We would like to thank the reviewer for working through our manuscript thoroughly. First we briefly summarise by commenting on some of the reviewers most significant concerns:

1) The reviewer identified some incorrect comments in the manuscript, such as the large impact of the marine carbon cycle. These comments largely reflected that we referred to an earlier online discussion version of the Buitenhuis et al., (2013) which erroneously showed foraminfieral standing stocks to be of more than four orders of magnitude larger than in reality. The results are unaffected, yet the motivations and implications of our results have been corrected to adjust for the much lower standing stocks of foraminifera in the global ocean.

2) The reviewer requested that we get some indication of how much of the total abundance the 8 species in the FORAMCLIM represent. This was a nice suggestion that helps put our results into perspective. We now show, based on the MARGO database of sediment top core data, that the eight species represented in FORAMCLIM account for about 50% of the total foraminiferal abundance. Thus, even though we represent only about 20% of the species diversity we capture a large proportion of the total abundance because the model includes the key dominant species. The projected changes in the foraminfieral abundance simulated here, would therefore be expected to have a significant impact on total abundance.

3) Both reviewers asked for a clearer explanation about the uncertainty in abundance due to not including variation in foraminiferal size in the model. We have included a detailed example to clarify this point.

4) A question about the uncertainty in the projected responses was raised by the reviewer. Unfortunately with only a single model it isn't feasible to determine the uncertainty in the future projection. Ideally this would require a multimodel study and a model-data evaluation of the interannual variability in of foraminiferal growth/abundance in response to environmental change. We could then compare the magnitudes of the future change in foraminiferal abundance to comparable present-day responses. In a dedicated section of the paper we emphasise the need for a database of the present-day changes in foramininfer abundance with concomitant environmental variables, so that it will be possible to carry out such a study.

`The manuscript "Projected impacts of climate change and ocean acidification on the global biogeography of planktonic foraminifera" by Tilla Roy et al. describes the effect of climate change, including ocean acidification (OA) on the distribution of the most abundant planktonic foraminiferal species. This is based on models results from an Earth system model incorporating temperature, food availability (plankton biomass) and light as the main drivers of foraminiferal biogeography. Results indicate shifts in foraminiferal abundance and diversity, depending on the region and or species to sometimes huge extents.

The research is original and provides interesting data to the community. The model setup is state of the art and data from the literature was incorporated appropriately. The presented data seems to be of appropriate quality. In a few cases the discussion of the data in relation to the already existing literature needs to extended to give a fuller and more correct view, as indicated below. Also some of the statements and conclusions drawn are not correct. I strongly encourage the authors to carefully check the grammar and language, preferably by a professional. I would recommend publication of this manuscript after major revisions have been carried out. I wish the authors good luck with the revisions and remain available for further feedback and discussions.

Comments: General:

- manuscript could be shortened in some cases to make it more concise

The manuscript has been shortened where possible

-Figure captions starting with "The". rephrase, e.g. Fig.6:"Zonally averaged changes...."

Done

-wrong tense: e.g. l.279 under climate change .... shifts... polewards, in this case it should be rather "was shifted". This is the case in many more examples, I would highly recommend to consult a language editor -the adjective of foraminifera is foraminiferal not foraminfer (e.g. caption of Fig.1)

The results section has been changed to past tense and the adjectives of foraminifera have been corrected.

-narrative order is sometimes confusing, eg. l. 88 -90 distinguishes spinose and nonspinose forams, however, the term spinose has been used earlier without introducing the term (l. 82). BGD has a broad audience, therefore explaining such terms is crucial (same goes for explaining OA, see comments below)

Done

-some figures have stripes (eg 3a, b, 4a,c,d,5a,5c), please remove

This shouldn't be an issue with the figure quality and should just require turning of the anti-aliasing option on the software used to view postscript figures. In any case, we will ensure that there are no issues with the final submitted figures.

-The abstract mentions: "changes in the marine carbon cycle would be expected...", however, this has not been discussed, also the potential effect remains questionable.

In the discussion version of the Buitenhuis et al. 2013 (the version referred to in writing this paper), the standing stock was quoted to be at least 4 orders of magnitude higher than in final Buitenhuis et al., 2013 paper. Based on the final published paper of Buitenhuis et al., 2013, rather than the earlier online discussion paper, the paper has been modified (i.e. foraminifera are now only a small contributor to the standing stock of planktonic biomass and therefore changes in their abundance not be expected to have a strong impact on the organic particulate carbon flux).

Comments according to sections:

Introduction:

l.48: of past what? word missing.

Done

l.52: add citation

The book chapter Honjo et al., 1996 has been added which summarises studies on the biogenic calcium carbonate flux.

l.63: explain what OA is and why reduction in carbonate production would decrease atmospheric CO2 (broad audience of BGD).

We have included a more detailed description of Ocean acidification and carbonate production. We have deemphasised the CO2 feedbacks, because it was never our intention for this effect to be the key motivation of the paper.

l.66: not depends but results from

Done

l.71: rephrase sentence "Towards this end, in this study investigate present and future changes in the 3D distribution..." (?)

Done

l.86: impact on, not of

Done

l. 93: to reconstruct

Done

l. 111:";" should be after the bracket

Done

l.117: change . with , after concentration

Done

l.127: living not live

Done

l.127: add citations

Citation included to the FORAMCLIM description

l.128: growth rate or growth? what is the unit of the growthrate? (um/ ug per day?)

It is in units of d-1, but to avoid confusion we now refer instead to the increase in weight per day ΔW, ($\mu gC\ d^{-1}$). More details in Lombard et al., 2011.

l.139 what are the factors a and b?

The scaling factors of the calibration between growth rates and abundance (See Lombard et al., (2011) for details).

Table 1: %P really in percent or as fraction?? eg. should 0.46 not really be 46%? (caption says percentage),

It is a fraction. To avoid confusion, we adopt the same symbol (i.e. %P) for this constant as used in the original reference describing the FORAMCLIM model (Lombard et al., 2011).

is Snb based on 250 ug or 250um individual (caption vs text l. 148)? references for the values?

It is based on 250 um individual. The error in the Table caption has been corrected.

l. 160/ 161: I understand that the number of foraminiferal species incorporated in the model needs

to be limited, however, it would be interesting to see how high the discrepancy is between only using 8 species and the reality? A short comment on this, e.g. differentiuated into the main regions of the model (tropics/ subtropics, etc and surface/ whole watercolumn)would be highly appreciated. (Maybe this can be achieved by comparison to MARGO database?)

This is an interesting point and something we had actually been interested in looking into. Based on the global compilation of topcore sediment data (Kucera et al., 2004), we now show that the 8 species represented in the FORAMCLIM model account for about 50% of the total foraminiferal abundance. This fact provides a much clearer perspective on our results. For example in the discussion section we now explain "… in the tropics/subtropics the 40% decrease in total simulated foraminiferal abundance could produce a 20% reduction in total planktic foraminiferal carbonate production, given that the 8 species in the FORAMCLIM model account for about 50% of the 'true' total planktonic foraminiferal abundance (Kucera *et al.,* 2004)."

l.166: sampling

Done

l.171: "and calculate..." rephrase

Done

l.171: explain Omega C here (l. 342 is too late in the document)

Done

1. 182: replace the with that

Sentence has been split into two parts and rewritten.

l. 188: replace [] with ()

Done

l.189: et al.

Done

l. 202/ 203: it has been possible to reproduce foraminifera in the lab (benthic ones), see for instance **Toyofuku et al., 2008**, G3, 9, 5, Q05005, doi:10.1029/2007GC001772 and **deNooijer et al., 2009**, Biogeosciences, 6, 2669–2675, 2009

The adjective "planktonic" to clarify that, here, we are referring only to planktonic foraminifera, not to all foraminifera.

l. 203: the fact that planktics do not reproduce in the lab might not be the only fact allowing us to conclude that foraminifera behave differently in the lab. Lab experiments are always artificial and do never correspond to real live, however, it is all we have to manipulate certain parameters.

We agree completely. A new sentence has been added to stress this point: "It is important to keep in mind that although all physiological laboratory experiments are artificial, they are currently the most direct approach available for quantifying the growth response of foraminifera to specific environmental changes."

l. 210/211: please explain a bit more.

Given the interest in this statement (both reviewers ask the authors to explain this point in more detail), we include the following explanation: "… a wide range of abundances can be fitted to the same total biomass of a foraminiferal population depending on how this biomass is distributed over different size classes. To illustrate this point, we can take the typical biomass size spectrum from Schiebel and Mollevan (2012): a 1 m^3 of water with a foraminiferal abundance with 100 individuals m^{-3} is grouped into 3 size classes 100–150 μm, 150–250 μm, and 250+ μm with each size class having 75, 19 and 6 individuals respectively. A small change in the size spectrum (e.g. having just two more individuals in the largest and intermediate size classes (i.e 75, 21, 8 individuals in each size class) would require a large decrease in the total abundance from 100 to 68 individuals to match the same total biomass."

l. 233: define RMSE

Done

l. 232-235: I think other numbers need to be cited here (those of the present study only), e.g. abundance: the one of the here presented data is 3-24 based on the table, in l. 233 "3-25%" is mentioned, I assume 25 is from the Fraile study, same for RMSE

Done. That is, only those of the present study are cited.

l.245 maybe put at different spot in manuscript, maybe more as a discussion, conclusion section, not as method?

Done. This section has been removed to the discussion.

l.245 five not 5

Done

Results: fig.4 add timeframe to "future change" (eg year 2100)

Done

l. 283: the total abundance IS shifted to greater depths...

Done

l.284: reference to Fig5a is not correct here

Done

l.286: under climate change scenario: rephrase

Done

Fig 4 could benefit if Fig. 4a and c were also showing the future scenarios, not only present day.

Such a figure would be somewhat redundant. The purpose of this figure is to give an indication of the magnitude of the present magnitudes and future change in the surface abundance and diversity, particularly given than many observations are made at the ocean surface.

l.286: are the decreases in the tropics and increase in subpolar regions statistically significant? What are the estimated errors of the simulation & calculation of the Shannon diversity index?

Since this is sensitivity study based on a single Earth system model, there is no way to determine an error in the uncertainty of the projection. To estimate uncertainties in climate projections it is necessary to perform a multi-model study (e.g. Bopp et al., 2013). Nevertheless, the Earth system model output used to drive the FORAMCLIM model has been extensively evaluated over the historical period (Schneider et al., 2008).

Schneider, B., Bopp, L., Gehlen, M., Segschneider, J., Frolicher, T. L., Cadule, P., ... & Joos, F. (2008). Climate-induced interannual variability of marine primary and export production in three global coupled climate carbon cycle models.

Figure 6: While Abund And Rabund are correctly defined in both the materials section and the caption of Figure 6, it is not used elsewhere (not even in the respective axis labeling of Figure 6) and should therefore be omitted to avid confusion.

Done

Fig. 6: what exactly refers to surface?

The surface ocean box has a thickness of 10 m and this information has now been included in the IPSL model description.

l.301: verb is missing after N. dutertrei (decrease?)

The missing verb has been added

l.304: "was accompanied by small increases"-> judging from Fig, 6c the decrease of 20% in N.pac is matched by the total increase of 20% in G.bull, N.inc, N.dut , therefore I would not say that generally species diversity is low, but that it seems that in the futures species diversity seems to increase in the higher lats (shift from N.pac to G.bull, N.inc, N.dut), also seen in fig. 5d.

This section has been reworded. The main point was to emphasise that the only significant change in abundance in the high-latitudes is the decrease in N. pachyderma (the abundance of G.bull, N.inc, N.dut barely change) and this indirectly drives an increase in the relative abundance of the other species present.

l.310: Both, Change order: Figure 8 before Figure 7, also change order in results section

Done

l.320: "changes in nutrition rates" ? Please explain this, as I do not see how temperature would affect nutrition rate solely in such a way that abundance shift. I would more attribute this to the physiological optimum temperature for a give species.

There is strong interplay between temperature and all physiological foraminiferal processes. It is true that in reality it is not possible to have temperature solely impacting the nutrition rates, i.e. respiration, photosynthesis and all other physiological processes will also be impacted. This is why we use the model. The impacts of temperature on nutrition, photosynthesis and respiration are built into the FORAMCLIM model, which allows us to disentangle the response of each physiological process to temperature (or food and light), such as the impact of temperature on nutrition.

From a biological point of view, the effect of temperature on foraminiferal nutrition is complex. It impacts behaviour (plankton can retract their cytoplasm and refuse to feed), enzymology (digestive enzymes are only functional within a certain temperature range, yet their efficiency varies within this range), and cytology (membranes can be more fluid with increasing

temperature, yet only functional under a given range that is controlled by the composition of the phospholipids). Each of these processes has a unique optimum temperature range and can impact the growth and abundance of a foraminiferal species.

Fig. 8: Please quickly comment about the general patterns of change in temperature and food observed, e.g. why is phytoplankton concentration in the Southern Ocean increasing in the future?

A consistent result in future projections is that phytoplankton concentration in the Southern Ocean increase both where mixed layer depths shoal and also around the poles where there is a reduction in sea ice extent. Both of these processes can alleviate light limitation on phytoplankton growth. The concentration of iron also plays a central role, since PP can only increase in the presence of iron (see Steinacher et al., 2010 for an explanation of the response of PP in the simulation used in this study, and also for a complete discussion of a range of PP responses in other Earth system models forced with the same IPCC SRES AR2 emission scenario).

Steinacher, M., Joos, F., Frölicher, T. L., Bopp, L., Cadule, P., Cocco, V., ... & Segschneider, J. (2010). Projected 21st century decrease in marine productivity: a multi-model analysis. *Biogeosciences*, *7*(3), 979-1005.

Fig.9: Why is the increase in habitat for O.uni, G.sacc, G.Siph and Grub not reflected in a relative increase in abundance? The negative impact of a decrease in habitat seems to be well reflected in a decrease in foraminiferal abundance, but not vice versa. This should be discussed in more detail in lines 417-421, as I find this interesting and puzzling. As stated in l. 415 it is generally expected that pelagic species should have the potential to escape to more favourable conditions, however, this study shows that while the more favourable conditions are predicted, abundance still drop (or do at least not benefit as much as would be expected).

The habitat area is the region where the conditions are sufficient for growth of a foraminifer given the ambient light, food and temperature conditions. It does not equate to the conditions being equally favourable. Under climate change a greater volume of the ocean may be within the temperature range that a particular species can exist, but this new habitat can be suboptimal. Take g. ruber and G. sacculifer for example. The available habitat of these species increases as it shifts towards the subtropical region in response to changes in temperature and deeper in the water column. Yet, large parts of the subtropical ocean contain oligotrophic gyres where food resources are scarce.

Fig. 11: red contours hardly visible (exp. Fig11a). change colour scheme so to avoid reddish colours in the figure to enhance contrast

The color of the contours has been changed for improved visibility.

Fig. 11c) make clear in caption this is for the future, not present. In general the captions are sometimes too short. The more information is found in the figures, the better.

Done

l.355 add citation

This is a result from this present study, so can't have a citation. The section has been reworded to make clarify this.

Discussion: order should reflect that of results. rearrange (e. OA is last in results and first in discussion) the addition of subheadings could increase readability

Done

l.367: "which reduces foraminiferAL calcification rates"

Done

l.367 this statement is not correct in its current form, it is different for different species and also different studies have found different responses, see e.g. Keul et al . 2013 (Biogeosciences, 10, 6185–6198, 2013, www.biogeosciences.net/10/6185/2013/ doi:10.5194/bg-10-6185-2013) for an overview.

Although this statement may be true for the species in this study, it is true that some species do not respond to ocean acidification in the same way: the sentence has been modified and the Keul et al. (2013) reference inserted. " Such population–driven impacts on carbonate production could be further amplified of dampened if calcification rates themselves are impacted by anthropogenic change. Ocean acidification and the associated decrease in carbonate concentrations can alter foraminiferal calcification rates (Lombard *et al.* 2010; Keul *et al.,* 2013), while higher ocean temperatures could accelerate calcification rates within certain temperature windows"

l. 368: can accelerate: only to a certain degree in a certain temperature window

The sentence has been reworded.

l.371: add reference to respective figure

Done

l.376: "are a response to higher atmospheric co2 concentrations" this statement in this general form is not true. On a physiological level, this might not be true for at least a few foraminifera, see for instance the study in Keul et al. 2013 where the disentaglement in the different C-system parameters allowed the conclusion that not the increase in CO2 but the reduction in CO32- causes the observed decrease in shell weights.

We agree that it is more likely that the decrease in carbonate ion concentration drives the shell thinning and not the increase in atmospheric CO2. The former is a consequence of the latter. We now state that shell thinning could be attributed to both the decrease in the carbonate ion concentration and the increase in atmospheric CO2 and have referenced Keul et al., 2013.

l.377: "is generally reduced at low carbonate ion concentrations" This is not true for all foraminifera (e.g. C. gaudichaudii in Hikami et al. 2011, see the discussion and references in Keul et al. 2013)

Although we did use the word 'generally' here, which implies that this is not universally true for all species, we have modified this sentence to "sensitive to change in carbonate ion concentrations"

l.382: how is this assessed to be 20%? …

We apply the quantitative relationships between carbonate ion concentrations and shell weights from the laboratory studies to the distributions simulated in the FORAMCLIM model. We do not dwell too heavily on this statement because this is a gross extrapolation and neglects many of the other processes known to control calcification rates, such as temperature. We now include a more detailed reference to the laboratory studies and species used to make this rough potential

estimate of the carbonate-only impact on calcification.

l.385: omit are

Done

l.386: and are thusly... (or better: consequently)

Done

l.387: Omega =1 is the theoretical threshold, however, studies have found that foraminifera can thrive in waters with Omega <1, or can be also affected by waters >1. This fact should at least be shortly mentioned.

We have not been able to locate a study documenting planktonic foraminifera that thrive at saturation states less than 1 and planktonic foraminifera live in the upper water column of the pelagic ocean where such levels are unlikely under present day conditions. Perhaps the reviewer is referring to studies of benthic foraminifera, which are not the subject of this paper?

l.397: "magnitude and the sign of the slope"... this strongly contrast the earlier statement in l. 377 "calcification is generally reduced at lower carbonate concentration"....! (the statement in l. 377 is not correct, see earlier comments)

The statement in l377 has been corrected (see correction associated with l377 above).

l.398: it does not only depend on how relationships were assessed, e.g. in laboratory cultures on the same species fundamental differences in the calcification response have been found (see eg. the discussion in Keul et al. 2013 on the differing calcification responses of Marginopora to OA in culture)

To take into account the intra-species variation in calcification responses the sentence has been modified to "…Both the magnitude and the sign of the slope of the relationships between shell weight and carbonate ion concentrations vary between and within a species (Keul *et al.,* 2013)…"

l. 416: add citation to Figure 9 (as a general comment, the discussion would be easier to navigate if comments such as 'we show" are backed up by the specific Figure references, also l. 422 ref. to fig. 6)

Done

l.437: each species' preferred..

Done

l.467: how would such a shift to deeper waters affect photosynthesis of symbionts and consequently foraminiferal growth?

We do get a lower photosynthesis for the foraminifera living deeper in the water column relative to the individuals living shallower in the water column, but the net effect of this downward shift is masked by the overall increase in photosynthesis with the increase in ocean temperatures with climate change. Also, the lower contribution of photosynthesis to growth deeper in the water column is compensated for by the higher contribution of nutrition to growth due to the improved temperature conditions and increased food supply.

Figures 9 and 10 seem a bit blurry

Since the original submission, these figures have been replaced for the upload to BGD.

References:

Titles are capitalized in some

Capitalized titles have been corrected.

l. 643: odd paragraph

Done

l.603: delete space after P in Pole

Done

l.592 and l.526: "pp Page": check l.579 and 523: issue and or page numbers seem to be missing

Done

l.514: 275-&: check

Done