C·MORE
CENTER FOR
microbial oceanography:
research and education

Estimating carbon export and sequestration in ocean at regional and global scales

Presenters

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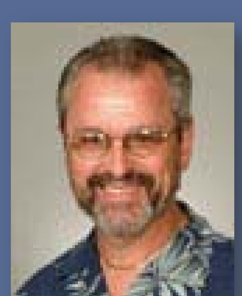

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Introduction

During the last decade, there has been a large increase in the number of satellite-derived marine biogeochemical products, which contributed to quantifying global biogeochemical cycles. Here, we propose a novel approach to derive, from surface chlorophyll *a* imagery, carbon export (i.e. at the base of the euphotic zone: Z_{eu}) and sequestration (i.e. at the base of the mesopelagic layer, 1000 m deep) in the world's open oceans..

Why?

1) Only few data available (Mainly sediment traps)

2) The remineralization length scale (b from the Martin curve) is usually presented with a unique value

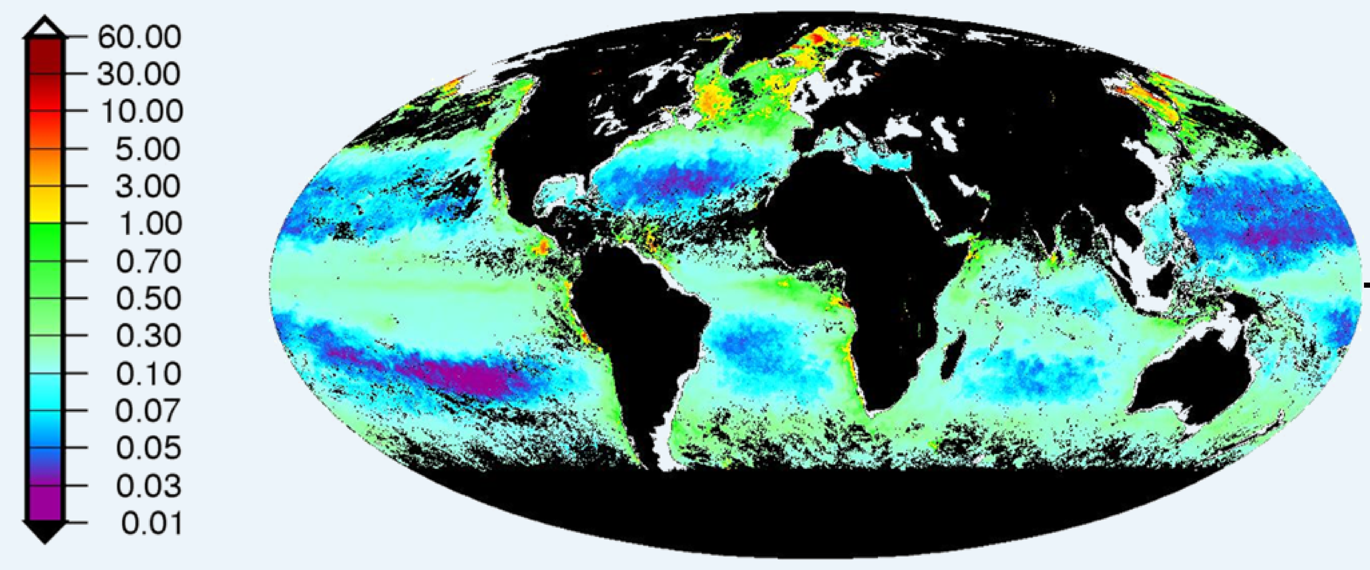
3) Biogeochemical models need more data (global) for validation and/or parameterization

How?

1) We can derive relationships between surface chlorophyll *a* concentration from SeaWiFS and vertical chlorophyll *a* profiles associated with micro-, nano-, and picophytoplankton (Uitz et al 2006).
2) There is global relationship between the size structure of phytoplankton biomass in the euphotic zone and the mass flux of particles in the mesopelagic layer (Guidi et al. 2009).

By combining (1) and (2), the mass flux can be estimated on a global scale

Method



SeaWiFS-derived surface Chla (Chl_{sat})

Depth of the euphotic zone (Z_{eu})

Mixed layer depth (MLD) Monthly climatology

Z_{eu} / MLD

Parameterization **for stratified waters (Z_{eu} > MLD)**
Gaussian vertical profile of Chla for each phytoplankton group (PG) at depth z:
$Chla_{PG}(z) = f(z, C_b, s, C_{max}, \zeta_{max}, \Delta\zeta)$

with C_b, s, C_{max}, ζ_{max}, $\Delta\zeta$: For each phytoplankton group a set of 5 parameters which are functions of $Chla_{sat}$

Parameterization **for mixed waters (Z_{eu} < MLD)**
Contribution to Chla for each phytoplankton group (PG) at surface:
$Chla_{PG} = \%_{PG} \times Chl_{sat}$
with $\%_{PG}$: function of Chl_{sat}

Vertical profiles of $Chla_{PG}$ are obtained by extending surface $Chla_{PG}$ values in the water column

$Chla_{micro}(z)$, $Chla_{nano}(z)$, $Chla_{pico}(z)$

Mass flux at any depth (Z)
Carbon Export (Flux at the base of Z_{eu})
Carbon Sequestration (Flux at 1000 m)
b from the Martin curve

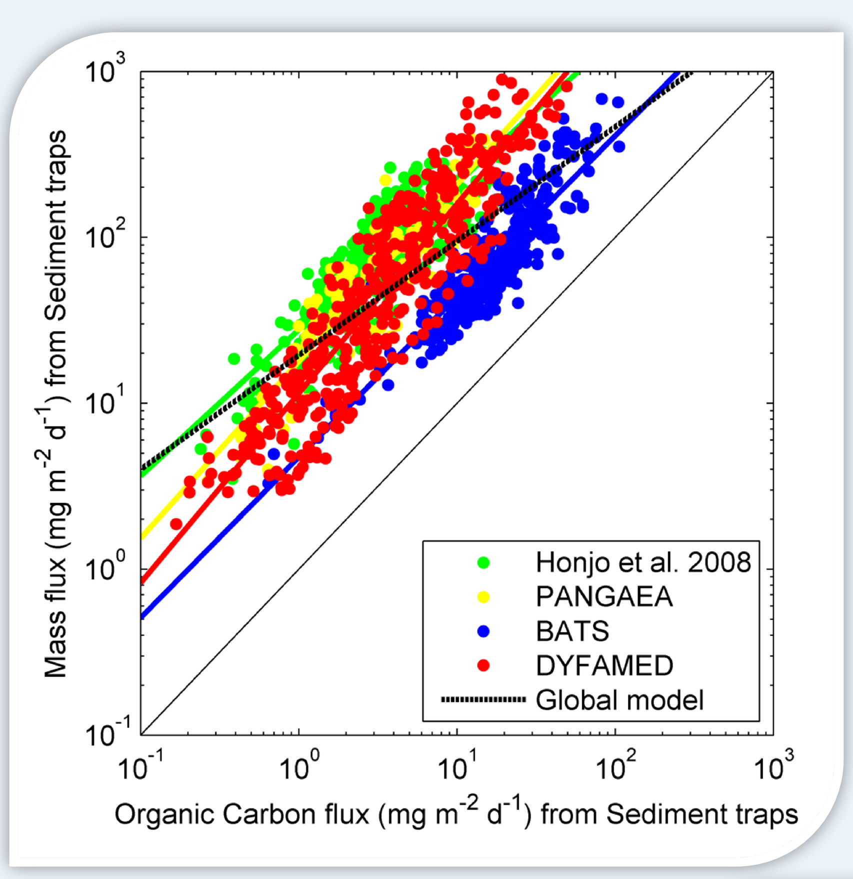
Multiple linear regressions

Validation and **correction** using *in-situ* sediment traps

Final global flux estimation

Results

Analysis of sediment traps fluxes (Mass vs POC) and comparison to SeaWiFS flux estimations



Sediment traps flux ratio
Mass flux / POC flux
(1st quartile <median< 3rd quartile):
5.3 < 13.2 < 24.3
r^2= 0.55 p<0.001

The Organic Carbon flux is strongly correlated to the mass flux on a global scale ($n \approx 1200$)

• No depth dependence

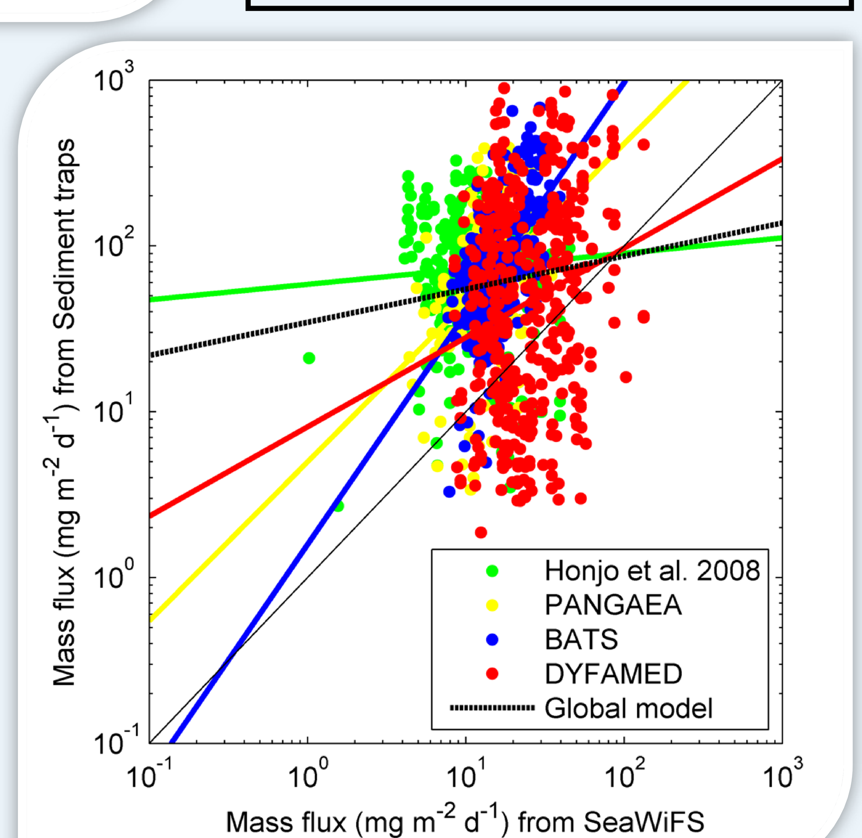
• There is an inter-site variability (ex: BATS vs DYFAMED) that can be used for regionalization

Mass flux ratio
Sediment traps / SeaWiFS
(1st quartile <median< 3rd quartile)
2.1 < 4.6 < 8.4
r^2= 0.01 p<0.001

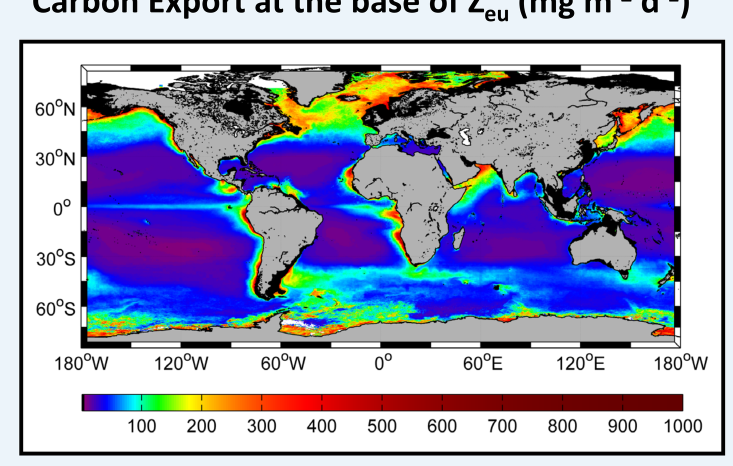
• General under-estimation using SeaWiFS

• Very large variability (weak r^2)

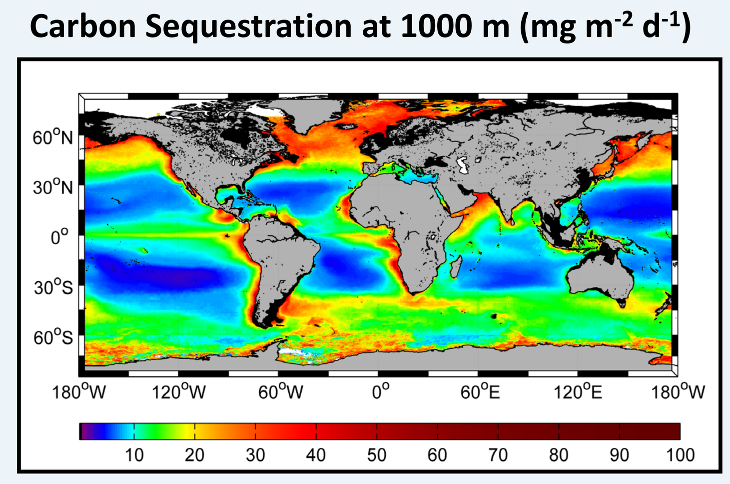
• Best relationship using BATS data (r^2=0.32)



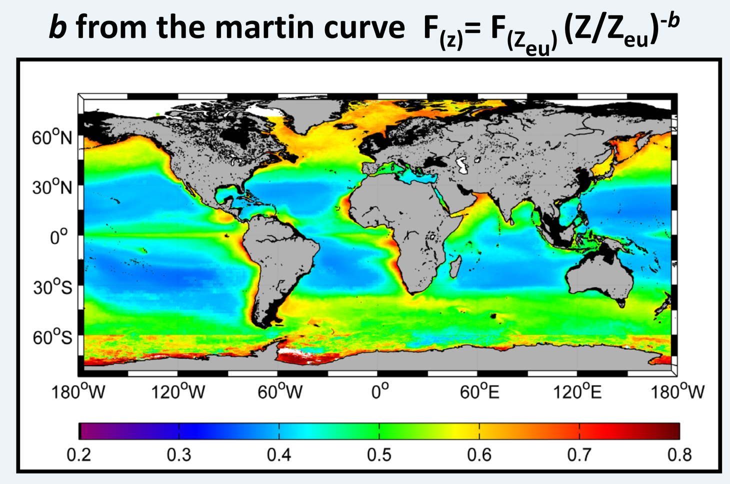
Carbon Export at the base of Z_{eu} (mg m^{-2} d^{-1})



Carbon Sequestration at 1000 m (mg m^{-2} d^{-1})



***b* from the martin curve $F_{(z)} = F_{(Z_{eu})}(Z/Z_{eu})^{-b}$**



Annual means (Climatology)

• Strong spatial variability

Global annual carbon export
0.75 < 3.03 < 13.77 (GtC)

This range is function of the ratios (median and quartiles) calculated using sediment traps data

•Estimations comparable to the literature (~12 GtC)

Global annual carbon Sequestration
0.15 < 0.61< 2.78 (GtC)

This range is function of the ratios (median and quartiles) calculated using sediment traps data

•Estimations comparable to the literature (~2 GtC)

• Large spatial variations (0.2 – 0.8)

Global mean annual *b*
0.5

• Inferior to the mean *b* from Martin et al. 1987 (*b* = 0.86) but into its range (0.32-0.97)

Large implications for modeling

References

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Cruises and Time Series: **Hawaii Ocean Time-Series (HOT), Bermuda Atlantic Time-series Study (BATS), DYnamique des Flux de mAtière en MEDiterranée (DYFAMED), Sea-viewing Wide Field of Vvew Sensor (SeaWiFS)**

linking genomes to biomes