

## ***Interactive comment on “Reconciling single chamber Mg/Ca with whole test $\delta^{18}\text{O}$ 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#1: General comments The paper of J. Steinhardt “Reconciling single chamber Mg/Ca with whole test  $\delta^{18}\text{O}$  in surface to deep dwelling planktonic foraminifera from the Mozambique Channel” is supposed to be published in “Biogeosciences”. Primary goal of the submitted paper is to reconstruct calcification and migration patterns of various planktonic foraminiferal species based on single-chamber Mg/Ca and single foraminiferal test  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$ . Sample material is from a deep ( $\sim 2.250$  m) sediment trap from the Mozambique Channel. The novel analytical results have been supported by a convincing depth resolved mass balance model. The overall topic is of quite large

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interest to the paleoceanographic community, which is commonly using foraminiferal tests as biotic carriers for geochemical proxy parameters. The manuscript shows that the authors spent quite a lot of work into this study, and the results for sure deserve publication. The paper is very well-written, concise, and clearly structured, and the figures are mostly of high quality. Error calculation and statistics are exemplary! Nonetheless, I hesitate to recommend this paper for publication without explicit improvement and thorough revision. First, the manuscript is very complex, and it affords very thorough reading. It could gain from shortening by leaving out the last chapters on foraminiferal  $\delta^{13}\text{C}$ . Second, the advantage to infer calcification and migration patterns of planktonic foraminifera from deep ( $>2000$  m) sediment trap material raises criticism as long it is not shown that results clearly differ from studies based on sediment surface material directly from below the trap. Sediment surface material should in fact be available in this region! Also and in particular with respect to the foraminiferal Mg/Ca data, it needs at least to be discussed whether and how foraminiferal Mg/Ca could have been altered by calcite dissolution processes during settling from the ocean surface to depths below  $>2000$  m. Overall, the study pinpoints the necessity to strengthen efforts to carry out plankton net studies. Third and similarly important, the author should cautiously avoid any suspicion on plagiarism. Large parts of Chapter 2 (Oceanographic setting) and Chapters 3.1, 3.3, and 3.4 were one-to-one taken from Steinhardt et al., 2014 (Marine Micropaleontology 113, 20–33). Plagiarism in science, in fact, is an important issue and is very precisely defined. Official guidelines should be considered by the author is very precisely defined. Official guidelines should be considered by the author.

Referee: First, the manuscript is very complex, and it affords very thorough reading. It could gain from shortening by leaving out the last chapters on foraminiferal  $\delta^{13}\text{C}$ . Author's response: We agree with the reviewer that the paper was somewhat long and that shortening improves the clarity of the discussion. We think that it is still worthwhile to keep the discussion on  $\delta^{13}\text{C}$  in the paper, as this is the only independent data available to cross-validate the proposed calcification depth model based on  $\delta^{18}\text{O}$ . Instead, we shortened our manuscript by deleting parts of sections 5.3.3 and 5.3.4, which de-

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scribed other factors in detail that could potentially affect calcitic  $\delta^{13}\text{C}$  and included a short paragraph summarizing the content of 5.3.3 and 5.3.4 in 5.3.2. Furthermore we deleted the second paragraph of the original section 5.3.4 streamlining this part of the discussion. We also shortened the text of the results section by putting the Mg/Ca and  $\delta^{18}\text{O}$  results in a table (Table 2). Together with several other more modest changes (see below) we think that overall readability of the manuscript has significantly improved. Referee: the advantage to infer calcification and migration patterns of planktonic foraminifers from deep (>2000m) sediment trap material raises criticism as long it is not shown that results clearly differ from studies based on sediment surface material directly from below the trap. Sediment surface material should in fact be available in this region! Also and in particular with respect to the foraminiferal Mg/Ca data, it needs at least to be discussed whether and how foraminiferal Mg/Ca could have been altered by calcite dissolution processes during settling from the ocean surface to depths below >2000 m. Overall, the study pinpoints the necessity to strengthen efforts to carry out plankton net studies. Author's response: The main advantage of using sediment trap material is that we can link the chemistry of the shells to actual ambient in situ measurements from the moorings and from real-time satellite derived observations. Therefore we are able to link short time changes in hydrography (i.e. eddies) to the differences in shell chemistry. This is now added to the manuscript (section 3.1). The reviewer is correct in that dissolution of (the surface of) foraminiferal shells might potentially affects their geochemistry. However, a previous study of Fallet et al. (2012) showed that in the Mozambique Channel, foraminiferal shells are not affected by dissolution by comparing size-normalized weights from specimens from core-tops and from sediment trap samples (~2000 meters). This indicates that dissolution did not affect our foraminifers and therefore their Mg/Ca,  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  reflect the original signal. This is in line with excellent preservation of foraminifera from core tops at ~3000 meters in the northern part of the Mozambique Channel (Birch et al., 2013). This information has been added to the revised version of our manuscript (section 3.3, p.17263 after original line 2). Referee: Third and similarly important, the author should cautiously avoid any suspicion

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on plagiarism. Large parts of chapter 2 (Oceanographic setting) and Chapters 3.1, 3.3, and 3.4 were one-to-one taken from Steinhardt et al., 2014 (Marine Micropaleontology 113, 20-33). Plagiarism in science, in fact, is an important issue and is very precisely defined. Official guidelines should be considered by the author. Author's response: Sections 2, 3.1, 3.3 and 3.4 appear indeed very similar to corresponding sections from Steinhardt et al. (2014). The reason for this is that we used similar material for this and our previous study. Some repetition of e.g. description of methods and oceanographic settings is therefore hard to avoid. For example, the first sentence of section 3.4 already referred to Steinhardt et al. (2014) to point out the similarity between the introductory parts of these papers. However, we agree with the reviewer that we should avoid even the suggestion of duplication of sections of previous publications. Therefore, we cautiously reconsidered the text of sections 3.1 and 3.3. Moreover, we deleted the previous section 3.4 to avoid unnecessary overlap with Steinhardt et al. (2014). Instead, we added a sentence at the beginning of section 3.5 (3.4 in the new version of our manuscript) to refer to our previous paper regarding the laser ablation measurements. We have also referenced Steinhardt et al. (2014) throughout sections 3.1 and 3.3 to explicitly indicate similarity of parts of the approach between these two studies. Few comments and suggestions:

Referee: Abstract: The abstract needs to be shortened and focussed. Avoid "too long" introductory passages. Avoid repetitions as "Here we present. ...".

Author's response: We have condensed our Abstract, which now measures 228 words instead of 317 words in the previous version.

Referee: Methods Chapter, p. 17265, line 4: Provide exact information on  $\delta^{18}\text{O}_{\text{sw}}$  database from the South Indian Ocean: chart, table, e.g. in supplement. Author's response: We added a supplementary table with  $\delta^{18}\text{O}_{\text{sw}}$  information. This contains salinity, temperature and seawater  $\delta^{18}\text{O}$  with a depth resolution of approximately 20 meters. The data as such was already referenced in the original submission.

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Referee: Chapter 4.1: Although the Mg/Ca data were already published in Steinhardt et al. (2014), a diagram summarizing those results would have been helpful. Author's response: We added a table (Table 1) summarizing the Mg/Ca results of Steinhardt et al. (2014) and added a summary of the newly measured  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  of the same specimens.

Referee: Conclusions: Change the ordering of conclusions. First, describe  $\delta^{18}\text{O}$  and Mg/Ca, then  $\delta^{13}\text{C}$ , in accordance with the structure of the paper. Author's response: We agree with the author and changed the ordering of the conclusion. We now describe  $\delta^{18}\text{O}$  and Mg/Ca, then  $\delta^{13}\text{C}$ , in accordance with the structure of the paper.

Detailed comments: Referee: Fig. 1: I would suggest to present a detailed chart showing eddies in the Mozambique Channel in much higher resolution, e.g. as sea surface height anomaly map or so. The overview chart could then be taken as inset. Also, the exact positions of the sediment trap PP5 and the CTD location lmc5A need to be shown in detail. Provide info on: How large is the distance between both:  $0.3^\circ = 20 \text{ nm}$ ? How is that in relation to the diameter of an eddy ( $\sim 300 \text{ km}$ ?).

Author's response: Figure 1 has been changed and now includes a detailed mooring array with the location of the sediment trap as well as a sea level anomaly snapshot showing the passing of an eddy during the deployment.

Referee: Fig. 2: Provide regression line for *G. scitula*.

Author's response: Figure 2 has been changed and includes now the regression for *G. scitula*.

Referee: Fig. 4: I would recommend to use different symbols for different species. The author should clarify in the figure caption whether the data – at least parts - were published elsewhere. Add an introductory sentence summarizing the intention of the figure.

Author's response: Figure 4 has been changed accordingly, using different symbols

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for different species and reference to original publication of the Mg/Ca data has been added.

Referee: Fig. 5: The figure caption should appear more self-explanatory and should provide more information on how the temperatures were calculated. Refer to the text or provide equations/references. Legend could be taken out, if the according information would be included into the figure caption. Add an introductory sentence on the intention of the figure.

Author's response: The figure caption has been changed accordingly, adding information on how temperatures were calculated.

Referee: Fig. 6: Symbols are difficult to distinguish! Make larger. Enlargen font! Indicate in figure caption, which symbol belongs to which species (squares = *N. dutertrei*?). Indicate what the large boxes mean: calcification depth ranges, color-coded for different species (green = *G. scitula*?)? Colored frames of boxes should be thicker. Check figure captions for typos. Add an introductory/summarizing sentence, e.g., "Apparent calcification depths of species are generally shallower during non-eddy conditions".

Author's response: Figure 6 has been changed. Font and symbols were enlarged and boxes are now more clearly indicated. Figure caption was checked for typos and changed accordingly. An introductory sentence has been added.

Referee: Fig. 7: Although this figure is very complex, it nicely brings together the major outcome of this paper. Unfortunately, the figure/labels/symbols are much too small and the authors need to find a way to considerably improve the figure. The many legends may be taken out and explained in the figure caption.

Author's response: We have attended the figure size issue by separating it into different parts, with the first part being applicable to all species considered, and the species all having a separate box. We also changed the fonts and made some room for the legends.

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Referee: Reference list: The list is not yet complete and should be checked (e.g., Hut et al., Regenberg et al.). The list would gain from additions of still missing important contributions of others to the topic. The paper should include a statement, in which databank the data will be electronically stored.

Author's response: Reference list has been checked and missing references were added accordingly. We added a reference to indicate that the data is now given in a supplementary file.

Referee: Page 17268, line 11: Must be Eq. 3 instead of Eq. 4

Author's response: Has been changed accordingly.

Referee: Page 17268, line 21: Full stop missing after *G. scitula*.

Author's response: Has been changed accordingly.

Referee: Page 17268, line 24: Must be Eq. 3 instead of Eq. 4

Author's response: Has been changed accordingly

Referee: Page 17268, line 11: Consistently use the term Tiso or  $\delta^{18}\text{O}$ -derived temperature in text and figures.

Author's response: We changed the term to  $\delta^{18}\text{O}$ -derived temperature consistently throughout the manuscript.

Referee: Page 17269, line 27: If I interpret Fig. 6 correctly, the calcification depths of *N. dutertrei* range between ca. 20 m and 130 m (blue squares????). Overall, the specifications of calcifications depths in the text should be congruent to what is shown in Fig. 6.

Author's response: This has been changed accordingly.

Referee: Page 17272, line 10: check wording of sentence!

Author's response: We have checked the wording and changed it accordingly.

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Referee: Page 17273, lines 22-24: Support these results by figure or reference. It is not obvious from where these results originate from.

Author's response: We have added the according reference for these results at line 24.

Referee: Page 17273, line 27: Check for typo.

Author's response: Has been changed accordingly.

Referee: Page 17274, line 14: Check for typo.

Author's response: Has been changed accordingly.

Referee: Page 17276, line 7: Check wording.

Author's response: Has been changed accordingly

Referee: Page 17279, line 7: Check for typo.

Author's response: Has been changed accordingly

Referee: Page 17279, line 13: Check for typo and wording.

Author's response: Has been changed accordingly

Referee: Page 17282, line 17: Change FS into R/V.

Author's response: Has been changed accordingly

Referee: Entire text: Stay consistent with wording: either foraminiferal "test" or "shell".

Author's response: This has been changed accordingly throughout the manuscript to the wording "shell".

Please also note the supplement to this comment:

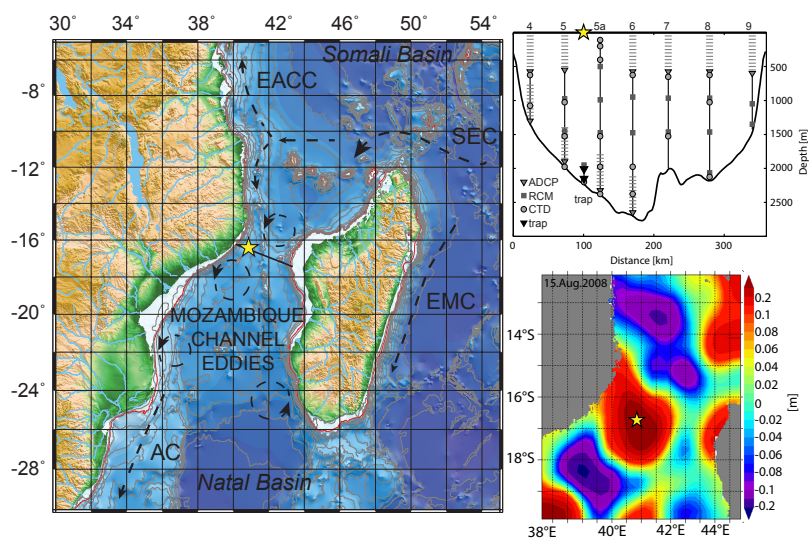
<http://www.biogeosciences-discuss.net/11/C9054/2015/bgd-11-C9054-2015-supplement.zip>

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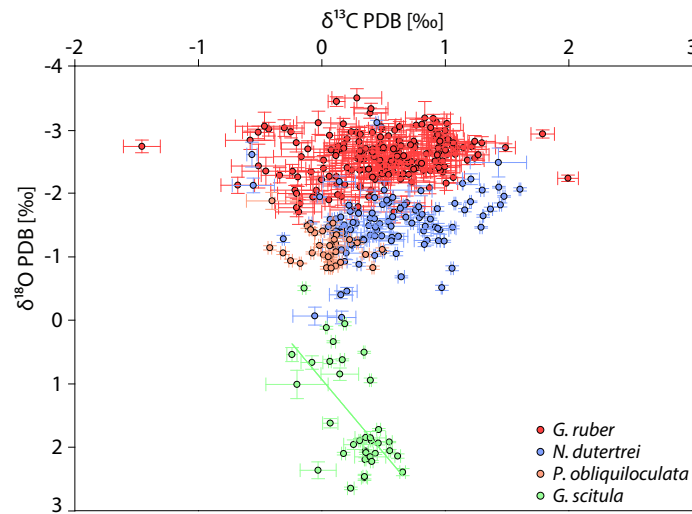


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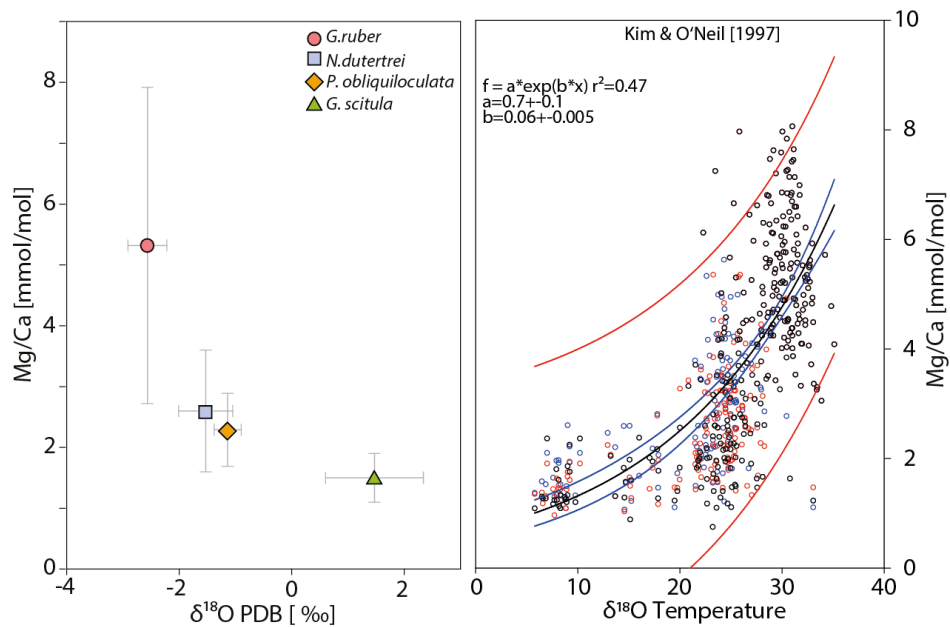
**Fig. 1.** Figure 1: Hydrography of southwestern Indian Ocean and location of the sediment trap (star) within the mooring array (right top). On the right bottom a map of sea level anomaly shows the passing of an

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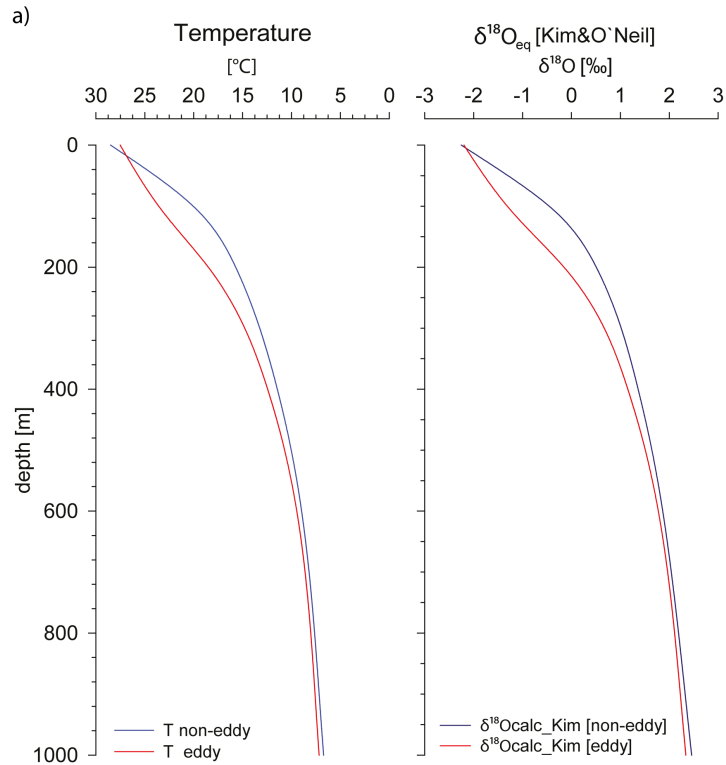
**Fig. 2.** Figure 2: Scatter plot of single shell  $\delta^{13}\text{C}$  versus  $\delta^{18}\text{O}$  with analytical error. Note the linear relation in *G. scitula* ( $r^2=0.388$ ,  $p<0.001$ ).

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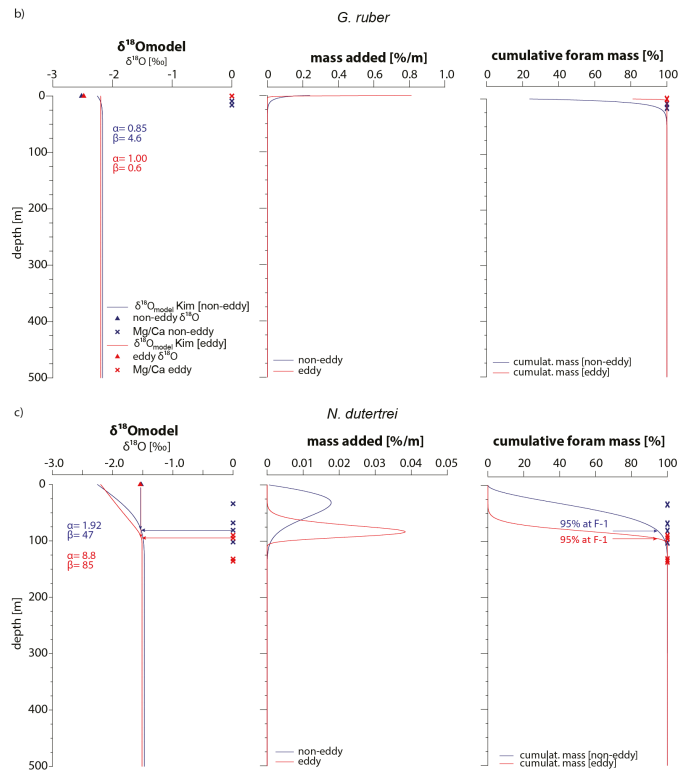
**Fig. 3.** Figure 4: Scatter plot of  $\text{Mg}/\text{Ca}$  versus  $\delta^{18}\text{O}_{\text{occ}}$  (left panel). Right panel: single chamber  $\text{Mg}/\text{Ca}$  exponential relationship with  $\delta^{18}\text{O}$ -derived Temperatures calculated using Kim & O'Neil (1997). Regression:

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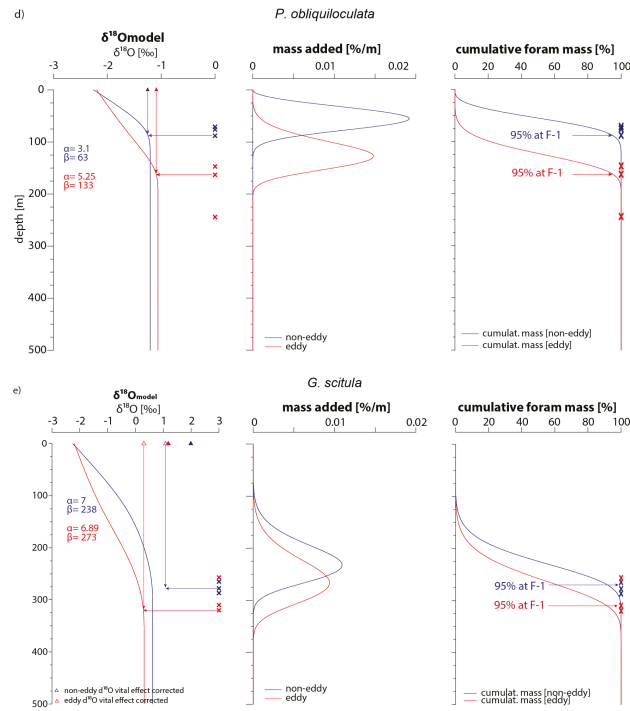
**Fig. 4.** Figure 7: Cumulative calcification model for eddy (red) and non-eddy (blue) conditions from left to right: temperature profiles as well as  $\delta^{18}\text{O}_{\text{equilibrium}}$  ( $\delta^{18}\text{O}_{\text{eq}}$ ) for the upper 1000 m and  $\delta^{18}\text{O}_{\text{cummul}}$

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**Fig. 5.** Figure 7: Cumulative calcification model for eddy (red) and non-eddy (blue) conditions from left to right: temperature profiles as well as  $\delta^{18}\text{O}_{\text{equilibrium}}$  ( $\delta^{18}\text{O}_{\text{eq}}$ ) for the upper 1000 m and  $\delta^{18}\text{O}_{\text{cummul}}$

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**Fig. 6.** Figure 7: Cumulative calcification model for eddy (red) and non-eddy (blue) conditions from left to right: temperature profiles as well as  $\delta^{18}\text{O}_{\text{equilibrium}}$  ( $\delta^{18}\text{O}_{\text{eq}}$ ) for the upper 1000 m and  $\delta^{18}\text{O}_{\text{cumul}}$