A well written paper which presents a multi-proxy based reconstruction of Pliocene marine sea surface temperatures and terrestrial climate of the Southern North Sea Basin. The core was taken in a marginal marine setting, and the interpretation particularly of the lipid biomarker proxy record is difficult as the signal is influenced by a multitude of marine and terrestrial factors. The authors are generally aware of the potential implications and the manuscript contains a thoughtful and careful discussion of the potential controls and limitations.

A: We thank Anonymous Reviewer #1 for their kind comments about the manuscript and the proceeding comments which will help us in improving the manuscript. We reply to specific comments below.

However, the authors final conclusion about marine and terrestrial climate evolution during the mid Piacenzian warm period (mPWP) and reorganization of the North Atlantic Current does not seem to be supported by data. I disagree with the statement that lipid biomarker and palynology-based temperature proxies suggest a stable warm climate during the mPWP. In fact, the lipid biomarker shows mean annual temperatures ranging from 7 to 12◦C during the mPWP (Fig. 6) and only between 3.17 Ma and 3.1 Ma a plateau. No conclusion on terrestrial climate variability during the mPWP can be drawn from the terrestrial pollen and spores as this 300 ka long interval is only covered by 4 samples.

A: Thank you for the comment. We agree with the reviewer that the proxy records indicate that the early part of the mPWP (>3200 ka) does not seem to have been very stable. However, this presumed instability may be an artefact of a disturbance in the record related to the recovery of the M2 or the M2 event itself (see discussion in response to Stijn de Schepper). Such a disturbance is also indicated by the coinciding peak in Osmunda pollen, which may indicate a sea level drawdown. In our discussion, we chose to focus on the period that we have been able to constrain with our new age model, and only covers a part of the mPWP, from ~3.18 Ma to ~3.0 Ma (black circles on Fig. 6), during which terrestrial climate appears stable. In the revised version of the manuscript, we will stress that the age tie-point represented by the red circle in Fig. 6 (~3.26 Ma) is based on biostratigraphy, and should therefore be interpreted with caution due to the large uncertainty associated with the last occurrence datum (LOD) of Melitasphaeridium choanophorum in the North Atlantic and the Nordic Seas, on which this point is based (see Dearing Crampton-Flood et al., 2018). Hence, we will also modify Fig. 6 to only shade the region that falls within the constraints of the updated age model based on $\delta^{18}O$ presented in this study. The proxy records that we discuss in Section 5 of the paper are associated with this shaded region on which we have the best age control.

Furthermore, based on this comment and the remarks of Stijn de Schepper we will review the possible influence of the North Atlantic Current on the study site from the discussion in the revised version of the manuscript, adding more speculative language.

TEX86, which has been interpreted as representing winter temperatures, shows relatively constant temperatures during the mPWP, while UK37 indicates very variable summer SSTs. However, the authors point out that the high values could in part be caused by freshwater algae that have little or no correlation with temperature. In fact, there are several indicators suggesting that at least some of the major changes in proxy values are controlled by the changing depositional environment and associated fluvial input. The statement of an overall "asynchronous shift of marine and terrestrial climate" indicating a reorganization of the NAC during the mPWP appears to be an unnecessary over-interpretation of the otherwise very interesting data.

A: Thank you. In light of the comments made by yourself, Stijn de Schepper and the second anonymous reviewer we will amend the title of the revised manuscript to: "A new age model for the Pliocene of the Southern North Sea Basin: a multi proxy climate reconstruction". As mentioned above, we will tone down the discussion in the manuscript that you and the other reviewers have identified as being too speculative, e.g. the influence of the NAC on the study area. In the revised manuscript, we will add the possible influence of the NAC as a hypothetical reason for the observed variability in SSTs recorded by lipid biomarkers.

Minor comments: Line 18 and 48: Be consistent with mPWP which is called in the abstract mid-Pliocene Warm Period and Introduction mid-Piacenzian Warm period. As the mPWP is part of the late Pliocene, the latter seems to be more appropriate.

A: We thank the reviewer for pointing out the inconsistency for the mPWP references. We will consistently refer to the mPWP as the mid-Piacenzian Warm Period in the revised manuscript.

Line 196: dinocysts and sporomorphs (or pollen and spores) were counted

A: Thank you, we will amend the sentence.

Line 260 ff.: Can the lipid biomarker method part be shortened?

A: We will shorten the specification and GDGT analysis method paragraph substantially, and will refer to Dearing Crampton-Flood et al. (2018; EPSL) for more details on the biomarker extraction methods and the GDGT analysis. The proceeding two paragraphs outlining the analysis of the long chain diols and alkenones have not yet been reported elsewhere and will be kept as is.

Line 327 and figures: "Heather" which represent the actual plants of the family Ericaceae is better than "heath" which normally means the entire heathland habitat.

A: Thank you for your suggestion, we will change the reference from 'Heath' to 'Heather' in the text and in Fig. 3G.

Line 329: The authors counted approximately 200 pollen and spores per sample and excluded the bisaccate taxa from the pollen sum. I am wondering how many angiosperm pollen are actually left? Please provide more details on the total pollen sum (e.g. in Fig S1) and the pollen sum which has been used to calculate non-bisaccate pollen percentages.

A: The pollen sum is not high, which is why we refrain from detailed paleoclimatological interpretations based on the pollen data. The main aim was to highlight the main quantitative trends, for which this pollen sum is adequate in a marine setting with no local vegetation variability. The pollen sum with and without bisaccates averages 250, and 60, respectively. The pollen sum includes all taxa except bisaccate conifers and Osmunda spores which were highly overrepresented in one sample. The caption of Figure S1 is incomplete, and we will adapt this. The two summary panels on the right side of the full diagram (Fig. S1) show both sums, the multi-colored panel excludes bisaccate conifers and is the primary percentage sum, and the grey shaded panel shows the bisaccate pollen as percent of the total terrestrial palynomorphs (the sum including all conifers and Osmunda). This way the abundances of all taxa can be compared without being affected by the potential transportation bias of bisaccate pollen. We will expand the caption of Figure S1 to clarify.

Line 513: Fig. 4d should be 3d

A: We assume there was a typo and the reviewer is referring to Line 413. Thank you, we will amend this.

Line 425: Why do the authors refer to Donders et al, 2007? The palynological results from the Hank borehole seem to suggest the opposite in indicating the continuous presence of warm-temperate taxa (Fig. S1). Please discuss.

A: In Donders et al. (2007), the majority of warm temperate taxa listed are shown to disappear at the Pliocene/Pleistocene transition. However, in these upland sites, the variable deltaic/fluviatile Pliocene deposits and incomplete preservation caused a hiatus of the uppermost Pliocene and lowermost Pleistocene deposits. The Hank site, however, is located in a shallow marine basin with a broader catchment and a regionally integrated signal, with a relatively more complete and reliable stratigraphy. However, the Hank site is not in contradiction to the land-based study where the earliest Pleistocene is probably not completely preserved and the last occurrences of warm-temperate taxa seem more abrupt (Donders et al., 2007). The clearest indication for this are the very low values of Taxodium-type pollen toward the top (Fig. S1). Tiglian deposits from the Netherlands, approximately dated to 2.0 Ma (Zagwijn, 1992; Quat. Sci. Rev.), still contain abundant Pterocarya, but only trace quantities of Taxodium-type and Carya (possibly reworked), and no Nyssa. From sequences in the central North Sea (Donders et al., 2018; Climate of the Past), it became clear that the earliest Pleistocene glacial-interglacials (MIS 102-92) do no longer contain Taxodium, Nyssa, or Carya, however this area receives sediment from southern Scandinavia (Eridanos), rather than the Rhine catchment. In summary, warm-temperate taxa disappeared in the earliest Pleistocene but not all at the same time, and most likely slightly above the level of the top of the Hank sequence, although warm-temperate taxa are clearly in decline as is seen in Fig. S1. We will rephrase the statement to clarify this point and add an additional reference.

Line 605 and Fig. S1: The acme of Osmunda coincides with a decline of almost all other taxa in the pollen diagram. The authors state that Osmunda has been excluded from the pollen sum, and I am struggling to see which other taxa increased. They do not seem to sum up to 100% at ca. 306 m.

A: This is explained in the point above on the pollen sum and caused by the incomplete description in the caption of Fig. S1. Osmunda increases and bisaccate taxa decline. At the same time (within the non-bisaccate total), Ericaceae, Alnus, and other fern spores increase relative to especially Taxodium-type.

Fig.2 and Fig 3: Rephrase in figure captions "The intervals corresponding to A, B C depth discussed in the text are indicated" and provide keys to colours (e.g. marine/deltaic etc).

A: We will amend the figure captions of Figs. 2 and 3 to read: 'Intervals 1, 2 and 3 discussed in the text are indicated by green (Early Pliocene), grey (mid-Pliocene), and purple (late Pliocene-early Pleistocene).'

Fig 4. Provide proper depth scale instead of arrow.

A: We will provide a depth scale in Fig. 4.

Fig. 6 Add depth scale to age scale to allow better comparison across figures.

A: We have attempted to add a depth scale to Fig. 6, however as the sedimentation rate is not continuous in this interval (Fig. 5e), we believe that adding a depth scale would create unnecessary confusion to the reader by making the figure too 'busy'. Instead, we will include the depth interval of the period covered by the tuning of oxygen isotopes to the LR04 stack (Fig. 5) to the figure caption.