

Interactive comment on “A new age model for the Pliocene of the Southern North Sea Basin: evidence for asynchronous shifts of marine and terrestrial climate” by Emily Dearing Crampton-Flood et al.

Anonymous Referee #2

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Interesting data are presented, however, the manuscript needs major revision. It is not clear what the data actually tell us, and why. One major issue is that it is not clear what the authors actually want to present. The title suggest that the main aim of the paper is to present a new age model and the introduction is mainly written with a focus on the need for a new age model. Secondly, the title hints at an asynchronous relation between marine and terrestrial climate. Even though both marine and terrestrial data is presented I do not see a focus on an asynchronous relation reflected in the paper. The authors need to figure out if the aim is to present an age model paper or a climate

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paper, and structure the paper accordingly.

The discussion needs to be transferred from providing statements to become a discussion. What do your results show? How can they be explained/what can they tell? Why? What is the suggested mechanism? What is the argumentation for why that possible mechanism is most likely – and for others being less likely? When stating relations to other records, why don't you show some those records as well so that it can be evaluated?

The figure that presents the basis for the new age control is impossible to evaluate and needs to be redone. I would prefer to have the datasets correlated to each other shown underneath each other in the same direction so that the relations between the ups and downs of the two records are immediately visible. I would also like to see how the two records (LR04 and yours) match after correlation, showing both records towards age.

Some of the figures present a lot of data in a small format. Check font sizes and make sure they are readable.

Do you use the d13C data at all?

Comments that emerged while reading the manuscript:

L23: ...costal zones, linking the costal and continental climate evolution, are lacking.

L30: ... stable oxygen isotopes...

L57: Fewer and less well constrained temperature records exist for the terrestrial realm (Zagwijn, 1992; Salzmann et al., 2013), however, they all indicate that climate was warmer than present. Why do you consider them to be less well constrained? Should be specified – because of age control? Because of other issues?

L106: I would be more careful than to say that the infaunal species are unaffected. They can trace large scale climate inflicted changes equally well as epifaunal species, e.g. detect brine signals during glacial times (e.g. Dokken et al., 2013). Furthermore,

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you discuss a potential fresh water influence later on, so some inconsistency here.

L118: What is relative land cover?

L134: Your site is very close to the coast and I would expect much lower water depths than in the central basin. Do you have any idea about what the water depth was at your site? In such a shallow setting the water depth has implications for how to interpret your records.

L145: Why is it an advantage that you get a smoothed record?

L177: Did you rerun any of the samples you consider to be outliers? What is the argumentation for this choice for removing data point? It seems a bit arbitrary. What will the record look like if you include all measurements? What seems to be outliers can very well be true values if it just looks like the values don't belong.

L250: What about C37:4 as a fresh water indicator? Do you see similar changes there? I see that you state later that no C37:4 is present. Implications? Why do you see changes in one of your freshwater indicators but not in all?

L255: extracted and processed for what?

L283: What/why was it challenging?

L290: Here you state a variability of approximately 1‰ while based on the information above (L285 and onwards) it's closer to 2.6‰ (or 0.9 to 1.8‰ if you selectively look at specific transitions). And why would you expect the $\delta^{13}\text{C}$ variability (in amplitude) to match the $\delta^{18}\text{O}$ variability?

Line 336: Lipid biomarkers and proxies. Why do you include "and proxies" here? The isotopes, palynology and biomarkers are all proxies.

L347: This is a very large range. Given your choice regarding "outliers" for the oxygen isotope record, why do you keep the biomarker results as measured? Supports the feeling I get that the removal of some isotope measurements are done a bit randomly

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– even though you have a set way of defining which points you removed.

L355: selected

L374: Why do you get a stronger terrestrial influence towards the Pleistocene? Increased glacial erosion?

Line 411: MAT. Is this short for mean annual temperature? Not mentioned before, needs to be defined. Since you refer to your 1018 paper I assume the record is published and the method is described there, however, I am still curious about how certain you are regarding the absolute values presented given that your record includes extinct species, e.g. *Sciatopitys*? You refer to several other terrestrial profiles – can these be shown for comparison? If they lack age control, can you really link them to your record/state that it is the same?

L438: M2 is very pronounced in some records, but there are also several sites where it's less pronounced, making it an enigmatic period with large uncertainties related to the magnitude of the "glacial" event. Risebrobakken et al., 2016 consider the possibility of a hiatus as an explanation for the lack of the most extreme signature but also that it might have been a less extreme event than expected from e.g. LR04.

Line 443: I cannot see that the North Sea is mentioned specifically in Miller et al., 2011? Overall, estimates of sea level change during M2 varies tremendously in literature. This should be acknowledged. Also take into account the findings of Raymo et al., 2018 where they conclude that for the Pliocene, geochemical sea level proxies currently carry uncertainties too large to allow any meaningful ice volume (hence sea level estimates).

LL461-472: You should not forget that your data is from a very shallow site and hence cannot be expected to reflect the same absolute values as the intermediate and deep water records from Risebrobakken and LR04. How do you physically transfer the suggested freshwater signal from the rivers to the bottom of the North Sea? A river signal

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will be much less dense than a marine water mass and lay as a fresh lid on top of the denser water mass. This is one example of where knowledge of the paleodepth of your site is key to be able to make trustworthy interpretations of your data.

L479: The difference in amplitude of change between the global deep water stack and your shallow regional/costal site does not prove that the area is more sensitive to climate disturbances. Furthermore, what do you mean by climate disturbances? This is an empty term.

This section is also an example of statements without discussion. You should check this throughout and make sure that your discussion is a discussion and not just statements. Discuss your results, potential explanations, reasons for why one or the other potential explanation is more or less likely, and in the end conclude on what you find to be the most likely solution and why. The mechanisms are important. E.g. how do you physically make the fresh water reach the bottom of the North Sea in order to explain light benthic isotope values by fresh water influence.

L496: When you say that you tune the warmer periods, what exactly do you mean by that? I would never use the maxima or minima as tuning point between records, but rather go for transitions, since the character of the records you tune is bound to be different.

L505-513: From figure 5 it is impossible to evaluate the correlation between LR04 and your record and hence the basis for your age model. This figure needs to be improved. One suggestion would be to show the record so that you read them in the same way. Another thing I would require to see is a direct comparison the two isotope records vs age, following your new tuning of the record.

L527-528: I would expect that a dominance of deeper dwelling organisms influencing the GDGT data will provide colder temperatures than what you will expect for the surface, even if the water depth is shallow. At what depth is the thermocline located at the site today, annually and during summer? If it's a winter signal as you argue, what is

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the difference between your values and the present winter temperatures (looks to be around 6[°]C according to WOA18)? Or even better, can you compare your temperature datasets to present day measurements from the same proxy in the same site/close by? Same for alkenones (L543) and LDI?

L540: Can you show a comparison towards some of these other records? All of these would relate to bottom water temperatures at your site – again, even if it is shallow there will be a clear difference between the top surface and the bottom water, especially if there is any seasonal biases. What does the temperature profiles look like today?

L550: Okhotsk and Rhode Island are quite different settings from your site. Are there any more local relevant studies to take into account?

L624: What is the present ocean circulation regime of the area? Should be presented in the introduction part of the paper. How large a fraction of the NAC enters the North Sea through the English Channel relative to north of Great Britain? Given the Pliocene geography of the area how different do you expect the circulation regime to have been?

L639: Why? How? The full section here where you link the Zagwijn data to your data without showing them and without really making it clear if you can or cannot do this seems speculative to me.

L652/L656: Can the variability be linked to the colder and warmer isotope stages? Does your variability compare to the changes seen in these other records?

L661: The variability discussed by Bachem et al., 2017 and linked to gateway changes in not related to mPWP.

L663: The freshwater influence suggested for Clotten et al. 2018 cannot be used as direct support for fresh water influence at your site.

L684-687: What is the argumentation and reasoning behind this statement? It is not clear how you support this conclusion.

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L703: If this is the case you should show it. All the records you refer to are available online and can be plotted together with your data to document this statement. I would also like to see this relative to LR04 and your own d18O record, with the individual isotope stages visualized.

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