

# ***Interactive comment on “Alkenone isotopes show evidence of active carbon concentrating mechanisms in coccolithophores as aqueous carbon dioxide concentrations fall below $7 \mu\text{mol L}^{-1}$ ” by Marcus P. S. Badger***

## **Anonymous Referee #2**

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The manuscript by Badger presents the capability of the haptophyte alkenone proxy to reconstruct past atmospheric CO<sub>2</sub> concentrations compared to the ice core CO<sub>2</sub> records during the Pleistocene, based on alkenone CO<sub>2</sub> reconstructions of numerous sites. Deviations that the proxy exhibit from the ice core records are attributed to the activation of carbon concentrating mechanisms (CCMs) in the haptophytes during C acquisition under low CO<sub>2</sub> environments, and the author therefore concludes this proxy may not be valid during periods of expected low atmospheric CO<sub>2</sub> conditions (corresponding to below  $\sim 7 \mu\text{mol/L}$  of aqueous CO<sub>2</sub>). Overall, this work is very relevant

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to the field and well written, especially the inclusion of multiple sites, the comparison to the ice core record, and the overall very clear presentation. However, the statement that deviations between the proxy and ice core record is due to the activation of CCMs is a bit too short and does not consider all the knowledge we have on CCMs in haptophytes. This can be improved by sufficient introduction into the subject and more discussion on possible explanations on why this deviation between the ice core record and the alkenone proxy may exist. After addressing the following points (minor revisions) the manuscript is worthy of publication.

### General comments

As mentioned above, the main issue I have is the statement that the activation of CCMs is the sole explanation between the offset in CO<sub>2</sub> reconstructions between the alkenone proxy and ice core record. There is no evidence that since the development of CCMs in haptophytes (which may have occurred during the late Miocene – early Pliocene) these CCMs could be turned on and off. On the contrary, a study from Van de Waal et al. 2019 (L&O Letters) suggests that haptophyte CCMs (measured in present day haptophytes) are not so adjustable even in high CO<sub>2</sub> environments. Although this is from present day haptophytes, no mention of such findings is made, even though the data presented here is closer in age to the present-day haptophytes than those from late Miocene.

The main conclusion of the paper also revolves around CCMs, but this topic is hardly introduced or properly explained in the introduction and explored in the discussion. This can certainly be improved. CCMs also comprise various mechanisms of acquiring C and it can be explored how alterations in these strategies may compromise alkenones being a reliable proxy for atmospheric CO<sub>2</sub>. It may have something to do with increased uptake of HCO<sub>3</sub> relative to CO<sub>2</sub>, but no mention of this is made. Just stating CCMs are turned on or off is a bit oversimplified, especially since there is not a lot of evidence for this.

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A bit more emphasis on the comparison of the alkenone proxy to the ice core record may be made in the title and in the abstract, as it is very nice that data from multiple sites are combined and also demonstrates the pitfalls of this proxy.

## Specific comments

There are still a few mistakes and a few awkward sentences in the text.

Line 17-21 Quite a long and confusing sentence with conjugations that do not fit.

Line 30 two times “to” close together, reads a bit odd

Line 32 However, recent. . .

Line 35 Differences

Line 36 appear

Line 38 operation instead of action

Line 40 it is written here as though CCMs are usually not active and sometimes get active, but it is usually the case that they are active from what we know of present-day phytoplankton

Line 58 take up instead of uptake

Line 59 were instead of I

Line 61, but also Line 84 here you state that additional corrections from the original records were removed, but you accounted for that in the fractionation with the “b” term, right? How exactly is this term calculated for all the sites?

Line 106 worse instead of less well

Line 108 haptophytes

Line 143 twice that

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Line 153 were instead of was

Line 172 take up instead of uptake

Line 175 what do you mean here? The study you did or the one from Laws? Not clear from sentence structure, although I assume you mean your study as you refer to alkenones. If so, I would not state it like this, as you only look at sedimentary records which is not clear behavior of activation of CCMs.

Line 178 influenced

Line 182 not sure if this is necessarily a CCM threshold or a switch maybe from one of mechanisms of the CCM (for instance a switch from CO<sub>2</sub> to HCO<sub>3</sub>uptake)

Line 187 maybe also state how SST influences aqueous CO<sub>2</sub>, as this is not yet mentioned.

Line 196 word missing after “recent” Line 203 critical for

Line 204 as long as

Line 206 take up

Line 209 comma after Cenozoic

Line 210 may be abnormally, or is expected to be abnormally

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