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# *Interactive comment on* "Deglacial carbon cycle changes observed in a compilation of 117 benthic $\delta^{13}$C time series (20–6 ka)" *by* Carlye Peterson and Lorraine Lisiecki

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We thank referee #2, Andreas Schmittner for his comments and improvements to the manuscript. Our responses (AR) are listed after a synopsis of Andreas' comments (R2).

R2 1) I think typically the relationship between the terrestrial carbon storage and whole-ocean $\delta$13C changes is calculated using a closed system approach with land, ocean and atmospheric reservoirs of carbon (e.g. page 1, lines 14-15; Ciais et al. 2012). I wonder if this is appropriate for glacial-interglacial changes because it is likely that ocean sediments responded by adding/removing alkalinity and carbon from dissolu-



tion/accumulation of calcium carbonate. This would also affect $\delta$13C of DIC. Is this considered here? It would be good to discuss this point.

In Figure 5, which relationship between $\delta$13C and land carbon was used? See comment above. Does it consider sediment carbon changes?

AR 1) Our "global mean $\delta$13C" is a volume-weighted average of benthic $\delta$13C (per mil). In the discussion, we refrain from converting the $\delta$13C estimate to terrestrial carbon storage because it is difficult to propagate errors through the mass balance calculations. To avoid making this conversion, we use two separate y-axes when comparing terrestrial carbon storage change and benthic $\delta$13C change in Figure 5. We will modify the text to clarify that the magnitude of carbon storage and benthic $\delta$13C change is not necessarily equivalent, and that Figure 5 is not meant to be a quantitative comparison. In this manuscript, we are simply noting the remarkable similarity in the pattern of change between our data compilation and the only model results of terrestrial carbon storage change across the deglaciation that we were able to find before submission.

R2 2) Benthic $\delta$13C is affected by carbonate ion and pressure effects (e.g. Schmittner et al., 2017). Were these effects considered here? I guess not since carbonate ion changes are not available. In this case it may be useful to try one of their regression equations that don't require carbonate ion to calculate d13C_DIC

AR 2) That is correct, the effects of carbonate ion are not considered here because estimates of past carbonate ion concentration are currently difficult to constrain. We will make this clear in the revised text and cite the regressions from Schmittner et al. (2017) as way to account for carbonate ion changes if carbonate ion data becomes available or if readers want to consider model-based estimates of carbonate ion concentration. We will also mention the available regressions that can be used when carbonate ion conc. records are unavailable. Because the relevant experiments (LW6 and CW6) suggest a linear scaling of $\delta$13C (i.e., do not include a depth-dependent term), applying these regressions would not impact the correlation coefficients in our manuscript.

Additionally, we will mention that these regressions would impact the apparent scaling between $\delta$13C and terrestrial carbon implied by Figure 5. We prefer not to apply the regression scaling to $\delta$13C in this figure because it could confuse readers and cause misinterpretation of our results.

R2 3) Page 8, 21: "DSA $\delta$13C begins increasing at 18 ka" This finding seems to be at odds with Lund et al's (2015, doi:10.1002/2014PA002657) findings that the DSA begins increasing only later (after HS1). Are those data included here? Discuss.

AR 3) The records from Lund et al. (2015) were not originally included in the manuscript because they were published after Stern & Lisiecki (2014) created their original compilation and were not included in their regional stack age models. We have now included 12 of the Brazil Margin sites from Lund et al. (2015) using their 14C age models. This doesn't change our overall results or the timing of $\delta$13C changes in the DSA region. The DSA $\delta$13C value at the LGM is slightly more depleted than the original version without these sites, but the timing of deglacial increase is visually similar to before. We didn't do any formal change point analysis to quantify the timing of $\delta$13C changes because the focus of this paper is on comparing the global $\delta$13C gradient with the ice core CO2 record throughout the entire deglacial transition.

R2 4) Page 9, 13: The North Pacific (>30N) is also not included. Page 10, 9: what volume was used for the deep Pacific box? <30N?

AR 4) We have two Pacific records at $\sim$32N (one each in the intermediate and deep Pacific regions), but none further north. However, our Pacific volume estimates are based on the latitude range of 60S to 60N. Therefore, the North Pacific (>30N) is volumetrically included but not well constrained.

We are aware of efforts currently underway to compile and publish North Pacific $\delta$13C records, and we expect these data will slightly alter mean global $\delta$13C estimates. However, our compilation and its comparison to ice core CO2 provides an important scientific contribution in its current form, and our analyses can be revisited as additional



data become available.

R2 5) Page 11, 1-3: Schmittner and Lund (2015, Climate of the Past, doi:10.5194/cp-11-135- 2015) have suggested a different mechanism. Please consider.

AR 5) We have done our best to include a variety of hypotheses, but the number of possible citations is quite large. On Page 11, 1-3, we will revise the text to include the hypothesis that AMOC shutdown induced a decline of biologically sequestered ocean carbon storage (Schmittner and Lund, 2015).

R2 6) Page 5, 9-11: include study by Schmittner and Somes (2016, Paleoceanography, doi:10.1002/2015PA002905)

AR 6) Thank you for the suggestion, we will include the citation.

R2 7) Page 7, 12: I didn't find this number (0.15‰ for the standard deviation) in Gebbie et al., (2015). Schmittner et al. (2017) suggest a larger error of $\sim$0.25‰

AR 7) The error estimate of 0.15‰ we used is actually a compromise between the errors reported by Gebbie et al. (2015)'s 0.20‰ and Marchal and Curry (2008)'s 0.10‰Ḣowever, during revision we plan to change our uncertainty estimate to 0.20‰ which will increase our stack 95% confidence intervals by +/- 0.02‰Ȧn uncertainty of 0.20‰ will also be approximately consistent with Schmittner et al. (2017); we will add this citation and an explanation of why the value of 0.20‰ was selected. Specifically, the most relevant uncertainty from Schmittner et al. (2017) would likely be a standard deviation 0.22‰ as observed in experiments LW6 and CW6 in Table 2 of that paper because those experiments are the ones that include only C. wuellerstorfi. To the extent that modern-day observations also contribute uncertainty in comparison with late Holocene $\delta$13C, 0.20‰ is a reasonable estimate of the uncertainty contribution from foraminiferal $\delta$13C. Additionally, the largest discrepancies between foram $\delta$13C and DIC $\delta$13C in Schmittner's compilation (their Figure 4) comes from shallow cores (<1 km) and high-latitude regions (especially the Arctic), which are not included in our compilation.

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