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Interactive
Comment

Interactive comment on "Increasing coccolithophore abundance in the subtropical North Atlantic from 1990 to 2014" *by* K. M. Krumhardt et al.

Anonymous Referee #2

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The manuscript by Krumhardt et al. used phytoplankton pigment data from the Bermuda Atlantic Time Series collected over the last 20 years to derive potential changes in coccolithophore abundances. Furthermore, they correlated observed abundances with other environmental factors such as dissolved inorganic carbon concentrations, nitrate or temperature. Finally, they also looked into temporal changes in particulate inorganic carbon, known to be produced by coccolithophores, as derived by satellite observations. Overall this is an interesting data compilation, however, I do not agree with the main conclusions of this manuscript (see comments below).

General Comments:

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Interactive Discussion

Discussion Paper

1) Concerning deriving coccolithophore abundance from pigment data the authors make two key assumptions. First, that the ratio of marker pigments to chlorophyll a, such as 19-Hex for haptophytes, is constant in time and space, thus there is no acclimation to changes in light conditions, temperature or nutrient regime. Another inherent assumption here is that all haptophytes have the same 19-Hex to chlorophyll ratio, thus changes in the dominant species will not change the ratio and thus the estimate of overall haptophyte abundance. The second assumption is that it's only coccolithophores which contribute to haptophyte biomass, but what about other non-calcifying members which appear to be extremely diverse (compare Liu et al. 2009)?

2) Pondering over the chlorophyll a contribution by haptophytes integrated over the upper 30 meters shown in figure 5 I was intrigued about the apparent increase at the end of the time series of the Gaussian filtered data set as seemingly opposed to the single data points. I digitized the data and tried to reproduce the curve, however I didn't get a pronounced increase towards the end. Also, a linear fit through that dataset had a negative slope, indicating a decrease in haptophyte biomass (but also see comment #5) with time, contrary to the authors observations. Are there data points missing from figure 5? Please explain.

3) Invoking increases in DIC and HCO3- concentrations for increasing haptophyte concentrations in the last 20 years doesn't seem to make too much sense. The issue I have with this is that at a reported rate of 1.4 micro mol/kg per annum, the overall increase would be on the order of 30 micro mol/kg. That's about a 1.5% increase in DIC or HCO3- concentration, corresponding to an increase in pCO2 by about 50 micro atmospheres. Considering measured growth rate responses of coccolithophores in culture experiments (also see comment #1) I wouldn't expect a 37% increase (also see comment #2) in haptophyte biomass over time (also see comment #5). The DIC correlation of coccolithophore occurance (not concentration!) reported in the cited paper by Rivero-Calle et al. (2015) is over a much longer time span and thus DIC increase. In this respect, the most obvious explanation for increases in overall chlorophyll a and

other phytoplankton taxa contributions with time seem increasing nitrate concentrations.

4) Satellite derived PIC concentrations during the last ten years shown in figure 5 do not seem to match haptophyte abundance estimated from marker pigments neither in the upper 30 nor 140 meters of the water column. Thus, I wonder which is the better or more reliable indicator for coccolithophore abundance?

5) A recent study by Freeman and Lovenduski (2015) reported decreasing coccolithophore calcification in the Southern Ocean during the last 15 years while another by Winter et al. (2014) reported a poleward expansion of the bloom forming coccolithophore Emiliania huxleyi during the last 30 years. Both studies are based on satellite derived PIC estimates and the most obvious difference leading to such contrasting results is the time span for which the analysis was carried out. The same issue is affecting this study and can be seen in figure 7a. Depending on the chosen start and end year for trend estimates of haptophyte abundances the answer will be different. And it is not the majority of cases which show a positive trend as the authors claim but for the majority of cases there is no statistically significant trend!

Specific comments and suggestions

1) P18627, L14: In the last six years following the Doney et al. summary on coccolithophore responses to increasing CO_2 there has been a lot of progress in terms of process understanding. I suggest incorporating some more recent reviews. Furthermore, how exactly ocean acidification is going to affect coccolithophore populations in the future is still unknown.

2) P18628, L7: To the best of my knowledge, Schlueter et al. (2014) did not report higher calcification rates at higher in comparison to lower CO_2 treatments as suggested by the authors.

3) P18629, L28: see general comment #1 above.

BGD

12, C8923–C8926, 2016

4) P18633, L12: There was a similar period in the mid 90s with higher haptophyte derived chlorophyll a in the upper 30m (see also general comment #5 above).

5) P18640, last paragraph: The argument that Synechococcus draws down DIC which could then limit the growth of coccolithophores could be made for any autotrophic group including coccolithophores.

6) P18643, L2: A decrease in the opal to carbonate ratio observed in sediment traps reported by Antia et al. (2001) and Deuser et al. (1995) does not necessarily imply an increase in coccolithophore abundance at the oceans' surface. First, it is a ratio and changes in diatom abundance or species composition can equally explain observed changes, and second there could also be a change in calcium carbonate/biogenic silica preservation.

Cited references:

Liu et al. (2009), Extreme diversity in noncalcifying haptophytes explains a major pigment paradox in open oceans, PNAS 106: 12803-12808.

Winter et al. (2014) Poleward expansion of the coccolithophore Emiliania huxleyi, JPR 36: 316-325.

Interactive comment on Biogeosciences Discuss., 12, 18625, 2015.