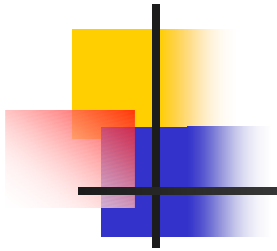

Needs in GHG observations from ocean carbon cycle modeling

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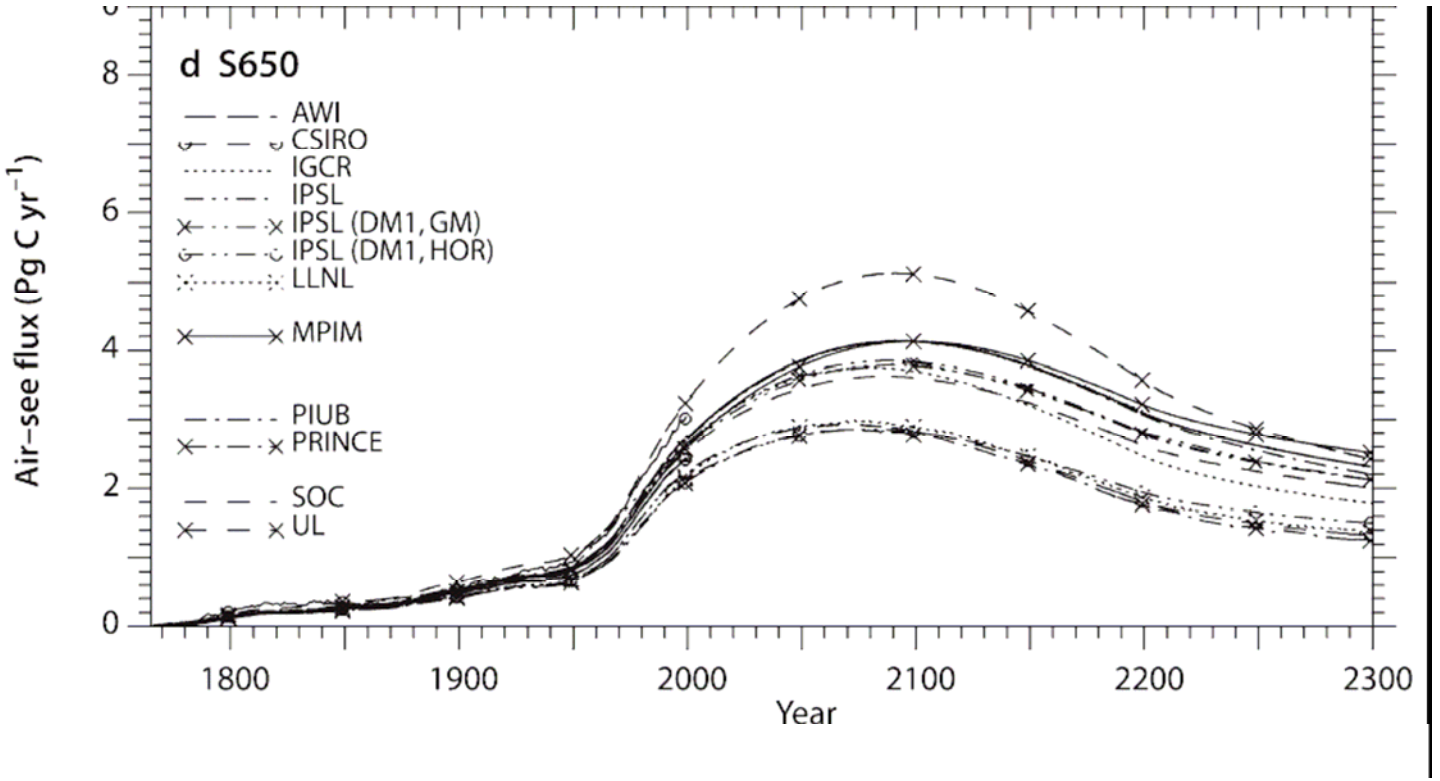
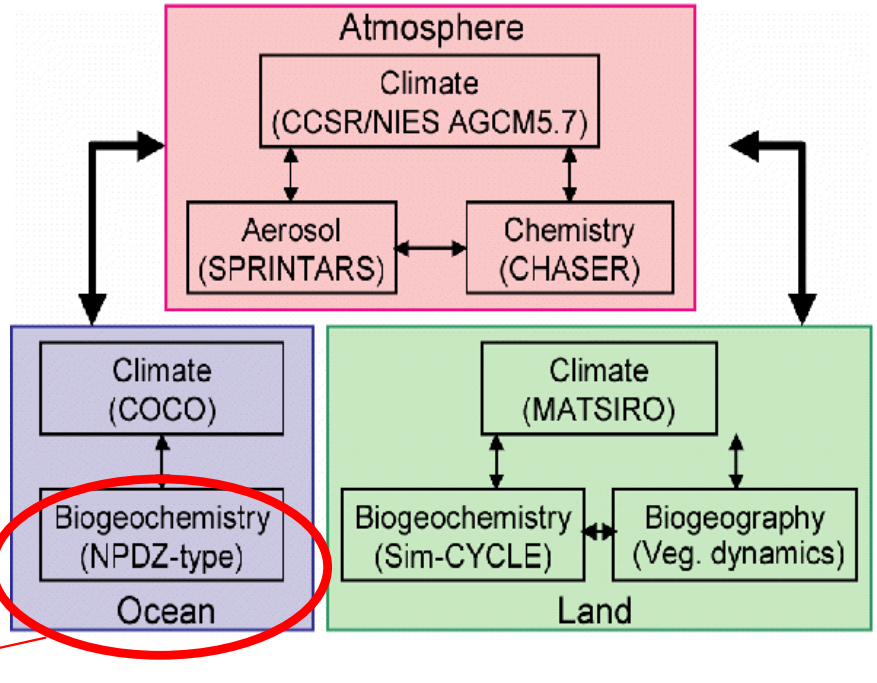
Introduction

An outstanding problem in ocean carbon cycle modeling:
Model-model difference of future CO2 uptake by the ocean



(result from OCMIP, Fasham et al., 2003)

Model structure of the MIROC-based earth system model



Resolution

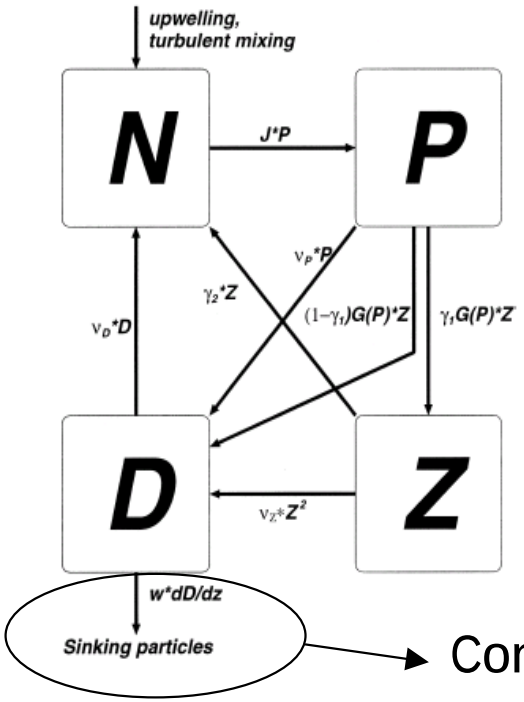
Atm: ~2.8 °

80 levels

(Top: 80km)

Ocean: ~1 °

44 levels

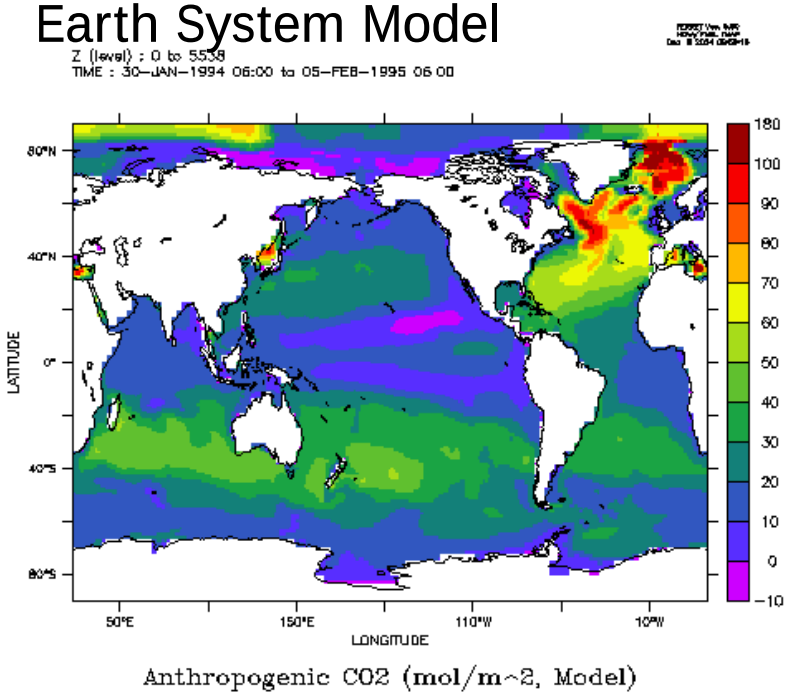


Constant sinking rate + Martin curve

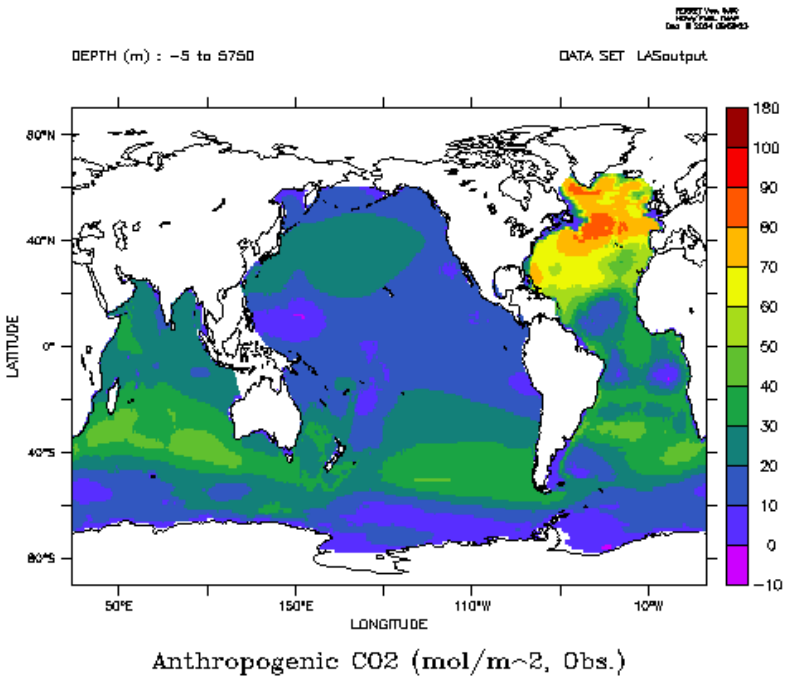
Result from a typical ocean carbon cycle model

Anthropogenic CO2 in the ocean

Result from MIROC-based Earth System Model



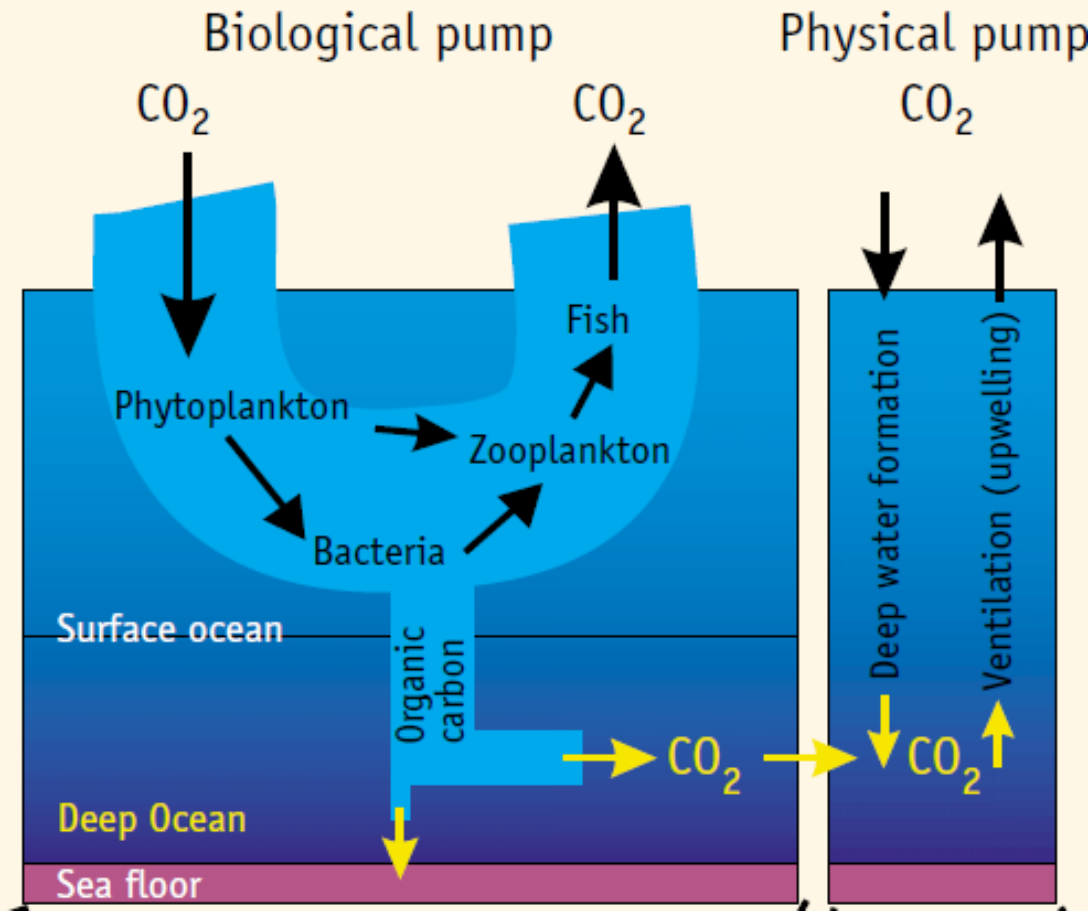
Obs. (Sabine et al, 2004)

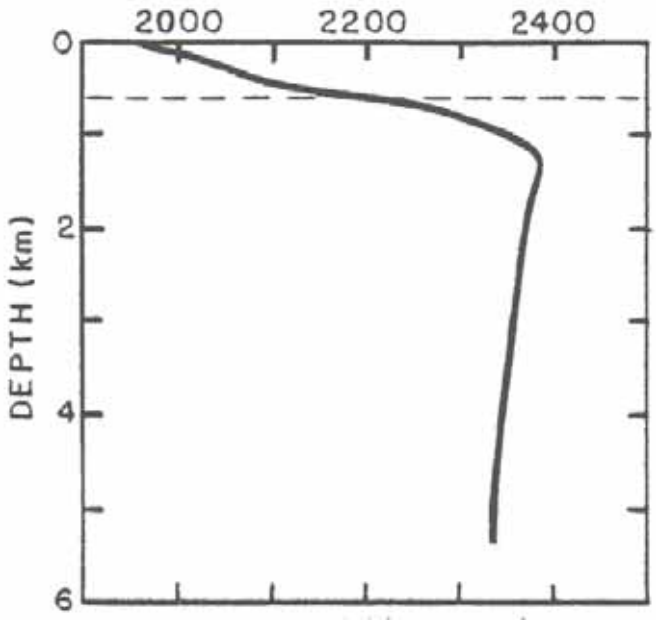


Ocean uptake for 1800-1994 = 98 PgC (Model)
118 ± 19 PgC (Obs.)

(Kawamiya et al., 2006)

Carbon “pumps”

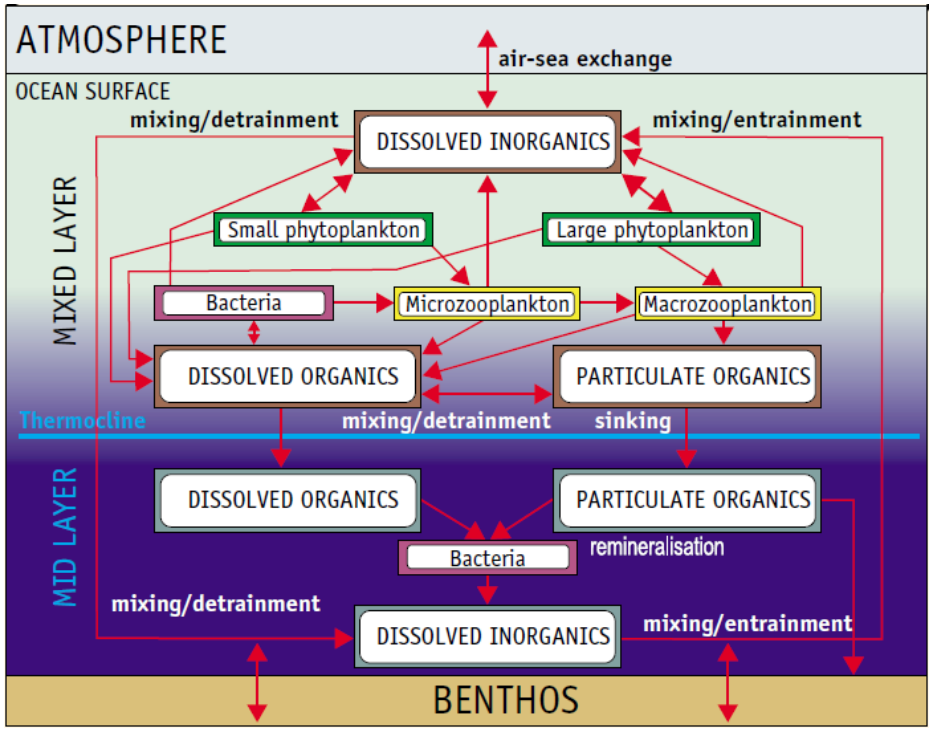




Dissolved inorganic carbon (DIC)
(= $H_2CO_3+HCO_3^-+CO_3^{2-}$)
[mmol/m^3]

Factors regulating the biological pump

- Productivity
- Species composition
  - Size-structure
  - Ballast ($CaCO_3$, SiO_2)
  - Microbial loop
- Particle dynamics
  - Aggregation
  - TEP (transparent exopolymer particles)

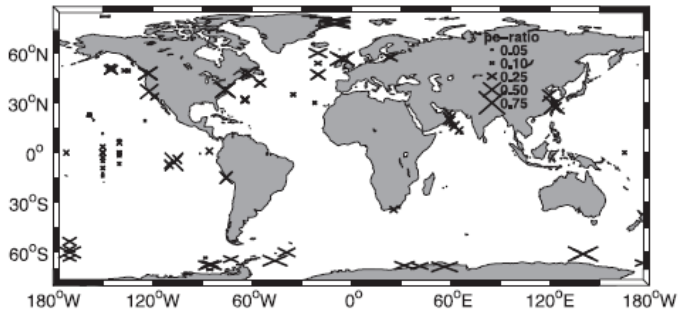


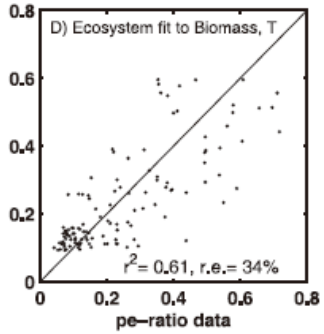
Possible approaches

- Reductionistic approach
  - Understand and model relevant processes as realistically as possible
- “Holistic” approach
  - Treat surface ecosystems as a “gray” box and relate sinking flux with environmental variables

Examples of “holistic” approach (1): Dunne et al. (2005)

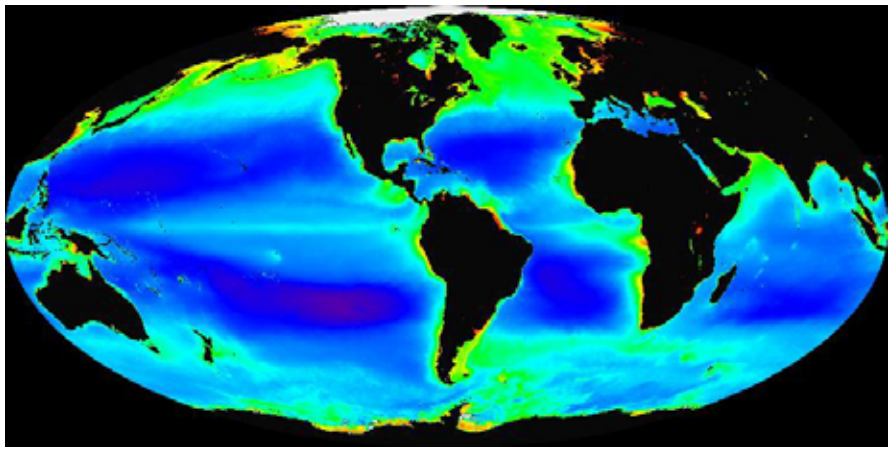
Estimate of sinking flux based on satellite-detected chlorophyll



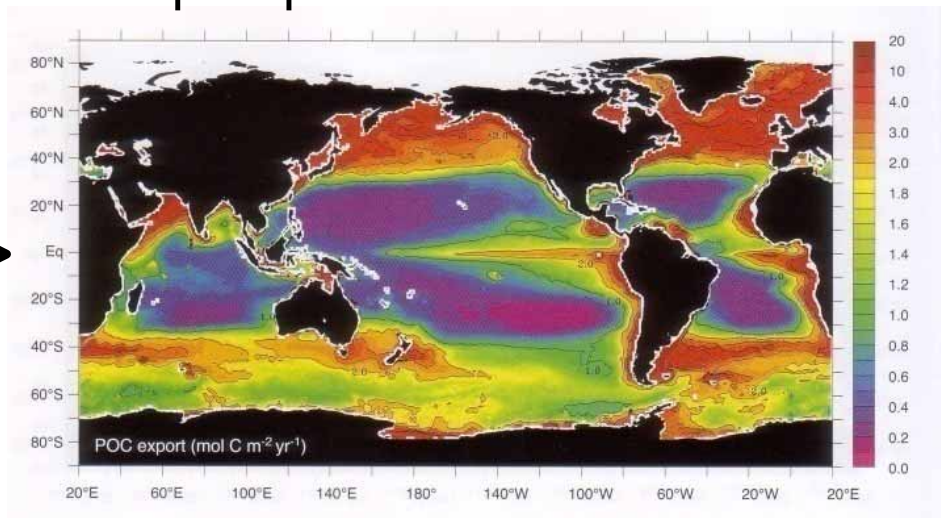


$$pe_r = -0.0081\,^{\circ}C^{-1} \times T + 0.0668 \times \ln(Chl/Z_{eu}) + 0.426$$

Satellite obs. (chl.)

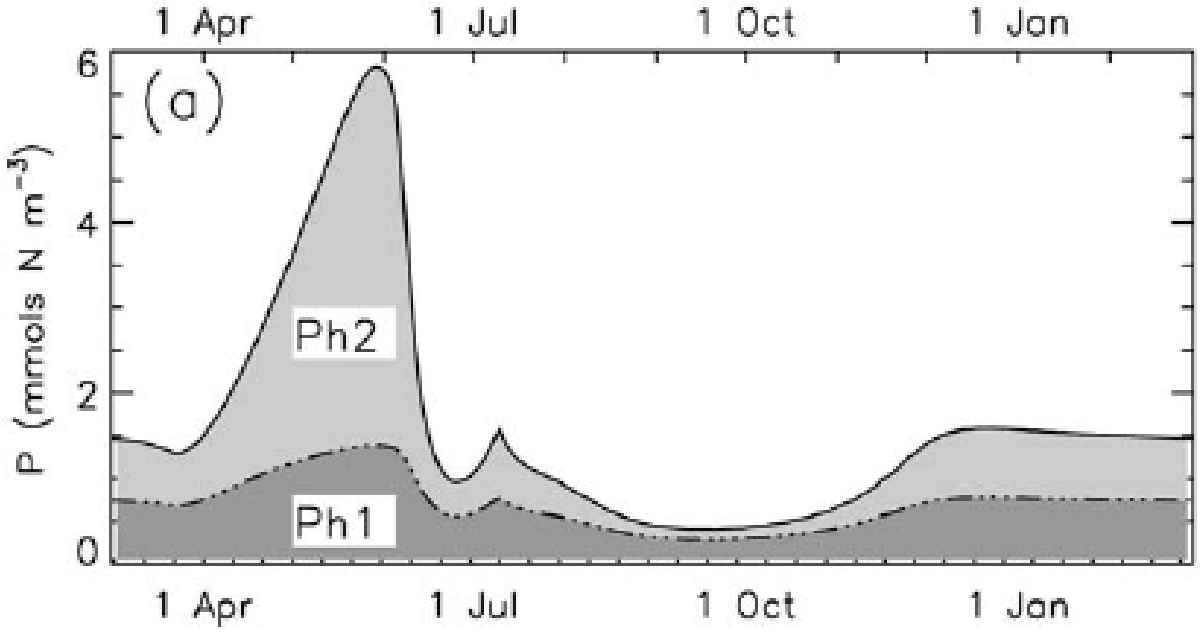


Export production estimate



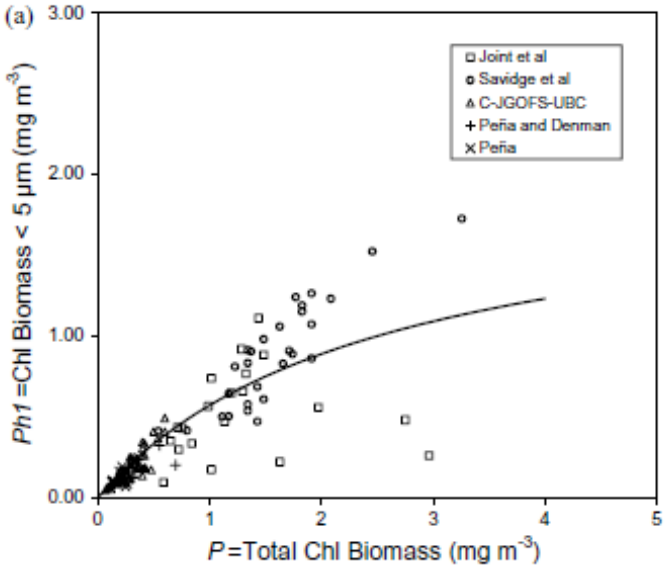
Examples of “holistic” approach (2): Denman and Peña (2002)

Incorporate size-structure keeping simplicity of the model.



$$\frac{dP}{dt} = (\text{growth})P - (\text{grazing})Z - m_{pd}P$$

$$Ph1 = \frac{P_S P}{k_S + P}$$



Small (<5µm) phytoplankton biomass as a function of total biomass

Expectations

- ARGO, TRITON with biogeochemical capability
  - TCO2, Chl, DO, Alk and nutrients as well as temperature and salinity
    - ->Time series of TCO2, DO
    - -> export production, air-sea exchange
- Combination with in-situ (ocean-going) data
  - ^{234}Th, Sediment trap, zooplankton

Other Foci

- Ocean acidification
  - Second rapid acidification in the Western North Pacific, next to the Southern Ocean
- Observations for physical properties
  - Vertical mixing is the key for CO2 uptake
  - Dust supply
- Fisheries oceanography
  - Need explicit representation of community structure?

Caveats (or evasions...)

- Information on detailed community structure is nevertheless invaluable because...
  - empirical laws obtained through the holistic approach may not necessarily hold in the future that we are trying to project ,
  - for some purposes, such as fisheries impact assessment, species composition might have to be explicitly resolved.

Summary

- Significant model-model difference in future oceanic CO2 uptake
- Strategy for sophistication of biological pump modeling:
  - “holistic” approach: relate sinking flux with environmental variables
  - importance of physics cannot be exaggerated.
- Still, need to be aware of biological details