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Climate of the Past Discussions

Interactive comment on "A Late Pleistocene sea level stack" *by* R. M. Spratt and L. E. Lisiecki

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Referee comment:

"Firstly, Spratt & Lisiecki use a handful of records from a range of different proxy/model approaches. In doing so, they use the published error associated with initial publication. I believe this is inadequate and need to apply a more rigorous, possibly a probabilistic assessment, to fully evaluate the uncertainties in each record. For example, the Mg/Ca-BWT derived records both quote a $\pm$1 to $\pm$1.1 C on BWT estimates, however, both records are based on core-top calibrations that are either regional or bootstrapped. Consideration of the uncertainty around this needs to be revisited along with the other records. "

Authors' reply:

"Thank you for your careful consideration. We quote the uncertainty estimated by the original authors as they are most familiar with their data and these error estimates have gone through a review process associated with their original publication. Reassessing the errors of each individual record (e.g., with regard to core top calibration) is beyond the scope of the current manuscript, although it would certainly be a valuable scientific contribution. The goals of the current manuscript are to identify (1) the common signal in Late Pleistocene sea level records, (2) correlated biases affecting multiple records (ie, PC2 and PC3), and (3) the overall level of agreement among the records (ie, the standard deviation of highstand and lowstand estimates in tables 2 and 3), which is an indirect measure of noise/uncertainty in the individual records. For clarification, we do not actually apply the authors' estimates of individual record uncertainty in any of our analyses."

Referee comment:

"Also both Mg/Ca-derived BWT records lead the d18Osw record by 10-20 kyr. How does this phasing affect the alignment or interpretation of peak interglacial sea level estimates?"

Authors' reply:

"We do not interpret the phase of the sea level response because of significant age model uncertainties associated with the alignment techniques. Additionally, we identify the peak interglacial levels estimated by each record independent of their precise age in Table 3. Both benthic d18Osw records have above average interglacial sea level estimates, potentially indicating a bias in the approach. However, the bias may be counterbalanced in our stack by our signal pre-processing (ie, normalizing) and by the below average estimates from planktonic d18Osw. In fact, PC3 (which largely reflects differences between the benthic and planktonic signal) may be helpful for identifying/quantifying the bias associated with these signals. "

Referee comment:

"The authors do not clearly provide a criteria for their choice of sea level records. And although they provide a general review of the chosen records it does not seem to be exhaustive. Available for the late Pleistocene are the records of Dwyer et al. 1995 (ostracod Mg/Ca-BWT) and the record of Martin et al. 1999 (benthic foram Mg/Ca-BWT record). Additionally, they omit they record of Siddall et al. 2010 who expands up the technique of Waelbroeck et al 2002 applying a benthic d18Oc-coral regression. Does the stack have a sensitivity to records included or excluded?"

Authors' reply:

"Thank you for these suggestions. Many of these records did not fit our inclusion criteria, which we will clarify in revision. The criteria for inclusion in the stack were (a) availability, (b) at least 400 ka long, and (c) a minimum temporal resolution of 5 ka. The Dwyer et al. (1995) record was not long enough, spanning only 0-120 ka. We could not find Martin et al (1999); we wonder if instead the reviewer meant Martin et al (2002). This record was not included because it is only $\sim$350 kyr long. However, we will add highstand and lowstand estimates from these records to our tables. Additionally, we are currently in the process of trying to acquire the Siddall et al (2010) data.

As a sensitivity test, we compared PC scores 1, 2, and 3 of the shorter seven-record stack to the longer five-record stack. For PC1, we find almost no difference (page 3716, lines 17-19). We can add more detailed explanation about this comparison in our revised manuscript."

Referee comment:

"More clarification around the age model alignment for each record is needed. In the paper they authors state " the LRO4 age model has an uncertainty of 4ka" and state

that their "age model alignment involved either aligning . . . to the LRO4 d18Oc stack or aligning ..to other sea levels . . . on the LRO4 age model". Details about the alignment and records used need to be fully explained."

Authors' reply:

"We will add more detail and clarification of the method aligning the 5 records not already on the LR04 age model in our revision of this manuscript."

Referee comment:

"Secondly, the authors seem to only briefly explore the features of the record. They make the point that roughly 40% of the benthic d18Oc record is derived from ice volume change and 60% BWT change. How does this %ice:%BWT contribution change over the course of the record? "

Authors' reply:

"We include orbital band percentages in our paper (lines 5-9, page number 3712). However, we don't do more analysis because the conversion between sea level and d18O of seawater likely changes through time. For example, smaller ice sheets are likely less depleted in d18O. This would introduce bias to a time series of %sea level. Additionally, this calculation would be relatively sensitive to age model errors and the BWT:d18Osw phase shift described above by the reviewer. Lastly, similar calculations have been presented in several previous publications (eg, Bintanja et al, 2005, Elderfield, 2012, Sosdian and Rosenthal, 2009) and a re-calculation of it here would not be a significant contribution because it would be affected by similar (if not greater) uncertainties."

Referee comment:

"The establishment of the stack allows for it to be compared to available CO2 records and other paleoclimate indicators to elucidate some basic appreciate for the Pleistocene climate. The authors are lacking a critical discussion beyond the stack features and contribution to the d18Oc variability. I would suggest they attempt to provide some added observations."

Authors' reply:

"Section 6 provides some comparison of ice volume versus ice core paleoclimate proxies (e.g., CO2 and d18Oice). We could also add a comparison of the stack's spectra with a CO2 record in our revision. However, a more detailed analysis is not possible due to relative age uncertainty between LR04 and the ice sheet age models (Lisiecki, 2010). "

Referee comment:

"Thirdly, the authors choose to use PCA analysis for this task but don't specify the criteria they used to choose the most appropriate method."

Authors' reply:

"We will add more discussion of our choice to use PCA in the revision. As in our answer to reviewer one, we choose PCA because it allows us to identify similarities and differences between the seven records used. PCA (equivalent to EOF) is also a very commonly used technique to create a stack (e.g., Huybers and Wunsch, 2004; Clark et al, 2012; Gibbons et al, 2014). The first principal component is representative of the common sea level signal and is not largely different from an unweighted mean. Additionally, the subsequent components allow us to examine the other influences on the proxies: e.g., Atlantic vs. Pacific (PC2) and surface vs. deep (PC3). "

Referee comment:

"Specific comments: Section 1 The introduction would be more suitable if the authors provided additional background info around Pleistocene sea level variations, mechanisms, and gaps. Currently it is missing some critical references and doesn't fully introduce the topic."

Authors' reply:

"We will add more detail in our introduction about the current knowledge and gaps surrounding Pleistocene sea level variations."

Referee comment:

"Section 6 -the authors state that 40-65% of the benthic change is related to ice volume-does this derive from their H-LGM estimate and Pleistocene stack approximation?"

Authors' reply:

"The 60% estimate is derived for benthic change from the Holocene-Last Glacial Maximum estimate (page 3713, line 2) while the 40% is derived from our spectral analysis (page 3712, lines 5-9) We will clarify this in revision"

Referee comment:

"The 607 mg/ca-bwt record shows a lead of temperature over ice volume as well. -the authors apply a 2ka lag to the smoothed LRO4 stack to improve the correlation-specify reason for lag"

Authors' reply:

"The lag was empirically found as the phase shift which maximized correlation between benthic d18O and sea level, which we will clarify in the revised text. We will cite both

Sosdian and Rosenthal (2009) and Elderfield et al (2012), to explain that the lag is likely a result of temperature changes."

Referee comment:

"Figure 4C-it is hard to decipher between the two regression lines"

Authors' reply:

"We will make this figure larger and adjust the line styles to enhance the difference between the regression lines."

Referee comment:

"Overall, the authors need to be more precise in their referencing as some are missing."

Authors' reply:

"Thank you. We will address this concern in revision."

References:

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Interactive comment on Clim. Past Discuss., 11, 3699, 2015.