**Biogeosciences
Discussions**

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Comment

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

E. Litchman et al.

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Reply to comment by T. Tyrrell (coccolithophores and phosphate)

All groups in the model, including coccolithophores, were parameterized, when possible, using physiological studies in the lab, where parameters were measured directly. Coccolithophores were parameterized this way, without any a priori assumptions about their competitive abilities. Actually, when the competitive abilities (measured as R*s) of different groups are compared (Table 4 in the manuscript), it appears that coccolithophores and diatoms have very similar competitive abilities for both nitrate and phosphate and are better competitors for these nutrients than green algae and dinoflagellates. Coccolithophores' good competitive abilities for nitrate may thus explain their observed blooms in the Bering Sea under nitrate-limited conditions (see Tyrrell's comment). Therefore, there is no contradiction between our model parameterizations and

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the recent data on coccolithophore blooms. Of course, when more physiological data on coccolithophores will be published, model parameterizations should improve.

Reply to the comments by Referee 1.

1. Choice of functional groups. We chose to model diatoms, coccolithophores, dinoflagellates and green algae (prasinophytes) as separate functional groups for several reasons. Diatoms and coccolithophores are often the dominant groups at the sites we modeled in the modern ocean. Dinoflagellates and prasinophytes are common phytoplankton groups in the modern ocean as well and, in addition, they were the prominent players in the paleocean. We were especially interested in explicitly modeling prasinophytes to potentially investigate the paleocean scenarios (intended for another manuscript), as green algae may have dominated the oceans before the rise of the "red" group (coccolithophores, dinoflagellates and diatoms, Falkowski et al., 2004).

2. Dinoflagellates. Dinoflagellates have parameter combinations that result in a less efficient acquisition of inorganic nitrogen and phosphate, compared to other groups, as per the compilation of literature data. These characteristics do not allow for their persistence under limitation by those nutrients. We agree that future improvements of the model should include the mixotrophic model of nutrition by dinoflagellates. In the present manuscript we now added the discussion of the potential reasons for exclusion of dinoflagellates and how the model could be amended to account for mixotrophy.

3. Parameter compilation. The parameters for different groups were compiled from the published laboratory studies. Depending on a parameter and a group, the median values were determined based on data from 1 to 9 species. The parameter distributions among groups were compared using either t-tests (pairwise comparisons between groups) or one-way ANOVAs. For many of the parameters, the distributions had means significantly different across groups (Litchman et al., manuscript in review). We now added a brief mention of this.

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4. The R* applicability. The R* is a useful metric of competitive ability for heuristic use. We agree with Reviewer 1 that it does not provide a complete picture of ecological success, for example, because grazing losses are not included. Nevertheless, in many instances the model predictions agreed well with the R* competitive rankings of different groups. For example, coccolithophorids have the lowest R* for iron (based on available parameterizations) and are, thus, best iron competitors. Consequently, they increase in dominance under a reduced iron input scenario, while other groups decline, in agreement with the R* competitive rankings.

5. In addition to entrainment, iron can be supplied and by atmospheric input and from the shelf by mesoscale eddies, at least at Sta Papa (Whitney et al., 2005). Modifying the iron concentration in the deep water is a simplified way to model future changes in iron loading that does not introduce variability in iron supply. If iron supply is to be modeled as a result of increased or decreased atmospheric input, more variables would have to be specified that are not known at present (i.e., frequency, magnitude and variability of atmospheric events). Varying each of them could potentially produce distinctly different dynamics and thus exploring those effects would make the manuscript even longer. It would be interesting, however, to explore in the future how different patterns of variability in general impact ecosystem dynamics.

6. We agree that the number of tables in the manuscript is large but feel that it is important to present systematically the results of sensitivity analysis and future scenarios model runs and a tabular form is the most concise. The final decision is, of course, in the hands of the editors.

Responses to comments by Referee 3.

1. We of course agree with the Referee 3 in that future ocean acidification may play an important role in mediating the abundance of coccolithophores and, perhaps, indirectly, other groups. We did not, however, include its influence in the model as, to our knowledge, there is no an established mechanistic way to model such effects. However, we

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added a discussion on the importance of ocean acidification in changing future coccolithophore abundance and would be interested in adding the effect of acidification on coccolithophore growth in the future renditions of the model.

2. Dinoflagellates. Please see the response 2 to Referee 1.

Falkowski, P.G., Katz, M.E., Knoll, A.H., et al. (2004) The evolution of modern eukaryotic phytoplankton. Science, 305, 354-360. Whitney, F.A., Crawford, W.R., and Harrison, P.J. (2005) Physical processes that enhance nutrient transport and primary productivity in the coastal and open ocean of the subarctic NE Pacific. Deep Sea Research Part II: Topical Studies in Oceanography, 52, 681-706.

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