Biogeosciences Discussions

Biogeosciences Discuss., author comment AC1
https://doi.org/10.5194/bg-2021-105-AC1, 2021

Answer to anonymous Referee #1 Comment on "Distribution of coccoliths in surface sediments across the Drake Passage and calcification of Emiliania huxleyi morphotypes" by Nele Manon Vollmar et al., Biogeosciences Discuss., https://doi.org/10.

Nele Manon Vollmar et al.

Author comment on "Distribution of coccoliths in surface sediments across the Drake Passage and calcification of *Emiliania huxleyi* morphotypes" by Nele Manon Vollmar et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-105-AC1, 2021

Reviewer #1 comment (RC#1): The MS by Nele Manon Vollmar and colleagues examined 28 surface sediment samples in order to determine the geographic distributions of coccolithophore species in the south Chile and across the Drake Passage. In addition, authors estimated the mass and length of Emiliania huxleyi coccoliths using two approaches and evaluated the distribution of coccolithophore species and E. huxleyi morphotypes in relation with environmental parameters. Coccolith abundance, diversity and coccolith mass of E. huxleyi decreased with increasing latitude. Overall, the manuscript is well written and provide new data on the distribution of coccolithophore species in the sediments of the Southern Ocean. This information is important to improve paleoceanographic reconstructions in the region and to assess possible changes in the distribution of coccolithophores associated to ongoing environmental change in the region. However, there are some important points in the methods, results and discussion that need clarity. Below I list several suggestions, which I hope contribute to clarify some issues and help the authors to improve their MS.

Author's comment (AC): We thank reviewer #1 for providing this constructive review on our paper and would like to answer to the listed points and clarify them.

RC#1: Lines 9-10 Results of the relationship between coccolithophore species and environment are barely discussed. Why not salinity, phosphate or other relevant environmental parameters are mentioned in the discussion? I believe Figure 10 is not even mentioned in the discussion.

AC: With the brief presentation in the abstract, we just want to shortly explain what we have actually done. The findings in Figure 10 are of course taken into account in the discussion, although we have actually forgotten to reference Figure 10 in the text so far (missing in line 467). That has been changed. We thank reviewer #1 for pointing this out.

We did not mention salinity, phosphate, or other environmental parameters because the

main outcome of the two independent statistical analysis (Hierarchical Cluster Analysis and Redundancy Analysis) made in this study is that, among the included environmental variables, sample depth is the main driver of differences in the assemblage distribution (see lines 452). The outcome of the RDA is how much variation in the coccolith assemblages can be explained by the environmental variables and if this variation is significant. In this case, the environmental variables together explain 56% of the variation (i.e. by the constraints). The first axis is the only significant explaining 38 % variation and being strongly (negatively) correlated to sample depth, while the second axis explains only 9% of the variation. Further interpretation of less significant parameters as suggested by reviewer #1 (PAR, salinity and phosphate, all at 10m water depth), should be taken with great caution and are (from our perspective) not worthwhile, especially considering the sample size and the unknown, approximately Late Holocene age.

RC#1: Line 30 The content of this paragraph is correct but too descriptive. It should be placed in material and methods.

AC: We think that an overview of the Southern Ocean (SO) oceanography is relevant information for this study and the placement in the introduction is appropriate. We consider that the investigation is also important because of the special situation and location of the study area. We want to take this into account by placing this section in the Introduction. In our opinion, this has nothing to do with material and methods.

RC#1: Line 46 Carbon is not respired. Please rephrase.

AC: We revised the sentence and made clear that Carbon Dioxide is respired (instead of Carbon).

RC#1: Line 57 Please note that diatoms dominate in the subantarctic waters in terms of biomass. In fact, coccolithophores account for small fraction of the primary production in all the zonal systems of the Southern Ocean. In terms of cell numbers, it is likely that coccolithophores dominate even south of the polar front. While the content of this sentence is correct, it is somewhat misleading, so please, re-write clearly stating the role of each group. Moreover, some of the references do not report diatoms. Please find more appropriate references, for example:

Smith, H.E.K., Poulton, A.J., Garley, R., Hopkins, J., Lubelczyk, L.C., Drapeau, D.T., Rauschenberg, S., Twining, B.S., Bates, N.R., Balch, W.M., 2017. The influence of environmental variability on the biogeography of coccolithophores and diatoms in the Great Calcite Belt. Biogeosciences 14, 4905-4925.

AC: We are aware that diatoms dominate in the subantarctic waters and never questioned that. However, with our statement and the reference of the model results by Nissen et al. (2018), we only wanted to indicate that coccolithophores are also of (subordinate) importance in this region. We tried to clarify this better in the text and have now added the reference suggested by reviewer #1.

RC#1: Line 74 The poleward expansion of E. huxleyi in the Southern Ocean remains as a hypothesis that need to be proven. Please provide robust evidences (i.e. references) of

leave it as a hypothesis.

AC: We attenuated the statement pointed to (lines 74-75): "Repeated sampling in the Australian sector of the SO over the past four decades suggests a dramatic range expansion of coccolithophores south of 60° S, dominated by the globally ubiquitous species E. huxleyi (Cubillos et al., 2007)".

In addition, we have added more references to provide more robust evidence (Winter et al, 2014; Charalampopoulou et al., 2016).

RC#1: Line 76 "Here, any ocean acidification effect appears outweighed by surface-ocean warming." This sentence is unclear, any effect on what? Please rephrase and also provide reference/s to support your statement.

AC: We acknowledge that this sentence was unclear, so we reworded it. We meant to state that in that specific region of the SO (referring still to Cubillos et al., 2007) temperature seems to be a more prominent factor affecting E. huxleyi morphotype distribution and coccolith mass than the carbonate chemistry, therefore suggesting that the influence of global warming will be stronger than ocean acidification in the future.

RC#1: Line 82-83 "However, the number of coccolithophore studies in surface sediment in this area is very limited, and they mostly focus on assemblages." Please provide references.

AC: To our knowledge there are only three papers dealing with coccoliths in surface sediments of the Pacific and Atlantic sectors of the SO, which we have added to the text. These are:

Boeckel, B., Baumann, K.-H., Henrich, R., and Kinkel, H.: Coccolith distribution patterns in South Atlantic and Southern Ocean surface sediments in relation to environmental gradients, Deep Sea Research Part I: Oceanographic Research Papers, 53, 1073–1099, https://doi.org/10.1016/j.dsr.2005.11.006, 2006.

Findlay, C. S. and Giraudeau, J.: Movement of oceanic fronts south of Australia during the last 10 ka: interpretation of calcareous nannoplankton in surface sediments from the Southern Ocean, Marine Micropaleontology, 46, 431–444, https://doi.org/10.1016/S0377-8398(02)00084-1, 2002.

Saavedra-Pellitero, M. and Baumann, K.-H.: Comparison of living and surface sediment coccolithophore assemblages in the Pacific sector of the Southern Ocean, 61, 14, 2015a.

RC#1: Line 91 It is unclear why authors analysed the coccolith mass of this species. Please clarify the purpose of this analysis.

AC: We analysed the coccolith mass of E. huxleyi because it is nowadays the dominant taxa in this region, as well in many other oceans, and an important driver of changes in the carbon cycle. Due to its relevance, this coccolithophore species, and not others, is considered in studies which analyse the sensitivity of their calcification parameters to present-day (e.g., Rigual Hernandez et al. 2020) or past (e.g., Baliestreri et al., 2021) shifting environmental conditions(e.g., Rigual Hernandez et al. 2020). Therefore, we consider that understanding mass variations in this taxon in the SO is of wide importance for the scientific community. We have now included this in the manuscript, stating that "Additionally, we evaluated the coccolith mass variations in the dominant taxa E. huxleyi within each different morphotype, an important information as part of the morphological diversity of E. huxleyi and their biogeography, which can serve as an estimate for CaCO3 export that may be affected by projected environmental change (e.g. Rigual-Hernandez et al., 2020)."

Balestrieri, C., Ziveri, P., Grelaud, M., Mortyn, P. G., & Agnini, C. (2021). Enhanced E. huxleyi carbonate counterpump as a positive feedback to increase deglacial pCO2sw in the Eastern Equatorial Pacific. Quaternary Science Reviews, 260, 106921.

RC#1: Line 131 Delete "coccolithophores".

AC: That word was deleted from the text.

RC#1: Line 131 If possible, include information about the model of the multicorer sampling device.

AC: Samples were retrieved with a 12-tubes Multicorer (MUC67; manufactures by Fa. Wuttke, Henstedt-Ulzburg, Germany), with an inner tube diameter of 6 cm and a length of 60 cm (Lamy et al., 2016). This information was added to the text.

RC#1: Line 134 It is unclear if this dating was made on any of the samples analysed in this study or if it was undertaken in nearby samples. Please clarify.

AC: None of the samples we used had been dated so far. Since it was not possible for us to carry out our own datings, we relied on published age data, which give calibrated accelerator mass spectrometry (AMS) 14C ages for surface sediments in the work area of about 3 to 4.8 ka BP. The information is included in lines 131-135 and we wrote now the following: "Datings of adjacent near-surface sediments at the southern Chilean margin (Caniupán et al., 2011b) as well as south of the PF within the DP (Vorrath et al., 2019) give calibrated accelerator mass spectrometry (AMS) 14C ages of 2.91 – 3.06 ka BP and 4.83 ka BP respectively."

However, a newly published paper in which changes in ACC strength in the central Drake Passage were calculated for the last 140 kyr (Wu et al., 2021) using sediments of one of our stations (station PS97/085, in the Antarctic Zone). The calibrated AMS 14C ages for the sediments from the piston core PS97/085-3 at 0.5 cm (= 56.5 cm composite depth)

and for 20.5 cm (= 76.5 cm composite depth) were, 1.13 ka and 6.64 ka, respectively. The real sediment surface was partly missing in the piston core, so Wu et al. calculated a recent age for the trigger weight core, but even the surface of the piston core had an age which allows us to assume that the surface sediment is at least close to Recent. We therefore assume that our studied surface sediments represent relatively modern conditions.

Wu, S., Lembke-Jene, L., Lamy, F. et al. Orbital- and millennial-scale Antarctic Circumpolar Current variability in Drake Passage over the past 140,000 years. Nat Commun 12, 3948 (2021). https://doi.org/10.1038/s41467-021-24264-9

RC#1: Line 145 The sentence "were aimed to be counted" is not clear enough. Do authors mean that they actually counted at least 100 coccoliths or this target number was not always met?

AC: We actually aimed to count at a minimum of 300 coccoliths per sample, but counted at least 100 coccoliths in those samples with very low coccolith abundances. We clarified the sentence and add the respective sample names and a cross-reference to Table 2, where the total counted coccoliths is noted.

"A minimum of 300 coccoliths per sample was counted in transects across the filter area, except for eight relatively coccolith-poor samples south of the PF (083-1, 080-2, 042-1,044-1, 074-1, 048-1049-2, 052-3) and two in the SAZ (096-1, 094-1) in which at least 100 coccoliths were counted (see Table 2). All the sampling points were considered when plotting the number of coccoliths per gram of sediment, except for three samples with extremely low counts that were excluded in the plots of relative abundances. "

RC#1: Line 166 Since one of the aims of the study is to compare results with modern living assemblages, why not using the classification of Savedra-Pellitero et al. (2019)?

AC: The one difference in the classification is that Saavedra-Pellitero et al. (2019) distinguished the E. huxleyi morphotypes in morphogroup B into types B (>=4µm), B/C (<4µm), C (<3.5µm) and O (with open central area or lamella in central area) in their studied water samples, while we did only classified them into types B/C (plated central area) and O (open central area, see Table 1) based on the central area feature. This grouping is based on the fact that we found no coherent characteristics in the studied surface sediment samples – other than size - that could help us to distinguish the studied E. huxleyi morphogroup B coccoliths into more than one morphotype. As it can be seen in Figure 6, the size range for morphotype B/C in this study lies between <3µm to >4µm with most coccoliths around 3.5µm. Similar size variability can be found within the coccoliths of one single coccosphere and "may originate from the variability in size of the OBPS during the cell growth/division cycle" (Beuvier et al. 2019).

RC#1: Line 175 Does this mean that an average of 27 E. huxleyi coccoliths were analysed per sample? If this is correct, the dimensions of a some morphotypes in some samples are based on a very low number of specimens. Authors should provide statistical evidence that the sample size is representative of the different populations (i.e. morphotypes). Please provide a table indicating the number of coccoliths of each morphotype that were analysed

in each sample.

AC: We guess that reviewer #1 simply divided the analysed 613 coccoliths of E. huxleyi by the number of samples. However the differentiation between the five E. huxleyi morphotypes within morphogroups A and B was done in additional counts (see line 164 f) of at least 100 coccoliths. We used the morphometric data measured with the Coccobiom2 Macro to describe the 5 morphotypes (and not 22 samples) in a second step. We therefore believe that we have a representative number of measurements per morphotype available for this classification (335 measurements of morphotype B/C, 134 measurements of morphotype O, 52 measurements of morphotypes A and A overcalcified merged together) The associated morphometric data, like all counting data, have been submitted to Pangea and is being currently curated. The data will be made publically available after publication.

RC#1: Line 184 This explanation is not clear enough. Could you please explain how these constants with ranges were applied to the coccoliths measured in the sample?

AC: We did not apply the ranges in our mass calculations. When applying the maximum ranges of kn and β both, the calculated masses are higher with up to approximately doubled maxima. Applying the minimum ranges do have a weaker effect. Overall, the total mass range lies between approximately 1 to 10pg, when considering the ranges of the two constants in the formula from Beuvier et al. (2019). However, since we want to focus on the biogeographical trend within our sample set and compare this trend to other studies in the Drake Passage area (Saavedra-Pellitero et al. 2019, Charalampopoulou et al. 2016, see figure 12), we think that this approach is appropriate.

We also realized that there is a typo in the caption of Table 3 – the unit for the mass measurements is of course pg and not µm, so we fixed it.

RC#1: Line 195 The description provided by Poulton suggests that they lumped together B/C and O. In his figure 1c, the coccosphere looks like the B/C described here. Did you double-check this identification with him? Please verify.

AC: We did not double-check the identification with Poulton. However, the point is, that for morphotype O, the shape factor of 0.015 is leading to smaller masses in comparison to the shape factor of 0.02 (for A, and B/C), which makes sense because there is no calcite in the central area. If Poulton et al (2011) lumped O together with B/C, the "real" shape factor for O would be even smaller so the resulting mass would be even lighter. Additionally, it is possible and probable that some of the E. huxleyi coccoliths that we identified as morphotype O are originally morphotype B/C which lost their central area filling during and after sedimentation (but this is discussed in the manuscript, see line 518).

We also realized that there is typo in line 193, which has been fixed now (the shape factor for morphotype O is 0.015 and not 0.15).

RC#1: Line 199 replace “approache” by “approach”

AC: We replaced it.

RC#1: Section 3.4 Authors should explain the objective of each of the statistical analyses and data transformations.

AC: We added more information in this section as suggested by reviewer #1: “Prior to any statistical analysis, we excluded three samples (PS97/077-1, PS97/079-1 and PS97/071-2) because of the very low number of coccoliths counted (< 40 per sample). We identified suitable ordination methods by applying detrended correspondence analysis (DCA) on the species relative abundance dataset. DCA resulted in a first axis length of 1 SD suggesting a short gradient for which linear ordination methods are more appropriate. The relative abundance data was standardized using Hellinger transformation, which is well suited for species abundance data, to make variability of the species abundances comparable and giving low weights to rare species (Legendre and Gallagher, 2001), using R package adespatial 0.3-8 (Dray et al., 2020). We chose the Hellinger distance measure because it is metric and performs well in linear ordination (Buttigieg and Ramette, 2014). To find groups of samples that are most similar to each other, average-linkage (UPGMA) hierarchical clustering was performed on the assemblage data with R function hclust (R Core Team, 2020) because it takes into account the average pair-wise distance between all members of clusters. The best number of clusters was suggested by the majority of 30 indices calculated with R package NbClust version 3.0 (Charrad et al., 2014). The significance of each cluster was assessed by multiscale bootstrap resampling with 10,000 replications using R package pvclust version 2.2-0 (Suzuki et al., 2019), to assess the stability of the clusters. We assessed relationships between environmental and biotic data using a transformation-based RDA (tb-RDA). We constrained our assemblage data (response, 16 species at 25 sites) to seven standardized environmental variables (explanatory): salinity, temperature, phosphate, and PAR at 10 m water depth; CO3 as representative variable for the carbonate system at surface sediment sample depth; the MLD and the respective surface sediment sample depth itself. The adjusted R2 was calculated, and the significance of the tb-RDA was tested at 9,999 permutations. Analysis was performed using R package vegan version 2.5-6 (decostand, rda, RsquareAdj, anova.cca, Oksanen et al., 2019). We determined the similarity between water column and fossil coccolithphore assemblages in this region by calculating the analogue distance of a subset of the sediment surface samples to the nearest plankton samples (Saavedra-Pellitero et al., 2019) using R package ggpalaeo version 0.0.0.9005 (Telford, 2019), see Figure A3. All figures were made with R package ggplot2 version 3.3.2 (Wickham, 2016) and modified with Inkscape version 1.0.2.”

New reference included: Buttigieg, P. L. and Ramette, A.: A guide to statistical analysis in microbial ecology: a community-focused, living review of multivariate data analyses, FEMS Microbiology Ecology, 90, 543–550, https://doi.org/10.1111/1574-6941.12437, 2014.

RC#1: Line 200 If the morphometric-based approach brings higher values than the birefringence-based method, why the analysis on the living assemblages in the Drake passage suggests higher values? Please explain better.

AC: Rigual Hernandez et al. (2020) indeed showed that the birefringence-based method gave higher coccolith mass estimates than the morphometric-based method. However, they also showed that this difference is negligible in small species, such as E. huxleyi, since it is within the margin of error.

We can only speculate about the higher mass values in the plankton samples from Saavedra-Pellitero et al. (2019) in comparison to our mass data on E. huxleyi as well as the published masses from Charalampopoulou et al. (2016). Since the systematic uncertainty of the method in that plankton study is higher than in our study (due to the fact that calibration is not always done with a calcite wedge of known thickness), we consider that the measurements on the living assemblages in the Drake Passage are overestimated. Still, the trends in all three studies are comparable and this is what matters for our study (not the absolute values), as mentioned in the paper (line 530).

RC#1: Line 233 Please acknowledge the limitations of this comparison. Coccolithophore living communities may experience important seasonal changes through the year and, therefore the assemblages collected in a single water sample cannot be considered representative of an annual cycle.

AC: We fully agree with reviewer #1, but calculating the analogue distance allowed us to see how similar/different these communities are (quantitatively). In fact, Figure A3 shows that they are very different supporting reviewer‘s #1 statement.

RC#1: Line 236 Include subheading

AC: We are not sure about this statement from the reviewer. We wanted to include some information before section 4.1, so we did it right after 4. Perhaps reviewer #1 is suggesting a formatting issue. In that case, we are sure that the editorial team will point out the issue and they will help us to address it.

RC#1: Line 262 Do you mean “at the deepest stations”?

AC: We meant at the stations below 3.1 km of depth, so we prefer to leave it as it is now.

RC#1: Line 286 Many physical and chemical parameters that might influence coccolithophore community composition and abundance are known to decrease close to monotonically poleward across the Southern Ocean. These include temperature, salinity, alkalinity, pH and the saturation state of calcite. Thus, it is not easy to separate their possible influences on coccolithophore distributions. This problem has been previously noted by Charalampopoulou et al. (2016) in the Drake Passage. This should be taken into consideration when performing and interpreting the statistical analyses. Did authors consider this problem? And if so, how did you deal with it?

AC: This is an inherent problem in the SO, because of the strong gradients occurring

there, which are specially marked in the Drake Passage. As reviewer #1 mentions, some of the variables co-vary with other dependent variables and the effect of one over any of the others is difficult to distinguish. However, the fact that two independent statistical analyses (hierarchical and multivariate) point towards the same factor (i.e. depth related to the calcium carbonate saturation state) makes to our interpretations robust. While parameters such as temperature, PAR, or salinity co-vary across the gradient, depth of the samples is a variable that does not show a general poleward variation in the SO. Of course, we acknowledge that during their life cycle, coccolithophore assemblages were affected by these other physico-chemical parameters, but ultimately the main driver here was the depth of the samples.

RC#1: Line 289 Please clarify how many specimens of E. huxleyi coccoliths were used to estimate the relative abundance. You can provide the average value including the minimum and maximum numbers for all samples.

AC: We provided additional information regarding the morphotype counts in the Material and Methods section (sect. 3.1):

"In the additional E. huxleyi morphotype counts we aimed for at least 50 E. huxleyi coccoliths and reached 53 to 115 morphotype counts for most samples in the SAZ and four samples in the AZ. Due to the low coccolith abundance in eight samples from the AZ and SZ+CZ and in one sample in the SAZ we only reached up to 48 E. huxleyi morphotype counts. "

We also noticed an error in the relative abundances of morphotype B/C and corrected the numbers (it is 33 to 83% of coccoliths belonging to morphotype B/C, and not 2 to 77%)

RC#1: Line 295 as authors state in the discussion it is very likely that at least a fraction of the type O coccoliths belong to B/C. Did you try to find correlations between this morphotype and any dissolution indicators (e.g. CEX)?

AC: In fact, we cannot tell for sure whether a fraction of the type O coccoliths belongs to B/C. That is the main reason why we did not explore further the relationship with the dissolution.

RC#1: Line 300 Type O coccoliths display an almost identical size range than those of B/C. Could this be taken as an indication that both morphotypes belong to the same type/variety of E. huxleyi? What about their geographical distribution? Is there a relationship between abundance of type O and dissolution?

AC: This is a very interesting question similar to one of the points raised by reviewer #2. Although we could not distinguish sufficiently enough between the types B, B/C (which is an integration of B and C), and C, we could clearly distinguish a type O with open central area or lamella in central area. In the end, we cannot rule out that these may be

disguised, dissolution-related B / C types, but we consider that most of them are real.

It is interesting to note, that E. huxleyi morphotype B/C dominates over morphotype O in plankton samples (Saavedra-Pellitero et al., 2019) but it does not in the presently studied surface sediments in the DP. This, together with the differences in the biogeographical distributions makes us speculate that this morphotype may be highly sensitive to lower calcite saturation state in depth south of the Polar Front (see discussion in lines 579ff). Still, with our data we cannot be sure if E. huxleyi type O and B/C belong to the same type/variety of E. huxleyi or not.

RC#1: Line 310 Coccolith mass values estimated here should be compared with previously published works in the Southern Ocean.

AC: Due to the fact that different methodologies have been used in the available studies (adding uncertainty), we prefer to stick to just comparing the trends, which are very similar (see previous comment regarding line 200).

RC#1: Line 317 please be more precise and include a proportion or order of magnitude in the latitudinal comparison.

AC: A more precise description of the changes has been added to the text.

RC#1: Line 321 It makes sense that studies based on plankton samples are less diverse since they only capture a "moment" of the annual cycle while sediment samples must encompass hundreds of years. Also, the mentioned studies covered different latitudinal ranges. So, I wouldn't consider these results "surprising".

AC: This would be generally true but considering that we are in a low-diversity (sub-)polar area and that dissolution can notably diminish coccolithophore diversity in the surface sediments (Saavedra-Pellitero and Baumann 2015), it was indeed surprising for us. Therefore, we decided to keep this statement.

RC#1: Line 328 “unusually high” compared to what?

AC: compared to other studies, which we have added now to the text (the same papers that we listed on the note to lines 82-83).

RC#1: Line 346 This is somewhat confusing, the best way to assess algal biomass concentration in a region is to look at satellite chlorophyll-a in the region. High abundance of coccolithophores doesn't necessarily imply high productivity since they only account for small fraction of the phytoplankton community. So please, rephrase.

AC: We have not mentioned algal biomass in the paper, but in any case, we meant coccolithophore productivity as stated in the following (line 349). We have clarified this in the text.

RC#1: Line 367 Please cite Cubillos et al. (2007) paper here.

AC: We have added the suggested reference to the text.

RC#1: Line 377 why shape? please clarify.

AC: We do not fully understand the question -– we mean the shape of a coccolith … (big or small, more or less elements, the filling/shape of the central area, etc.)

RC#1: Line 380 what does "quite common" mean? please be more precise.

AC: For us it means that it is often present (=common) in relatively high abundances. We reworded the sentence.

RC#1: Line 413 not only south the PF. Did any of these studies reported descriptions of the seasonal cycles of coccolithophores?

AC: Unfortunately not. The only “seasonal” studies come from sediment trap investigations (lines 364 and later), which are not located in the Drake Passage.

RC#1: Line 418 What do you mean with "selectively enriched"? Are you suggesting selective dissolution? Please explain better.

AC: Yes, we believe that the larger species are selectively enriched due to the dissolution of the smaller and more fragile taxa. We tried to clarify this in the text.

RC#1: Line 519 This is an important point. Please note that even in the same coccosphere type B/C and Type O coccoliths can be observed. See Figure 3 of Cubillos et al. (2007) paper. Please discuss this point. Did authors compared the spatial distribution of B/C and "O" in terms of absolute abundances and relative abundances? is it similar between them?

AC: We actually do not see any differing types in Figure 3 of Cubillos et al. (2007). One can certainly intensely argue about this, but we definitely see differences in preservation of the coccoliths in Figure 3e. Still, all visible coccoliths can still be clearly assigned to one type in that specific coccosphere. We have also taken a close look at the plankton communities in the study area (Saavedra-Pellitero et al., 2019), have not observed any coccosphere with two clearly different morphotypes, and we are also not aware of any publication in which such a thing is described.

We only showed the absolute abundances of the total assemblages (we called it total numbers, see Figure 3), and the relative abundances of the species as well as the relative proportions of the E. huxleyi morphotypes (see Figure 5). We did this because the changes in the absolute abundances would have resulted in very similar representations in the distributions, as can be seen from the comparison of the E. huxleyi types in Figure 5.

RC#1: Line 521 Müller et. al. did not assess the response of type "O". Do you know any culture experiments with this morphotype? I find this statement quite speculative. The fact that type O displays slightly morphological differences with the rest of E. huxleyi morphotypes does not necessarily imply that they have different physiological responses. Please be more cautious.

AC: We do not know of any corresponding culture studies on type O and we also do not know whether the type was (ever) cultured. We agree with the reviewer that types B/C and O do not necessarily have to differ in their ecological adaptations, but Type A seems definitely different in its ecology, as pointed out in the literature.

RC#1: Line 525 Please compare your values and distributions with similar studies conducted in the Atlantic and Indian sectors of the Southern Ocean:

Horigome, M.T., Ziveri, P., Grelaud, M., Baumann, K.H., Marino, G., Mortyn, P.G., 2014. Environmental controls on the Emiliania huxleyi calcite mass. Biogeosciences 11, 2295-2308.

Rigual-Hernández, A.S., Sánchez-Santos, J.M., Eriksen, R., Moy, A.D., Sierro, F.J., Flores, J.A., Abrantes, F., Bostock, H., Nodder, S.D., González-Lanchas, A., Trull, T.W., 2020.

Limited variability in the phytoplankton Emiliania huxleyi since the pre-industrial era in the Subantarctic Southern Ocean. Anthropocene, 100254.

AC: We have increased the discussion and compared our data to the mentioned studies.

RC#1: Line 586 Please clarify that pteropods are made of aragonite which is substantially more prone to dissolution than calcite. As it reads now, this statement is misleading for the reader.

AC: We have changed that accordingly. We believe that it is common knowledge for the reader that pteropods have an aragonite shell, and just wanted to show that more easily soluble carbonate organisms are already affected by increased ocean acidification.

RC#1: Line 586, second sentence. Authors cannot be completely sure that the dissolution in the sediments is necessarily enhanced by anthropogenic ocean acidification. Please rephrase being more cautious with your words.

AC: We have reworded that sentence to make our statement looser (even though we believe it is likely).

Figures

RC#1: Please include the name of the fronts and zonal systems in the maps

AC: Done (note that the names of the fronts were already given).

RC#1: Figure 10. Please discuss in detail the role of the most important environmental factors in the distribution of coccolithophore species in the sediments.

AC: We already discussed this aspect in detail above (see comment about lines 9-10 and 286).

RC#1: Table 3. "All measurements in µm." Mass cannot be measured in micrometers, please correct. Also please include the name of the authors of the method in the column "methods", it would facilitate the interpretation of the table.

AC: That has been changed (see also comment on line 184). We did not notice that mistake and thank reviewer #1 for pointing this out. We have also added the author(s) of the method in the column „methods".

Supplementary materials

RC#1: All coccolith counts and morphological measurements should be provided as supplementary materials.

AC: All data has been uploaded in the world data center repository Pangaea and it will be available after publication.