Essential Climate Variable:

Ocean Color Radiometry

Globcour/MedspirationWorkshop
19-20 Nov. 2008

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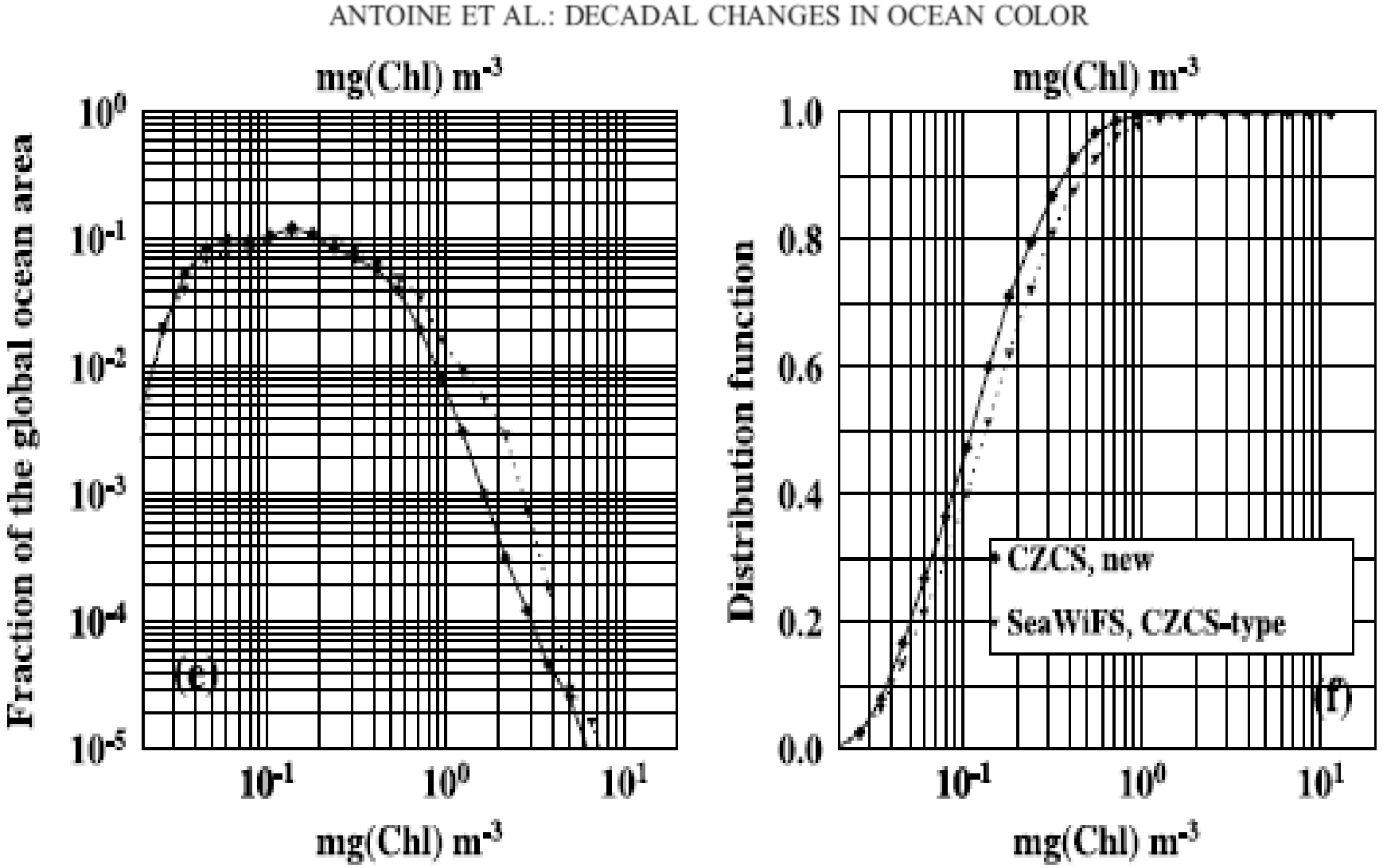
Essential Biogeochemical information provided by OCR, and related to climate and C-cycle:

Phytoplanktonic biomass at global scale:

- Algal standing stock in terms of [Chl]
  - Derived productivity (C-fixation),
    Control of pCO2 in upper layer, and air-sea CO2 exchange
  - C transfer toward the interior of the ocean
  - Upper layer bio-optical properties
    (e.g. heating rate, Mixed layer dynamics, circulation patterns..)

- Compared to open ocean (98%), Coastal zones (2%) have a minor impact on global and climate-related productivity

Antoine D., Morel, A., Gordon H.R., Banzon, V.F., Evans R. H, JGR, 2005



Chl distribution in the world ocean

Antoine D, André J-M, Morel A , Global Biogeochem. Cycles, 1995
(based on CZCS data)

Table 2. Division of the Ocean Into Provinces According to Their Annual Mean Levels of Chlorophyll Concentration in the Upper Layer

Province	Chlorophyll mg m^{-3}	Area (%)	Production		
			%	Gt C yr^{-1}	g C m^{-2} yr^{-1}
Oligotrophic	Chl ≤ 0.1	55.8	44.0	14.5	91.0
Mesotrophic	0.1 < Chl ≤ 1	41.8	47.5	15.7	131.5
Eutrophic	Chl > 1	2.4	8.5	2.8	422.0
Total		100	100	33.0	

Only the 50°S to 50°N zonal belt is considered here, thus the total area actually represents 81% of the entire ocean and the total production represents 91% of the production of the entire ocean (line 1 in Table 1).

Climate evolution of global algal biomass

from the « CZCS era » (1979-1983)
To the « SeaWiFS era » (1998-onward)

- Gregg & Conkright GRL, 2002) :

A decrease in global chlorophyll by 6%

- Antoine, Morel, Gordon, Banzon, Ewans (JGR, 2005):

An increase in global chlorophyll by 22%

Note: this study includes a re-processing of theCZCS data And

the use of CZCS-type algorithm for SeaWifS data processing

Recent global Chl evolution

Gregg, Casey, McClain (GRL, 2005)

Mean Chl declined as the mean SST increased within the subtropical gyres (over 6 years)

Behrenfeld (+ 9 co-authors, Nature, 2006)

Phytoplankton biomass and productivity decrease during the recent post-1999 warming

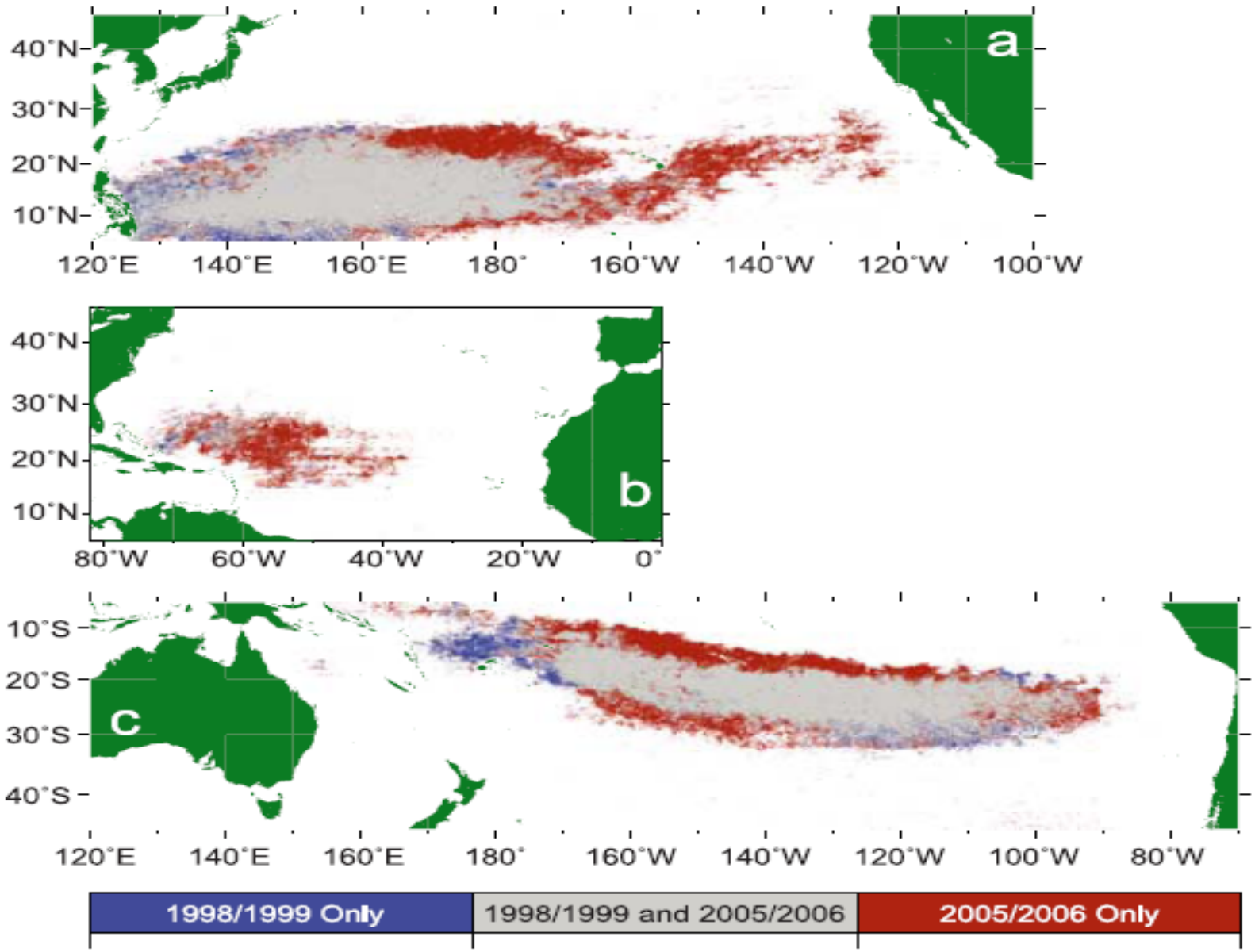
Polovina, Howell & Abecassis (GRL, 2008)

Expansion of oligotrophic sub-tropical gyres by 15% over the last 8 years

Polovina, Howell & Abecassis (GRL, 2008)

« Oligotrophic gyres »

defined by [Chl] < 0.07 mg/m3



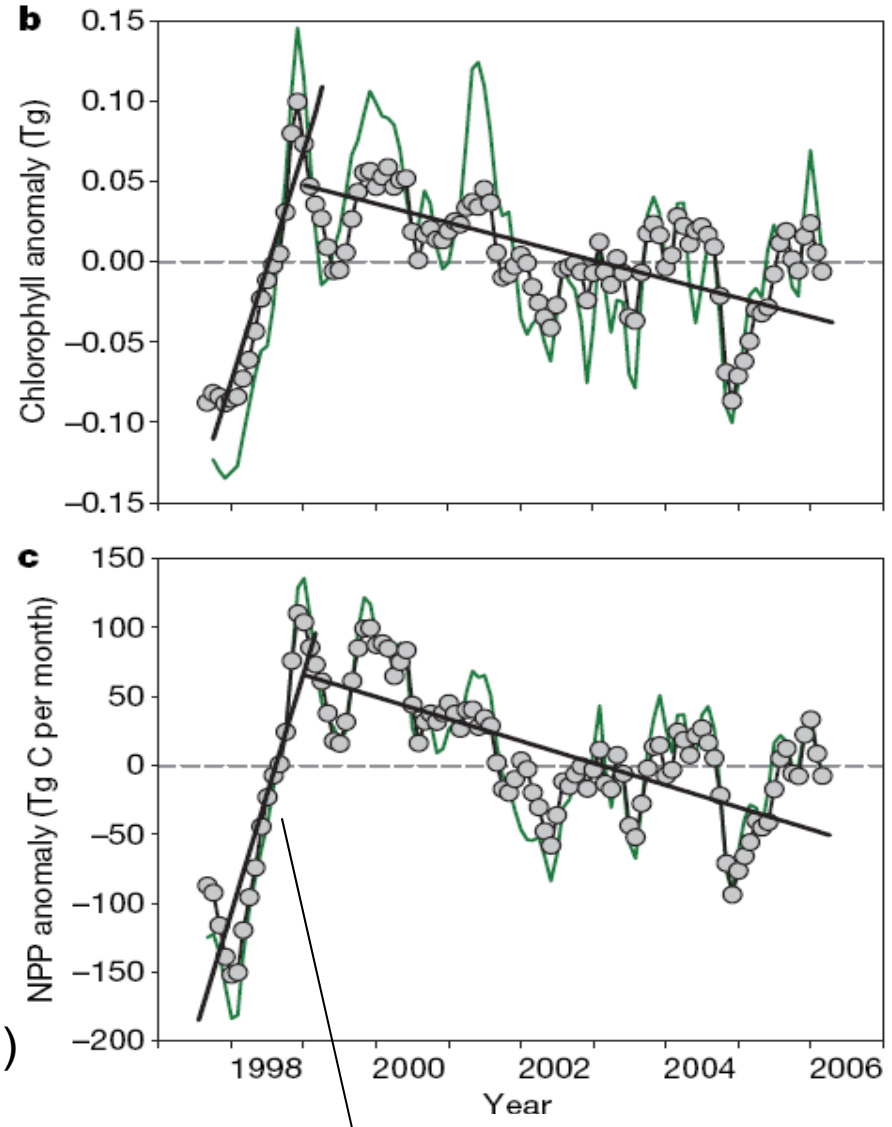
Behrenfeld et al., Nature, 2006

Chlorophyll « anomalies»
within the permanently stratified ocean
(SST > 15°C)

Monthly means of SSTgrey circles and black lines

NPP « anomalies »

(based on SeaWiFS/AVHRR data)



El niño – la niña transition

Behrenfeld et al., Nature, 2006

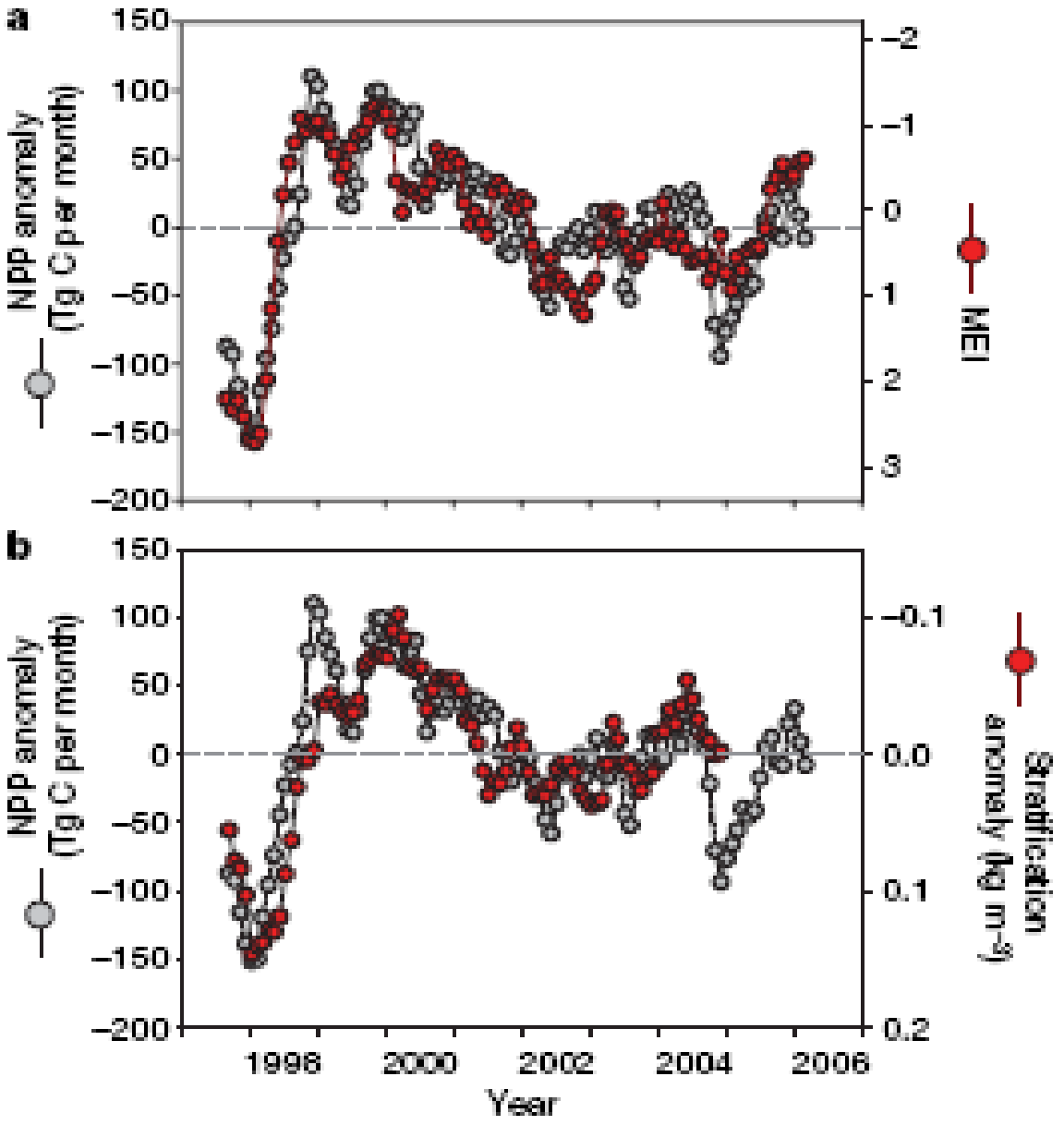
Multivariate Enso (El niño Southern Oscillation) Index (MEI)

MEI decreases (post 1999)

Stratification index Increases

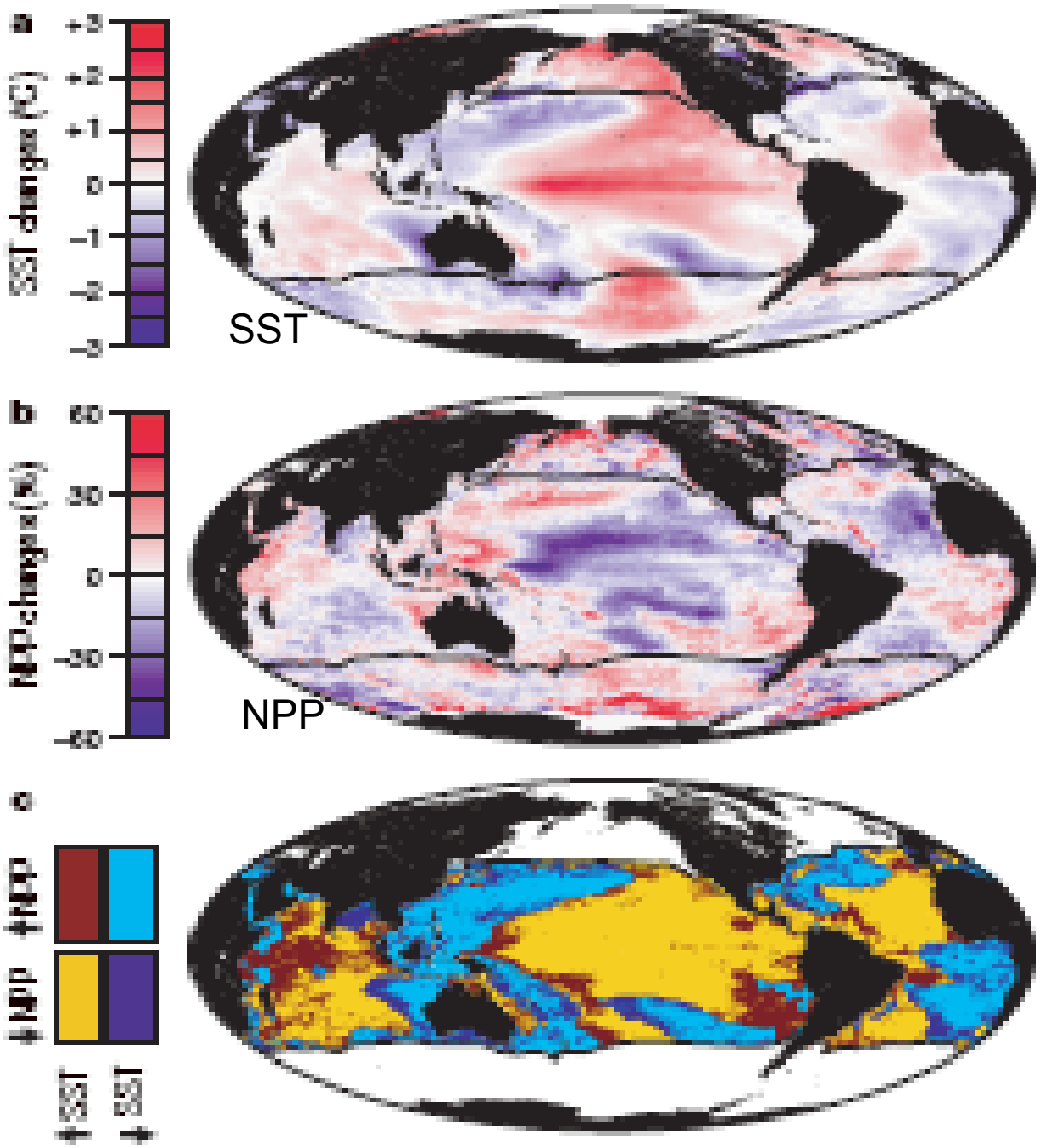
↓

Vertical flux of Nutrient decrease, NPP decrease.



Behrenfeld et al., (Nature, 2006)

Global change
(1999 to 2004)
warming period



Behrenfeld et al.'s conclusions:

« .. Changes in upper ocean temperature and stratification influence the availability of nutrients for phytoplankton growth.. » …. ok

« .. Observed reductions in ocean productivity during the recent Post-1999 warming period provide insight on how future climate change can alter marine food web. » …..?

but…

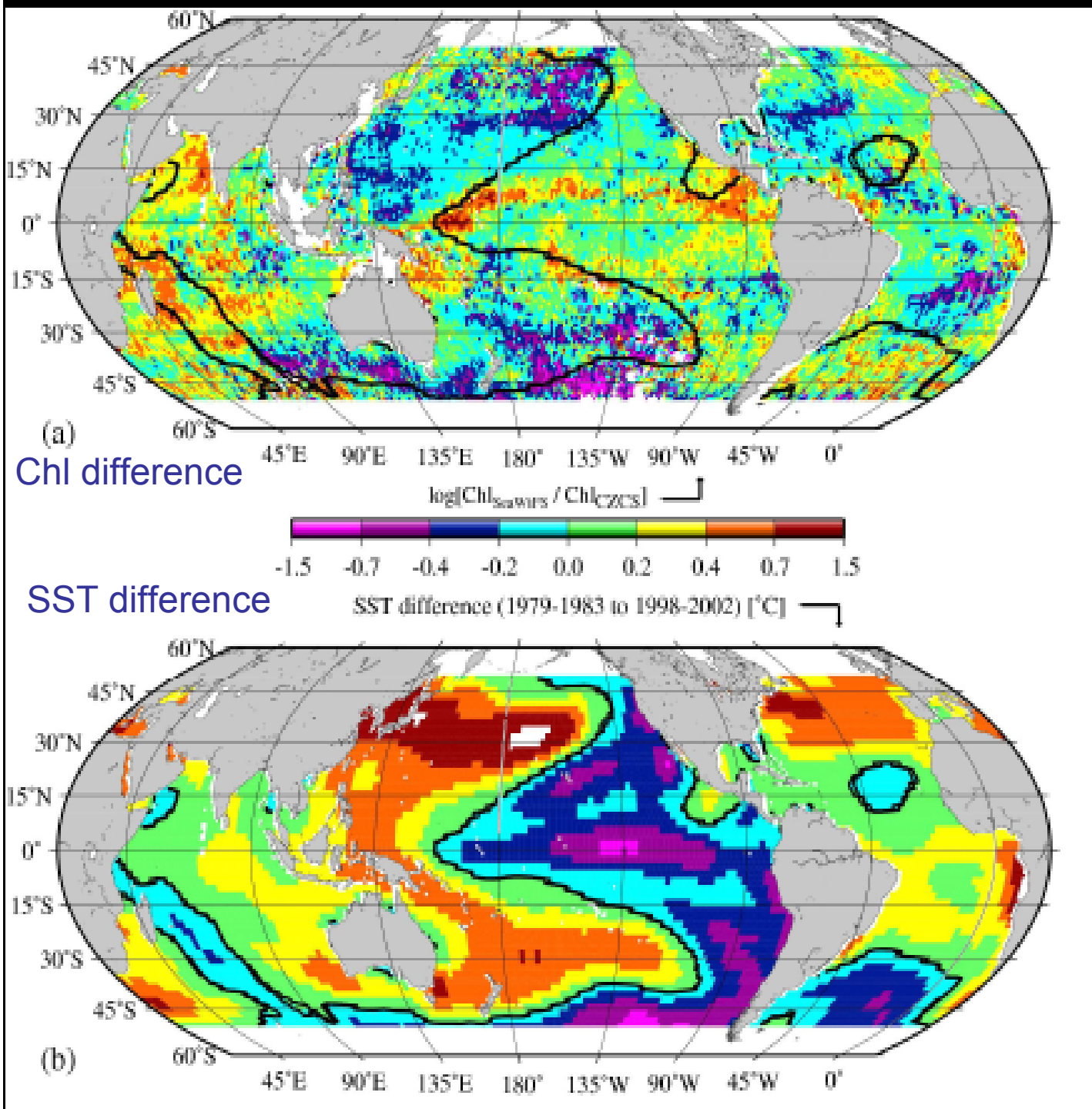
Effect of warming or Something else…?

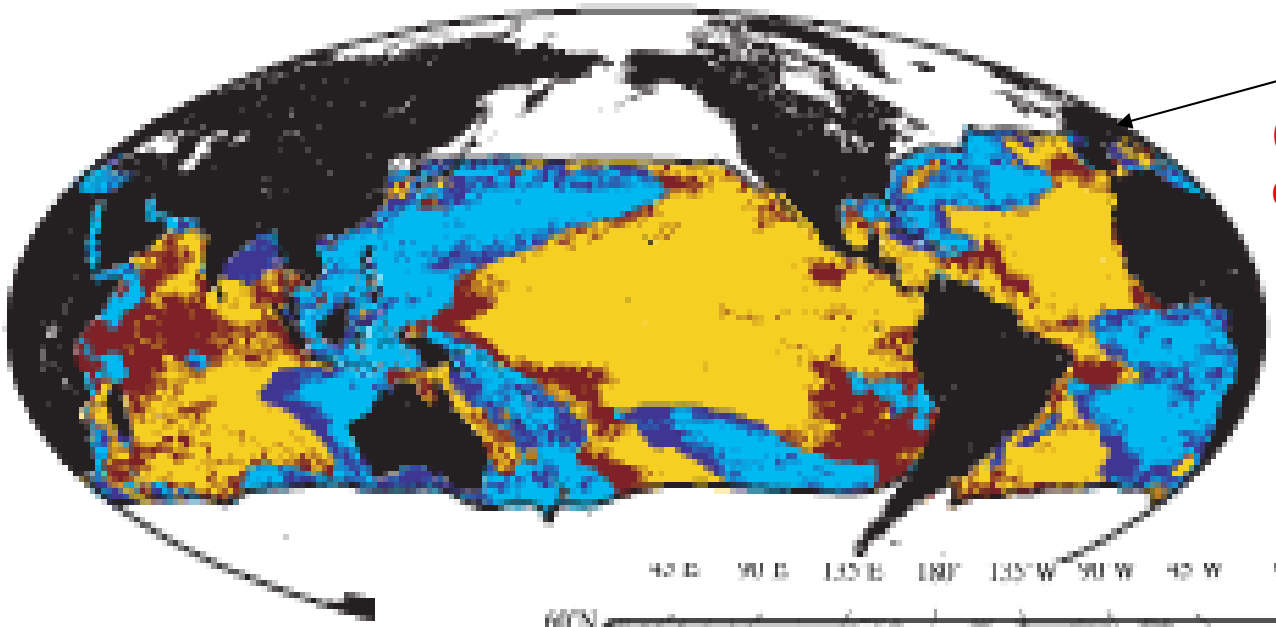
E. Martinez
D. Antoine
F. d'Ortenzio
Ocean Optics XIX
(Oct.2008)

Chl and SST change

from
the CZCS era
(1979-1983)
to the
SeaWiFS era
(1998-2002

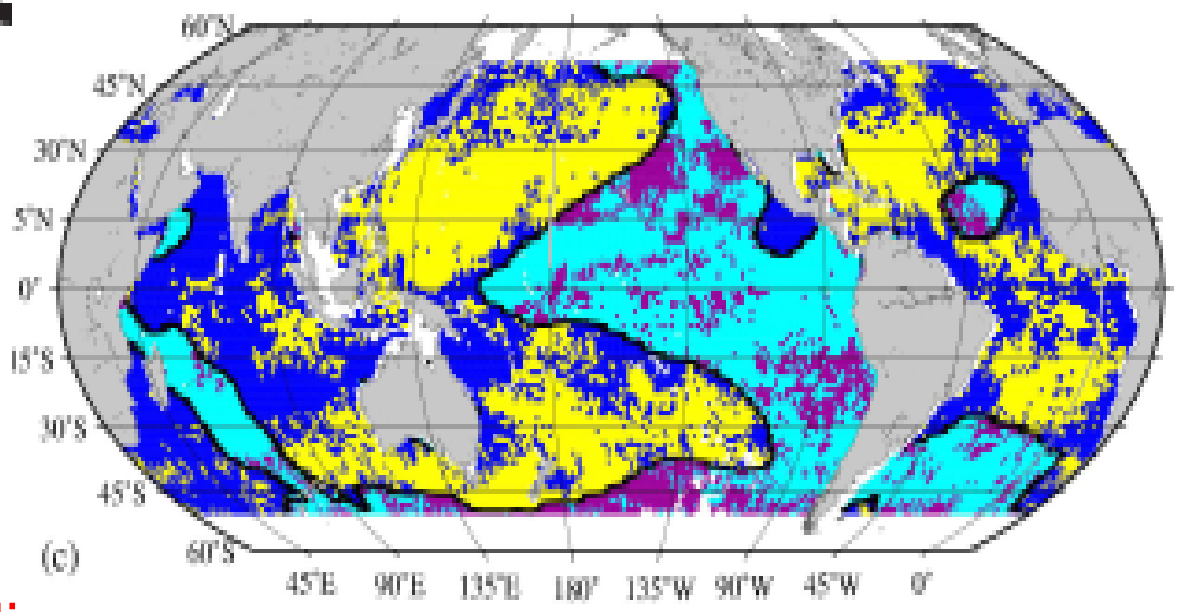
Black line:
0 change in SST





1999 -2004
(Behrenfeld
et al.)

1979 -1983
Compared to
1998-2002
(Martinez et al.)



Same color encoding

ChI-SST Multivariate Empirical Orthogonal Functions

Common Principal Components (PC-1 in Black) (Martinez et al., 2008)

Atlantic **M**ultidecadal **O**scillation

AMO

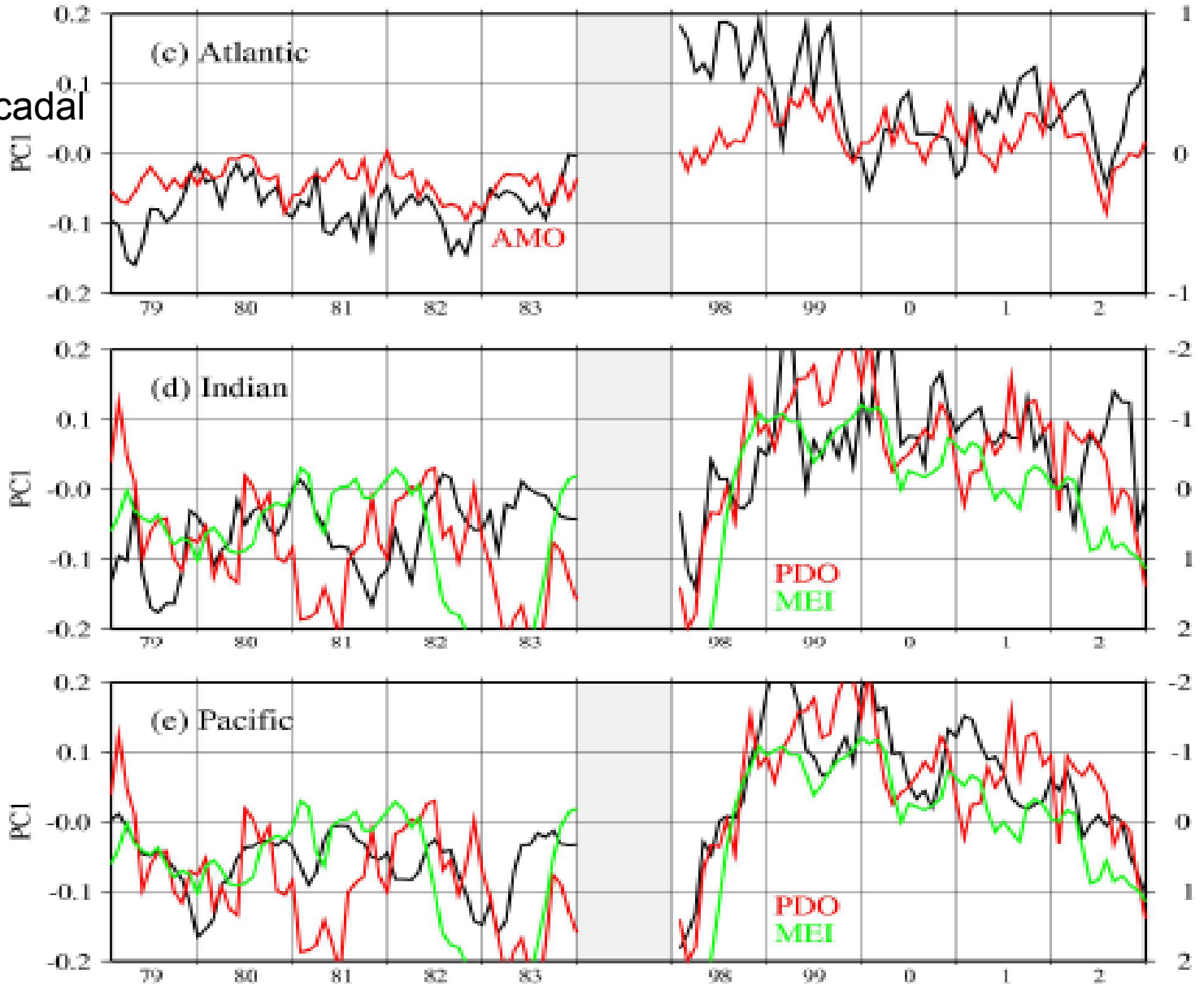
Pacific **D**ecadal **O**scillation

PDO

&

Multivariate **E**nso Index

MEI



First Conclusion:

When considering a 27 years (including a 13-y gap !) period…

The changes in Chlorophyll content in the three oceanic basins appear to follow the multi-decadal natural physical oscillations (AMO, MEI..)

(not only a temporary warming episode)

Underlaying reason: vertical displacement of the permanent deep thermocline associated with decadal oscillations

(not the seasonal thermocline)

Possible to show such a (multi-decadal) relationship thanks to the coherently reprocessed CZCS to SeaWiFS archives and thus bridging OC observations over 3 decades.

Second and general Conclusion:

Beside a re-analyse of historical data,

DEFINITELY A NEED

for ensuring a permanent climate-quality satellite OC coverage, able to encompass next decades with similar (or improved) capabilities

essential, main biogeochemical, climate variable:
LOCAL [Chl] at GLOBAL SCALE

- As an index of possible climatic changes (Chl patterns) (superimposed to natural oscillations),
- As a descriptor of general circulation and upper layer changes,
- As a key-element of ecosystem-dynamical modelling,
- As a key-component of biogeochemical-physical models, either for validation of, or for assimilation into, models,
- As a crucial parameter (with CDOM) of the oceanic C cycle.

A bunch of other applications, beside the description of the Chl field …..

However, (somewhat ironically)

CHL

Again Chl

Always Chl