Climate Modeling: Ocean Biology and Biogeochemical Cycles

- How do climate and habitat changes influence productivity and elemental cycles of the global oceans?
- What are the standing stocks, transformation rates and fates of marine organic carbon pools, as well as inorganic particles?
- How do aerosols deposited on ocean surface influence nutrient levels and stressors for ecosystems?
- How do ocean biological processes influence aerosols and cloud distributions?
Current Ocean/Climate Biogeochemistry Models

- Coarse resolution
  - Don't resolve mesoscale/sub-mesoscale
  - Separate open ocean and coastal
- Begin to resolve functional groups of phytoplankton
- Typically ocean only; beginning to couple with climate models
- Data assimilation approaches in development (Chl-a)
- Typically simple RT model (PAR)

Gregg et al. (2003)
Ongoing/future developments

- Computational advances will allow finer-scale resolution of environment & full coupling of climate system components
  - Fine scale physical resolution
    - Resolve sub-mesoscale ocean features globally
    - Simultaneously resolve coastal and open ocean environments
  - Complex, “self-assembling” food web models
  - Fully coupled climate and biogeochemistry models
  - Application of mature data assimilation technologies
Community structure regulates export and biogeochemical function.
Marine ecosystem modeling: Near future...

- Finer resolution of ecosystem structure & function
  - Multiple/many functional groups
  - Size structuring (optical and physiological impacts)
  - Resolving food web (key for export)
  - Explicit, spectral radiative transfer models
  - Suite of limiting nutrients & trace metals
Resolving functional groups of phytoplankton

MODELS

- Modeled total biomass

OBSERVATIONS

- Component functional groups - different biogeochemical function
- Size structure functional groups from Optical Property inversions

MODIS AQUA Chl-a, 2004
Size Structured Models

Structure in observed size distributions

Size dependence of physiological traits and optical properties
Ocean-atmosphere coupling

- Climate-ecosystem-biogeochemistry feedbacks
- Aeolian trace metal & macro-nutrient sources
- DMS – aerosol – clouds – climate
  - microbial physiology?
  - ???

[Diagram showing the interactions between Atmospheric Chemistry/Physics, Climate, Marine Biogeochemistry, Marine Physical Processes, and Marine Biological Systems.]
## Summary

- Marine ecosystem models will increasingly resolve food web structure and interactions
  - Observational resolution of phytoplankton functional types/size structuring from jet-streak to global scale
- Increasing focus on “Earth System” models examining feedbacks in fully coupled system
  - Interdisciplinary modeling approaches and data sets
- Data assimilation for biological & biogeochemical models will mature significantly
  - Remote observations only means to provide sufficient spatial and temporal constraints (c.f. SST, SSH for phys ocean)