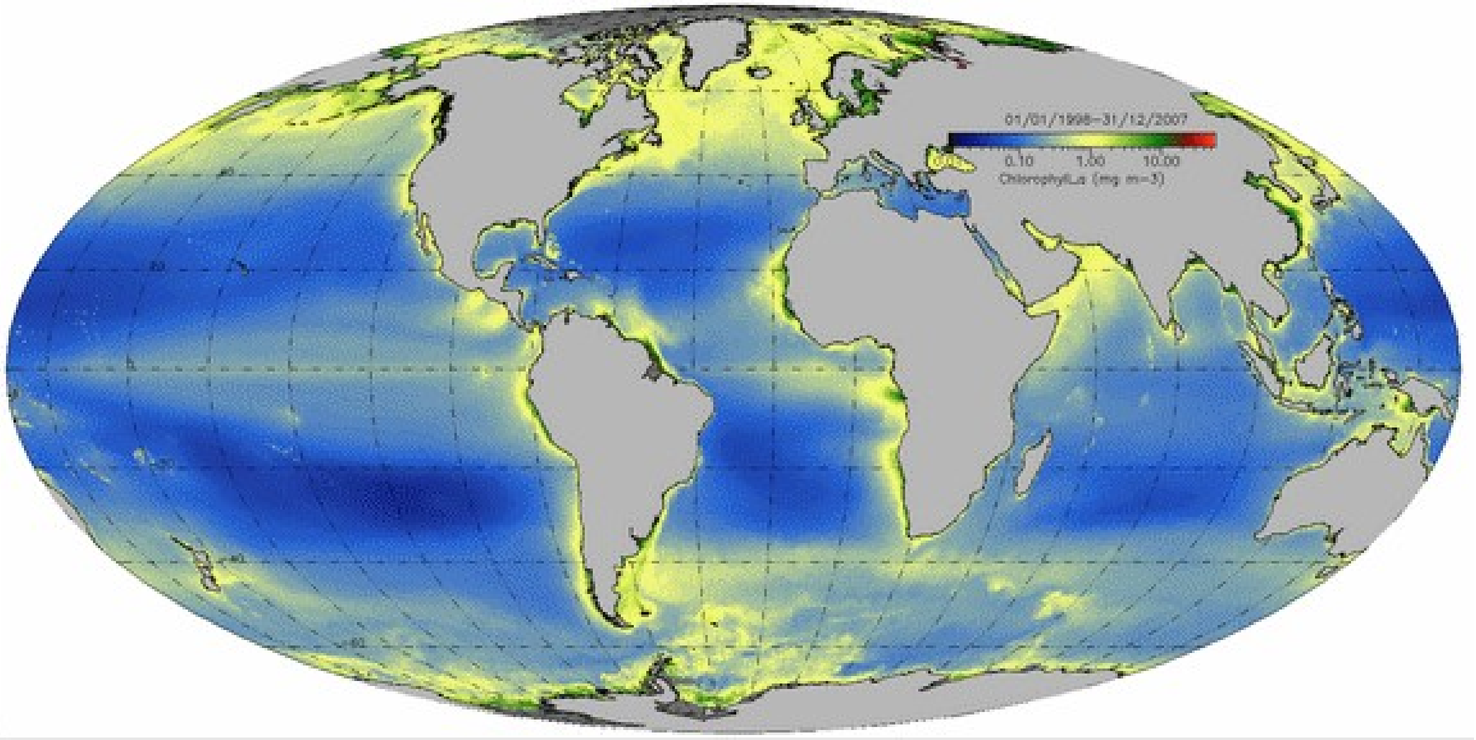
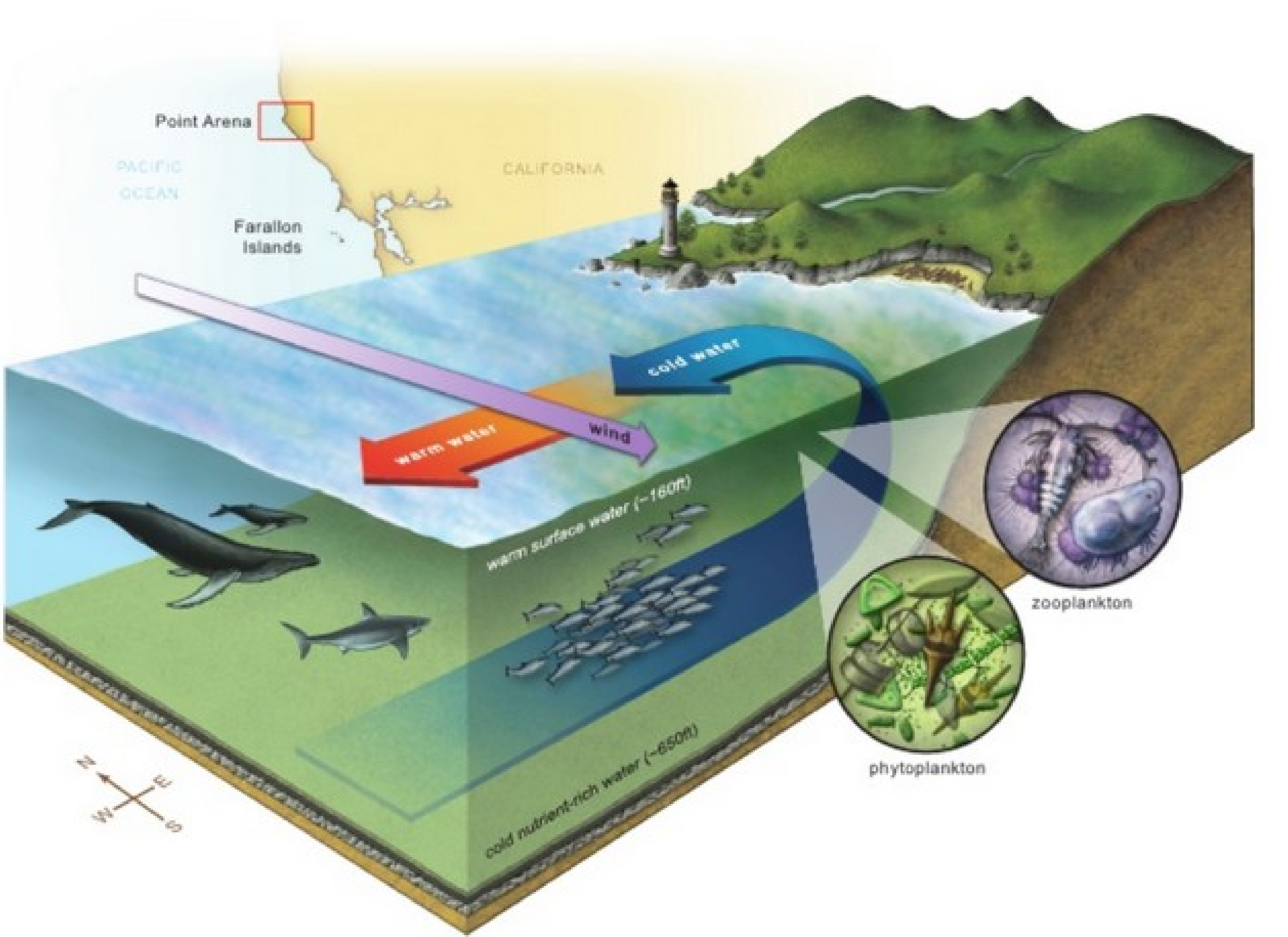
Trends in Primary Production in the Canary Upwelling system



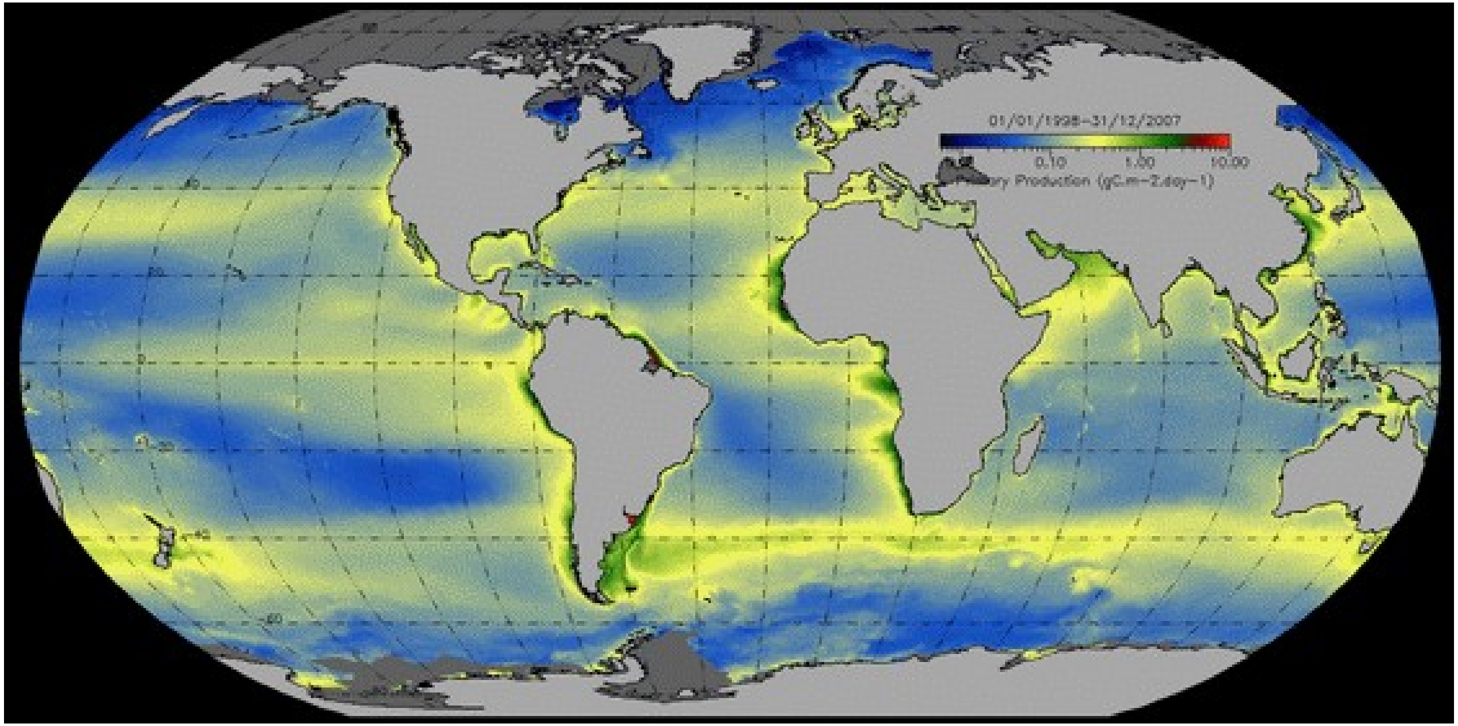
H.Demarcq

Institut de Recherche pour le Développement
FRANCE

TRAINING WORKSHOP ON “THE CANARY CURRENT EASTERN BOUNDARY UPWELLING SYSTEM”
OCEAN SCIENCE CENTRE MINDELO (OSCM)
C/O INSTITUTO DO MAR MINDELO 10-12 MARCH 2020


Point Arena
PACIFIC
OCEAN
CALIFORNIA
Farallon
Islands
wind
cold water
warm water
warm surface water (~160ft)
cold nutrient-rich water (~650ft)
zooplankton
phytoplankton
N
E
S
W

Global Primary production (VGPM model)

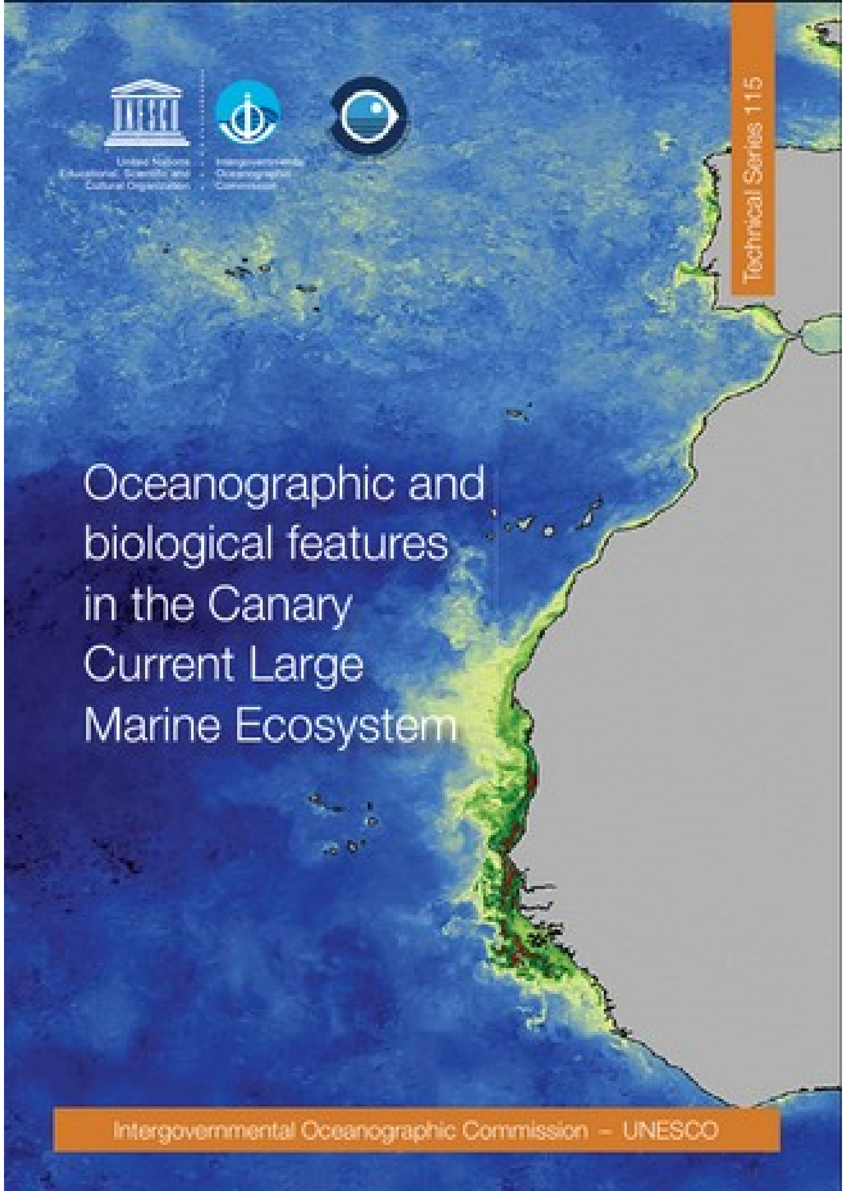


Upwelling systems : A simple calculation based on SeaWiFS data of chlorophyll a concentration (a proxy for the phytoplankton biomass) from 1998 to 2007 shows that despite representing only 1.5% of the oceanic surface between 45°S and 45°N, upwelling systems account for 9.3% of the biomass of primary producers.
This computation is based on the limit of 0.5 mg of chlorophyll a as the best limit to delineate the productive part of the upwelling region as used is previous studies

United Nations
Educational, Scientific and
Cultural Organization

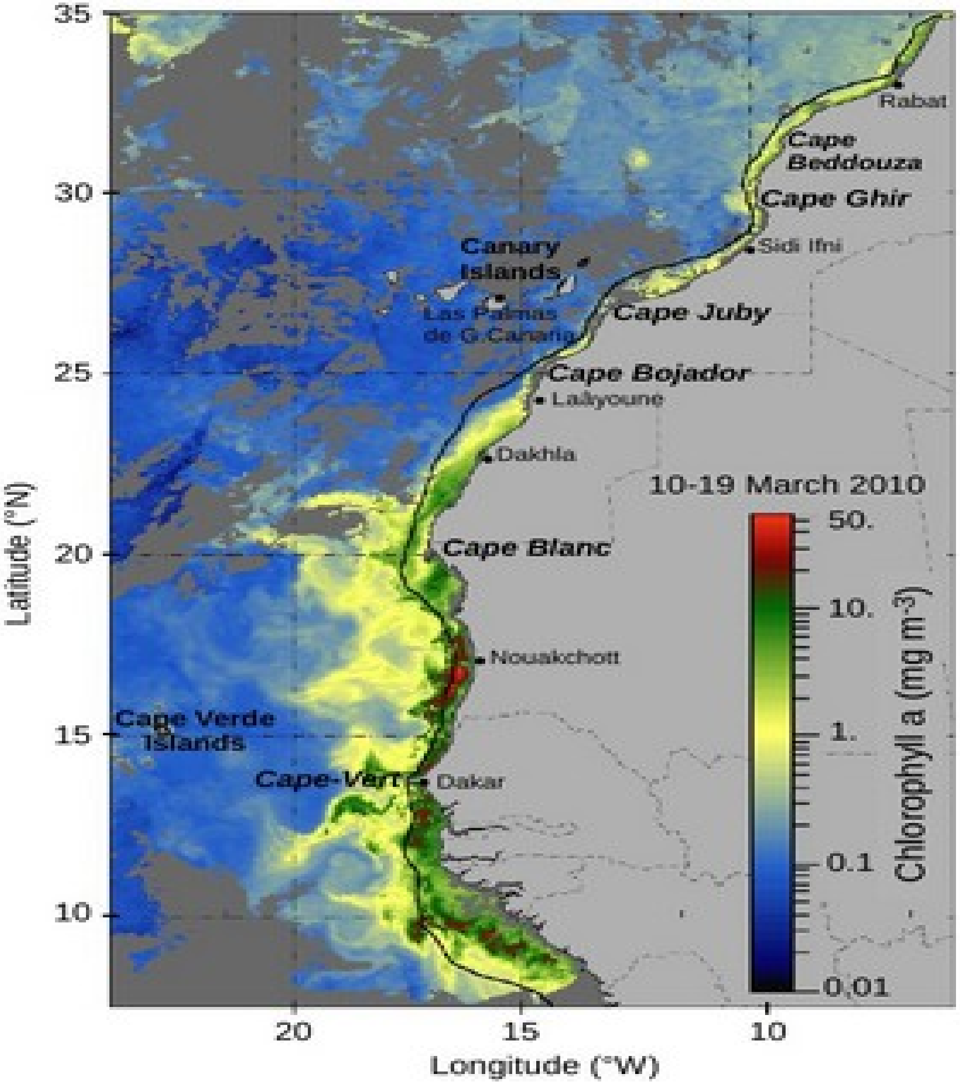
Intergovernmental
Oceanographic
Commission

Technical Series 115



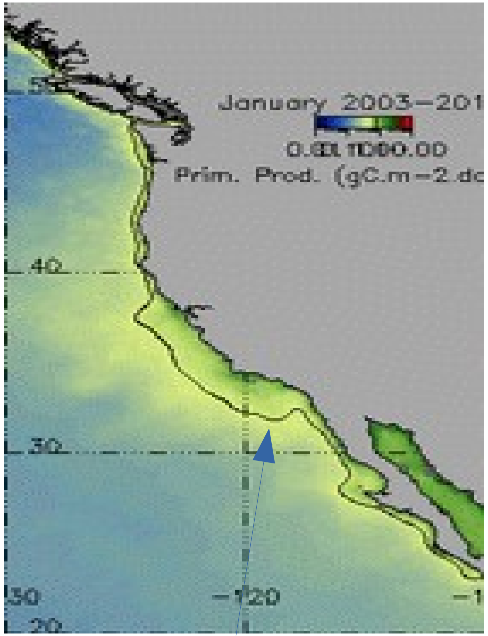
Oceanographic and biological features in the Canary Current Large Marine Ecosystem

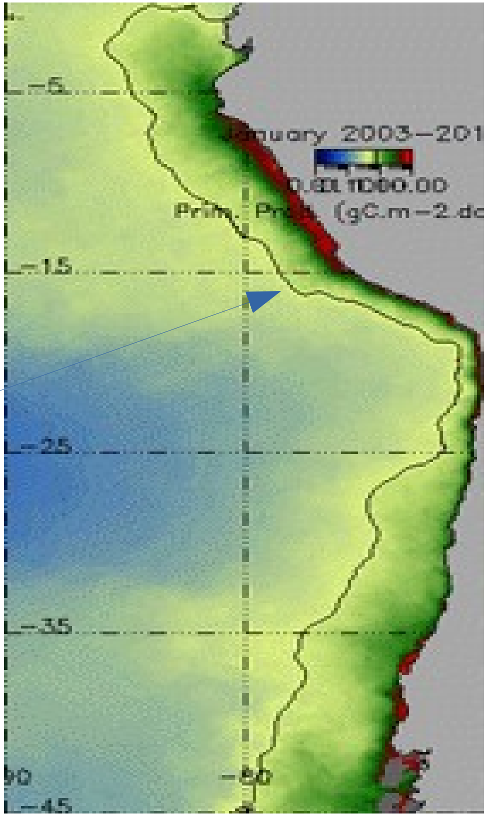
Intergovernmental Oceanographic Commission – UNESCO

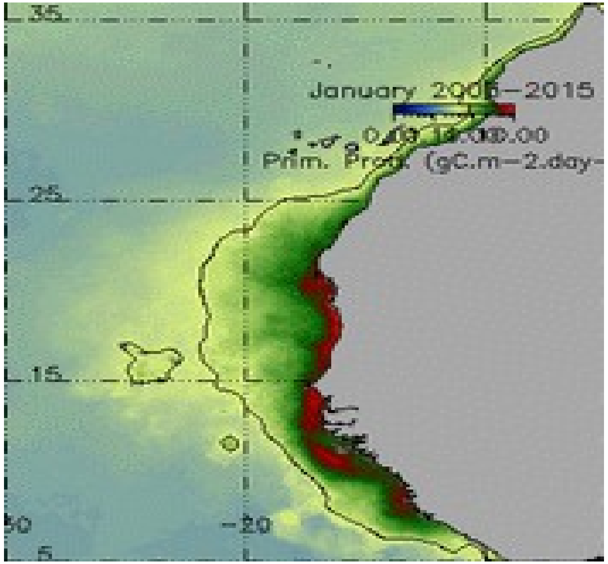


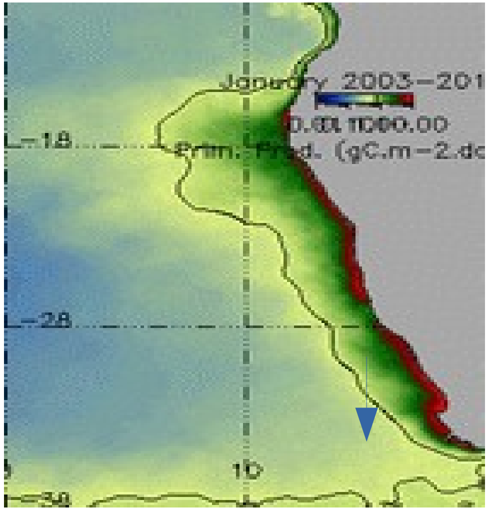
Average chlorophyll *a* computed from **MODIS** sensor data for the period 10-19 March 2010, during the maximum southward extension of the trade winds concomitant of the maximum intensity of the Mauritanian-Senegalese upwelling. The 200m bathymetry contour (black line) is added

Whole productive area (up to the limit 0.8 mg m^{-3}) vs extracted area [0,100]km



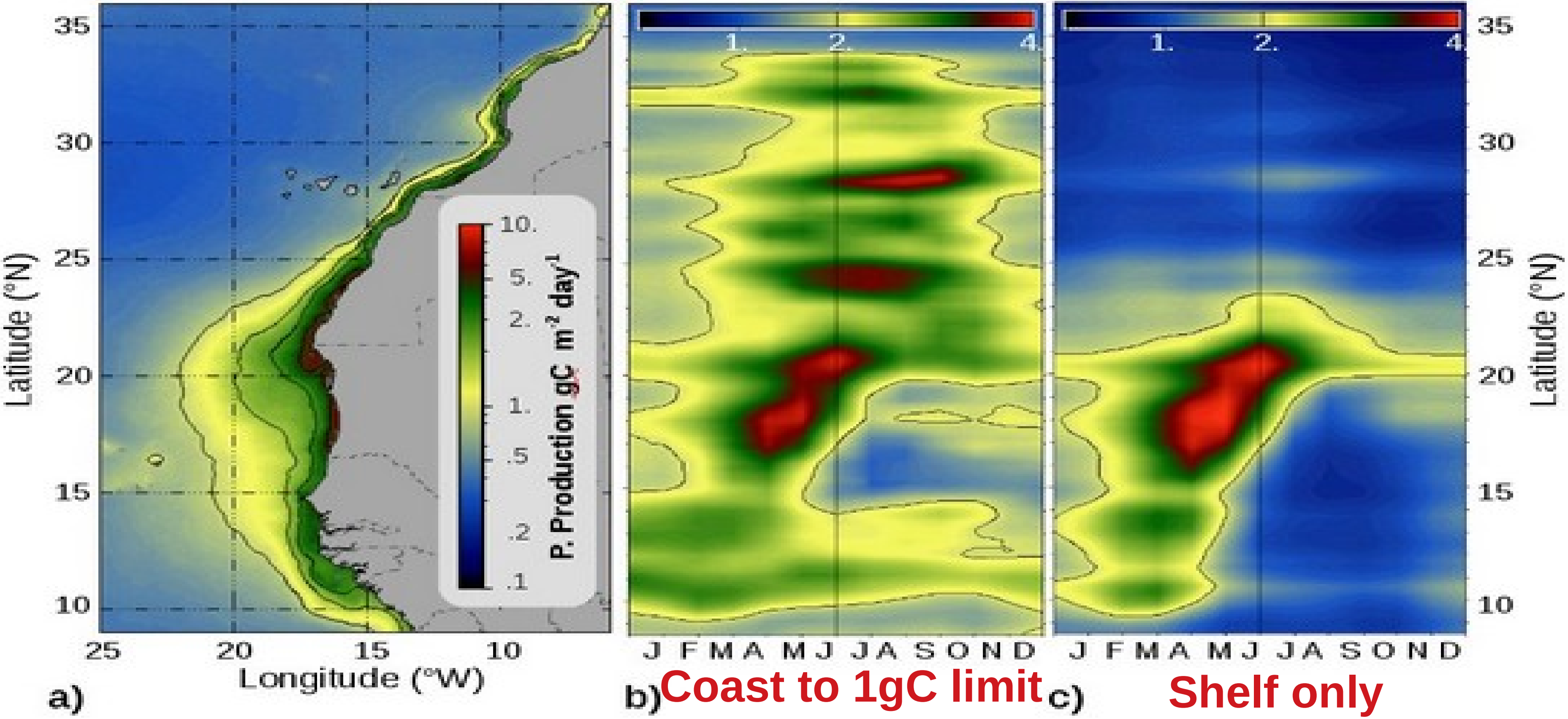






limit 0.8 mg m^{-3}

Spatio-temporal data integration

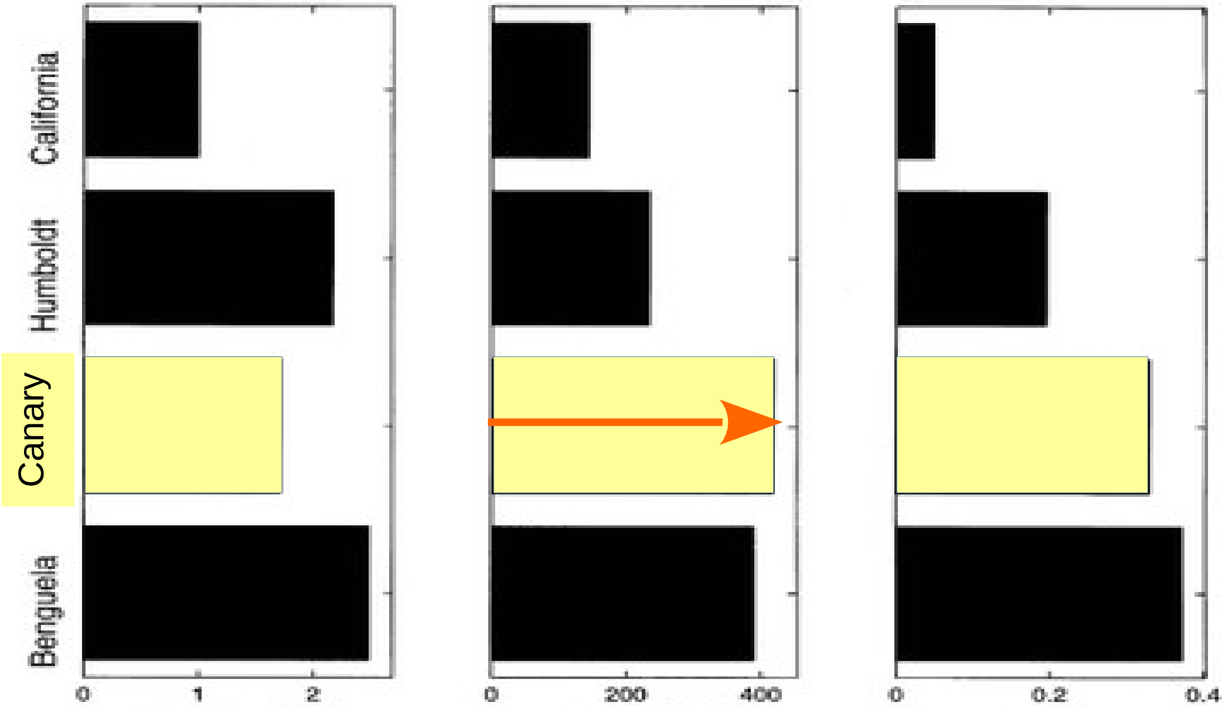


Coast to 1gC limit

Shelf only

Annual average of the NPP (VGMP model), values 1 gC m^{-2} day^{-1}, 2 gC m^{-2} day^{-1} and 3 gC m^{-2} day^{-1} are contoured, b) local average from the coast to the value 1 gC m^{-2} day^{-1} (most distant contour in figure 4.4.2a), c) integrated Zonal average from the coast to 500 km. All values are in gC m^{-2} day^{-1}. Isovalue 2 gC m^{-2} day^{-1} is contoured in b) and c).

M.-E. Carr / Deep-Sea Research II 49 (2002) 59–80



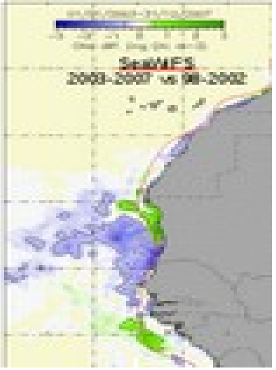
PP (mg C m^{-2} d^{-1})

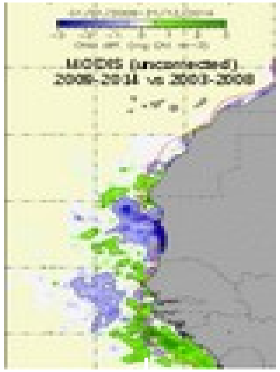
Area (10^3 km^2)

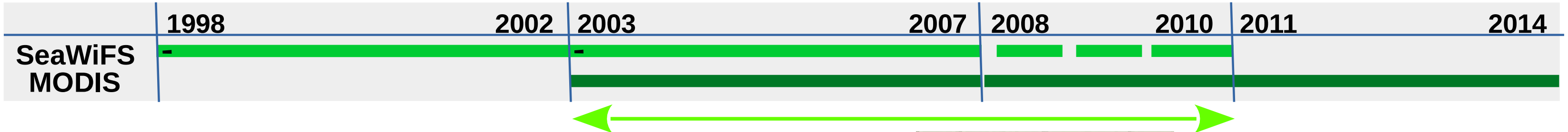
Annual PP (Gt C y^{-1})

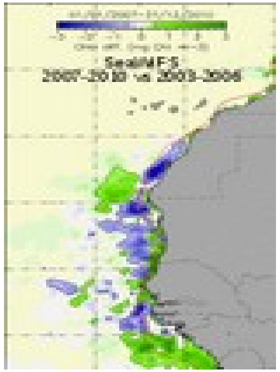
Combinations of trends by sensor (SeaWiFS / MODIS)

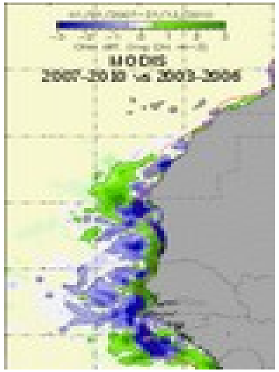
see also: Demarcq and Benazzouz 2015 6.4 Trends in phytoplancton and primary productivity off northwest Africa, in Oceanographic and biological features in the Canary Current Large Marine Ecosystem .
http://unesdoc.unesco.org/images/0023/002332/233299E.pdf



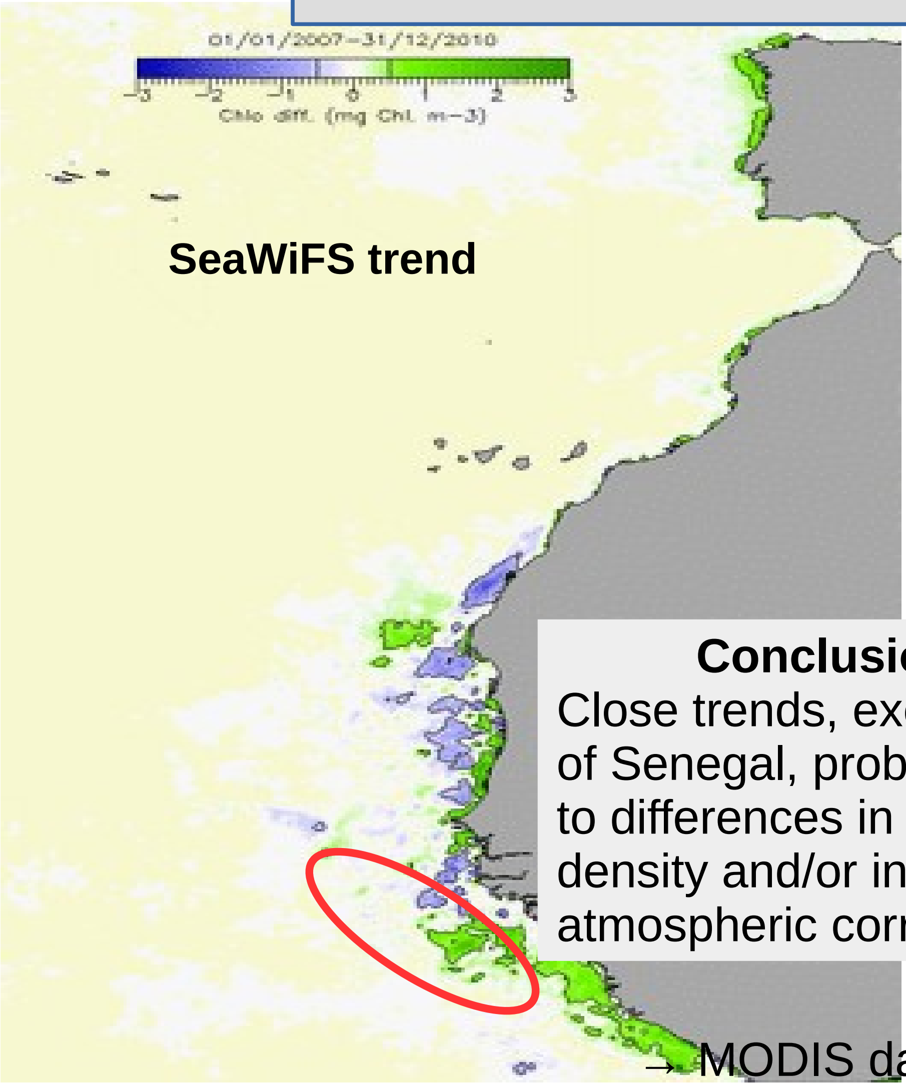




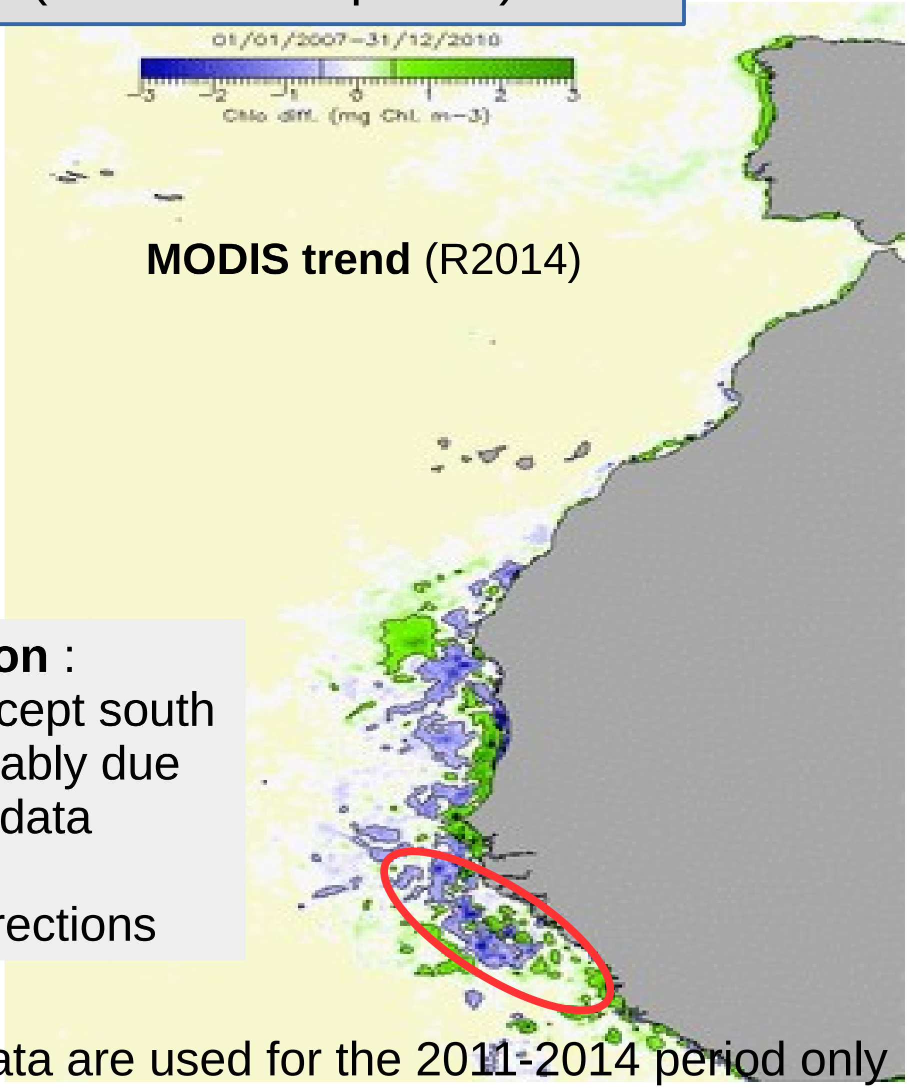




2003-2010 (full common period)



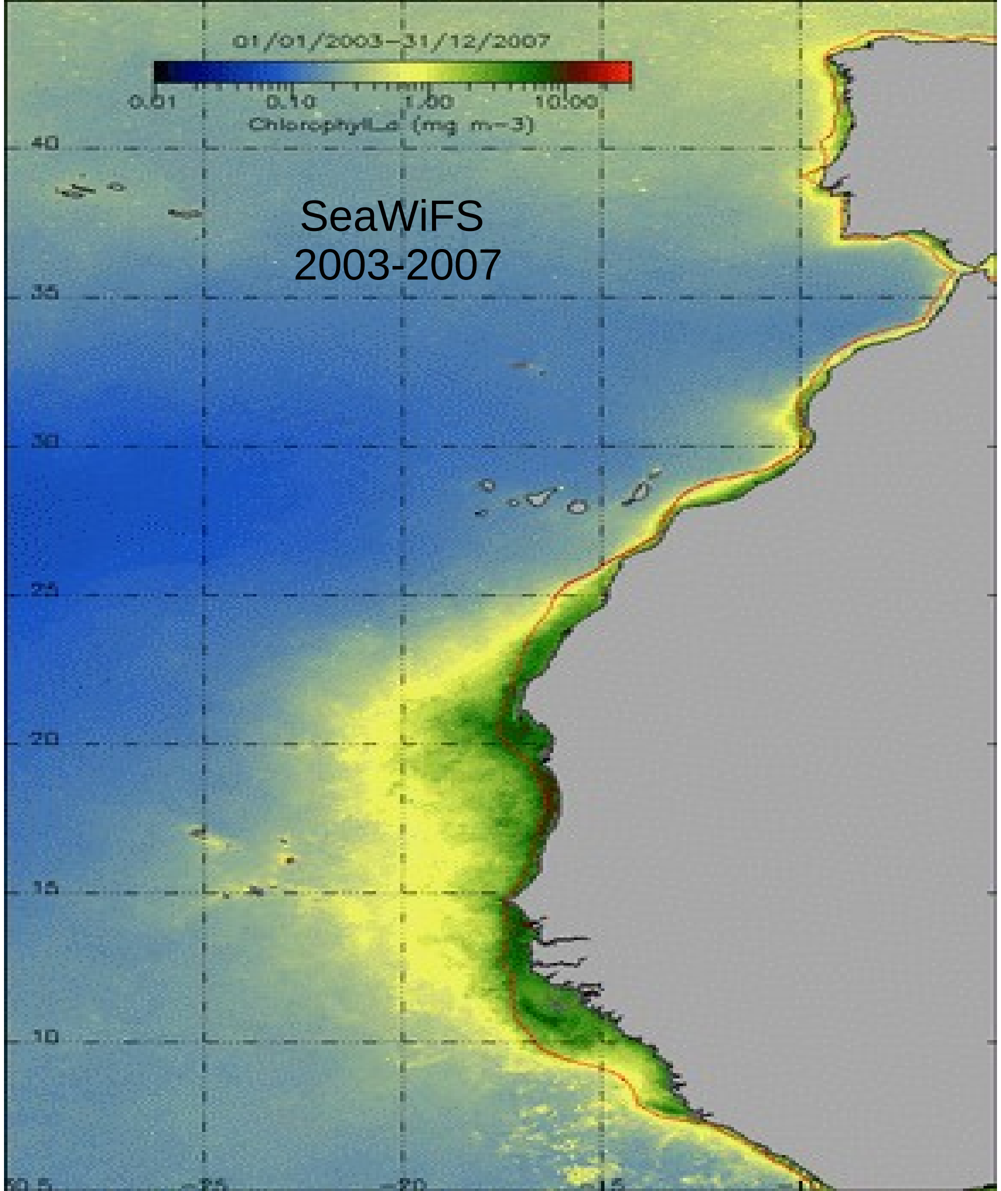
SeaWiFS trend

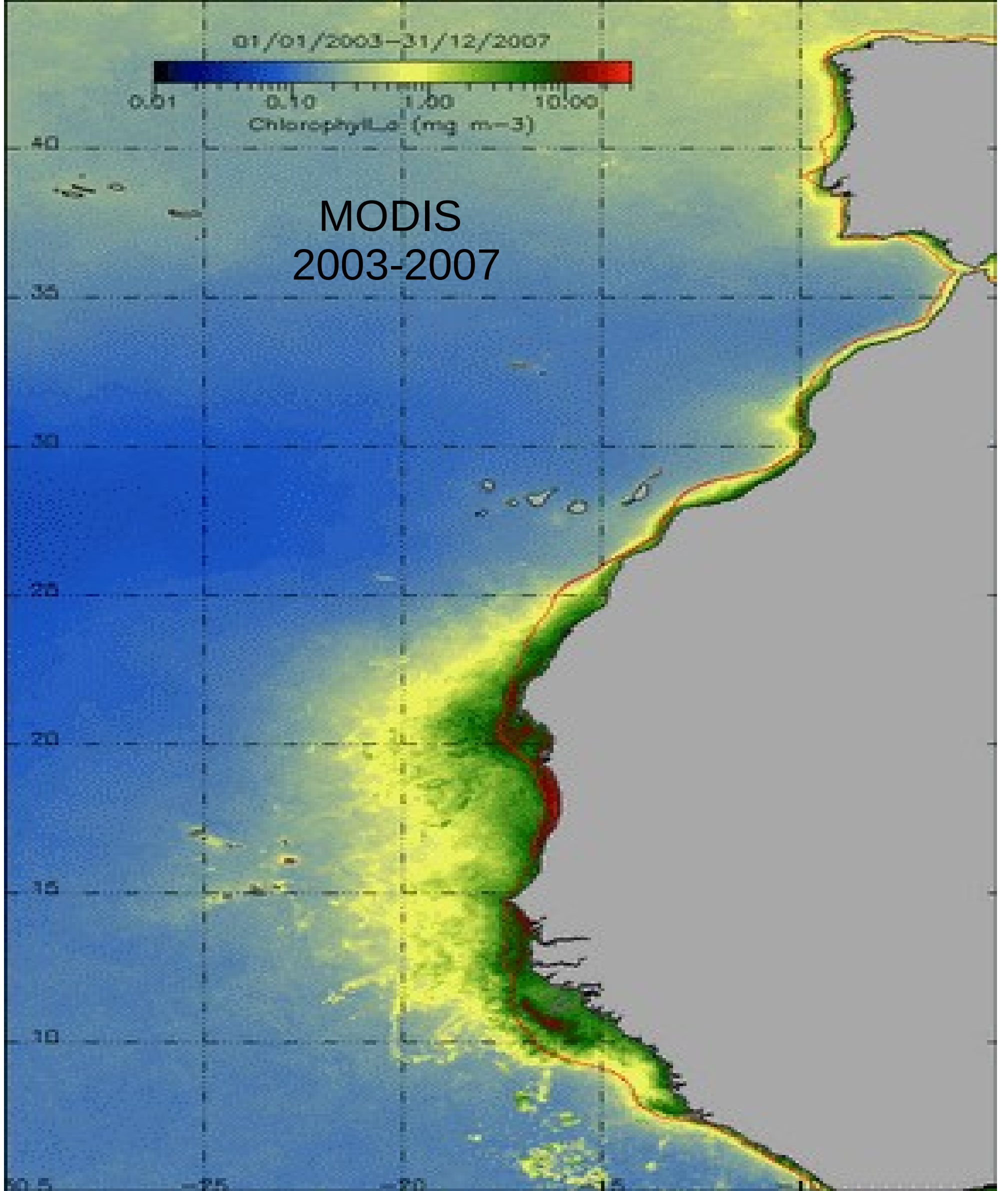


MODIS trend (R2014)

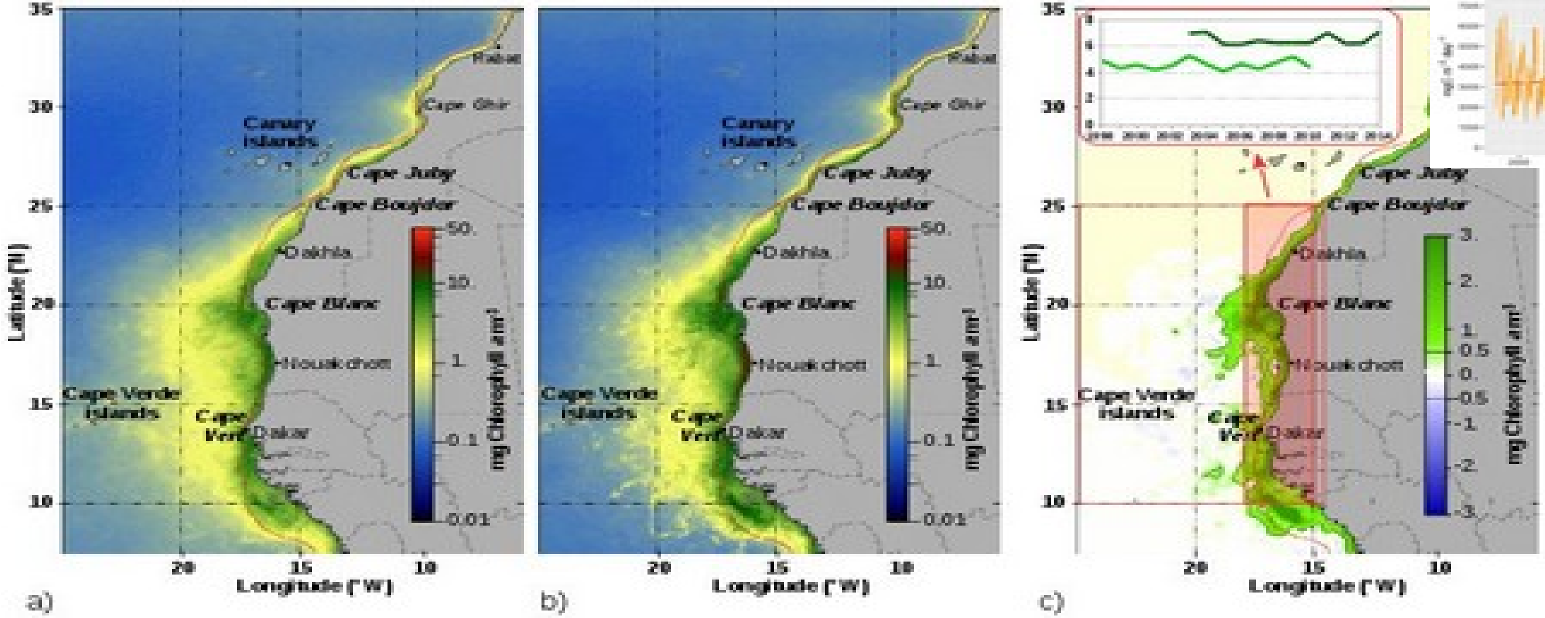
Conclusion :
Close trends, except south of Senegal, probably due to differences in data density and/or in atmospheric corrections

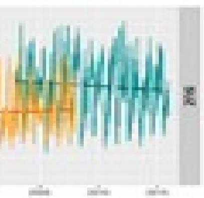
→ MODIS data are used for the 2011-2014 period only


SeaWiFS
2003-2007


MODIS
2003-2007

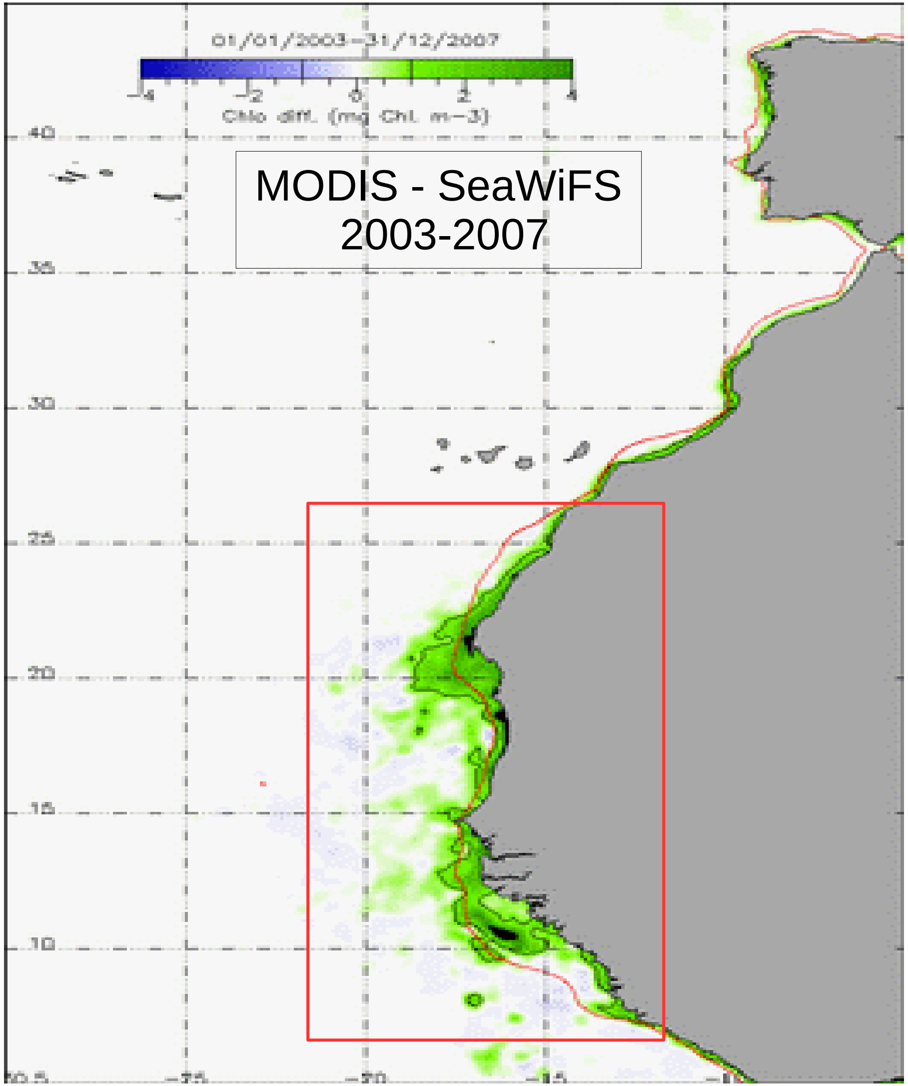
2003-2010 (full common period)





From Gomez-Letona et al. 2017 Frontiers in Marine Science, Trends in Prim. Production in the CCUS

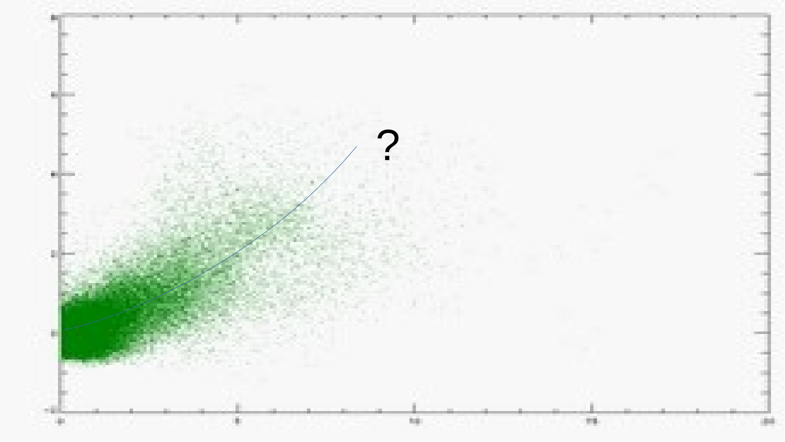
Average Chl-a concentration respectively from a) SeaWiFS data and b) MODIS data from 2003 to 2007 and c) the MODIS-SeaWiFS difference for the same period. The 200 m bathymetry contour (red line) is superimposed. The plot (c), insert) shows the yearly averages of both sensors from 1998 to 2014 in the coastal area (red rectangle)

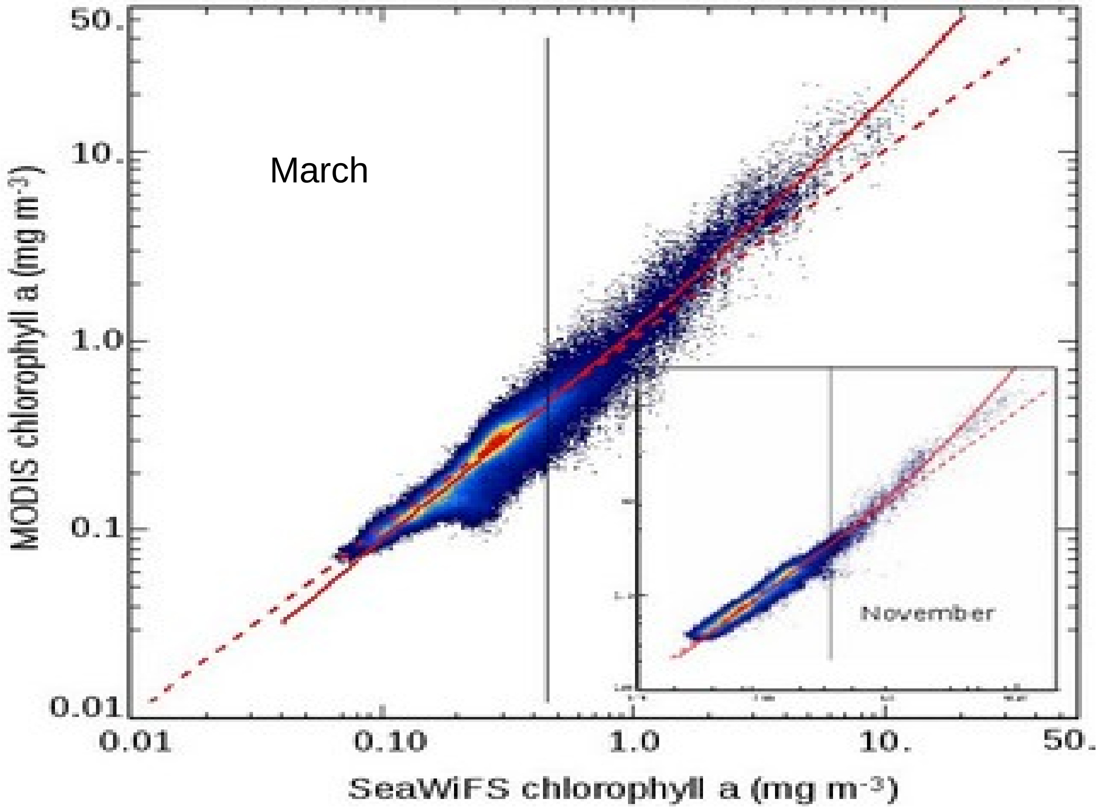


MODIS - SeaWiFS
2003-2007

Average overestimate of the full area 5°N-25°N: **30.7%** (1.932/1.478)

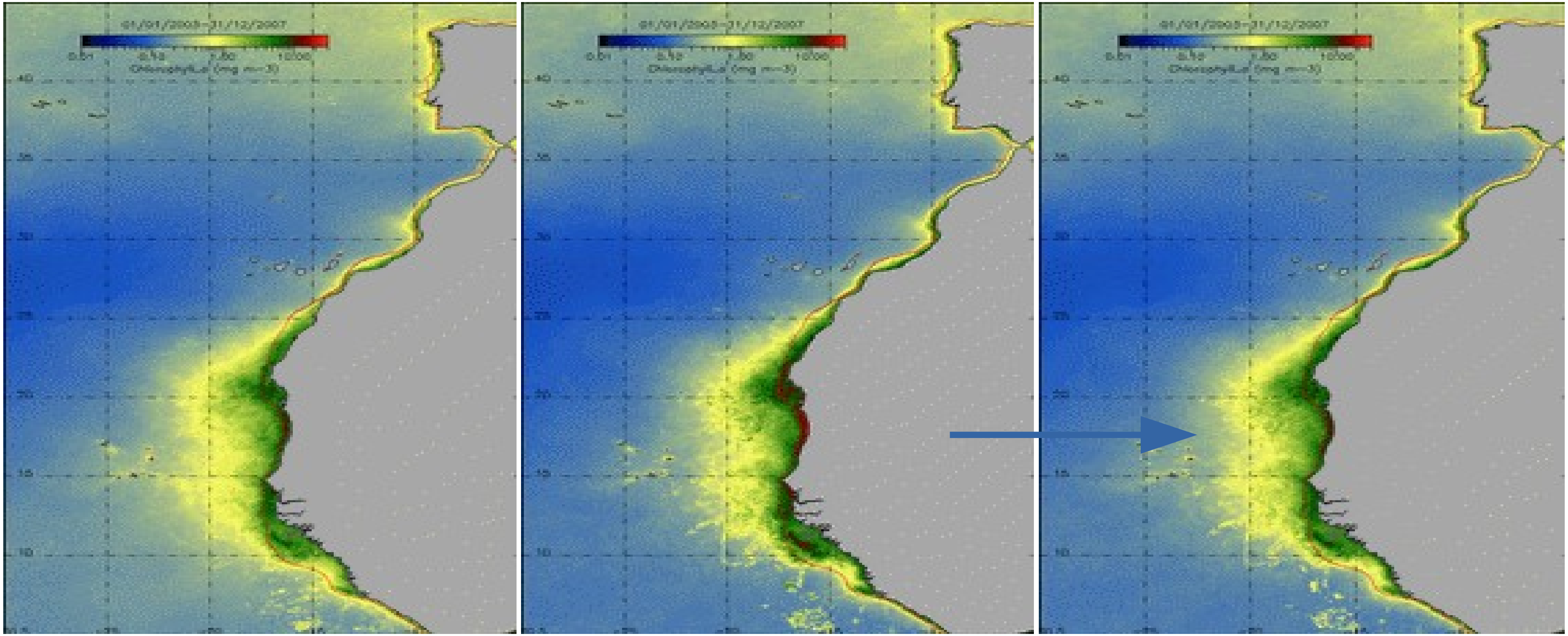
Shelf only : **42.3%**





Example of bidimensional histogram of the MODIS and SeaWiFS Chl-a data (2003-2007 average) and derived linear and quadratic fit (red lines, respectively for values <0.5 mg m-3 and above) for the month of March. The month of November (secondary frame) is presented for comparison.

Ex. of resulting correction in the yearly average

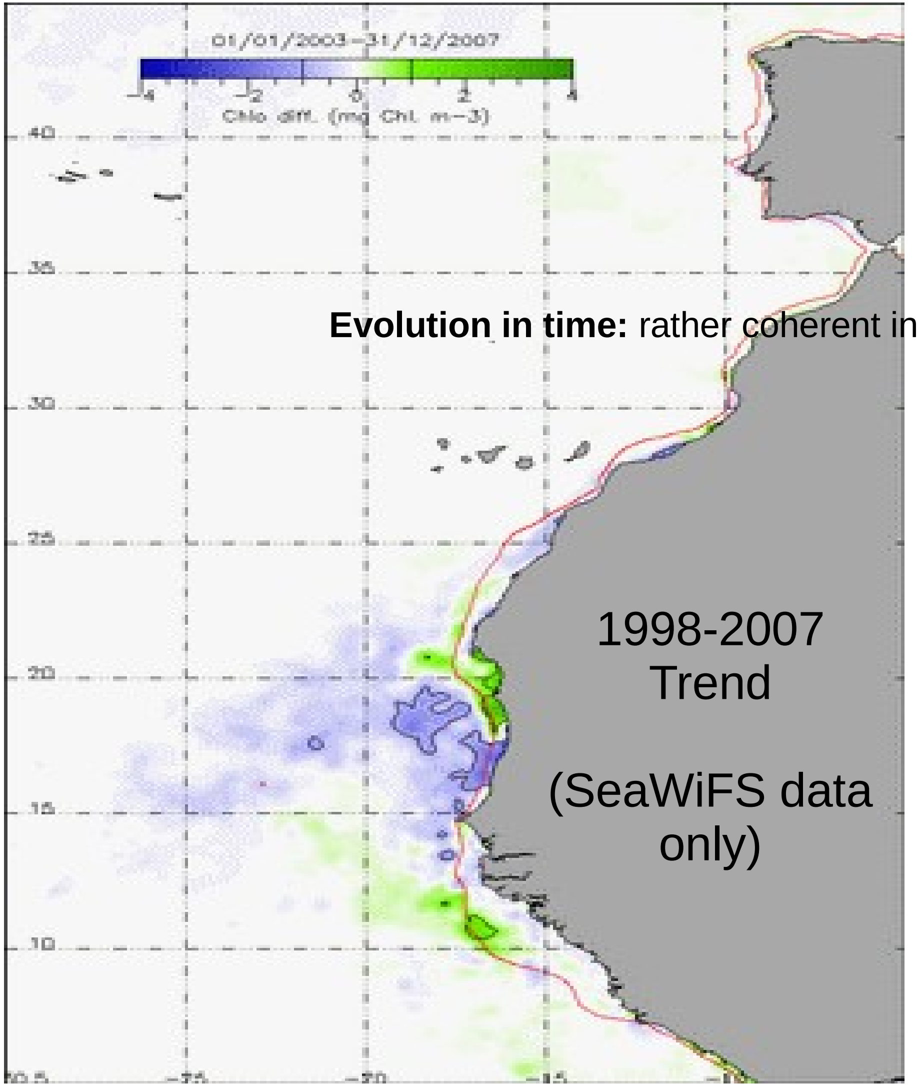


SeaWiFS

MODIS

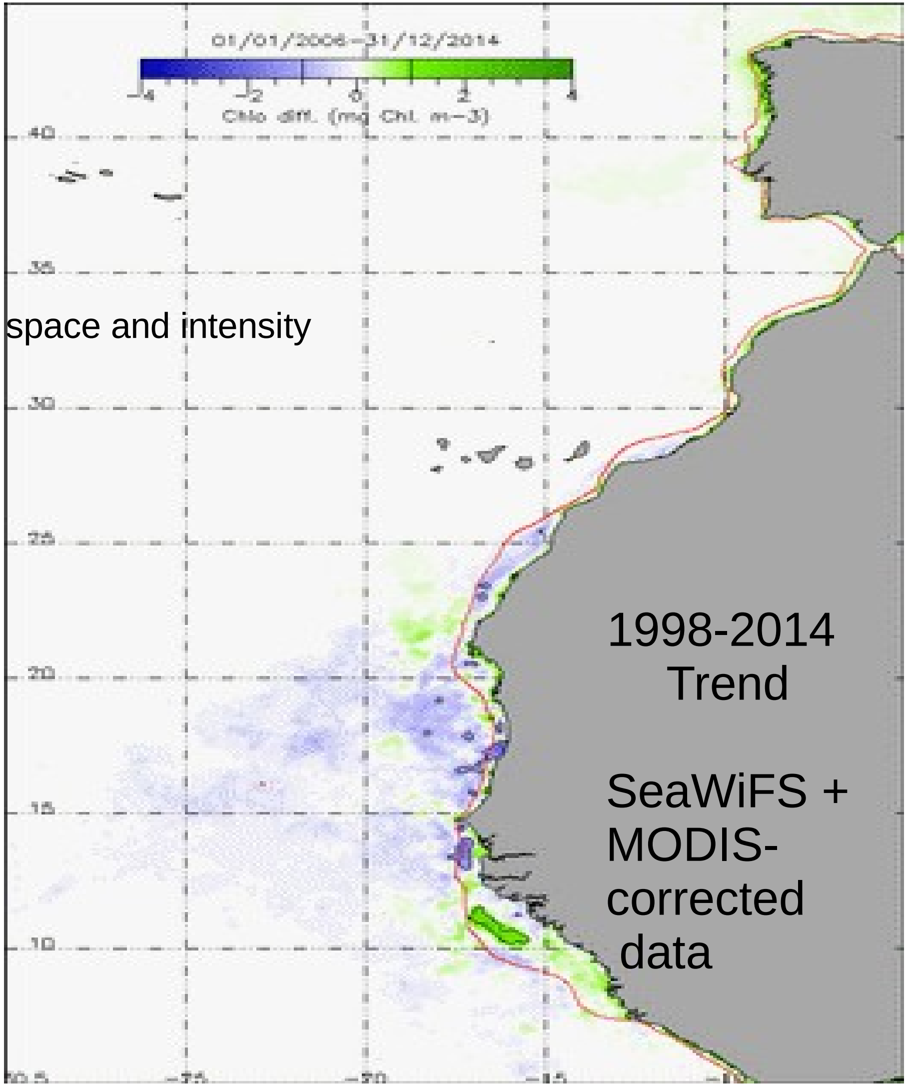
MODIS corrected

Evolution in time: rather coherent in space and intensity



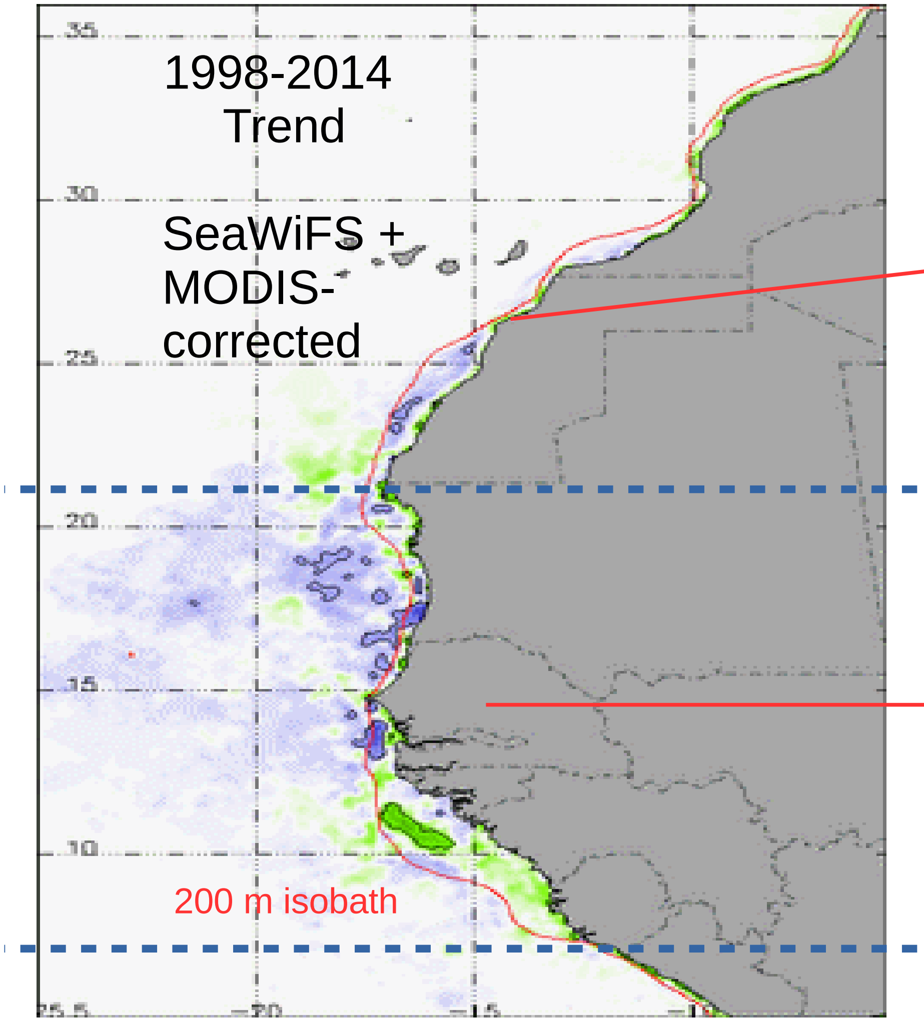
1998-2007
Trend

(SeaWiFS data
only)



1998-2014
Trend

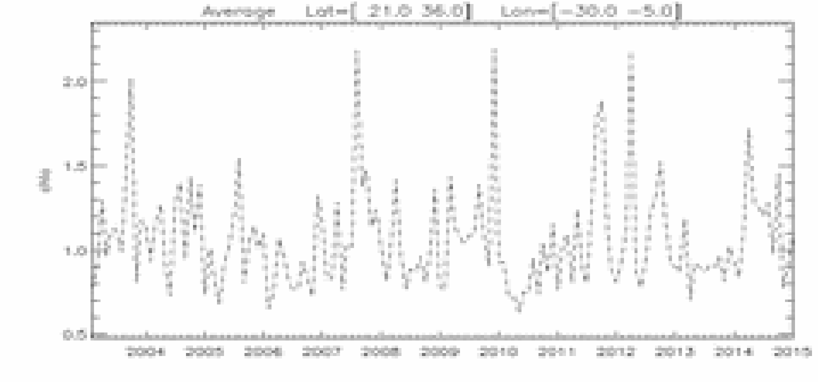
SeaWiFS +
MODIS-
corrected
data



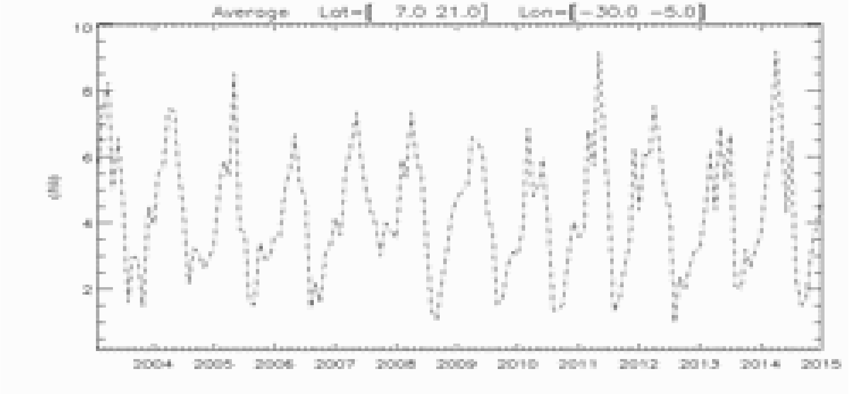
1998-2014
Trend

SeaWiFS +
MODIS-
corrected

200 m isobath

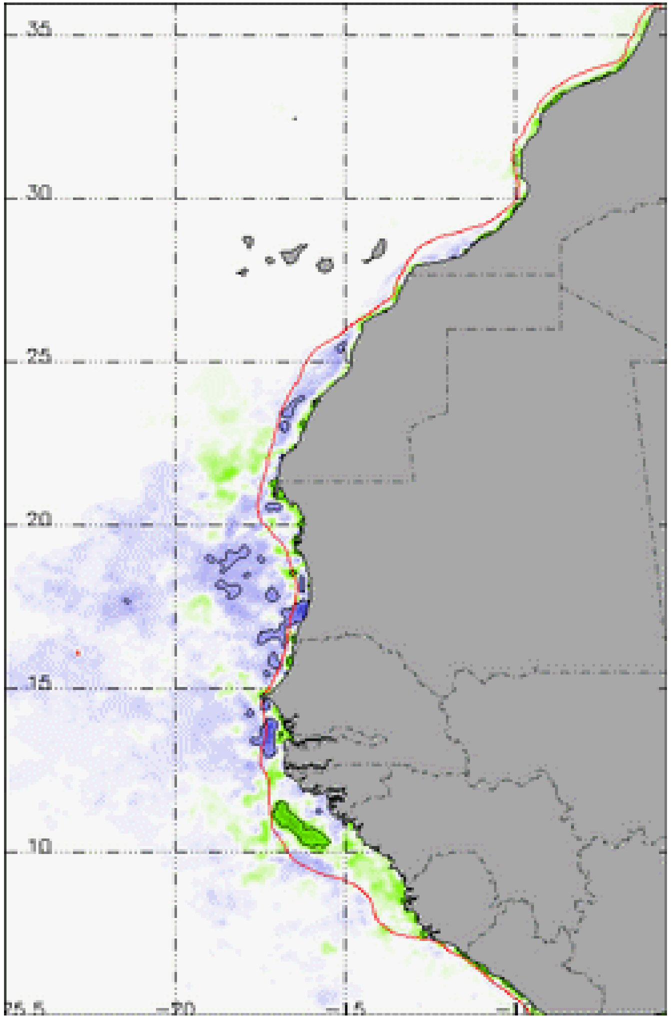


Slightly decreasing trends and
episodic extreme events

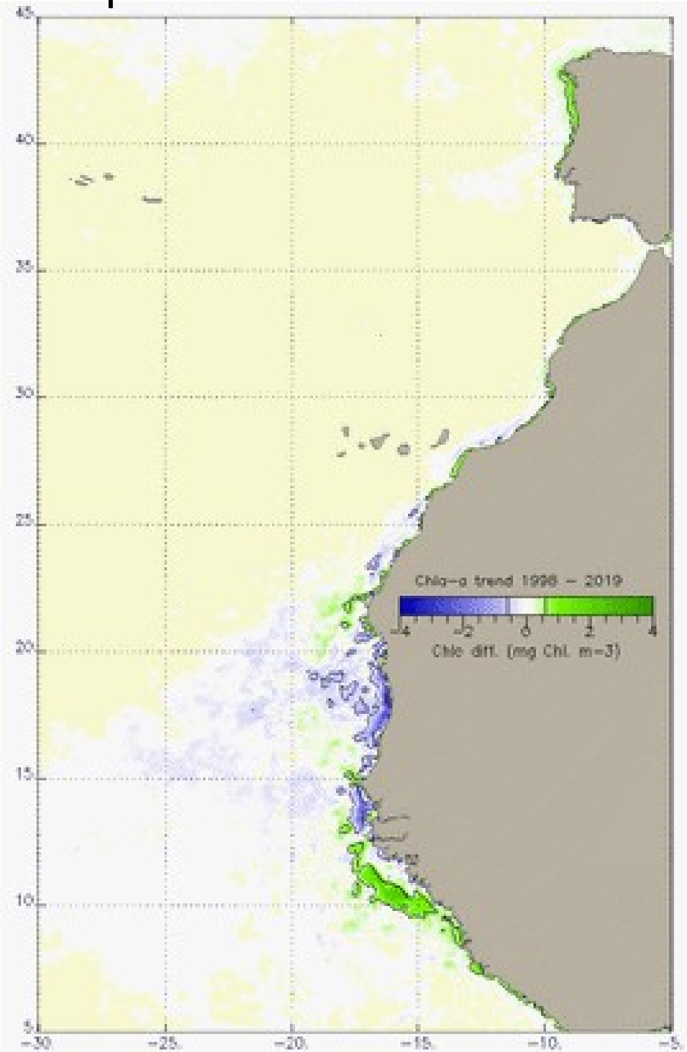


Variable and spatially dependent trends...

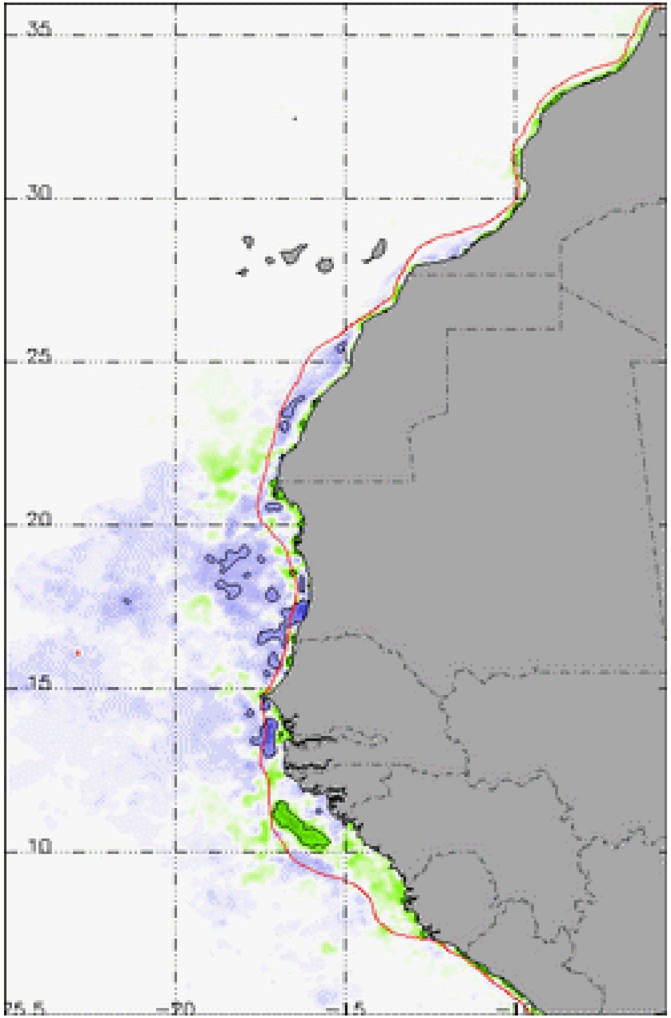
1998-2014 Trend



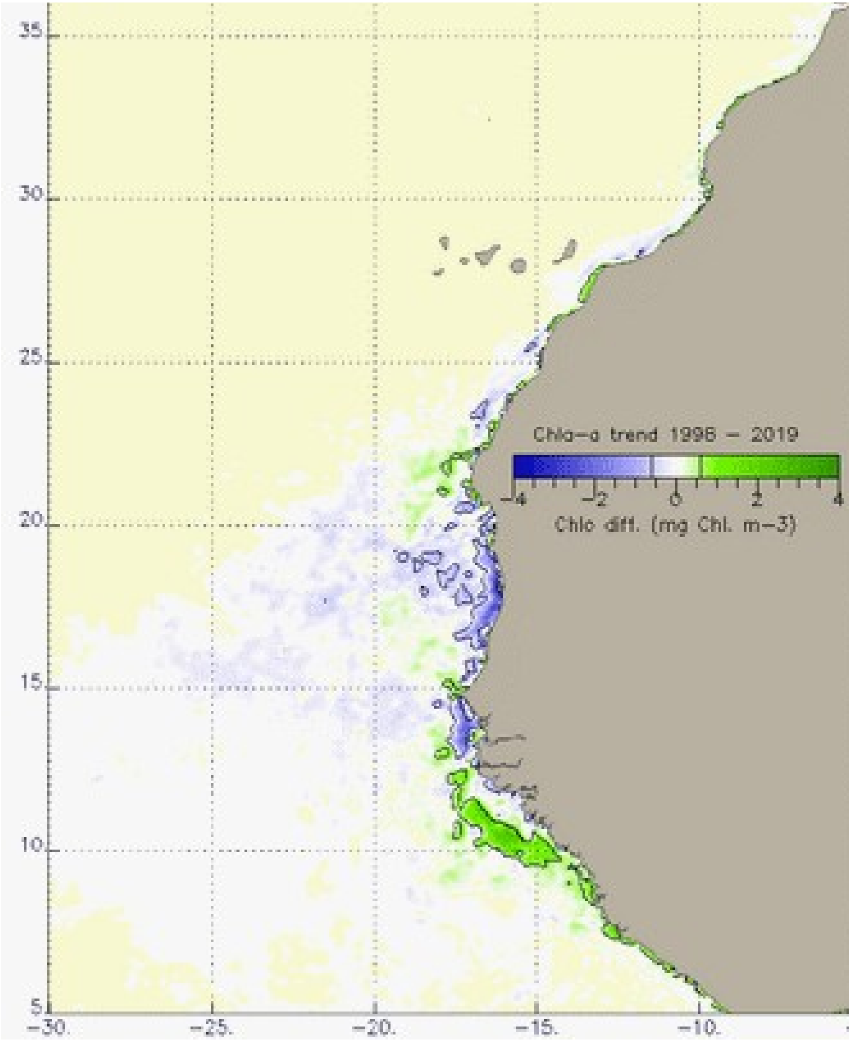
Updated 1998-2019 Trend



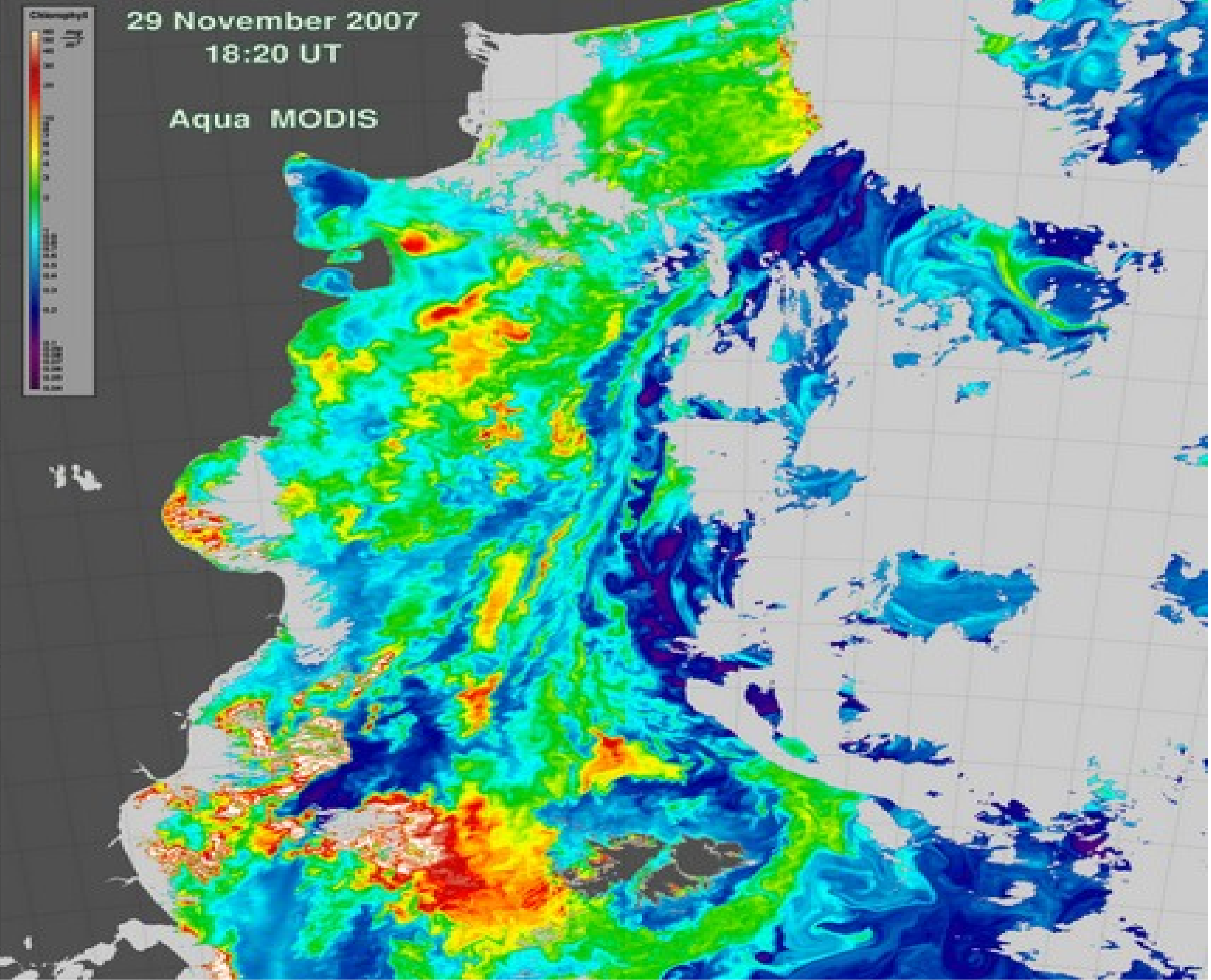
1998-2014 Trend



Updated 1998-2019 Trend

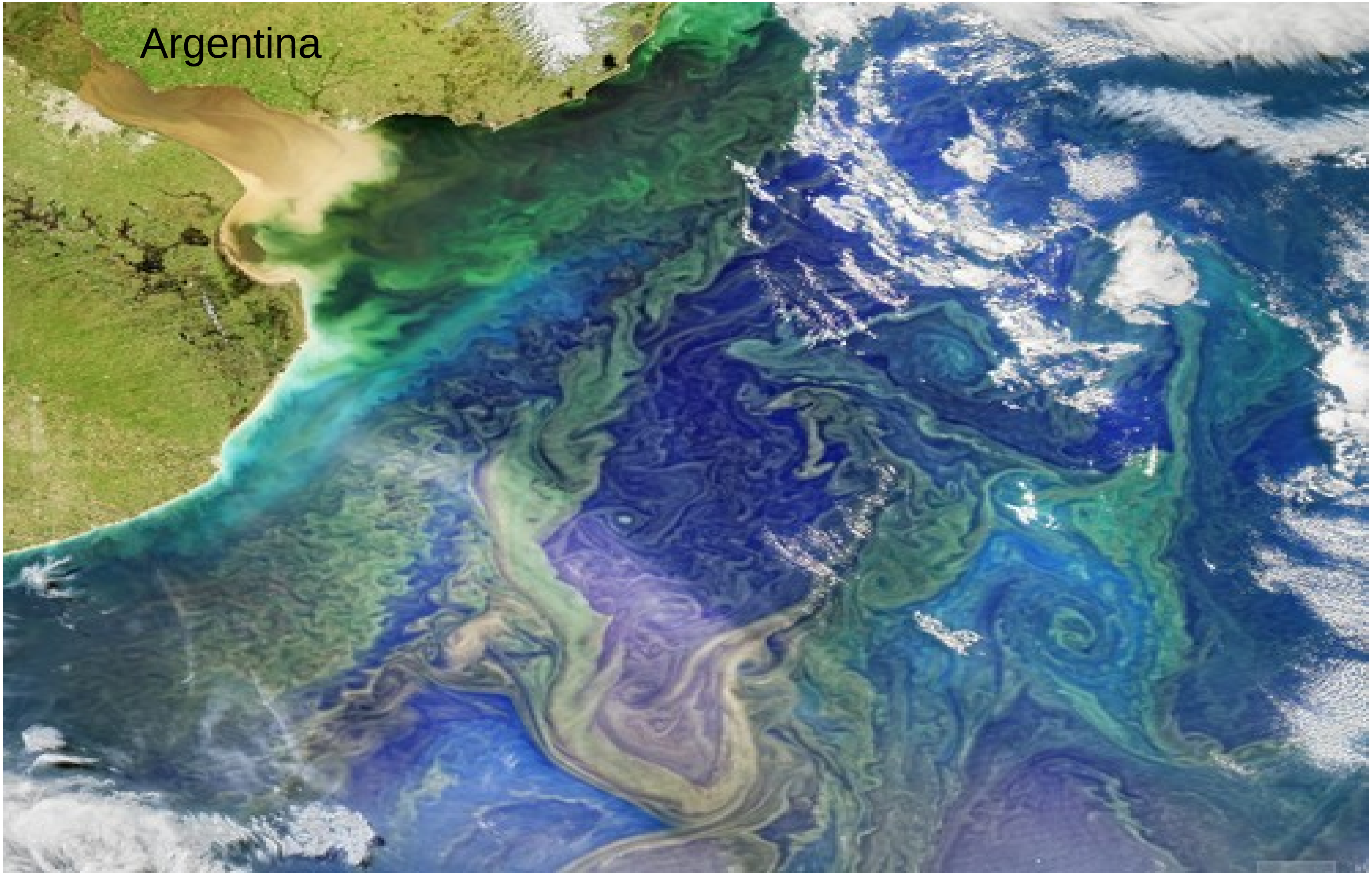


There is still important issues to explore beyond simple trends….



Behind what we see as the standard « chlorophyll *a* » concentration, there is...

… A much higher variability, even in term of color



The PHYSAT method (Alvain et al., 2002, 2003)

Daily Level-3 GAC data

nLw_{obs} and Chl-a SeaWiFS

↓

$nLw^* = nLw_{obs} / nLw_{ref}(\text{Chl-a})$

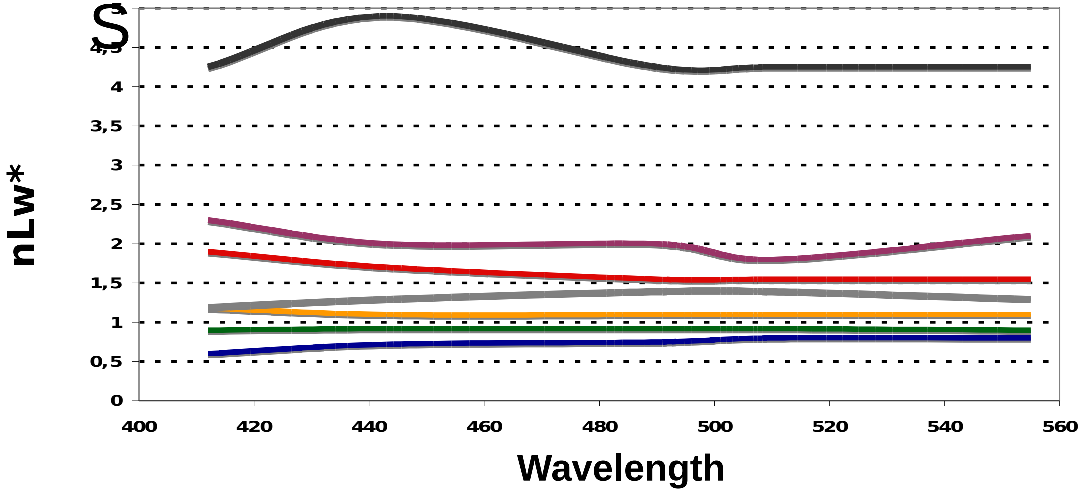
↓

Identification of the dominant PFT for the pixel

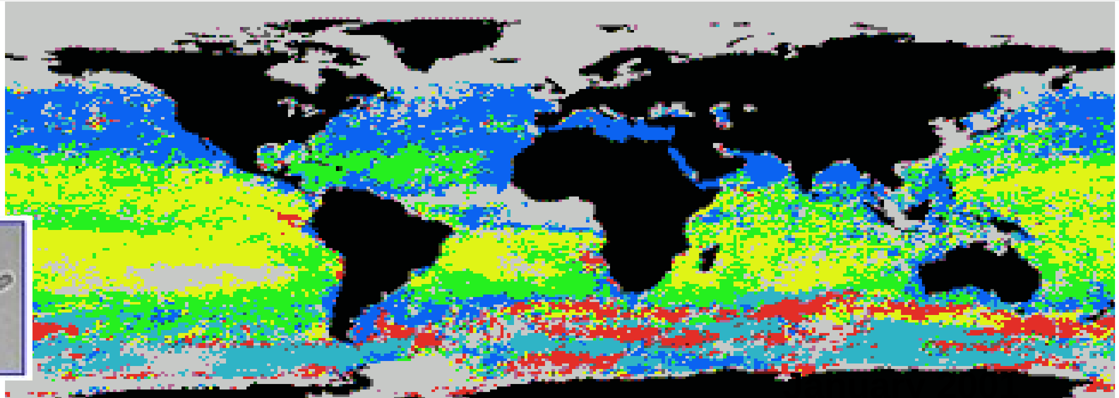
↓

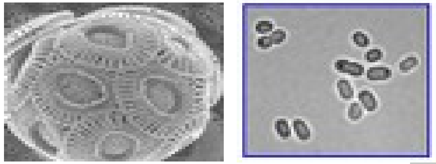
Most frequent dominant PFT (by month):

Main phytoplancton types detectable from Ocean color from space:

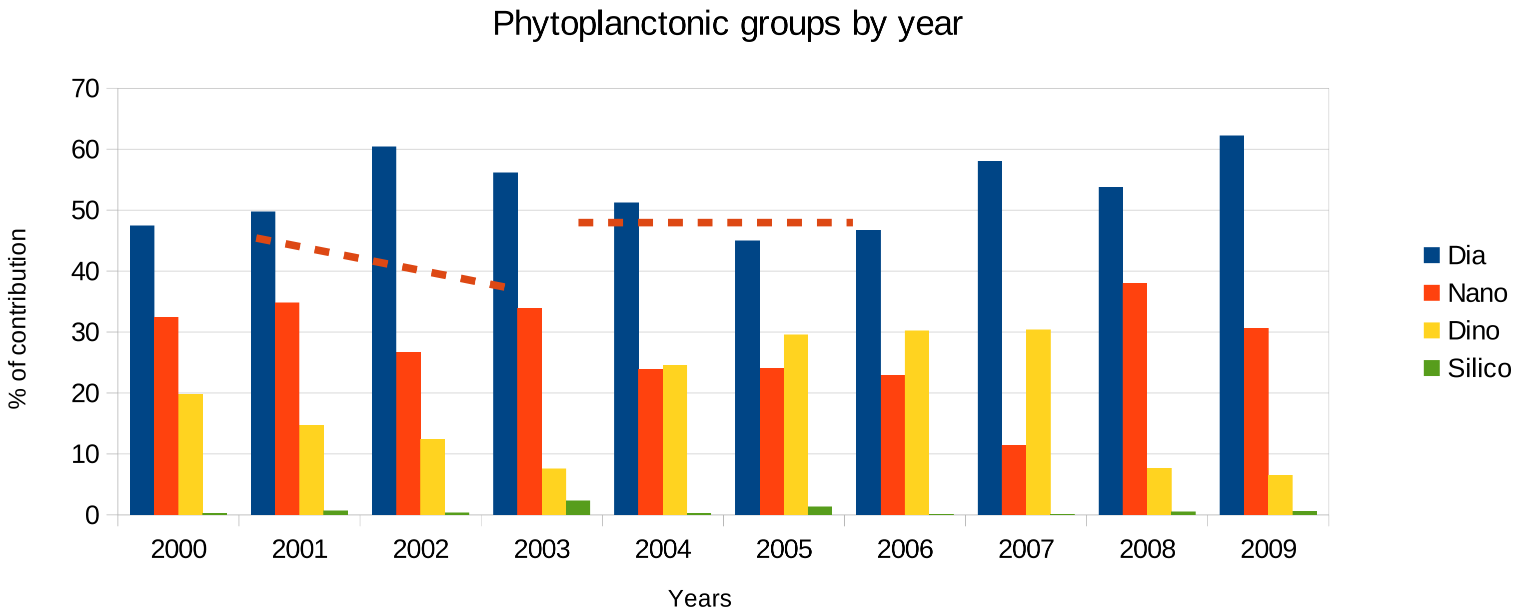


Haptophytes-Prochlorococcus-Synechococcus-Diatoms

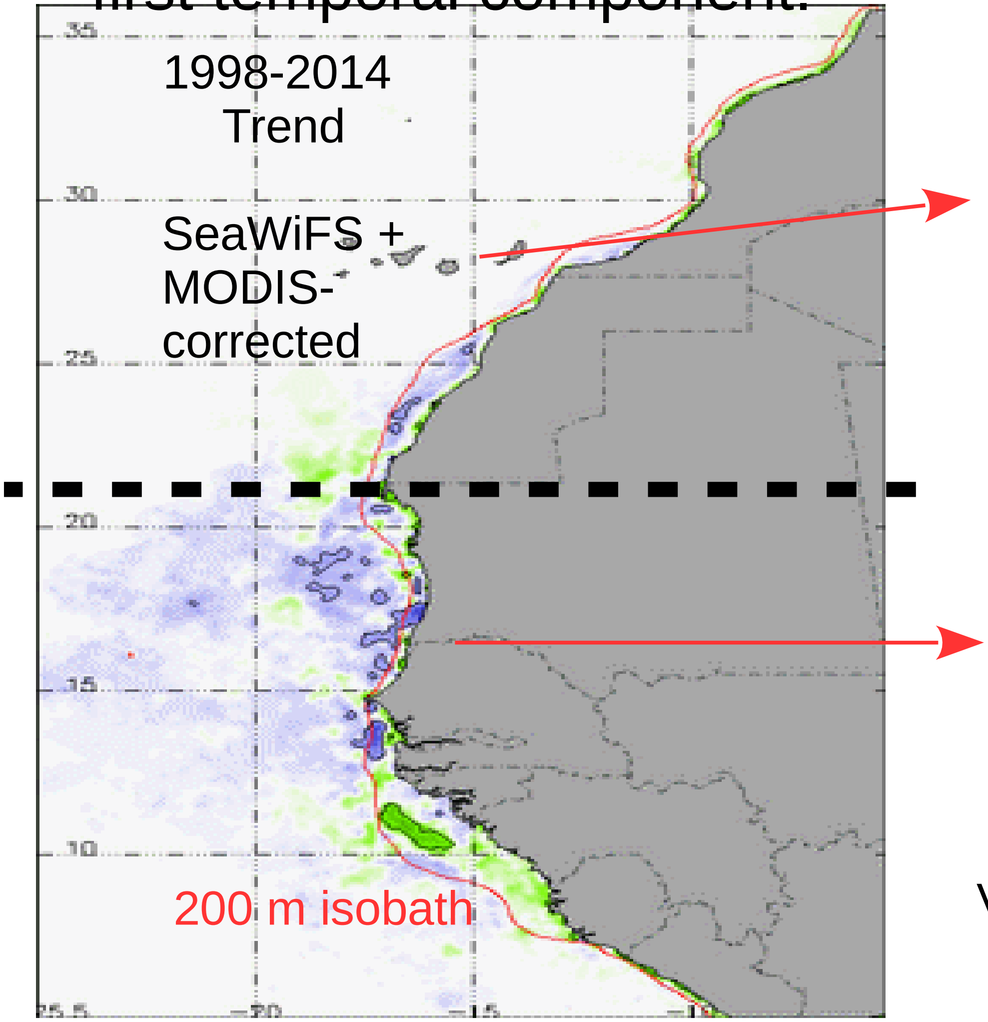




Taxonomic groups (example in the Humboldt, system, IMARPE, Peru)



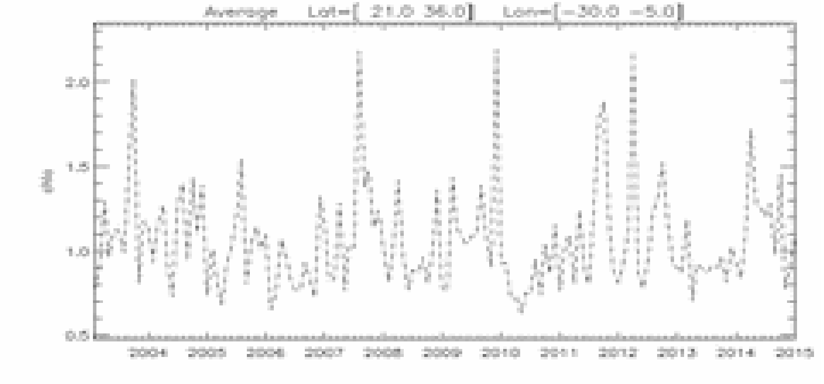
We know that the seasonal variability is almost always the first temporal component.



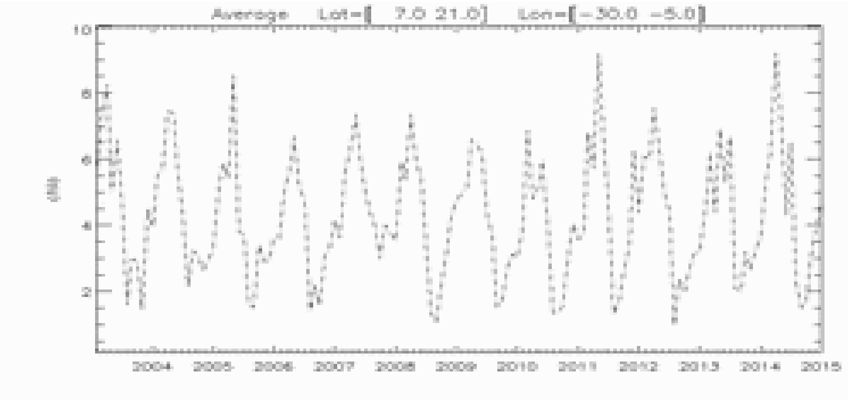
1998-2014
Trend

SeaWiFS +
MODIS-
corrected

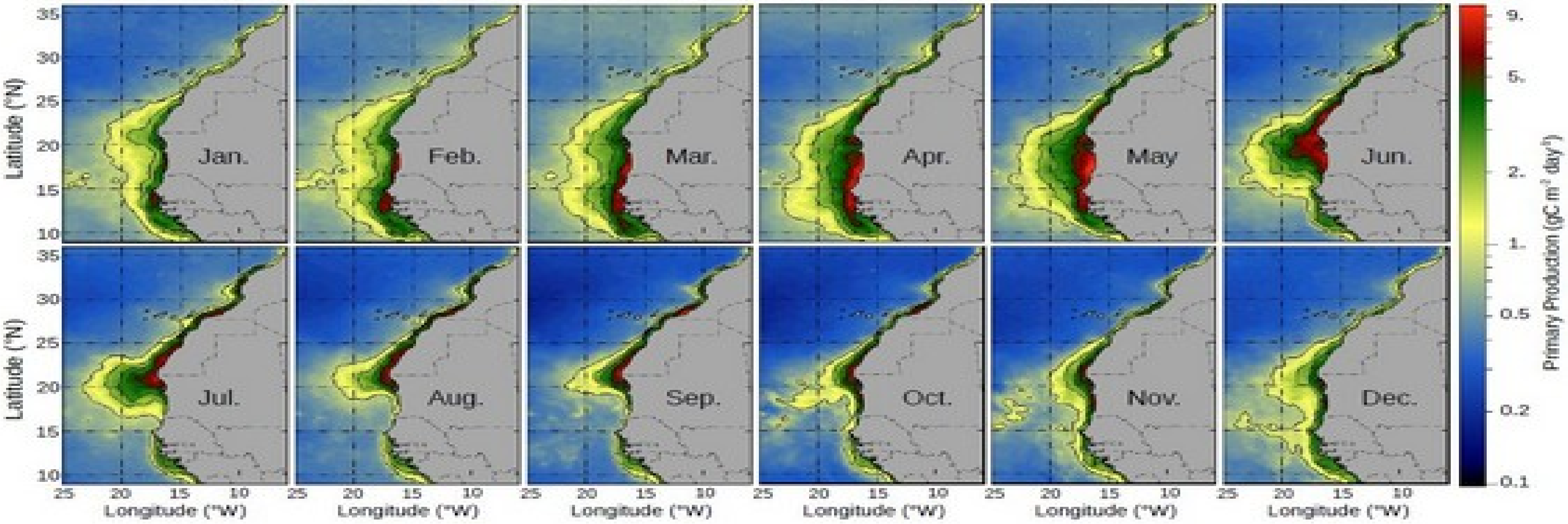
200 m isobath



Slightly decreasing trends and episodic extreme events

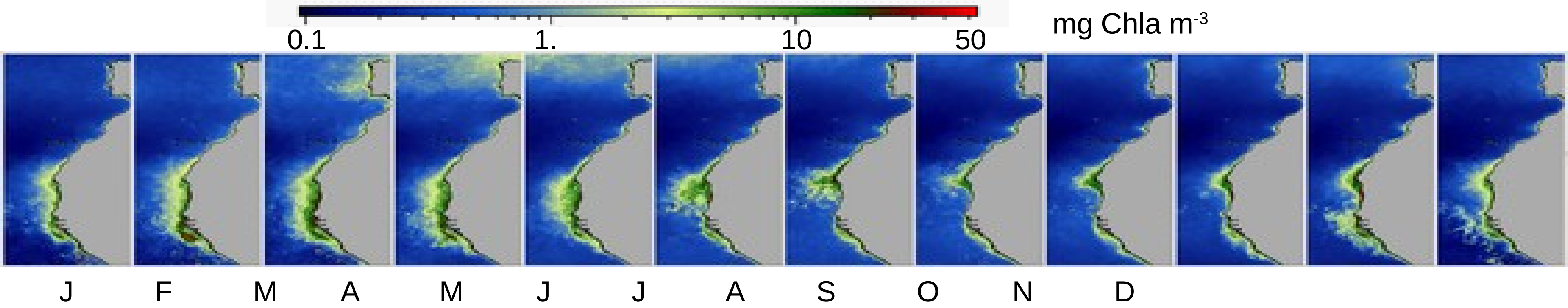


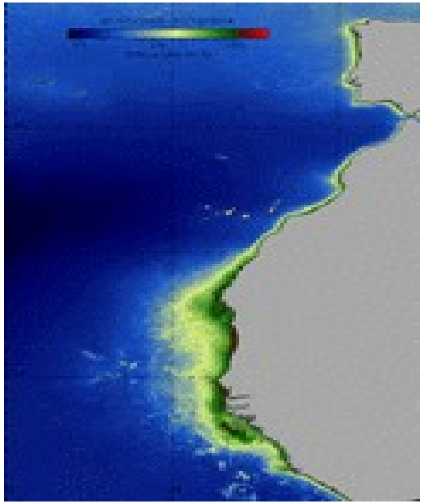
Variable and spatially dependent trends...



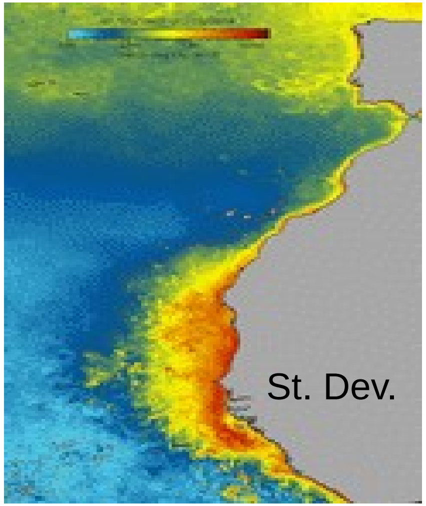
Seasonal variability of the NPP in the Canary Current from Morocco to Guinea, computed from SeaWiFS data, from 1998 to 2007 (VGPM algorithm, Behrenfeld and Falkowsky, 1998). Values 1 gC m^{-2} day^{-1}, 2 gC m^{-2} day^{-1}, 3 gC m^{-2} day^{-1} and 5 gC m^{-2} day^{-1} are contoured.

Ocean Color to describe Seasonality of planctonic blooms from Surface Chlorophyll *a*

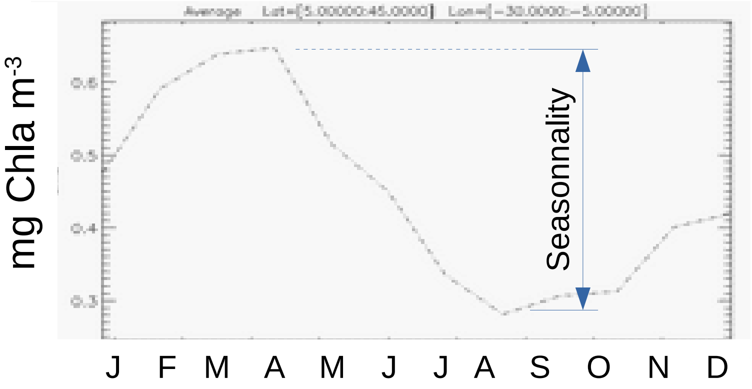




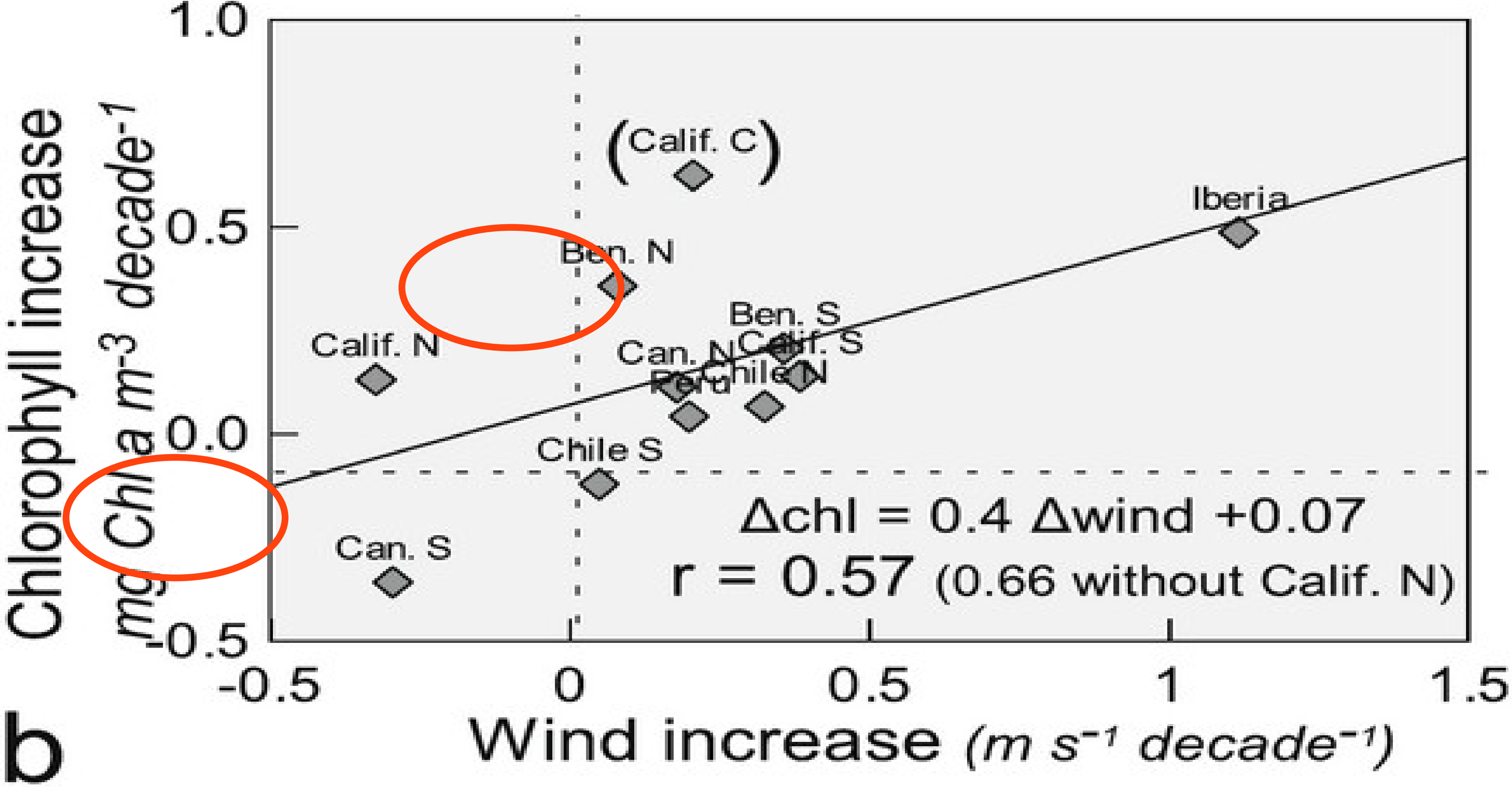
Annual mean



Seasonal variability



Physical mechanisms alone only poorly explain the productive processes … Most of them are far from linear



(Demarcq, 2009)

Is there practical implications of estimating trends in EBUs ?

- Linear trends represent only a part of the variability! (changes in seasonal variability and higher frequencies are still largely unexplored)
- The trends we estimate only represents a part of the euphotic layer (according max Chlor. Depth). We need to integrate 3D observations (profiles)
- The length of the time series is increasing but still short (20 years), including sensor calibration issues and approximations in satellite atmospheric corrections
- Seasonal/phenological variability (including shifts) is pronounced (and well estimated from sat. data)
- As for NPZ models, satellite observations must be carefully evaluated from ***in situ* measurements** (it is still difficult to explore variability in phytoplankton groups from NPZ models by lack of *in situ* data)

Thank you

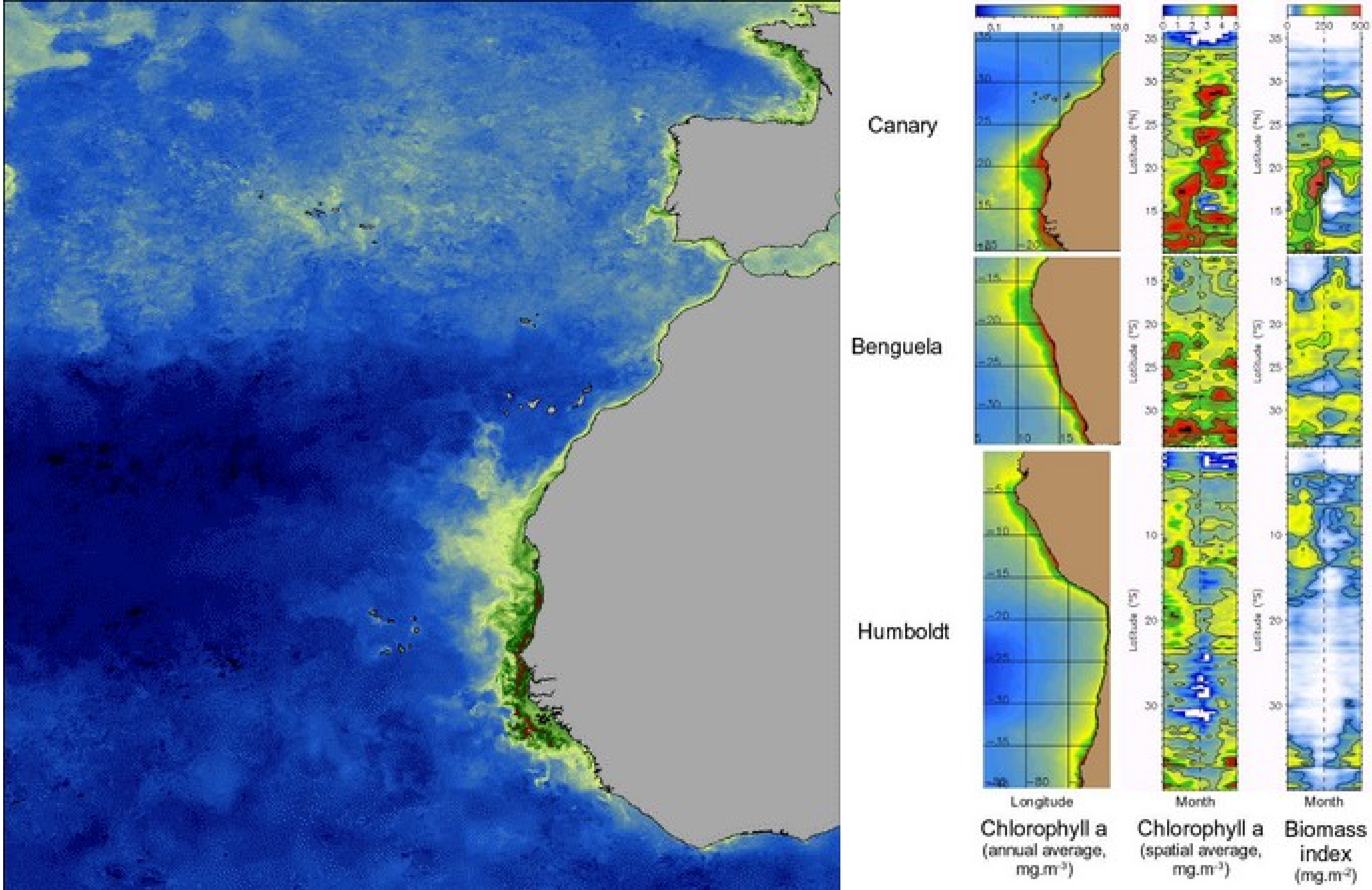

Canary
Benguela
Humboldt
0.1
1.0
10.0
0 1 2 3 4 5
0 250 500
Latitude (°N)
Latitude (°S)
Longitude
Month
Month
Chlorophyll a
(annual average, mg.m-3)
Chlorophyll a
(spatial average, mg.m-3)
Biomass index
(mg.m-2)

Figure 1.

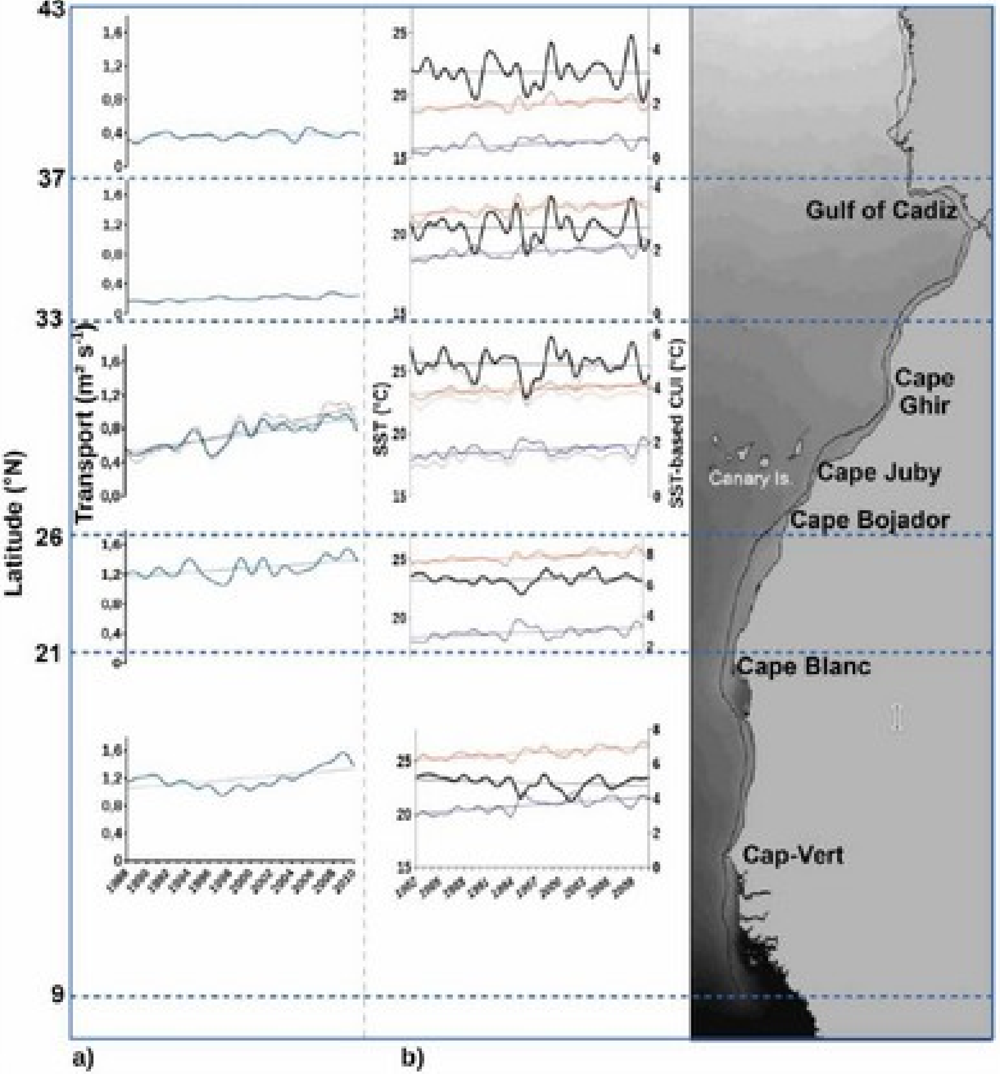


Figure 6.3.5. Linear trends for a) the annual-mean Ekman Transport ($m^2 s^{-1}$) during 1988-2011 for the five regions of upwelling regimes previously defined, and b) the annual-mean SST during 1982-2011 for SST_{max} (red line), SST_{min} (blue line) and CUI (thick black line).The Cape Ghir trends (dashed lines) are superimposed