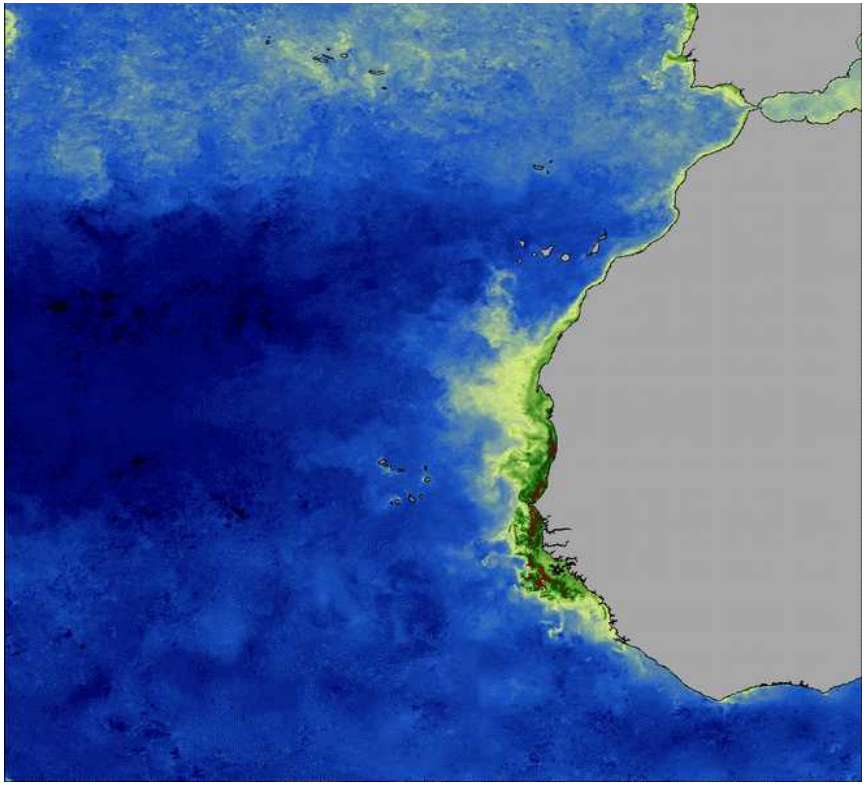
Trends in productivity in the Canary upwelling system

H.Demarcq, E.Machu, A.Benazzouz, P-A Augier



PREFACE

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Outline

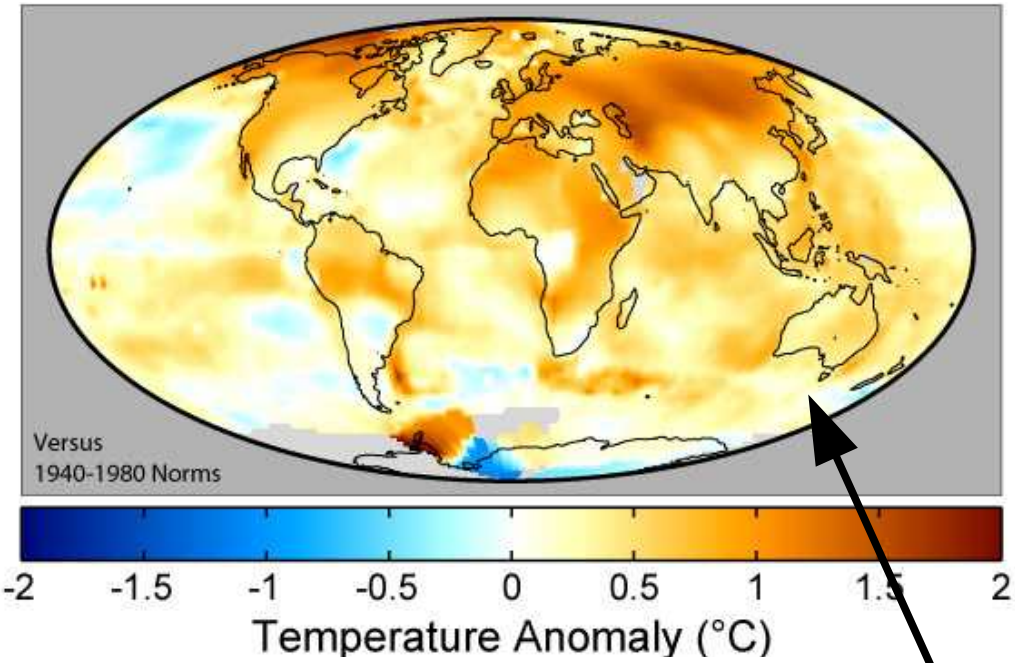
- A global warming context
- Trends from Ocean Color observations
- Trends from biogeochemical modelling
- Implications in Ecosystem-based management

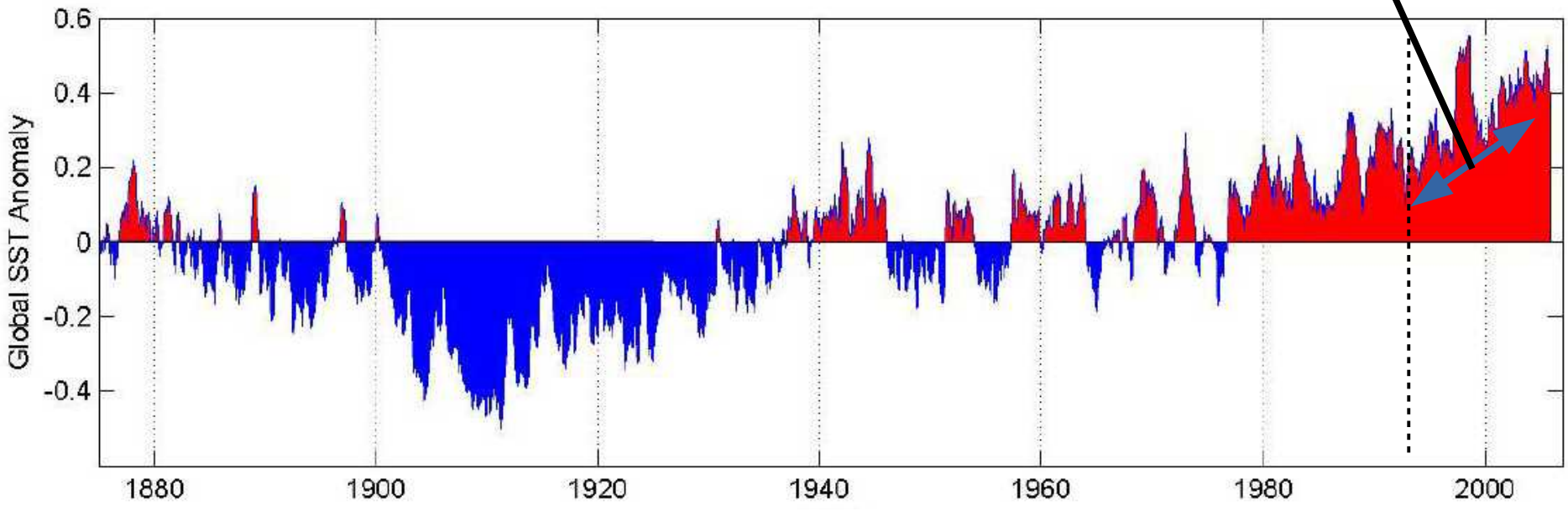
Worldwide context

- global warming : how much ?

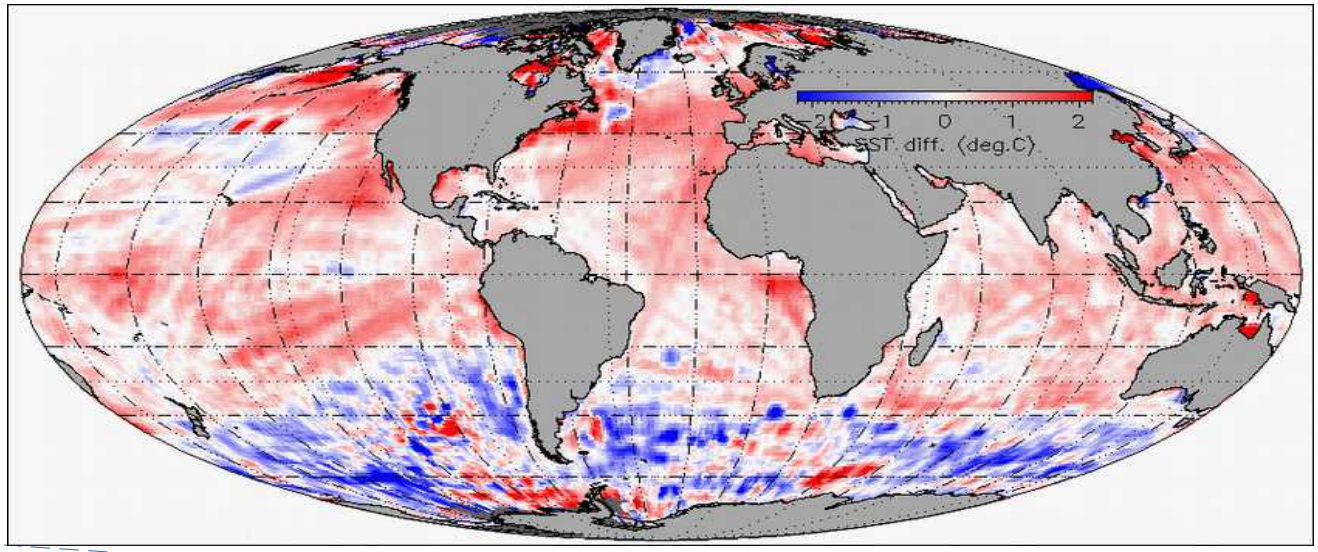
Just… an unprecedented global warming context

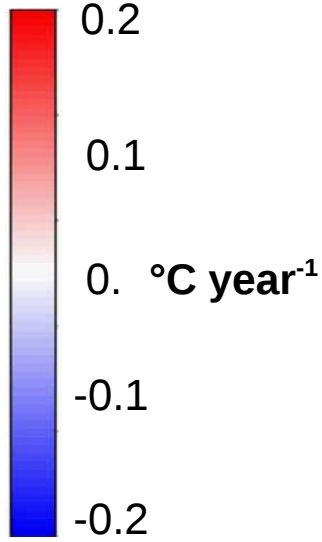
global effect on air and sea temperatures
(1995-2004 increase):

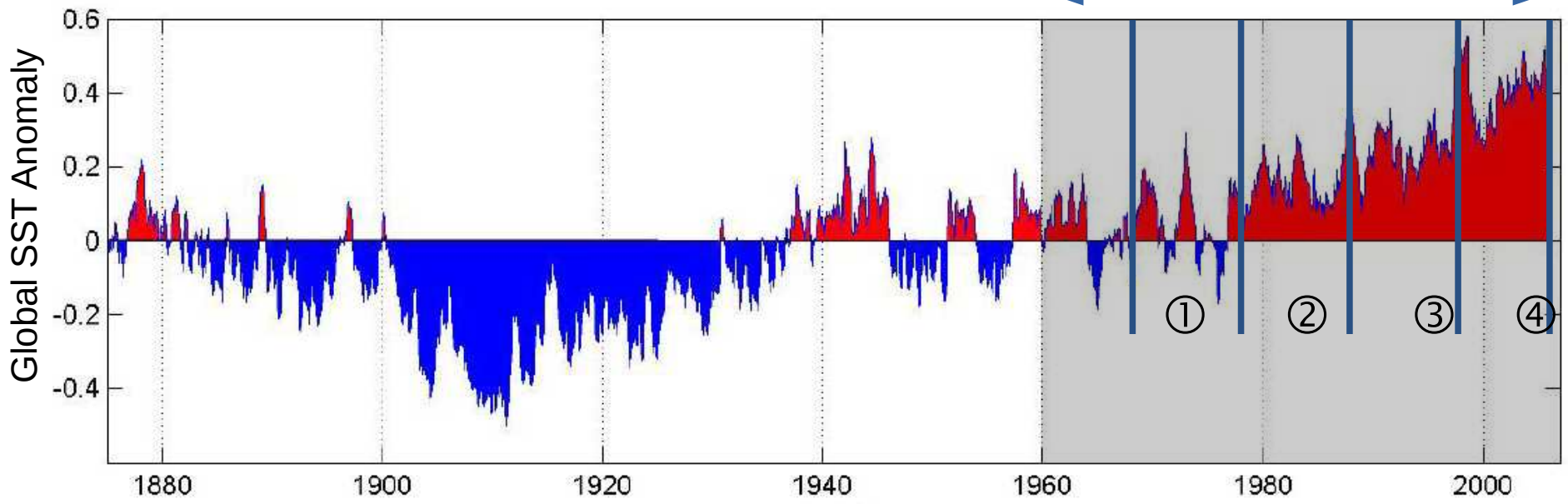




SST trend 1960 – 2007 (ICOADS data, 48 years)

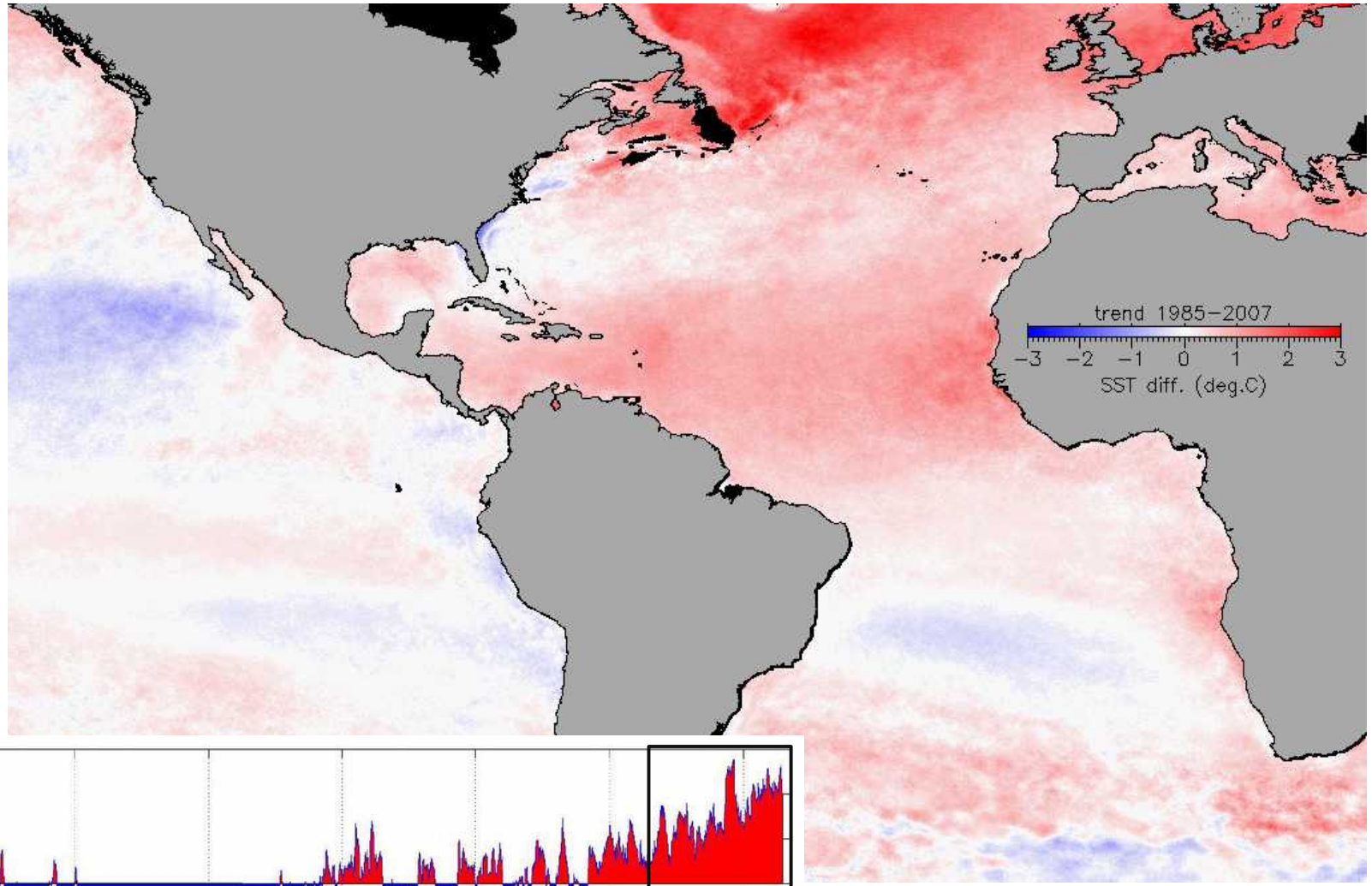


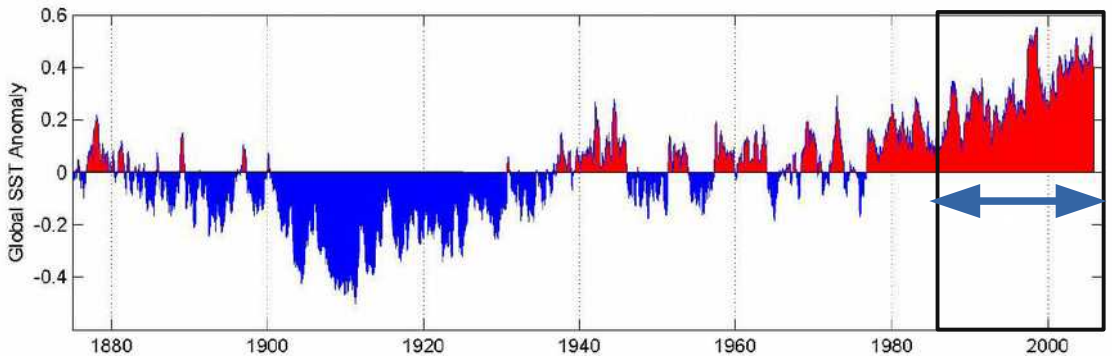




1985 – 2007 SST trend (AVHRR pathfinder)

(°C year^{-1})

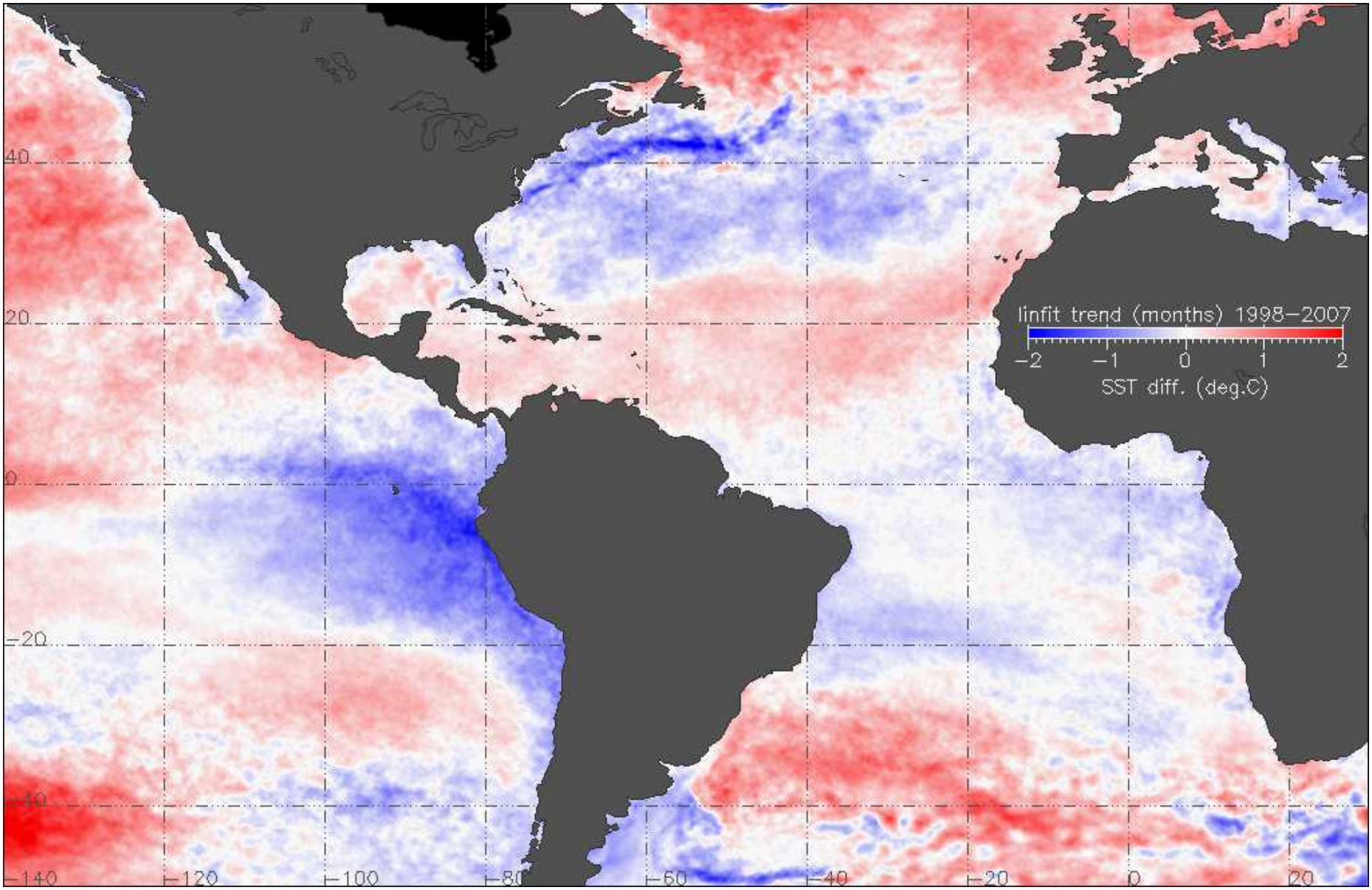




SST trend **1998** - 2007

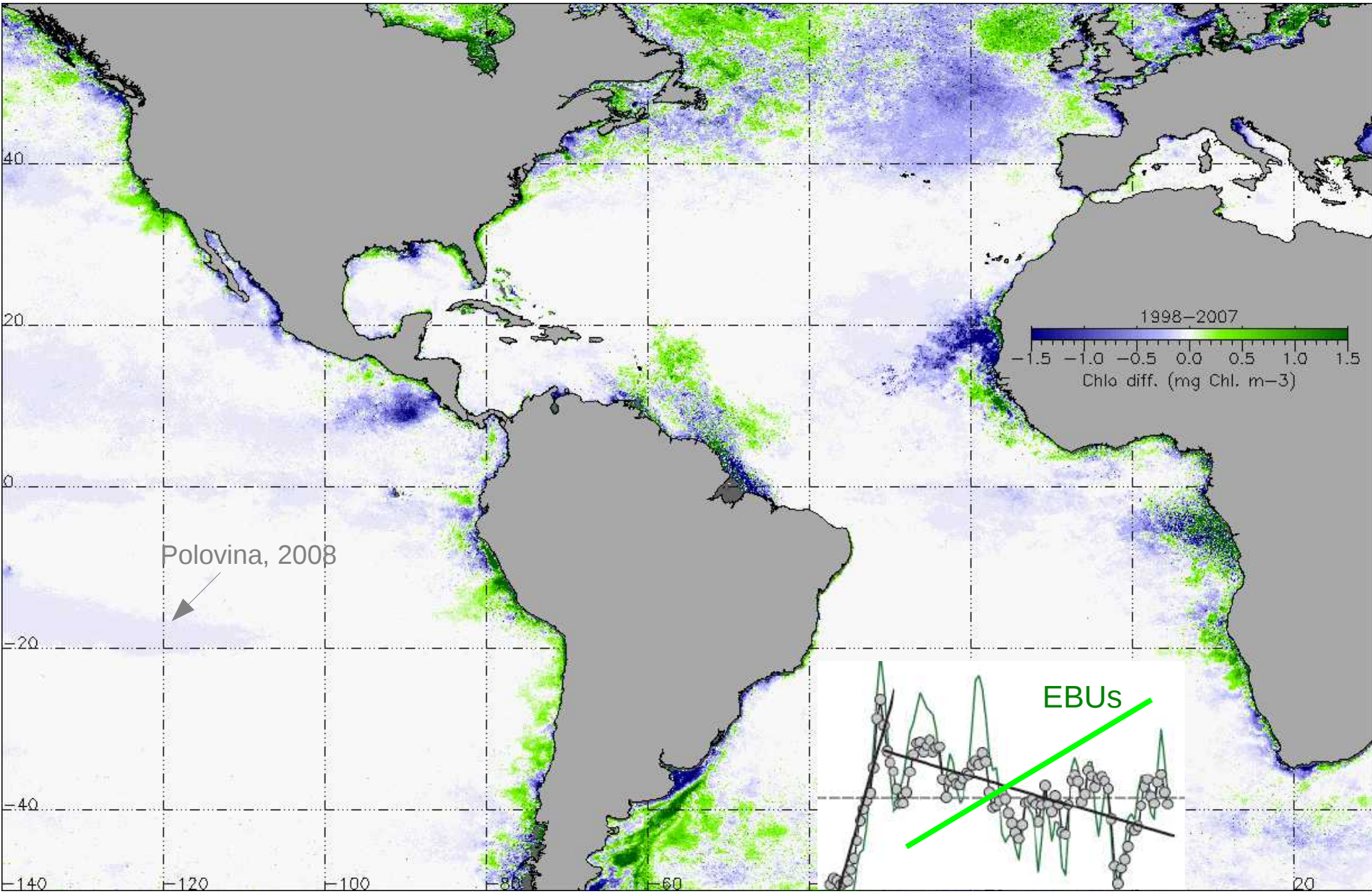
To match the satellite ocean color era

AVHRR Pfv5 data



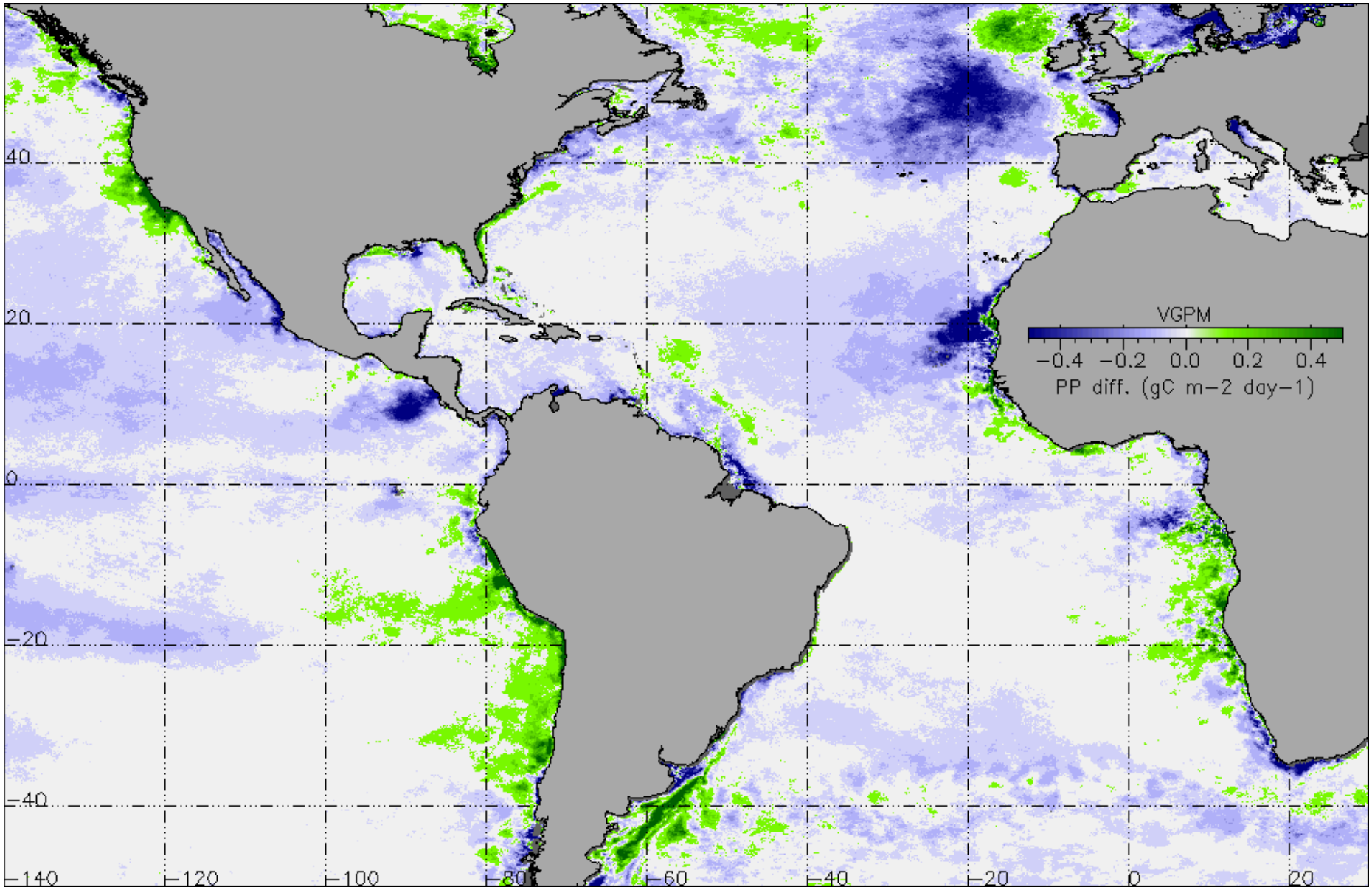
Trend in Chlorophyll concentration 1998 – 2007

see Demarcq 2009 Progress. In O. Trends in primary y production, sea surface temperature and wind in upwelling systems (1998-2007

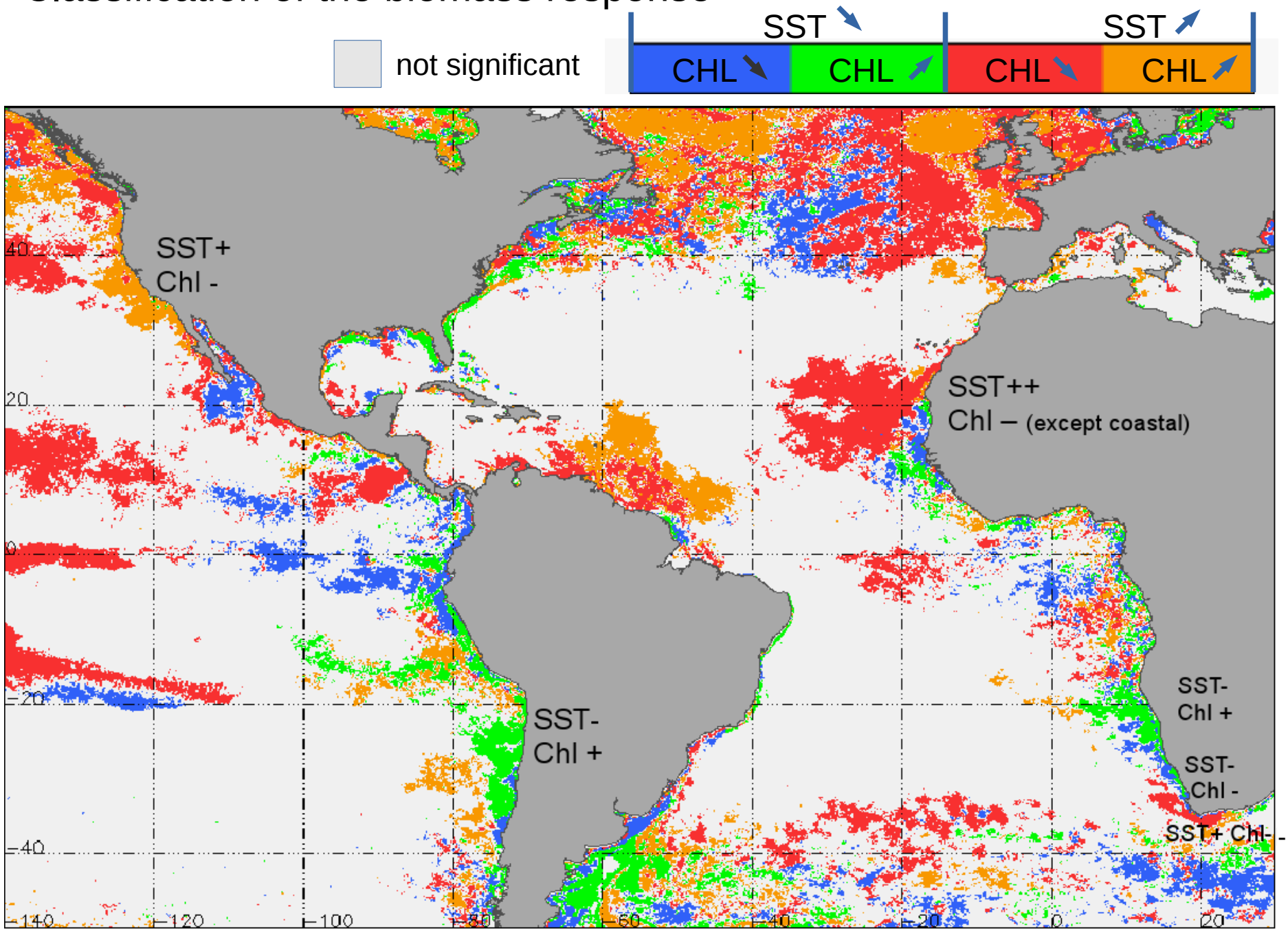


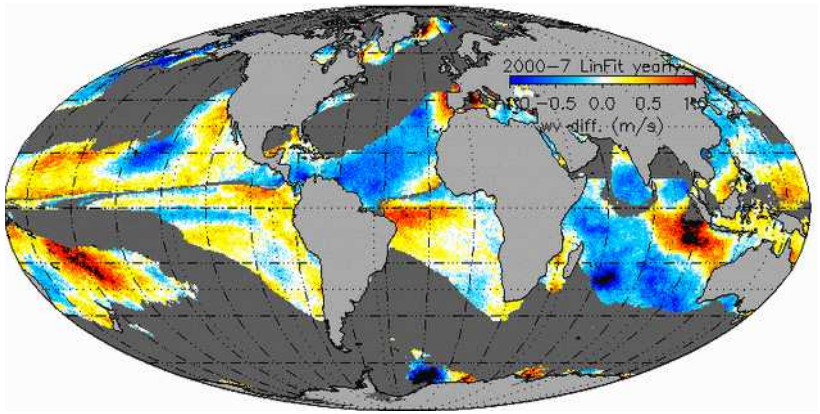
Trend in Production - Vertically Generalized Production **Model**

(absolute values)

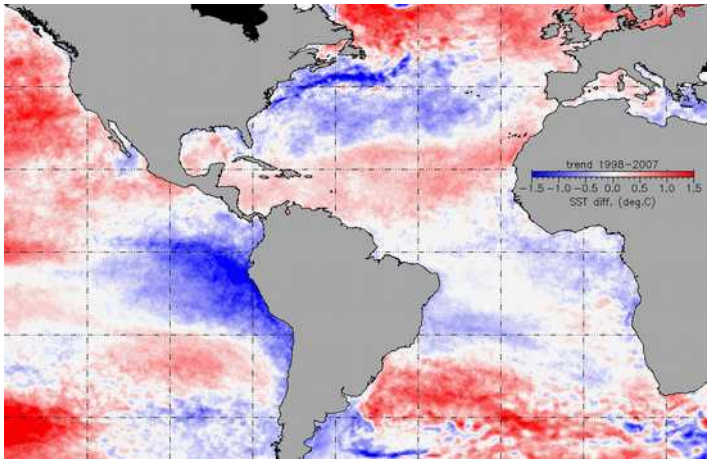


Classification of the biomass response

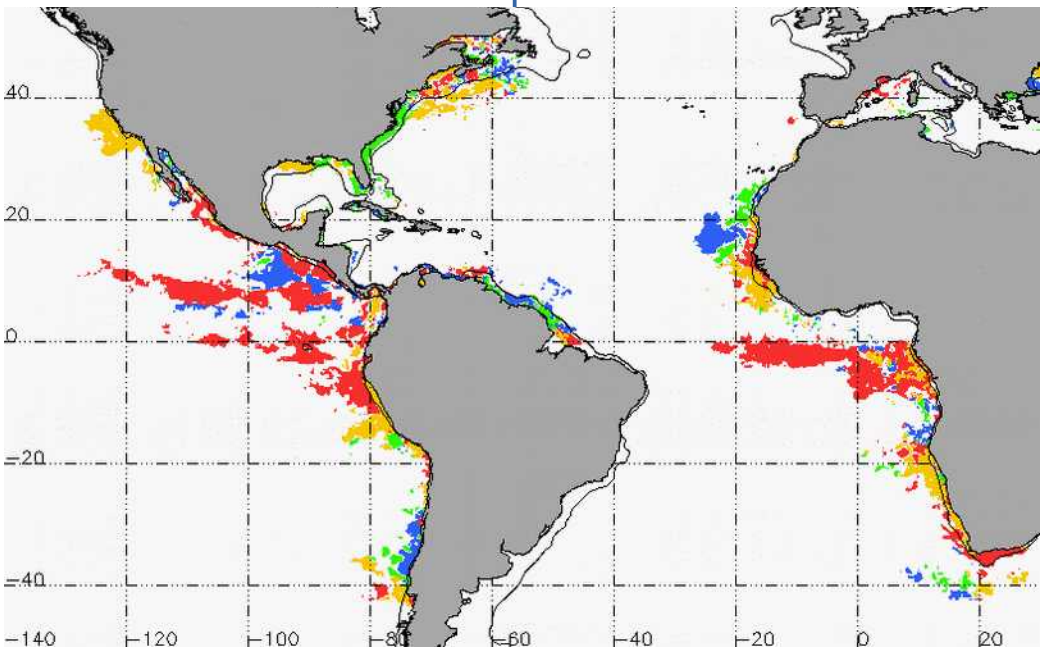


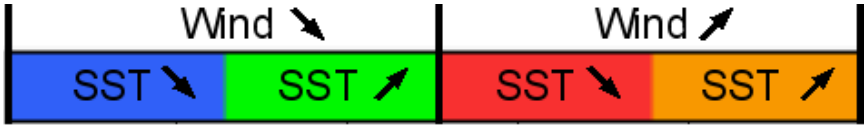


Trend of the Equatorward wind

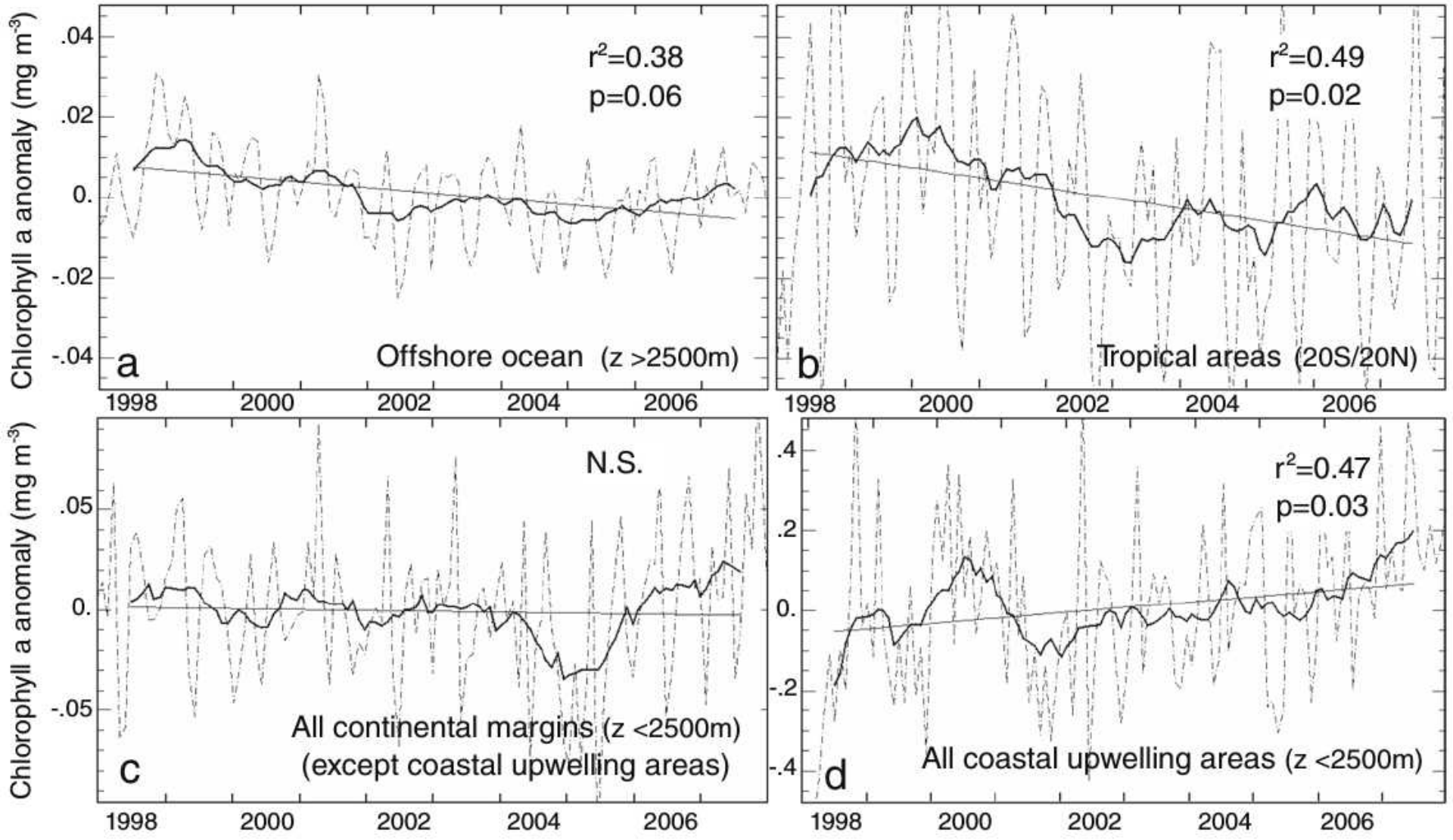


SST Trend

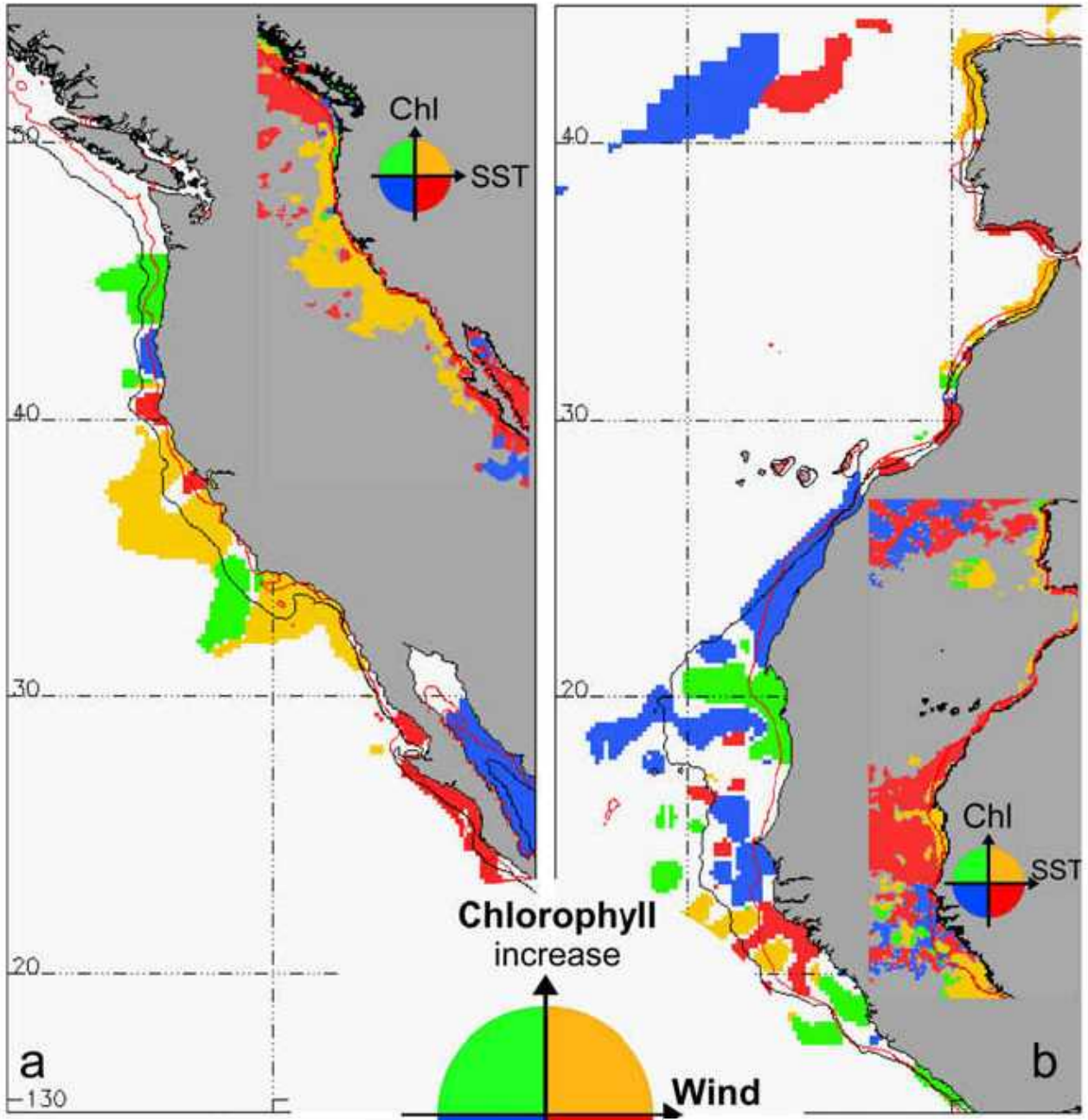




Chlorophyll trends by regions (1997-2007)

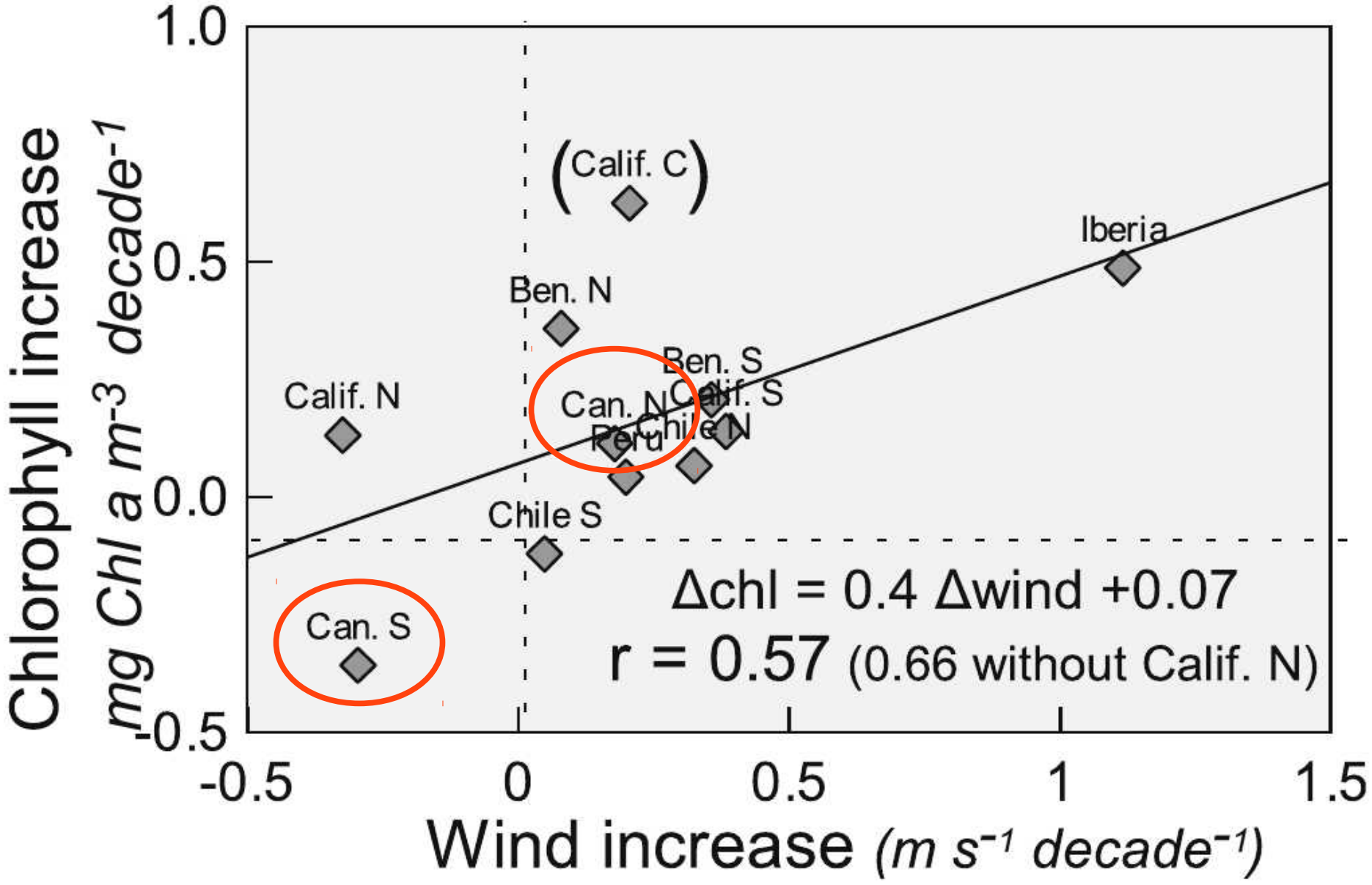


Trends
by upwelling
systems



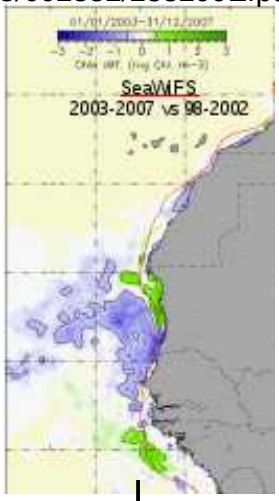
California

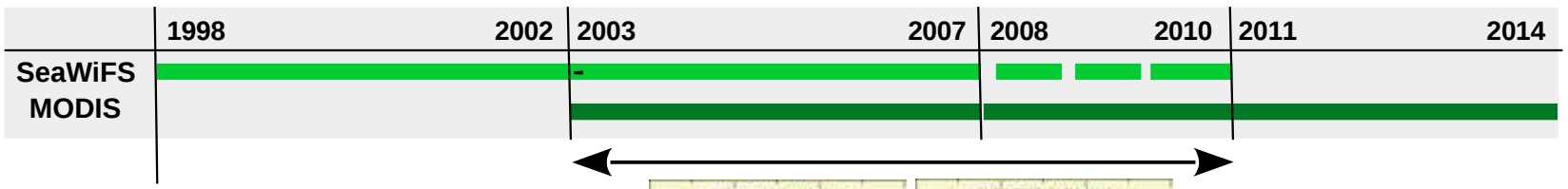
Canary

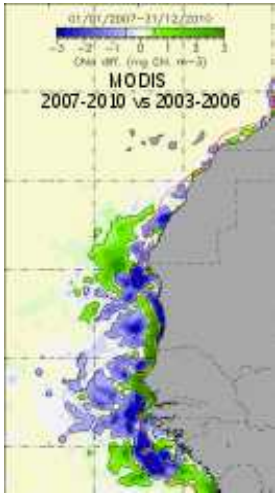

Chlorophyll increase
mg Chl a m-3 decade-1
Wind increase (m s-1 decade-1)
1.0
0.5
0.0
-0.5
-0.5
0
0.5
1
1.5
(Calif. C)
Iberia
Ben. N
Ben. S
Calif. N
Can. N
Calif. S
Peru
Chile N
Chile S
Can. S
Δchl = 0.4 Δwind +0.07
r = 0.57 (0.66 without Calif. N)

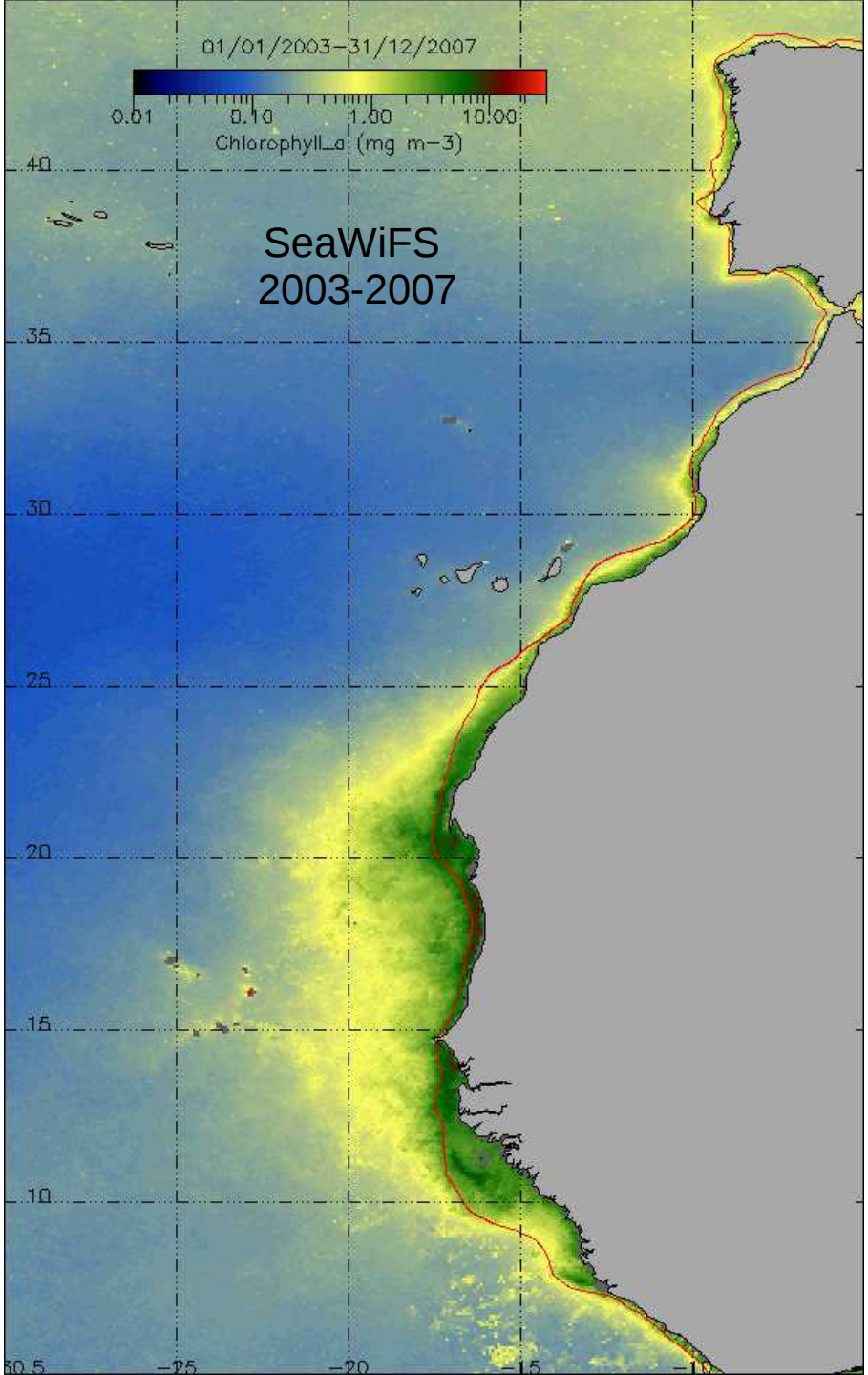
Combinations of trends by sensor (SeaWiFS / MODIS)

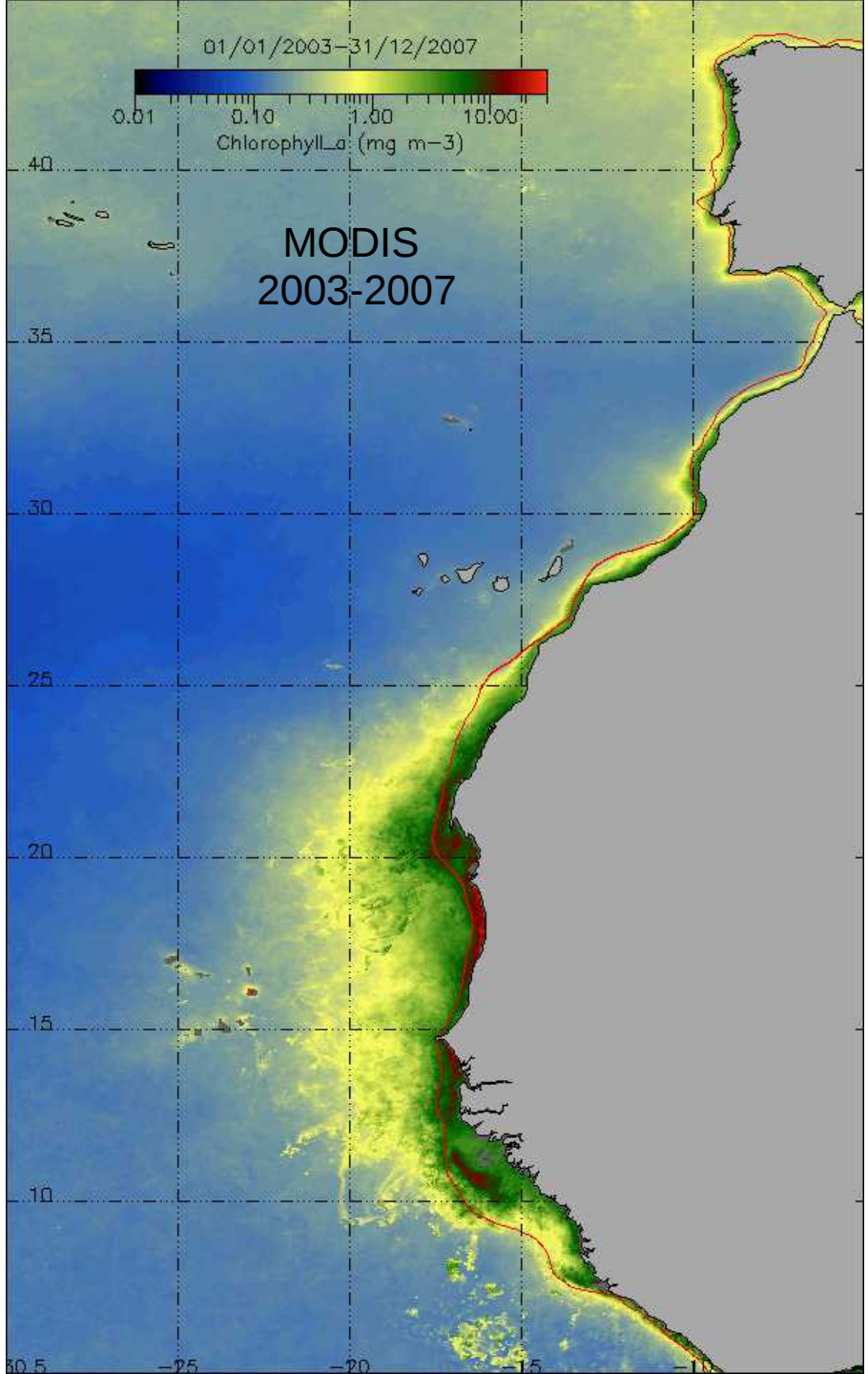
see Demarcq and Benazzouz 2015 6.4 Trends in phytoplancton and primary productivity off northwest Africa, in Oceanographic and biological features in the Canary Current Large Marine Ecosystem2015 Progress.
http://unesdoc.unesco.org/images/0023/002332/233299E.pdf

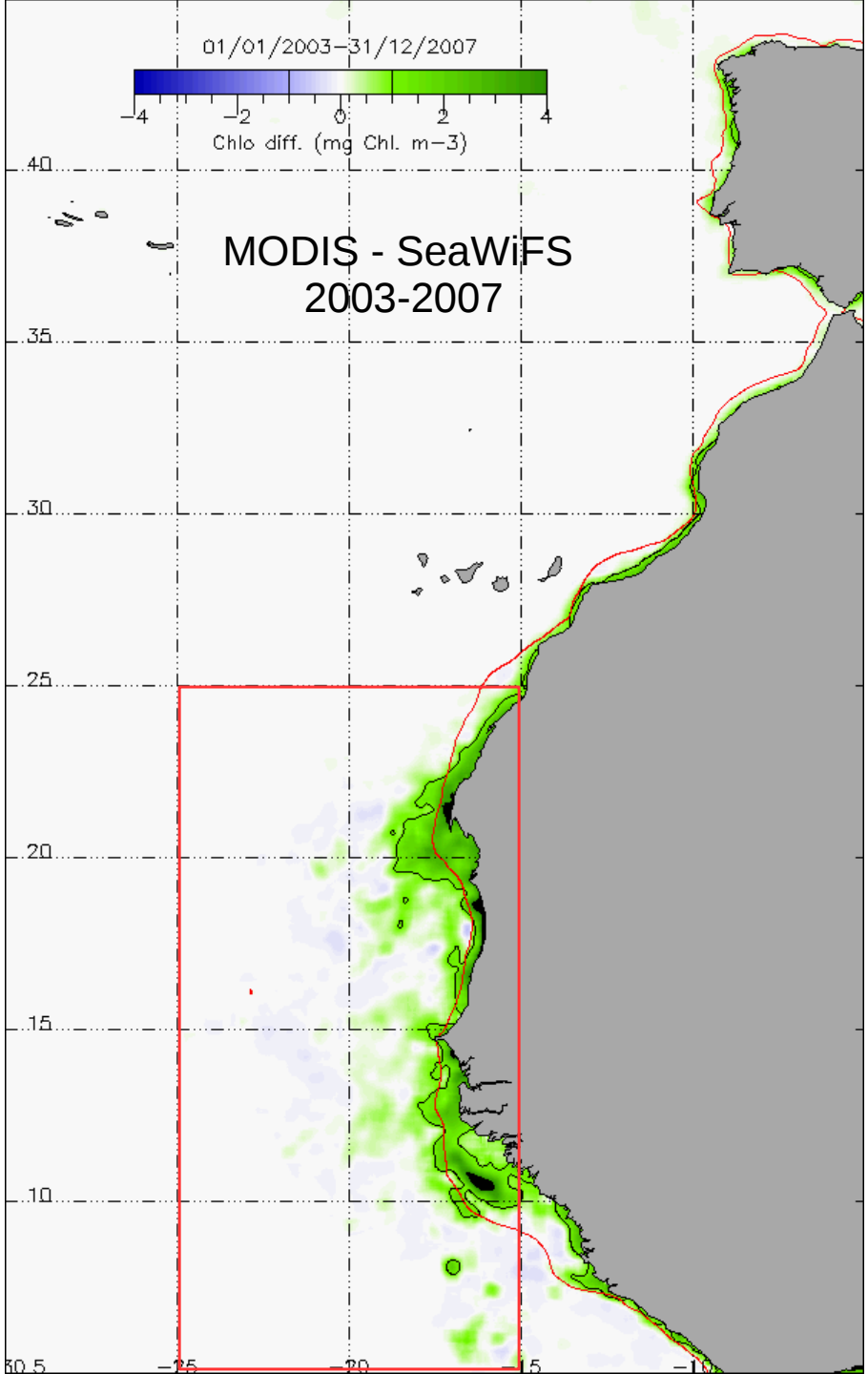






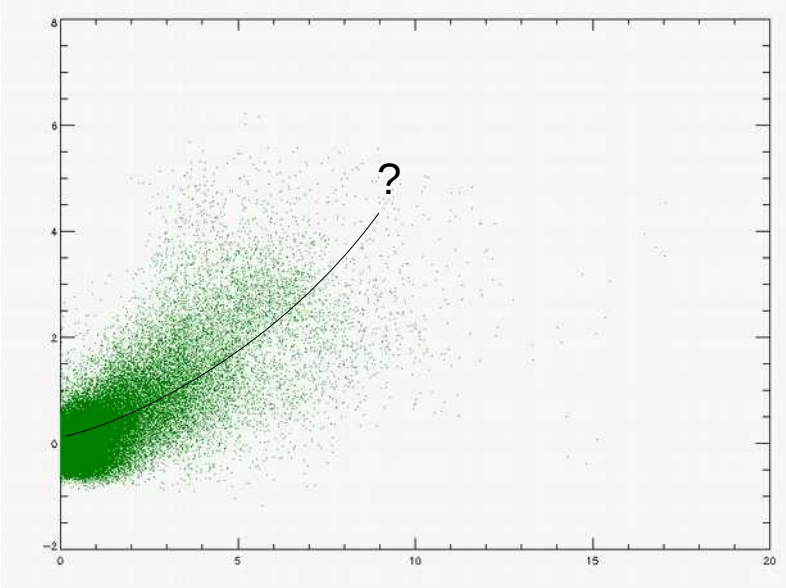

01/01/2003–31/12/2007
0.01
0.10
1.00
10.00
Chlorophyll_a (mg m–3)
SeaWiFS
2003-2007
40
35
30
25
20
15
10
30.5
–25
–20
–15
–10


01/01/2003–31/12/2007
0.01
0.10
1.00
10.00
Chlorophyll_a (mg m–3)
MODIS
2003-2007
40
35
30
25
20
15
10
30.5
–25
–20
–15
–10

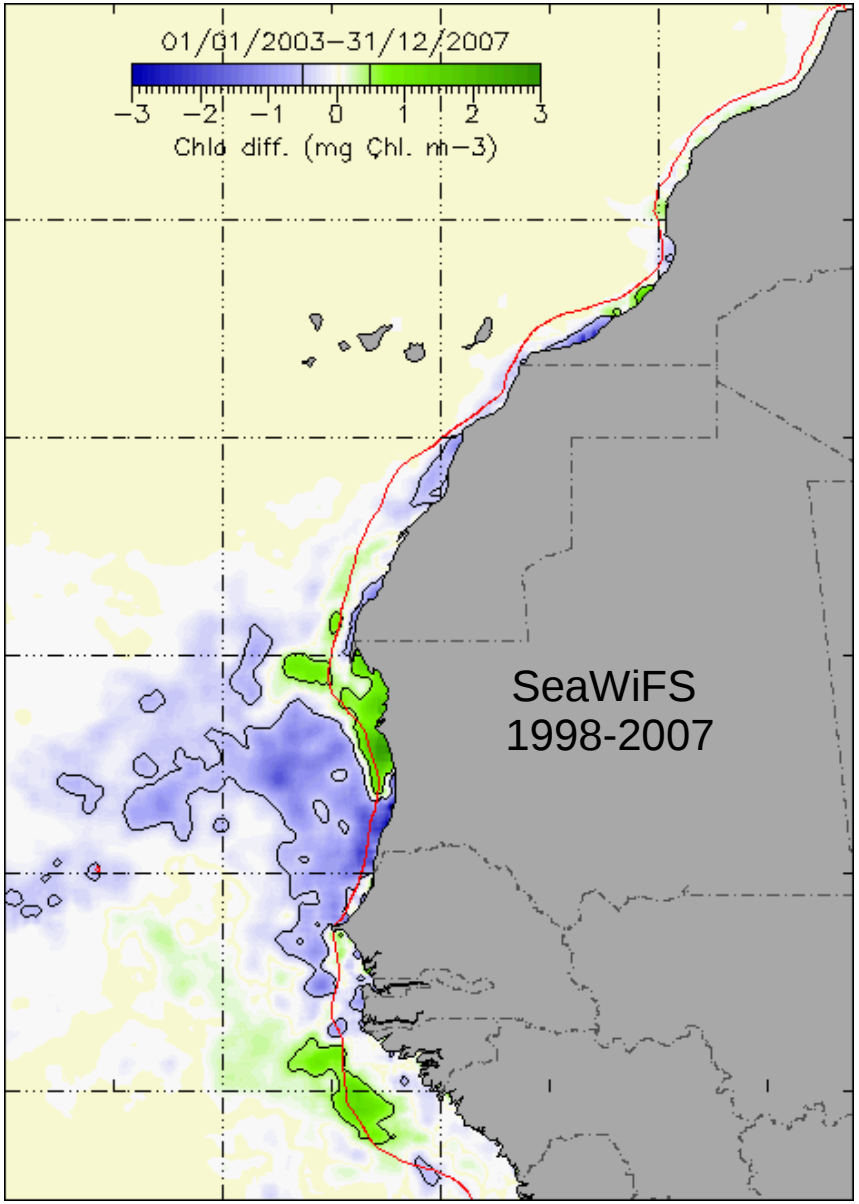


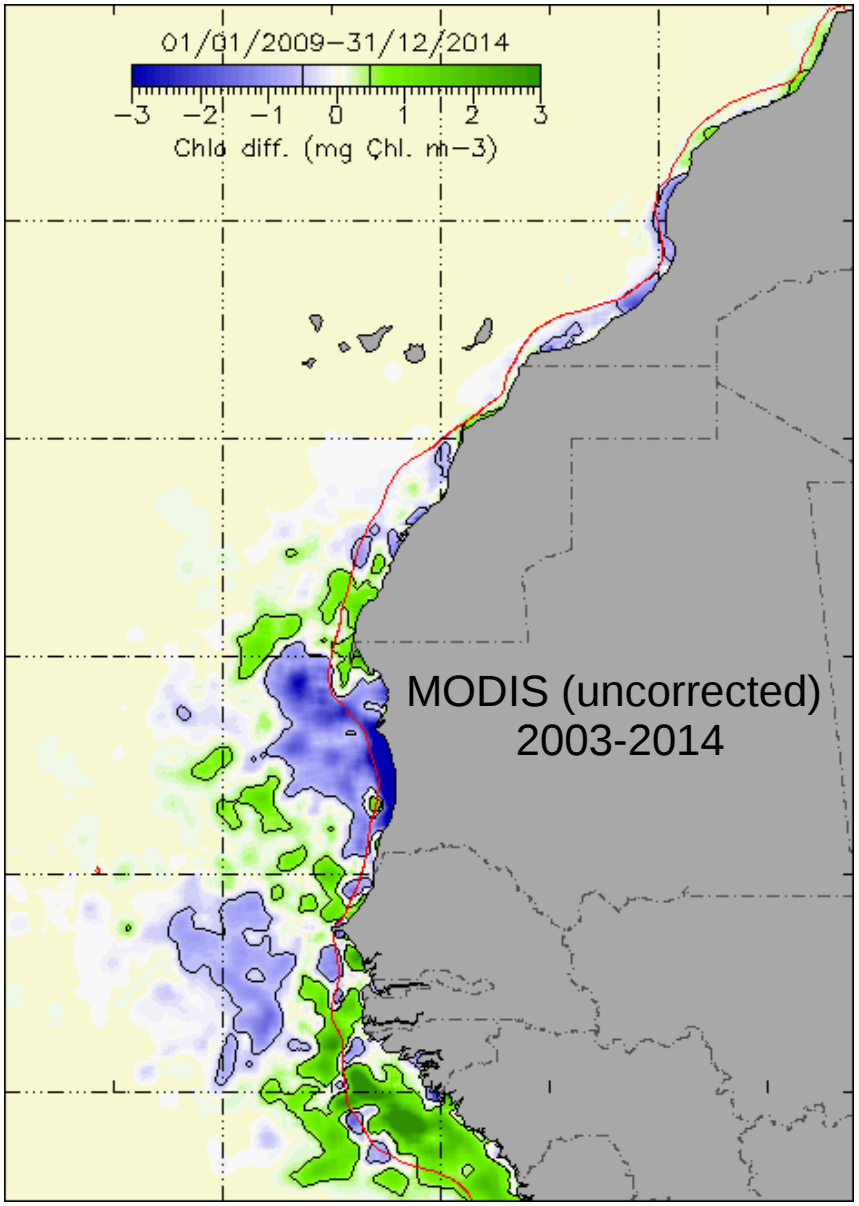
Average overestimate of the full area 5°N-25°N: **30.7%** (1.932/1.478)

Shelf only : **42.3%**

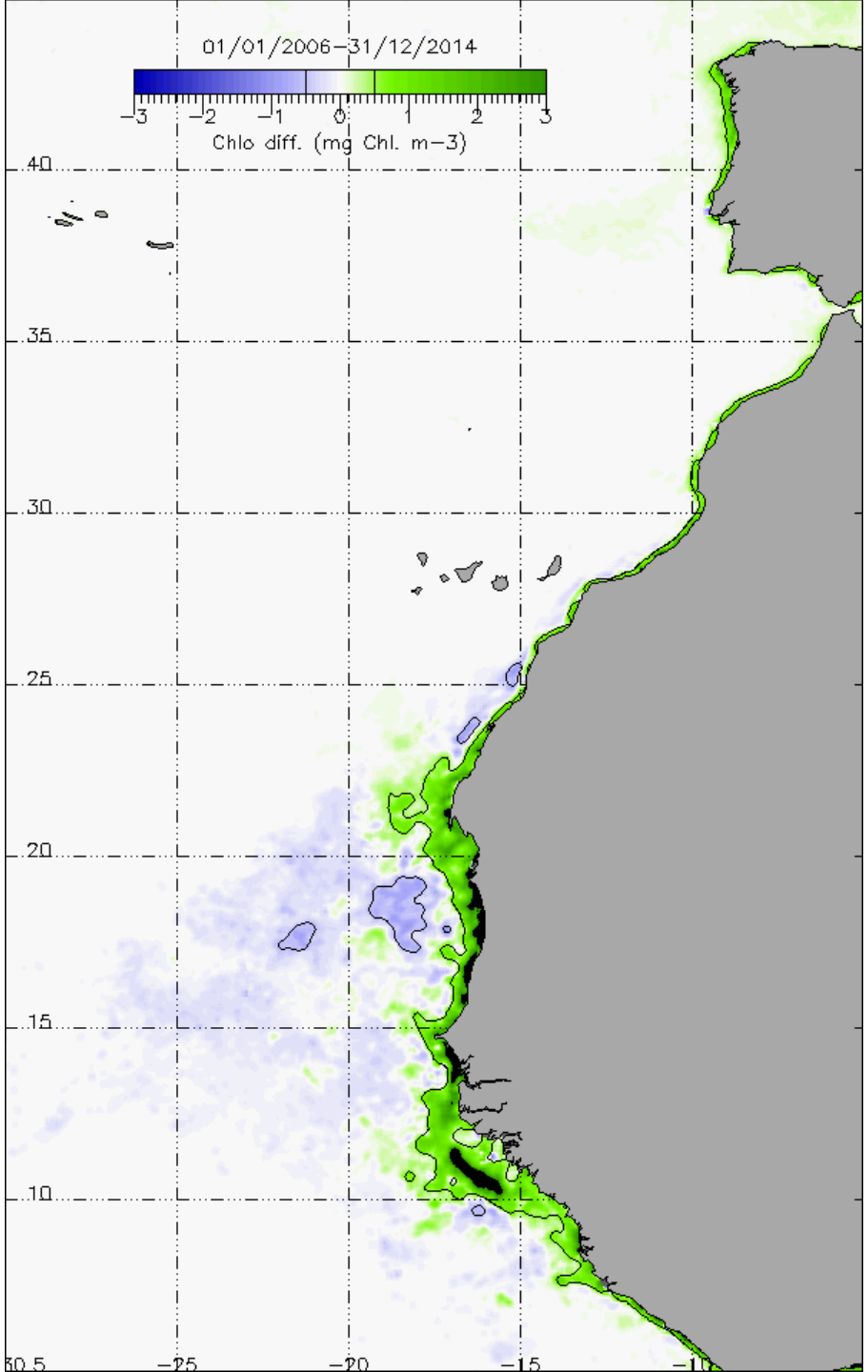


Diff-SW-MODIS_vs_SW.png





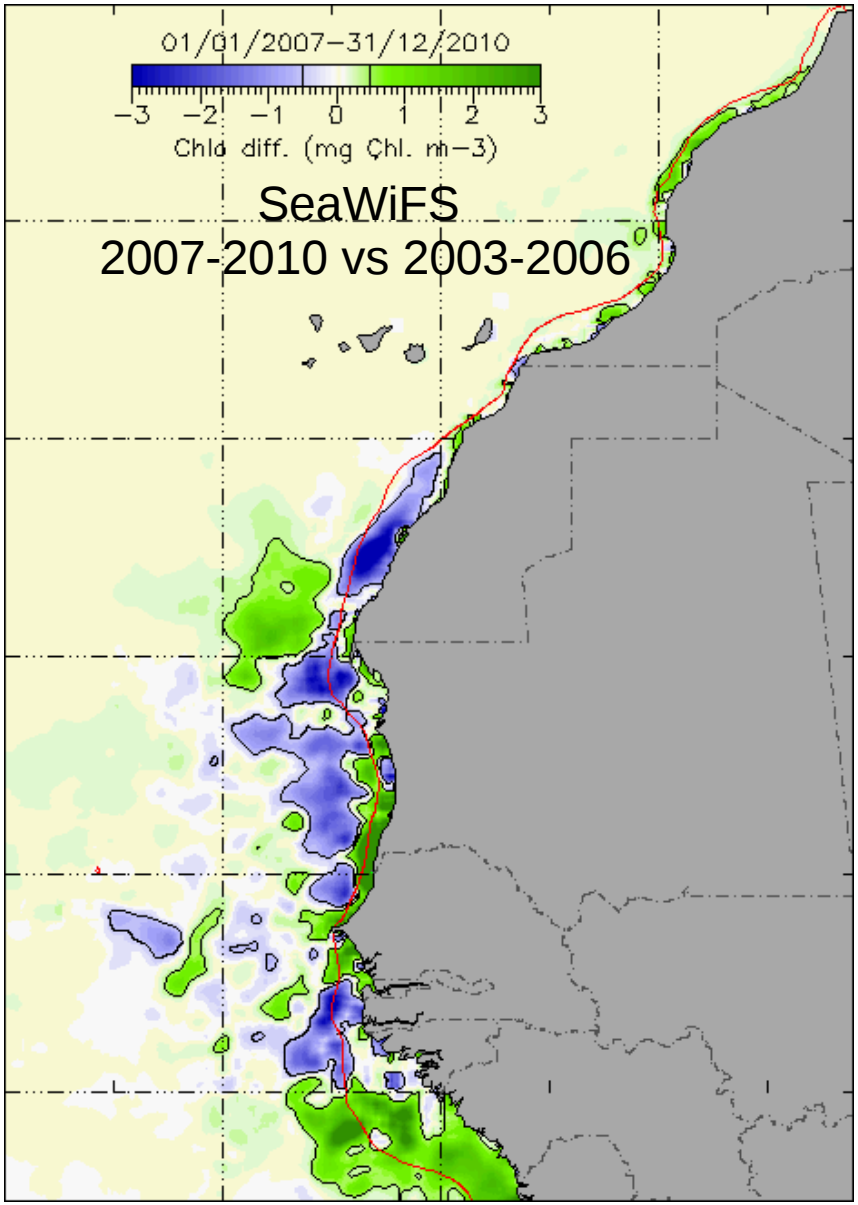
Both are probably correct… but difficult to merge

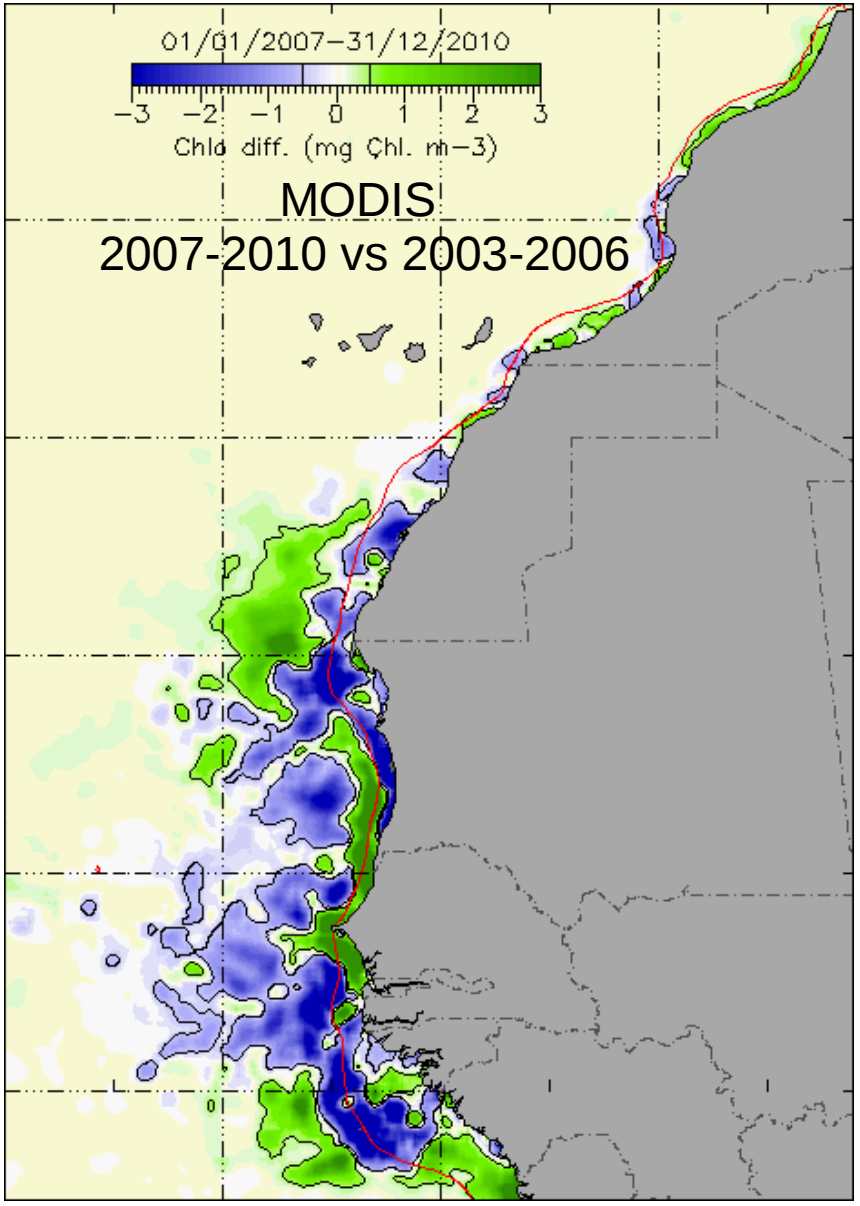


Chlorophyll trend from
1998 to 2014
(SeaWiFS + **uncorrected** MODIS data)

Spurious trend...

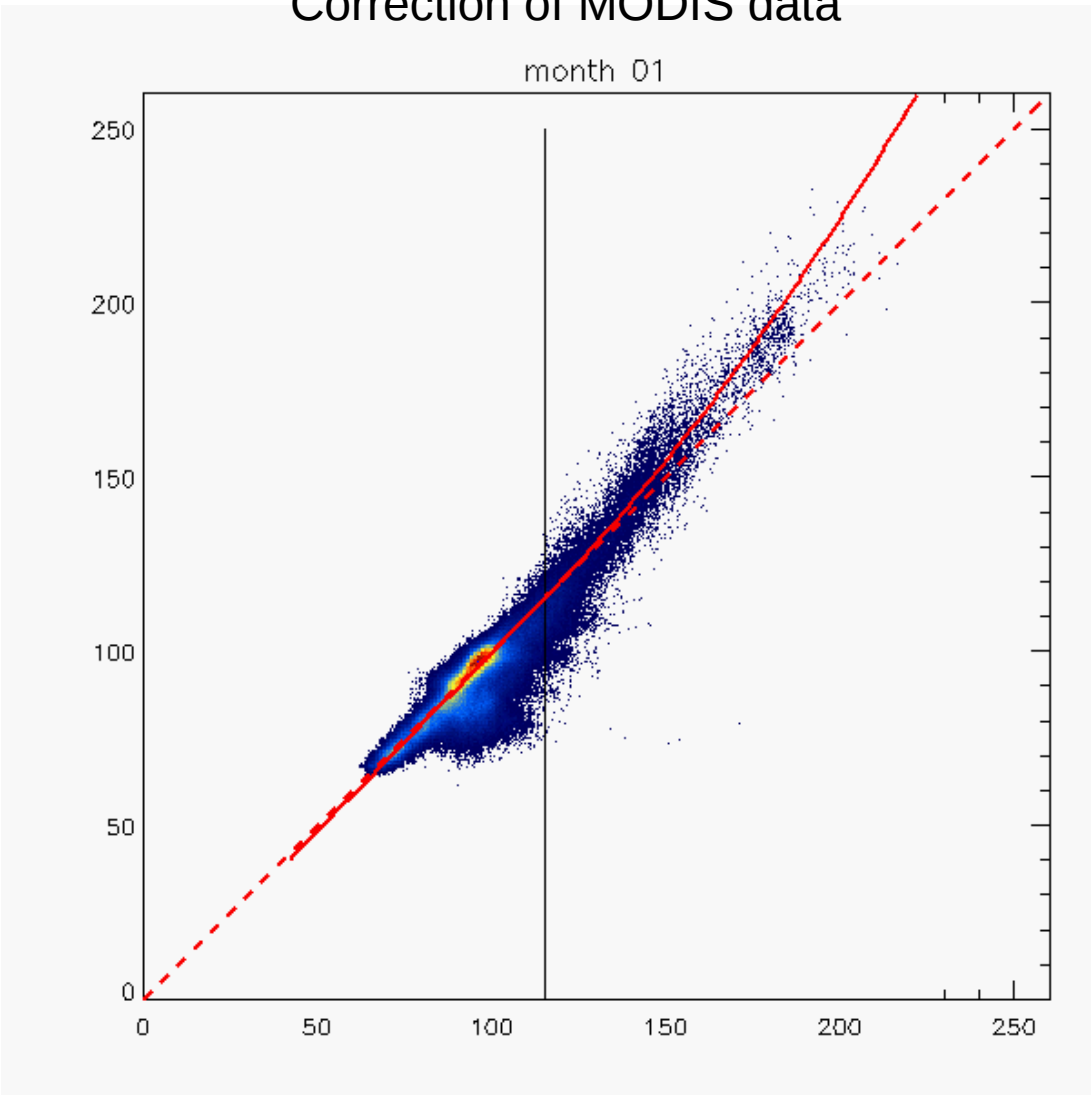
Comparison of chlrophyll trends from SeaWiFS and MODIS for their common period (2003 --> 2010)





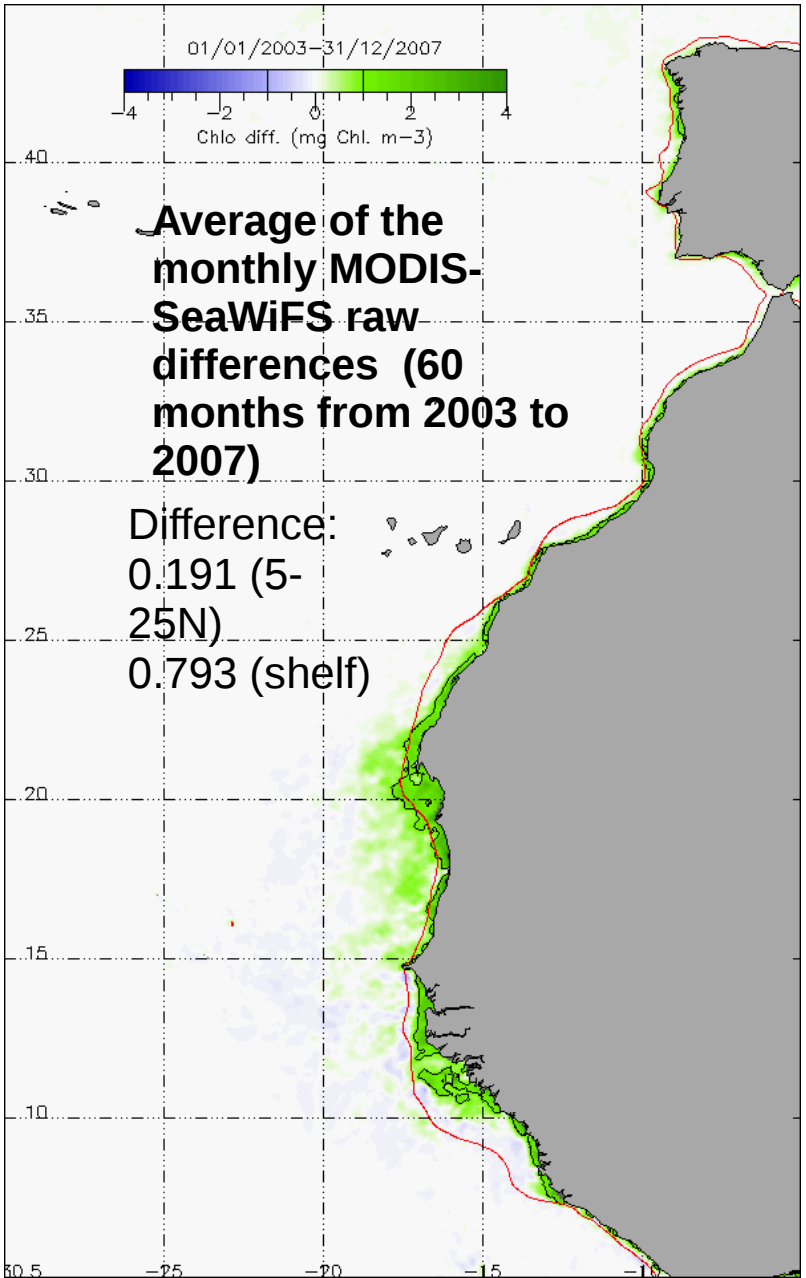
→ Quite similar...

Correction of MODIS data



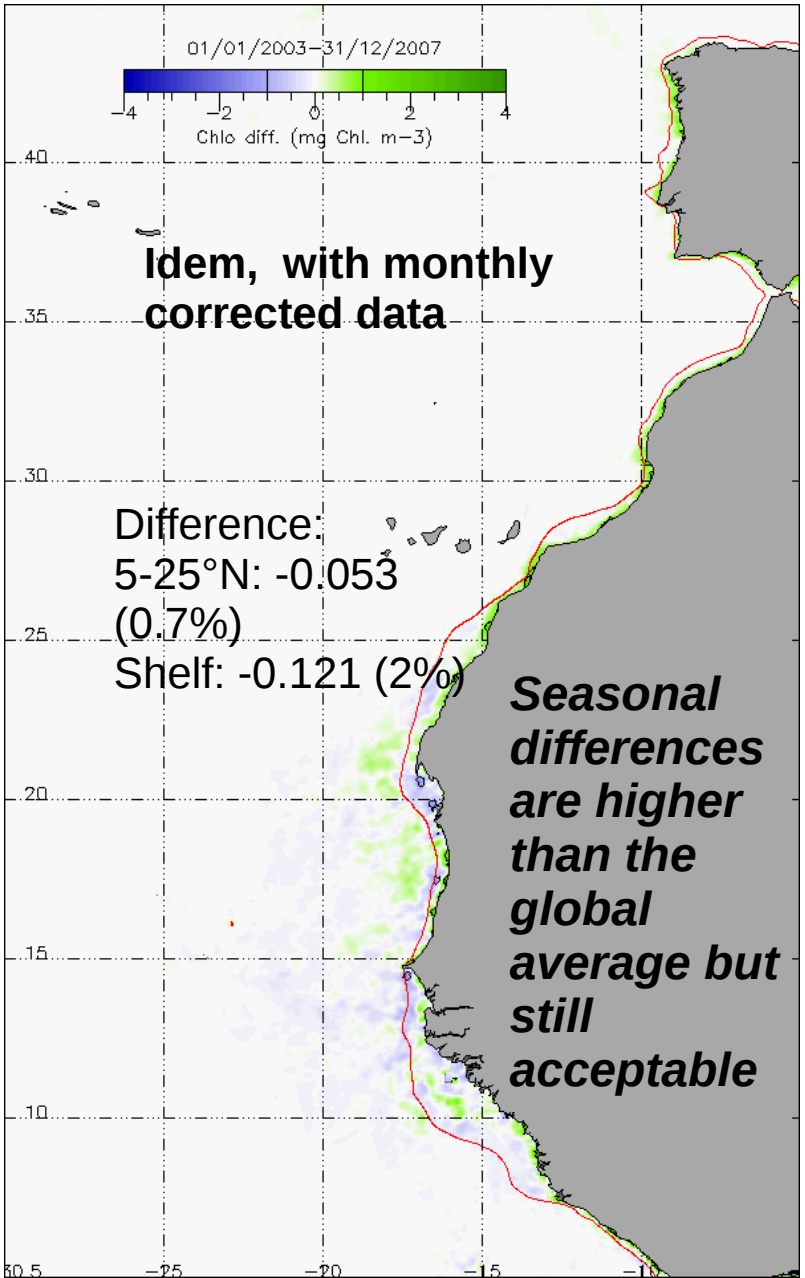
Empirical correction are made with spline functions to match the (better calibrated) SeaWiFS series.

Check of the remaining bias between MODIS Corrected data and SeaWiFS data



Average of the monthly MODIS-SeaWiFS raw differences (60 months from 2003 to 2007)

Difference:
0.191 (5-25N)
0.793 (shelf)



Idem, with monthly corrected data

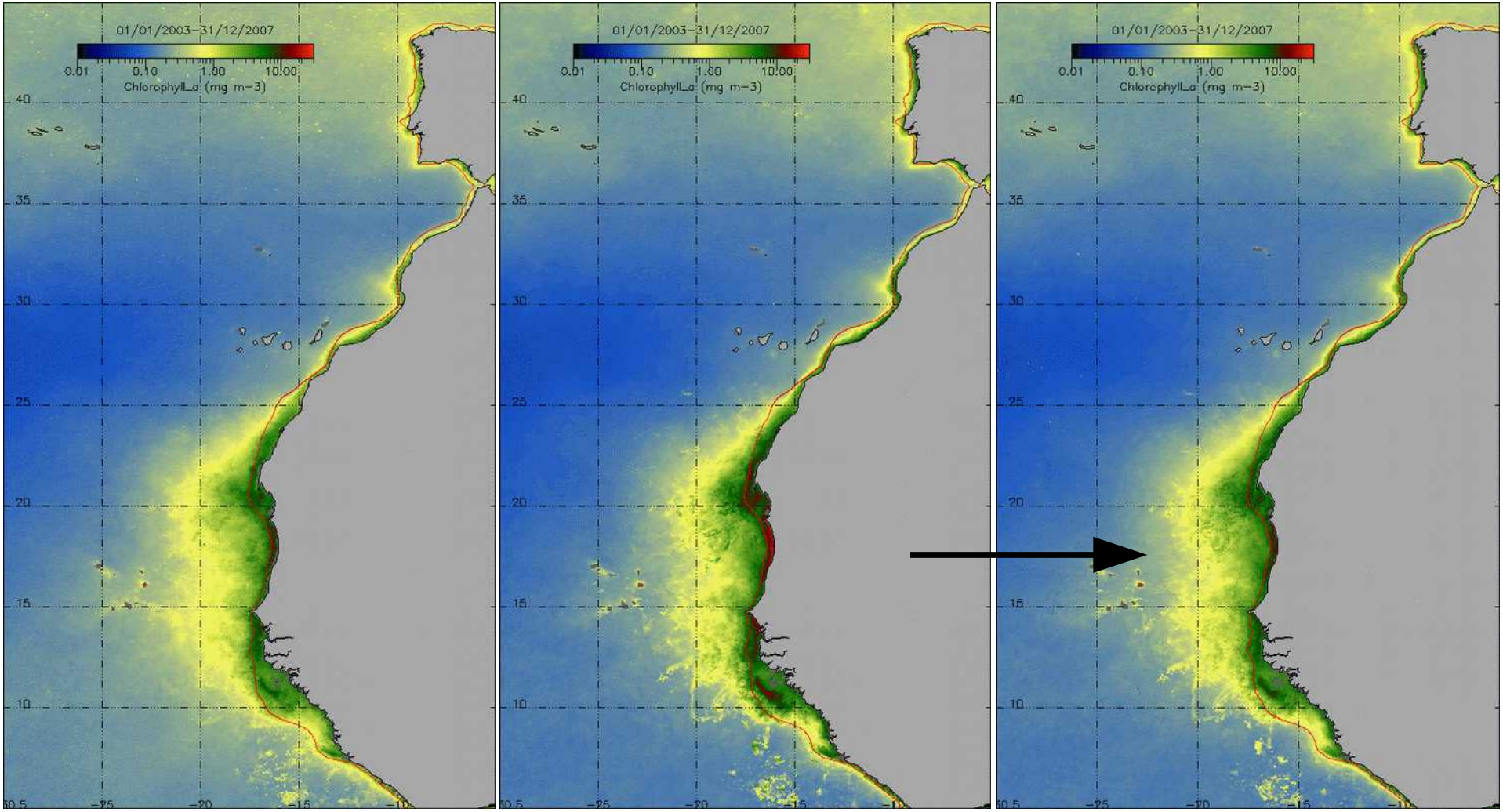
Difference:
5-25°N: -0.053 (0.7%)
Shelf: -0.121 (2%)

Seasonal differences are higher than the global average but still acceptable

Effect of the corrections for the four years 2003 to 2007: **Stable in time**

Year	raw data		Corrected MODIS data	
	5-25°N	5-25°N shelf only	5-25°N	5-25°N shelf only
2003	0.157	0.696	-0.023	-0.027
2004	0.146	0.682	0.026	0.094
2005	0.132	0.800	-0.005	0.084
2006	0.140	0.585	-0.035	-0.246
2007	0.184	0.780	0.035	0.146
average	**0.152**	**0.709**	**0.001**	**0.018**

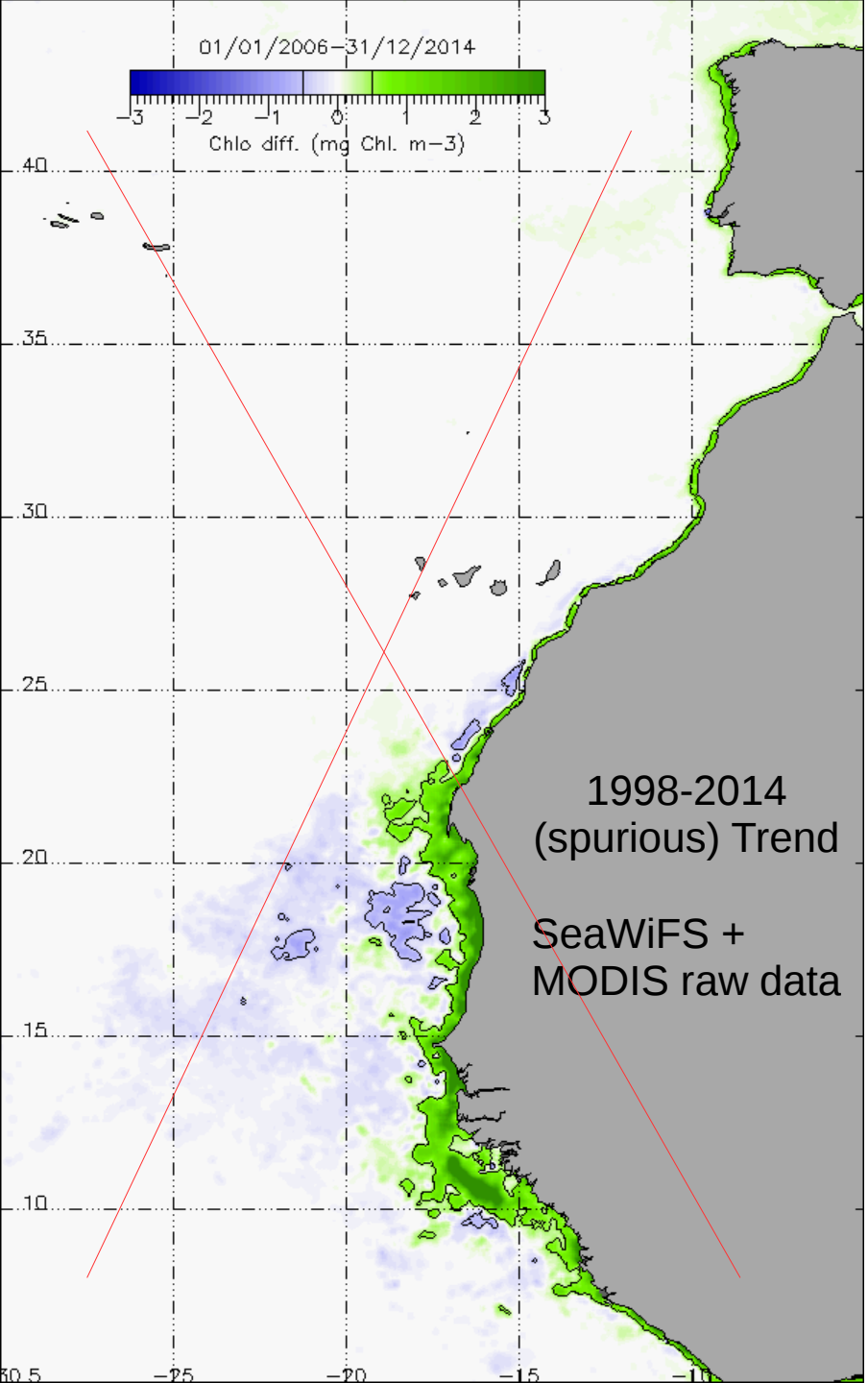
Conclusion : the climatological seasonal correction is fully adequate when separately applied on each year from 2003 to 2007, with a null average bias that do not show any significant trend during the five common years.
Nevertheless, slightly spatialized patterns persist in the average bias (previous figure) due to intrinsic differences between atmospheric corrections

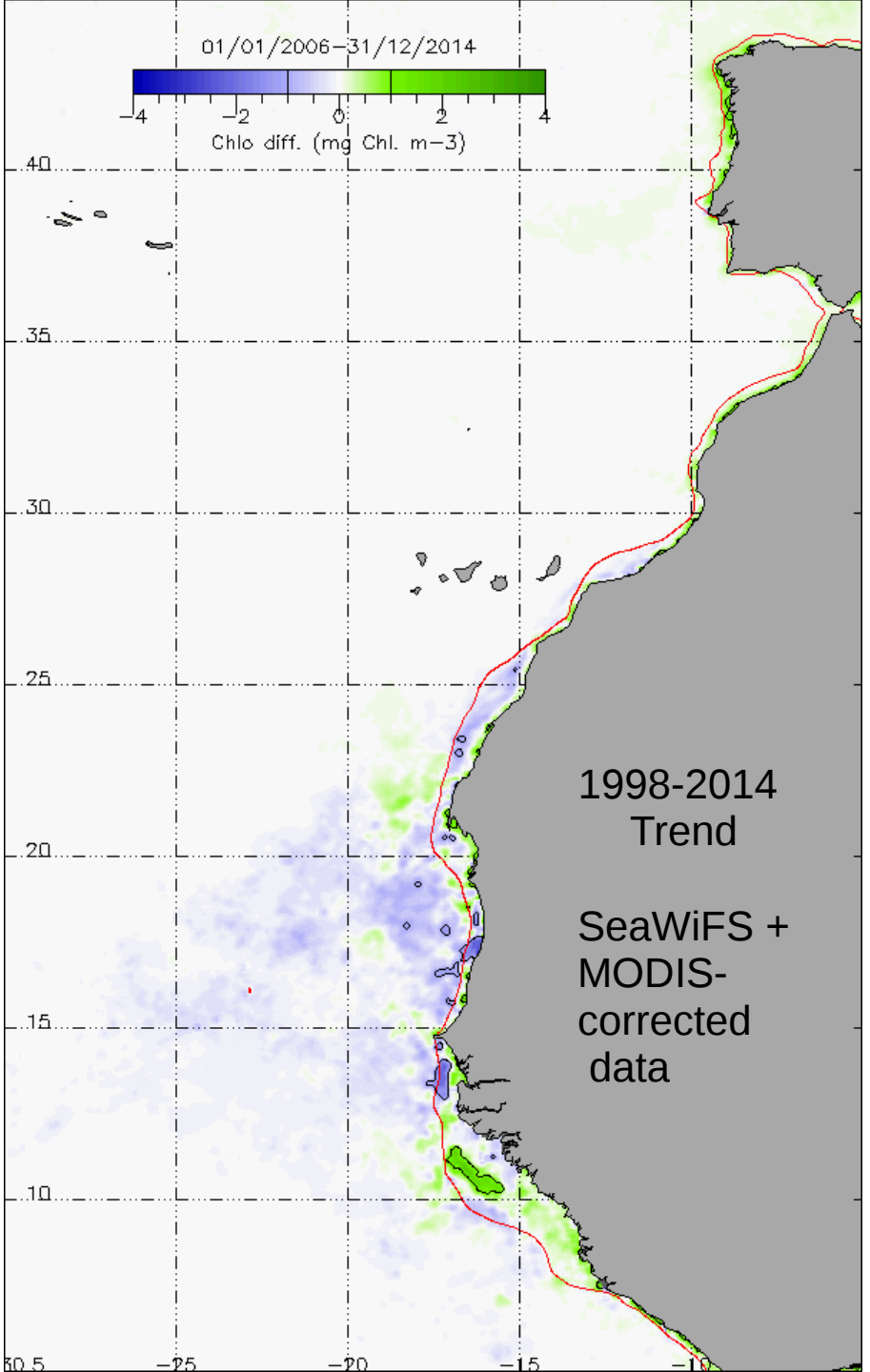


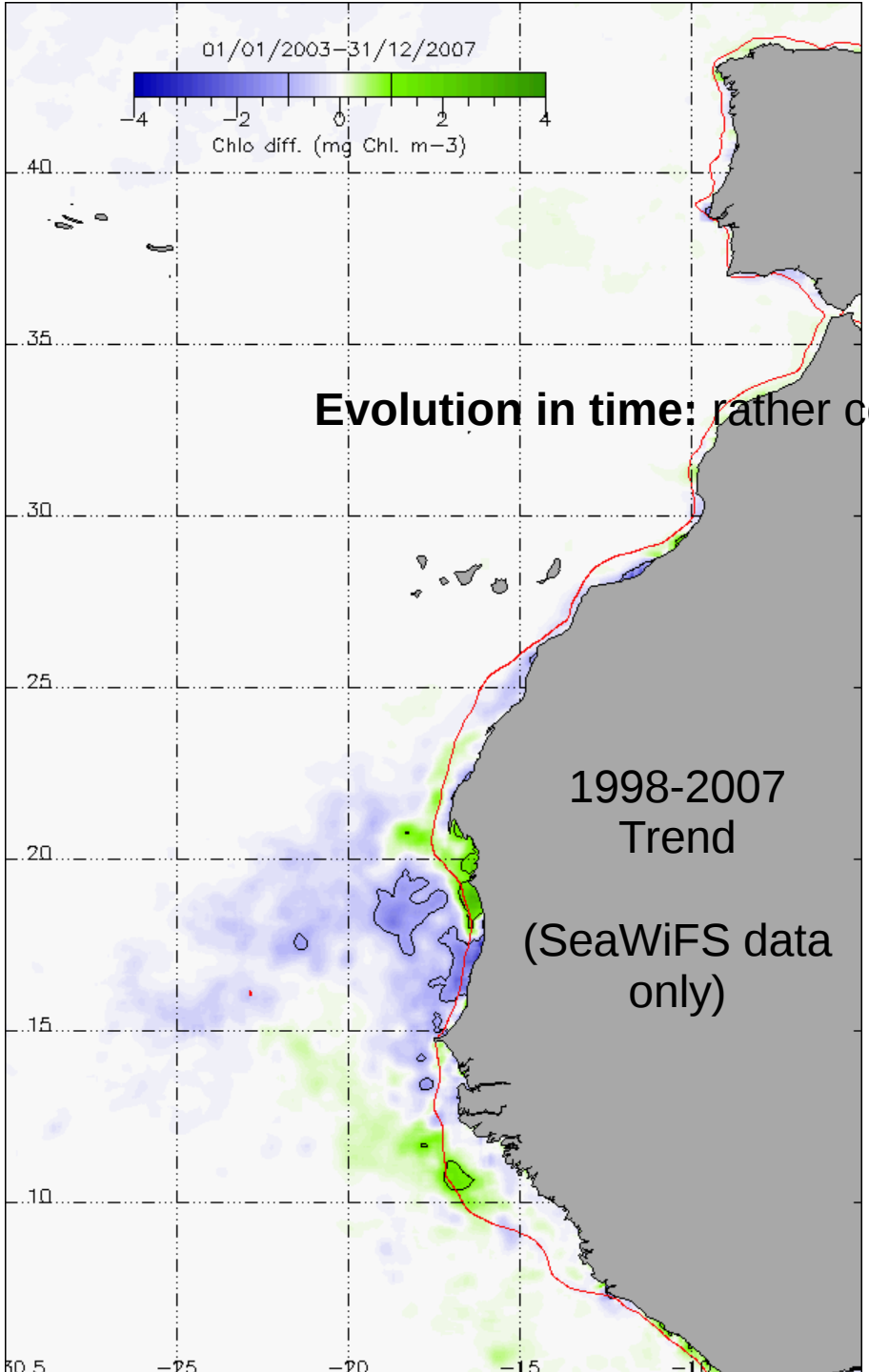
SeaWiFS

MODIS

MODIS corrected


01/01/2006–31/12/2014
−3 −2 −1 0 1 2 3
Chlo diff. (mg Chl. m−3)
40
35
30
25
20
15
10
1998-2014
(spurious) Trend
SeaWiFS +
MODIS raw data

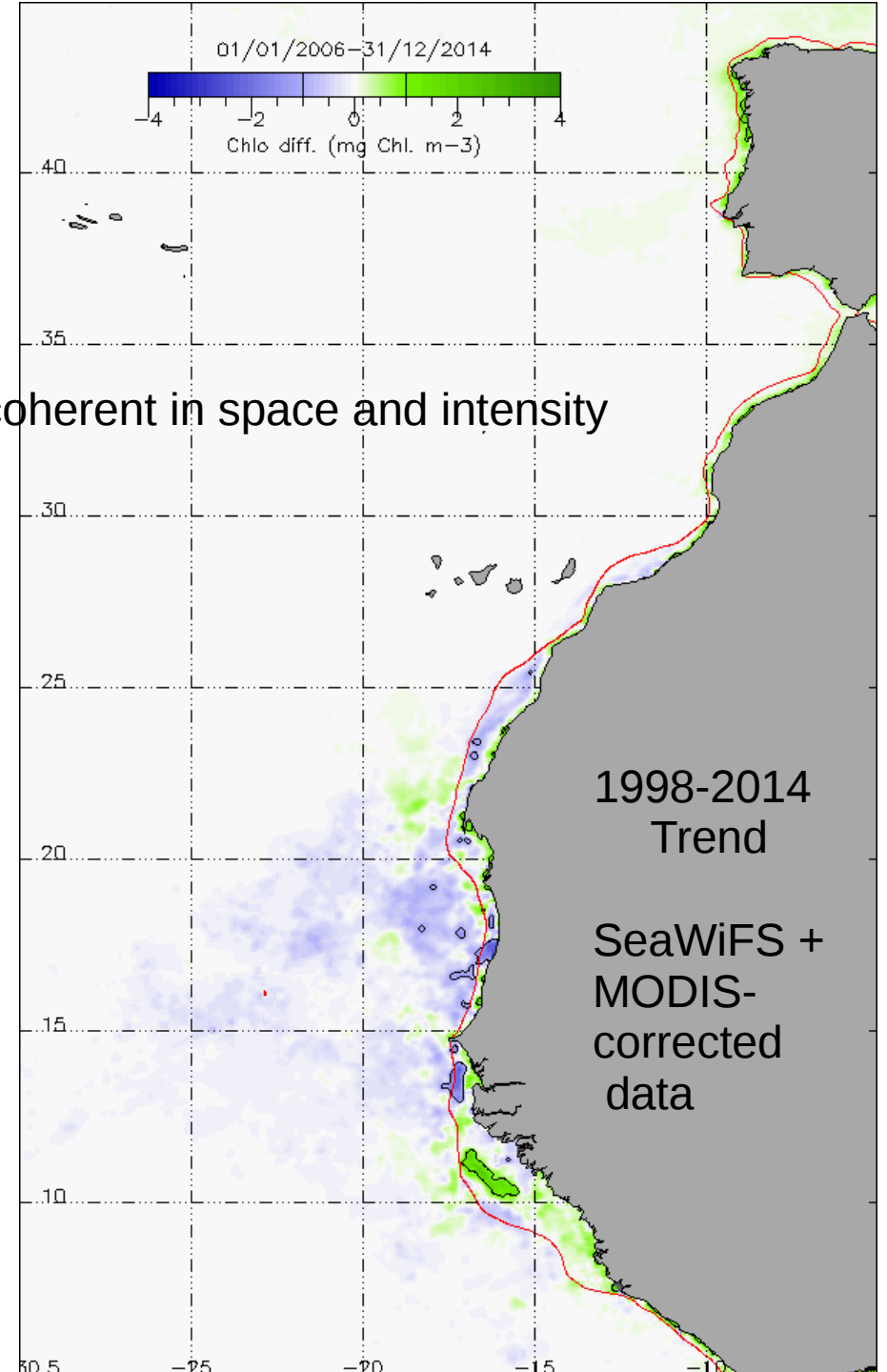

01/01/2006–31/12/2014
−4 −2 0 2 4
Chlo diff. (mg Chl. m−3)
40
35
30
25
20
15
10
1998-2014
Trend
SeaWiFS +
MODIS-
corrected
data



Evolution in time: rather coherent in space and intensity

1998-2007
Trend

(SeaWiFS data only)

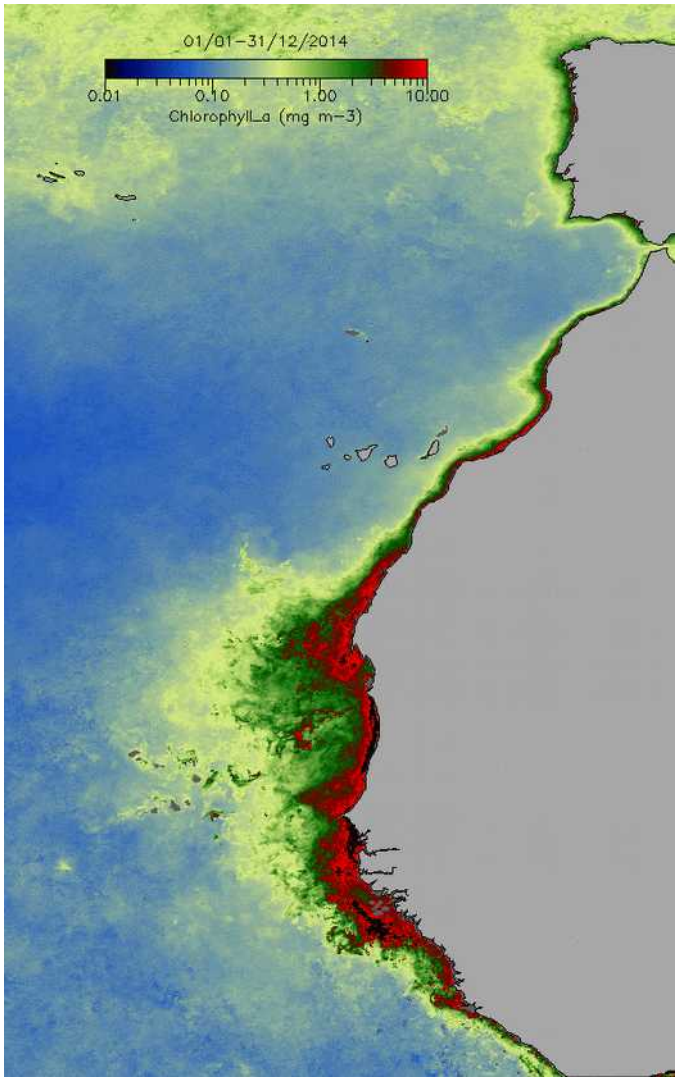


1998-2014
Trend

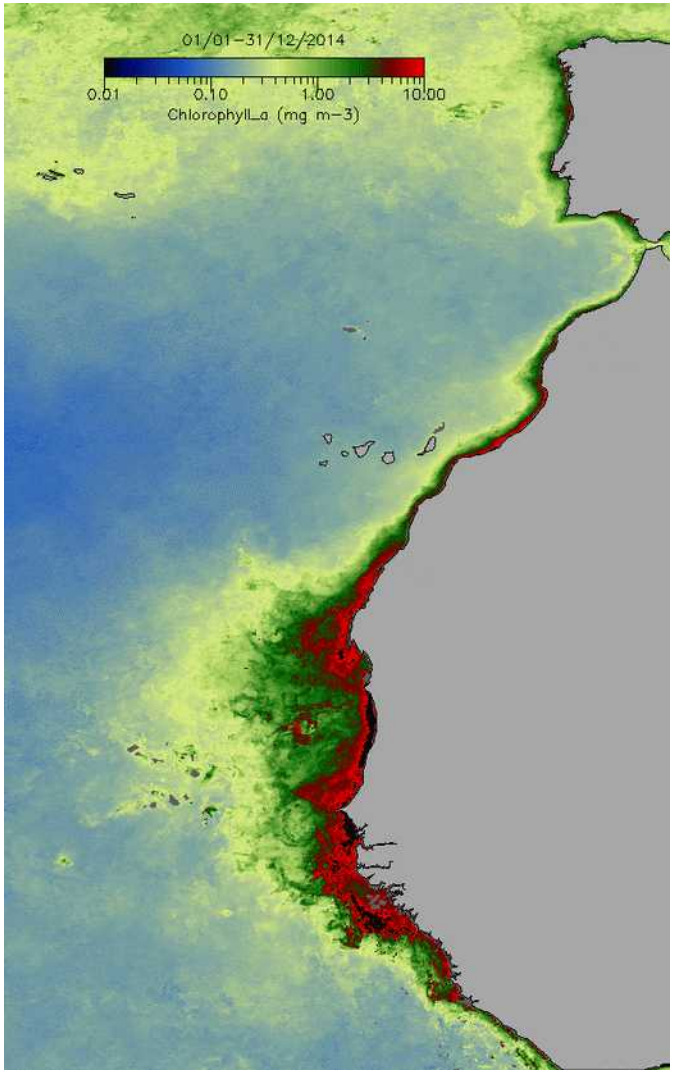
SeaWiFS + MODIS-corrected data

Now check if something has changed with the new R2014 MODIS reprocessing

R2013 (=R2012+R2013)

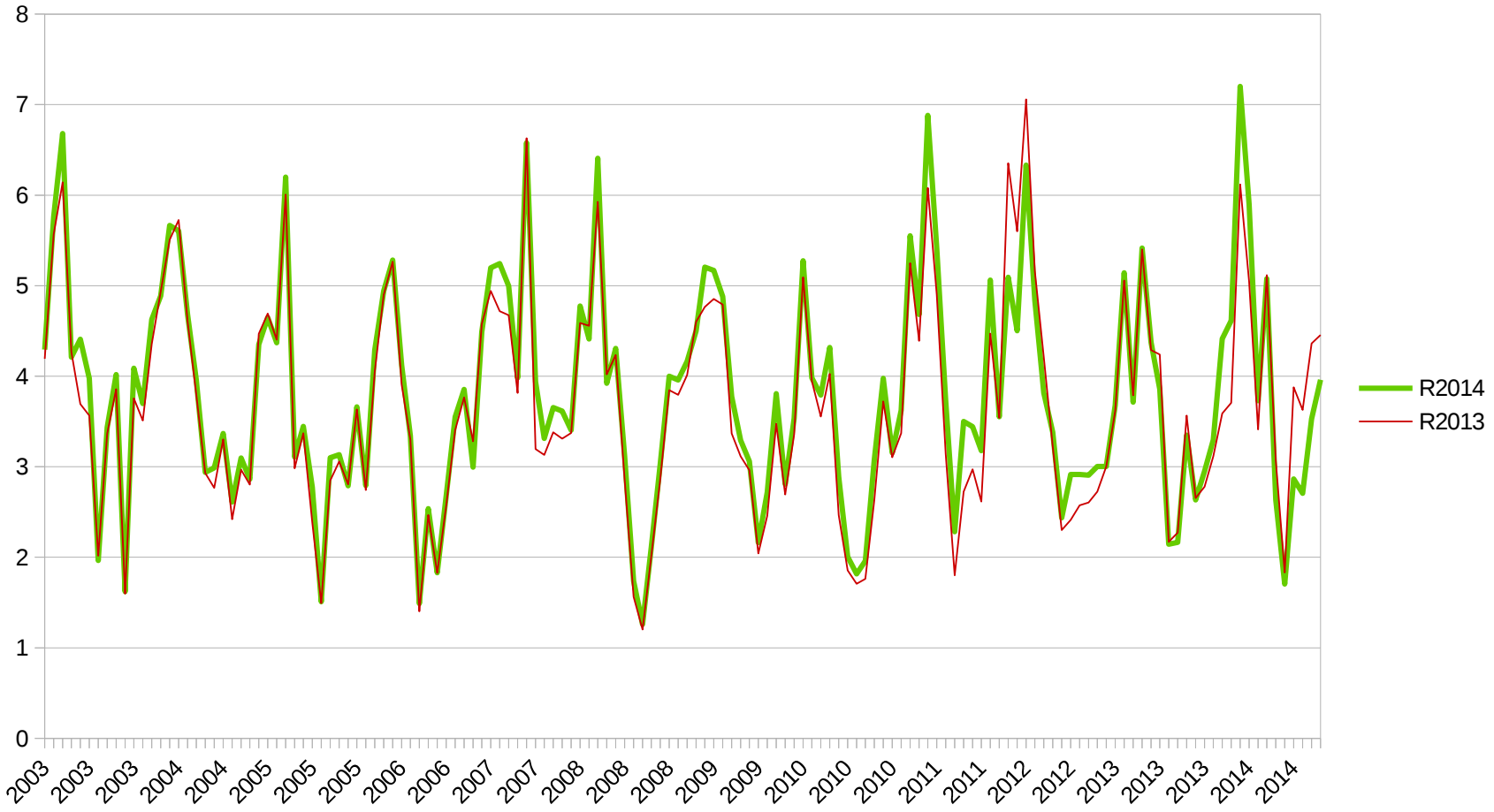


R2014 (NetCDF data) (just a bit higher)

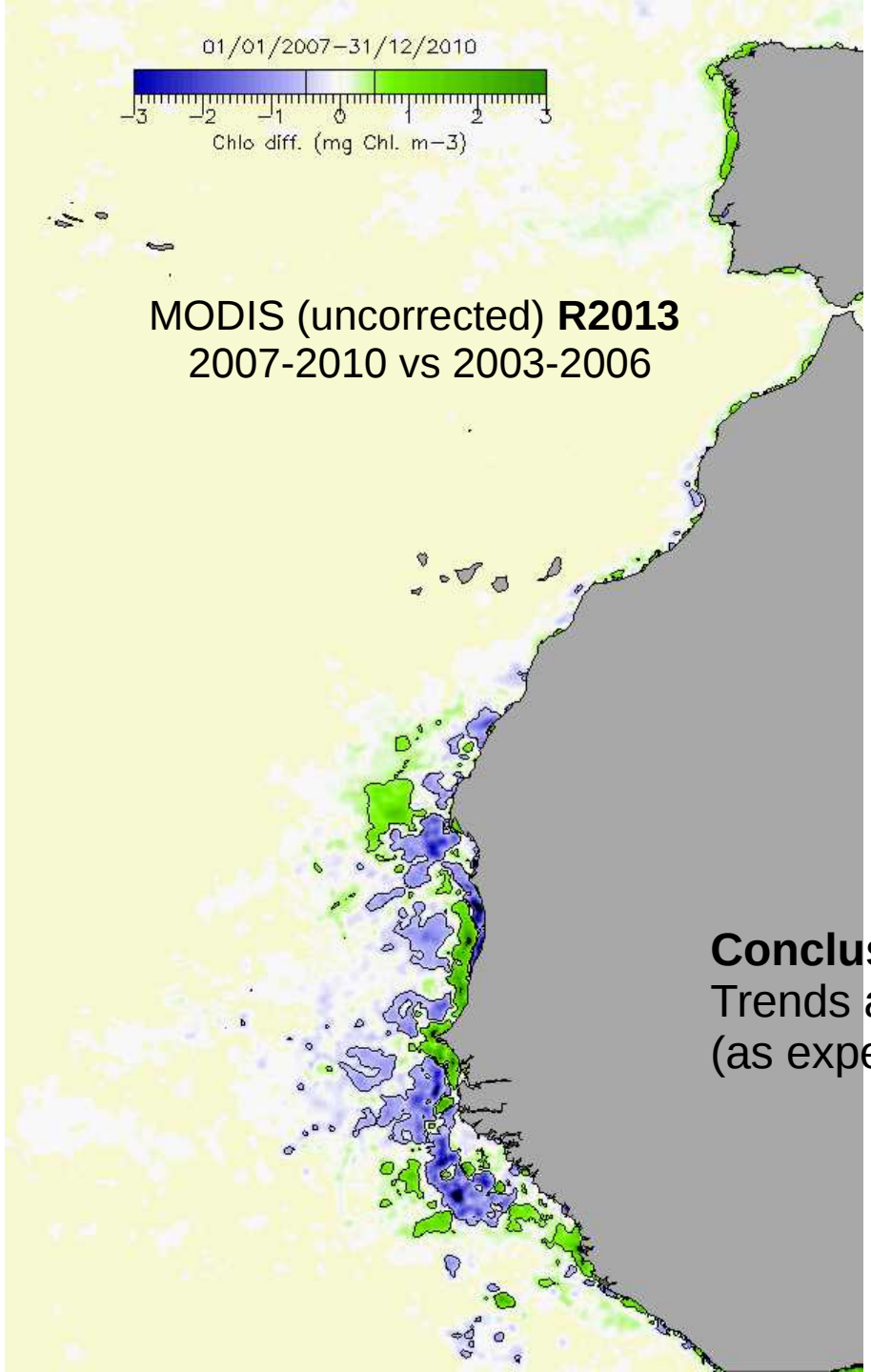


Differences are very weak (R2014 is 0.5 % higher) and far bellow the MODIS-SeaWIFS differences from 2003 to 2007

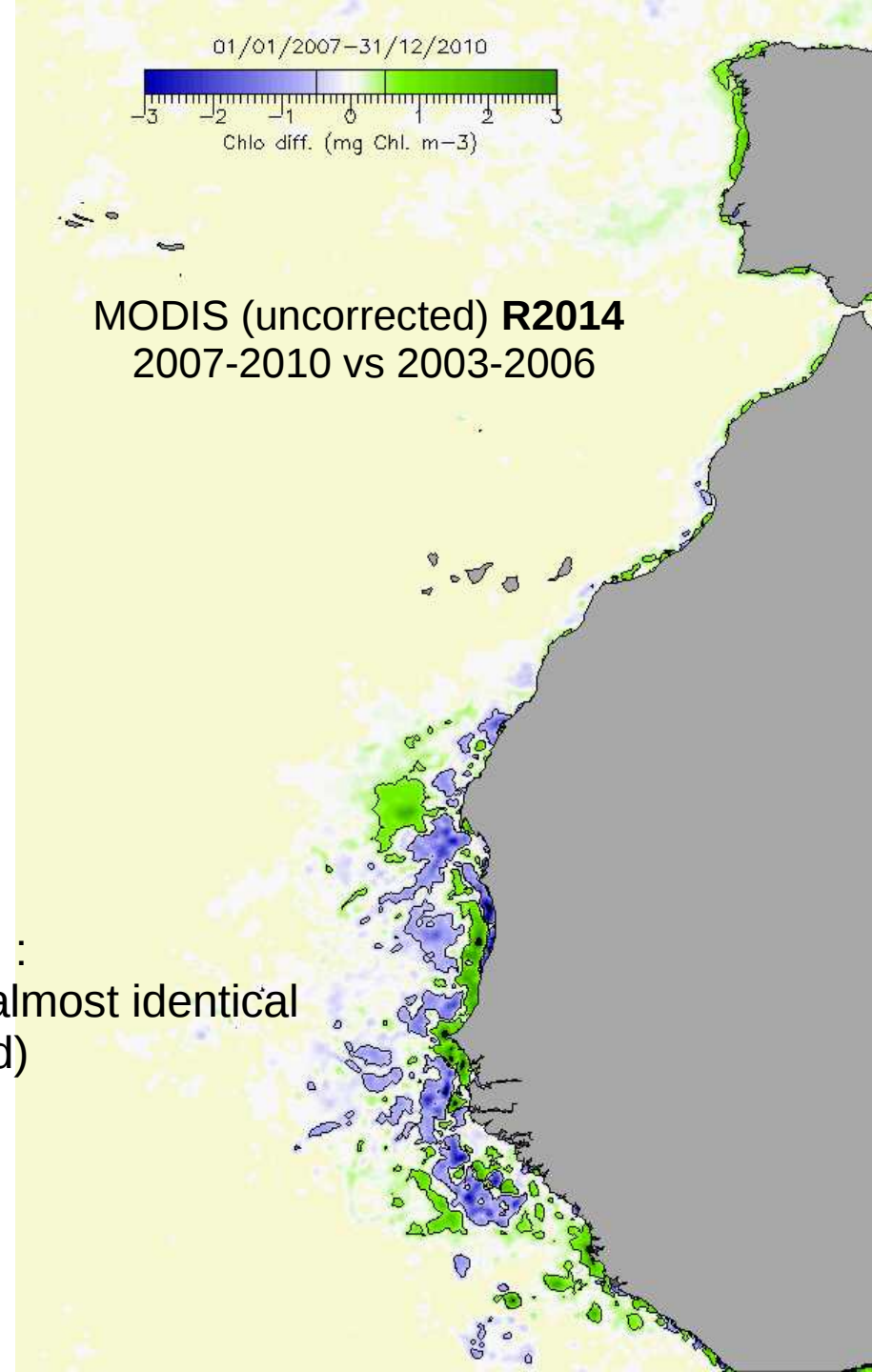
Improvements from the last reprocessing « R2014 » (June 2015)



Differences are moderate and do to affect trends computation

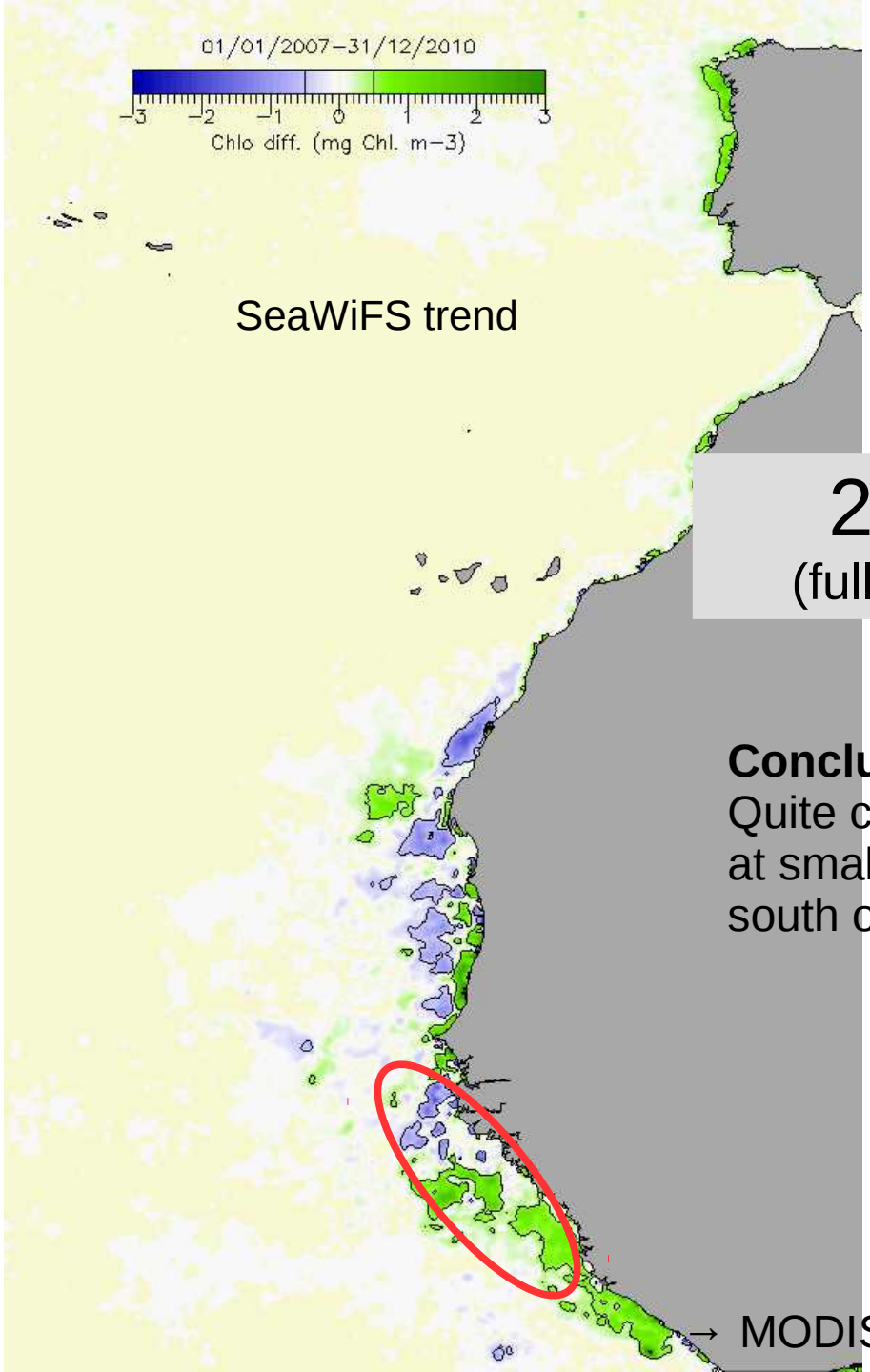


MODIS (uncorrected) **R2013**
2007-2010 vs 2003-2006

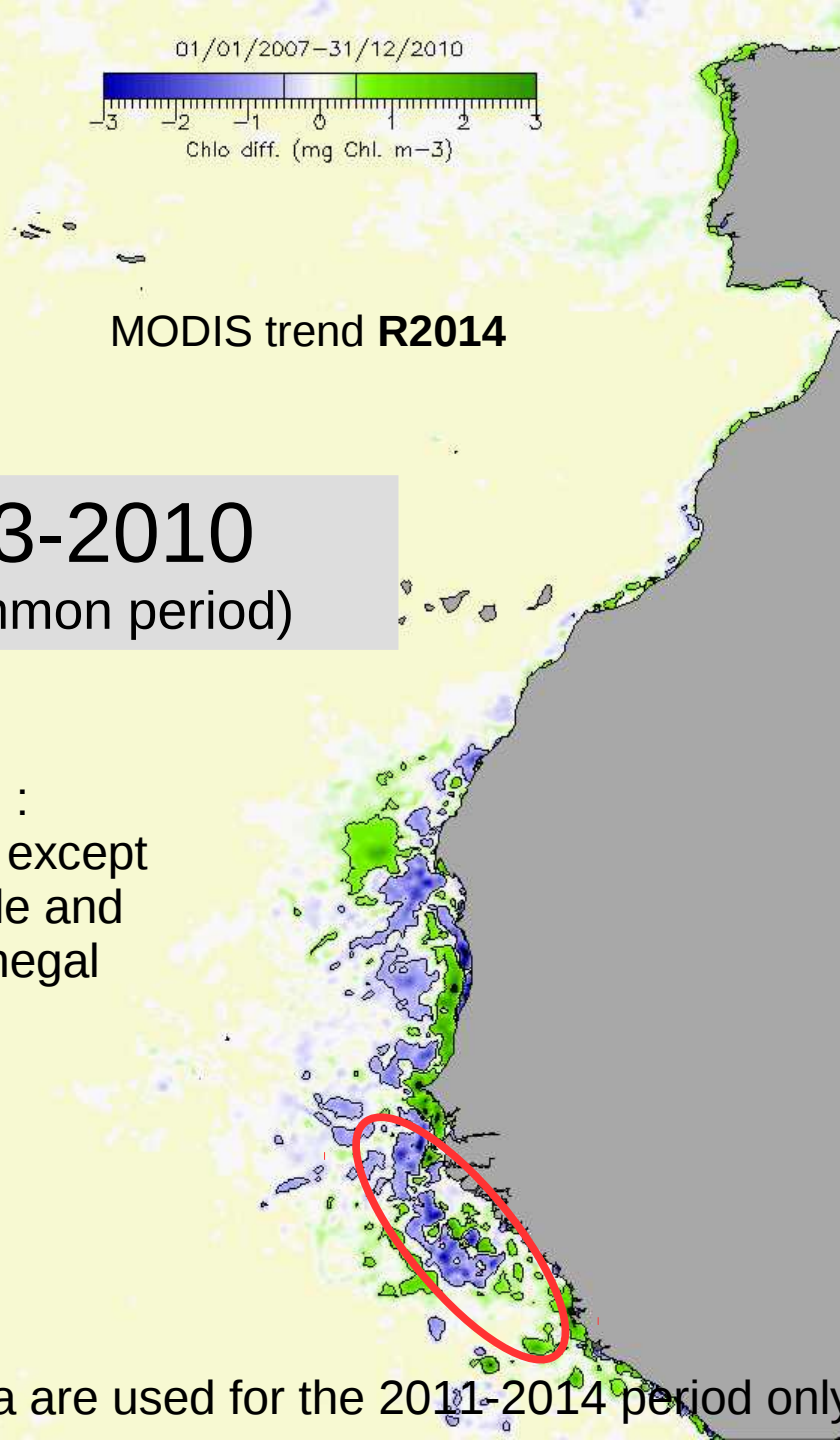


MODIS (uncorrected) **R2014**
2007-2010 vs 2003-2006

Conclusion :
Trends are almost identical
(as expected)



SeaWiFS trend

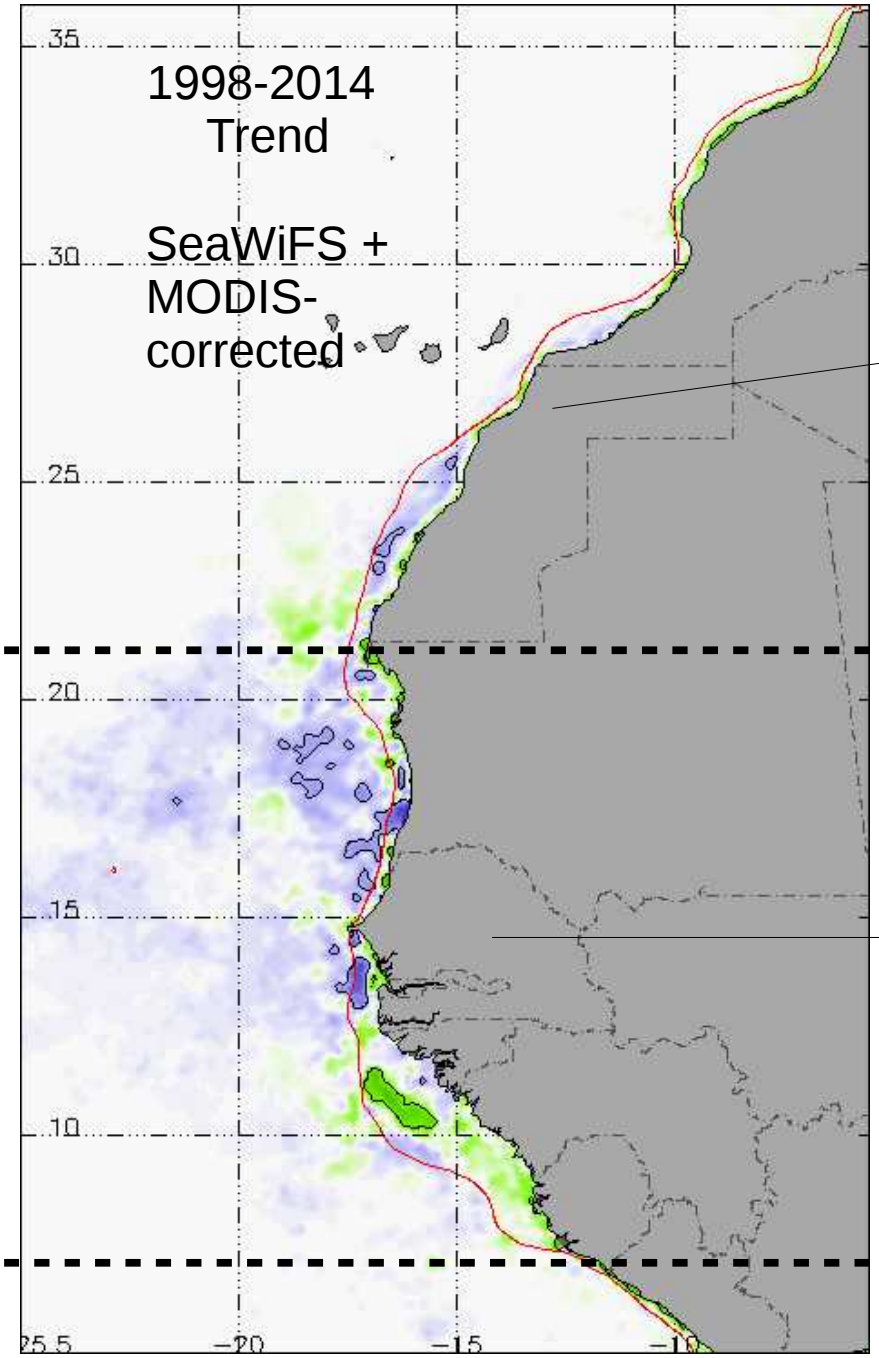


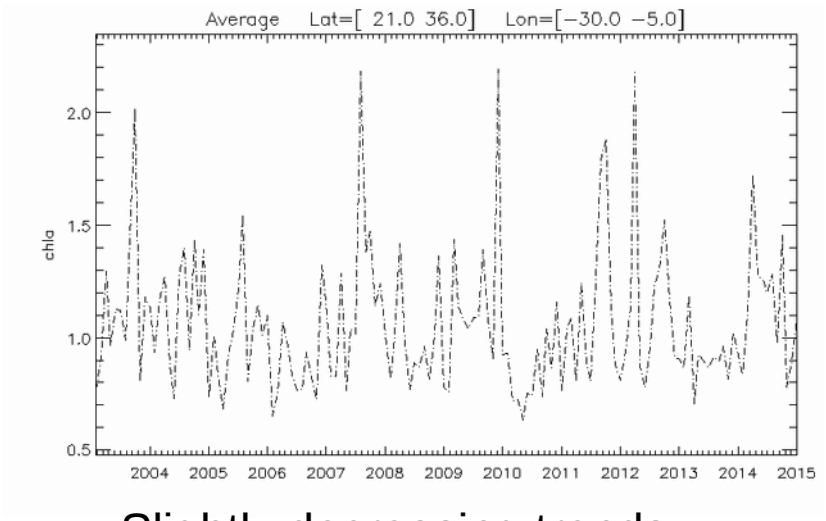
MODIS trend **R2014**

2003-2010
(full common period)

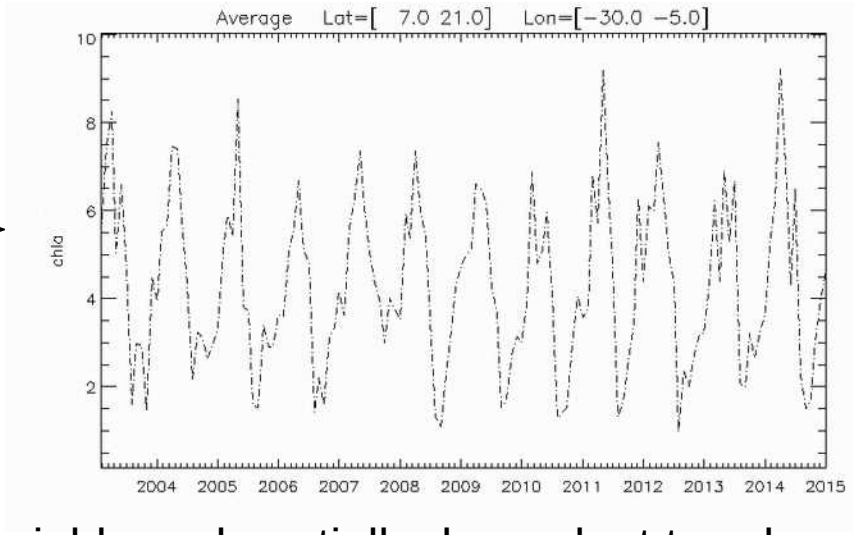
Conclusion :
Quite close, except at small scale and south of Senegal

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





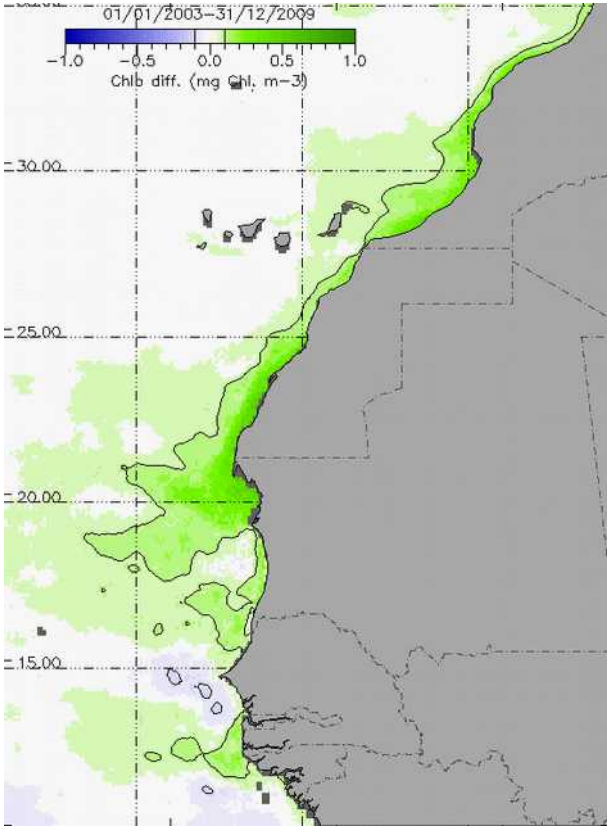
Slightly decreasing trends



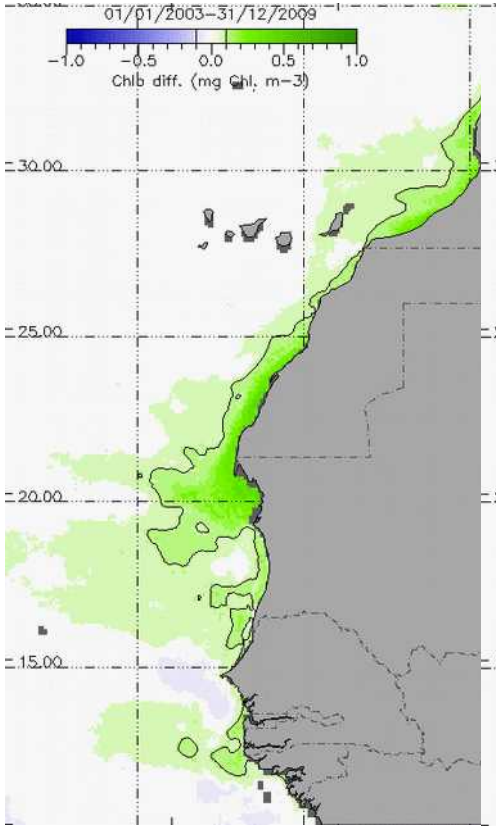
Variable and spatially dependent trends...

Trends in the 2 phytoplankton groups from ROMS-PISCES model from 1980 to 2009

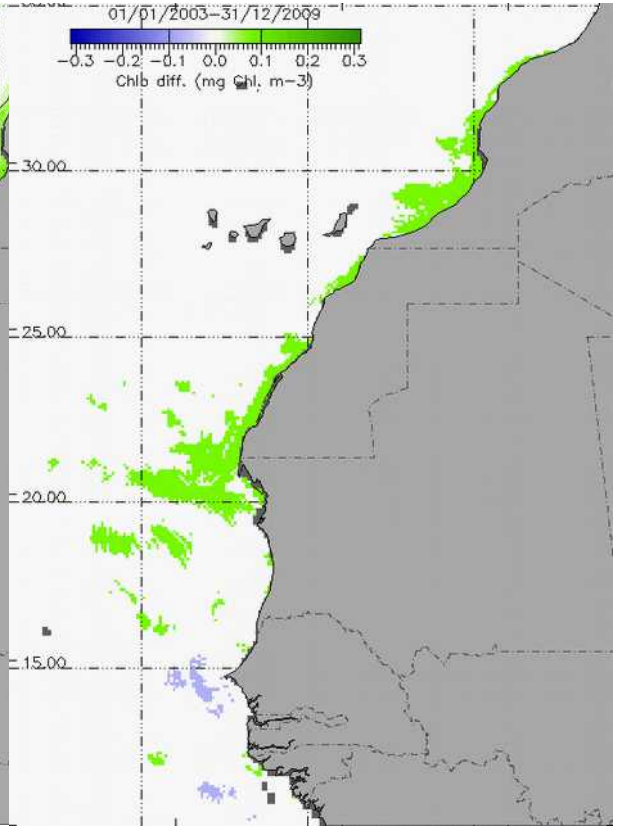
Surface wind stress: from satellite winds (ERS + QuikSCAT from 1999)



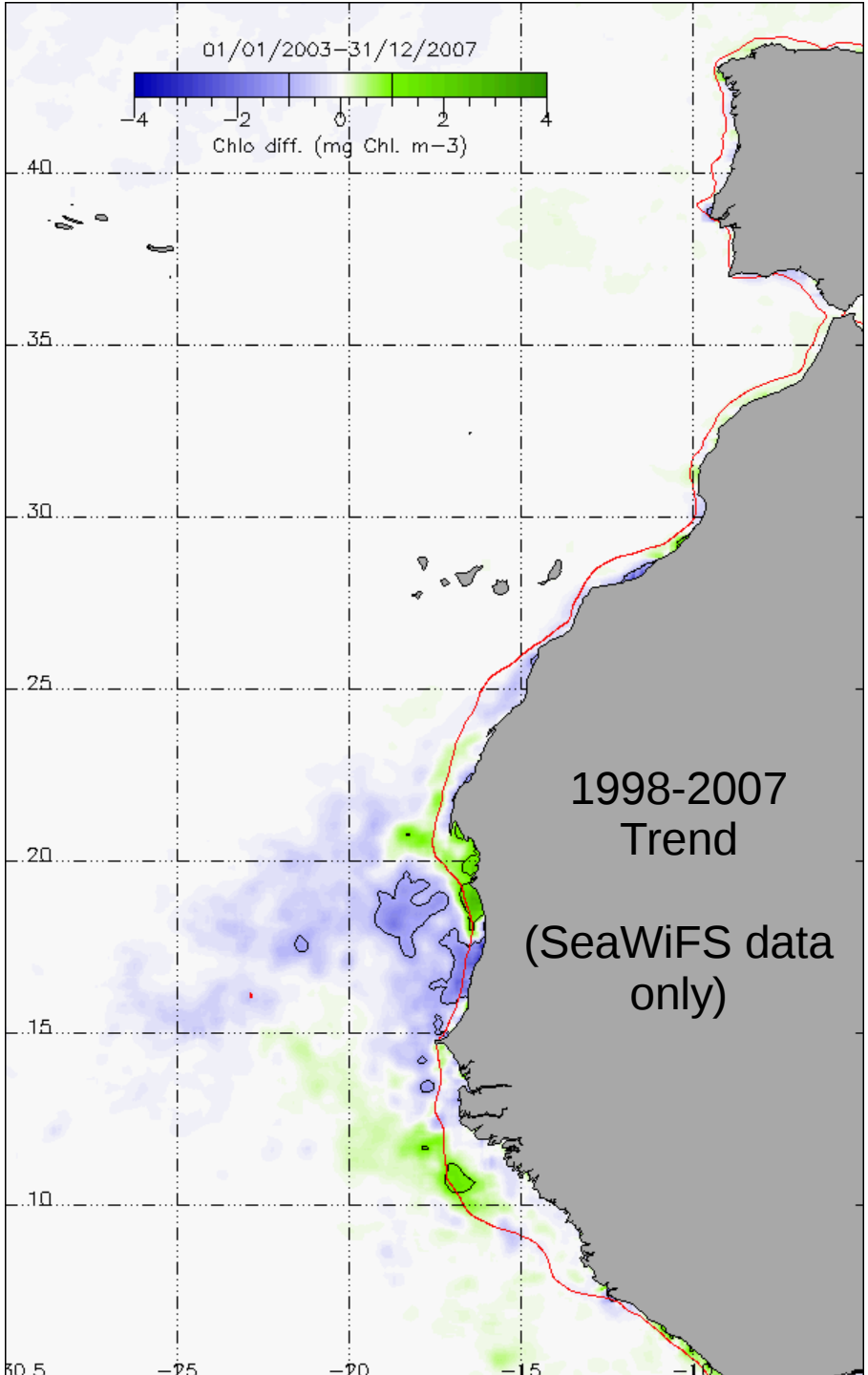
Total Chla



Diatoms

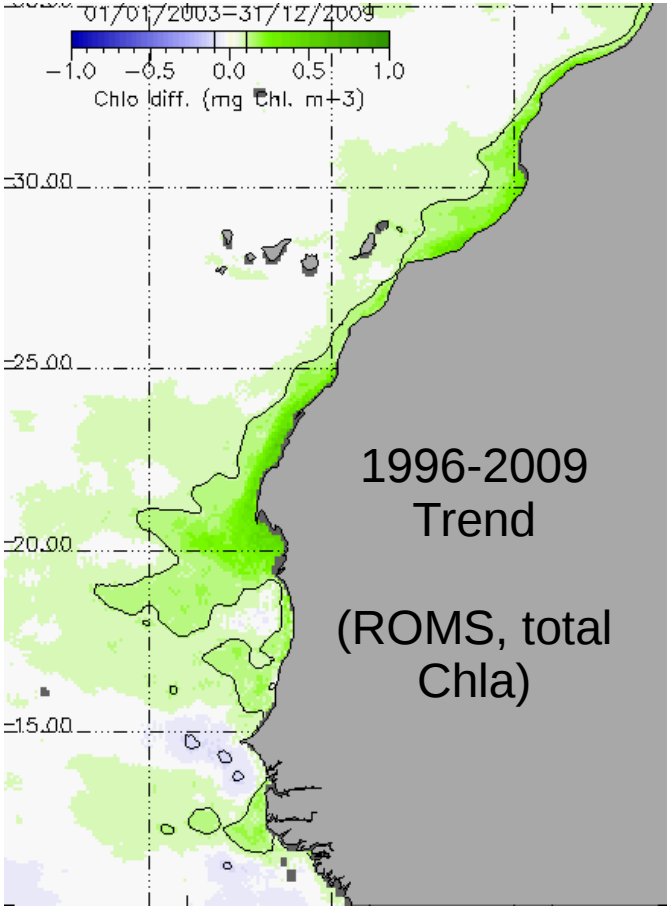


Nanoflagellates (nano-plankton)



Trend in the total chlorophyll

from the **ROMS-PISCES model** (run 1980-2009) with real winds (ERS + QuikSCAT)



Implications in Ecosystem-based management ?

- Not for now...
- The length of the time series is still short (17 years)
- Trends represent only a part of the variability!
- Seasonal/phenological variability (including shifts) is also pronounced (and well estimated from sat. data)

- NPZ models AND satellite observations must be better evaluated from in situ measurements
  - Still approximations in satellite atmospheric corrections
  - Difficult to generate intrinsic variability in phytoplankton groups from NPZ models
  - But... this is an interesting way to go since satellite obs. can be splitted into 4 groups or more...