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Interactive comment on "Environmental controls on the *Emiliania huxleyi* calcite mass" *by* M. T. Horigome et al.

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We wish to thank Reviewer #1 for the detailed analysis of our paper, which have been very helpful and greatly improved the quality of this manuscript. A detailed reply to each comment follows below:

1. page 9290 L. 24: Calcite mass calculation: There are some issues with the method used for the mass calculation of coccoliths. Apparently the method used for the calculation of single coccolith mass is based on a ïňĆawed calibration method (see the recent paper by Bollmann Biogeoscience Discussions 10, 11155-11179). Therefore, all data presented in this study are potentially wrong and the difference between the presented results and the results of Beaufort et al. (2011) might be simply caused by different calibrations. This is a serious problem as potentially all data collected with the

method ïňĄrst published by Beaufort (2005) are not comparable (see also the Biogeoscience Discussions paper by Bauke et al., bgd-10-9415-2013). This issue needs to be addressed including how the light intensity was controlled between samples.

Author Response: The new method described by Bollmann (2013) in BGD offers a new, interesting, and promising approach for calculating coccolith carbonate weight. Both methods (this study and that of Bollmann (2013)) are useful tools and have both strengths and limitations. As requested by Poulton and colleagues, we wish here to clarify our methodological approach and elaborate on the points raised by Bollmann. One of the main issues raised is that the calibration performed using our method relies on the use of inappropriate pure crystalline calcite particles. The author argues that particles of 1 to 5 μm are outside the valid range of 0 – 1.55μm thickness proposed by Beaufort (2005). This statement would be true if the considered particles were spherical. But, the particles that were used by Beaufort (2005) and in this study have an elongated shape as shown in Figure R1, making those particles appropriate for the calibration (i.e. within the valid range of 0 – 1.55 μm).

Another point is related to the accuracy of the weight transfer function calibration. This is potentially limited by the random particle orientation on the slide and not showing necessarily their maximum interference colour/grey value as they are randomly distributed with respect to the Crossed Polariser. This is an important points that it is continuously tested and validated. It is important to note that coccolith crystals are built very regularly with respect to the orientation of their calcite elements and are aligned in a circle, leading to the extinction cross. It could be argued that a randomly orientated calcite powder would have the same proportion of the powder in extinction as the elements in a coccolith. When the powder is ïňĄne enough (same coccolith size), also the slight differences due to different orientations could be minimized".

When comparing the data of E. huxleyi/small placoliths (n=70) presented in figure 2A (Bollmann, 2013) to our raw data (n=10333) (Figure R2), it is clear that the measurements performed by Bollmann (2013) do not cover a wide range of natural variability

of coccoliths' morphometry. This is most likely due to the low number of specimen measured in his study. However, it is interesting to note that ∼74.5% of the specimens (∼7700) measured in our study are in agreement with the values obtained by Bollmann (2013) if we take into account the accuracy of his method (see light grey boxes in the Figure R2).

Finally, the method developed by Beaufort (2005) and used in our study, in most cases, is in good agreement with others methods (Bollmann, 2013, Young and Ziveri, 2000) to estimate the calcite mass of an individual coccolith.

2. page 9291 line 23: Taxonomy/automated recognition: The authors used the SYRACO-program (Beaufort & Dollfus, 2004) to automatically identify coccoliths of E. huxleyi and G. oceanica. The system has been used successfully in a number of studies but apparently it cannot distinguish between small placoliths (<3 μm E. huxleyi, gephyrocapsids/reticulofenestrids). According to ïňĄgure 2 all length measurements are smaller than 2.6 μm and therefore, might include placoliths of other species than E. huxleyi. This is supported by the fact that the size spectrum of EHUX seems to be biased towards smaller coccolith lengths (min. 2.1μm max. 2.6μm) compared to the global average size spectrum (min 2.7μm – max. 3.7μm, see Bollmann et al. 2009). The biased size spectrum points to a) a size calibration problem or b) a taxonomic/recognition problem. Placoliths smaller than 2.4μm are mainly G. ericsonii or G. protohuxleyi. A taxonomic problem can be expected if the analysis were solely done on a light microscope. See also the Biogeoscience Discussions paper by Bauke et al., bgd-10-9415-2013.

Author Response: The values presented in our manuscript are averaged values. The raw data show a larger spectrum for the length (see Figure R2). We agree that the SYRACO (as much as the human eye) may have some difficulties to differentiate the different species found in the small placoliths. However, in the study area E. huxleyi is the most abundant species representing up to 75% of the assemblages (Boeckel and Baumann, 2008). Then even if some small placoliths (i.e. a mix of E. huxleyi,

gephyrocapsids/reticulofenestrids) are included into our data, they would have a negligible effect on the averaged mass of E. huxleyi, notably because of the large number of specimen (at least 150) analyzed for each sample.

3. page 9220 line 3: Sample selection/quality: The ms states that all samples were taken well above the lysocline insinuating that there is no preservational bias, e.g. calcite dissolution. As calcite dissolution already takes place well above the lysocline, I suggest to analyse the preservation of E. huxleyi coccoliths on SEM images and use a fragmentation index of E. huxleyi to quantify the preservation status. Furthermore, 14 out of the 70 samples are from depths greater than 4000m and I doubt that the preservation of E. huxleyi is sufiňĄcient to calculate the mass. Author Response: The modern hydrographic lysocline is around 4300-4400 m in the South Atlantic (Broecker and Peng, 1982). Moreover, it has been shown that extremely high coccolith carbonate contents exist even down to 4700 m in the South Atlantic (Baumann et al., 2004a; Baumann et al., 2004b)! Thus, coccoliths - or at least some species as E. huxleyi or the Gephyrocapsids - seem to be very resistant to dissolution (as already observed by Schneidermann, 1973 or by Berger, 1973). The preservation of the selected samples is generally good and has been documented by SEM work in Boeckel et al., 2006 and Boeckel and Baumann (2008). Assemblages preserved in samples from water depths less than 4000 m of course might be affected by dissolution, in areas of high TOC content, as at the continental margin of SW-Africa and thus in the periphery of the Namibian Upwelling. But in the present study most of the samples are from areas far away from the upwelling-influenced high-productive areas.

4. P. 9291 line 23: Sample preparation: I am not aware of any standard sample preparation published by Henderiks and Torner (2006). Henderiks and Torner compared the quality of the generic smear slide method and the spraying method. I wonder which method was used to prepare the samples.

Author Response: We will revise this reference for smear slide preparation. Smear slides were prepared following a standard procedure (Bown and Young, 1998).

5. The signiïňĄcance of the G. oceanica analysis is not clear. Why was G. oceanica analysed and why are the data lumped together with EHUX data?

Author Response: In the study of Beaufort et al 2011, the averaged coccolith mass presented in fiure 1b takes into account E. huxleyi and its different morphotypes as well as the gephyrocapsids and the reticulofaenestrids (placoliths sensu lato). In order to have a comparable dataset, we decided to put together E. huxleyi and G. oceanica (when G. oceanica was present in the samples) as shown in figure 4. This is why the averaged mass presented here is of ∼6pg since it takes into account E. huxleyi and G. oceanica. However, as our dataset (E. huxleyi + G. oceanica) did not reflect the entire variability attributable to the placoliths, we decide to add in figure 4 of the revised manuscript the average of the measurements for the placoliths instead of E. huxleyi and G. oceanica only.

6. Figure 1 is misleading as it shows SEM images of coccospheres. I suggest showing light microscope images of the different EHUX morphotypes instead.

Author Response: The SEM images presented in figure 1 are coccospheres and they were added to gave a visual example of E. huxleyi coccolith mass variability. We will remove these images from the revised figure 1. We would like to highlight that it is almost impossible to accurately distinguish the different E. huxleyi morphotypes by light microscope. Since these samples have been previously studied for coccolithophore assemblages by SEM, we are using these published results to support and help the interpretation of our results.

7. Figure 3b shows placolith weights up to 5pg. However, in ïňĄgure 2b only values up to 3.5pg are shown. What is reason for that?

Author Response: Thanks for highlighting this. There was a mistake concerning figure 2b. The mass of E. huxleyi can go up to 5pg. This will be changed in the revised manuscript.

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FIGURE CAPTIONS: Figure R1: Image of 100 of the pure crystalline calcite particles that were used for the calibration. Please note that due to their shape the thickness of those particles are in the valid range of 0 – 1.57μm necessary for the method.

Figure R2: Comparison between the measurements performed by Bollmann (2013) (red squares) and our study (open blue circles). The error bars accompanying Bollmann's series are extracted from his manuscript. The light grey boxes represent the full range of variability in agreement with his method. Please note that the regular pacing of our data along the X axis is only due to the resolution of our system which is 1 pixel ($\sim$0.15μm).

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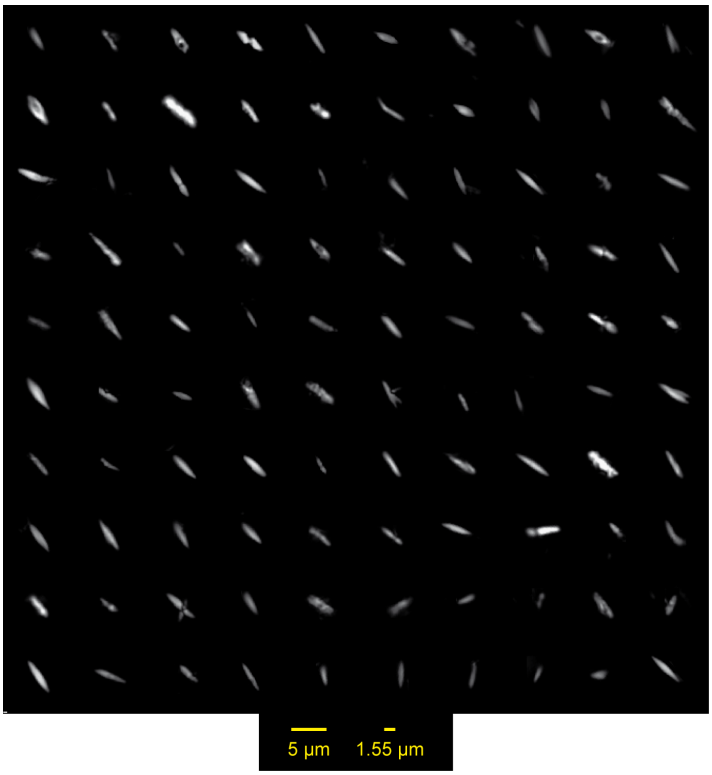

Fig. 1. Figure R1

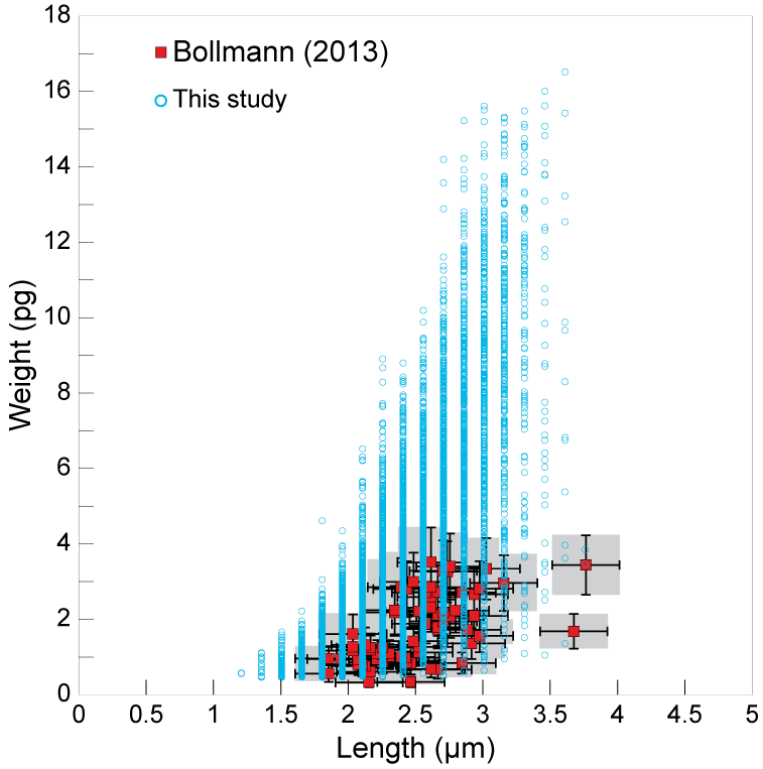

Fig. 2. Figure R2