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TITLE: Representing key phytoplankton functional groups in ocean carbon cycle models: Coccolithophorids

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ABSTRACT:

Carbonates are the largest reservoirs of carbon on Earth. From mid?Mesozoic time, the biologically catalyzed precipitation of calcium carbonates by pelagic phytoplankton has been primarily due to the production of calcite by coccolithophorids. In this paper we address the physical and chemical processes that select for coccolithophorid blooms detected in Sea?viewing Wide Field?of?view Sensor (SeaWiFS) ocean color imagery. Our primary goal is to develop both diagnostic and prognostic models that represent the spatial and temporal dynamics of coccolithophorid blooms in order to improve our knowledge of the role of these organisms in mediating fluxes of carbon between the ocean, the atmosphere, and the lithosphere. On the basis of monthly composite images of classified coccolithophorid blooms and global climatological maps of physical variables and nutrient fields, we developed a probability density function that accounts for the physical chemical variables that predict the spatiotemporal distribution of coccolithophorids in the world oceans. Our analysis revealed that areas with sea surface temperatures (SST) between 3° and 15°C, a critical irradiance between 25 and 150 ?mol quanta m ?2 s ?1 , and decreasing nitrate concentrations (?N/?t < 0) are selective for upper ocean large?scale coccolithophorid blooms. While these conditions favor both Northern and Southern Hemisphere blooms of the most abundant coccolithophorid in the modern oceans, Emiliania huxleyi , the Northern and Southern Hemisphere populations of this organism are genetically distinct. Applying amplified fragment length polymorphism as a marker of genetic diversity, we identified two major taxonomic clades of E. huxleyi ; one is associated with the Northern Hemisphere blooms, while the other is found in the Southern Hemisphere. We suggest a rule of ?universal distribution and local selection?: that is, coccolithophorids can be considered cosmopolitan taxa, but their genetic plasticity provides physiological accommodation to local environmental selection pressure. Sea surface temperature, critical irradiance, and ?N/?t were predicted for the years 2060?2070 using the NCAR Community Climate System Model to generate future monthly probability distributions of coccolithophorids based upon the relationships observed between the environmental variables and coccolithophorid blooms in modern oceans. Our projected probability distribution analysis suggests that in the North Atlantic, the largest habitat for coccolithophorids on Earth, the areal extent of blooms will decrease by up to 50% by the middle of this century. We discuss how the magnitude of carbon fluxes may be affected by the evolutionary success of coccolithophorids in future climate scenarios.

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