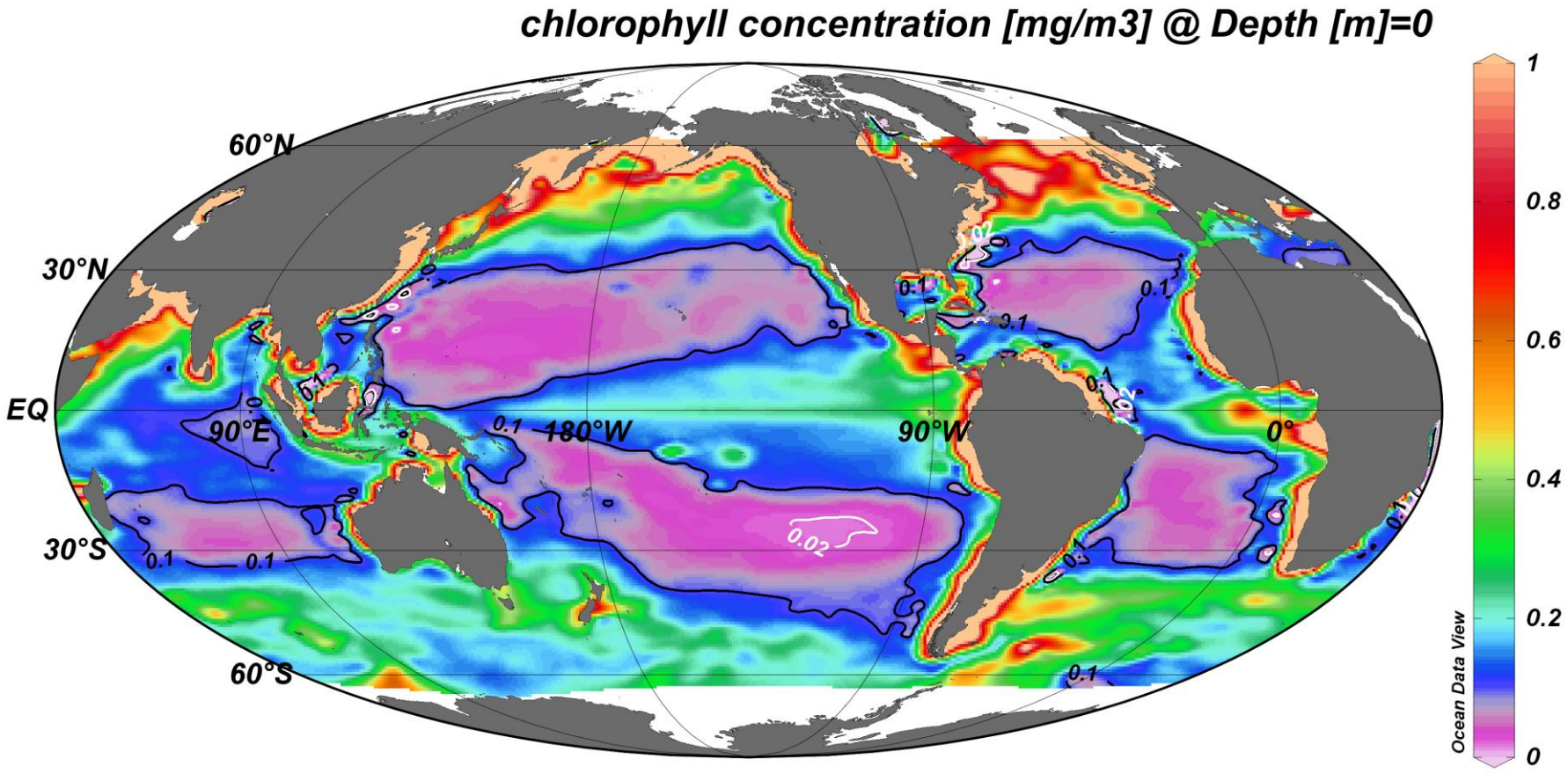


Float b_{bp}(532)
MODIS b_{bp}(443)

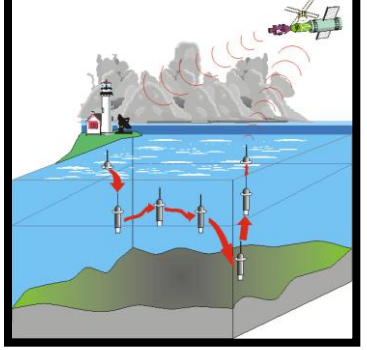
Conclusions and Perspectives

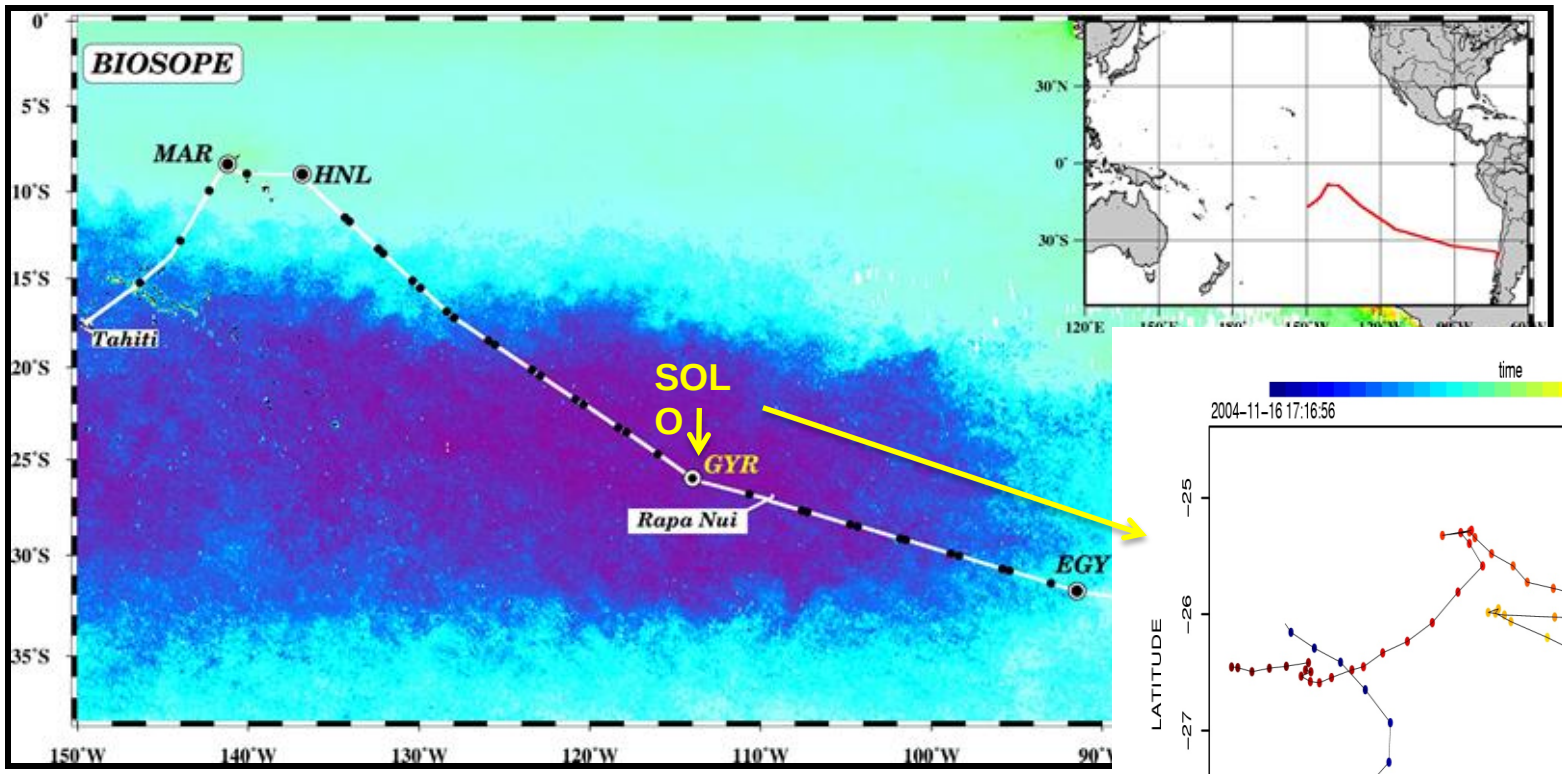
- Retrieval of [Chla] and $a_y(412)$ from radiometry and fluorometry, valid of over a Bio-Argo float life-time (2-3 years).
  - a priori insensitive to any sensor drift (hardware or biofouling) because based on the use of Kd (ratio of irradiance)
  - a priori a way to make dataset from different floats consistent because of the use of “global” generic bio-optical relationships (same way than empirical algorithms used for OC remote sensing).
- A possible method for delayed-mode data quality control
  - like in the Argo data stream
- CDOM, Chla, b_{bp} (POC) are also retrievable from space (Ocean Color)
  - When sufficient data will be acquired, a progressive 3D / 4D view for these variables will emerge
  - Initialization / validation of global biogeochemical models

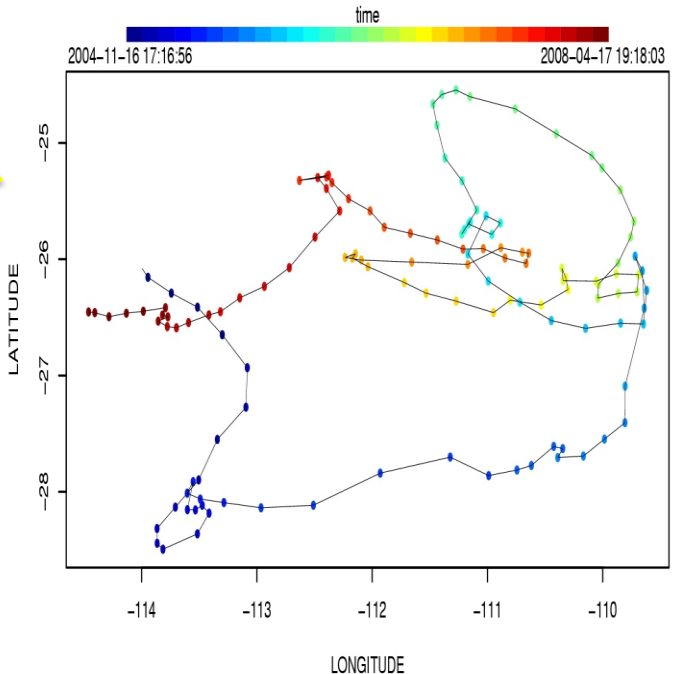
#2 Understanding the seasonal dynamics of phytoplankton in sub-tropical regime



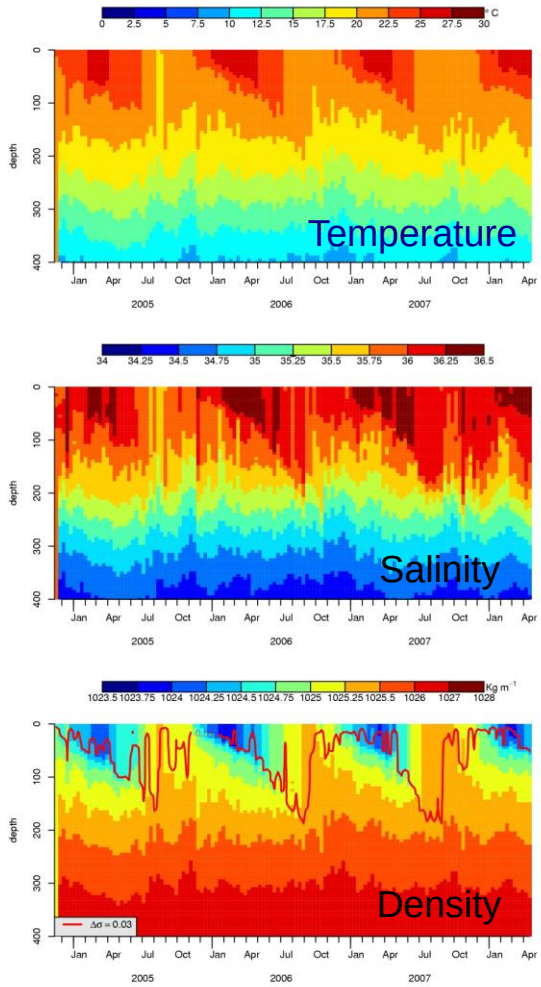
Argo float (TS) deployemts during the BIOSOPE cruise

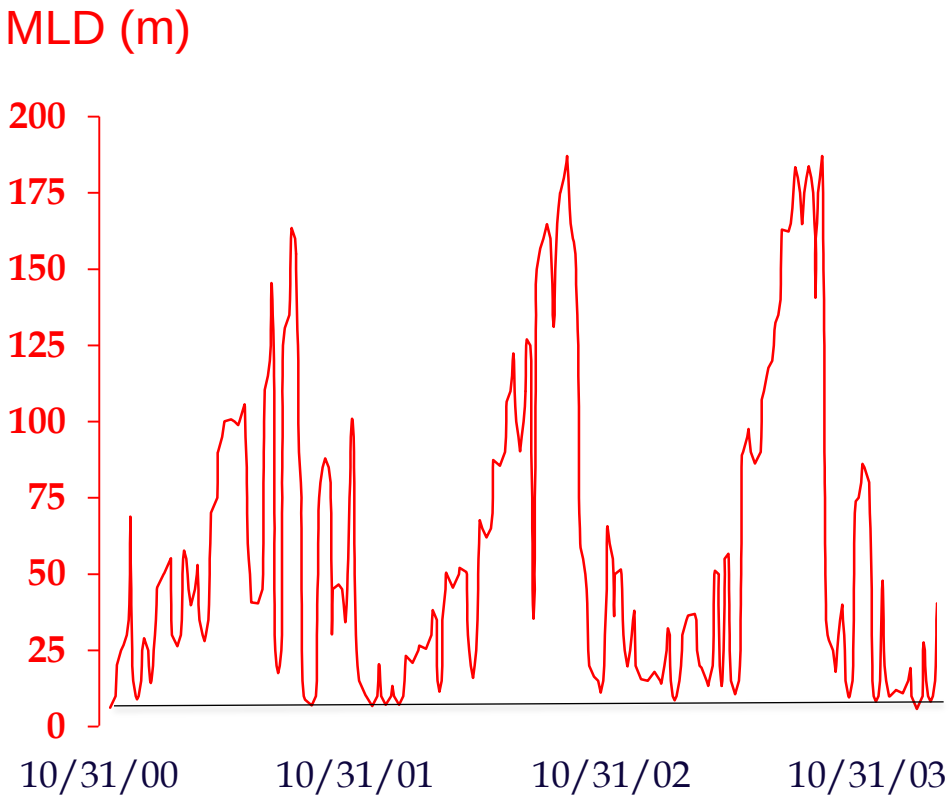




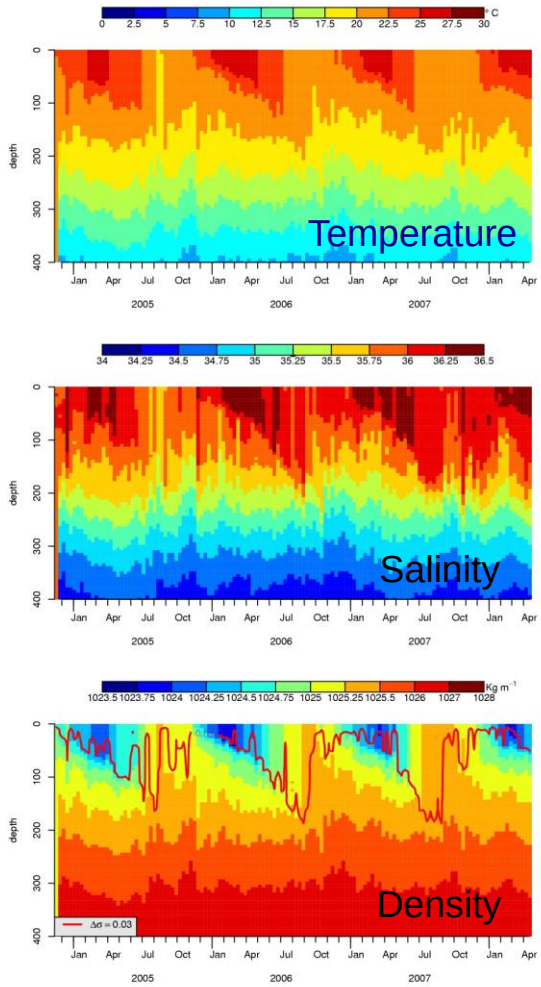


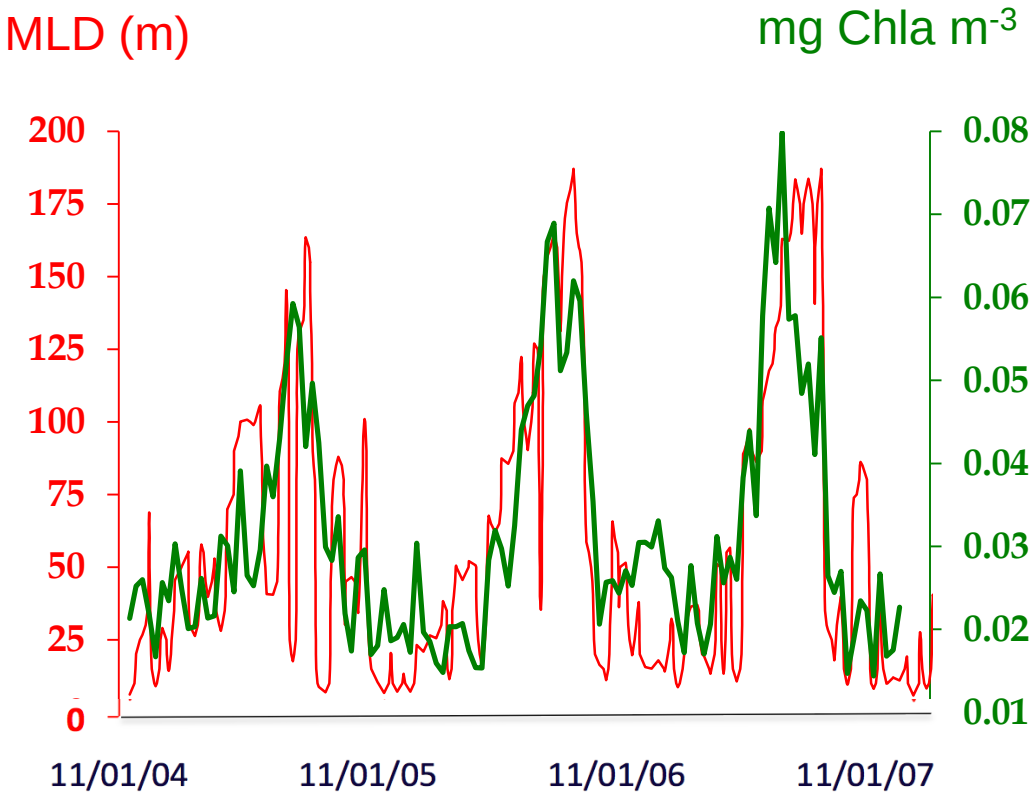
Seasonnal and interannual variations in hydrological properties and Zmld in the center of the South Pacific Gyre



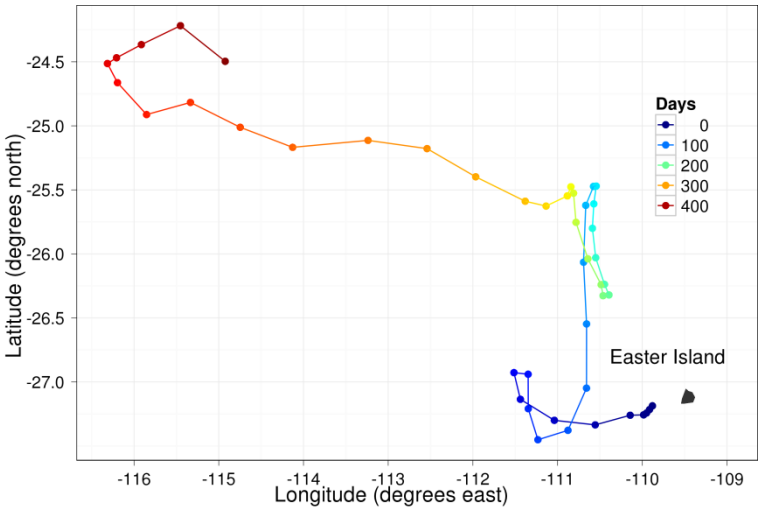


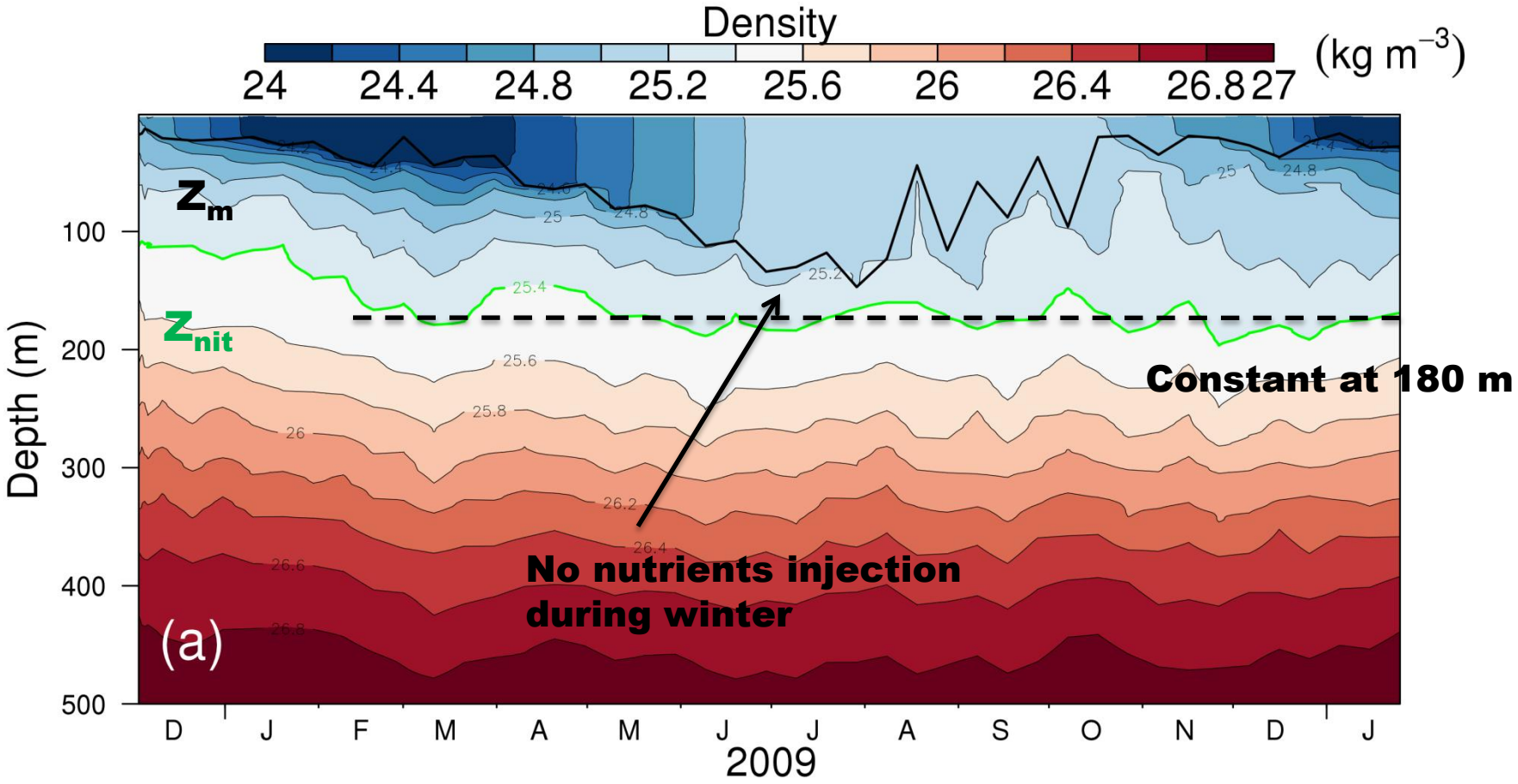
Surface Chla (SeaWiFS) dynamics closely matches MLD dynamics



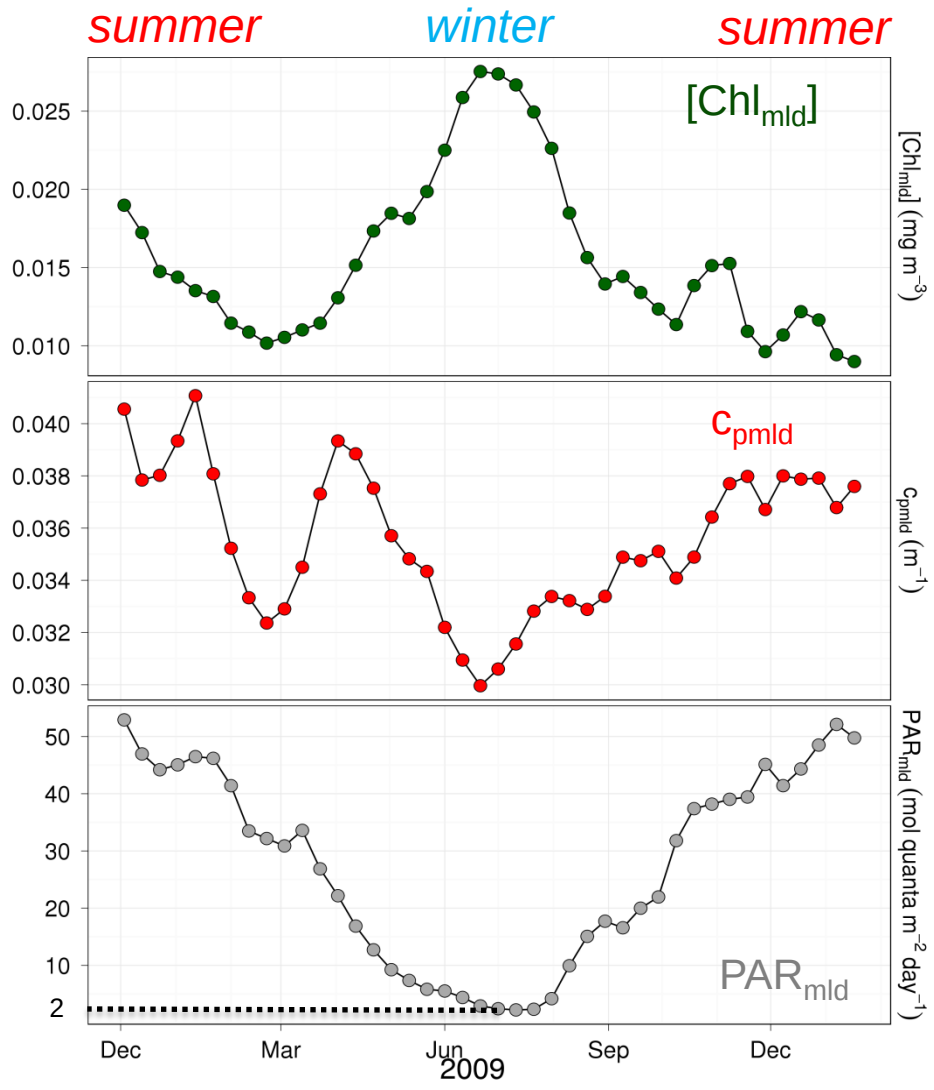


A bio-optical float in the same area





The upper euphotic-mixed layer zone



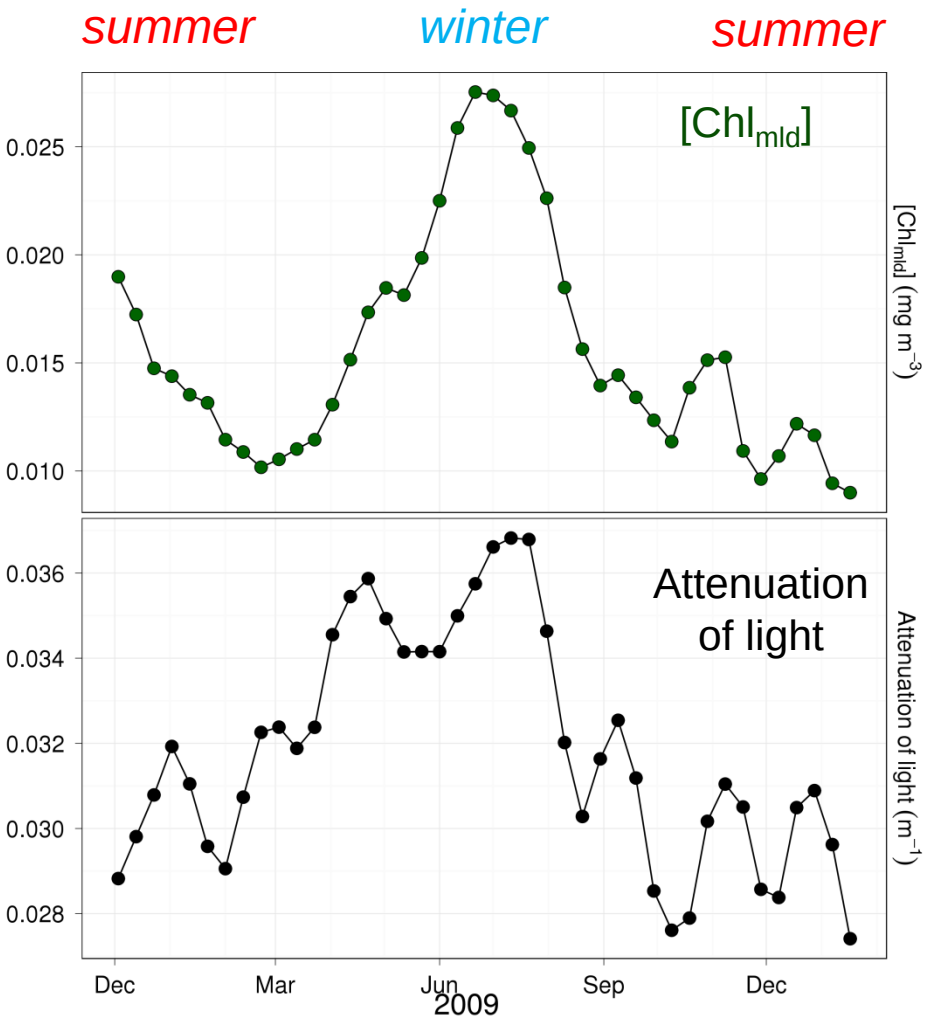
✓Chl-*a* concentration is maximum during winter.

✓Phytoplankton biomass (c_p) is minimum during winter.

✓ The light available for phytoplankton in the mixed layer is reduced by a factor ~25 during winter.

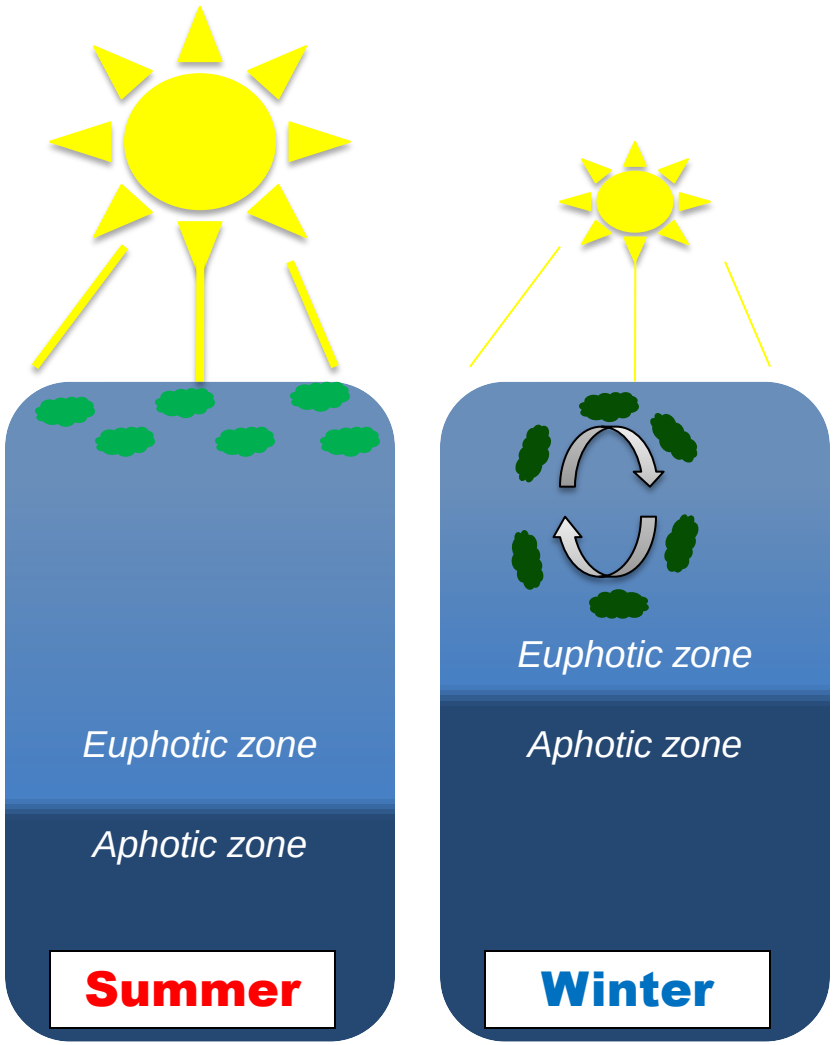
Under a permanent nutrient depleted condition, the Chl-*a* winter increase is very likely the result of a physiological adaptation to light limitation rather than a biomass increase.

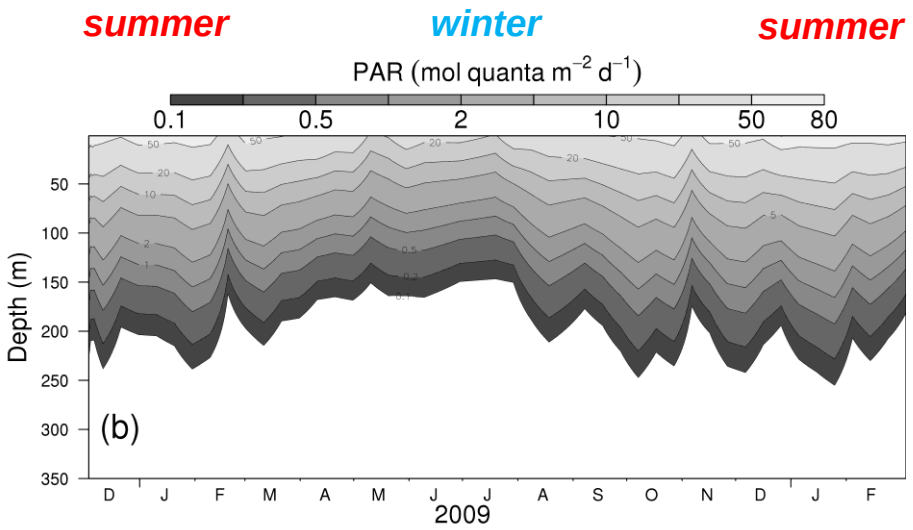
The upper euphotic-mixed layer zone

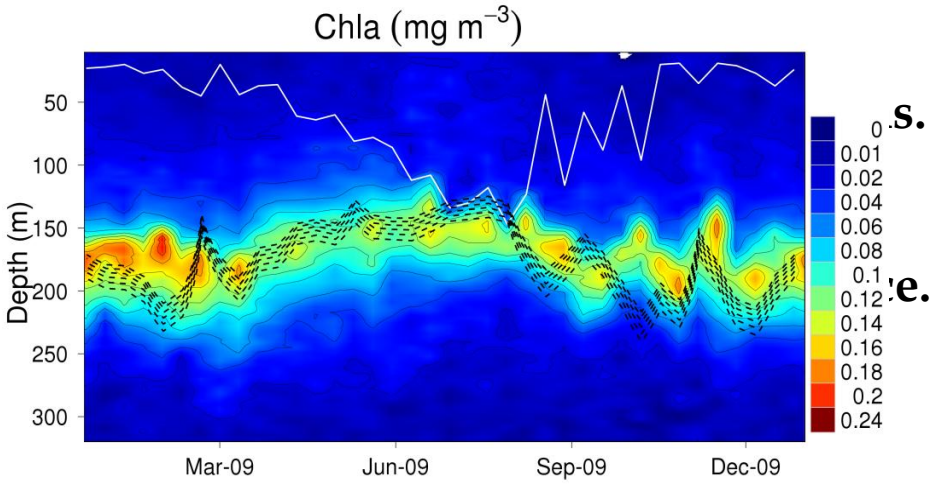


The winter increase of Chl-*a* in the mixed layer attenuates the light penetrating to the lower layers of the water column.

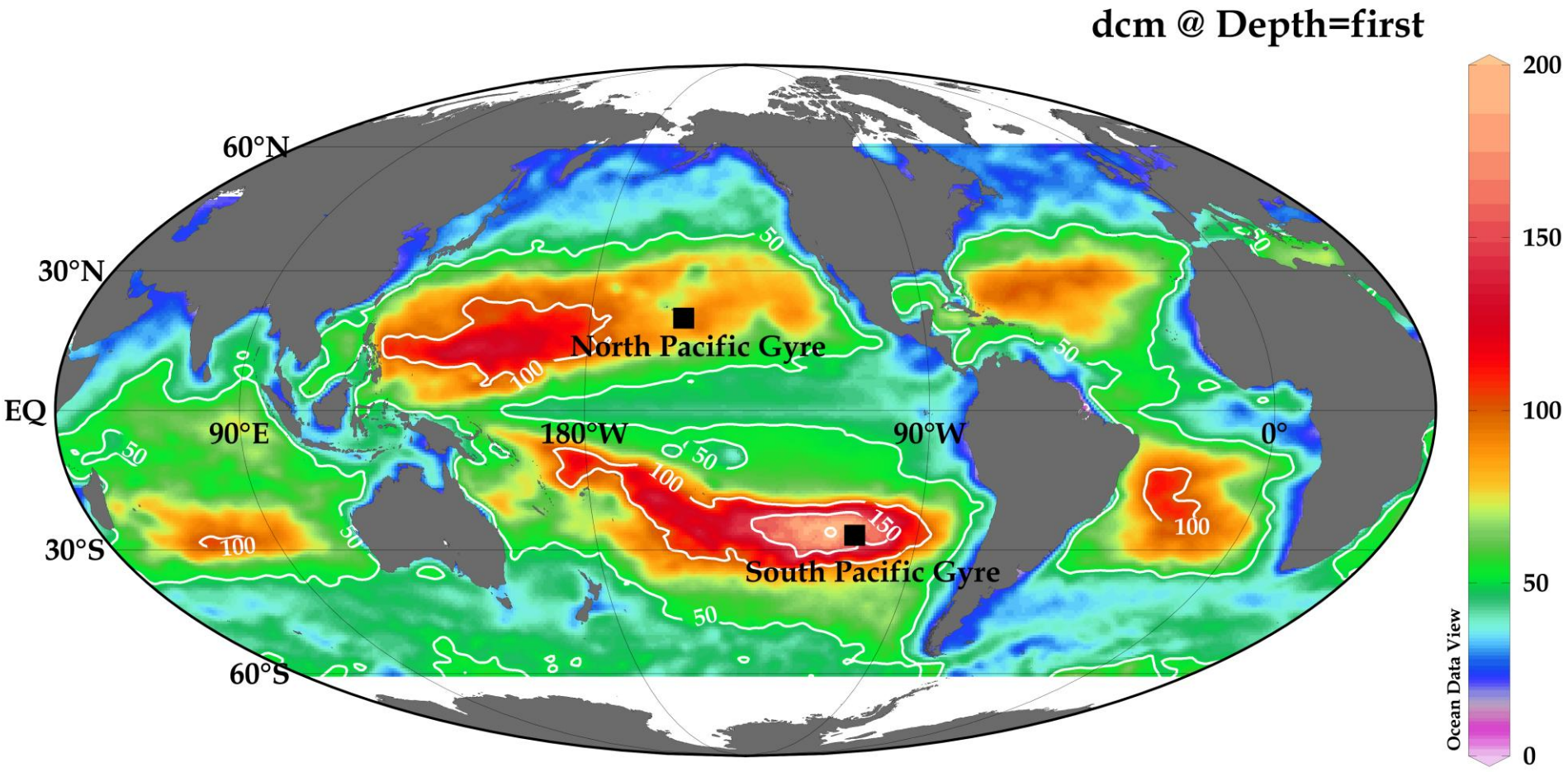
The upper euphotic-mixed layer zone



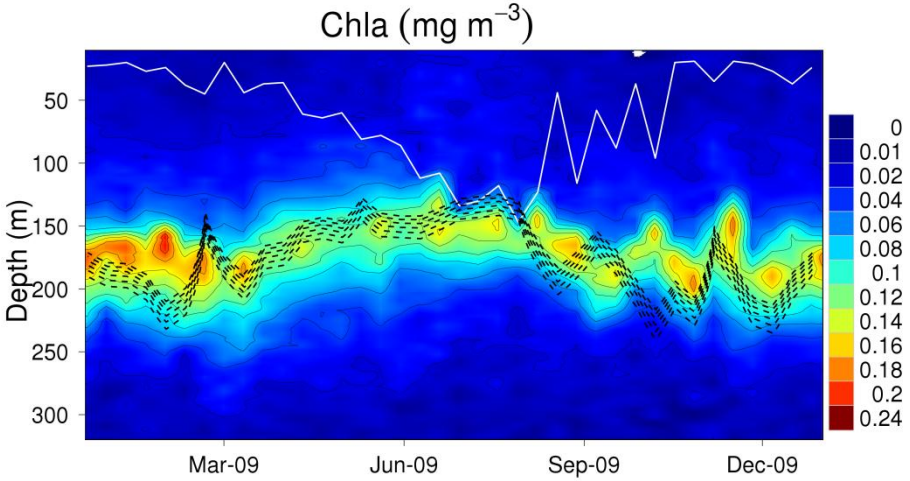




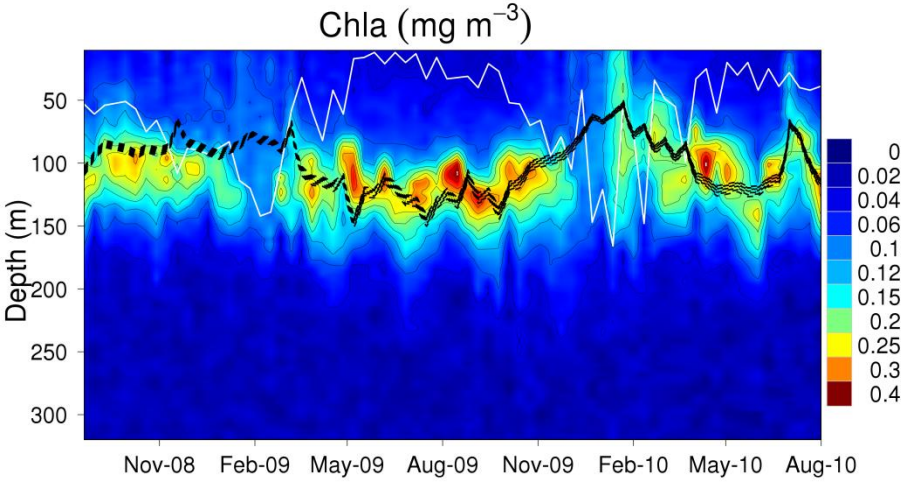
Depth of the DCM in the global ocean



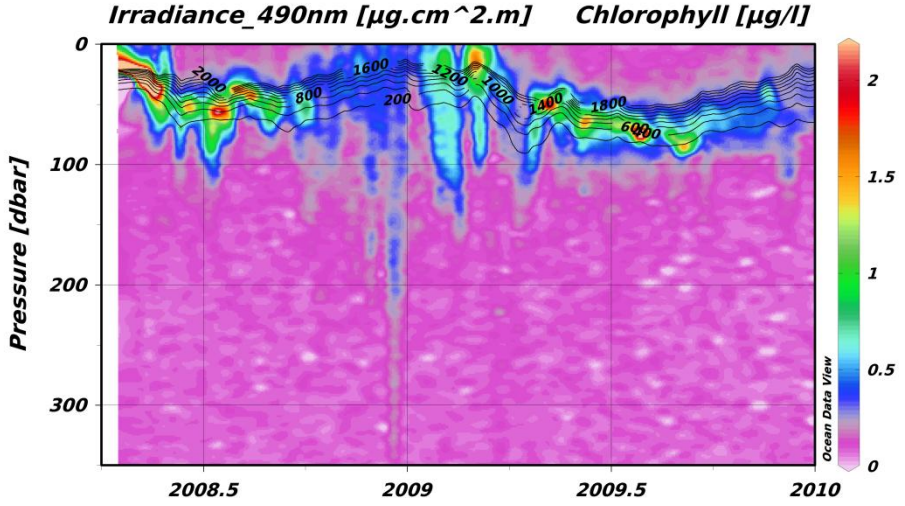
Generalizing the seasonal phytoplankton mechanism of the subtropical gyre (?)



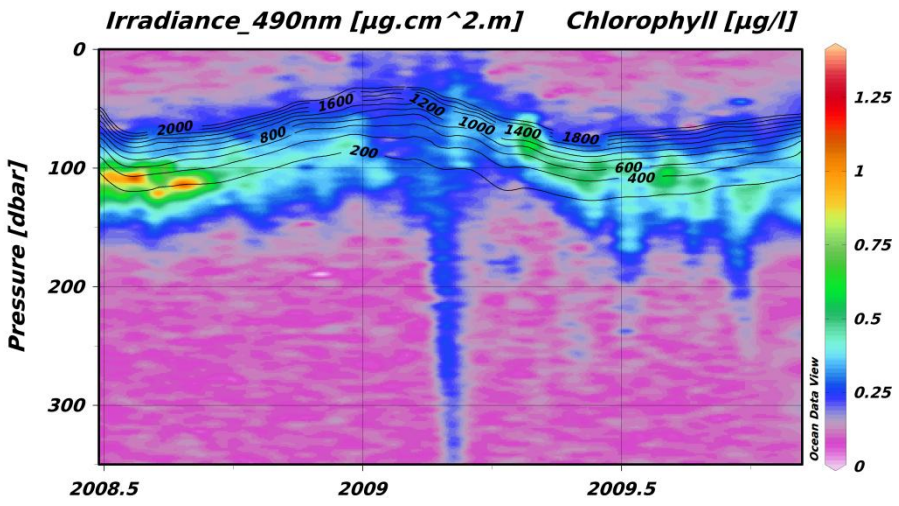
South Pacific gyre



North Pacific gyre

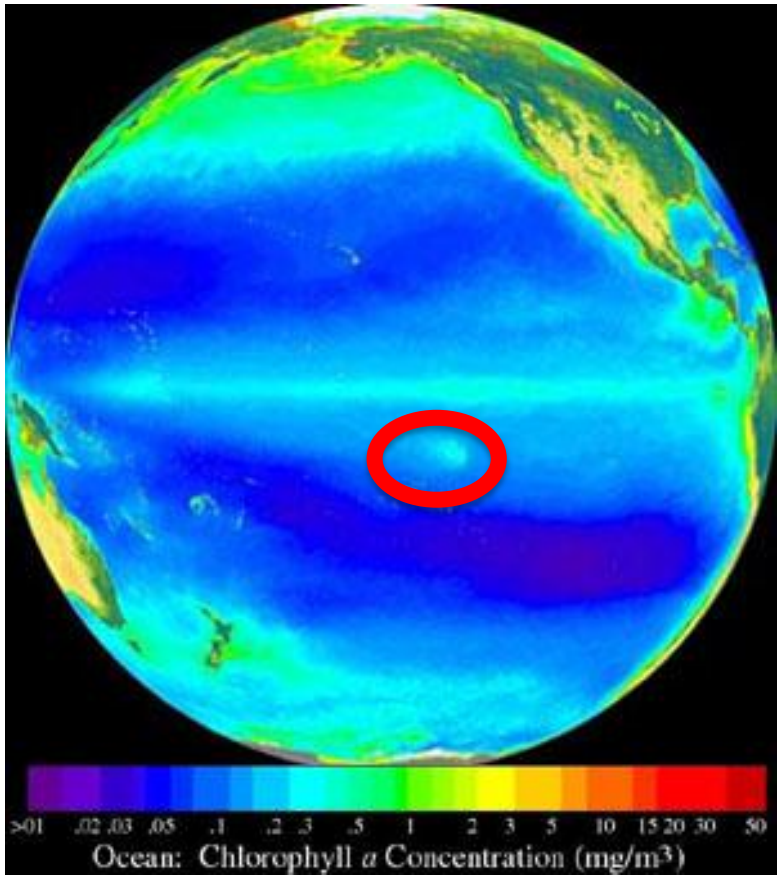


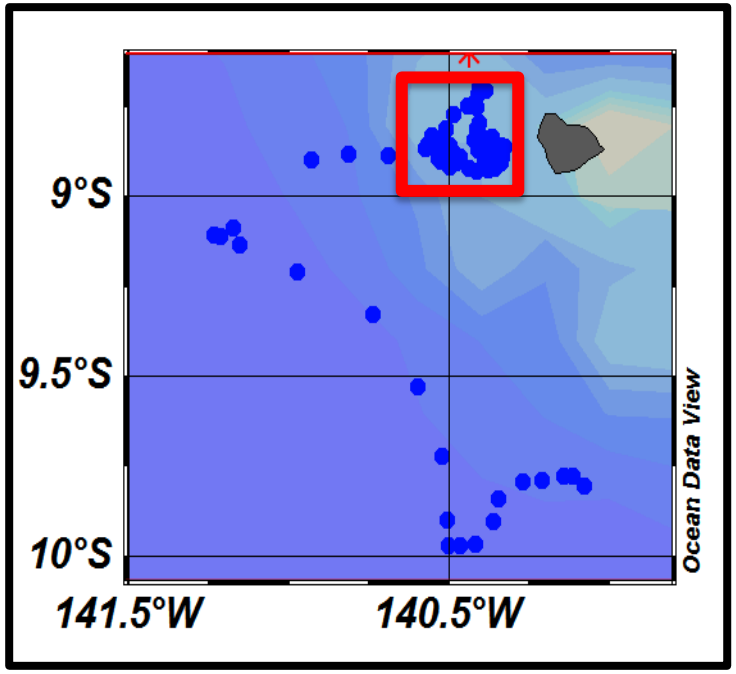
NW Mediterranean Sea



Levantine Sea

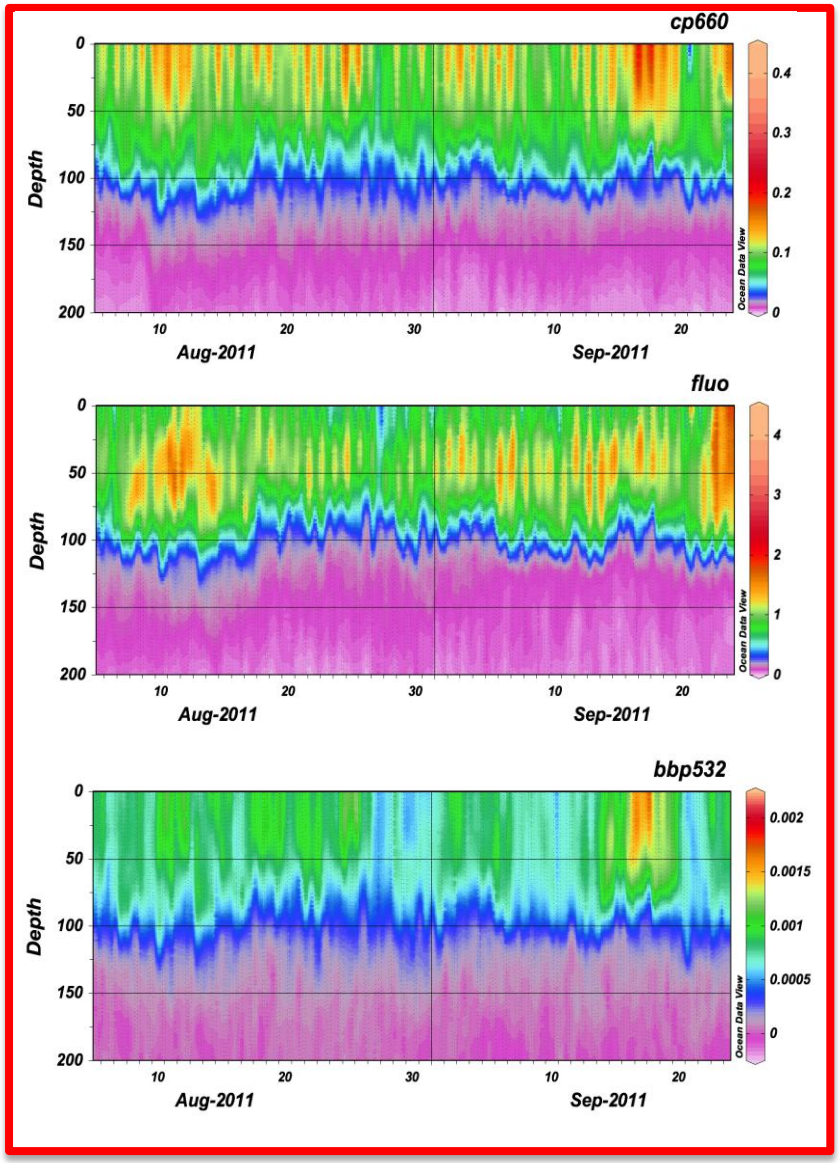
High resolution measurements of optical properties in the sub-equatorial Pacific

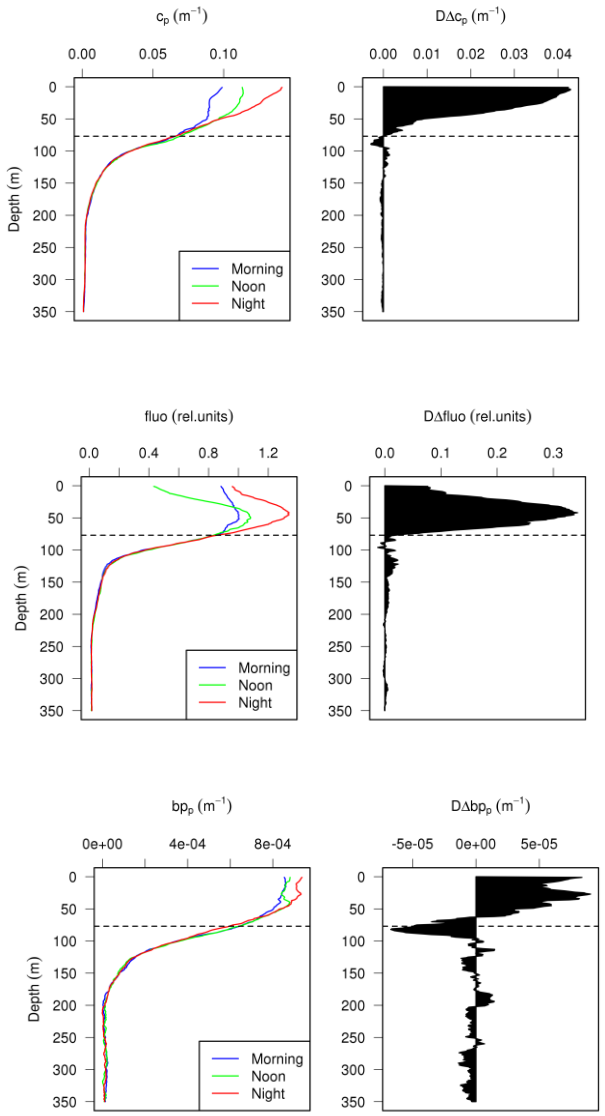




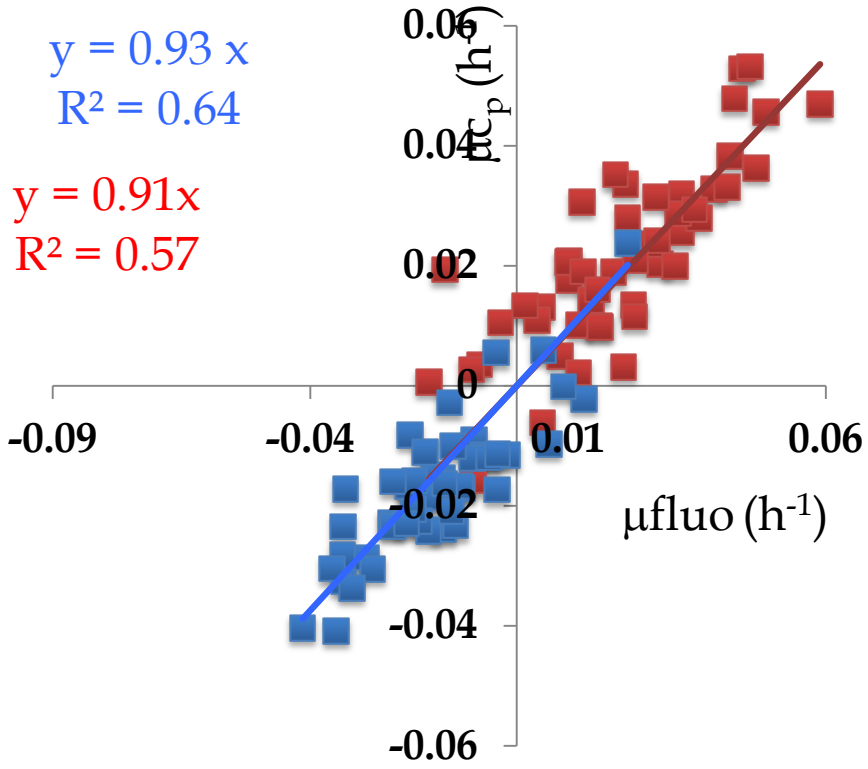
OAO
Oceanographic Autonomous Observations

Variations in bio-optical properties at the diurnal scale





Growth rates derived from fluoresence equivalent from growth rate derived from cp



The spikes: sometimes a biological signal……