Biogeosciences Discuss., 11, C9068–C9080, 2015
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Interactive comment on "Reconciling single chamber Mg/Ca with whole test δ^{18}O in surface to deep dwelling planktonic foraminifera from the Mozambique Channel" *by* J. Steinhardt et al.

J. Steinhardt et al.

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Referee#2: This paper contains a significant amount of geochemical data (d18O, d13C, and Mg/Ca) generated on four species of planktic foraminifera. The authors should be commended for this. I would be willing to review a revised version after significant editing, response to comments within attached pdf, and a careful check of whether the references are appropriate. General comments Referee: The paper badly needs editing. Many paragraphs lack cohesiveness and lack a topic sentence making a clear point followed by supporting observations or arguments. There are also missing words, typos, etc. I highlighted some of these but not all. It would be easier to read and to

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follow the arguments made if data were summarized in tables within the text instead of sentences containing multiple means, standard errors, etc.

Author's response: We have done our best at cross-checking the text for typos and trying to make the paragraphs as cohesive as possible. The data has now been summarized in a table, which should help in making the text easier to read. Several changes were also made in response to reviewer #1 (see above).

Referee: In general, if the data generated are from individual foraminifera, I think analytically sound "outliers" should not be excluded since they reflect the actual variability within the population. Whenever possible show all the data in figures; if it's necessary to summarize, show the range and quartiles (including outliers).

Author's response: We show all data we think are analytically sound. Still, to our opinion this requires the removal of outliers deviating more than 2 SDs from the calculated mean Mg/Ca or δ18O. These values clearly result in unrealistically high seawater temperatures and are therefore probably incorrect. As a compromise we have retained these data within the data set as such, to be uploaded as a supplementary file.

Referee: In several places, the references cited are not appropriate and/or do not say what the sentence claims they say. I highlighted these where I saw them.

Author's response: The suggestions by the reviewer were used to improve citing.

Referee: It is not clear why the Kim and O'Neill paleotemperature equation was used if it does not generate temperatures reflective of actual conditions (section 5.1). This discrepancy was noted in section 5.1 but the remainder of the paper still uses K & O'N. If the different paleotemp equations give such different results it's hard to have confidence in the data interpretation.

Author's response: We noted that using species-specific equations for G. ruber by Fallet et al. (2011) and Wilke et al. (2009) result in SSTs slightly closer to those based on satellite observations. Difference between them and those based on the calibration of

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Kim and O'Neill (1997) are, however, very small and, more importantly, result in similar estimated depth habitats. Using a different equation for the other species (e.g. that of Erez and Lutz, 1977 for N. dutertrei) would result in only a slightly different inferred depth habitat at which 95% of the shell would have been precipitated (∼10 meters). The choice for any of these equations, therefore, does not appreciably change the outcome and conclusions of our calculations. The fact that these different calibrations give such similar results gives us confidence in the inferred depth habitats, opposite to the reviewers' suggestion. This misunderstanding comes probably from the differences in using actual in situ temperatures versus annual averages. We have now made this clearer in the manuscript.

Detailed comments

Referee: Shouldn't this read "below the thermocline"? Species living below the mixed layer but within the thermocline would show more variability than either mixed layer dwellers or deeper dwellers.

Author's response: We agree with the referee that the sentence should rather state that these species calcify mostly below the thermocline. We changed the sentence accordingly.

Referee: Marked paragraph referring to comment c) not appropriate references. . .

Author's response: To our opinion the Eggins, 2003, Hathorne, 2009 and Kunioka papers are all highlighting Mg/Ca heterogeneity, being measured with different approaches. In this case we, therefore, think that these references are appropriate.

Referee: Given the spatial and temporal patchiness of phytoplankton blooms I would consider these chl-a values to be the same (ie no seasonal variability).

Author's response: We used these numbers to underline the fact that the MC is an oligotrophic area, but indeed they are not in line with a seasonal contrast. Still, as this seasonal contrast is well-known we have omitted specific numbers and only state that

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the MC is generally an oligotrophic area.

Referee: p. 17261, line 24: The mooring location is NOT shown in Figure 1 - needs to be added

Author's response: This Figure has been changed accordingly and now includes the mooring transect and the trap location.

Referee: p. 17262, line 3- 6: How well does the timing of these cruises match up with the sediment trap collection times (based on presence/absence of eddies)? How much difference in the reconstructed d18O temperatures would it make if you were wrong? This could be addressed with a single sentence.

Author's response: The method for eddy-detection and the matching of eddy intervals with the sediment trap intervals has been described in Steinhardt et al., 2014 in detail. We have now added the appropriate reference into the method section 3.2 (p. 17261, at line 25).

Referee: p. 17263, line 4-7: reword; perhaps 2 sentences.

Author's response: We agree and rephrased the sentence to "The Mg/Ca ratios of single chambers used in this study were previously published (Steinhardt et al., 2014)".

Referee: p. 17263, line 26-28: Does this screening refer to the laser ablation data for each individual spot? Or does "dataset" refer to the values obtained from the 695 ablation spots, or the data from the 373 individuals? Be more specific here. If data from individual foram outliers are excluded you are losing information about the population variability of that species by excluding them.

Author's response: We refer to a previous paper, Steinhardt et al., 2014.

Referee: p. 17264, line 20-23: Same comment: If the analyses are sound (ie the reason for the >2s offset is not analytical) you are losing information about population variability if you exclude outliers from further interpretation. I suggest you at least

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include them in the data table. The actual range of values obtained from a large sample set is important to preserve - you might pass on the impression to other researchers that the population variability is less than it actually is.

Author's response: We follow the reviewer's suggestion to add these points to the data table. We chose to remove the outliers (i.e. values deviating more than 2 SDs from the calculated mean Mg/Ca or δ18O) from the figures, see also above.

Referee: p. 17265, line 9: This intercept suggests that the source of the fresh-water end member is quite depleted in O-16, possibly indicating a contribution from AA. Did you try developing this relationship for eddy vs non-eddy conditions? I wonder if the fresh-water end member differs under different eddy conditions. How would an error in the S-δ18Ow relationship propagate through into the final δ18O-T?

Author's response: We did consider changes in δ18Osw, based on the salinities measured by the moorings into the δ18Oeq calculations for eddy vs non-eddy. This is still an approximation as salinity and δ18Osw are not one to one coupled, but in this area it will be very close. Hence, although we agree, that measured δ18Osw for eddy and non-eddy intervals would improve the model the difference expected is very limited. Since we do not have δ18Osw during specific eddy or non-eddy intervals it is not possible to further expand on this.

Referee: p. 17265, line 15-17: This sentence is convoluted: I think you mean that you used the averaged δ18Osw from the appropriate interval to calculate Tiso (you are not comparing δ18Osw with Tiso; that's comparing apples and oranges).

Author's response: We changed the sentence accordingly to: "We used averaged δ18Osw from the depth range suggested by previously measured single chamber Mg/Ca analyses (Steinhardt et al., 2014), to calculate δ18O-calcification temperatures, following the temperature equation of Kim and O'Neil (1997)"

Referee: p. 1726, line 4 - 12: I think the info in this paragraph would be easier to follow

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and more succinct if included in a table. Also, state that all errors will be reported as standard error unless otherwise stated, and then report mean±SE; this will save space too. And it's consistent with how means/errors are reported later in the paper.

Author′s response: We followed the referee's suggestion and added a table with the Mg/Ca, δ18O and δ13C results. To the manuscript (Tab. 1), including standard errors and standard deviations, as well as calculated calcification temperatures.

Referee: p. 1726, line 4 – 12: The last phrase ("corresponding to...") doesn't follow - is the 14°C a temperature difference? If not, include the temps for all three species - better still, include a table

Author′s response: We followed the referee's suggestion and included a table (Tab.1) with the results.

Referee: p. 17267, line 11-12: Since you determined size by sieving (not by individual size measurements), you should say "no significant trend between size fraction ...". The range of sizes in a given sieved sample is greater than the nominal range of the sieve.

Author′s response: We changed the sentence accordingly.

Referee: p. 17267, line 26-27: I see two groupings in the G. scitula data in Figure 2, rather than a linear relationship. The upper group (more depleted δ18O) has more scatter in both δ18O and δ13C. Is one group from eddy conditions and the other from non-eddy conditions? Do these groups also look different in Mg/Ca?

Author′s response: We agree that the G. scitula data looks divided into two clusters. We noted this at an early stage already, but were not able to establish a relation with other parameters, either measured on the same specimens (Mg/Ca) or related to the environment (eddy vs. no-eddy).

Referee: p. 17267, line 26-27: In the caption for Figure 2, say what the error bars represent (analytical error?).

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Author's response: We have added this to the figure caption.

Referee: p. 17268, line 9: I would rather see the actual data points in Figure 3, including analytically sound outliers, rather than a summary measure. If summary is absolutely necessary, show the range and quartiles (box and whiskers plot).

Author's response: We did not plot the outliers (i.e. values deviating more than 2 SDs from the calculated mean Mg/Ca or δ18O), but maintained the data in the tables. See also discussion earlier in the review. Referee: p. 17268, line 10: A summary table would be easier to read and would probably save space.

Author's response: We have added a table with the results to the manuscript.

Referee: p. 17268, line 11:There is no discussion here of the left panel of Figure 4 - I suggest removing it if space is a consideration

Author's response: We have changed the sentence accordingly, referring now to Eq. 3.

Referee: p. 17269, line 8-11: You don't state which relationship you are finally going to use. If you think the Kim and O'Neill relationship gives inaccurate results, revise section 3 to state that you use Fallet et al or Wilke (one or the other) and stick to it.

Author's response: We use the Kim and O'Neil equation, which is stated in the method description

Referee: p. 17269, line 19:

Author's response:We followed the referee's suggestion and rephrased sentence to: "In addition to its shallow living depth, G. ruber is known to occur in some areas relatively equally throughout the year. . ."

Referee: p. 17269, line 26: Using which paleotemperature equation?

Author's response:We use the Kim and O'Neil equation. This is now stated in line 26.

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Referee: p. 17270, line 15-16: This idea is outdated - see Eggins et al 2006 and Spero et al 2015

Author's response: Spero et al., 2015 is investigating cultured specimens of the symbiont bearing species O. universa. This species is generally regarded as atypical, both in terms of its test development and unusually high bulk Mg/Ca composition (Sadekov et al., 2005). The banding of O.universa has been linked to day and night cycles, which is not relevant for deeper dwelling species. We are not aware of an Eggins et al., 2006 paper dealing with Mg/Ca heterogeneity in planktonic foraminifera. Both Web of Science and Scopus do not show any paper from Eggins et al. in 2006.

Referee: p. 17270, line 19: This paper was written before banding was identified and shouldn't be cited as such. This sentence should be deleted or updated with more recent literature (especially see Spero et al. 2015, EPSL but also Eggins et al. 2006.

Author's response: The paper cited, "Mg/Ca variation in planktonic foraminifera tests: implications for reconstructing palaeo-seawater temperature and habitat migration" from Eggins et al. (2003) in EPSL is specifically dealing with banding in foraminiferal test walls. This is one of the first papers showing banding in Mg/Ca and although no explanation was given at the time, this is exactly what we are referring to.

Referee: p. 17272, line 4: How does this differ if you use Fallet's relationship?

Author's response: Using the Fallet's relationship, the δ18Oexp are higher than the measured δ18OCC of G. ruber and hence we would overestimate the cumulative δ18Oexp. This is related to the fact that mean SST during non-eddy are higher than mean annual SST's used by Fallet et al. (2010) for their empirical calibration. Since we do not refer to annual but in situ conditions our observations are closer to the calculated temperature based on Kim and O'Neil (1997).

Referee: p. 17272, line 9-12: This sentence is very confusing - reword.

Author's response: We rephrased the sentence to: "During eddy conditions, P.

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obliquiloculata calcifies between 89 and 124 m (average 107 m), whereas it calcifies at shallower depth, between 20 and 77 m (average calcification depth 60 m) during non-eddy conditions".

Referee: p. 17272, line 20: This entire paragraph is very confusing. The first sentence should clearly state what the main point is, and the remaining sentences should back that up with observations.

Author's response: We changed the order of this paragraph. "While Mg/Ca-based temperatures of G. ruber and N. dutertrei record eddy induced changes in upper water column stratification, δ18O-based temperatures suggest relatively similar calcification depths for both species (Fig. 6). Using the paleo-temperature equation (equation (1); Kim and O'Neil, 1997) and fitting δ18Ocalc with δ18Occ, we find that. . ."

Referee: p. 17273, line 3: or the wrong paleotemp equation - what if Fallet's relationship is used?

Author's response: Even if a different temperature equation is applied, the variability will still be larger. Only the absolute values depend on the calibration used, not the variability. Referee: p. 17275, line 14: Where is equation 6?

Author's response: We corrected the numbering for the equations.

Referee: p. 17276, line 17-18: The "vital effect" correction should be discussed earlier, with the discussion of the model itself.

Author's response: We already mentioned vital effects in the earlier section of the discussion (5.1), but restate the issue at the model paragraph.

Referee: p. 17277, line 11-12: Discuss with the discussion of the model itself and show exactly how the original model was changed (ie how the equation was changed).

Author's response: The Wilke et al. model was followed closely. The main difference was that we use the Mg/Ca value of the F-1 chamber to constrain the 95% calcification

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level. This is now added to the manuscript.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/11/C9068/2015/bgd-11-C9068-2015-supplement.zip

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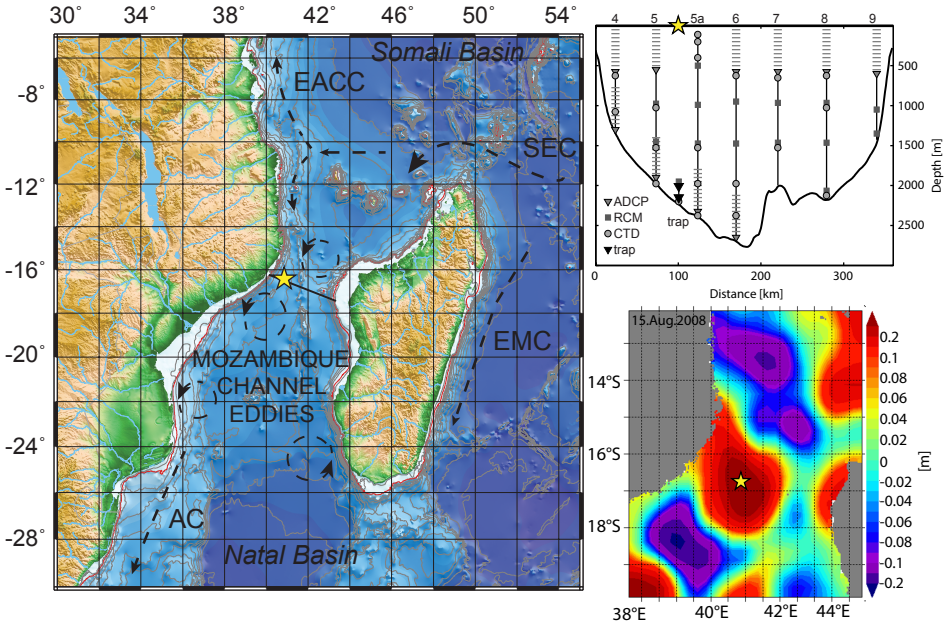

Fig. 1. Figure 1: Hydrography of southwestern Indian Ocean and location of the sediment trap (star) within the mooring array (right top). On the right bottom a map of sea level anomaly shows the passing of an

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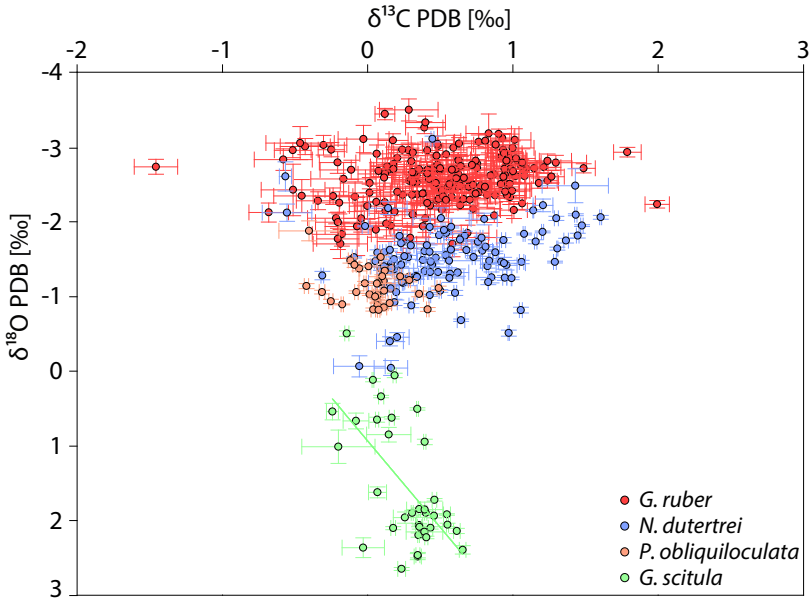

Fig. 2. Figure 2: Scatter plot of single shell δ13C versus δ18O with analytical error. Note the linear relation in G. scitula (r2=0.388, p<0.001).

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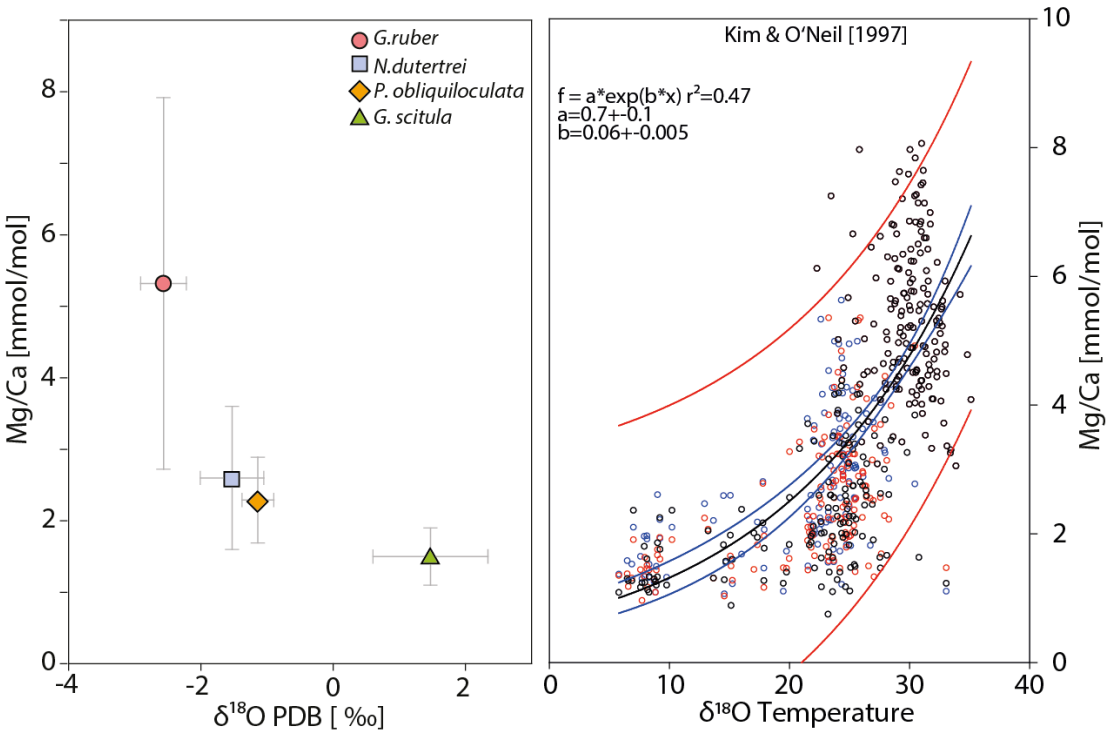

Fig. 3. Figure 4: Scatter plot of Mg/Ca versus δ18Occ (left panel). Right panel: single chamber Mg/Ca exponential relationship with δ18O-derived Temperatures calculated using Kim & O'Neil (1997). Regression:

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