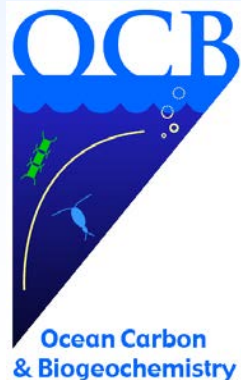
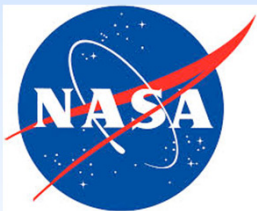
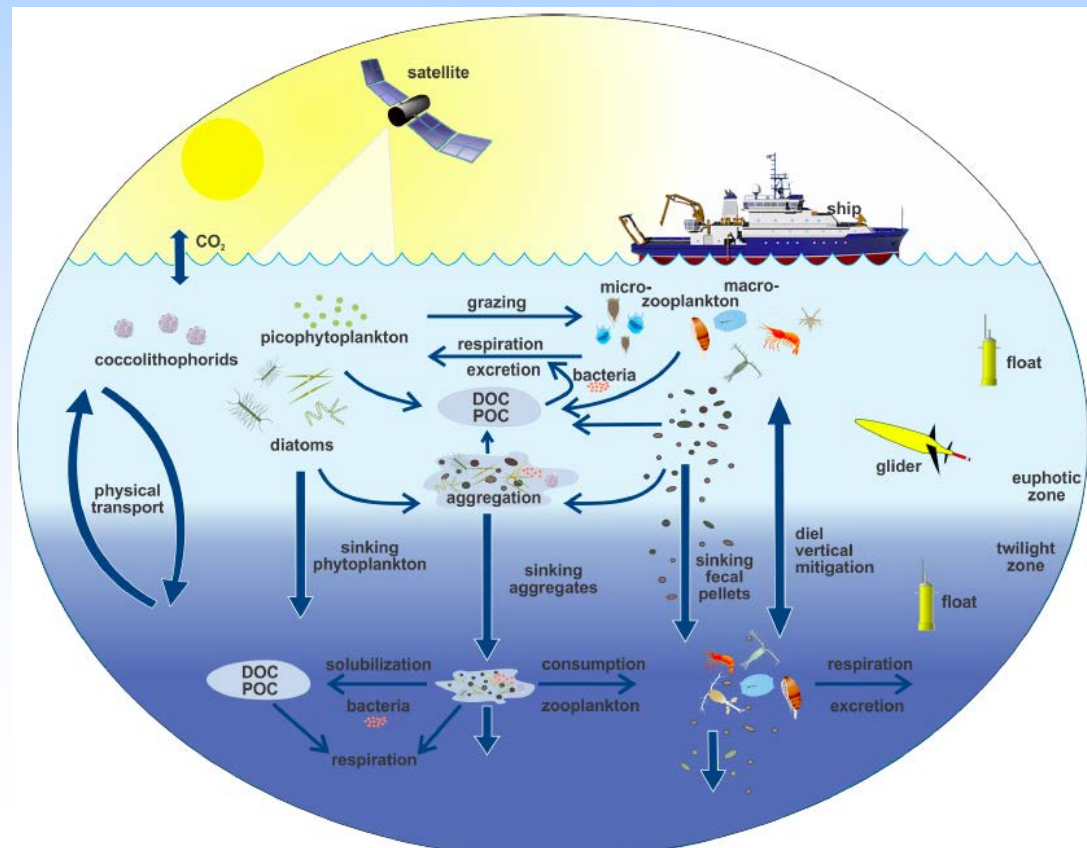


EXport Processes in the Ocean from RemoTe Sensing (EXPORTS): Predictability

Scott Doney (WHOI)

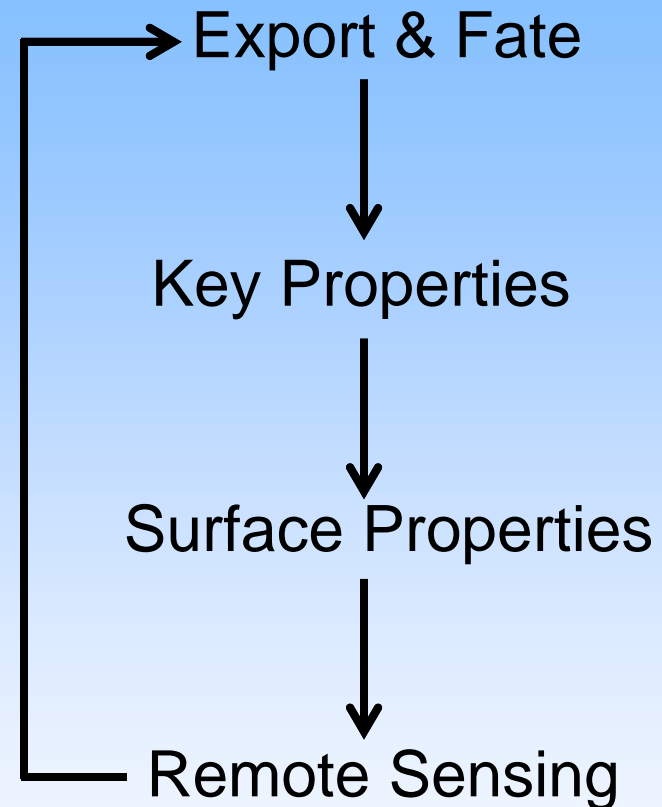
Ocean Carbon & Biogeochemistry Summer Meeting
Woods Hole, MA (July 2016)



EXPORTS Sub-Question 3 Schematic

Reduce uncertainties in contemporary & future estimates of the export and fate of upper ocean net primary production

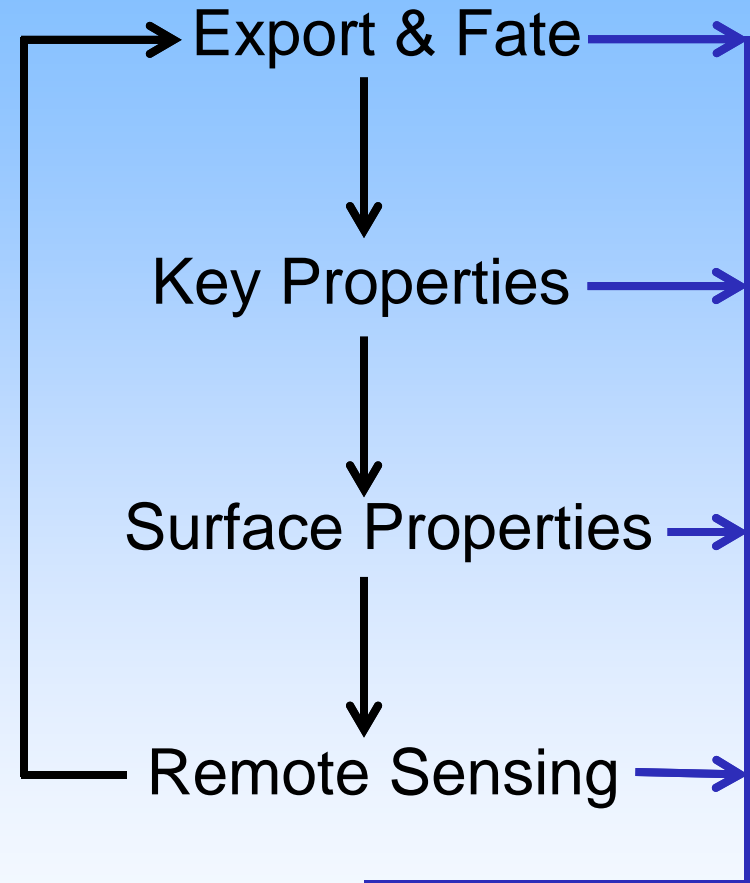
SQ3-A,B,C



EXPORTS Sub-Question 3 Schematic

Reduce uncertainties in contemporary & future estimates of the export and fate of upper ocean net primary production

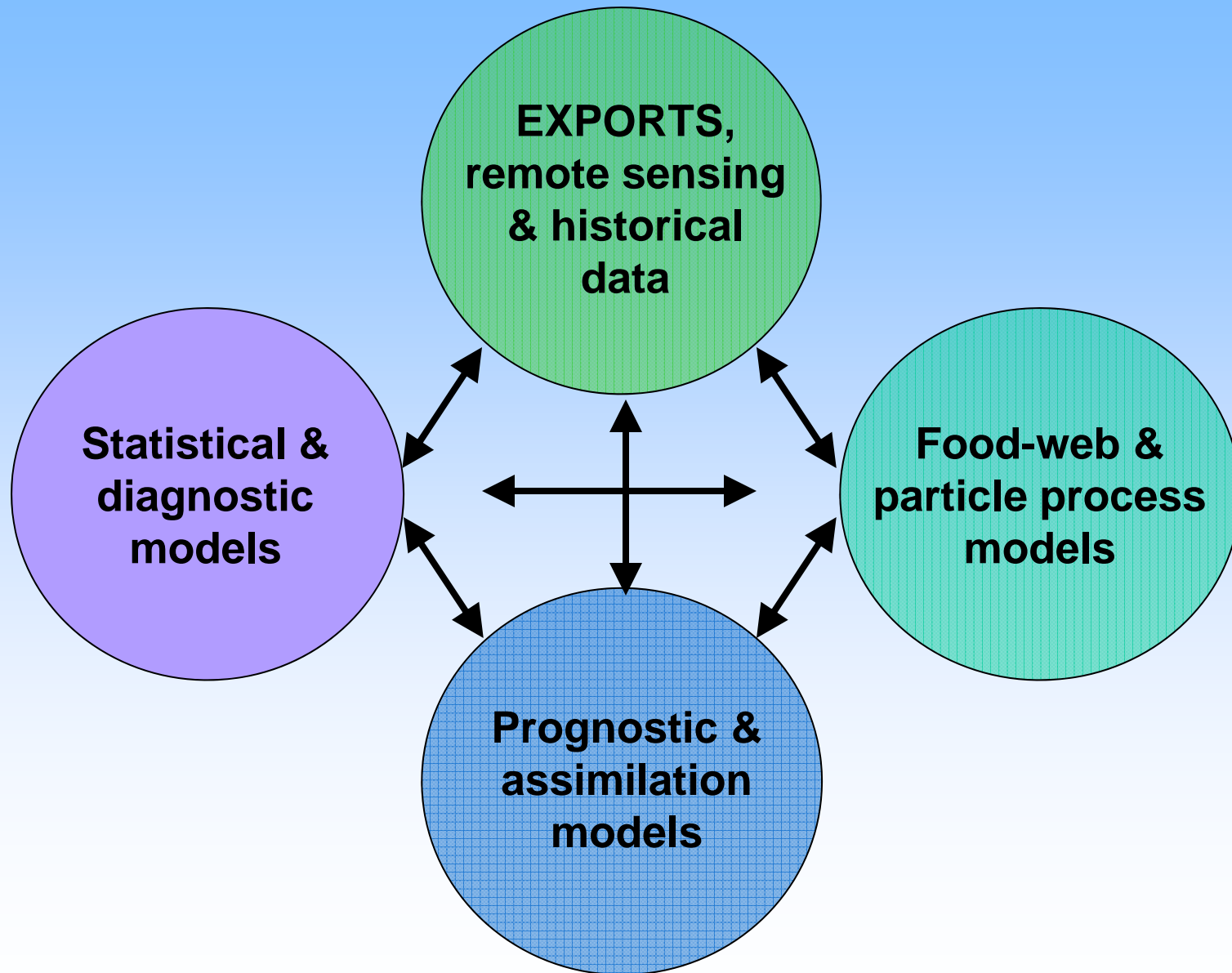
SQ3-A,B,C



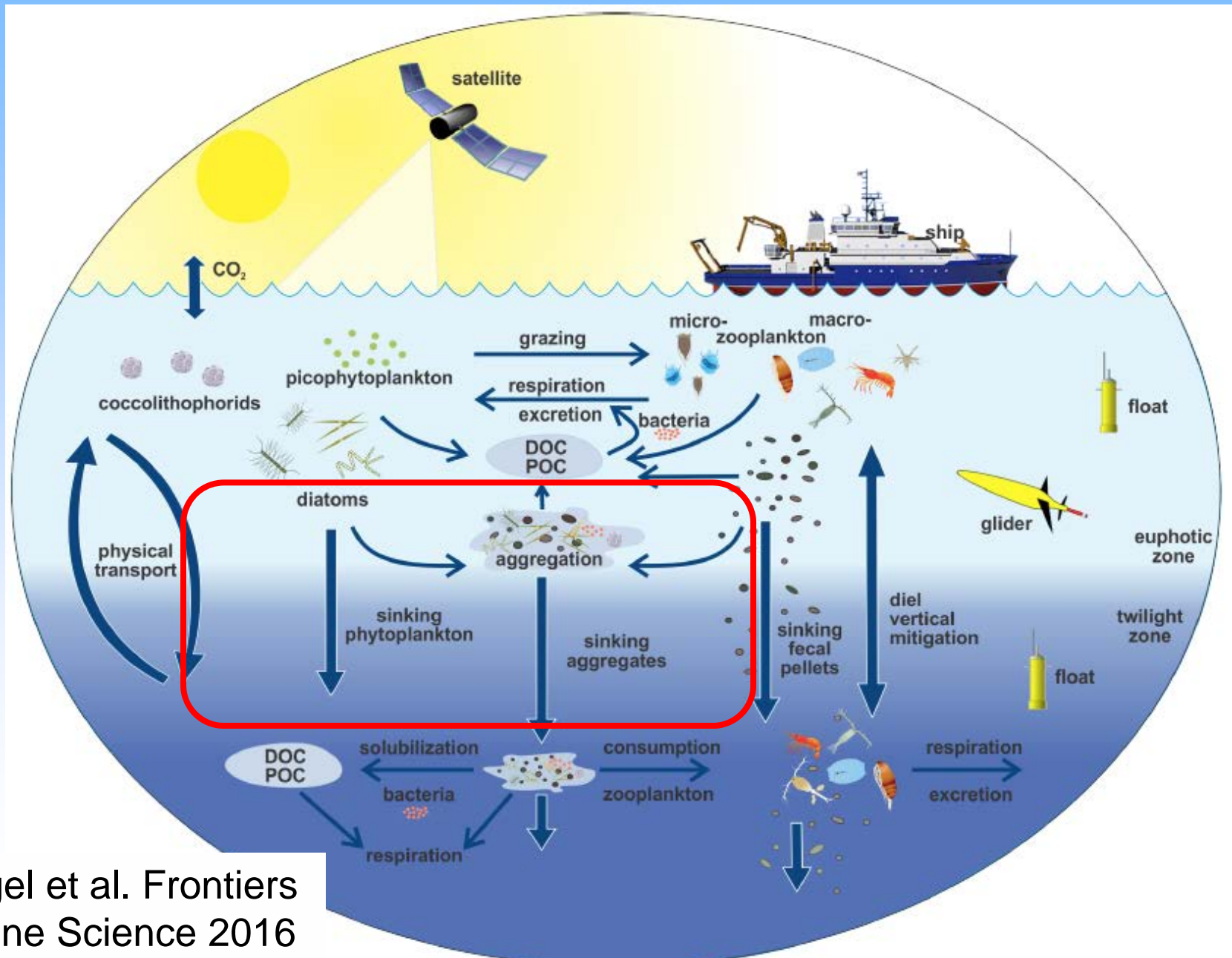
SQ3-D

Future Projections

EXPORTS Model-Data Hierarchy



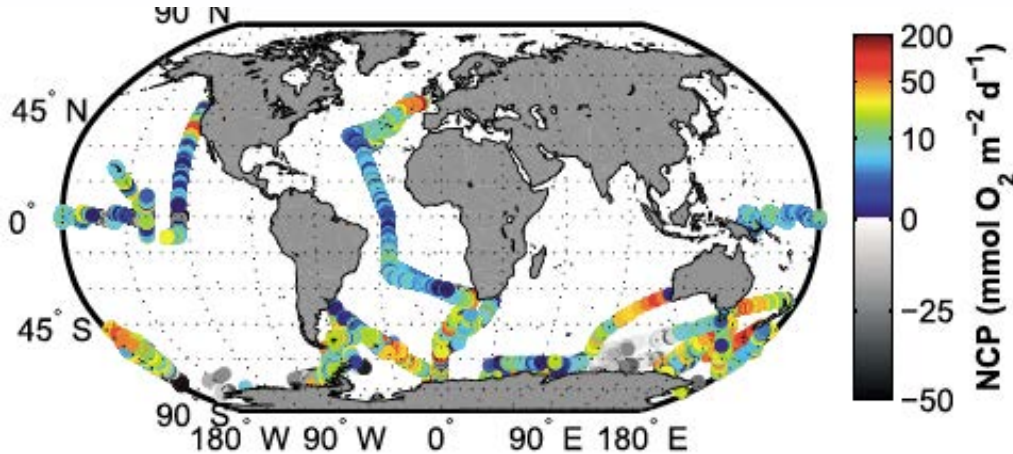
Sinking Phytoplankton, Aggregates & Fecal Pellets



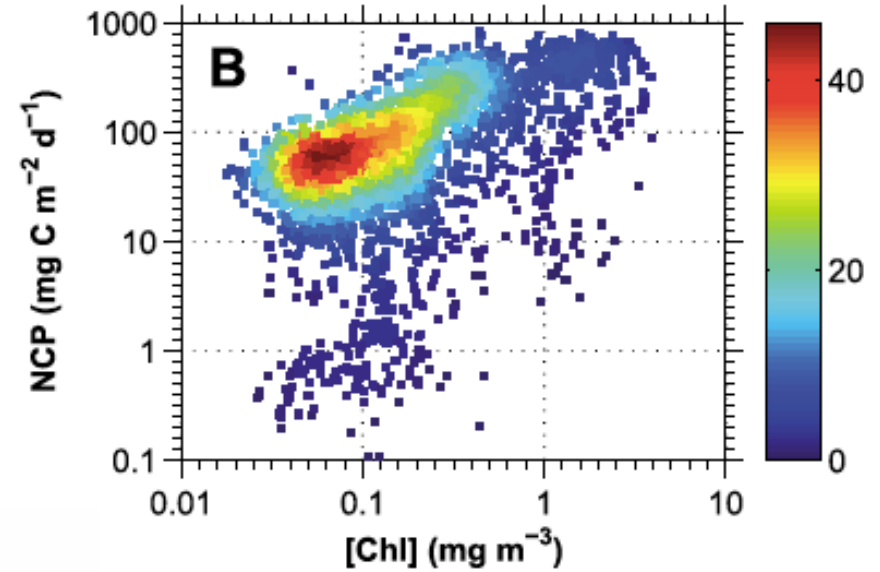
Siegel et al. *Frontiers Marine Science* 2016

Statistical & Diagnostic Model Estimates

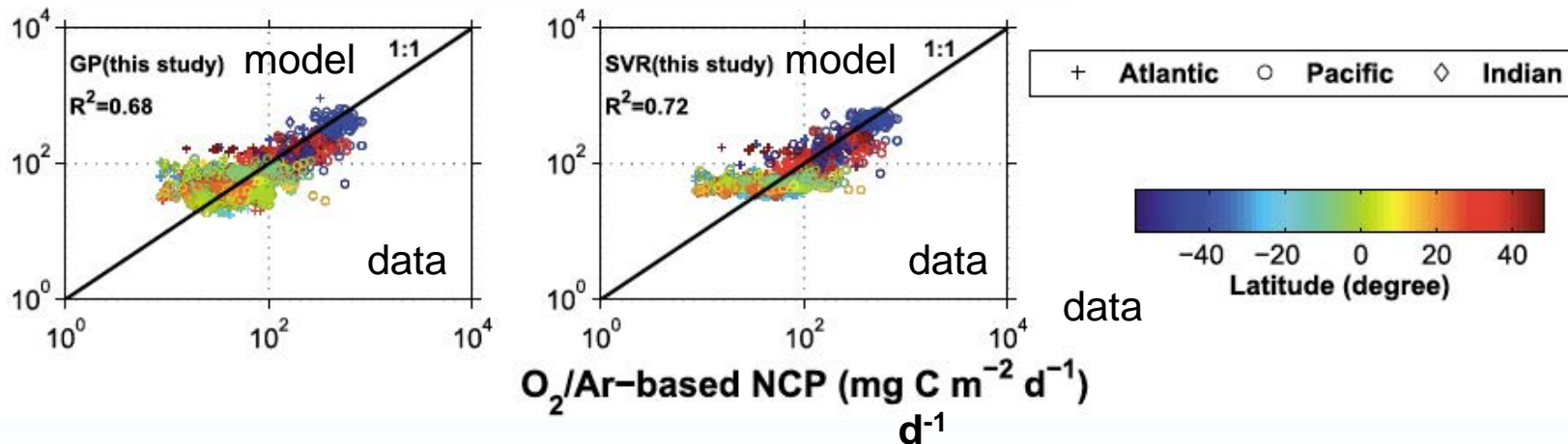
Calibration dataset

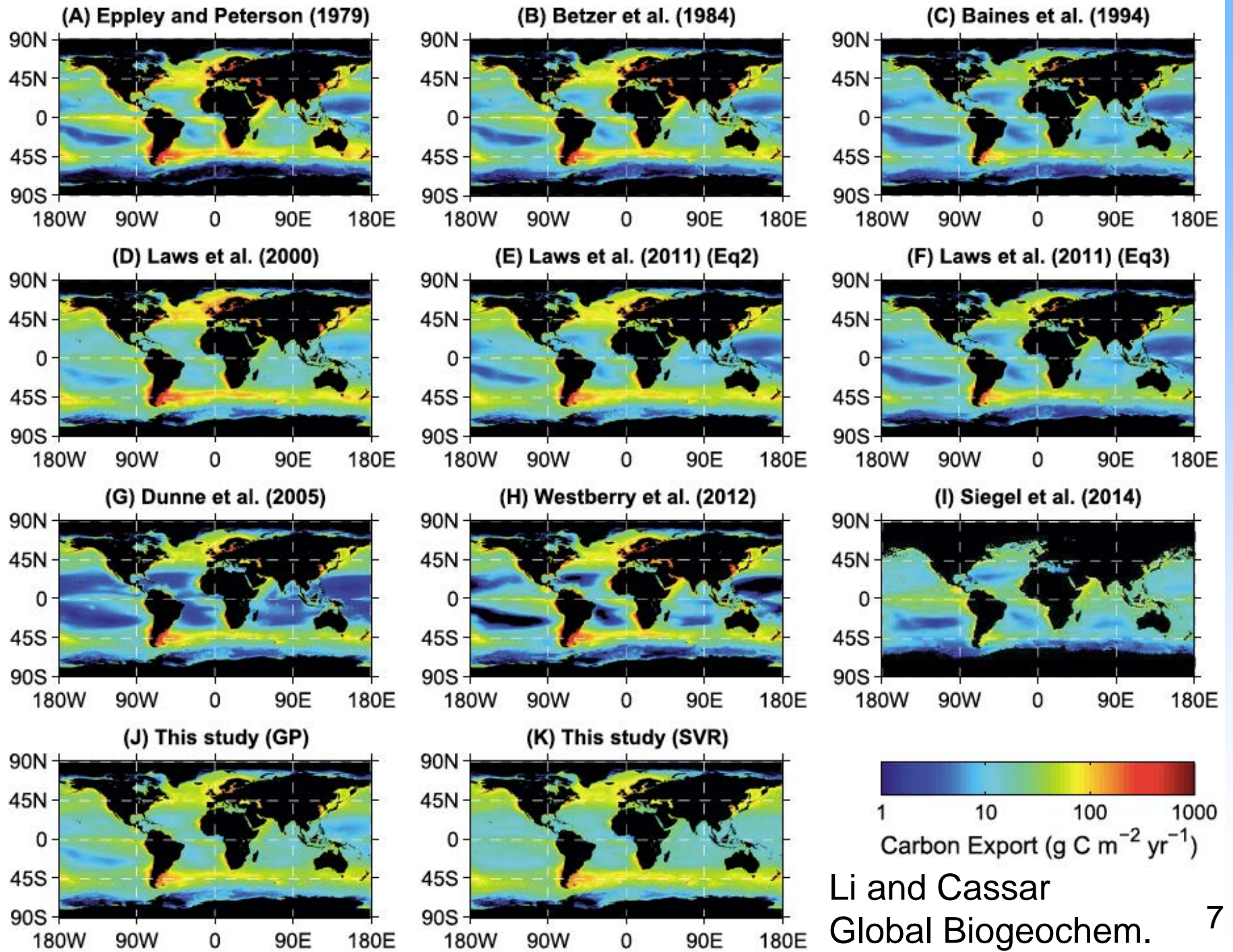


Comparison to observables



Statistical algorithm evaluation

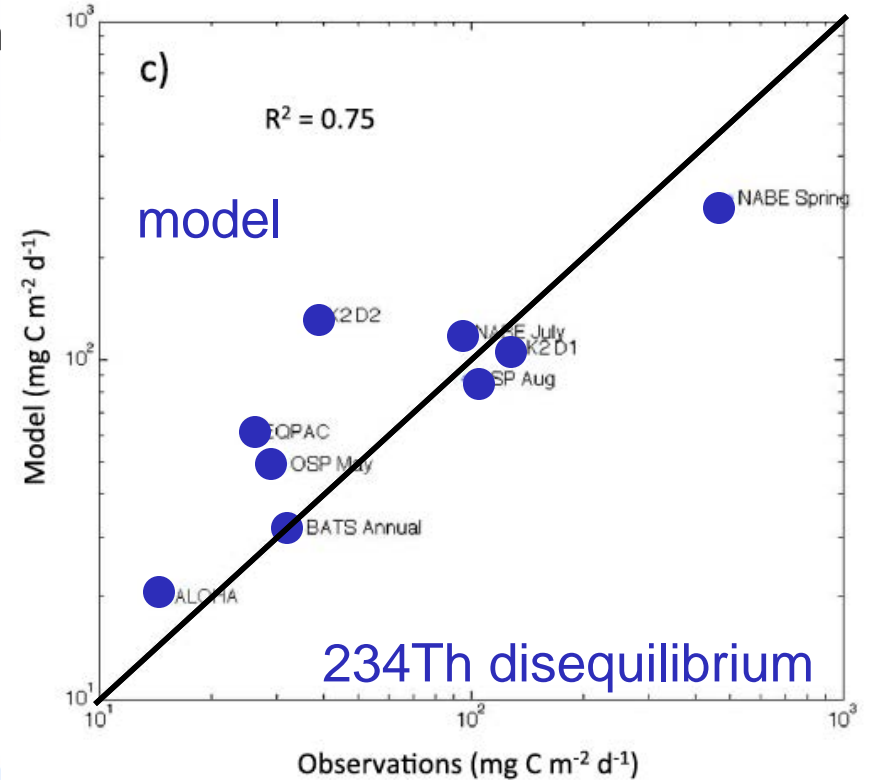
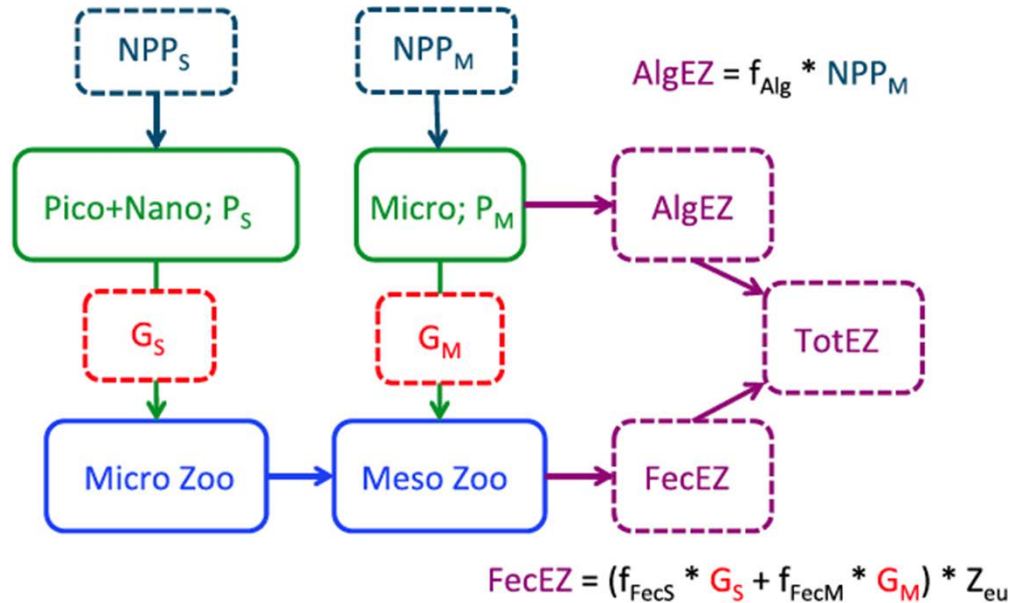




Li and Cassar
Global Biogeochem.

Diagnostic Satellite Food Web-Export Model

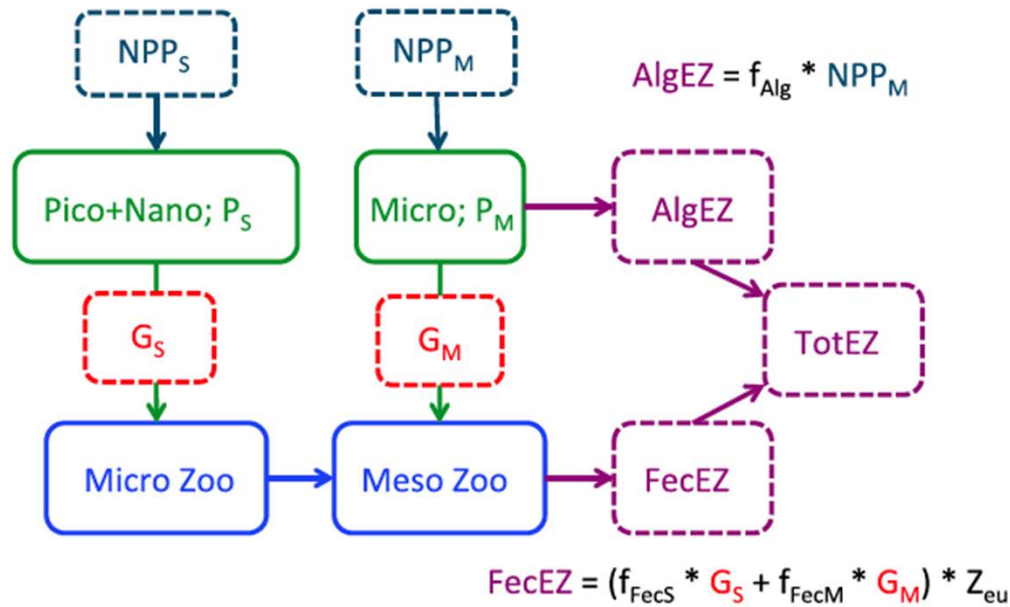
Two-size class food-web model forced with satellite estimates of NPP & biomass



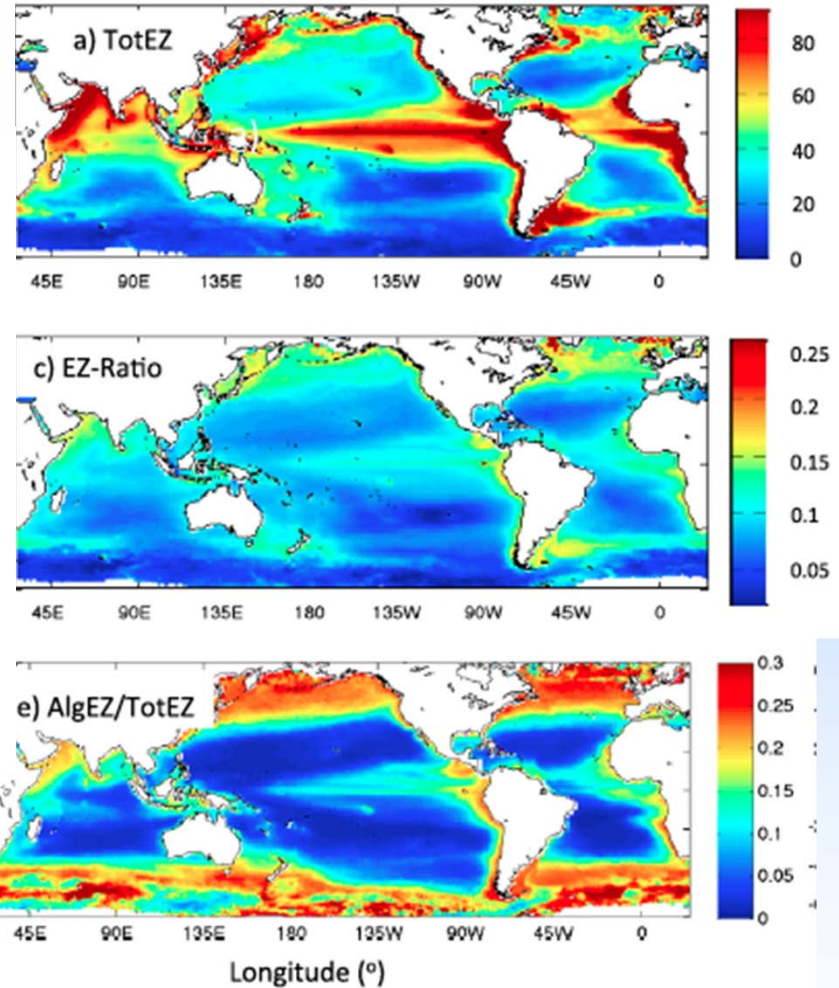
Siegel et al. Global Biogeochemical Cycles 2014

Diagnostic Satellite Food Web-Export Model

Two-size class food-web model forced with satellite estimates of NPP & biomass



Export ratio = Total Export / NPP

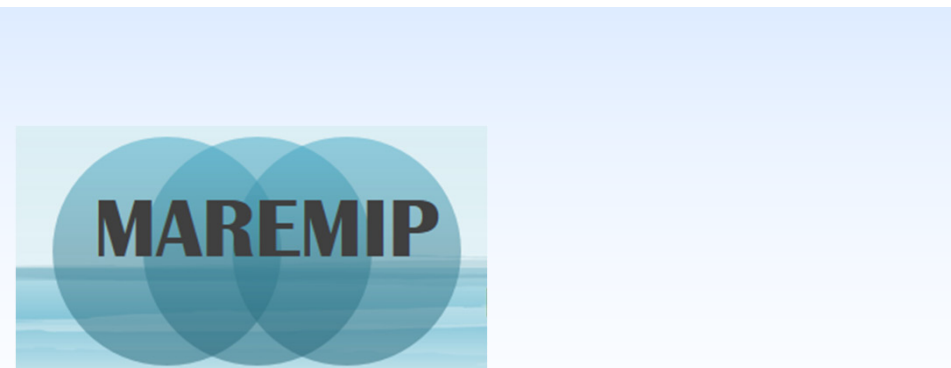
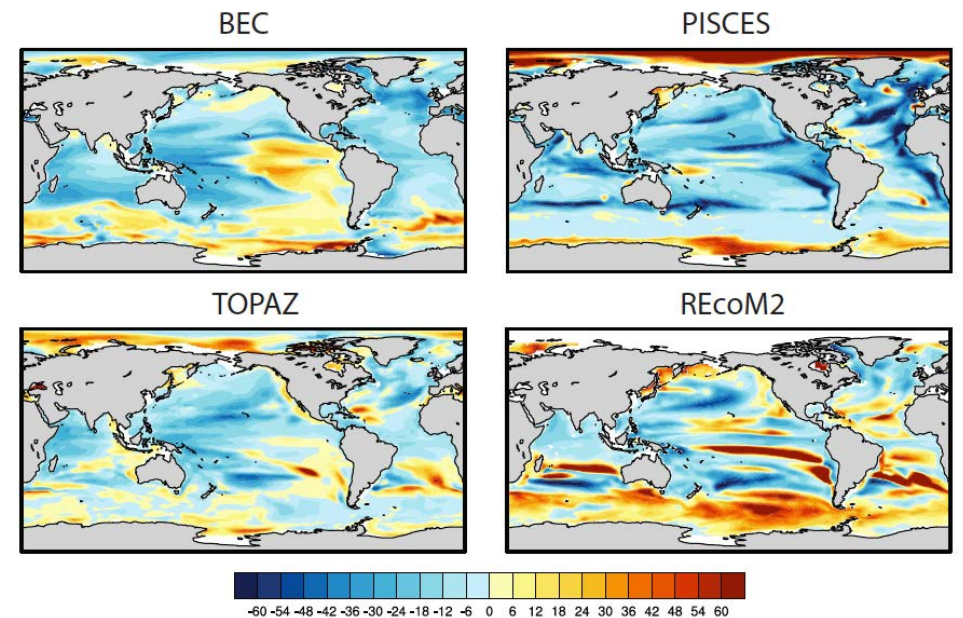
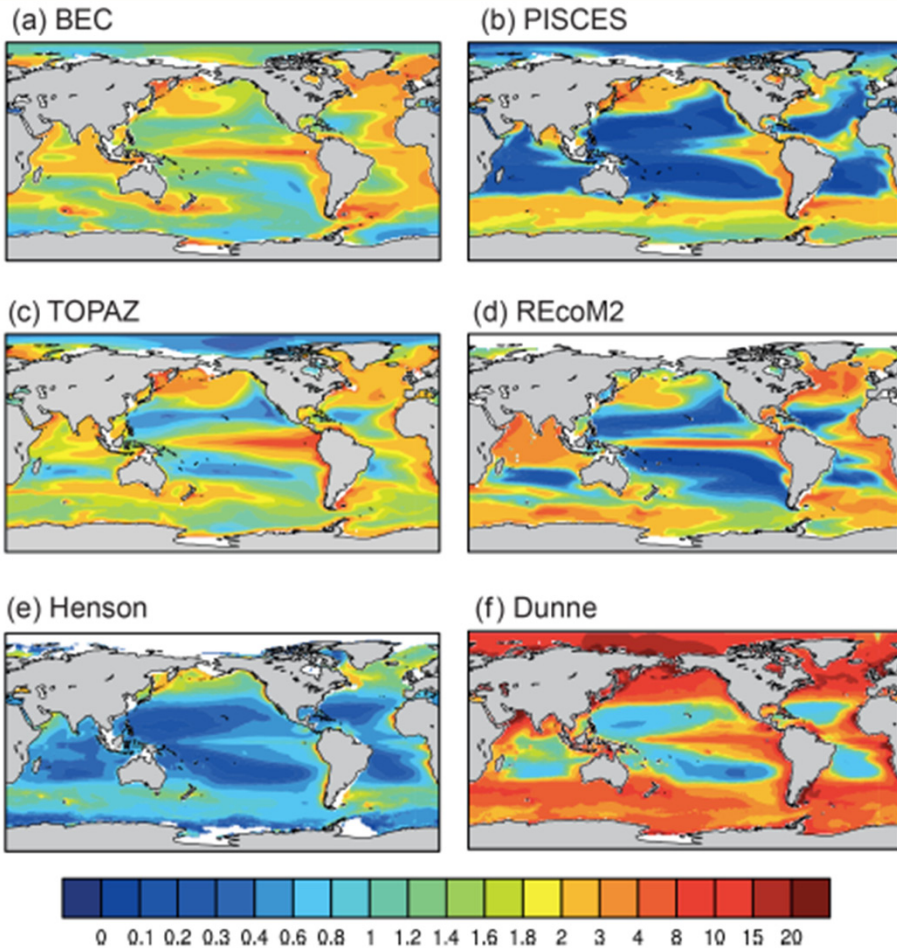


Siegel et al. Global Biogeochemical Cycles 2014

Earth System Models & Climate Sensitivity

Sinking Particle Export (mol C/m²/y)

Δ Particle Export (%) Future Climate



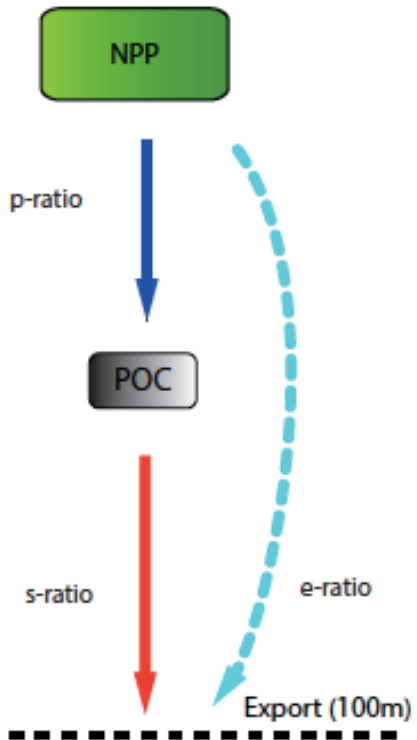
Laufkötter et al. Biogeosci. 2016
See also Hauck et al. GBC 2015

MARine Ecosystem Model
Inter-comparison Project

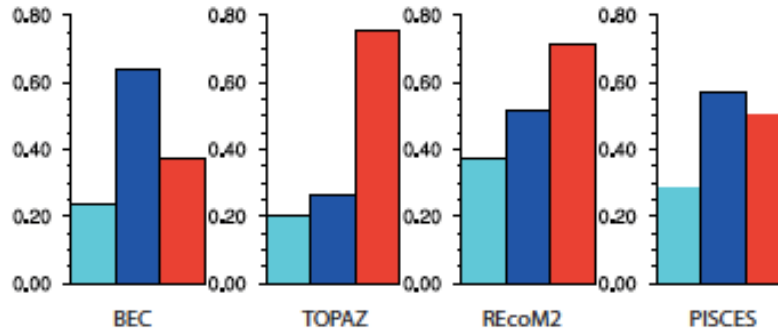
Elements of Export Ratio

% Change
Future Climate

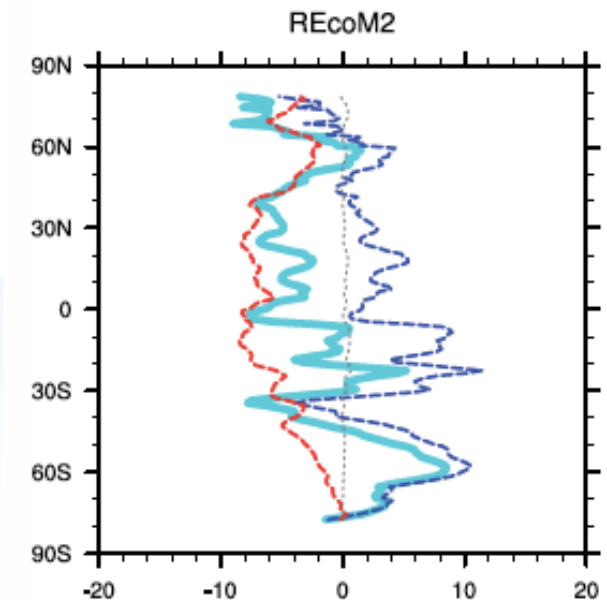
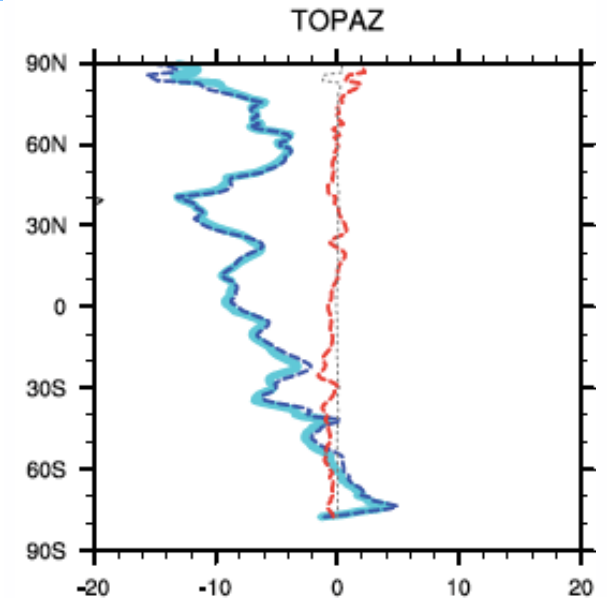
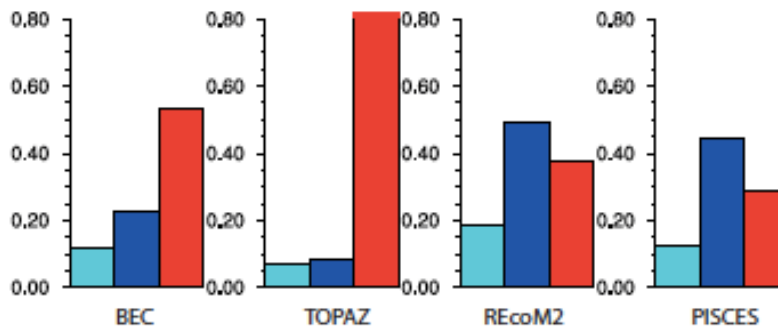
(a) Illustration of ratios



(b) High latitudes

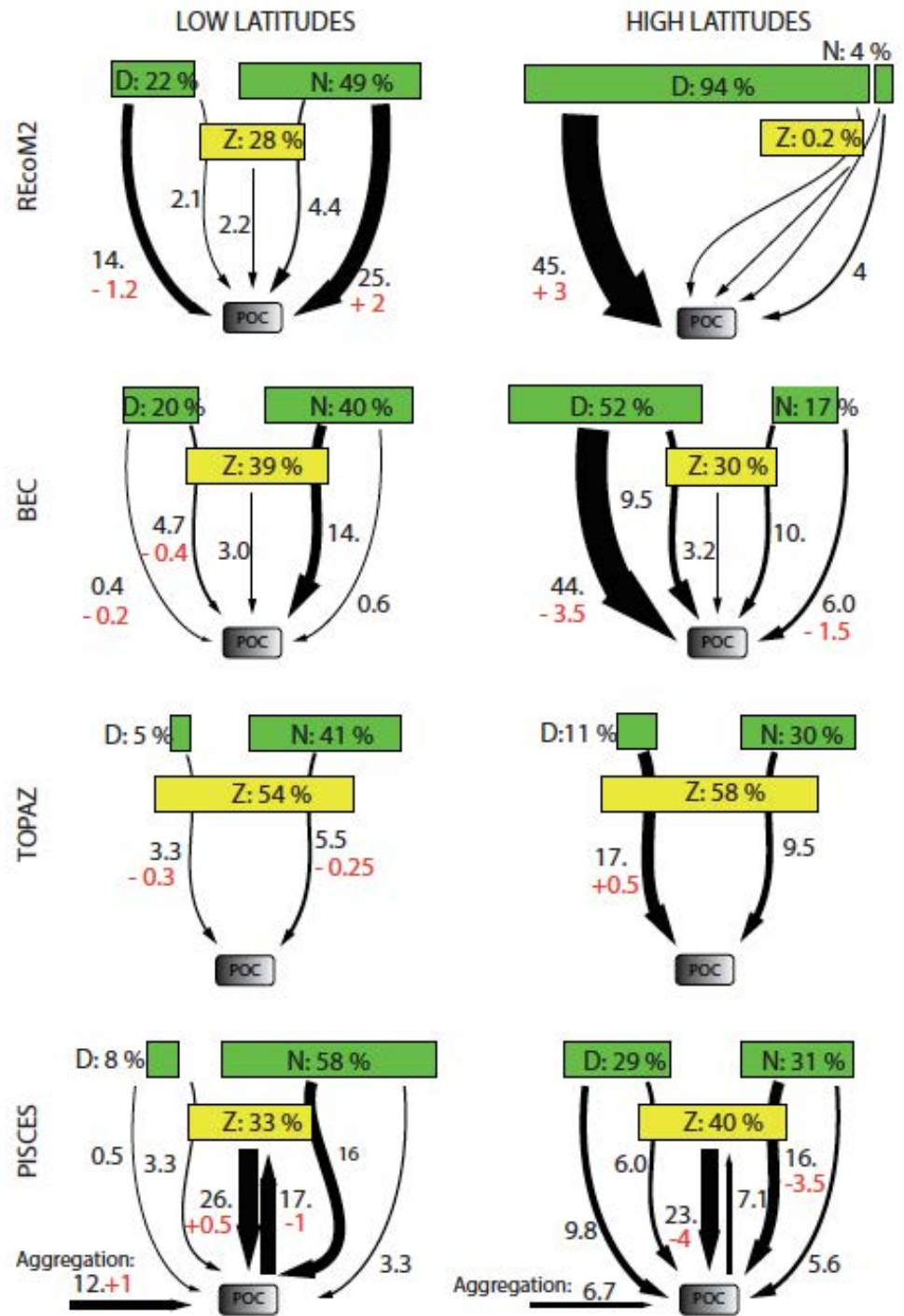
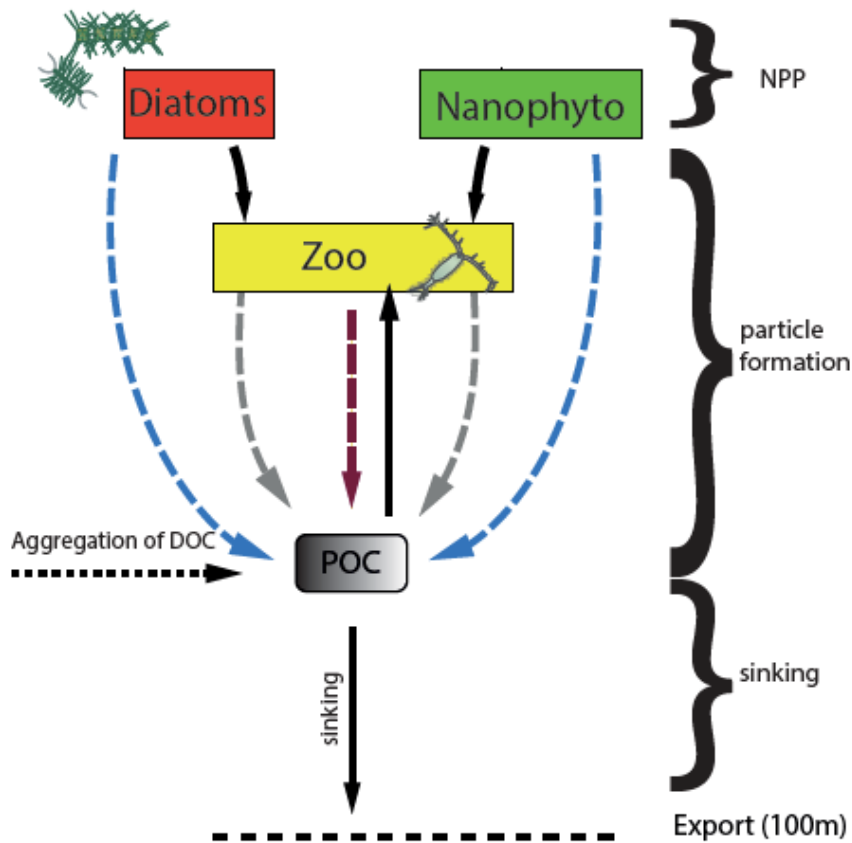


(c) Low latitudes

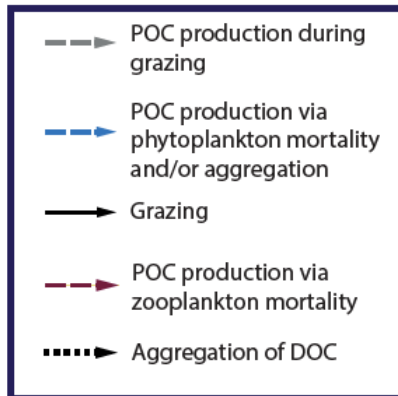


Laufkötter et al. Biogeosci. 2015; 2016

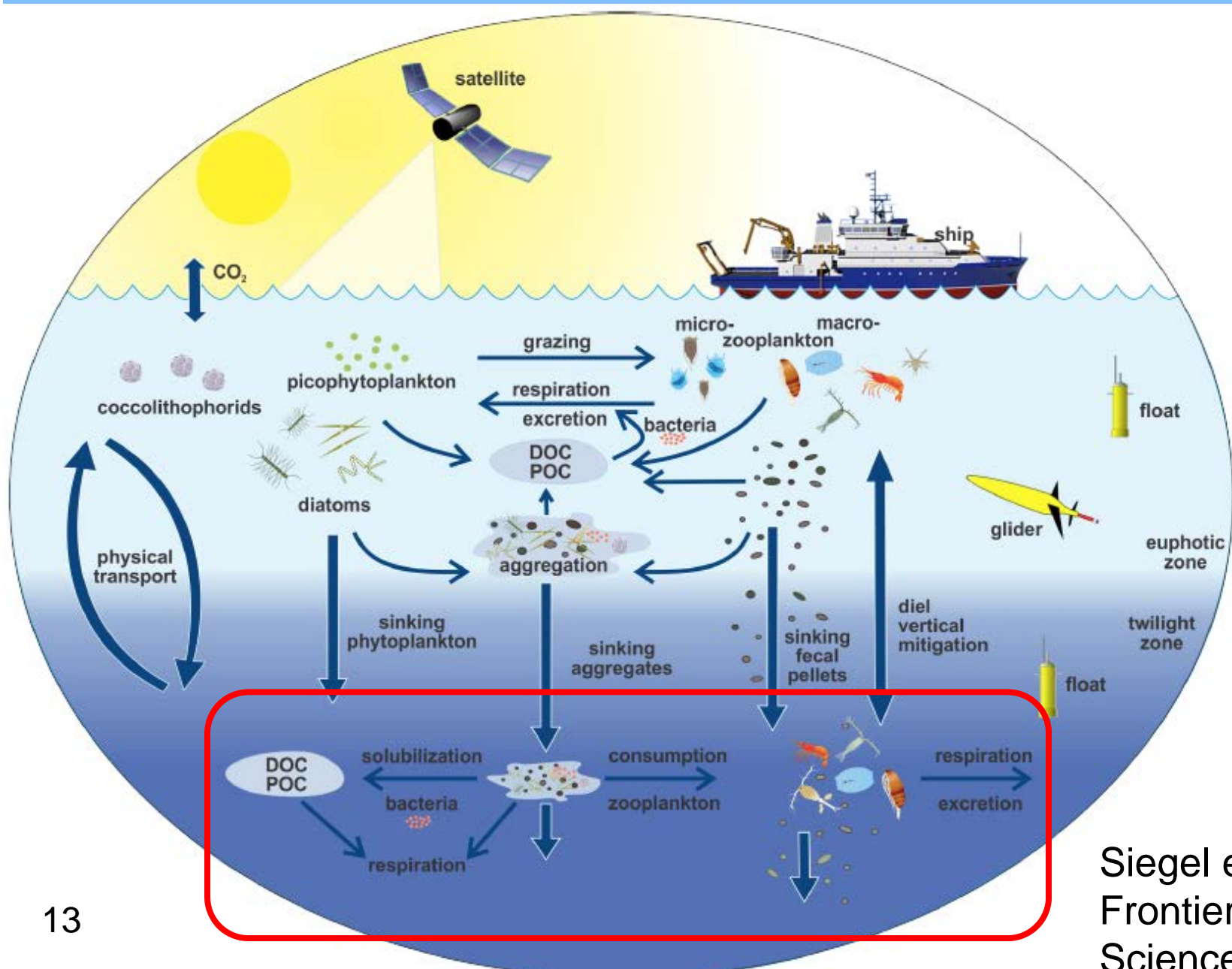
Model Food Webs



Laufkötter et al.
Biogeosci. 2016

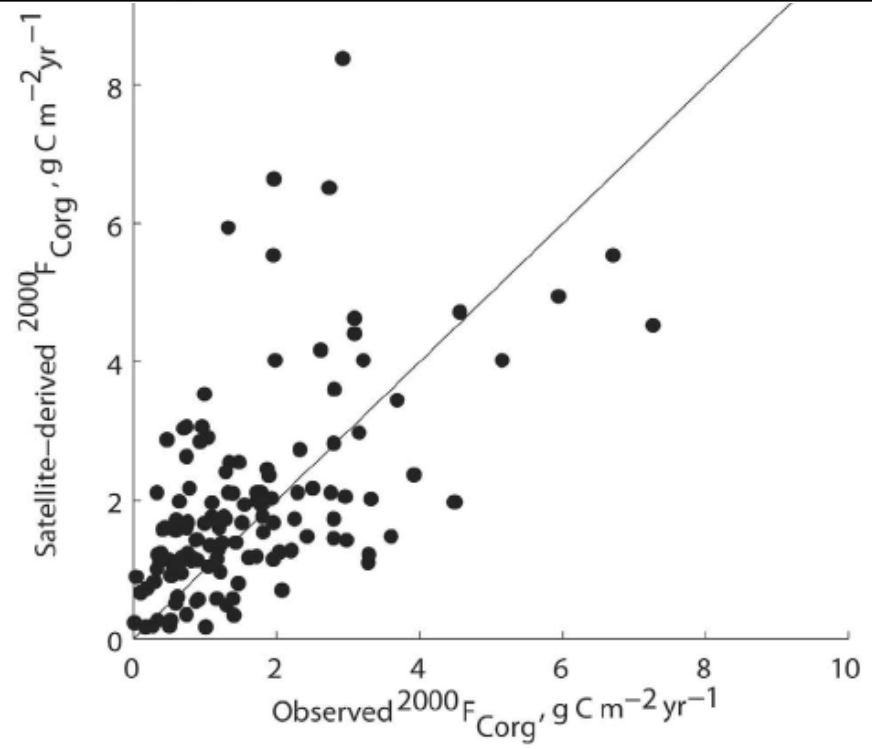
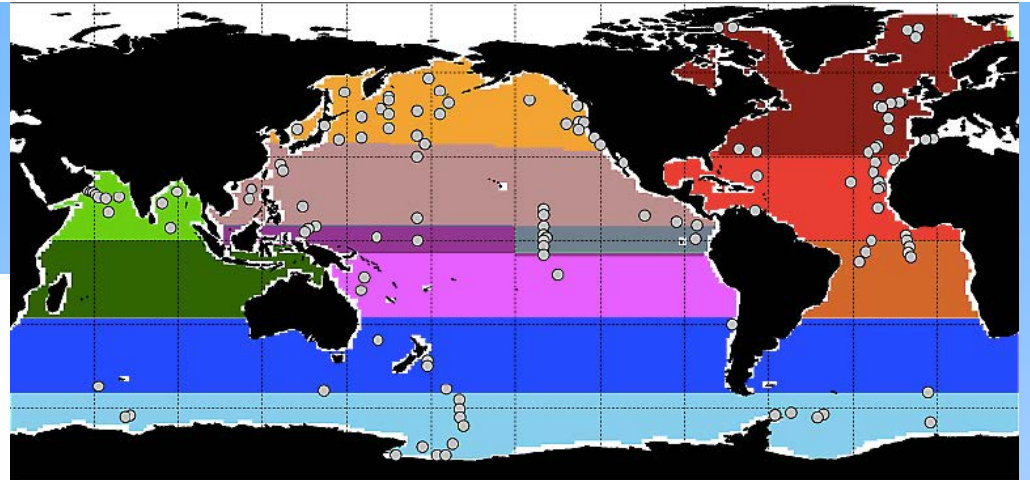
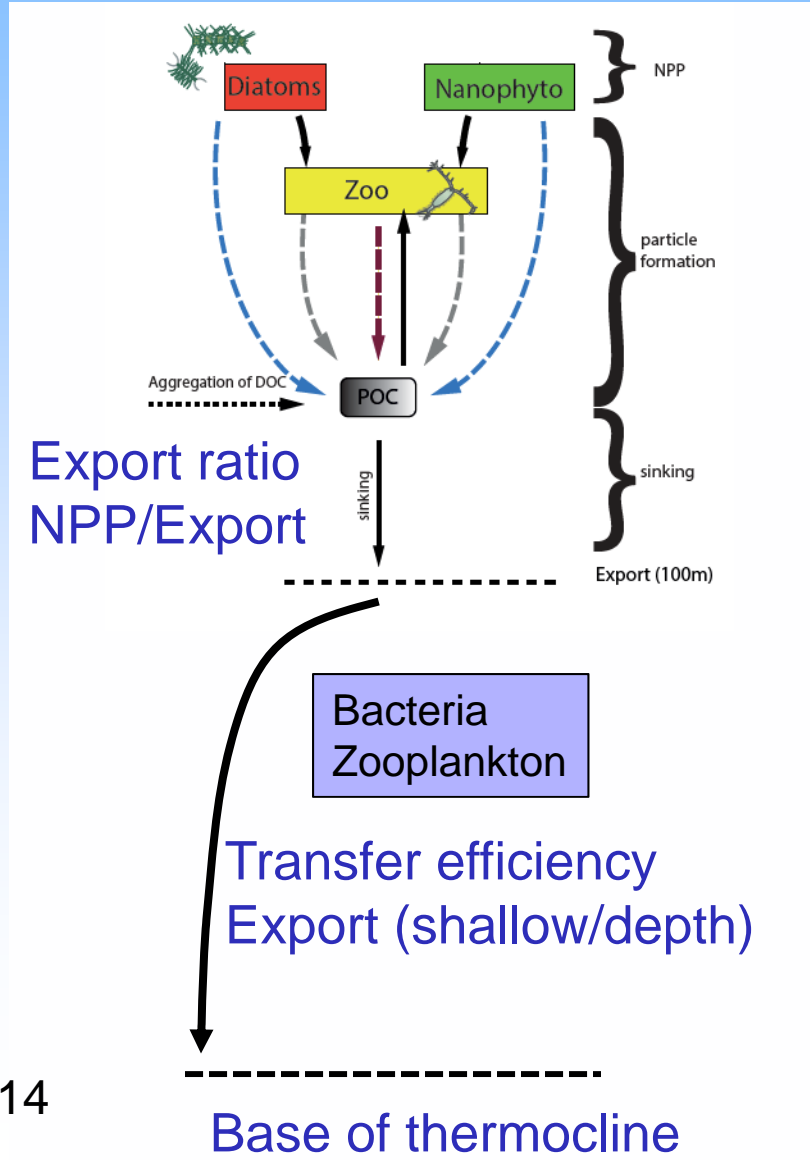


Mesopelagic Transport & Remineralization



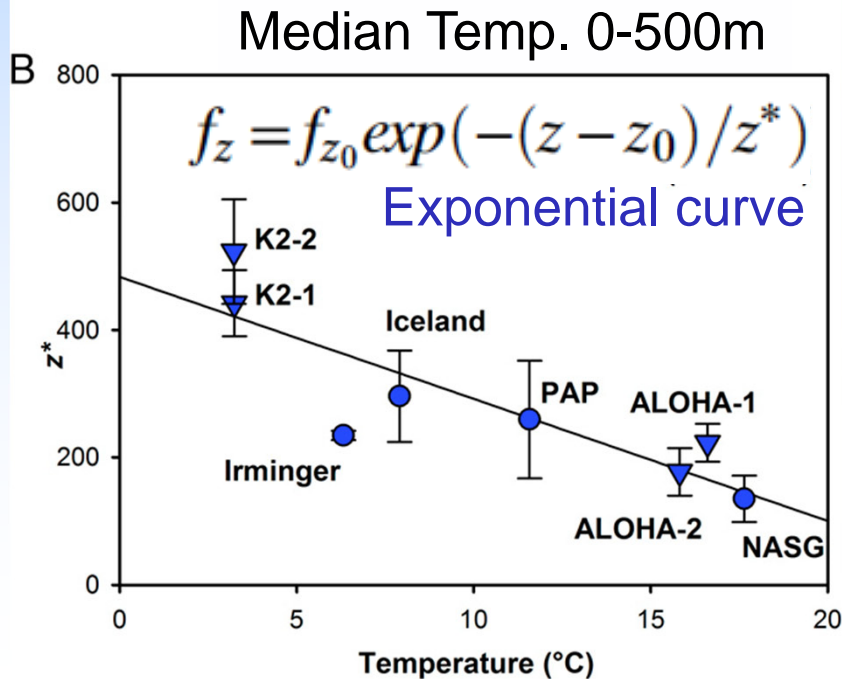
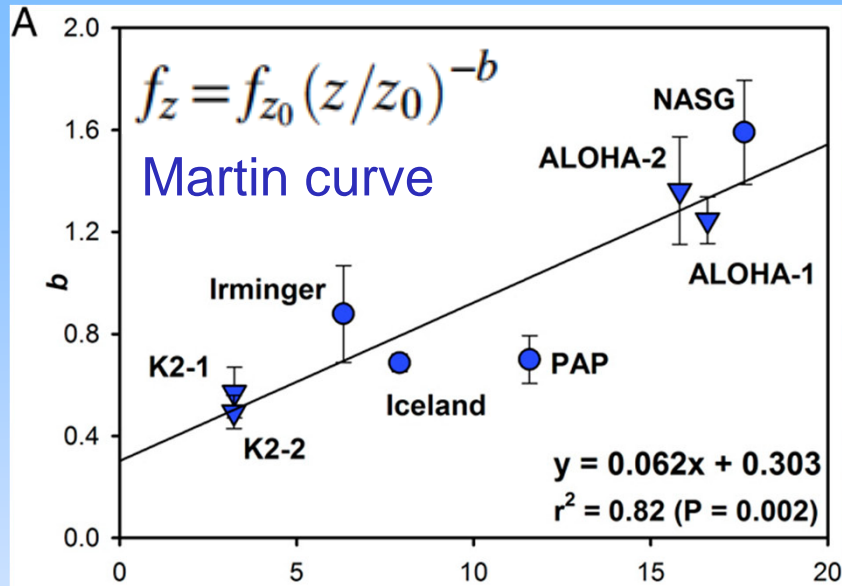
Siegel et al.
Frontiers Marine
Science 2016

Particle Flux Attenuation & Transfer Efficiency

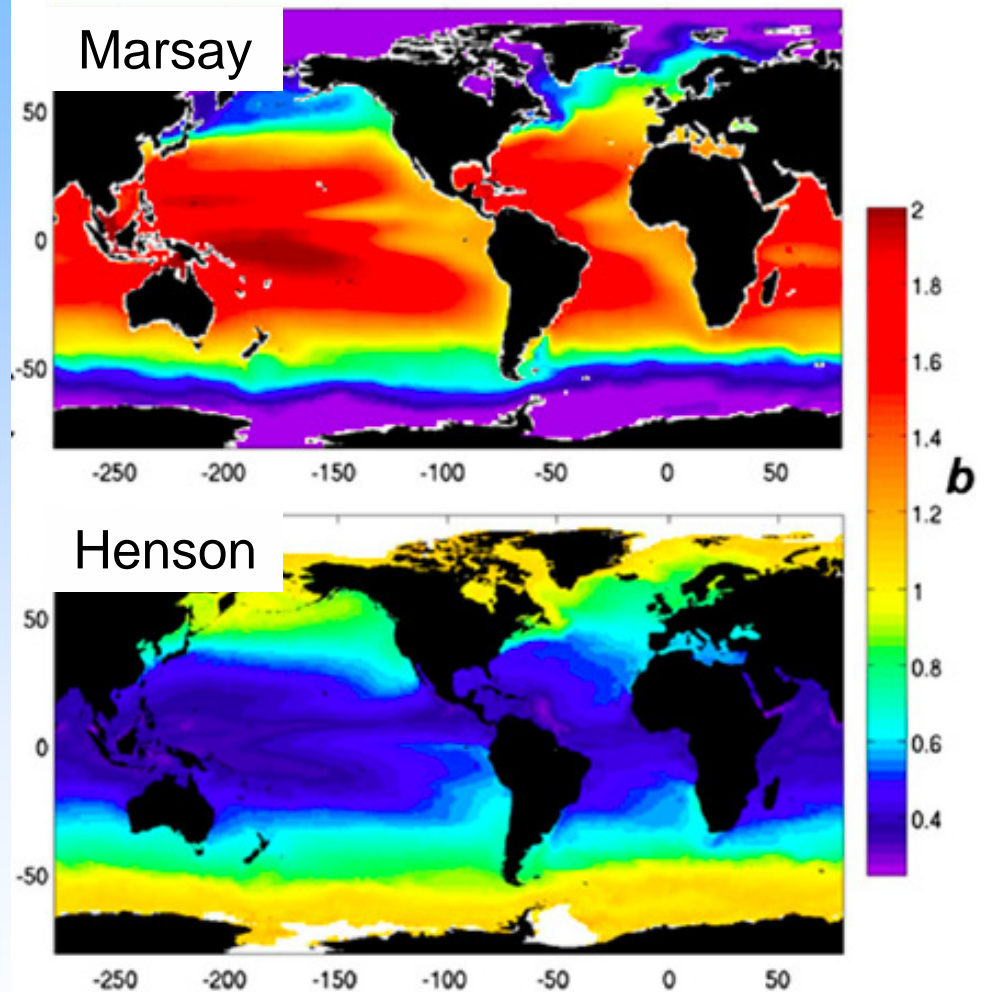


Henson et al. GBC 2012
 See also Francois et al. GBC 2002
 Lutz et al. JGR 2007

Empirical Particle Remineralization Curves



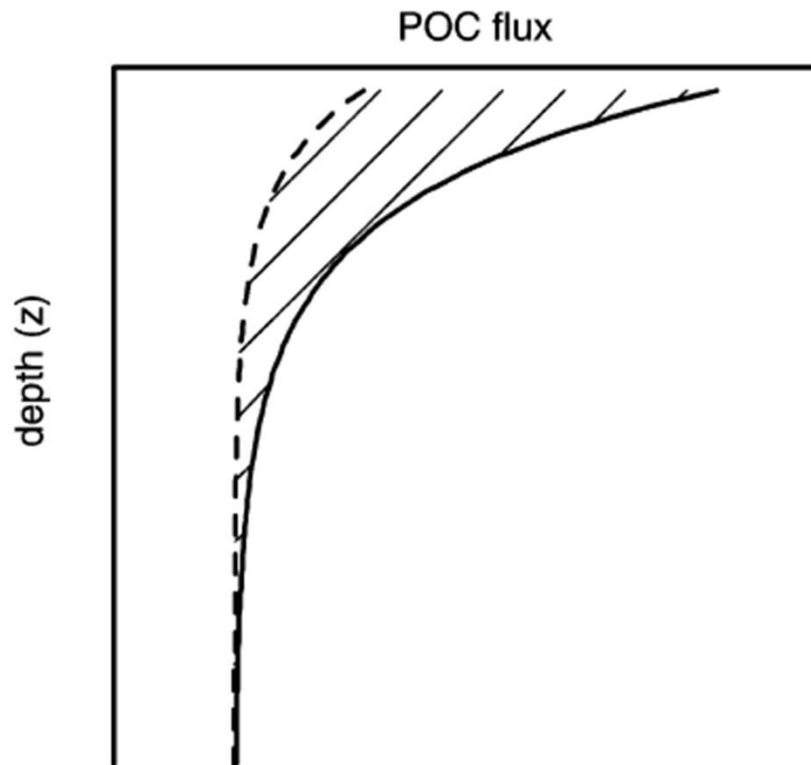
Martin curve exponent "b"



Marsay et al. PNAS 2015

15

Particle Size, Composition & Ballast Hypotheses

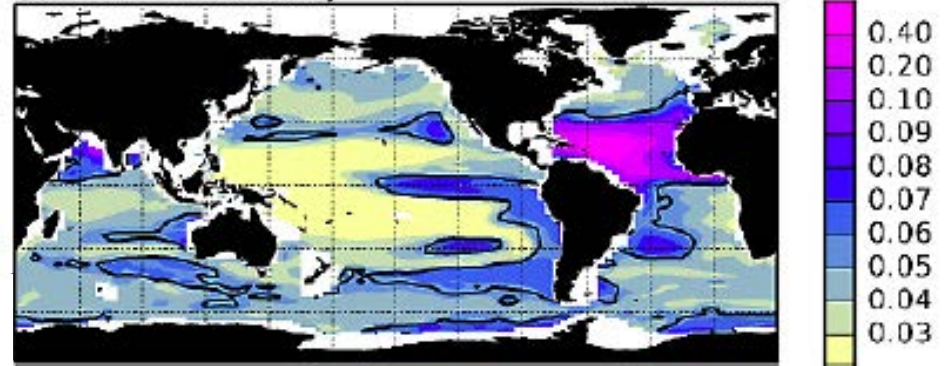


Armstrong et al. DSR II 2002
 Francois et al. GBC 2002

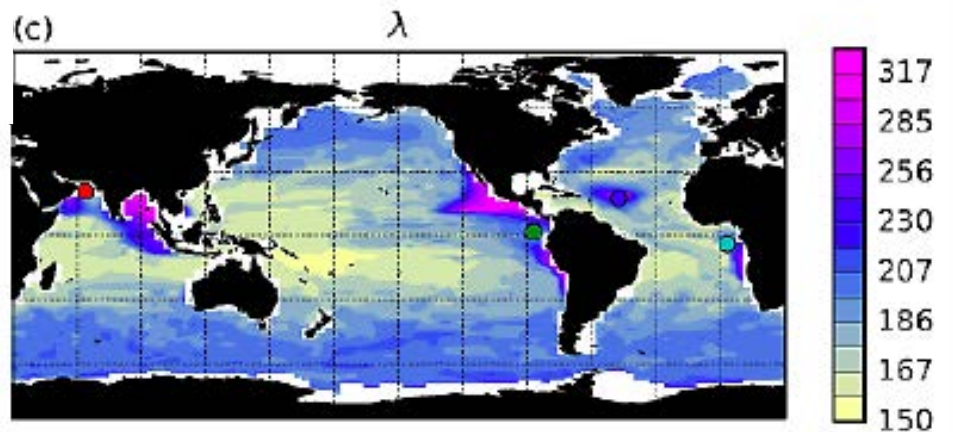
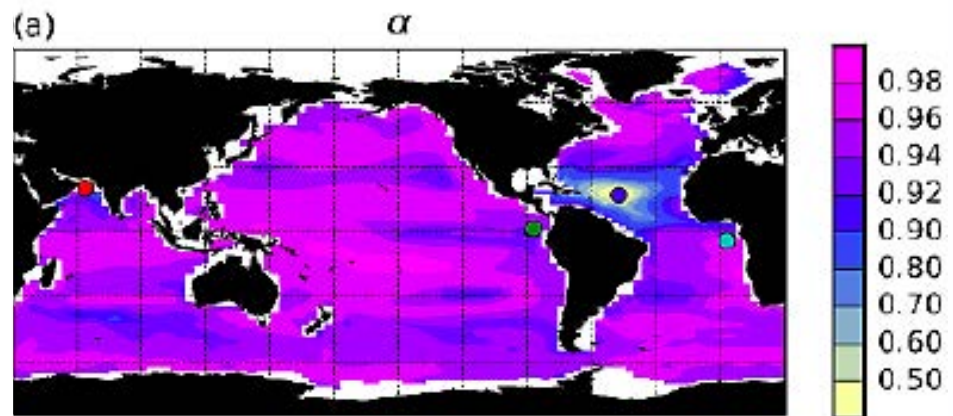
16

Lima et al. Biogeosci. 2014

(f) Transfer efficiency mean = 5.5%

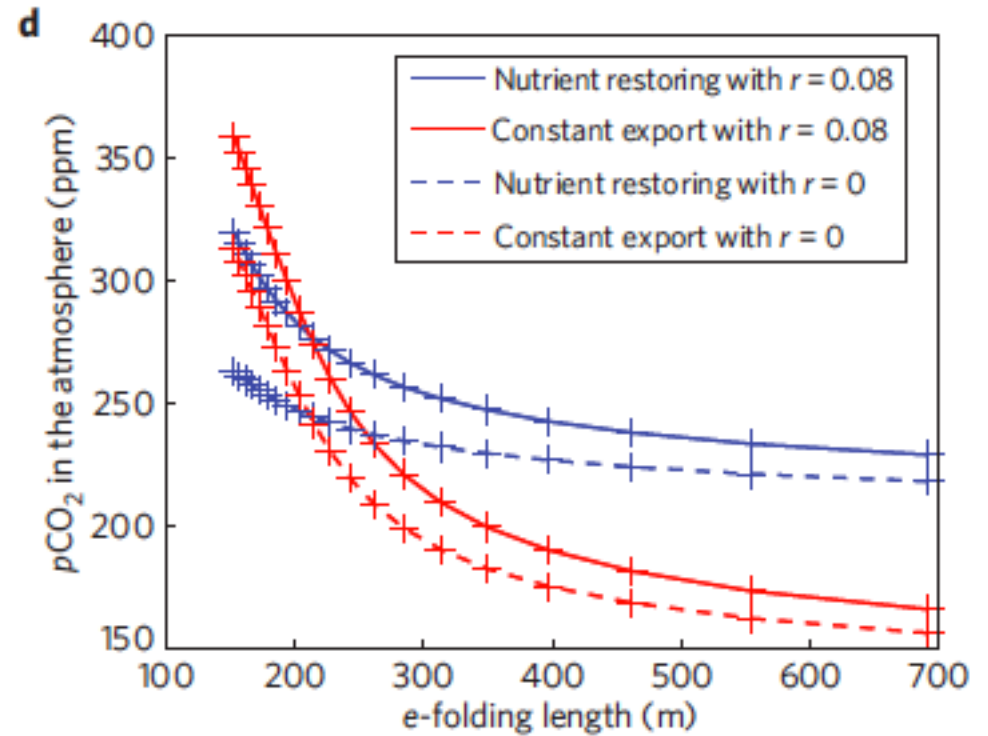
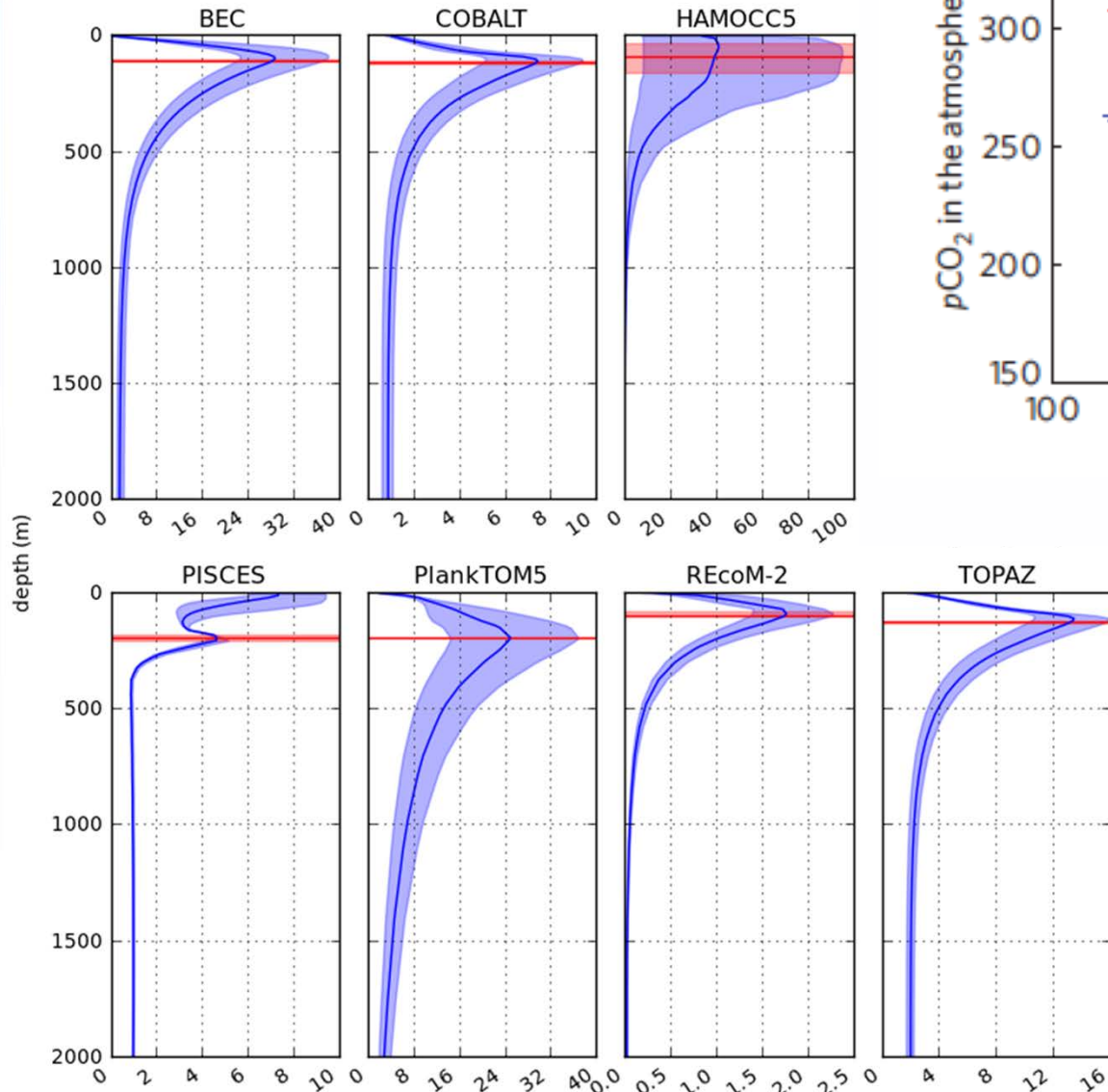


$$F(z) = f \text{NPP} \left(\alpha e^{-\frac{1}{\lambda}(z-z_0)} + (1 - \alpha) \right)$$



Length-scales & Biogeochemistry

1-North Subtropical Atlantic (22.5°N, 62.5°W)

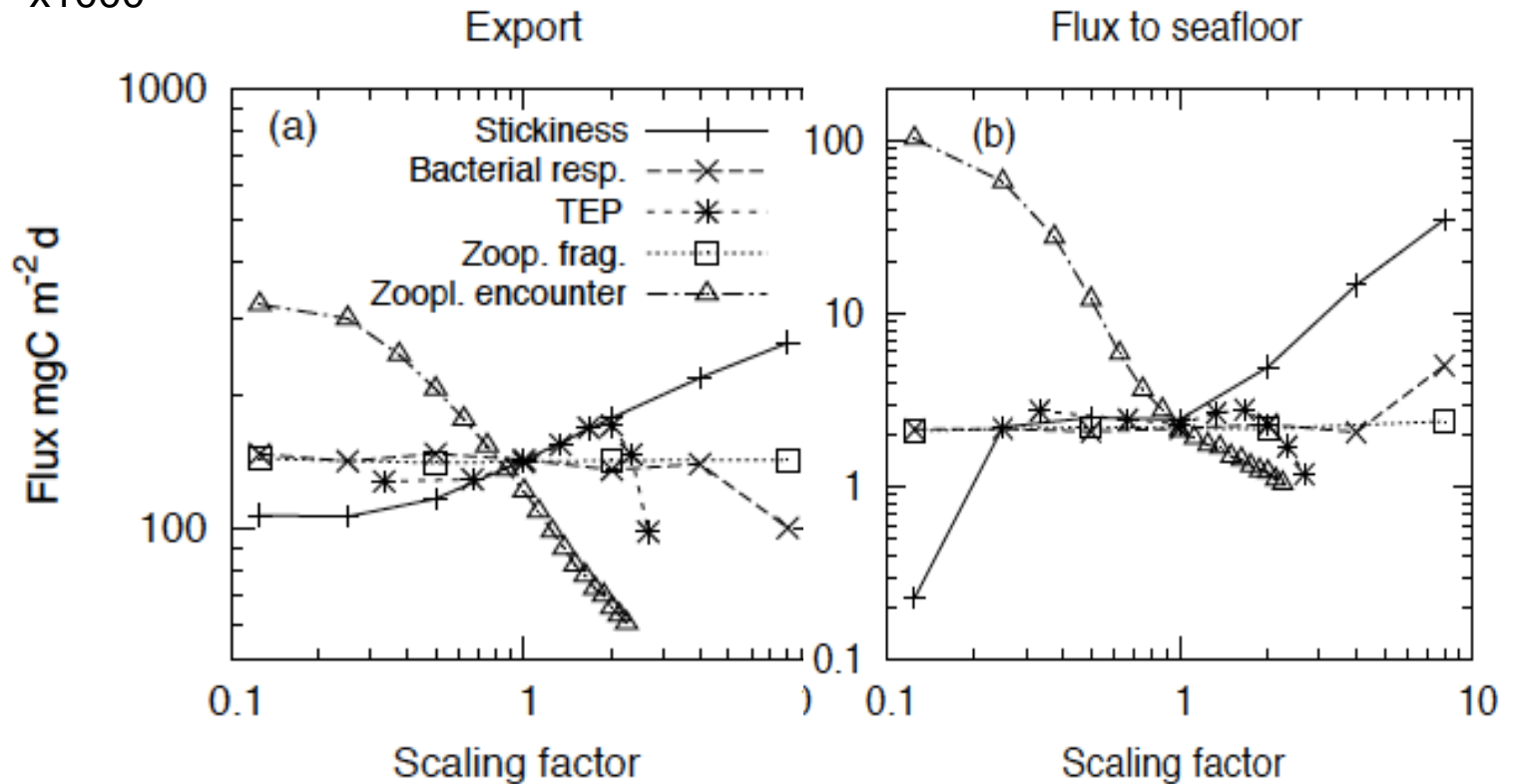
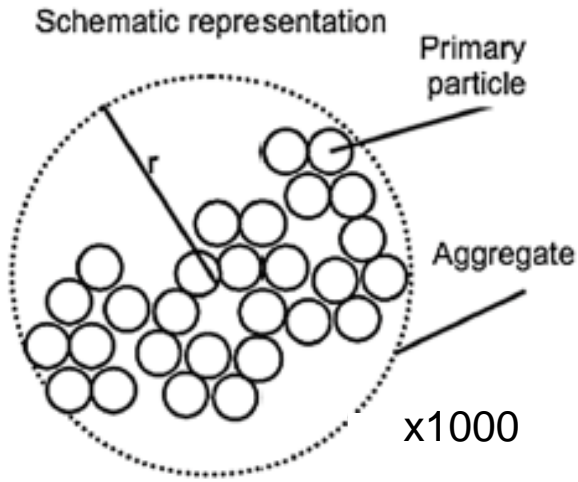


Kwon et al. Nature
Geoscience 2009
see also Marinov et al.
Global Biogeochem. Cycles
2008



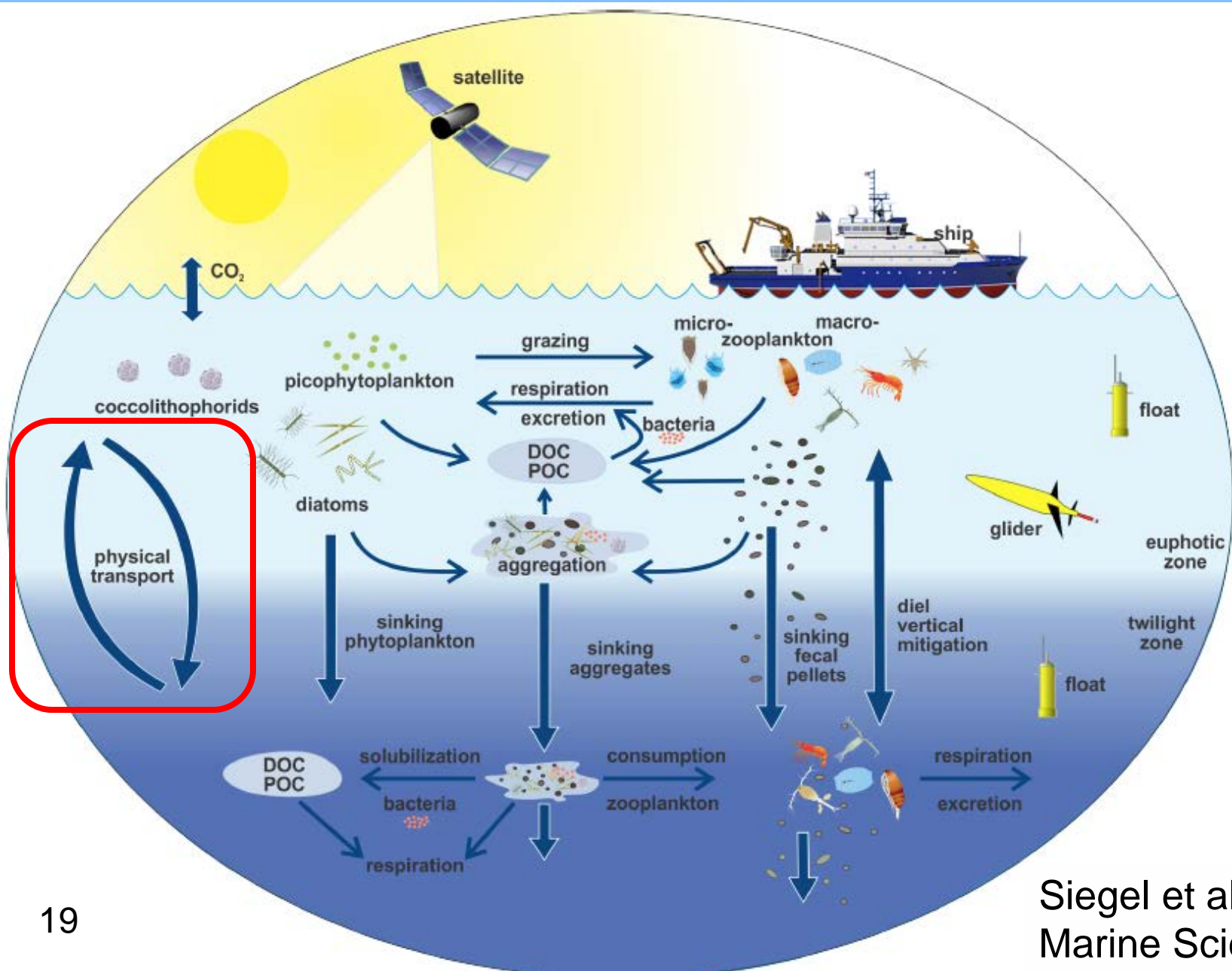
Particle Dynamics Process Models

stochastic, Lagrangian aggregate model of sinking particles



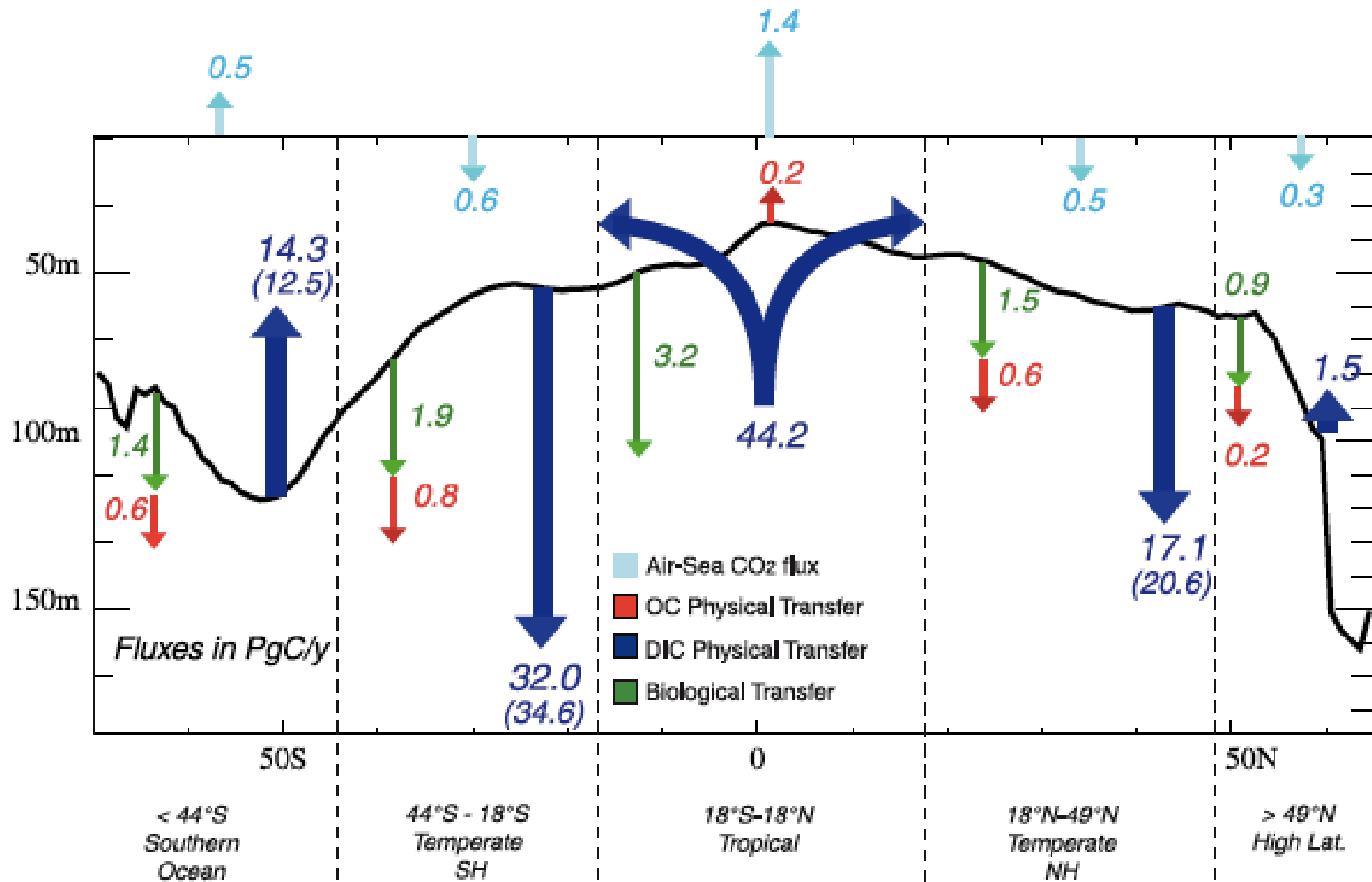
Jokulsdottir & Archer Geosci. Model Dev. 2016
 See also Burd & Jackson Ann. Rev. Mar. Sci. 2009

Physical Transport



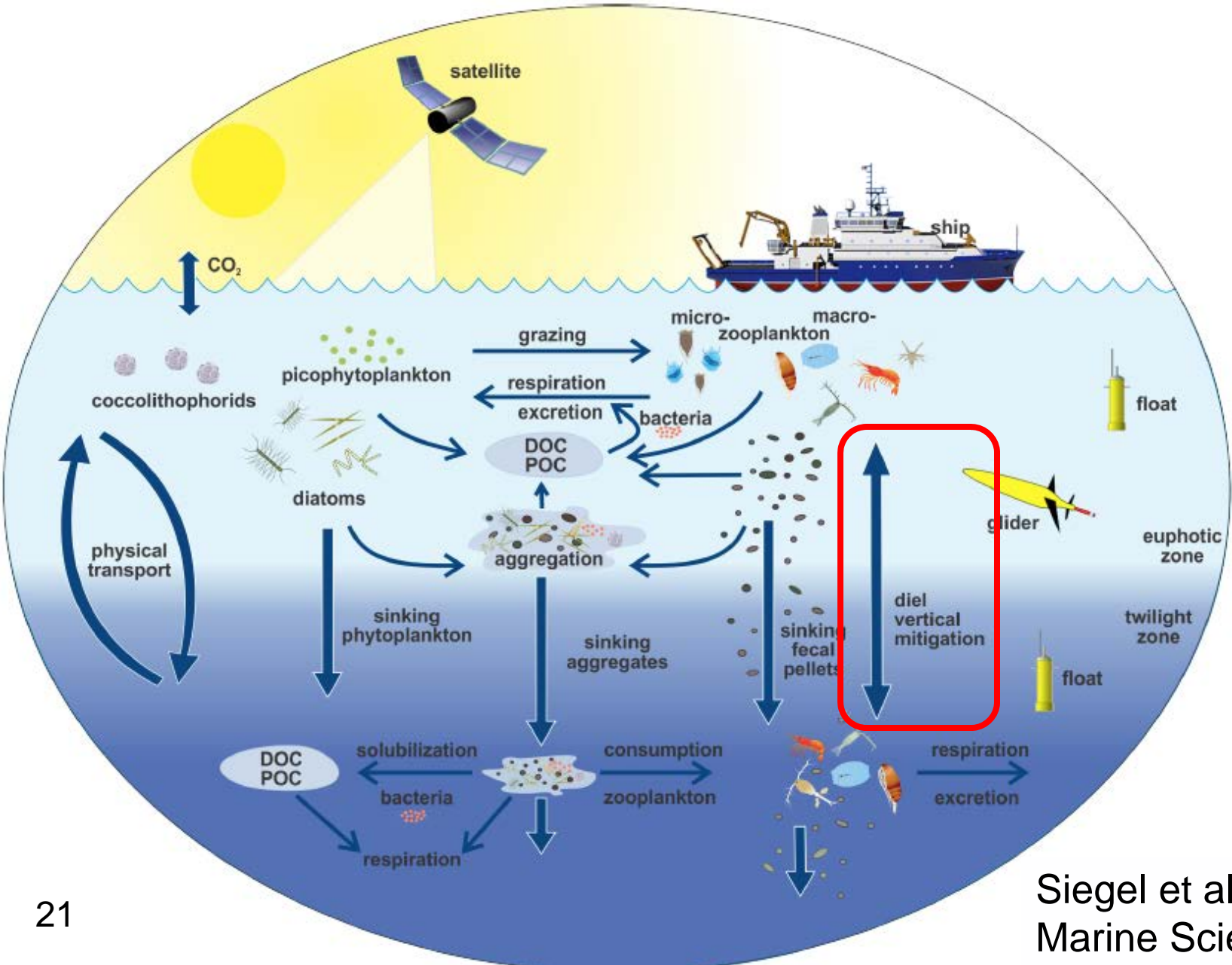
Siegel et al. Frontiers Marine Science 2016

Export from Physical Transport



Levy et al.
Global Biogeochem. Cycles 2013

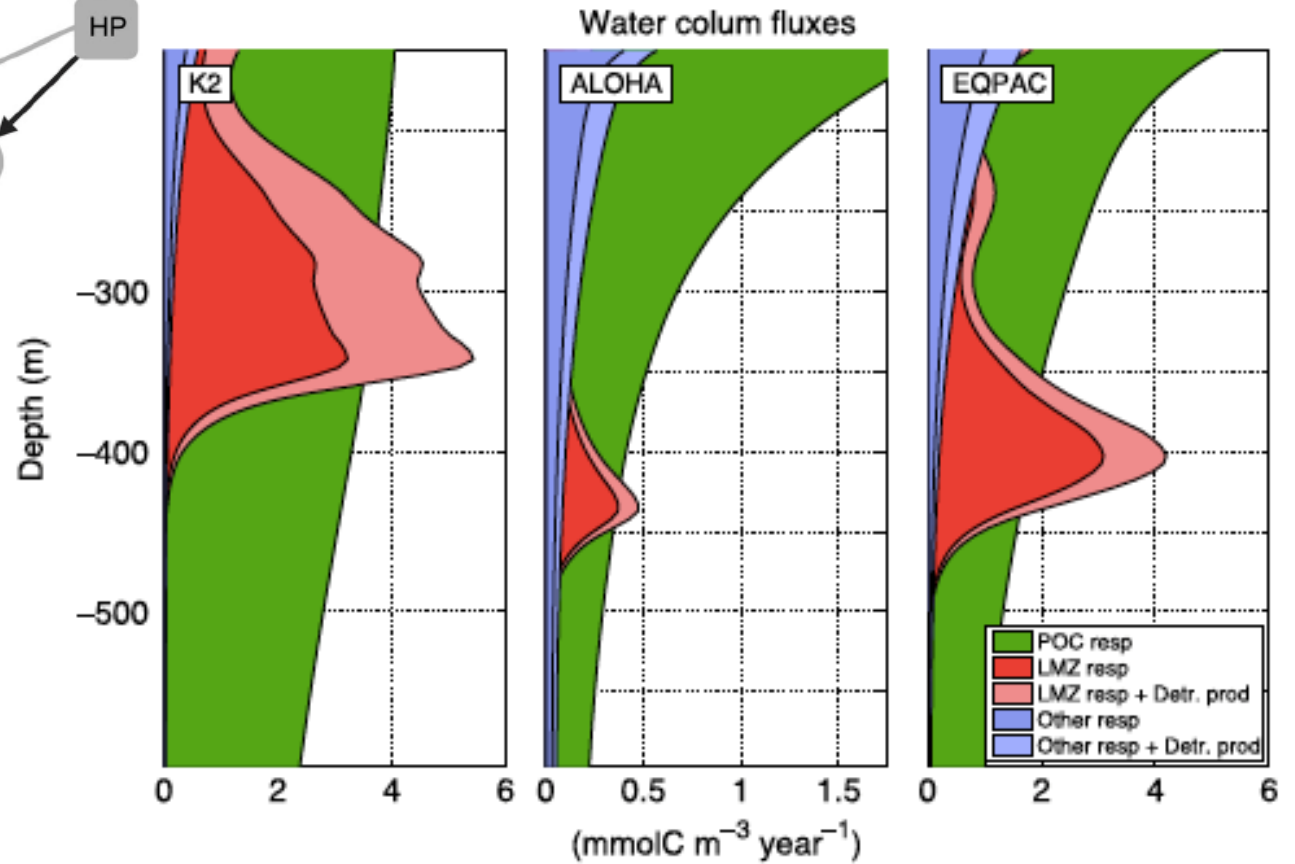
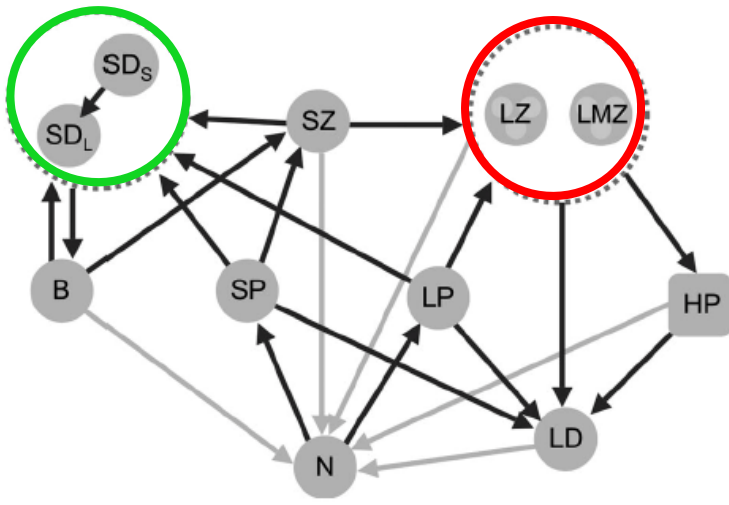
Diel Vertical Migration



Siegel et al. *Frontiers Marine Science* 2016

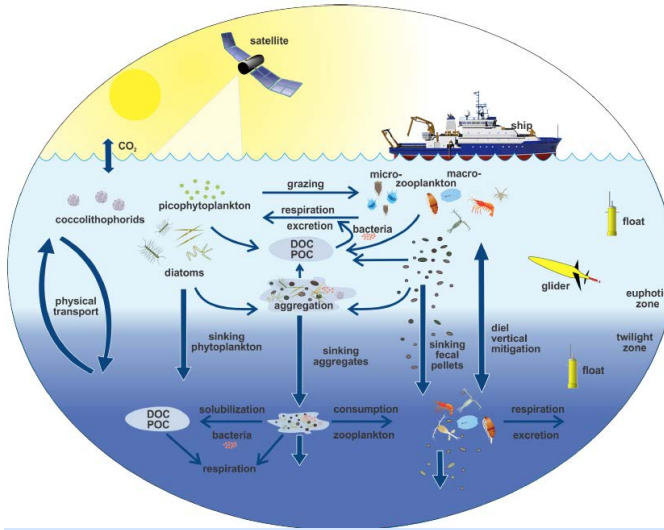
Model of Diel Vertical Migration

Water column fluxes POC respiration Migrators



Bianchi et al. Global Biogeochemical Cycles 2013

Predictability of Fate & Export of Net Primary Production

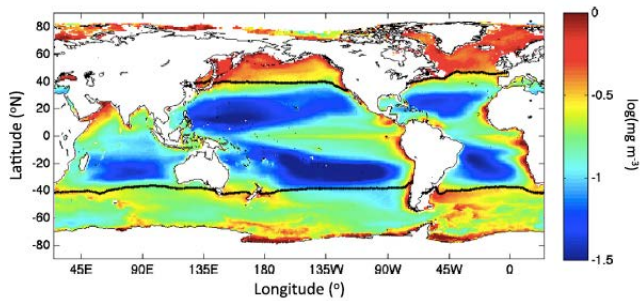


Export flux:

- remote sensing algorithms & diagnostic models
- incorporation of food web & size structure
- large differences in prognostic model patterns, dynamics & climate sensitivity
- some pathways missing in Earth System Models

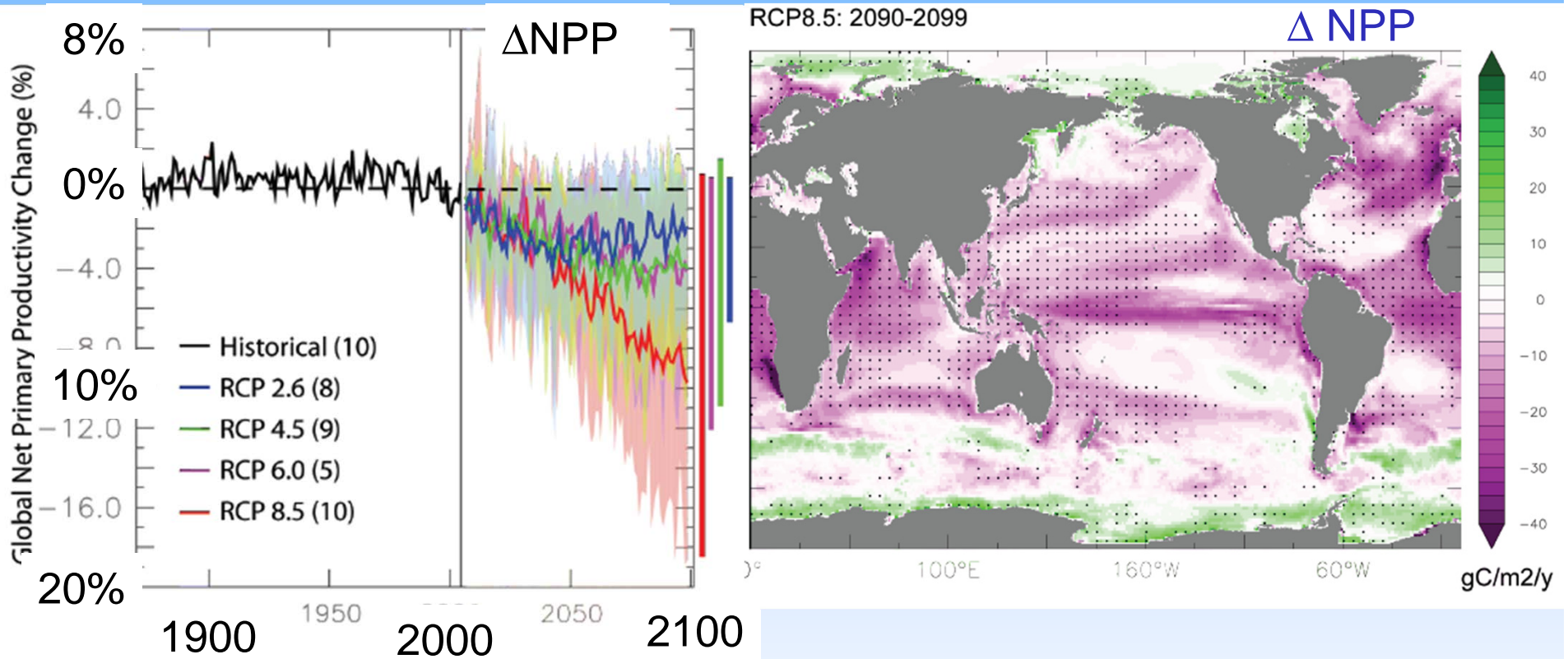
Mesoscale transport & remineralization

- empirical curve fitting used in most diagnostic & prognostic models
- mechanistic process models (particle dynamics and to lesser extent food web)



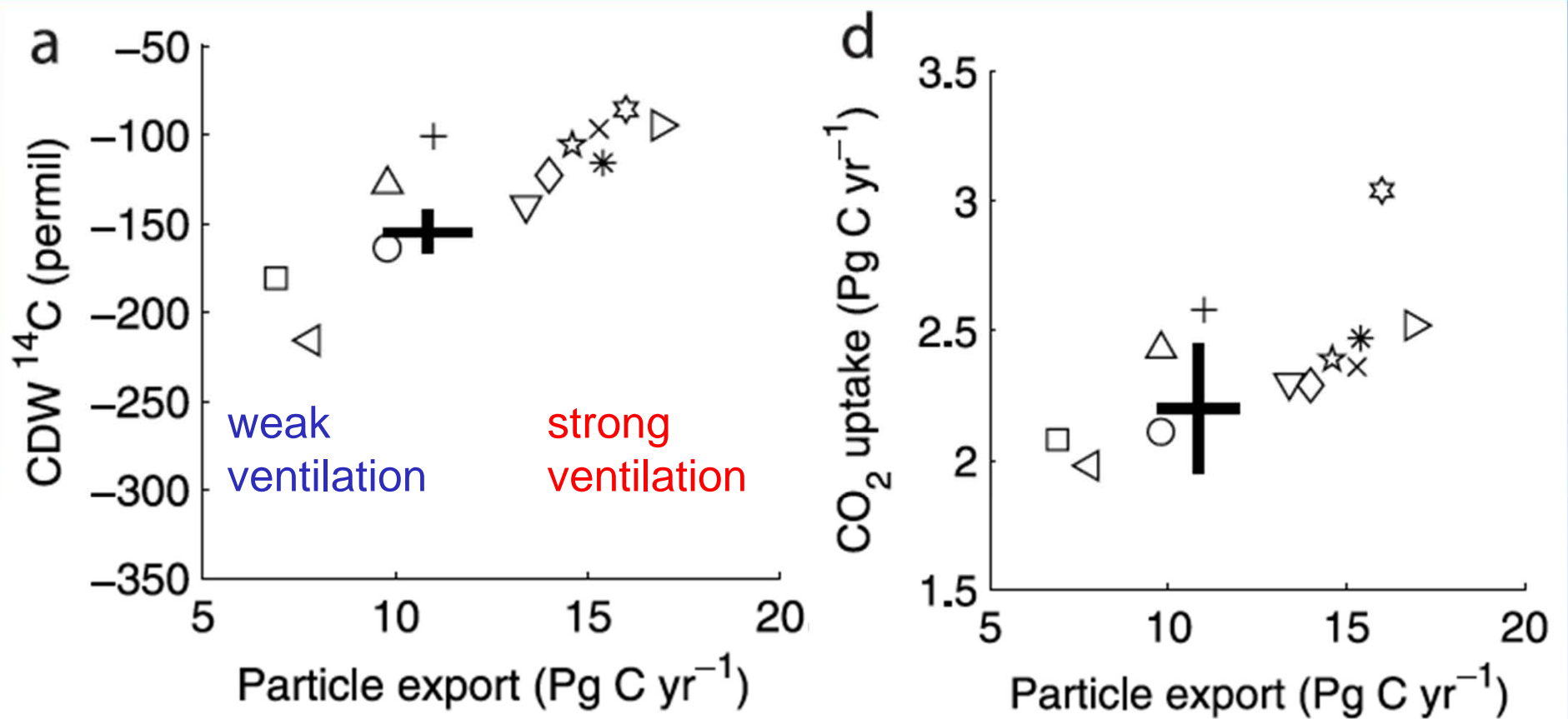
Extra Slides

Net Primary Productivity

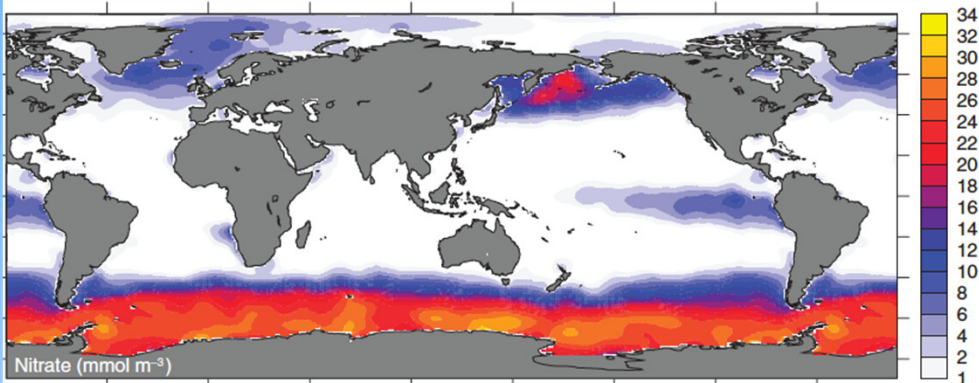


Bopp et al. Biogeosciences 2013

Role of Large-scale Circulation on Productivity

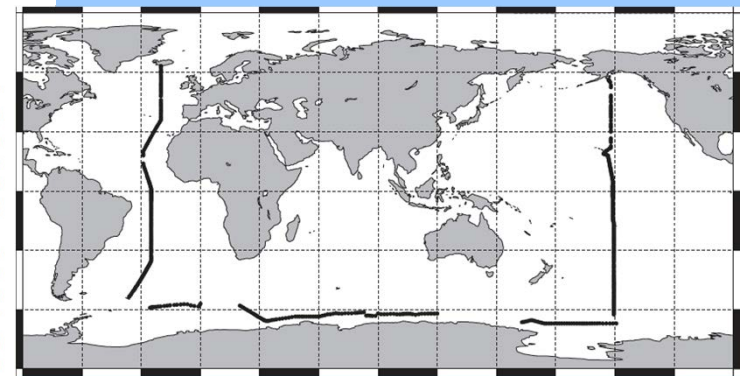


Najjar et al.
Global Biogeochem.
Cycles 2007

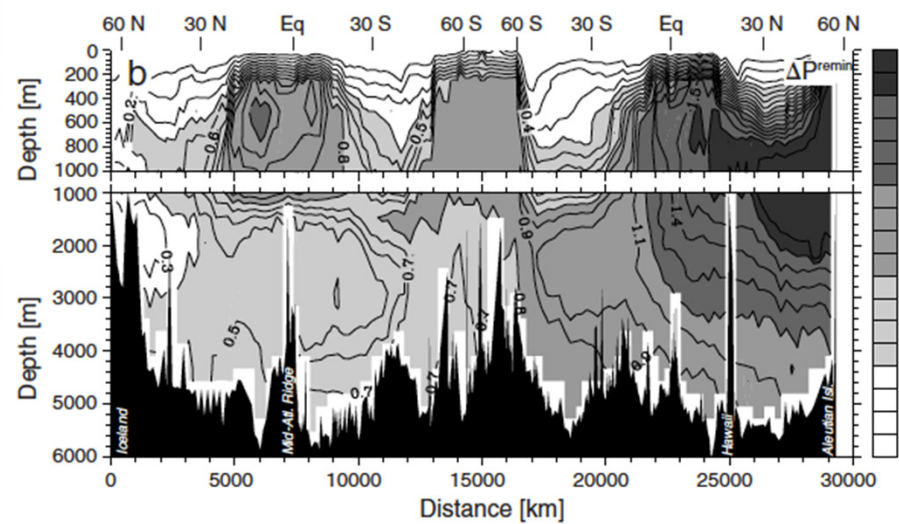
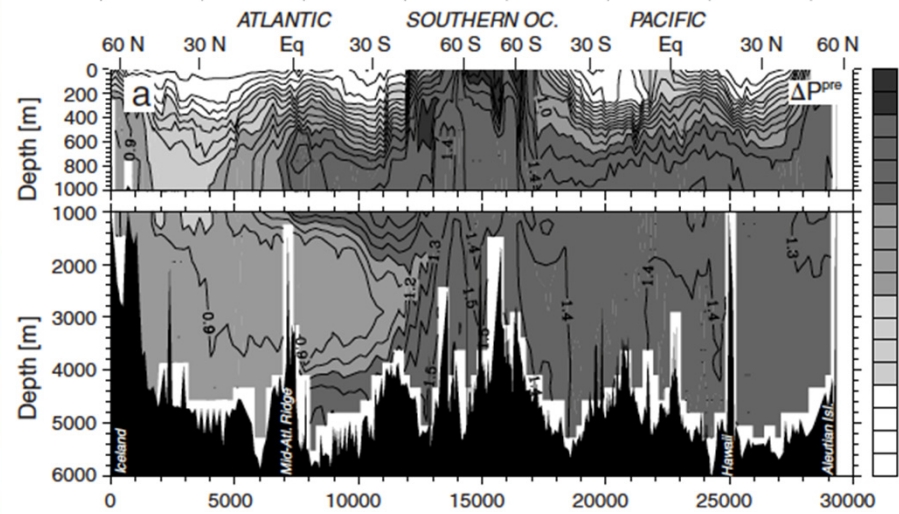


Preformed vs. Remineralized Nutrients

Surface Nitrate



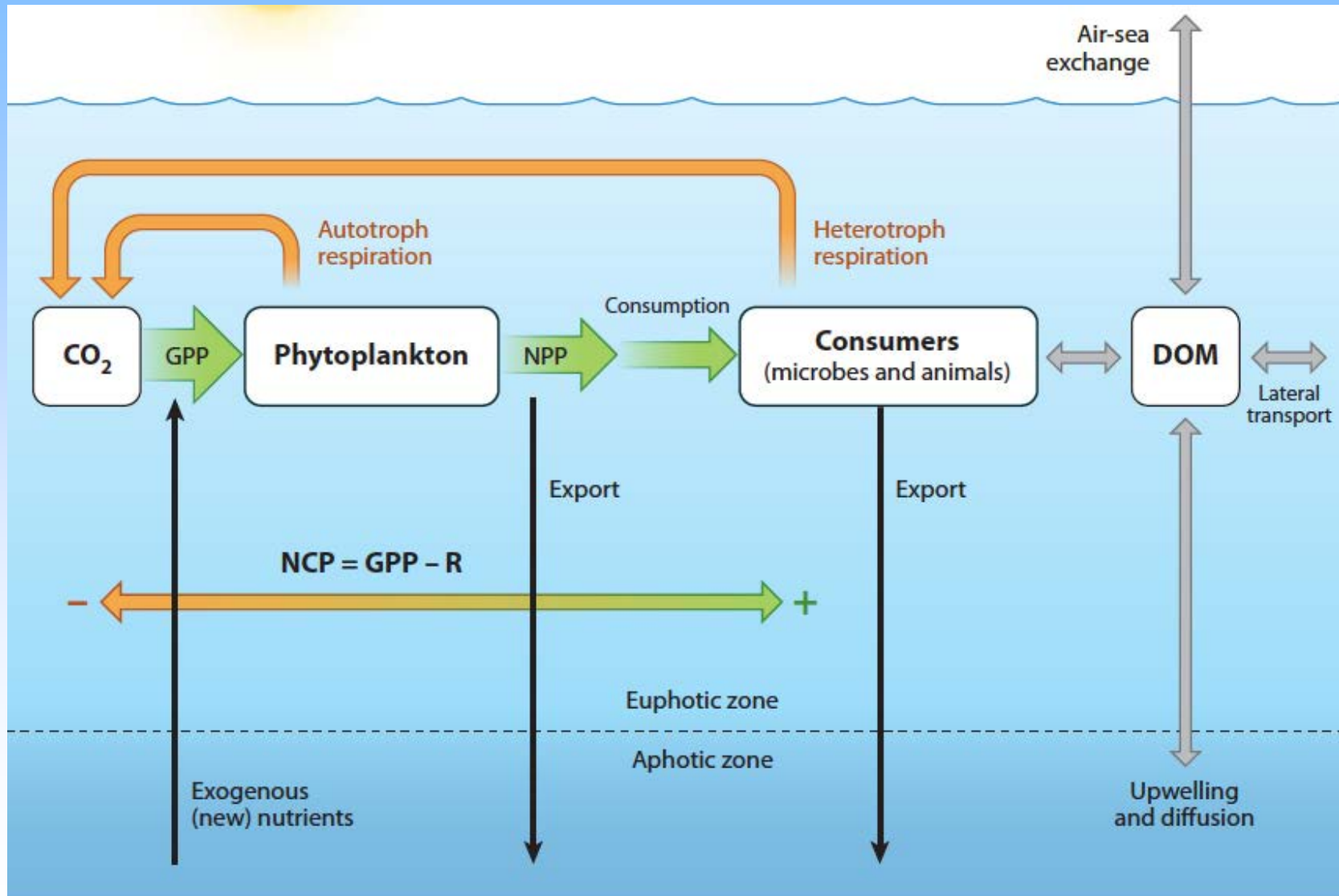
Preformed



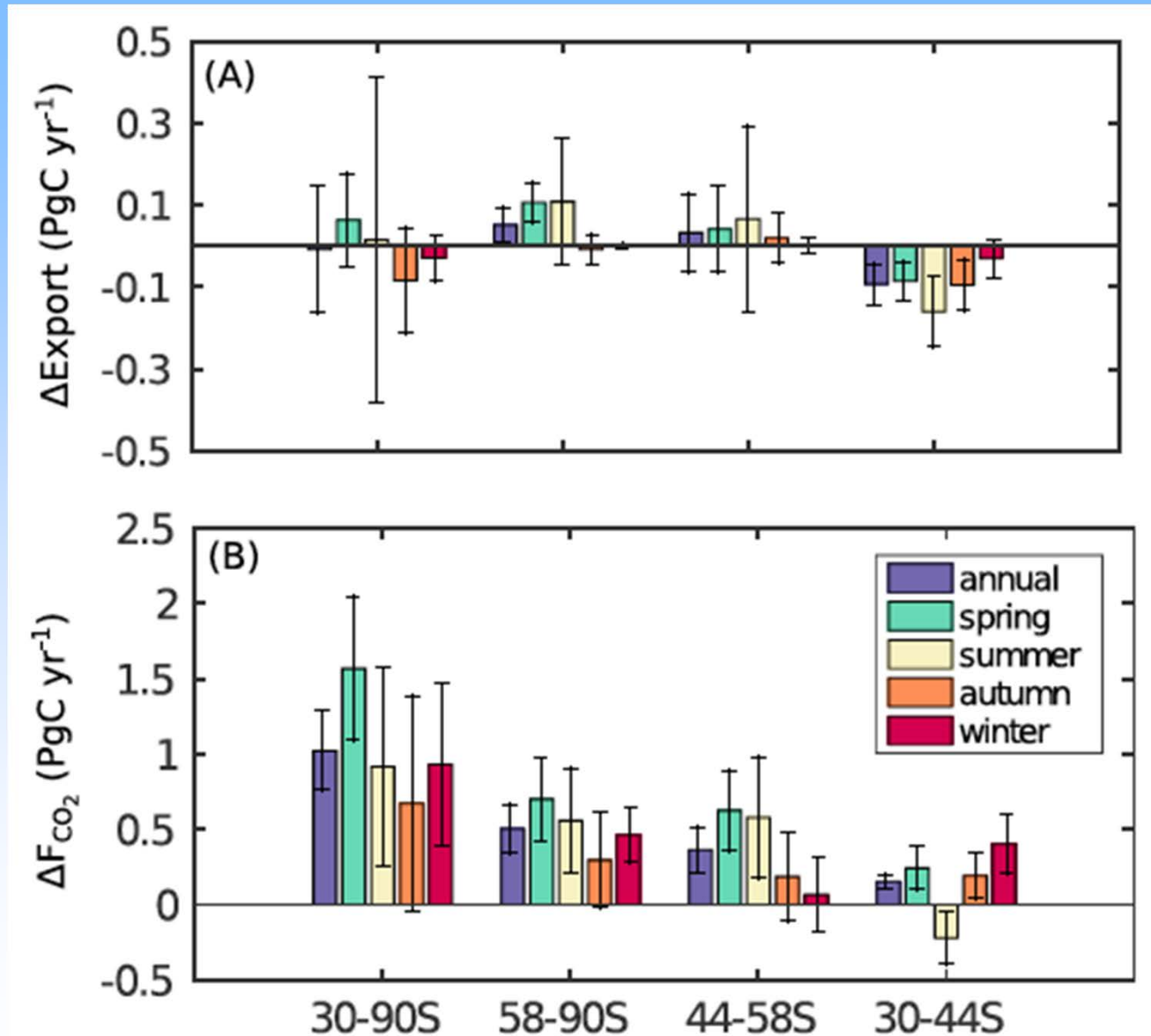
Remineralized

Gruber and Sarmiento
The Sea
2002

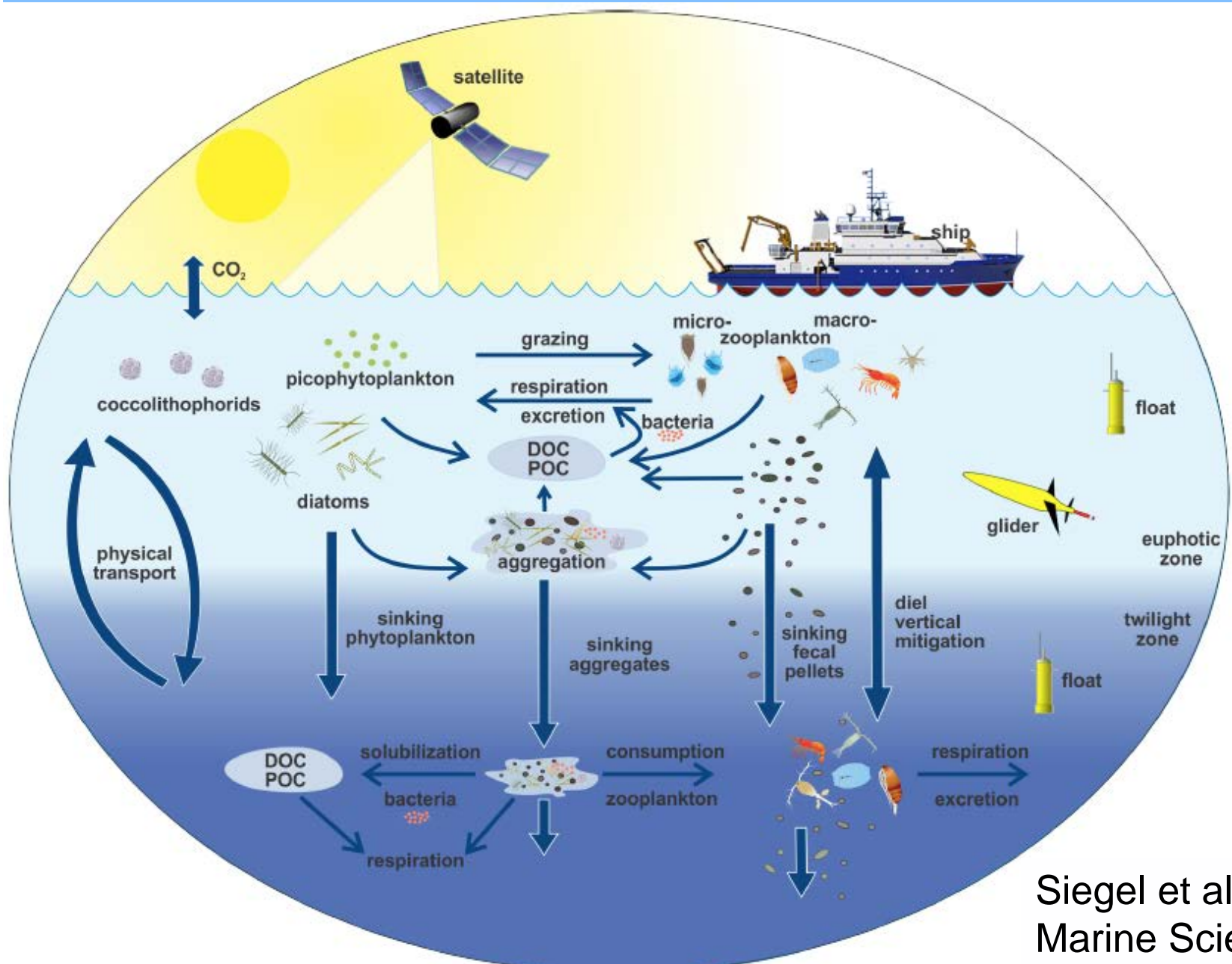
Upper Ocean Productivity Estimates Dependent on Process & Technique



Climate Effects on Ocean Biogeochemistry



Export Pathways



Siegel et al. *Frontiers Marine Science* 2016

