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Phytoplankton competition during the spring bloom in four Plankton Functional Type Models

Taketo Hashioka[1*], Takafumi Hirata[2], Maki Noguchi[1], Yasuhiro Yamanaka[2]

[1]Japan Agency for Marine-Science and Technology, Research Institute for Global Change, [2]Faculty of Environmental Earth Science, Hokkaido University

We considered the mechanisms of phytoplankton competition during the spring bloom, one of the most dramatic seasonal events in lower-trophic level ecosystems, in four current Plankton Functional Types (PFTs) models: PISCES, NEMURO, PlankTOM5 and CCSM-BEC. In particular, we investigated the relative importance of each ecophysiological process on the determination of the community structure, focusing both on the bottom-up and the top-down controls. The models reasonably reproduced the observed global distributions and seasonal variations of phytoplankton biomass. The percentage of diatoms with respect to the total phytoplankton increases with the magnitude of the spring bloom in all models. However, the governing mechanisms differ among models, despite the fact that current PFT models are representing ecophysiological processes using the same types of parameterization. The increasing trend in the percentage of diatoms is mainly caused by the difference in nutrient dependency of photosynthesis between diatoms and nanophytoplankton (bottom-up control). The difference in the maximum photosynthesis rate plays on an important role in NEMURO and PlankTOM5 and determines the absolute values of percentage of diatom. In CCSM-BEC, light dependency of photosynthesis plays an important role in the North Atlantic and the Southern Ocean. The grazing pressure by zooplankton (top-down control), however, strongly contributes to the dominance of diatoms in PISCES and CCSM-BEC. The regional differences of percentage of diatom in PlankTOM5 are mainly determined by top-down control. These differences in the mechanisms suggest that the response of marine ecosystems to climate change could significantly differ among models, even if the present-day ecosystem is reproduced to a similar degree of confidence. For further understanding of plankton competition, it is important to understand the relative differences in each physiological property in the bottom-up and the top-down controls between PFTs.

Keywords: Marine Ecosystem Model, Model Intercomparison, Spring Bloom, Phytoplankton Competition, Global Ocean Model