

Interactive comment on “Eccentricity-paced atmospheric carbon-dioxide variations across the middle Miocene climate transition” by Markus Raitzsch et al.

Anonymous Referee #2

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GENERAL COMMENTS Obtaining more B isotope-pH and CO₂ estimates for the middle Miocene climate transition is a long overdue goal, making this study very timely and of great importance. The authors provide a comprehensive view of CO₂ evolution for this period and potential mechanisms overlying potential eccentricity driven variations. The paper would benefit from some re-organization and focus on clarity, incorporation of recent studies in the discussion and the data, and a more comprehensive propagation of uncertainties, beyond the sensitivity analyses performed for alkalinity and salinity.

SPECIFIC COMMENTS Uncertainties: a)The analytical uncertainty reported is quite

C1

small compared to the uncertainty of replicate analyses. There may be differences between the use of IC vs. Faraday detectors in different studies and here. Nevertheless, the authors should provide more details here as well on how they calculate analytical uncertainty. For example, the consistency standard used to calculate long term precision should have been run at similar concentrations to those of samples, and the uncertainty of this should be larger at low B-levels. Additionally, the authors should provide more details on the B blank contribution (if any). b)Why is d11Bsw error systematic? If weathering is extremely pronounced, couldn't this cause variations in d11Bsw across this time window, even if the average residence time for B may be longer? Even if so, because of the non-linearity of the d11B-pH proxy, at different d11Bsw the dpH and thus dCO₂ could differ. Some could, thus, argue the uncertainty in d11Bsw encompasses both uncertainty in absolute value across the MMCT but also potential variations across the window. The authors should provide at minimum two scenarios based on minimum and maximum d11Bsw estimates for this period. c)The level of details in Fig. 7 with all sensitivity analyses is very much appreciated. However, could the authors provide more explanation on how they estimate the Alk and Temp uncertainties? If they compare to literature or proxy estimates, shouldn't they use the maximum uncertainty reported (i.e. $\pm 2\text{C}$, and $\pm 130 \text{ umol/kg Alk}$)?

Comparing to other studies: The authors should discuss their results in light of two recent publications for the middle Miocene, Leutert et al. 2020 (Nat. Geo) for both their SST and dpH estimates, and Sosdian et al. 2020 (Nat. Comm.) for C cycle in relationship to climate.

Comparing CO₂ records: e.g. Fig. 5: what drives the differences between different d11B records for the target age-window? Section 4.1 needs some more discussion, with focus on how this new record could differ from previous d11B records. Could there be an upwelling signal at the study site driving those high CO₂ estimates when they deviate from the other records? It could also be differences in the calibration used for d11B, or the assumptions for calculating carbonate system parameters. It may be

C2

wise to process the d11B records in the same manner, exclude the potential of any regional and variable CO₂ disequilibrium, and then merge reliable d11B records into a single record with full propagation of uncertainties. If uncertainties are not propagated, and instead sensitivity runs are provided (i.e. d11Bsw), then better to display relative changes in pH/CO₂ instead of absolute values. (Here it may be wise to remove the alkenone CO₂ as they are not discussed enough beyond what is already available in the literature and thus do not contribute to the story.)

Focusing on the d11B records available and this new one, it would be also beneficial to display not only CO₂ but also pH evolution across the MMCT, and how different records compare.

Site setting: It is argued that the site is not affected by upwelling being north of the frontal systems in the Southern Ocean. However, can this be said with certainty for the middle Miocene? Is there any evidence for that?

Carbonate system calculations: The authors should consider the effect of Mg and Ca concentrations in seawater on carbonate system calculations (i.e. K₁, K₂, K_{sp}), such as in Hain et al. 2015; 2018 or Zeebe and Tyrrell 2019.

Benthic-planktic pH records: Although the uncertainties are very large to make discernible conclusions about pH gradient values during the middle Miocene, it is interesting to further explore the dpH evolution and the surface-to-deep gradient evolution during the Miocene, and what drives this. If the benthic foraminiferal pH record is included, it should be discussed further.

Discussion on role of eccentricity and deep water ventilation: Here the section leaves us wanting more! It could benefit from some reorganization for clarity and flow, including recent studies such as those mentioned above.

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