Biogeosciences Discuss., 3, S390–S392, 2006
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Biogeosciences Discussions

Interactive comment on "Multi-nutrient, multi-group model of present and future oceanic phytoplankton communities" *by* E. Litchman et al.

Anonymous Referee #3

Received and published: 21 August 2006

This paper uses a computer simulation of the dynamics of functional groups of phytoplankton to predict likely changes in the composition of phytoplankton communities in response to climate change. The model focuses on conditions in the North Atlantic and North Pacific. The climate-induced changes envisioned by the authors include shoaling of the mixed layer depth, changes in the timing of stratification, increase in the N:P ratio in deep water, and changes in iron deposition. The computer model includes iron, phosphorus, nitrate, ammonium, and light as potential bottom-up limiting factors and grazing as top-down control.

I have a couple of concerns with the model. First, the model completely ignores ocean acidification. There have been a number of recent publications on this subject, e.g., Royal Society, *Ocean acidification due to increasing atmospheric carbon dioxide*

(Clyvedon Press, 2005) and J. A. Kleypas, R. A. Feely, V. J. Fabry, C. Langdon, C. L. Sabine, and L. L. Robbins, "Impacts of ocean acidification on coral reefs and other marine calcifiers (Washington, D.C., National Oceanic and Atmospheric Administration, 2006). The ability of coccolithophores to compete with other phytoplankton will certainly be compromised as the pH of the oceans' surface waters declines. The conclusion (abstract) that, "under decreased iron deposition coccolithophores are likely to increase and other phytoplankton groups and zooplankton to decrease at both sites" should be qualified by the caveat that the model assumes no change in pH. Caldeira and Wickett (K. Caldeira and M. E. Wickett, "Anthropogenic carbon and ocean pH," *Nature* 425 (2003): 365) have predicted that projected burning of fossil fuels will drop ocean mixed layer pH by more than 0.7 pH units by the year 2250 and that the pH will remain depressed by at least 0.7 pH units for roughly 500 years. Raven and Falkowski (J. A. Raven and P. G. Falkowski, "Oceanic sinks for atmospheric CO_2," *Plant, Cell & Environment* 6 (1999): 741-755.) state that calcification essentially ceases at pH values less than 7.6. Combining Caldeira and Wickett (2003) with Raven and Falkowski (1999), I am inclined to conclude that coccolithophores will be out of business by the year 2250 if not sooner. A model that correctly describes the distribution of coccolithophores at the present time is unlikely to predict their distribution when the pH of their habitat has dropped by 0.7 pH units. One could, I suppose, blow this off if the authors pointed out that they have ignored pH effects and that their conclusions about the future distribution of coccolithophores might be compromised by that fact, but they never mention pH.

The other concern relates to dinoflagellates. The authors say (p. 612), "We also do not include dinoflagellates in the model as in all preliminary runs dinoflagellates were competitively excluded both in current and future ocean scenarios. ... Mixotrophy likely contributes to the success of dinoflagellates in the ocean ... but is not included in our model." Falkowski et al. (P. G. Falkowski, M. E. Katz, A. H. Knoll, A. Quigg, J. A. Raven, O. Schofield, and F. J. R. Taylor, "The evolution of modern eukaryotic phytoplankton," *Science* 305 (2004): 354-360) point out (p. 359) that, "the relatively

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warm Mesozoic ... favored coccolithophorids and dinoflagellates." If the relatively warm Mesozoic favored coccolithophorids and dinoflagellates, why would we assume that a warmer ocean would not again favor those two functional groups? In the case of coccolithophorids, I can easily imagine why. The drop in pH associated with future CO_2 increases will likely create an environment unfavorable to coccolithophorids, but what about dinoflagellates? Why would dinoflagellates not again be favored? If mixotrophy is one of the keys to the success of dinoflagellates and if the model ignores mixotrophy, then how good are the predictions of the model?

My reaction is that the model is incomplete in some important ways. Of course any model is going to be a simplification of the real world. However, if the model is going to predict the abundance of coccolithophores in a changing climate, then I think pH effects need to be considered. And considering the apparent success of dinoflagellates during the Mesozoic, I think it is hard to defend dismissing dinoflagellates in section 2.1 and never mentioning them again.

Interactive comment on Biogeosciences Discuss., 3, 607, 2006.