# From surface Chl a to phytoplankton size classes:
## a first step towards size-specific primary production

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MAG Workshop (24-26 Mars, 2004)

# Context of the Study

- **Utilization of ocean color**
  - ⇨ Estimation of **phytoplankton biomass quantity**
  - ⇨ Estimation of **primary production**

- **Requirements**
  - ⇨ Understanding and prediction of **phytoplankton community composition:**

    Ciotti *et al.* (JGR, 1999)

    Gregg *et al.* (DSR, 2002)

    Iglesias-Rodriguez *et al.* (GBC, 2002)

    Bouman *et al.* (MEPS, 2003)

# Objective of the Study

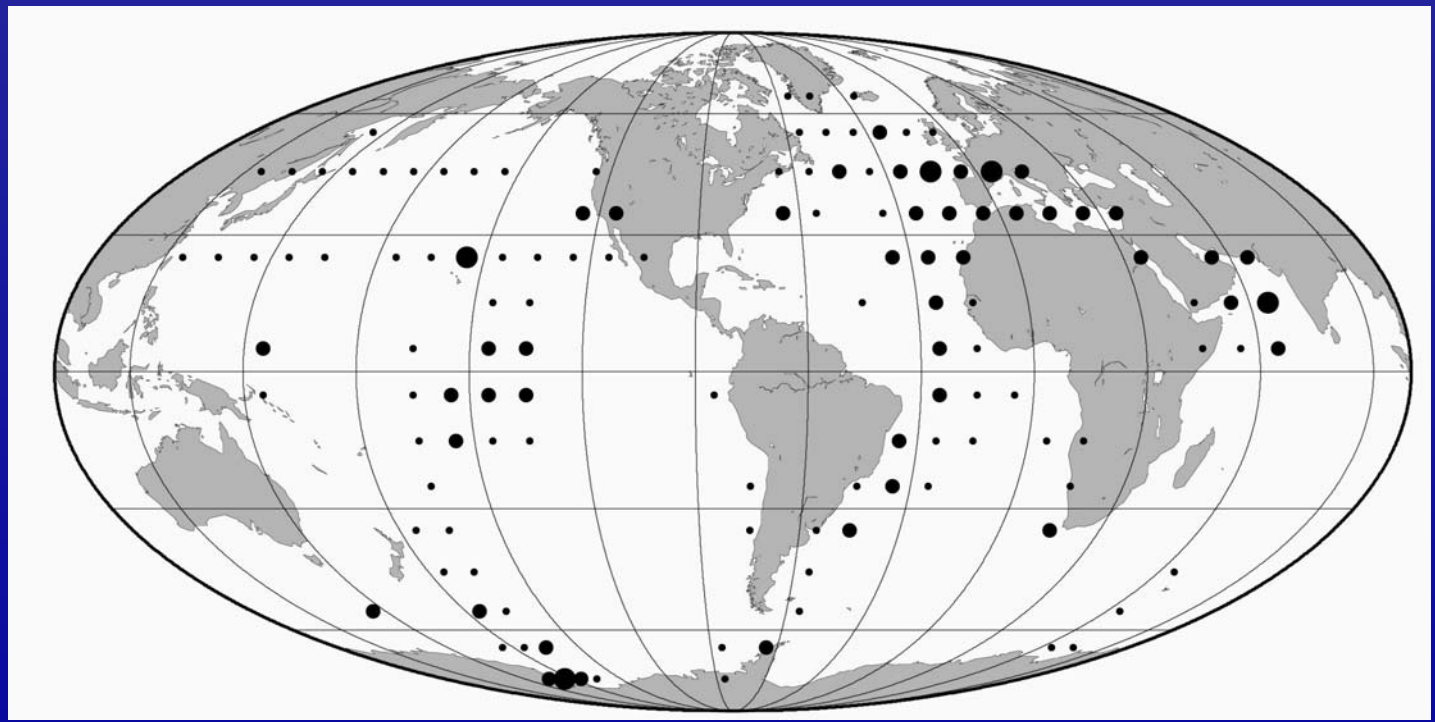
**Surface Chla concentration**
(Chl$a_{surf}$)

**Phytoplankton biomass quality:**

- Composition
- Vertical distribution

# Data

- **HPLC pigment database**: 2419 stations (1990-2002)



Number of stations per square of 10°x 10°; small spots: < 10 stations, medium spots: 10-100 stations, large spots: > 100 stations.

# Method: from diagnostic pigment to phytoplankton classes

- **Sum of the diagnostic pigments :**

$$\Sigma = \underbrace{1.4\ \text{Fuco} + 1.4\ \text{Peri}}_{\sim\ \text{Micro} > 20\ \mu\text{m}} + \underbrace{1.3\ \text{Hex} + 0.4\ \text{But} + 0.6\ \text{Allo}}_{\sim\ \text{Nano 2-20}\ \mu\text{m}} + \underbrace{0.9\ \text{Zea} + 1.0\ \text{TChlb}}_{\sim\ \text{Pico} < 2\ \mu\text{m}}$$

- **Size classes percentage:**

**%micro = 100 * (1.4 Fuco + 1.4 Peri) / Σ**

**%nano = 100 * (1.3 Hex + 0.4 But + 0.6 Allo) / Σ**

**%pico = 100 * (0.9 Zea + 1.0 TChlb) / Σ**

- **Chla associated to each size class (sc-Chla):**

**micro-Chla = %micro * Chla**

**nano-Chla = %nano * Chla**

**pico-Chla = %pico * Chla**

***After : Claustre (L&O, 1994); Vidussi et al. (JGR, 2001)***

# Method: Standardization and Sorting of the profiles

- **Standardization of the sc-Chla profiles:**

  zeta = z / $Z_{eu}$

  sc-Chla(zeta) / $\overline{C}_{Zeu}$

- **Interpolation of the dimensionless sc-Chla profiles:**

  zeta = 0 (surface) - 2 ($2*Z_{eu}$) ⟶ 20 points / profile

- **Sorting of the interpolated sc-Chla profiles:**

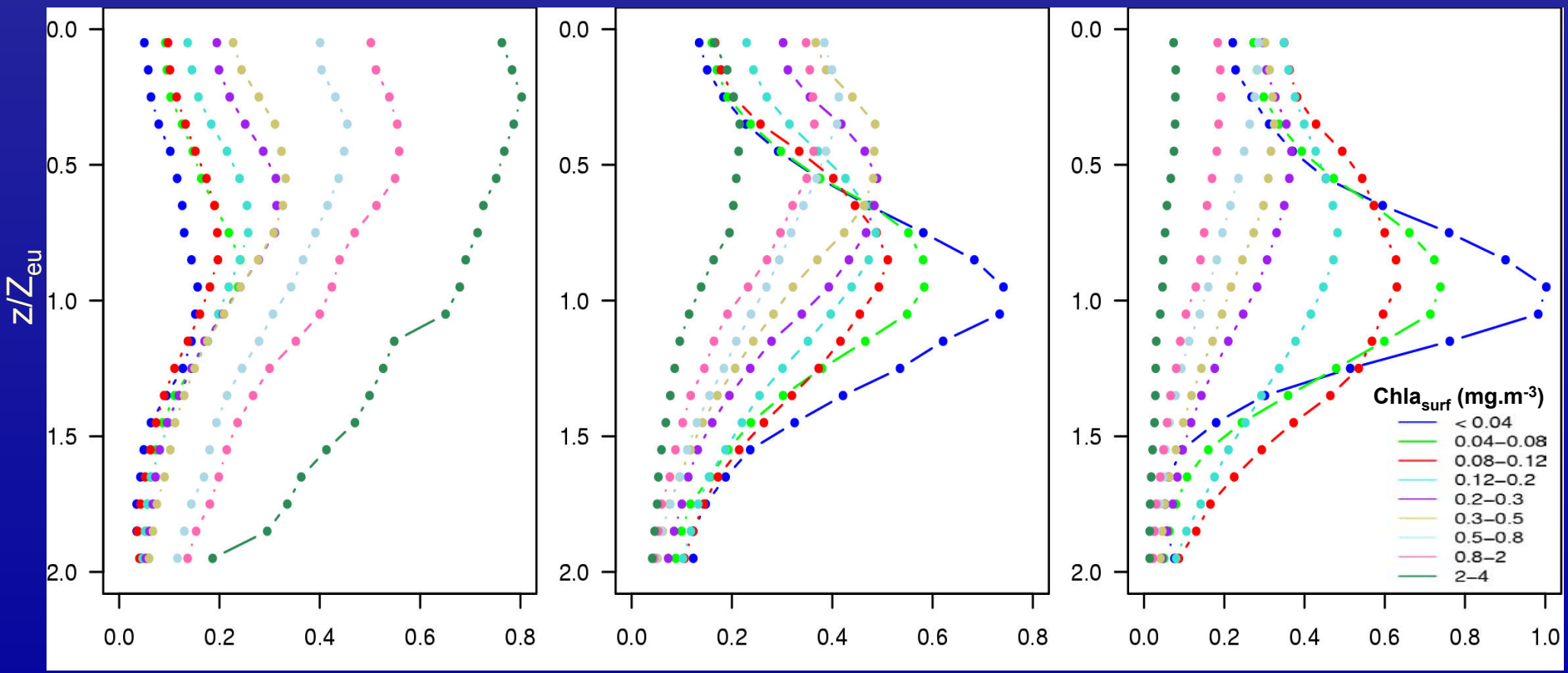
  ⟶ according to the hydrological regime: stratified / mixed

  ⟶ according to $Chla_{surf}$: trophic classes

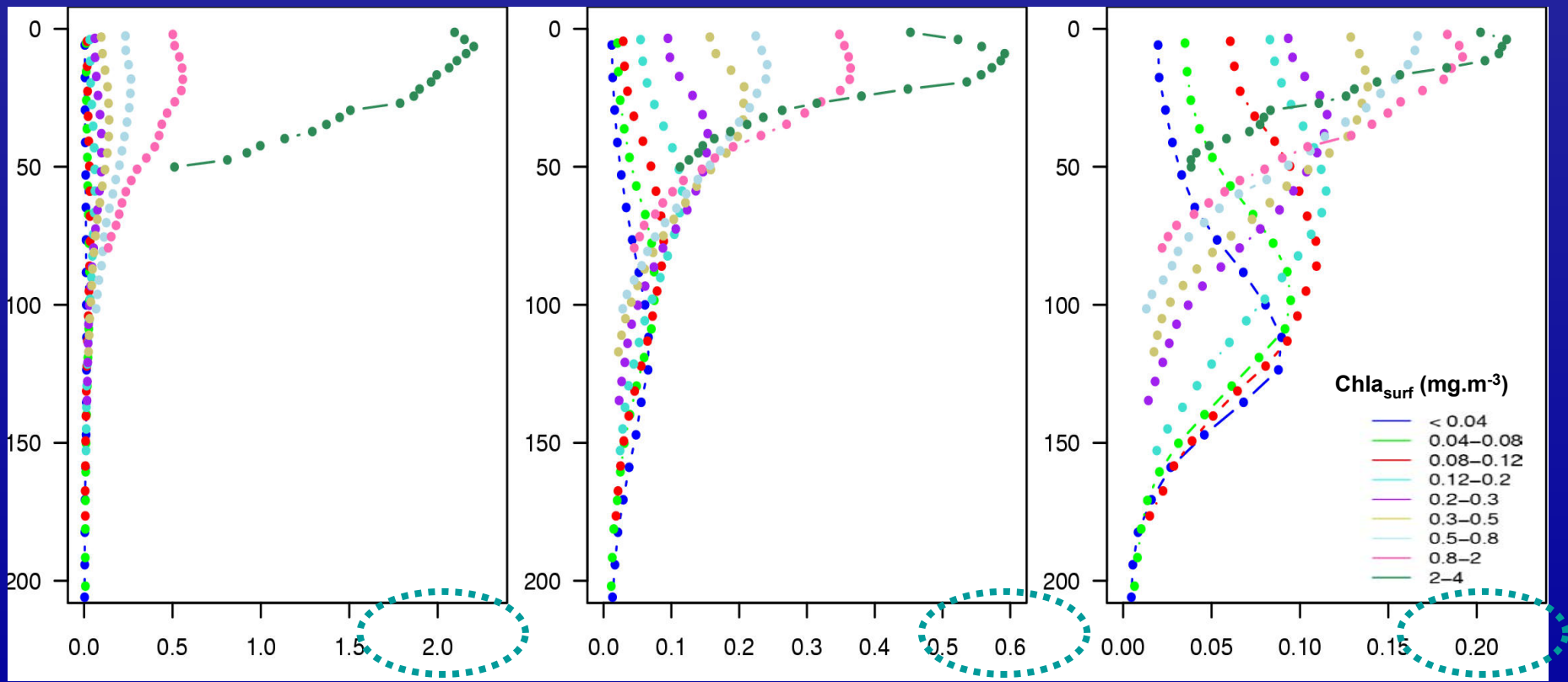
- **For each trophic class: computation of average sc-Chla profiles**

*After : Morel & Berthon (L&O, 1989)*

# Results: Dimensionless mean profiles



# Results: Mean « rescaled » profiles




micro-Chla(mg.m$^{-3}$)

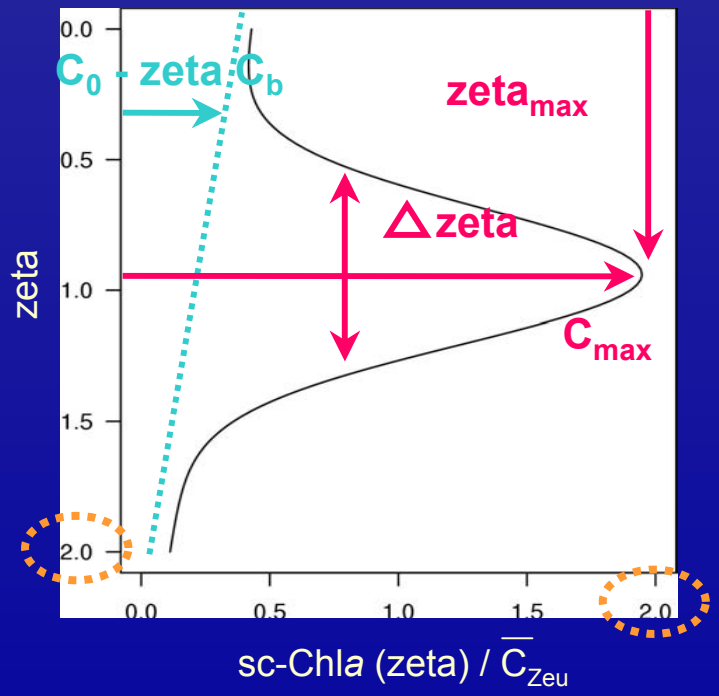
nano-Chla(mg.m$^{-3}$)

pico-Chla(mg.m$^{-3}$)

# Parameterization of the profiles

- **Equation fitted to each mean sc-Chla profile:**

$$\text{sc-Chla(zeta)} = \underbrace{C_0 - C_b\ \text{zeta}}_{\text{Background concentration}} + \underbrace{C_{max}\ \exp\{-[(\text{zeta} - \text{zeta}_{max}) / \Delta\text{zeta}]^2\}}_{\text{Gaussian profile}}$$




- **Computation of the 5 parameters:**

The adjustment procedure allows $C_0$, $C_b$, $C_{max}$, $zeta_{max}$, $\Delta$zeta to be calculated for each trophic class

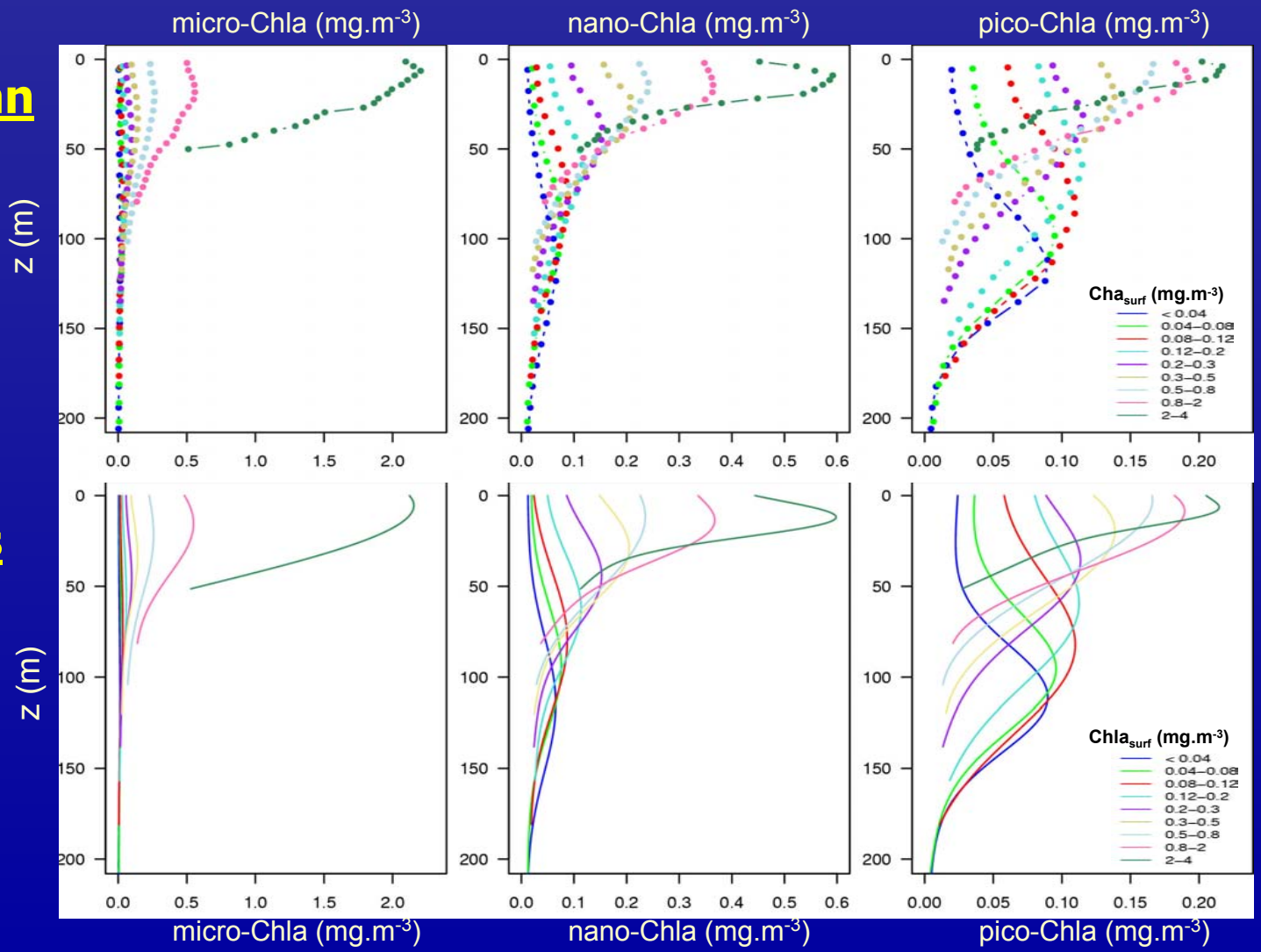
- **Parameterization used in a continuous manner:**

For any $C_{surf}$ value, the 5 parameters can be retrieved using an interpolation between the discrete values specific to each trophic class

# Modeled / Measured « rescaled » profiles

**Measured mean profiles**

**Modeled profiles**

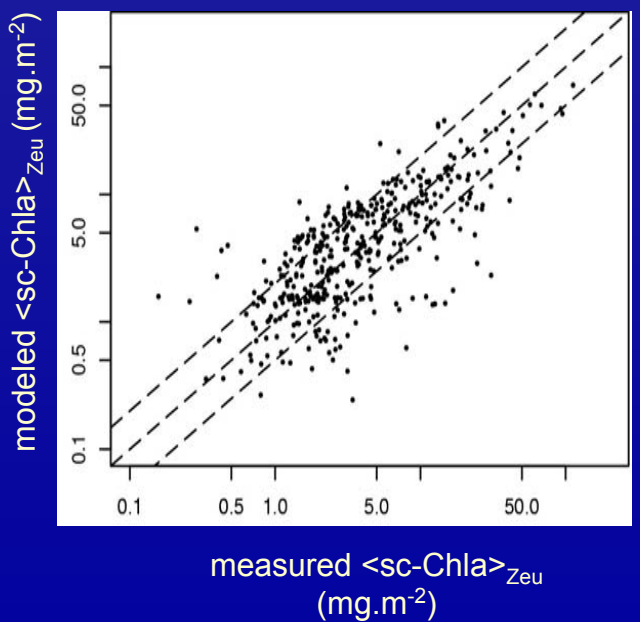


# Validation: Modeled *vs* measured integrated contents

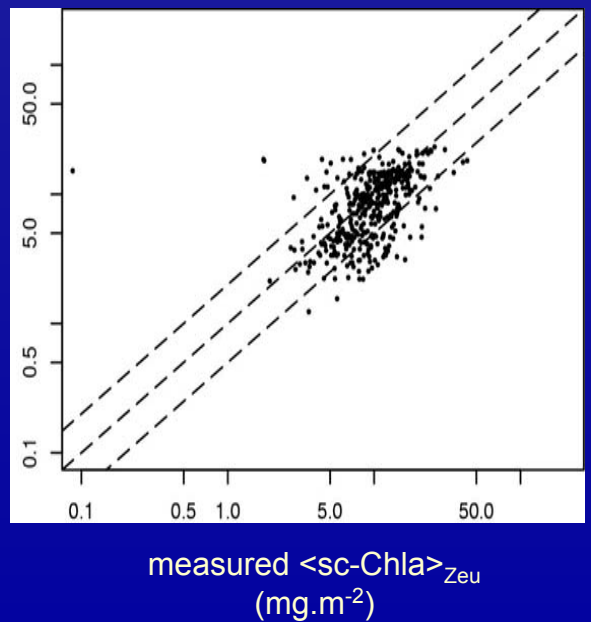
- **HPLC database:**

  80% for the parameterization / 20% for the validation

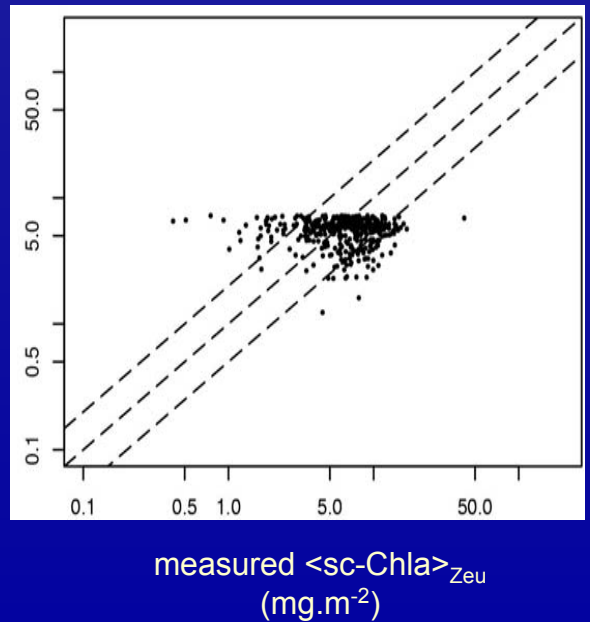
Micro



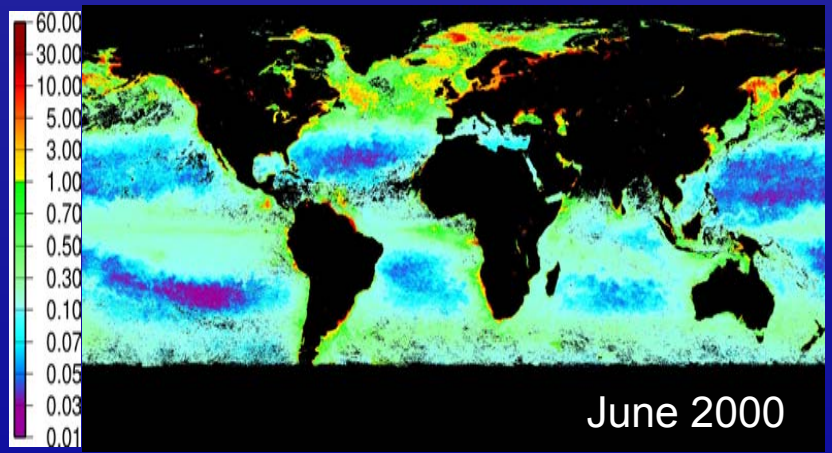

Nano




Pico



# Application: phytoplankton size classes climatology

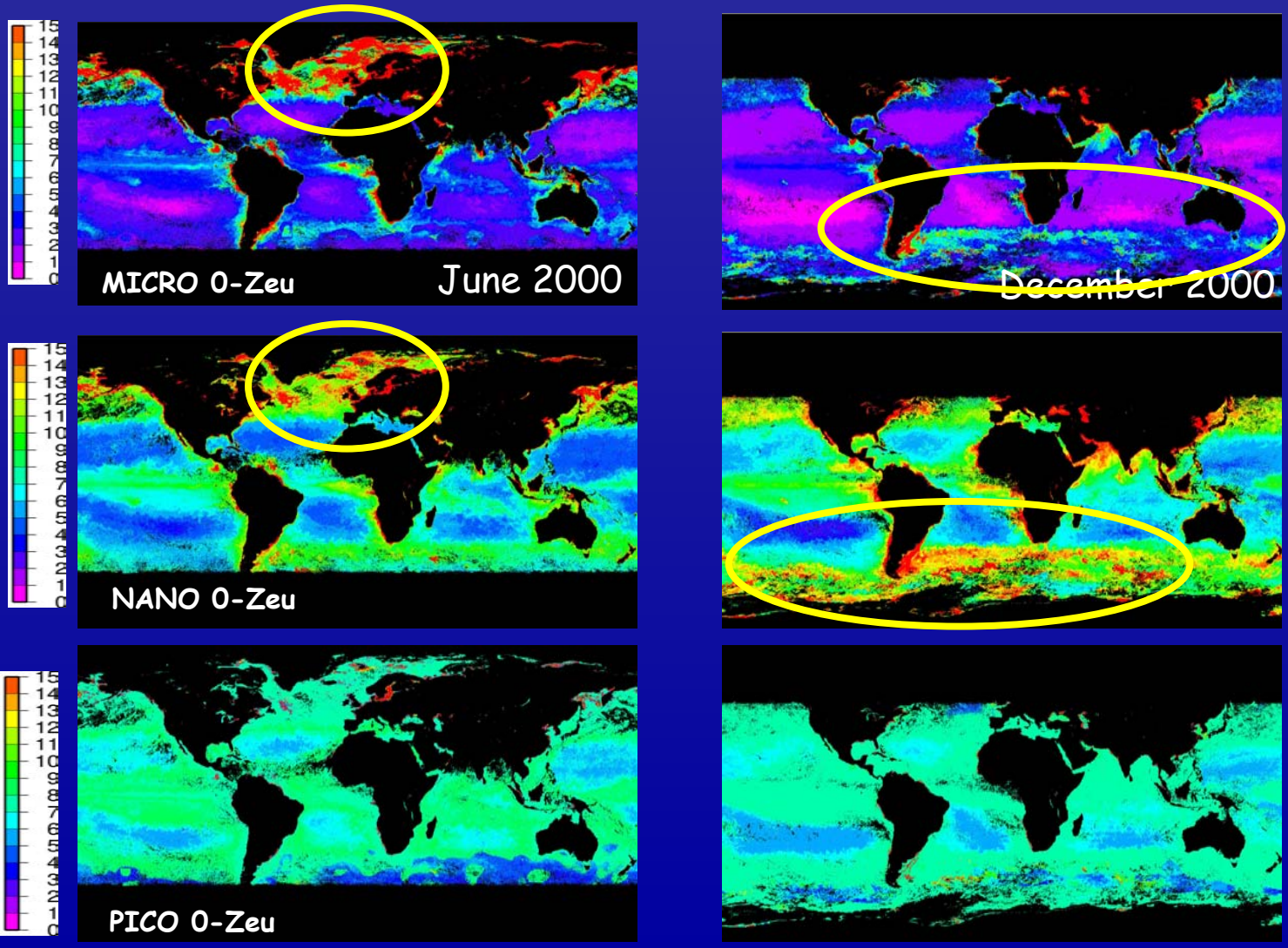



Map of monthly average SeaWIFS $Chla_{surf}$ ($mg.m^{-3}$)

Statistical model

micro-, nano-, pico-Chla vertical profiles

# Application: phytoplankton size classes climatology



# Perspectives

- **Objective:**

From specific biomass fields (*e.g.* the one inferred from remote sensing) to size-specific primary production

- **How?**

Bio-optical models are a possible link, but currently they work with total algal biomass:

$$P = \underset{[gC\ m^{-2}\ d^{-1}]}{} \quad 1/39 \quad PAR(0^+) \quad <Chla> \quad \Psi^* \quad \text{(Morel, 1991)}$$

$$[KJ\ m^{-2}\ d^{-1}] \quad [g\ Chl\mathit{a}\ m^{-2}] \quad [m^2\ g\ \mathit{C}hla^{-1}]$$

$$P(z) = 12 \quad PAR(z) \quad Chla(z) \quad \bar{a}^*(z) \quad \Phi_c(z)$$

$$[gC\ mole\ C^{-1}] \quad [mole\ Quanta\ m^{-2}\ s^{-1}] \quad [mg\ Chla\ m^{-3}] \quad [mg\ Chla\ m^{-3}] \quad [mole\ C\ mole\ Quanta^{-1}]$$

**Derived from P *vs* E curves parameters**

# Perspectives

**P(z) = 12 PAR(z) Chla(z) ā*(z) Φc(z)**

P(z) = micro-P(z) + nano-P(z) + pico-P(z)

**Present study:**

Chla(z) = micro-Chla(z) + nano-Chla(z) + pico-Chla(z)

**Question:**

Are photo-physiological parameters phytoplankton **community composition dependant** ?

-> Is it possible to **index** some of the bio-optical models **parameters** on some **community composition** indexes?

# Perspectives

**How to check this?**

Database comprising **HPLC** data + **P-I** curves parameters + **absorption** data

$\bar{a} \overset{?}{=} \bar{a}^*_{micro}$ micro-Chla + $\bar{a}^*_{nano}$ nano-Chla + $\bar{a}^*_{pico}$ pico-Chla

$P_m \overset{?}{=} {}_{micro}P_m{}^b$ micro-Chla + ${}_{nano}P^b{}_m$ nano-Chla + ${}_{pico}P^b{}_m$ pico-Chla

$\alpha \overset{?}{=} \alpha^{\,b}{}_{micro}$ micro-Chla + $\alpha^{\,b}{}_{nano}$ nano-Chla + $\alpha^{\,b}{}_{pico}$ pico-Chla

➡ $\Phi_{Cmax} = \alpha^b / \bar{a}^*$ -> ${}_{micro}\Phi_{Cmax}$ , ${}_{nano}\Phi_{Cmax}$, ${}_{pico}\Phi_{Cmax}$

**If it works …**

P(z) = micro-P(z) + nano-P(z) + pico-P(z)

$$\frac{39\ P}{PAR(0^+)} = \langle Chla \rangle \quad \Psi^*$$

$$= \langle \text{micro-Chla} \rangle\ {}_{micro}\Psi^* + \langle \text{nano-Chla} \rangle\ {}_{nano}\Psi^* + \langle \text{pico-Chla} \rangle\ {}_{pico}\Psi^*$$

# Preliminary results

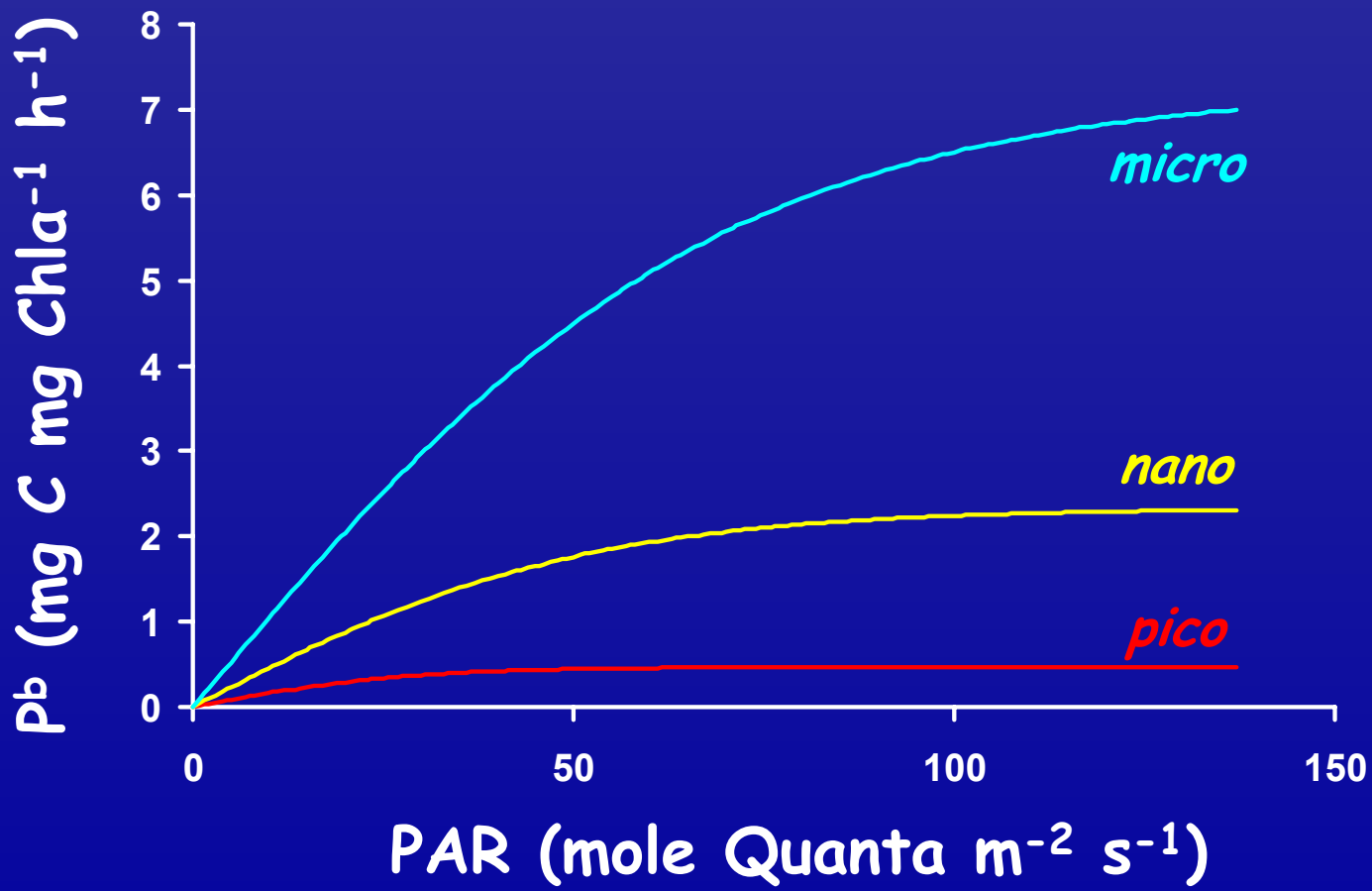
**Results from the POMME dataset (H. Claustre, unpublished data):**

| | $\bar{a}^*$ | $P^b_{max}$ | $\alpha^b$ | $\Phi_{Cmax}$ |
|---|---|---|---|---|
| | $m^2$ mg $Chla^{-1}$ | mg C mg $Chla^{-1}$ $h^{-1}$ | mg C mg $Chla^{-1}$ $h^{-1}$ / mole Quanta $m^{-2}$ $s^{-1}$ | mole C / mole quanta |
| micro | 0.020 ± 0.002 | 7.27 ± 0.66 | 0.105 ± 0.660 | 0.125 |
| nano | 0.021 ± 0.001 | 2.33 ± 0.24 | 0.046 ± 0.004 | 0.051 |
| pico | 0.037 ± 0.001 | 0.47 ± 0.29 | 0.017 ± 0.005 | 0.011 |
| | $R^2$ = 0.91 | $R^2$ = 0.73 | $R^2$ = 0.72 | |
| | n = 344 | n = 344 | n = 344 | |

! 0.125 is a theoretical limit !….

# Preliminary results

*The derived « specific » P vs E curves*




Low for picophytoplankton….

# Acknowledgements

J. Aiken, K. Arrigo, R. Barlow, R. Bidigare, C. Caillau, D. Clarck, Y. Dandonneau, G.R. DiTullio, R. Goericke, E. Head, H. Higgins, G. Kraay, J.C. Marty, G. Mitchell, K. Oubelkheir, J. Ras, S. Roy, C. Targa, D. Thibault, C. Trees, D. Van der Linde, L. Van Heukelem, M. Veldhuis, F. Vidussi, S. Wright and others who contributed to pigment acquisition in various programs…