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The Chlorophyll-Albedo feedback in the NASA-GISS climate model

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Climate variability and Climate Change affect life on Earth in many different ways and especially ocean phytoplankton which is the basis of nearly all ocean life.

Here we investigate the changes in ocean phytoplankton population structure in a changing environment using the Goddard Institute for Space Studies (GISS) climate models and the NASA Biogeochemical Ocean Model (NBOM, Gregg et al, ???). Simulations span the interannual through decadal to century time scales and global ocean coverage. The NASA-Goddard Institute for Space Studies (GISS) climate model is an improvement to the IPCC-AR4 GISS3 model (Schmidt et al, 2006; Hansen et al, 2007) with higher resolution both in the atmosphere and the ocean (2x2.5degs) and better representation of lake and ice dynamics. Gas exchange of CO2 is completely interactive following where needed the OCMIP-II protocol. The coupling is synchronous every half an hour and is carried out for constant atmospheric CO2 concentrations and pre-industrial atmosphere conditions. The NASA Biogeochemical Ocean Model (NBOM, Gregg and Casey, 2007) contains 4 phytoplankton groups (diatoms, chlorophytes, cyanobacteria, and coccolithophores), which differ in maximum growth rates, sinking rates, nutrient requirements, and optical properties to help represent the extreme variety of physical and biological environments encountered in a global model. Four nutrients are included. Nitrogen limitation involves "new" use represented by nitrate and regenerated use represented by ammonium. Silica is also included to regulate diatom growth, and iron as an important micro-nutrient in some oceanographic basins. Surface iron fluxes are derived from the NASA Goddard Chemistry Aerosol Radiation and Transport (GOCART) soil dust model (Ginoux et al., 2001). Phytoplankton are ingested by a separate herbivore component, which also contributes to the ammonium field through excretion. Three detrital components provide for storage of organic material, sinking, and eventual remineralization back to usable nutrients. A carbon model represents the cycling of carbon through the phytoplankton, herbivore, detrital components, affecting the inorganic carbon in the ocean and interacting with the atmosphere.

Radiative transfer calculations provide the underwater irradiance fields necessary to drive growth of the phytoplankton groups, and interact with the heat budget. 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. Optical properties of phytoplankton groups were derived from laboratory studies.

Changes in the surface chlorophyll concentrations lead to differential absorption of incident solar radiation thereby changing the Earth's surface albedo and cloud properties which in turn affect the amount of solar radiation and surface heating occurs that controls biological activity in the ocean. The magnitude of the effect is assessed through comparison to a run without chlorophyll and a second with constant climatological SeaWIFs based concentrations. Results show that although the magnitude of the effect is small, the regional patterns alter significantly the biodiversity in each region.