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Controls on phytoplankton cell size distributions in contrasting physical environments

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A key challenge for marine ecosystem and biogeochemical models is to capture the multiple ecological and evolutionary processes driving the adaptation of diverse communities to changed environmental conditions over different spatial and temporal scales. These range from short-term acclimation in individuals, to population-level selection, immigration and ecological succession on intermediate scales, to shifts in the global biogeochemical cycling of key elements. As part of the "EVE" project, we have been working toward improving the representation of ecological and evolutionary processes in models, with a focus on understanding the role of marine ecosystems in the past, present, and future Earth system. Our approach is to develop a mechanistic understanding of trade-offs between different functional traits through the explicit representation of resource investment in sub-cellular components controlled by a synthetic genome. Trait expression (including size, metabolic strategies on a continuum from autotrophy to heterotrophy, and predation strategies) and adaptation to the environment are then emergent properties of the model, following from natural selection operating in the model environment. Here we show results relating to controls on phytoplankton cell size - a key phytoplankton trait which is inextricably linked to the structuring and functioning of marine ecosystems. Coupled to the MIT OGCM, we use the model to derive dynamic optimal size-class distributions at representative oligotrophic and high-latitude time series sites, which are then compared with in situ data. Particular attention is given to the relative importance of top-down vs bottom-up drivers for phytoplankton cell size, and their influence on global patterns in phytoplankton cell size, as well as changes in the cell size distribution during phytoplankton bloom periods.