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Interactive comment on "Oxygen isotope composition of final chamber of planktic foraminifera provides evidence for vertical migration and depth integrated growth" *by* Hilde Pracht et al.

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General Comments

This is an interesting paper that thoroughly investigates the δ18O signals recorded by planktic foraminifera using novel small sample isotope ratio measurements. The objectives of the paper are clearly stated and quantitatively investigated with statistical hypothesis testing. The application of rigorous statistical techniques including the clear statement of the null hypothesis and explanation of each test with associated as-

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Discussion paper

sumptions is excellent and should be utilized more in the discipline. Foraminifera are broadly studied by ecologists, oceanographers, and paleoclimatologists, which makes this paper well-suited for publication in Biogeosciences. I fully encourage the publication of this paper after the authors consider some minor suggestions that will provide clarification and more context for their results.

Specific Comments

I recommend the authors also cite Kozdon et al. (2009). Kozdon et al. (2009) used SIMS to measure the d18O values of the ontogenetic calcite and reproductive crust of N. pachyderma to reconstruct the species' water depth migration.

Kozdon, R., Ushikubo, T., Kita, N.T., Spicuzza, M.J., and Valley, J.W., 2009, Intratest oxygen isotope variability in the planktonic foraminifer N. pachyderma: Real vs. apparent vital effects by ion microprobe: Chemical Geology, v. 258, no. 3-4, p. 327–337, doi: 10.1016/j.chemgeo.2008.10.032.

Page 5 - Lines 20-22: How many G. ruber and N dutertrei were analyzed or were they just not weighed and measured for size? Perhaps breaking the description of T. Sacculifer analyses into a subsection within 2.1 will help (or changing the title of this section to be specific to T. sacculifer). What were the additional steps used for T. sacculifers prior to stable isotope analysis? If the additional steps involve the heated block, the authors should also describe how the d18O analyses were performed for the G. ruber and N. dutertrei shells.

Page 6 - Lines 20-21: What is the vital effect d18O correction? I think readers will be able to better interpret Fig. 6b with clarification. Is the correction necessary if you use the d18O-temperature calibration of Mulitza et al. (2003) instead of Kim and O'Neil (1997) (see comment regarding Page 6 – Line 30)?

Page 6 - Line 30: Why use Kim and O'Neil (1997) instead of a foram-based calibration such as Mulitza et al. (2003)? I suggest adding a sentence or two for explanation.

Page 8 - Lines 7-9: I'm not sure how Figs. 5c-d show statistical significance (although the trend is quite obvious visually). Perhaps you could plot the 95% confidence interval on the robust regression (iteratively reweighted least squares) to show the slope is statistically different from zero. Alternatively, you could leave the plot as is and change the sentence to state D18O is dependent upon the d18O of the measured fragment.

Page 9 – Lines 18-19: "above and below 100 m" is a bit vague. Note which water depths have temperatures of 24.5°C and 25.5°C at this site. If 25.5 °C measured from the <F fragment is not in the upper 0-50 m, that would suggest the fragment is also partly composed of GAM crust (see comment for Page 10 -Lines 18-21).

Page 10 – Lines 18-21: I've used image processing of shell walls in cross-section, which suggests that GAM crust composes 32-44% of T. sacculifer shells. I've also used SIMS to analyze the δ18O of PREGAM and GAM calcites in the penultimate chamber of Holocene and Pliocene T. sacculifer shells from several Atlantic and Pacific sites, and have found that the GAM is $\sim$1‰ higher in δ18O than the PREGAM. That work is still in prep, but you could cite one of the following abstracts or my dissertation (refs below). I think Lines 18-21 undervalue the issues with GAM crust so at the very least, I suggest noting that the presence of GAM crust in the <F fraction may skew your results towards higher δ18O (colder temperatures and a deeper depth habitat).

Wycech, J (2017) Novel techniques and approaches to enhance the fidelity of foraminiferal paleoclimate records: University of Wisconsin-Madison, 231 p.

Wycech J, Kelly DC, Kozdon R and Valley J (2016) On the fidelity of δ18Osw reconstructions: comparing paired foraminiferal Mg/Ca-δ18O values from conventional and in situ techniques. Poster, International Conference on Paleoceanography, P-287.

Wycech J, Kelly D, Kozdon R, Fournelle J and Valley JW (2013) Warm Tropical Sea Surface Temperatures During the Pliocene: A New Record from Mg/Ca and δ18O In Situ Techniques. Poster, American Geophysics Union Fall Meeting, PP53C-2016.

Page 11 – Lines 32-33: This section really highlights issues with the δ18O proxy, and suggests that the values do not reflect sea-surface conditions. I love the statistical methods used to reconstruct depth habitats, but the estimates seem too deep relative to culturing and plankton tow observations. For example, foram culturing scientists collect wild G. ruber and T. sacculifer from the upper 20 m of the water column so the probability of finding these species in the upper 50 m is not zero as your δ18O results suggest. I recommend shifting the focus of the section away from where the forams are actually calcifying and focus instead on your δ18O results, why they deviate from field observations, and what this means for others who try to use δ18O to infer ocean conditions.

Page 19 (Fig. 2): I suggest adding labels in the figure to identify the s.l. and s.s. morphotypes of G. ruber (or add a note into the figure caption which numbers are s.l. and s.s.).

Page 21 (Fig. 4B): I think it may help to color code the points based on the morphologies noted in figure 2. I like the inset images and I think you should keep them, but I was curious about the morphology of the shells with high whole shell area and high final chamber area that didn't have a corresponding inset photo (points in the upper right).

Technical Corrections

Even though the mass spec produces δ18O values to many decimal places, values beyond the tenth place are uncertain so d18O values should only be reported to the tenth decimal place (i.e., 0.1‰ precision).

Page 1 - Lines 16-17: I suggest noting the direction of this difference, I.e. "We show that the d18O of the final chamber (δ18OF) is 0.2 ‰ $\pm$ 0.4 ‰ (1σ) higher than the d18O value of the test minus the final chamber (δ18O<F) of T. sacculifer"

Page 1 - Line 17: Specify if sigma is standard deviation or standard error. Also, note

how many shells you analyzed in the parentheses “(n=__)”

Page 2 - Line 16: Remove the double parentheses

Page 3 – Line 2: The word “do” is not necessary

Page 4 - Line 10: Change “were” to “was” if only one test was performed (ANOVA with a post-hoc test)

Page 4 – Line 16: I stumbled over the statement “[. . .] our third objective Seasonality is a [. . .]“ Page 5 – Line 2: Condense the sentence to read “[. . .] same location, which would mean [. . .]”

Page 8 - Line 16: I suggest separating these sentences to read something like “[. . .](Figure 6b). An ANOVA to test whether the species had equal means resulted in a p value of 0.0001 and led to a rejection [. . .]”

Page 10 - Line 8: Change negative to positive (colder SSTs = more positive foram d18O values)

Page 10 - Line 43: Use parentheses only around the year, i.e. “Berger et al. (1978b)”

Page 10 - Line 28: Change the comma to a period

Page 11 - Line 5: Use parentheses only around the year, i.e. “Brummer et al. (1987, 1986)”

Page 11 - Line 6: Use parentheses only around the year, i.e. “Peeters et al. (1999)”

Page 11 - Line 18: Add parentheses around the figure reference

Page 11 - Line 27-29: Use parentheses only around the year, i.e. “Wit et al. (2010)”. The verbiage is a bit awkward. I suggest dividing it into two sentences, I.e. “Wit et al. (2010) stated [. . .], which was inferred from measurements of single species (G. Ruber) at multiple core locations. Here we test [. . .]”.

Page 12 - Line 3: The verbiage is a bit awkward. I suggest, “First, we tested depth

migration and found [. . .]".

Page 12 - Line 7: Similar to line 3 I suggest, "Second, we tested covariance with size and found [. . .]"

Page 12 - Line 8-9: "found" is used twice in the sentence. I suggest deleting the second one, "[. . .] the three measured size classes."

Page 12 – Line 9: If you use my suggestion for lines 3 and 7, this should be consistent, i.e. "Third, we tested [. . .]."

Page 12 – Line 10: Divide into two sentences. "[. . .] archives. Comparison between [. . .]"

Page 12 – Line 21: Remove period after "BM"

Page 14 – Line 12: Remove the extra ", "

Page 17 – Line 24: Remove the extra ", "

Page 17 – Line 31: Add superscript to 18 in δ18O

Page 24 – Line 8: italicize the latin "in situ"

Page 24 (Fig. 6 caption): Add in what the whiskers represent (e.g. 95% confidence interval) and if the horizontal lines within the boxes are the median or mean. The lines are typically medians, but the text compares means of the datasets so you may want to show both the mean and the median (perhaps one as a bold line and one as a dashed line?)

Page 26, 27, 28 (Fig captions): Note what "p(δ18O)" is. I initially thought it was a p-value.

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