

Interactive comment on “Can morphological features of coccolithophores serve as a reliable proxy to reconstruct environmental conditions of the past?” by Giulia Faucher et al.

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GENERAL COMMENTS

In this manuscript, Faucher et al. report how they cultured four extant coccolithophore taxa (*Emiliania huxleyi*, *Gephyrocapsa oceanica*, *Coccolithus braarudii*, and *Pleurochrysis carterae*) with different environmental variables (light intensity, Mg/Ca ratio, nutrient availability, temperature and carbonate chemistry) and how they assessed the potential response analysing coccolith morphology. Based on the culture experiments, the authors extrapolate to the past and conclude that coccolith morphology cannot be used as a proxy for reconstructions of palaeoenvironmental conditions, but instead

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they suggest that malformations can be a good indicator for high CO₂ levels in the sedimentary record.

The manuscript is in general well written and follows a logic structure. The authors provide an interesting dataset, relevant for the scientific community, especially researchers working with phytoplankton communities and/or coccolithophores/calcareous nanofossils in palaeoclimate and paleoceanographic reconstructions.

The methodology chosen is adequate and the authors explain it shortly but concisely. Still, I think that sometimes the authors could elaborate more (see specific comments and supplementary material, where there are sections with one single sentence).

Faucher et al. generated a valuable high quality dataset, however, they somehow fail to discuss their findings in detail. The discussion part is one of the weakest points of the manuscript at the moment, not only regarding the coccolith morphometries, but also because the authors do not compare their findings/results as much as they could to previously published papers (mostly dealing with a) high CO₂ past time intervals, and b) coccolith malformations).

Although I think that this manuscript it is not yet ready for publication and it will need a thorough revision, I still recommend it for publication *Climate of the Past*. I am confident that the authors will be able to improve this version of the manuscript with the specific comments and suggestions provided.

SPECIFIC COMMENTS:

Abstract: Page (P) 1, lines (L) 15-16. Rephrase; “evolutionarily distinct for millions of years” is misleading and not the case for *E. huxleyi* and *Gephyrocapsa*. P 1, L 18-20. I understand that this is one of the main motivations of this piece of research, but the authors are jumping here from hours/days to Millions of years. They need to be more careful linking present-day changes to past evolution. P 1, L 22-25. This conclusion needs to be discussed in more detail (not here, but in section 4).

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1. Introduction: P 1, L 27. Add reference after “producers on Earth”. P 1, L 28-29. “. . .exoskeleton (coccosphere) composed of single platelets called coccoliths and nannoliths”. Rephrase, being more accurate. If I am not mistaken, some nannoliths can be internal (e.g., *Ceratholithus*). P 1, L 29 “...ability to precipitate calcium carbonate” = to calcify? P 2, L 34-39. Reword, because this part is a bit confusing for the reader and it sounds contradictory to sentence 39-40. P 2, L 41-43. “In case that coccolith morphology responses to a changing environmental driver are similar in the four species this could be indicative of a response pattern that was conserved over geological timescales”. This is a general assumption that the authors do for all the 4 taxa. Can the authors add some reference(s) backing up this? (I.e. explaining why these taxa would have to behave in the same way, I could imagine that would be the case for *E. huxleyi* and *Gephyrocapsa*, but it might be worthy to additional information in that regard). P 2, L 47-48. They way this sentence is written is tricky/misleading, because *E. huxleyi* and *Gephyrocapsa* are already half of the taxa considered. Also, despite the long evolutionary history mentioned, no traces of the delicate coccoliths of the calcifying species within the family *Pleurochrysidaceae* have been observed in the fossil record (e.g. De Vargas et al., 2007). Therefore Faucher et al should be careful how they objectively show the state of the art information). P 2, L 47. Double check if *Pleurochrysis carterae* is the more adequate name for this taxa or if it should be changed to *Chrysotila carterae*. <http://www.mikrotax.org/system/index.php?dir=Coccolithophores/Coccolithales/Pleurochrysidaceae/Chrysotila> P 2, L 50-51. Change one of the words “whether” to avoid repetition. 2. Material and methods P 2, L 54. Delete “generally” P 2, L 56. Do you mean nutrient limitations or content? If the authors are referring to limitation, maybe it would be worthy to add a bit more information regarding this. P 2, L 56. Carbonate chemistry. . .parameters? Maybe it would be worthy to list them here, at the very beginning of the section. P 2, L 57. Which *E. huxleyi* morphoptype? Do the authors have information about it? There might be different responses by different morphotypes. P 2, L 57-59. It might be worthy to specify where all those strains originally come from. P 3, L 59. Delete ASW,

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because it is the only time authors use this abbreviation P 3, L 70. Change “start” for “beginning”. P 3, L 71. “It was assured” sounds odd to the reader. P 4, L 106 and 113. Why there are two different references for the program CO2SYS (Lewis and Wallace, 1998 and Schulz et al., 2017)? Why the authors did not use Pierrot et al. (2006) instead of Lewis and Wallace (1998) that seems to be a more recent program? P 4, L 107. Roy et al. (1993) Parenthesis are missing. P 4, L 109. Was this following Gattuso et al. (2010)? Rephrase. P 5, L 124. I sentence should not start in that way. Rephrase or write “Fifteen to ten ml. . .” P 5, L 130-131. What those references (Langer et al., 2006; Langer et al., 2010) refer to? The way that the malformations were quantified? P 5, L 138. Why a non-linear regression? Elaborate.

3. Results: P 5, L 142. Delete “all”, add “selected” after species and add “variable” before light intensity. P 5, L 144. No need for a new paragraph after only one sentence. P 5, L 145. Here and elsewhere in the manuscript. A sentence should not start with an abbreviation or a number, therefore “G. oceanica” should be “Gephyrocapsa oceanica” here. Please, double check this throughout the manuscript (and supplementary material). There are plenty of abbreviations at the beginning of sentences, especially in section 3 (L. 153, 155, 156, 160, 161, 162, 163. . .). P 6, L 166. Inner tube? P 6, L 169. Replace “any” by “no”. P 6, L 173. No need for a new paragraph after only one sentence. P 6, L 173. Replace “under” by “at”. P 6, L 173. What do the authors mean by rays? T-elements? Revise this and use the adequate nomenclature. P 6, L 176. I suggest to change the title of this section to “Carbonate chemistry parameters” or something along those lines. P 7, L 183. A dot is missing after (Table 5). P 7, L 185. “oceanica formed a high number of malformed coccoliths” sounds odd. Reword if possible. P 7, L 187. Do the authors mean Figure 2 or Figure 4? P 7, L 191. Add “variations” after “carbonate chemistry”

4. Discussion: P 7, L 193. How do we know it is a biological innovation? Any reference for that? P 7, L 194-195. “A great diversification in morphologies occurred in the Mesozoic and Paleocene where many new morphologies occurred.” Rephrase. It sounds

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like circular reasoning. P 7, L 198. Coccolithophore algae (without s). P 7, L 201-202 “The cause of this impressive number of structures is unknown but there might be a reason connected to the function of coccoliths for the different species to produce such different shapes.” This sounds very vague. P 7, L 202-203. I miss a reference here.

P 7-8, L 210-212. “However, fossils and living coccolithophores diverged a long time ago, have a different genetic background and therefore, calcareous nannoplankton in the past and nowadays did and do not necessarily act in the same way to external stress”. This sentence kind of undermines some of the author’s basic assumption(s) for this study, but I like that they mention this kind information. I even suggest to discuss this more in detail. Maybe it would be worthy also to add something along those lines in the introduction/state of the art (this applies to information provided from L210 to L220) to outline better the main goals, but also limitations, of this research work.

P 8, L235-242. This is one of the main conclusions drawn from this research, but somehow the authors only mention it superficially, and do not even discuss it. Discussion needs to be added, especially considering existing literature (already cited by the authors!) regarding relatively well preserved nannofossils in high pCO₂ past environments; e.g., during Paleocene-Eocene Thermal Maximum, O’Dea et al., 2015, Gibbs et al., 2016. . .). In my opinion this part needs to be improved,

The fact that coccolithophores are generating malformed coccoliths in extreme/“harsh” boundary conditions (high CO₂ concentrations in this very specific case) is something that has been previously noted or at least mentioned by other authors. Still Faucher et al. miss the chance to discuss it in section 4. I recommend the authors to add some more references to make stronger the discussion.

P 8, L243. Change “excess” to “high concentration”

As a general comment, I got the impression that there is a lot of morphometric data displayed in tables and mentioned in the results part, but I miss some discussion on top of L 221-225 comparing to other published studies.

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5. Conclusions: P 9, L253. Conclusions P 9, L255. I would rewrite this sentence as: “. . .in response to temperature, light, nutrient, and Mg/Ca variations”. P 9, L260-262. Rephrase this sentence. Make it simpler or split into two sentences.

6. References: Check the way dois are cited, e.g., L271 vs L274.

7. Figures: Figure 1: Is it possible to use italics for the name of the species? What is the meaning of the numbers at the nodes (47, 57. . .)? Maybe it is worthy to specify what they mean in the caption

L 360. Caption: I suggest to reword it as follows: “Phylogeny and divergence times of the Haptophytes, modified from Liu et al., (2010). Time is indicated in billion years. The species selected for this study are shown in red.”

Figure 2. Caption: Based on the (very nice) figure itself, I would change this sentence to “. . .incomplete and incomplete / malformed for *E. huxleyi*. . .”

Figure 3. Is it possible to add the chemistry parameters (i.e., pH, TA. . .)? I would also recommend to use the same (or similar) size font. The authors can always use abbreviations if the whole word does not fit.

L 369. Figure 4. Caption and figure. Use incomplete / malformed, as in figure 2.

Table 1. Use the same font size (This applies to all the tables). L 390. Caption (here and elsewhere): double check that these units are correct: “Growth rate (μ)”. L 392. Here and elsewhere: “*E. huxleyi* ray number (rays)” Do you mean T-elements?

I would also recommend the authors to re-structure all the tables. Do not mix different parameters in the same column (e.g., rays and tube thick. In Table 1). I think it would be better to leave gaps or specify that there is no data (as in Table 5) rather than mixing different measurements. It is confusing for the reader.

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