

## **Response to Reviewer #1**

*We would like to take this opportunity to thank the anonymous reviewer for their helpful comments on our manuscript. Below we provide a detailed response to their comments (in italics), indicating the changes that have been made. Line numbers refer to those of the revised manuscript that includes all tracked changes.*

*With kind regards,*

*Mattia Greco (on the behalf of all co-authors)*

Greco et al. present an interesting study on the variability of depth habitat of the planktonic foraminifera N. pachyderma, the most important species in the Arctic. Due to the ubiquity of N. pachyderma both in paleo-records and in present-day Arctic and the significance of its depth habitat for paleoreconstructions, the authors address a relevant scientific question within the scope of BG. The presented results can be used in paleoreconstructions as long as there are proxy on chlorophyll and sea-ice concentration available. The authors compile new and existing data from the Arctic and the North Atlantic Ocean and the substantial conclusions that they come up with are also novel. The scientific methods and assumptions are valid and clearly outlined and the results are sufficient to support the interpretations and conclusions. The authors compare the observational data with a numerical model though this comparison only shows that the model does not perform very well. The methods are described sufficiently precisely. However, as I am not an expert on statistics, I cannot evaluate this aspect of the manuscript. The authors give proper credit to related work and clearly indicate their own contributions. The title clearly reflects the contents of the paper and the abstract provides a concise and complete summary. The MS is well-structured and written and the language is fluent and precise. Therefore I find the MS suitable for publication in Biogeosciences after minor revisions according to general, specific and technical comments listed below. I am looking forward for the authors' response and further discussion.

### **General Comments**

The authors use the term ‘habitat depth’ along with ‘depth habitat (DH)’, which is a bit confusing. Are these two different terms? If so, what is the difference between them? Wouldn’t it be better to stick to only one of these terms? I don’t see a significant difference between them.

*The reviewer rightly mentions that this is confusing, the two terms refer to the same parameter; we will correct and homogenize the terminology adopting only the term “depth habitat”.*

A table listing all the published profiles used in the study and/or a more detailed location map would be useful, at least as an appendix or supplementary material. Now it is completely unclear what published data are you using.

*We appreciate this comment. Due to the size of such a table we prefer to make it available as supplementary material at zenodo.org, where long-term storage is guaranteed. We would like to point out that the link to the table with the complete metadata and environmental data was already provided in the “Data availability” section in the original manuscript.*

A weak, though unavoidable, point of the study is that it compiles data with different sampling depth intervals which might bias the calculated DHs. The authors should stress and discuss this issue a bit more.

*The reviewer rightly points out that the precision with which the DH can be determined depends on the vertical resolution of the individual casts. By mixing casts with different vertical resolution we unavoidably lose some precision, but we would argue that this introduces random noise, rather than a*

*systematic bias. This is probably part of the reason why our predictive models do not explain all the variability in DH. We will add some discussion on this in the method section at page 6, lines 7-9:*

*'Anyway, since the accuracy with which the DH is determined is linked to the vertical resolution of the single profiles, mixing casts with different vertical resolution causes unavoidably the loss of some precision and the introduction of random noise in the data.'*

#### Specific comments

2.3 (page 2, line 3) and 2.20: I know that ‘climate change’ is a catchy phrase but *N. pachyderma* is a marine species and so it doesn’t directly react to climate changes but rather to changes in marine environment (which, of course, are usually related to climate changes). Please be more precise in your wording!

*We will change the sentence to ‘To assess the reaction of this species to a future shaped by climate change and to be able to interpret the paleoecological signal contained in its shells...’*

2.22: Please change ‘Arctic and its marginal seas’ to either ‘Arctic Ocean and its marginal seas’ or just ‘Arctic’ (or ‘Arctic seas’).

*We will change ‘Arctic and its marginal seas’ to Arctic Ocean and its marginal seas.*

4.3: similar as above

*We will change Eurasian Arctic and its marginal seas to Eurasian Arctic Ocean and its marginal seas.*

4.30-32: It is not clear whether the satellite data were used only for data generated by the authors or also for the data from the literature. Please explain.

*We rewrote the sentence to avoid confusion ‘In addition to the in-situ data, daily sea ice concentrations for each location of all the 104 sites included were extracted from 25 × 25 km resolution passive microwave satellite raster imagery obtained from the National Snow and Ice Data Centre’*

7.8: In the text the adjusted  $r^2 = 0.32$ , while in Table 3 it’s 0.336 - 0.34. Please correct or explain the difference.

*We apologise for this mistake, the number referred to in the table is correct and we have changed the text accordingly.*

8.27: It might not be clear to a reader whether ‘lowering the DCM’ means lowering the value of the DCM, i.e. moving it up the water column (shallowing) or lowering it ‘geometrically’, i.e. moving it down the water column (deepening, which I guess is the case). Please clarify.

*We modified the sentence replacing ‘lowering’ with ‘deepening’.*

9.26: ‘at the depth of DH’ please rephrase.

*We rewrote the sentence using ‘at the level of DH’.*

24: The small diagrams in Fig. 4b (normalized density profiles?) need more explanation.

*These profiles only serve to illustrate the meaning of loadings of the first principle component. To make this clearer we rewrote the sentence in the caption: ‘The density profiles based on the standardized counts in the plot show examples of shape of the vertical distribution of *N. pachyderma* at three PCI loadings.’*

#### Technical comments

2.32: I'm not sure about the rules concerning citing of papers with three authors in Biogeosciences but shouldn't it be just 'Ding et al., 2014'?

*The reviewer is correct and we have changed it accordingly.*

5.9: Table 2 is referenced in the text before Table 1. Again I am not sure about the rules in BG, but I guess you should change the numeration.

*We will correct the reference to Table 1 as we refer to the DVM results.*

5.14: I suppose 'Fig. 2d' was meant.

*Correct and amended.*

5.33 & 6.1-2: You already introduce the DVM abbreviation so use it!

*Done.*

6.14: Use 'DH' instead of 'depth habitat'

*Done.*

9.2: 'sea-surface' instead of 'seas-surface'

*Done.*

10.27: An unnecessary 'the' after 'mismatch'.

*Done.*