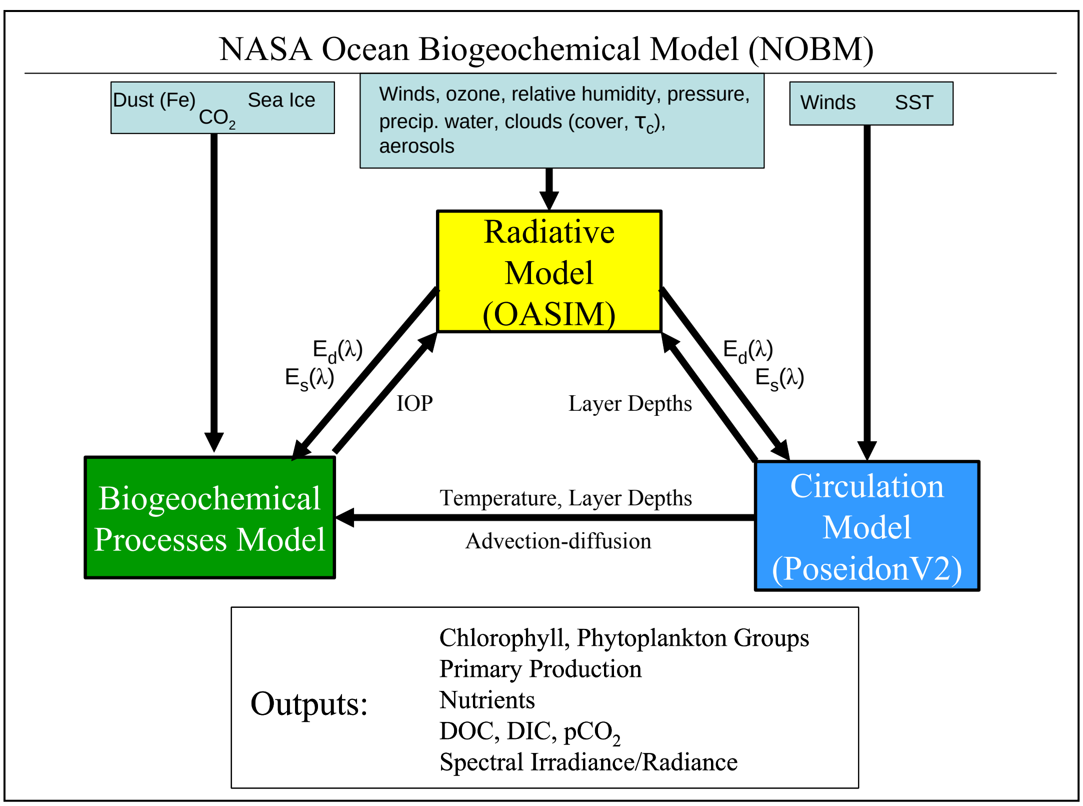
GMAO Ocean Biology and Biogeochemical Modeling

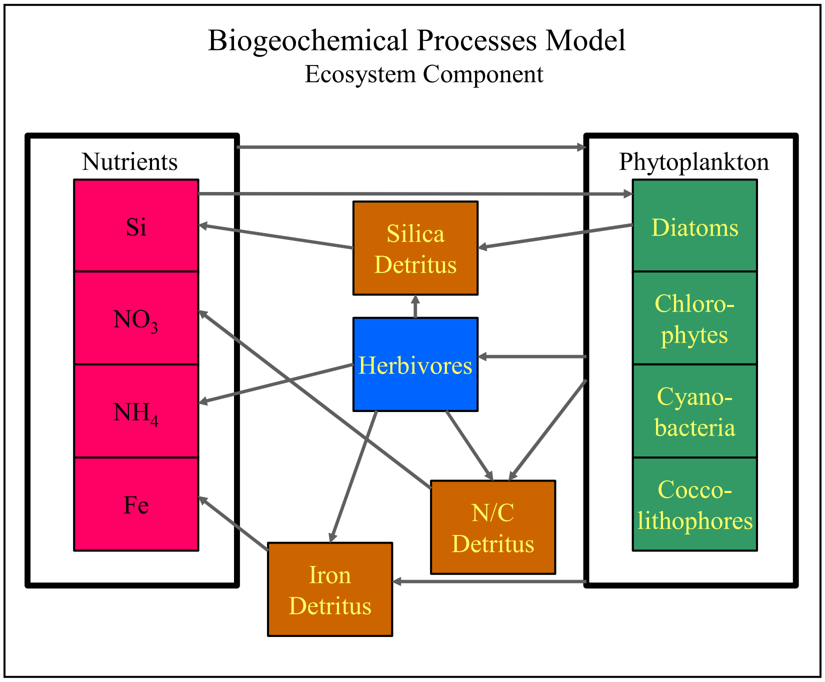
Ocean biology plays important roles in global ecosystems, fisheries, and climate. Ocean biological constituents represent some of the most diverse ecosystems on the planet. The many species astound biological oceanographers at the variety and complexity of phytoplankton and zooplankton communities found in the vast expanses of the Earth's oceans. These communities form the base of the ocean food chain, which eventually determines the abundances and health of fisheries. Phytoplankton uptake carbon dioxide in the process of photosynthesis, and thus play an important role in the global carbon cycle. Although they represent only a minor fraction of the global carbon biomass, their uptake and turnover rates are so high that they represent about half the total primary production of the Earth. The uptake, cycling, and transformations of carbon and nutrients by biological systems is known as biogeochemistry.

It is important on many levels to understand the processes involved in phytoplankton distributions in the oceans, and how they affect and may be affected by climate. Including them in global coupled modeling efforts is an emerging field, and it is not yet understood how important they are in climate simulation and prediction.

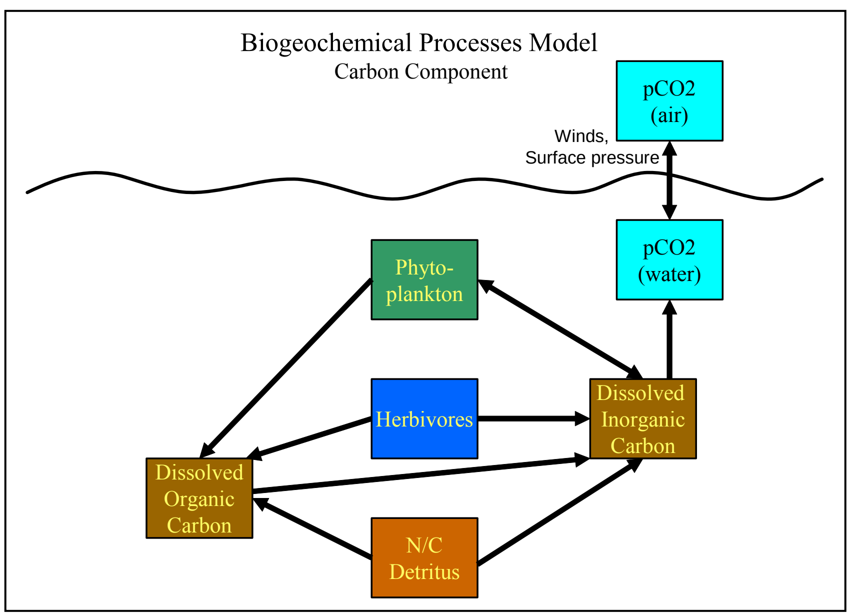


GMAO is a leader in the effort to include ocean biological and biogeochemical processes in coupled models. The NASA Ocean Biogeochemical Model (NOBM) was built by GMAO personnel and is in the process of being coupled to the complex and interactive GEOS-5 climate systems. As currently configured, NOBM is coupled with the GMAO's Poseidon ocean general circulation model, which requires external forcing fields to run.

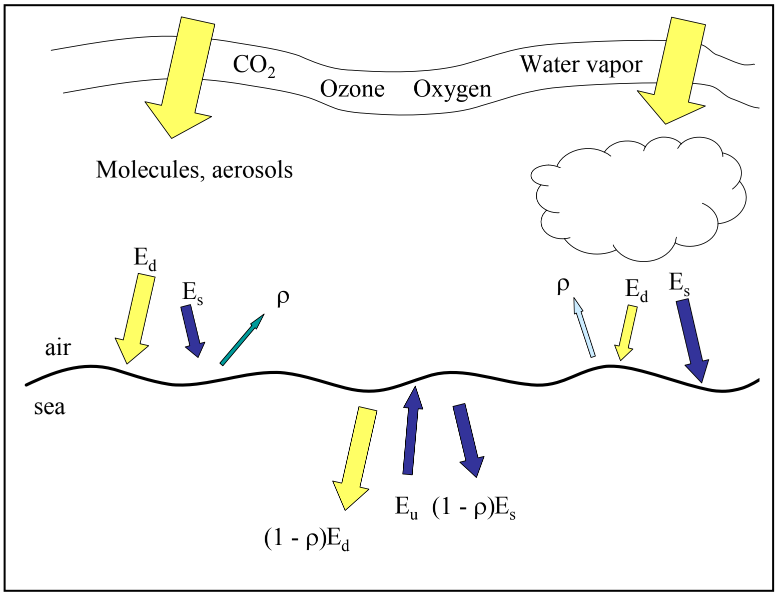
NOBM is a fully coupled general circulation/biogeochemical/radiative model of the global oceans. The Ocean General Circulation Model (OGCM) is a reduced gravity representation of circulation fields (Schopf and Loughe, 1995). It is global in scale, extending from near the South Pole to 72° N, in increments of 2/3° latitude and 1 1/4° longitude, comprising all regions where bottom depth > 200m. The model contains 14 vertical layers, in quasi-isopycnal coordinates, and is driven by wind stress, sea surface temperature, and shortwave radiation.



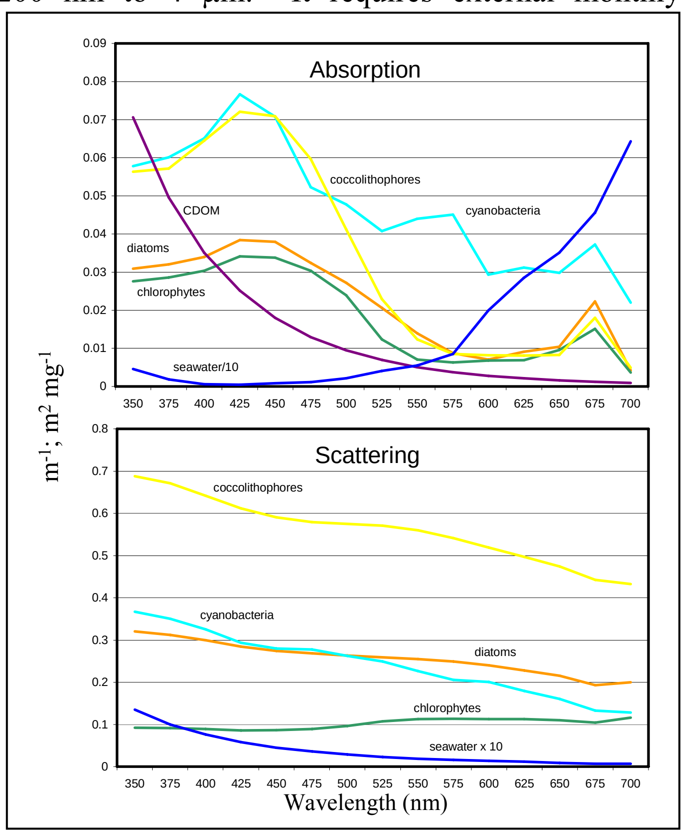
The biogeochemical processes model contains 4 phytoplankton groups, 4 nutrient groups, a single herbivore group, and 3 detrital pools. The phytoplankton groups differ in maximum growth rates, sinking rates, nutrient requirements, and optical properties. The 4 nutrients are nitrate, regenerated ammonium, silica to regulate diatom growth, and iron. Three detrital pools provide for storage of organic material, sinking, and eventual remineralization back to usable nutrients. Atmospheric deposition of iron and sea ice are required as external forcing fields. Carbon cycling involves dissolved organic carbon (DOC) and dissolved inorganic carbon (DIC). DOC has sources from phyto-plankton, herbivores, and carbon detritus, and a sink to DIC. DIC has sources from phytoplankton, herbivores, carbon detritus, and DOC, and



communicates with the atmosphere, which can be either a source or sink. The ecosystem sink for DIC is phytoplankton, through photosynthesis.



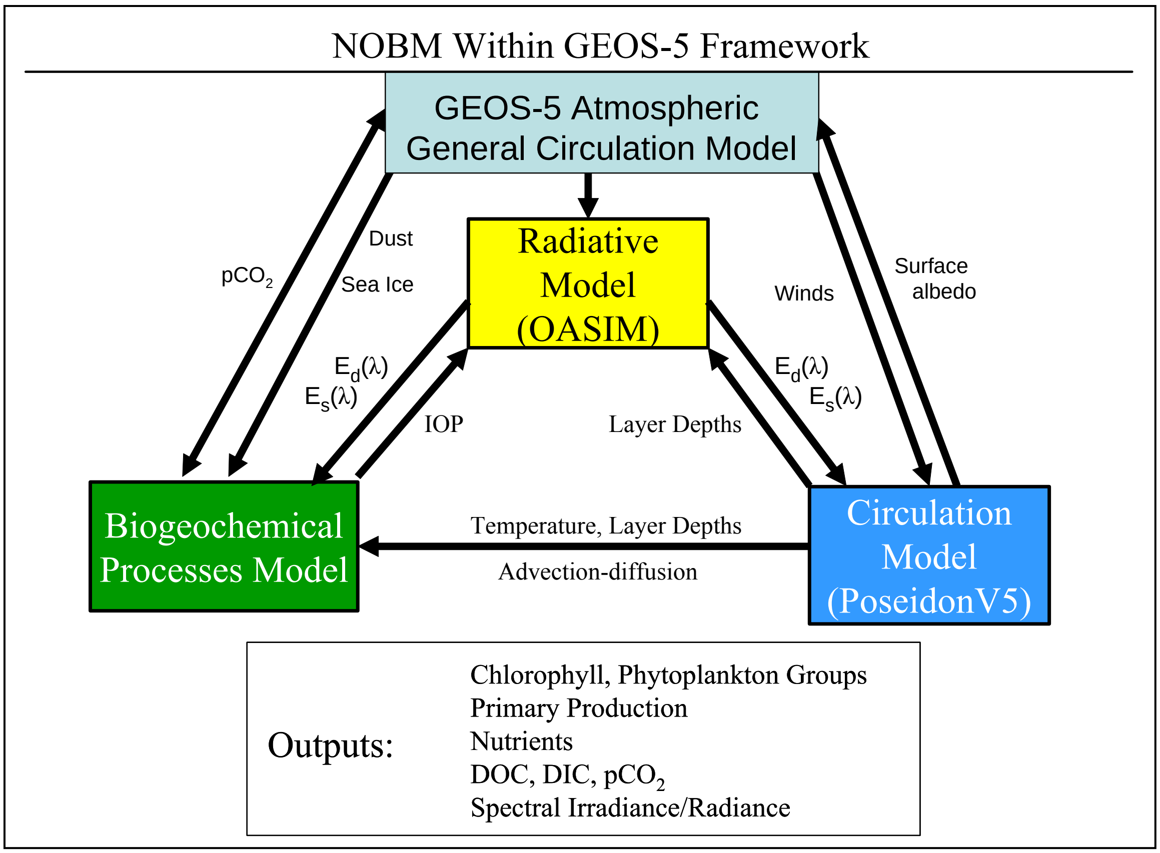
Radiative transfer calculations provide the underwater irradiance fields necessary to drive growth of the phytoplankton groups, and interact with the heat budget. The Ocean-Atmosphere Radiative Model (OARM; Gregg, 2002a) contains a treatment of the spectral and directional properties of radiative transfer in the oceans, and explicitly accounts for clouds. The atmospheric radiative model is based on the Gregg and Carder (1990) spectral model, extended to the spectral regions 200 nm to 4 μm. It requires external monthly climatologies of cloud properties (cloud cover and liquid water path), surface pressure, wind speeds, relative humidity, precipitable water, and ozone. Aerosols are considered to be strictly of marine origin and are computed as in Gregg and Carder (1990).



Oceanic radiative properties are driven by water absorption and scattering, the optical properties of the phytoplankton groups, and chromophoric dissolved organic matter (CDOM). Three irradiance paths are enabled: a downwelling direct path, a downwelling diffuse (scattered) path, and an upwelling diffuse path. All oceanic radiative calculations include the spectral nature of the irradiance.

NOBM has been used to track the interannual variability of chlorophyll as observed by ocean color satellites (Gregg, 2002b), understand distribution of phytoplankton groups and dissolved iron n the global oceans (Gregg et al., 2003), and compared against algorithms and other models for estimating primary production (Carr et al., 2006). Currently, ocean chlorophyll data from SeaWiFS and Aqua is routinely assimilated by NOBM (Gregg, 2006).

NOBM is currently being re-designed for coupling with atmospheric models in the GEOS-5 configuration at GMAO. In this design, forcing data fields will be replaced by outputs from the GEOS-5 Atmospheric General Circulation Model, and a new full-ocean version of the OGCM Poseidon V5. Exchanges of carbon and heat among the model components will enable a more realistic Earth System model.



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