Optical sensors on profiling floats and gliders

potential synergies with ocean color satellites

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Working Group : Bio-optical sensors on Argo Floats

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CONSEIL GENERAL DES ALPES-MARITIMES

Région Provence-Alpes-Côte d'Azur

Introduction : context of the presentation

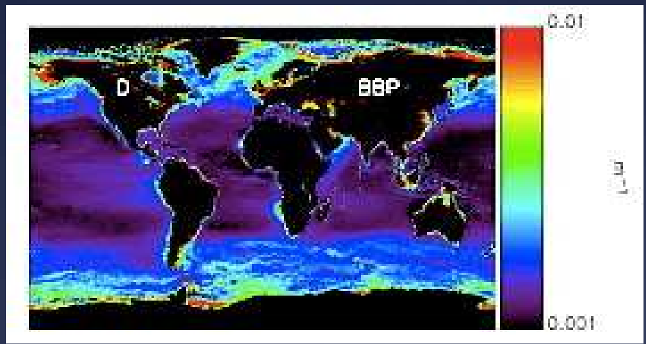
Satellite ocean color: Over the last decade, algorithmic development has allowed a suite of "**new**" **optically significant substances** and associated derived **biogeochemical products** to be extracted from space-based observations.

In situ sensors: Recent development of low-consumption and miniature neutrally buoyant optical sensors, sometimes measuring the **same properties as derived from space**, makes them good candidates for being mounted on **floats** and **gliders**.

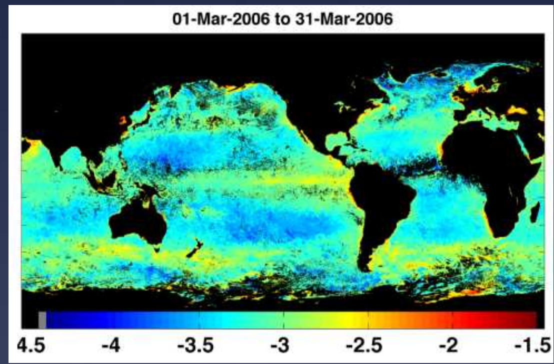
Synergetic combination of both remotely operated technique : gliders and profiling floats provide the vertical dimension of properties that is missed by satellites: => 3D/4D view of biogeochemical properties is becoming a reality *“new” biogeochemical / bio-optical products detected from space*

"new" biogeochemical / bio-optical products from space

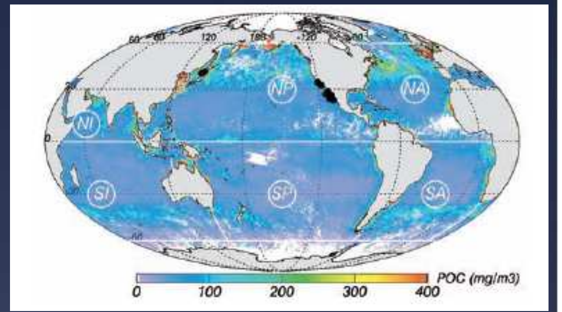
(1) Proxies of particle load or Particulate Organic Content (POC)



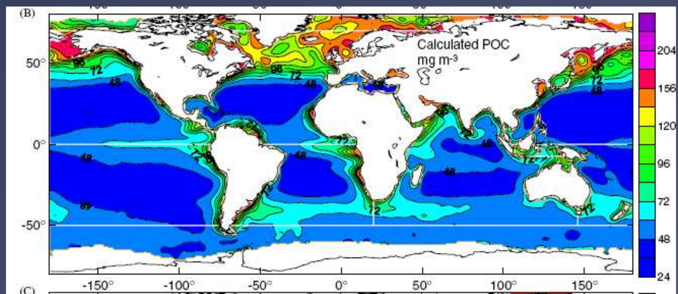
b_{bp} : Garver Siegel Maritorena



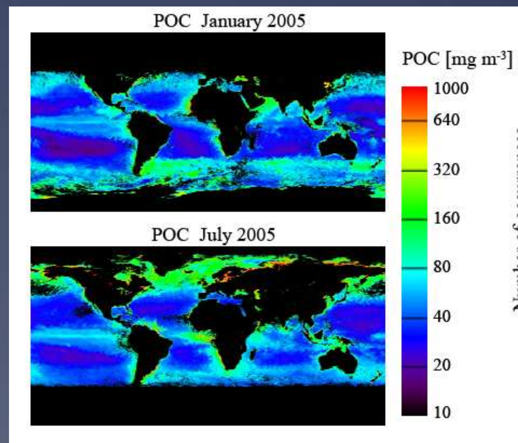
b_{bp} : Brown et al., RSE, 2008



b_{bp} / POC : Loisel et al. GRL 2002



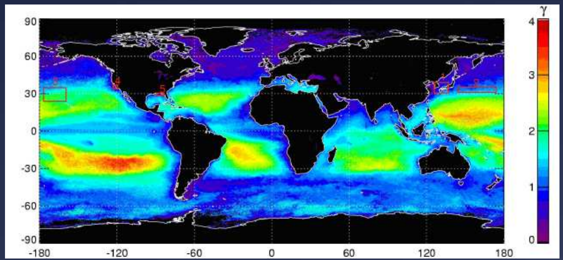
POC : Gardner et al., DSR II 2006



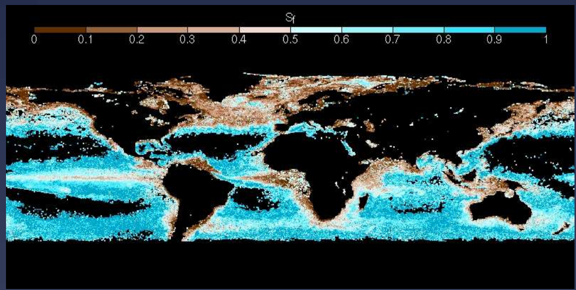
POC : Stramski et al., 2008, Biogeosciences

"new" biogeochemical / bio-optical products from space

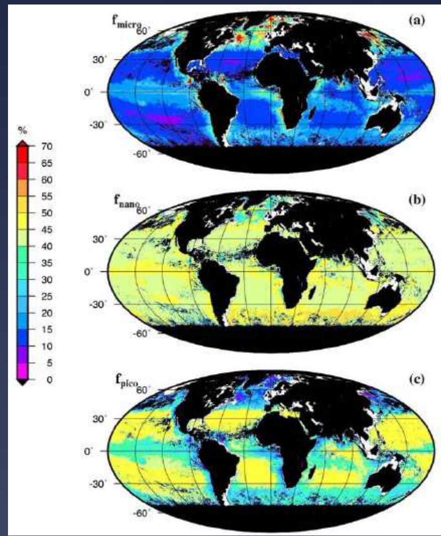
(2) Proxies of the qualitative nature of the particles (size, composition…)



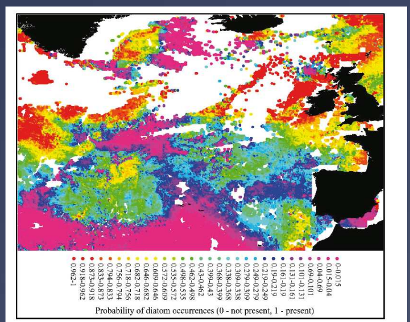
γ (particle size) : Loisel et al. JGR 2006



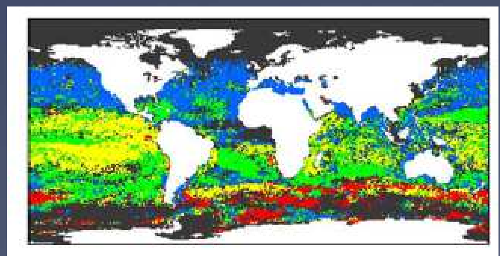
phyto size parameter : Ciotti and Bricaud (2006) Bricaud et al., in prep



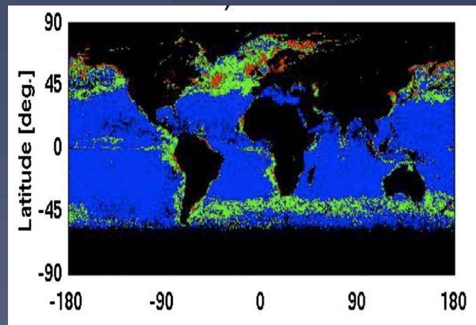
phyto size classes Uitz et al., JGR 2006



phyto community Raitsos, L & O 2008



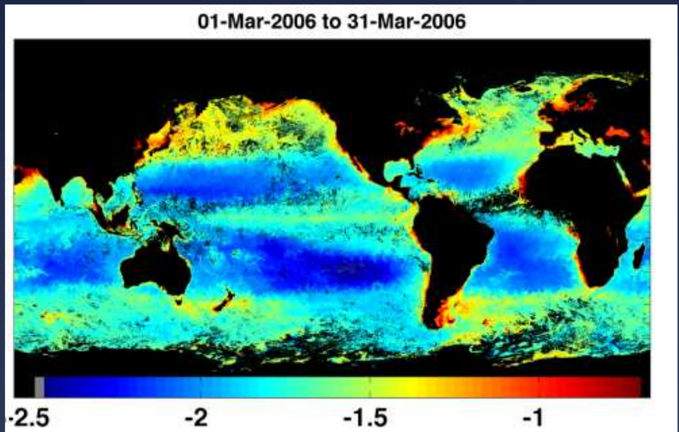
phyto community Alvain et al., DSR 2005



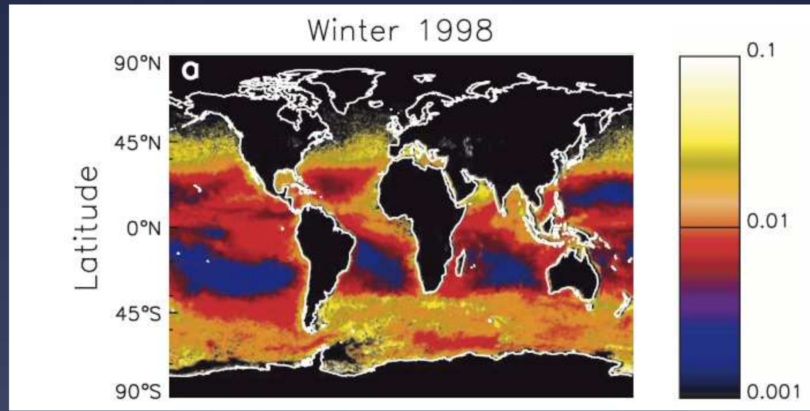
phyto size classes Hirata et al., RSE 2008

“new” biogeochemical / bio-optical products from space

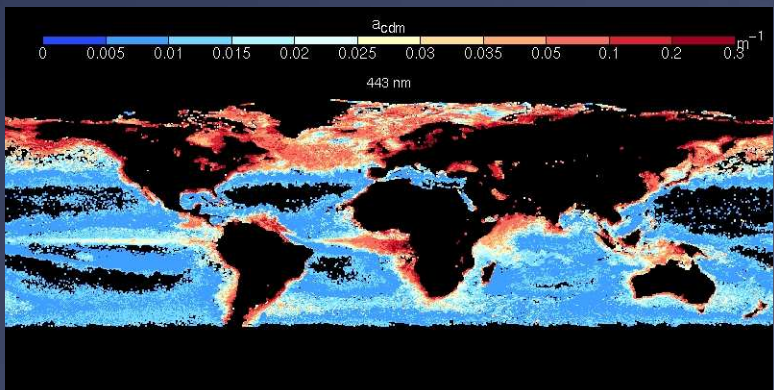
(3) Proxies of dissolved / detrital material



a_{cdm} : Brown et al., RSE 2008



CDM : Siegel et al., JGR 2002

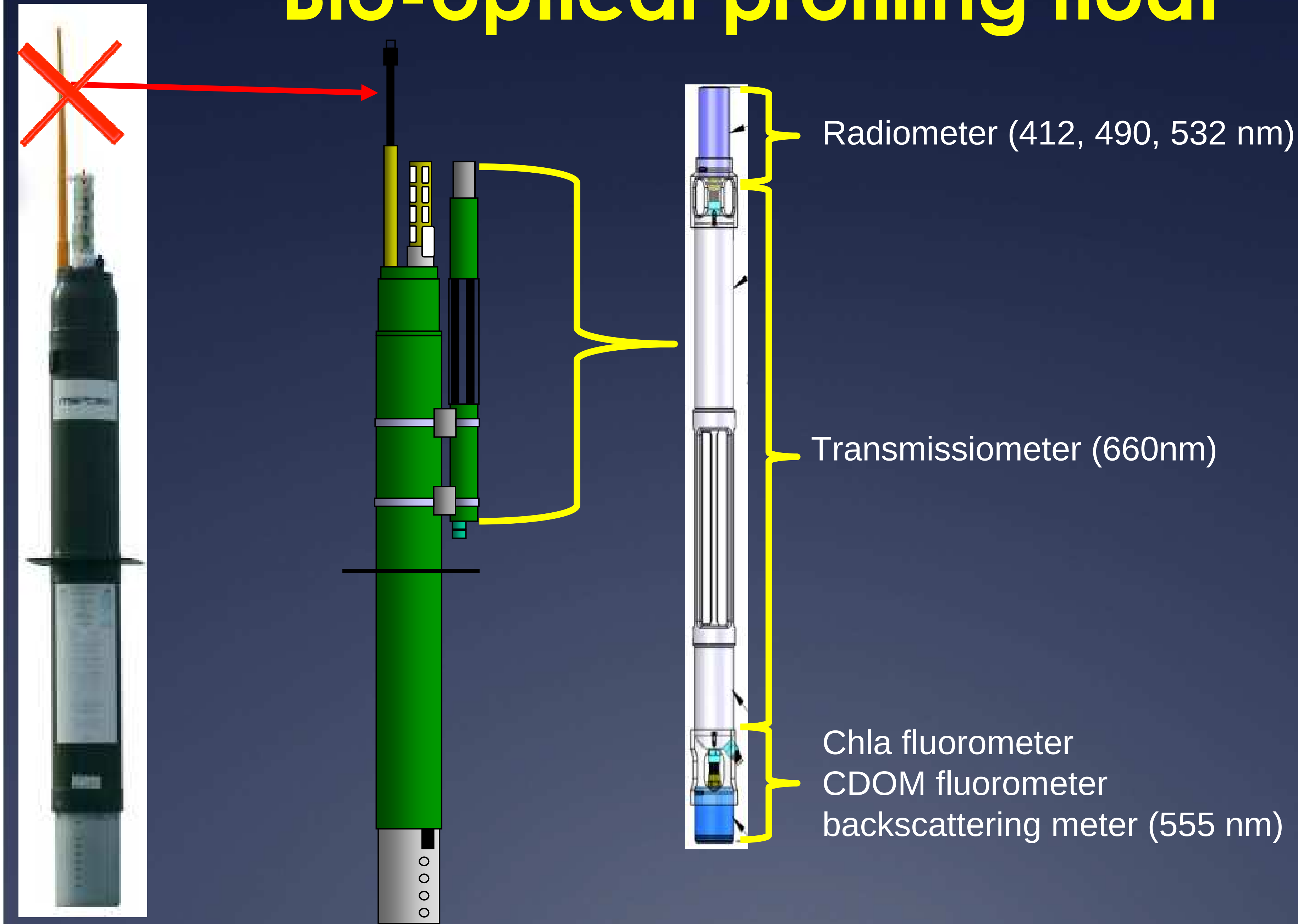


a_{cdm} (443) : Bricaud et al., in prep

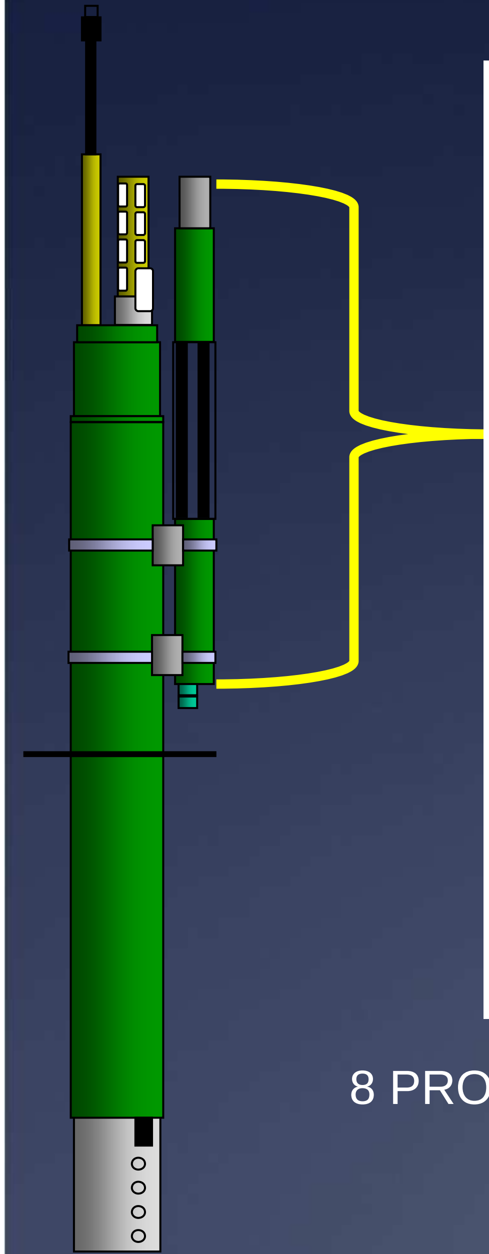
Optical sensors on floats and gliders

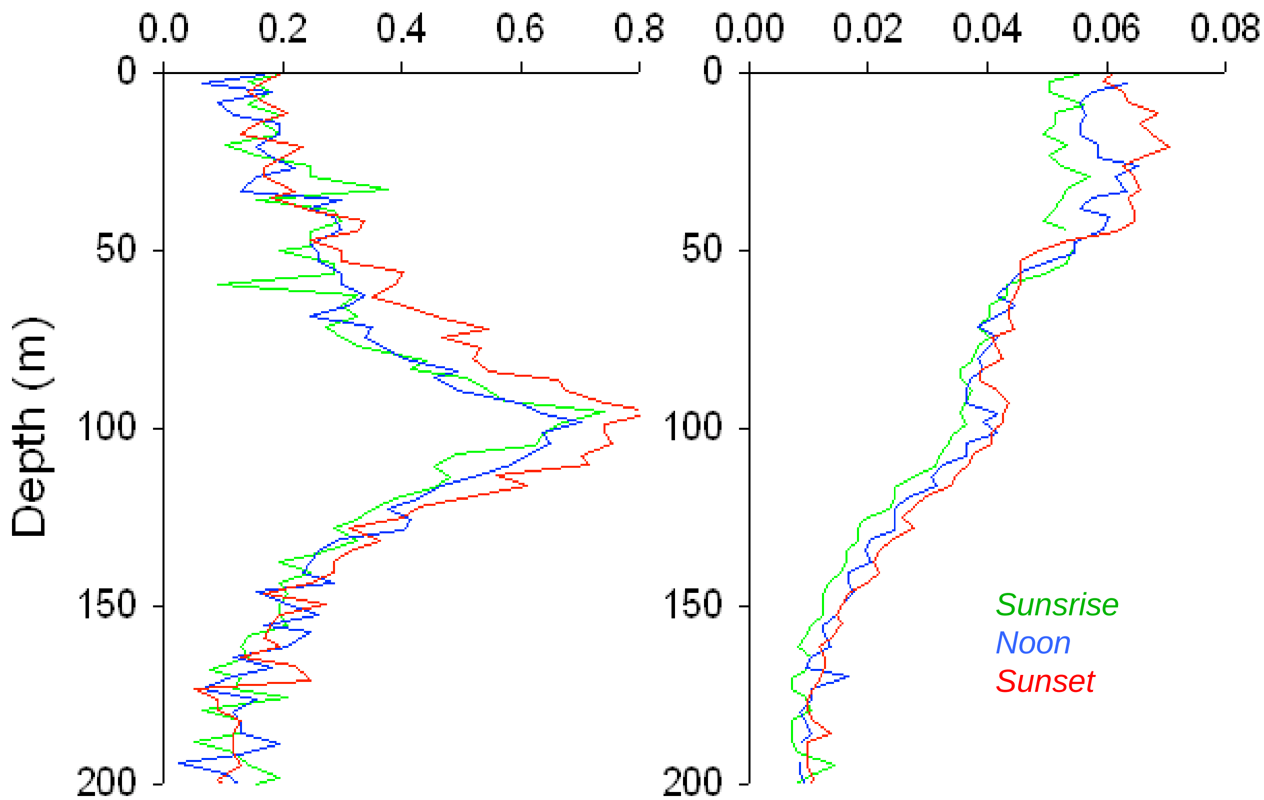
- ❑ Radiometers
- ❑ Fluorometers (Chla & CDOM)
- ❑ Transmissiometers
- ❑ Backscattering metters

Bio-optical profiling float



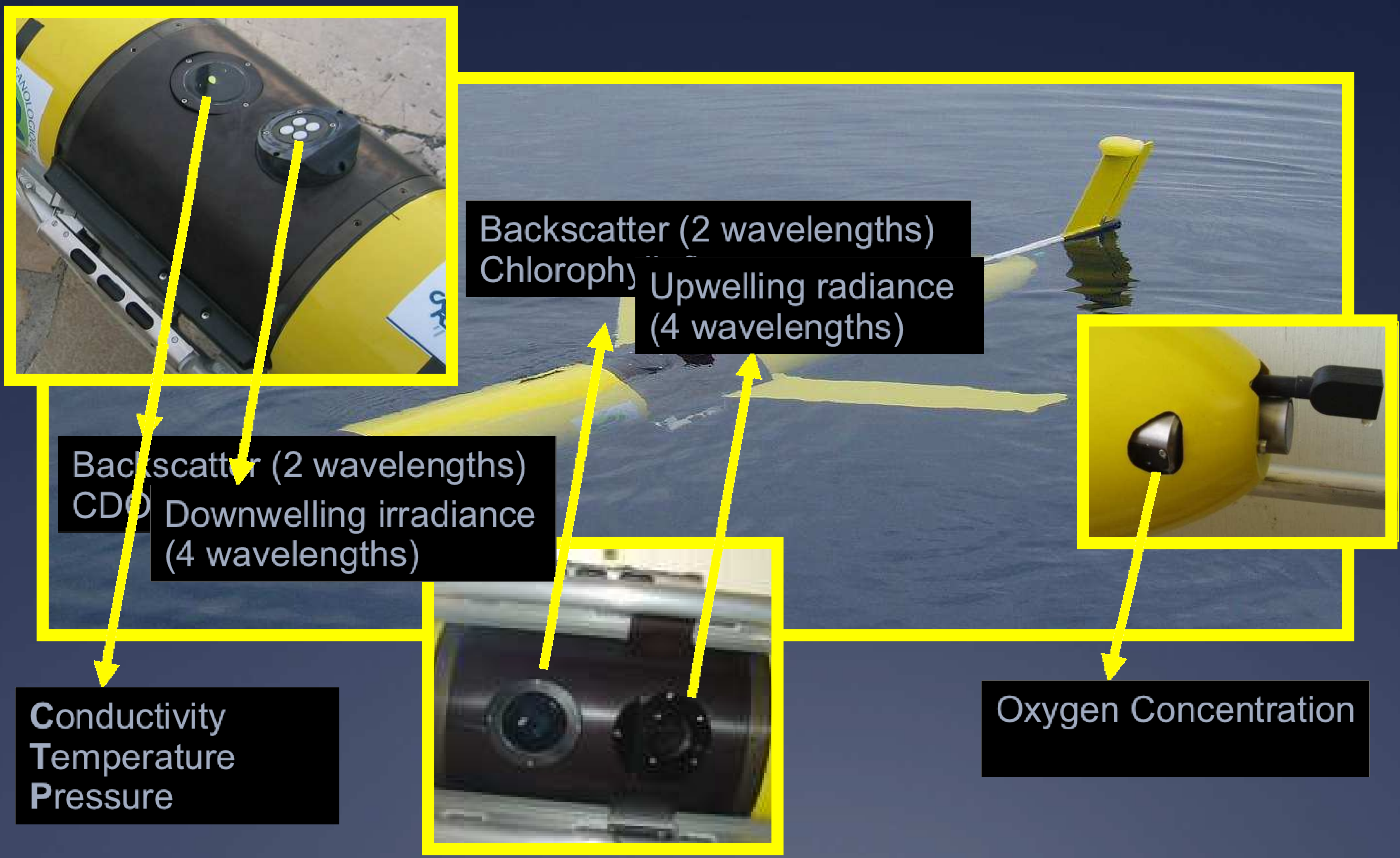
Bio-optical profiling float



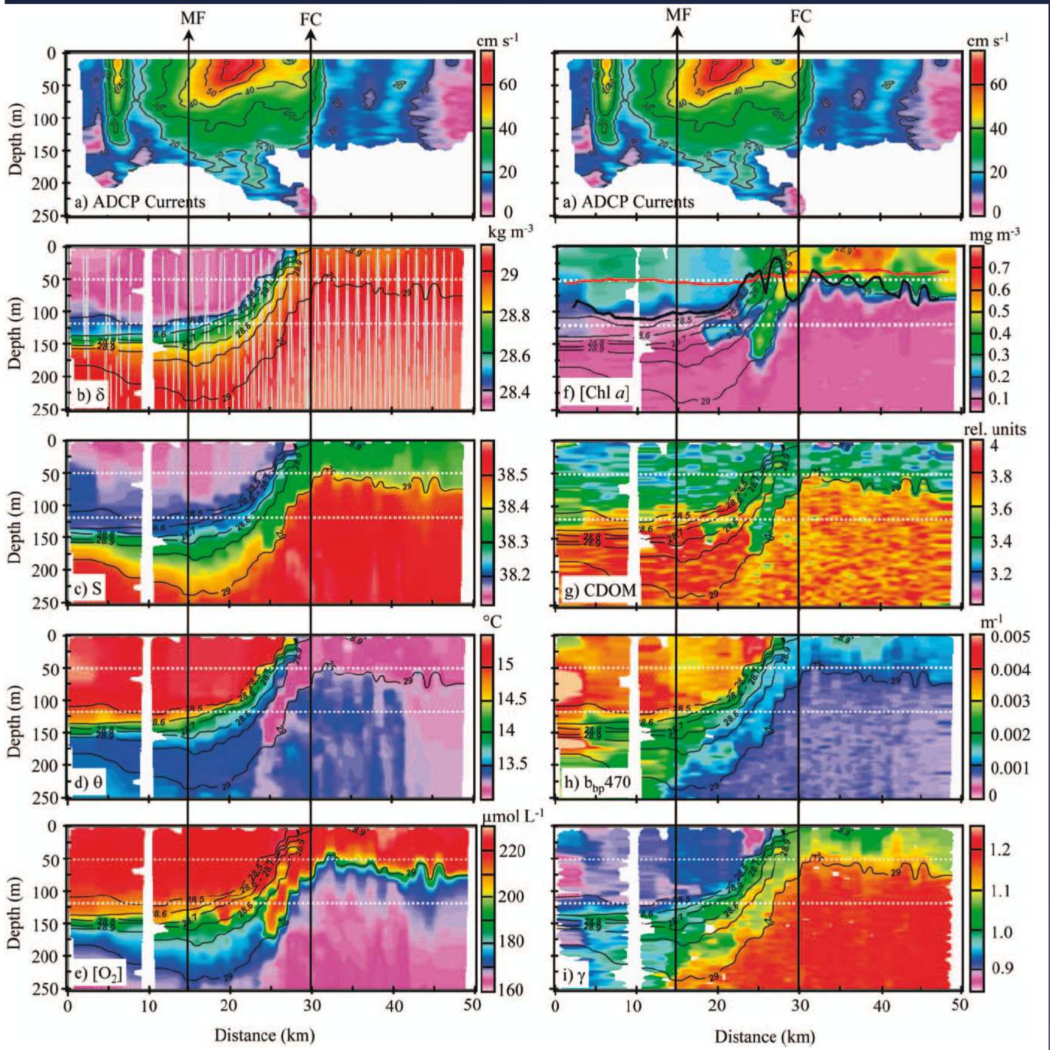


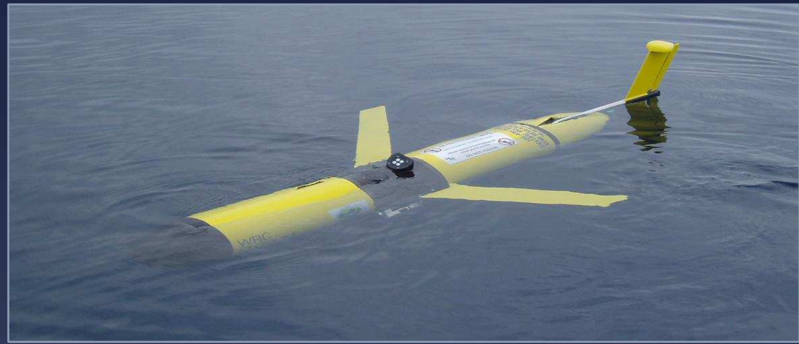
8 PROVBIO B floats in Med Sea (2), North Atalntic (2), NPG (2), SPG (2)

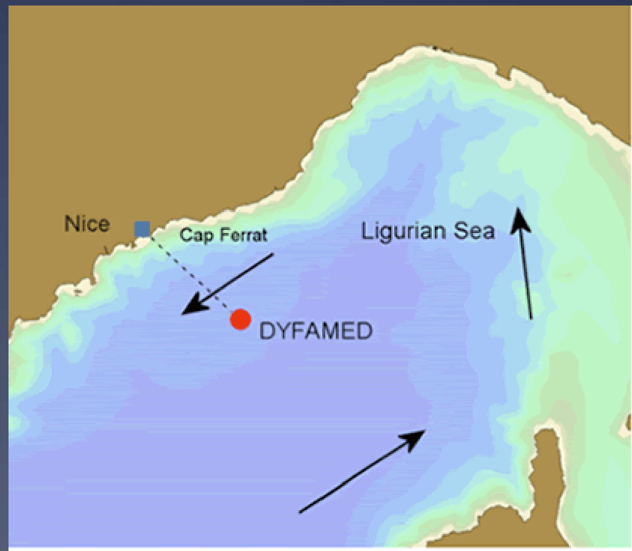
Bio-optical Glider



Bio-optical Glider







Niewiadomska et al. *L & O*, 2008

Optical sensors on floats and gliders

- ❑ Radiometers
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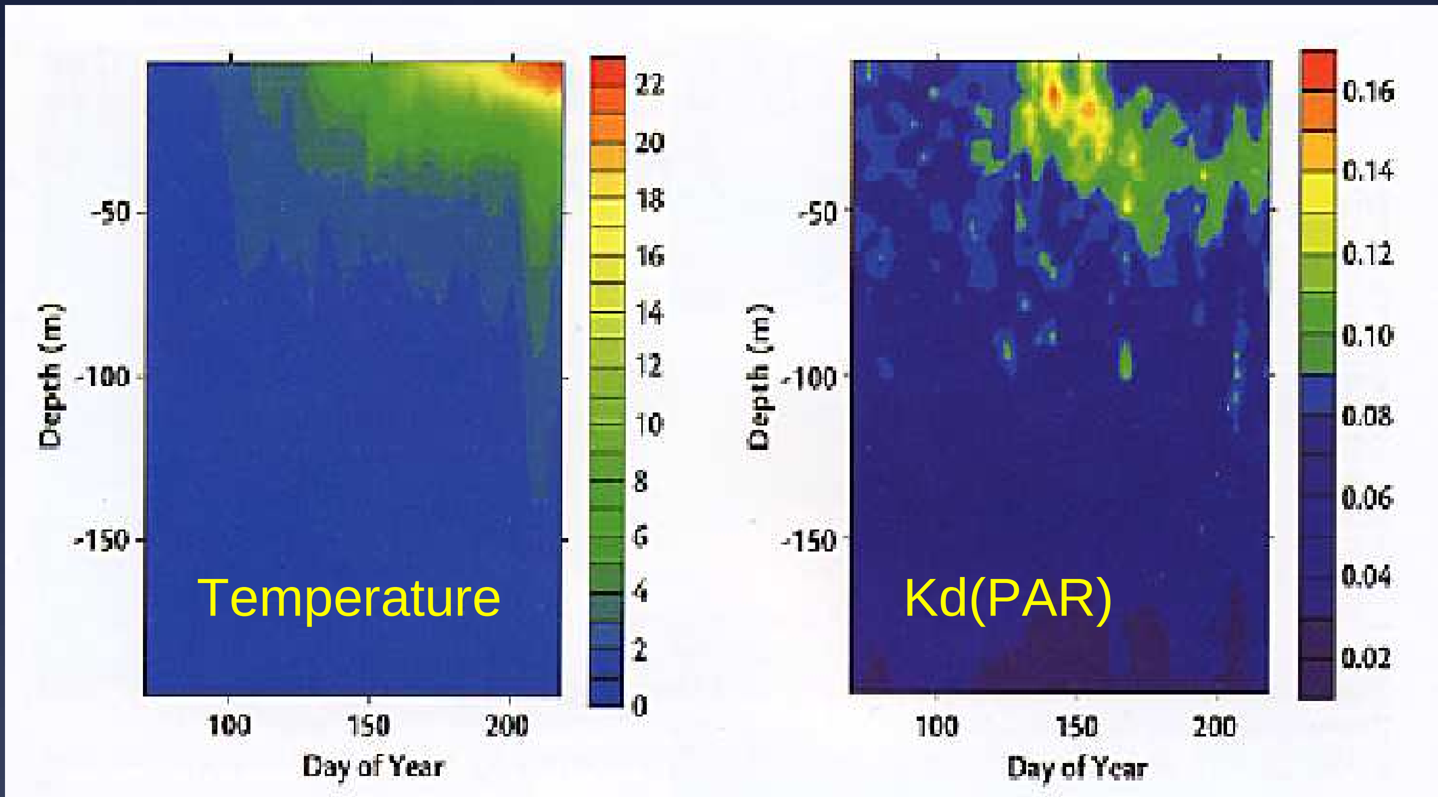
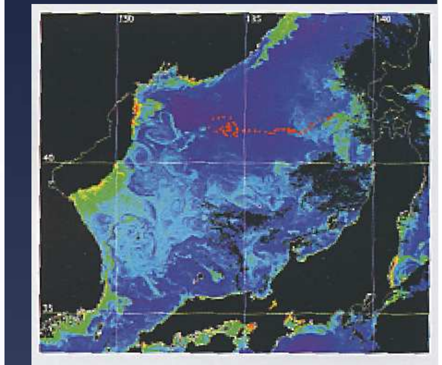
- ❑ Transmissiometers
- ❑ Backscattering metters

Radiometers

exemple : K-SOLO : SOLO float + radiometer PAR sensors



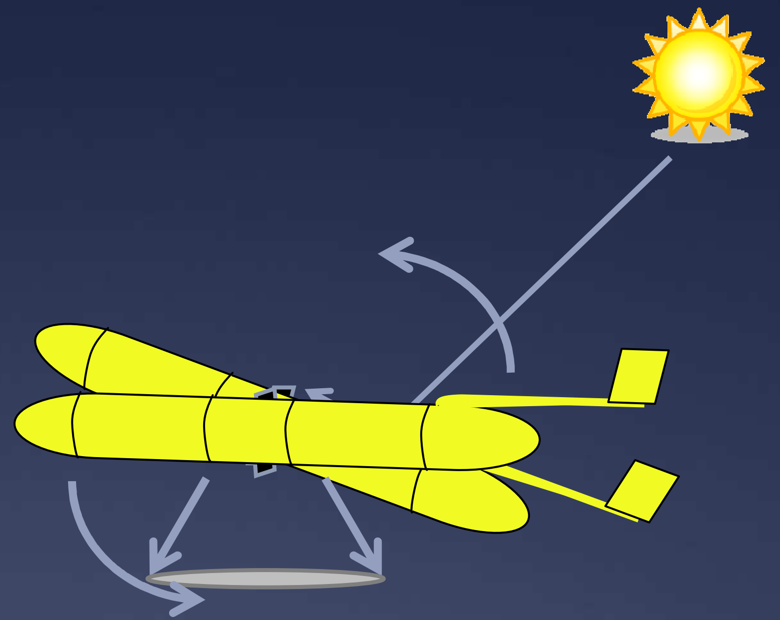


Experiment in the Japan Sea (Mitchell et al, 2003)

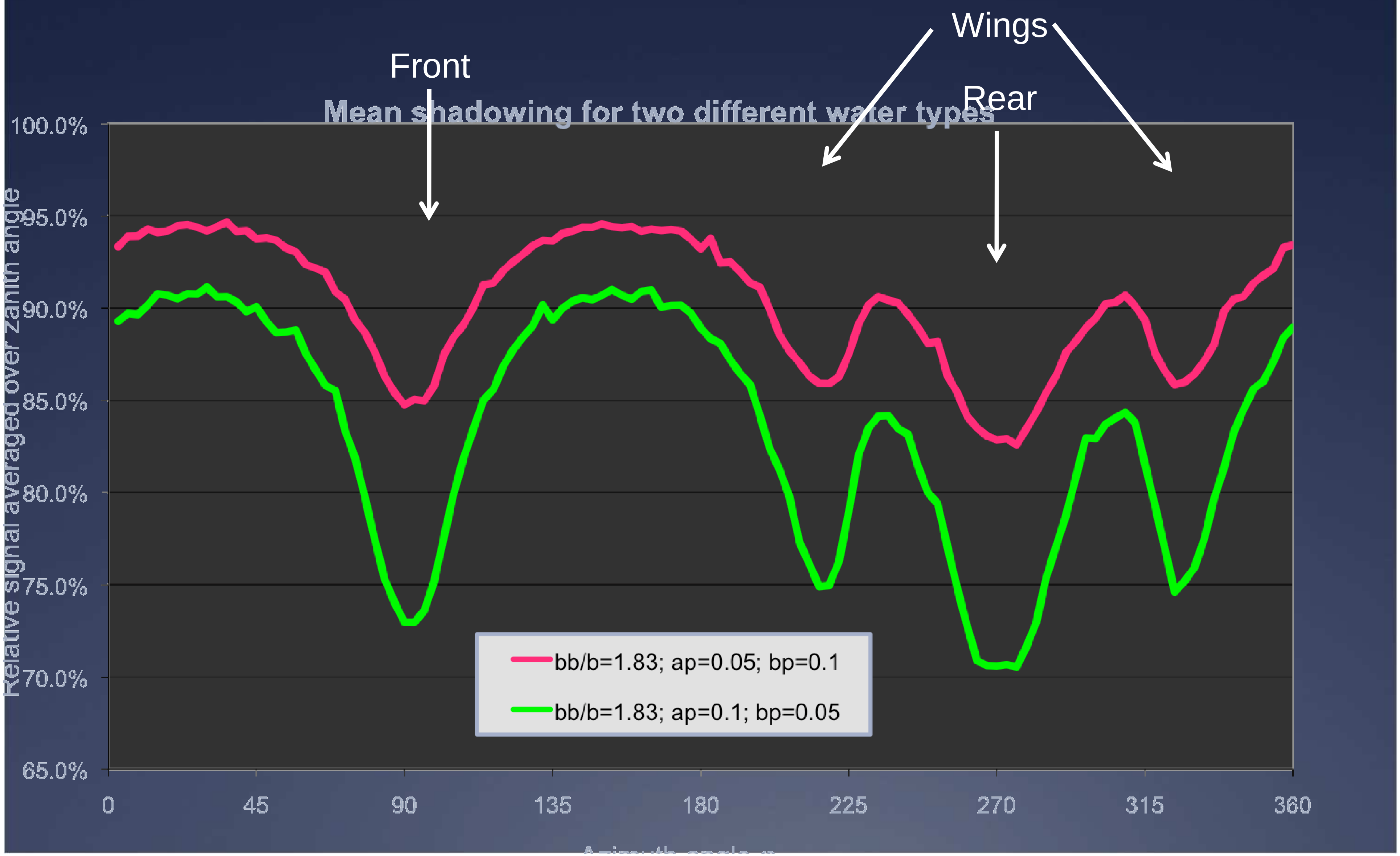
Multispectral / hyperspectral sensors : derivation of **Kd(λ)**, **R(λ)**. Inverse biooptical modeling on these properties can be used for the estimation of optically significant substances : $\mathbf{a_{CDOM}}$, $\mathbf{a_{phy}}$

Radiometers on gliders / profiling floats : issues of form factor effects

- Hull reflection
- Sensor tilt
- Self-shadowing



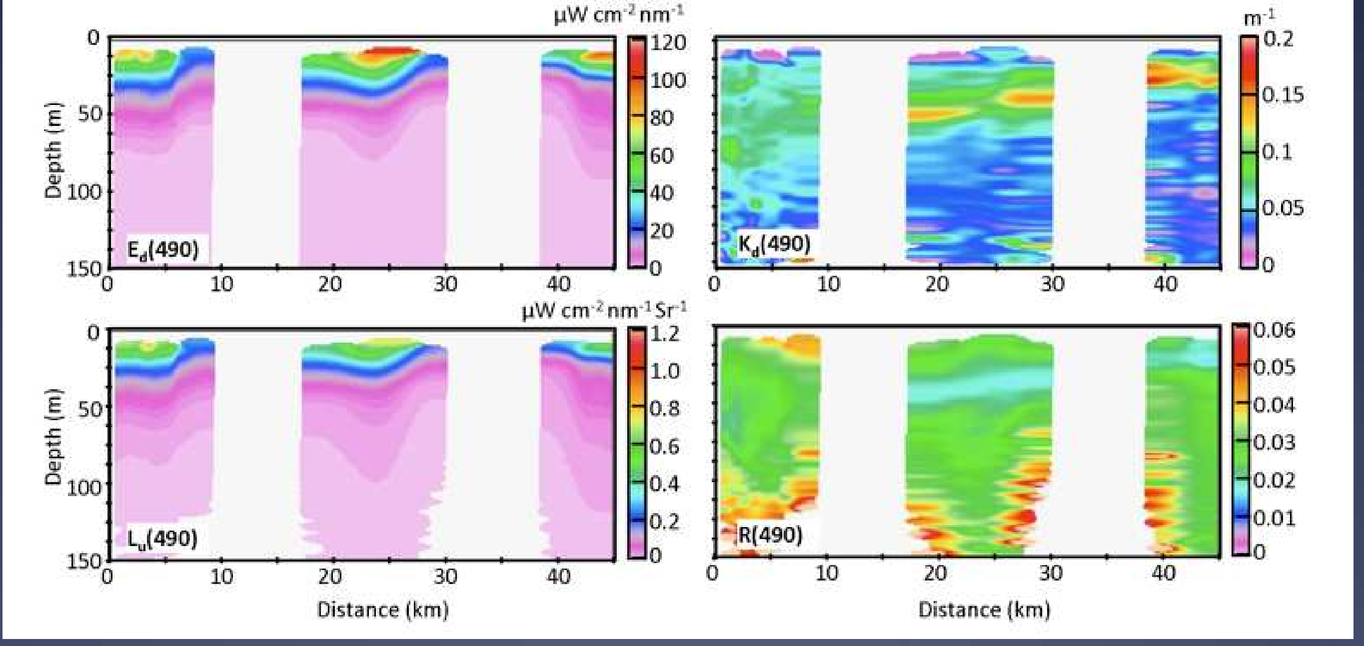
Self-shadowing Example



Radiometers

Not necessarily “good” sensors for a glider:

- shading issues : can be corrected by modeling, implementation can be improved.
- Measurement only during daytime: weakly relevant for the description of meso and sub-mesoscale processes.



A priori radiometers are easier to use on floats

- with iridium : surfacing at noon

Chla fluorometer

Fluorescence is likely the best technique to measure Chl*a* from gliders and / or profiling floats. But quite a number of issues to consider…

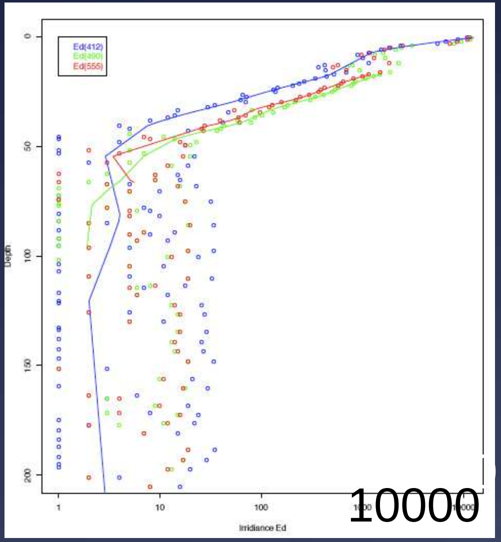
$$F = [Chla]\ E\ a^*\ \Phi f$$

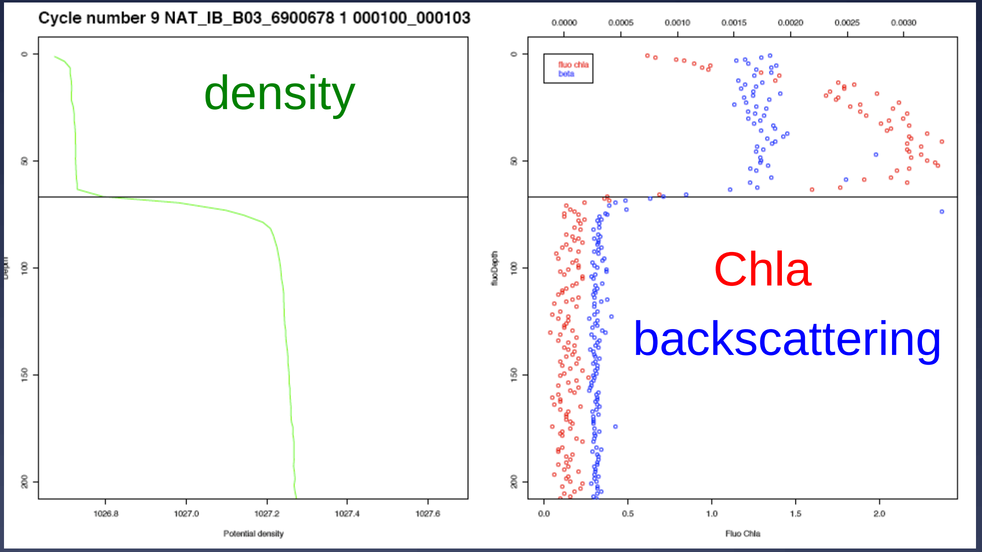
The estimation of [Chla] is dependant on:

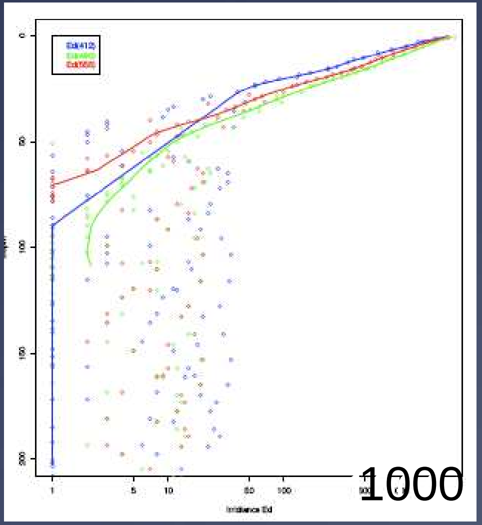
- an instrument term (E, light source) which might vary over time
- phytoplankton-dependant terms (a^* and Φf) which might vary according to environmental conditions

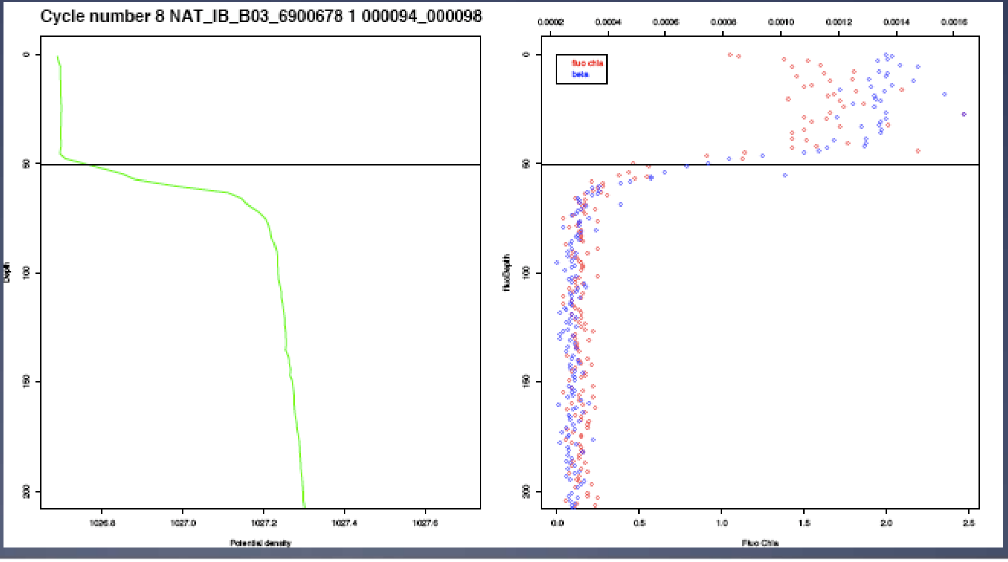
Procedures for retrieving accurate Chla measurement from fluorescence have to be developed

Chla fluorescence: Issue of non-photochemical quenching at noon: exemple from floats in the Irminger Sea

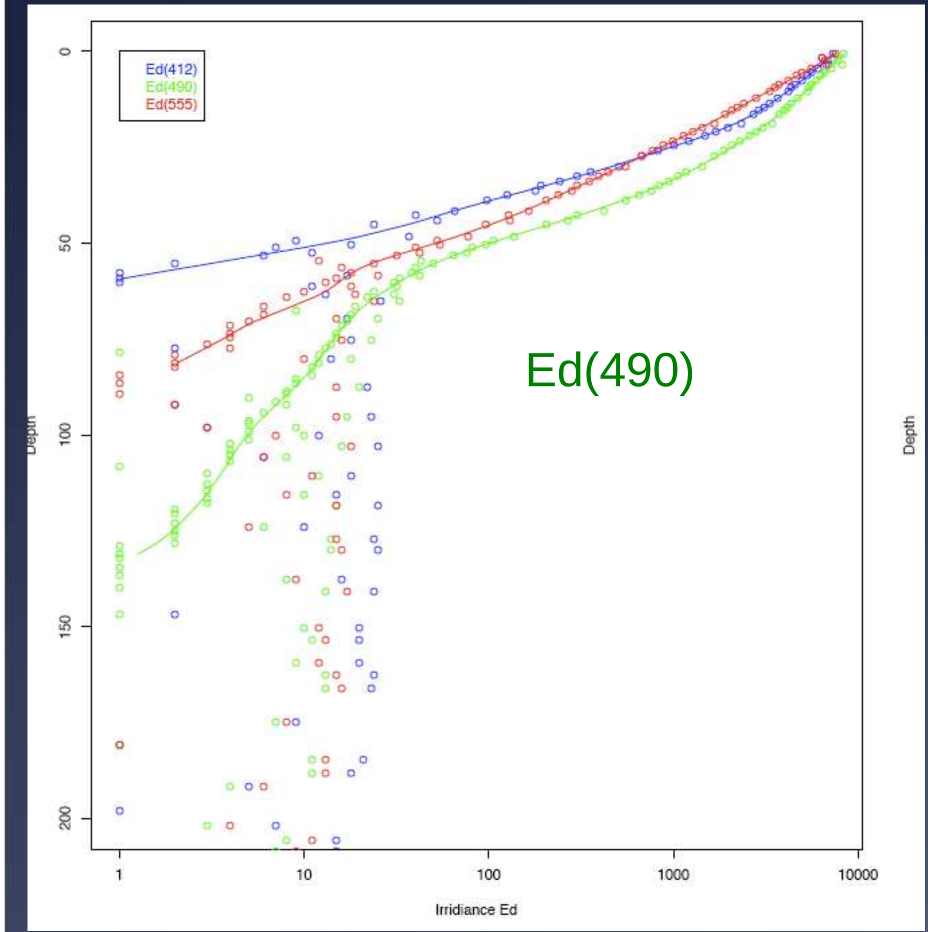


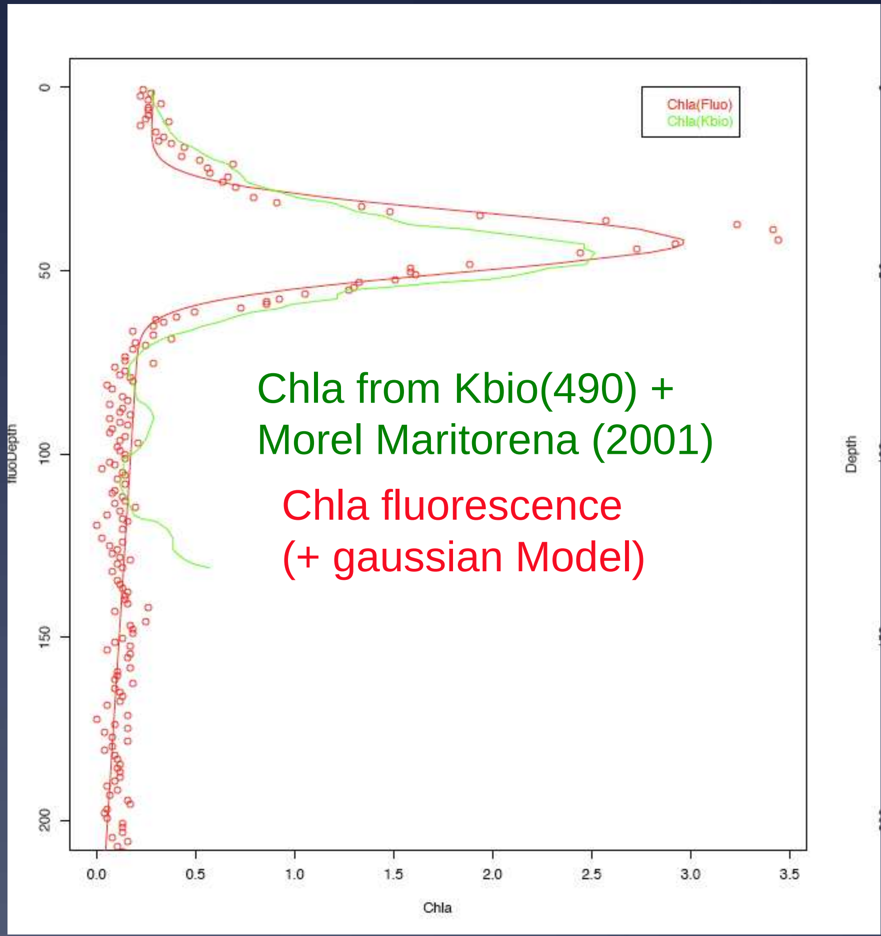






Chla fluorescence: using radiometric data for improving Chla estimates

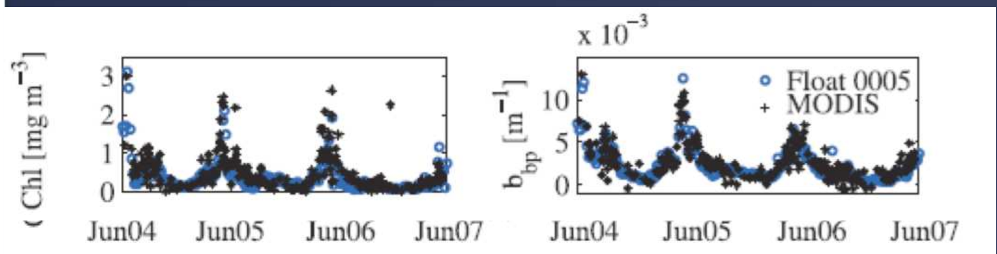




Chl*a* fluorescence: issues of « maintaining » calibration over long term, « cross-calibration » of an array of platforms

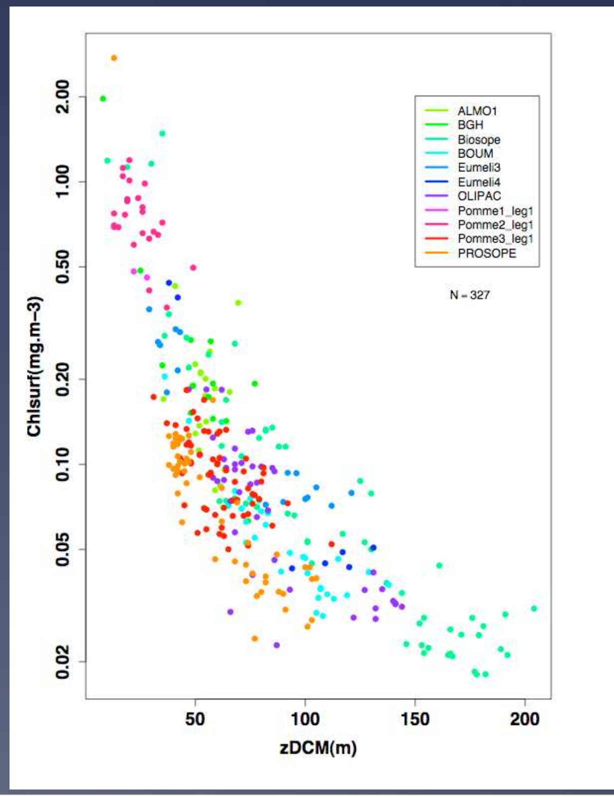
<u>New methods required</u>: essential for ensuring self consistency of data acquired by various float / fluorescence sensors.

- <u>using remote sensing, when available</u>



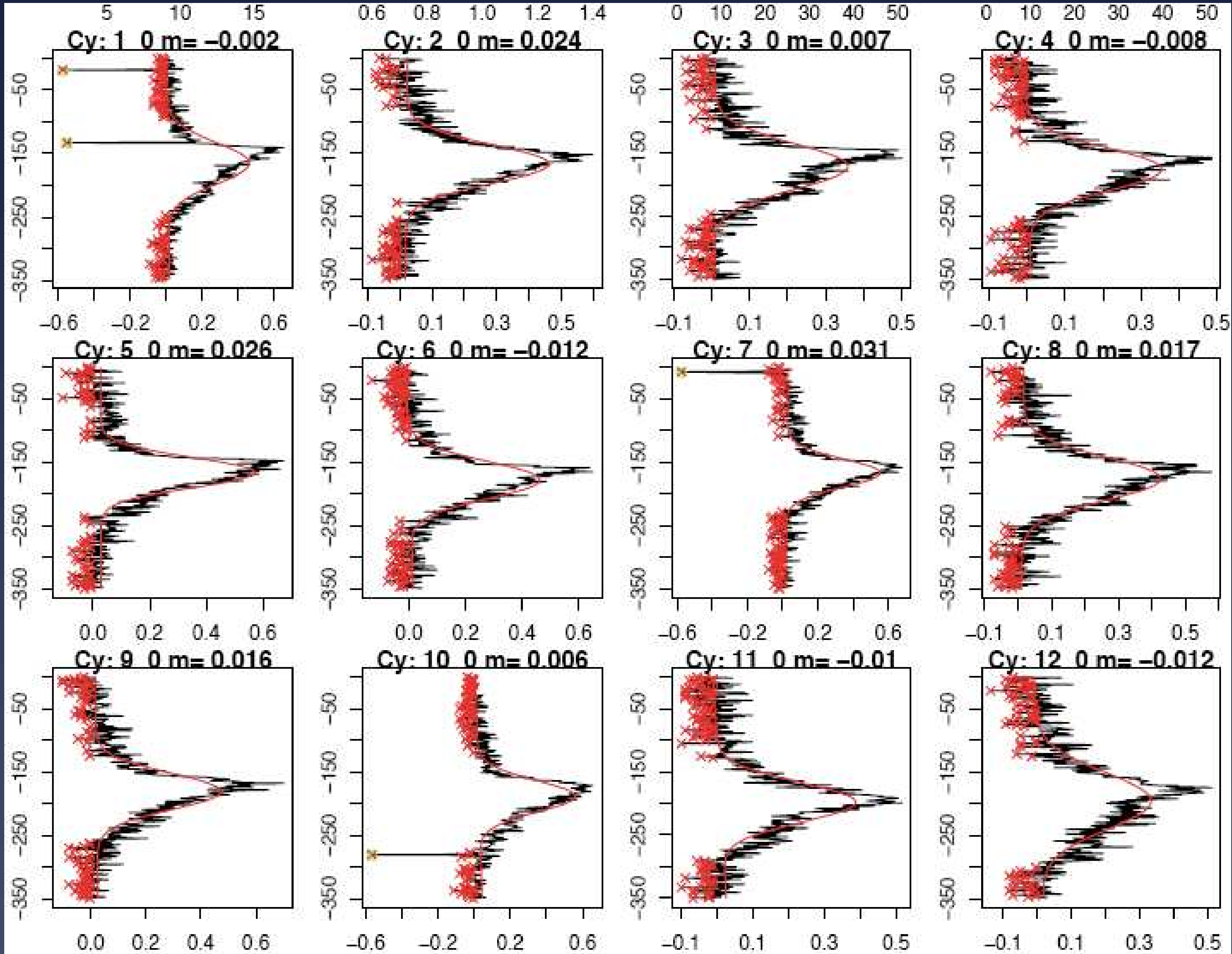
Boss et al., 2008

- <u>Relating unambigous form properties to concentration</u>



Mignot and Claustre, unpub.

Chla fluorescence : developping QC procedure



to be implemented as part of the CORIOLIS GDAC center

Scattering - backscattering - attenuation

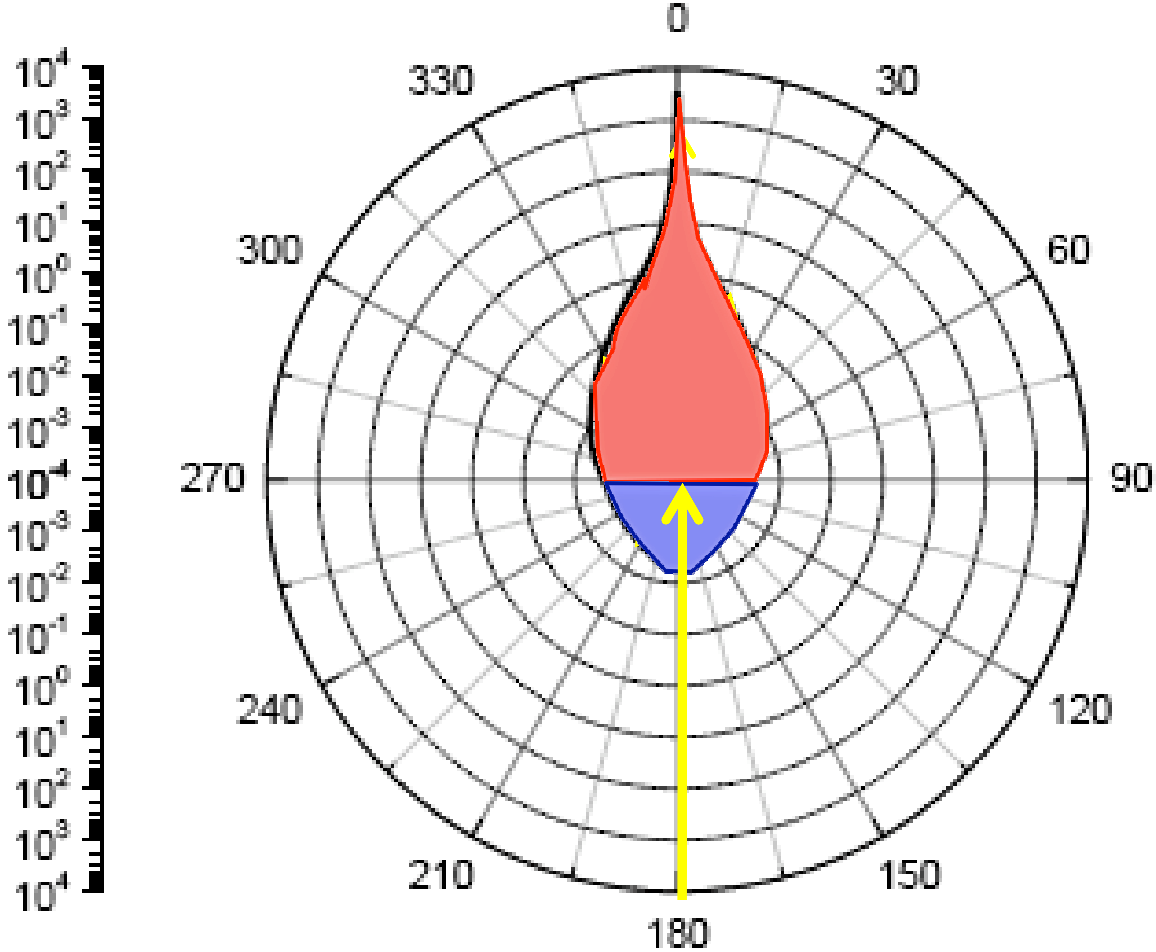
⇔ particule load (number, size) measurment ⇔ POC proxy in open ocean

$b_f + b_b$

$b_f >> b_b$

$b_b / b_f \approx 1\%$

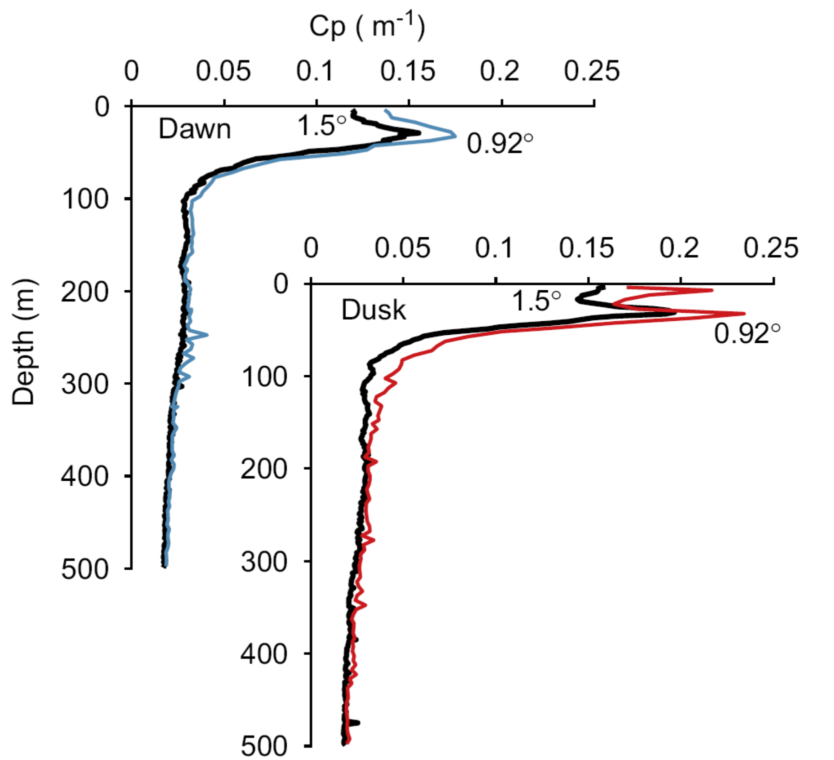
scattering intensity



potential sensitivity issues for backscattering detection (in clear waters)

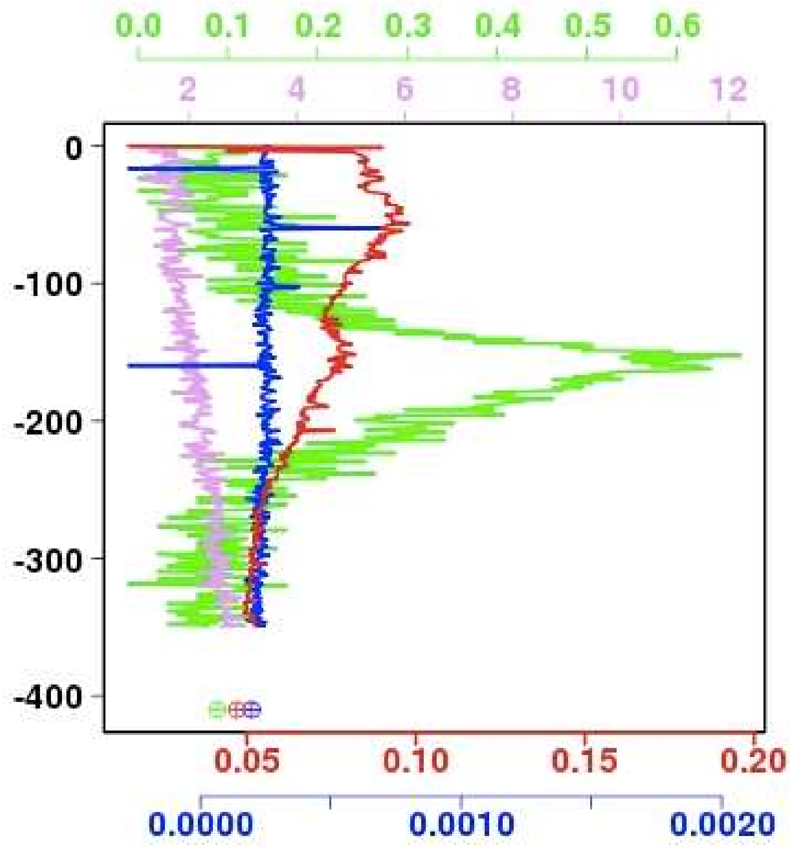
potential accuracy issues for sensors (tranmissiometers) whose detection depends on acceptance angle on the forward direction)

Scattering - backscattering - attenuation



acceptance angle effect Bishop and Wood (2008)

Attenuation, backscattering, Chla and CDOM in the clearest waters (South Pacific Gyre)

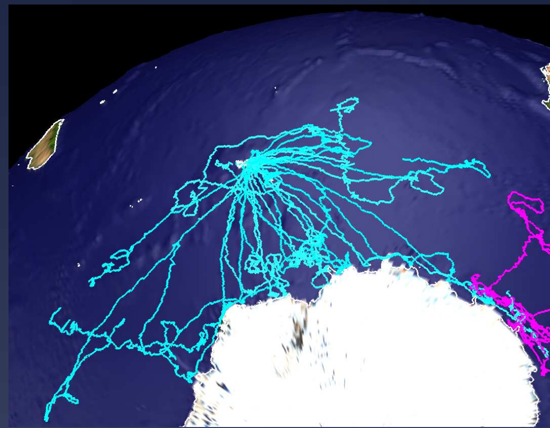


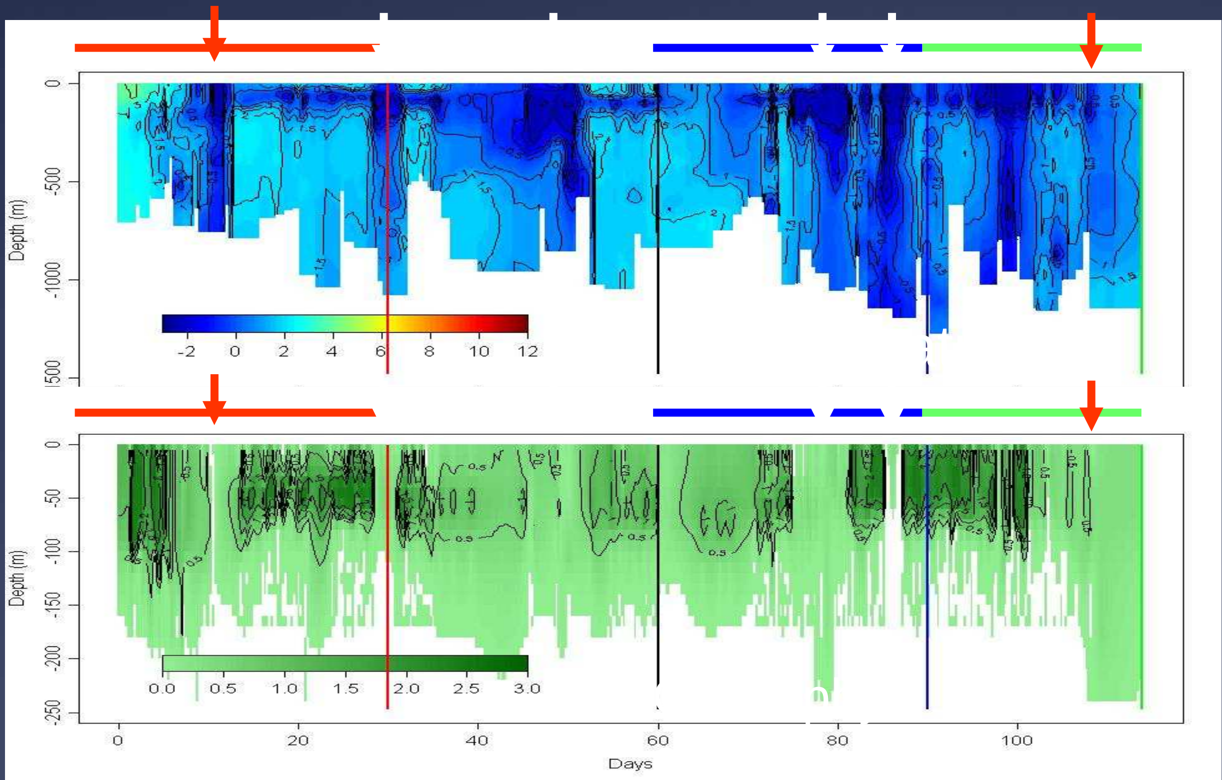
calibration / drift of active sensors

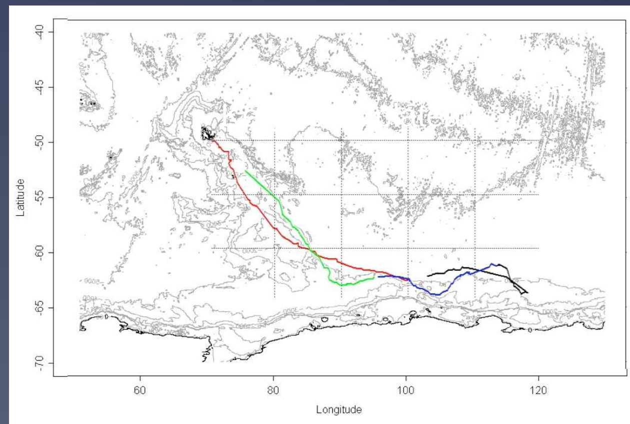
Reference, easy to use calibration material should be produced and used before each deployment (possible for fluorometer)

Bio-physical investigations in the Southern ocean

« Deep » elephant seal + T sensor + Chla fluorometer







Guinet (2008), pers. com.

Conclusions

• Remote oceanography for open ocean water is becoming a reality

• The new *in situ* platforms nicely complement remote sensing by allowing the ocean interior to be described with unprecedented space / time resolution

• At the moment investigations using these “remote” *in situ* technique are essentially restricted to mesoscale / processes studies

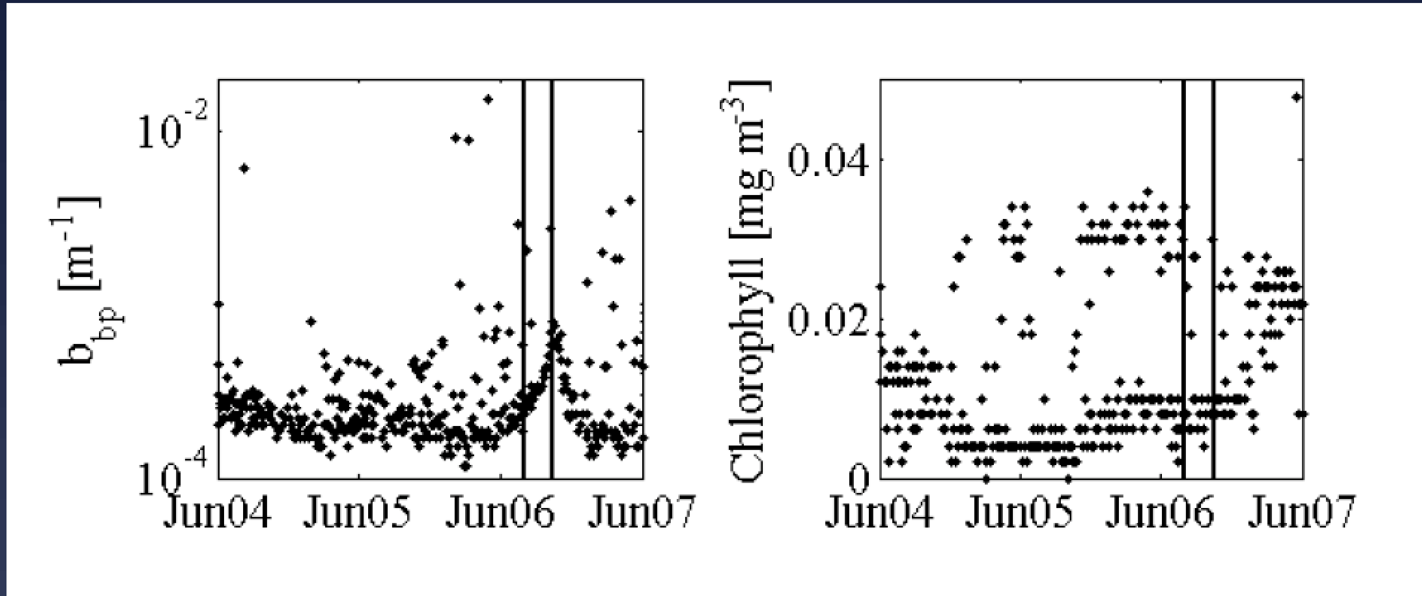
• If the community want to take advantage of these new techniques for global scale / decadal change studies (and others), it has to develop (from the very beginning) coherent data set (like for time series of ocean color data).

• Thus, in the same time as implementation plans are beginning to be discussed, it is also crucial that our community begin to discuss and size the procedures for sensor calibration, various platform “cross-calibration” as an integrated part of future data distribution (real time and delayed mode).

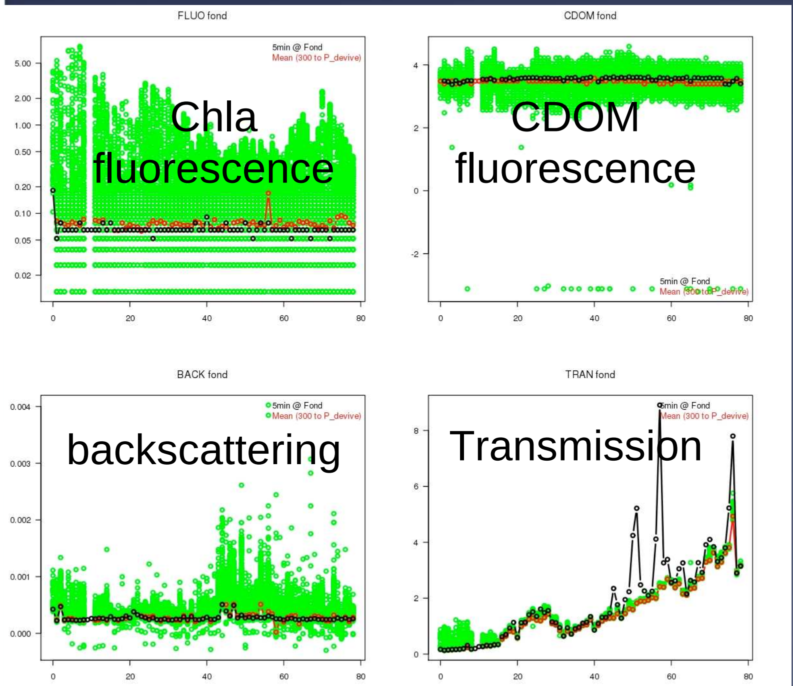
Other biogeochemical / bio-optical platforms

Elephant seal

calibration / drift of active sensors



From Boss et al. (2008)



<u>Sensors looking downwards are not sensitive to accumulation of material: very important for long term deployment</u>