Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2020-356-AC1, 2020

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

Marcus P. S. Badger

marcus.badger@open.ac.uk

Received and published: 19 October 2020

Many thanks for your kind comments on the manuscript. I hope if nothing else this manuscript spurs further discussion and research into this matter.

You are right that there are not large differences between equilibrium at the different sites, although there are some differences, which are lost in the scale needed for a global figure like figure 2. The more important site-to-site changes here are, as you deduce the different SSTs and SST history of each site, which, through Henry's law, have

a substantial impact on [CO2](aq) absolutely and through time. For SST over time I use the published records used for each of the records I have analysed. Salinity is much more difficult to estimate through time, and records of salinity was not easily to hand for each site so I kept S constant at each site. The combination of SST and disequilibrium differences between the site mean that through the interval that the records cover predicted [CO2](aq) varies across the sites from 5 to 10.6 umolL-1, as shown in Figure 4. The SST records are available for further interrogation in the original publications, and are compiled (alongside predicted [CO2](aq)) in the supplement.

I too am intrigued as to how my findings fit into the Wilkes et al., (2019) framework. The bloom-forming nature of the coccolithophores in particular do make it difficult to translate batch and chemostat cultures varying light and nutrient levels from the lab to the oceans, as both will vary through a bloom event. The Wilkes et al., (2019) model also doesn't rule out that kinetic, [CO2](aq) dependence of ep still occurs, and do note several examples in the ocean where that does appear to be the case. It may be that nutrients, light and CO2 availability all play a part, and my study picks out the times where CO2 availability becomes the most important. If ep is fully controlled by nutrients and light levels alone, then the good fit of the alkenone data to the ice core in Figure 10 needs explanation, as does the observation of Bolton et al., (2012) and Bolton and Stoll (2013) that CCMs only become widespread once we reach the lower atmospheric CO2 worlds of the Plio-Plesistocene compared to the rest of the Cenozoic, perhaps as an evolutionary response.

My suggestion that alkenone-pCO2 can be used confidently through the Cenozoic is only on the basis that the very low [CO2](aq) conditions observed in the Pleistocene ocean (particularly) in the glacials become less likely in the higher-CO2 world of the Neogene. I cannot (and do not) rule out that, if CCMs do become active at low [CO2](aq), the could be occasions in the Cenozoic where these conditions are seen at certain sites, but if the atmosphere is overall more replete in CO2, this should be less likely. For example, if you do a quick estimation of global ocean [CO2](aq) in a warmer world (+ 3 degC) with atmospheric CO2 at Pliocene-like levels is no region of the ocean where [CO2](aq) is expected to be below 7 umolL-1 (Figure 1).

Figure 1: Estimated global [CO2](aq) for a Pliocene-like world with atmospheric CO2 close to 400 ppm and SST 3 degrees warmer than today. (Based on data from Takahashi et al., (2014)).

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2020-356, 2020.

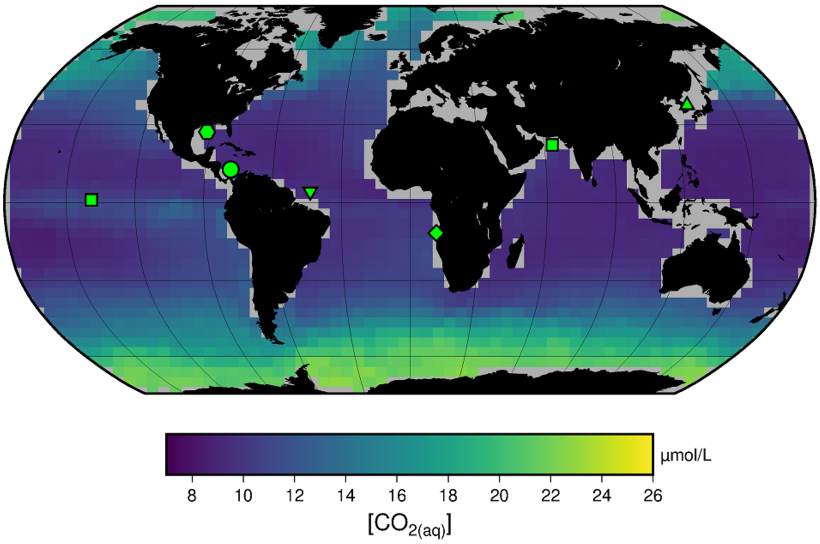

Fig. 1.