Referee 1

Review of "Holocene paleoceanography of the Northeast Greenland shelf" by Teodora Pados-Dibattista, Christof Pearce, Henrieka Detlef1, Jørgen Brendtsen, Marit-Solveig Seidenkrantz.

This manuscript is an interesting contribution to a number of ongoing international efforts to investigate the region of and off NE Greenland. This region is of particular importance for the Greenland Ice Sheet because it holds the NE Greenland Ice Stream, which accounts for a large part of the ice export from the ice sheet. The manuscript builds on established foraminiferal, isotopic and sediment-chemical data sets from a long sediment core obtained on the NE Greenland shelf which allow to reconstruct environmental change in this area at high temporal resolution and in great detail. The results are novel, the data interpretation is well-founded and in general I am in favor of a publication of this data set in Climate of the Past.

We are grateful to the reviewer for their valuable comments, which have been important for improving the manuscript. We have done our best to make corrections to the manuscript accordingly. In a few instances, we have chosen a different solution to an issue pointed out by the reviewer; in those cases, we provide explanations to this under each comment below.

However, I have two major concerns which should be addressed by the authors before publication is possible:

(1) The age model is based on a calibration which uses the Marine20 data set of Heaton et al. (2020, Radiocarbon). In this paper, Heaton et al. explicitly state already in the abstract (and in detail in the text) that the Marine20 data set "is not suitable for calibration in polar regions". Accordingly, Pados-Dibattista et al. need to find alternative ways of calibrating their radiocarbon data. They may think of using the IntCal20 data set and a suitable local reservoir correction. Proposed corrections have been published by e.g.,

Tauber, H., Funder, S., 1975. 14C content of recent molluscs from Scoresby Sund, central East Greenland. Grønlands Geol. Unders. Rapp. 75, 95–99.

Mangerud, J., Bondevik, S., Gulliksen, S., Hufthammer, A.K., Høisæter, T., 2006. Marine 14C reservoir ages for 19th century whales and molluscs from the North Atlantic. Quat. Sci. Rev. 25, 3228–3245.

Coulthard, R.D., Furze, M.F.A., Pienkowski, A.J., Nixon, F.C., England, J.E., 2010. New marine ΔR values for Arctic Canada. Quat. Geochronol. 5 (4), 419–434).

Thank you for your comment. The reviewer is correct that Heaton et al. (2020) state that the Marine20 is not suitable for polar regions. The same was true, however, for Marine13; it was just not explicitly stated as for the latter calibration curve. The presence of sea ice in polar regions impacts the local reservoir age, and therefore there is added uncertainty; this issue is not resolved by using an older calibration dataset. It is also not resolved by using the terrestrial IntCal20 as this would lead to further uncertainties. Without the presence of alternative dating methods (e.g. tephrochronology, paleomagnetism), all we can do is acknowledge this added uncertainty in the chronology of these Arctic marine sediment archives. Moreover, since its publication, the Marine20 has been widely used in the Arctic

realm, e.g., Farmer et al., 2021 (Nat. Geoscience https://doi.org/10.1038/s41561-021-00789-y), Altuna et al., 2021 (Commun. Earth Environment https://doi.org/10.1038/s43247-021-00264-x) to name just a few. Finally, the differences for this specific Holocene reconstruction between using Marine13 and Marine20 are much smaller than the associated uncertainties. When evaluating the reservoir age we have taken all existing literature into account.

(2) The Discussion chapter needs to be reorganized. Currently, in its first part it consists of several subchapters (6.1-6.2) discussing Holocene environmental change on the NE Greenland shelf as derived from own data. This text is mostly fine, but more comparisons should be made with the paper of Zehnich et al. (2020) which contains (among other data) benthic isotopic data sets of higher temporal resolution than the ones of Pados-Dibattista et al. In the present manuscript the second part of the Discussion chapter holds two subchapters (6.3 and 6.4) which present a review of published knowledge concerning larger-scale Holocene climatic and environmental connections in and around the research area. What is missing is the combination of both parts. The authors need to show how their own results relate to larger scale developments and how they may improve our understanding of these developments.
Each paragraph in the discussion chapter 5.3 (Paleoenvironmental interpretation) starts with a short environmental interpretation of the data from our own core. It is necessary first to provide an environmental interpretation before discussing its significance. We chose to combine this environmental interpretation with the broader discussion in order to both avoid repetitions and make the links clearer. However, we keep the short interpretation in a separate subsection, in order to clearly separate, which part of the discussion is based on our new study, and which is based on comparison to previous studies.
The last two paragraphs of the discussion (5.4 and 5.5) place our results in an even broader context, but here we have now added more references to our own data. Moreover, we have added more comparisons to Zehnich et al. (2020).

Minor and more specific comments and proposed corrections (general and by line numbers):

Check the entire manuscript for consistency:

- sea ice vs. sea-ice
Corrected.

- West Spitzbergen Current vs. West Spitsbergen Current
Corrected.

Be consistent with using either British or American spelling (grey/gray, colour/color, -ise/-ize)
Done.

9: stable isotope and
Corrected.

14: iceberg
Corrected.

26-27: The reader might want to know why the "societal and environmental relevance of this sea-ice reduction" is particular important for Greenland...
Sentence added.

34: meltwater
Corrected.

35: budget and stratification, and it influences
Corrected.

36: Indicate Northeast Greenland ice stream on the map! Later you use "Northeast Greenland Ice Stream". Be consistent with capital letters!
Corrected and added text with the glacier outlets. We indicated the Northeast Greenland Ice Stream on the map (Fig. 1).

39ff: Is it necessary to mention all the site numbers and citations in the figure caption if they reappear in the Discussion anyway? I guess something like "Locations of cores discussed in the text are indicated" would be enough...
Thank you for your comment, however, we think that it is quite important for the easy overview to indicate the site numbers and citations in the figure capture. In this way, the reader doesn´t have to spend a lot of time looking for this information in the text and can compare easily our results to other relevant papers.

51: Moossen
Corrected.

55/56: "the returning branch of the West Spitzbergen Current" - if you mean the RAC, then call it RAC!
Corrected.

57: freshwater (check also in the entire manuscript!)
Corrected.

58: affects
Corrected.

63: Better: demanding an improved...
Corrected.

65-69: You should either be more specific in explaining the features connected with the NAO or delete this paragraph and introduce NAO later. As it reads now, it is very general and details (e.g., NAO+ and NAO-) need to be introduced later, anyway (e.g., "a redistribution of atmospheric mass" - what kind?; shifts from one phase to another" - what kind of "phases"?)
We agree that the description was rather generic and we have thus moved the detailed description of NAO (which describes the impact on Atlantic Water inflow in the Fram Strait and sea-ice formation) from the discussion to the introduction.

76: most of the Holocene
Corrected.

82: of the NE
Corrected.

83: better "neighbored banks"? The banks are not really surrounding the troughs!
Thank you for your comment. We do see your point, but we took the term from Arndt et al., 2015, which is describing the detailed bathymetry of the Northeast Greenland continental shelf. As this paper has become a standard background paper for the region, we prefer to keep this terminology.

87: Johannessen (check also in ref list!)
Corrected.

88-89: In your Fig. 2a, waters with S<32 only reach down to 150 m!
In figure 2a we show CTD data, which is reflecting the water column at the moment of sampling. On 2b we show an annual temperature average. We added this information to the figure capture to make the difference more understandable.

90: Atlantic sources
Corrected.

93-94: From Fig. 1 I cannot see that the RAC runs along the Greenland coast.
We changed the text in order to make it more understandable that the RAC is joining the EGC.

99: modulates the glaciers' basal
Corrected.

101-102: Make two sentences!
Corrected.

102: Start sentence with "Today, ..."
Corrected.

103: Polar Front lie east... Start new sentence with "However, ..."
Corrected.

105-107: Make two sentences!
Corrected.

108: increases in size
Corrected.

108-110: Make two sentences!
Corrected.

113 vs. 120: Why are coordinates of the core site differing in detail?
We added “coring station” in the figure capture of figure 2, in order to indicate that the CTD sampler and the gravity corer was deployed at slightly different positions but at the same station.

117: Temperatures (WOA) from which season?
Added “Annual average”.

117: this transect
Corrected.

140: top sediment loss?
Corrected.

155: are shown
Corrected.

159: the 100-1000 μm fraction
Corrected.

167: bulk sample
Corrected.

169: intervals
Corrected.

170: The official silt size is 2-63 microns. Are you sure that you used a 60 micron mesh?
The particle sizes measured are dependent on the available instrument. We did not use sieves (i.e. thus not a 63 μm mesh) to identify the particle sizes but a laser diffractometer. The laser particle sizer (Sympatec Helos) at the Department of Geoscience, AU has settings for these three groups: sand (>60 μm), silt (2-60 μm) and clay (<2 μm), and the 60 μm is so close to the 63 μm that this does not have any significant impact on the fractions.

176: Clearly describe what is shown in this figure, from left to right!
Corrected.

185: Better: below the lowest radiocarbon-dated sample
Corrected.

186-187: Give a cross-reference to chapter 4.4 for the reworked species.
Corrected.

191: ... and focus on the last 9.4 ka.
Corrected.

200: lowest radiocarbon-dated level
As we modified slightly the figure (instead of dashed line a hatched box under the lowest radiocarbon date), we exchanged this sentence to: “The hatched box in the bottom of the core indicates an interval containing reworked microfossils and is therefore of uncertain age”.

203: insert reference to Fig. 3
Inserted.

203-204: I agree that there is mostly a good visual correlation (maybe you should calculate correlation coefficients?), but I do not see a "trend" to either higher or lower values. If it is there, it is weakly developed.
We have changed the text to “relatively constant values”.

206: For me this "steady increase" is hard to see.
The reviewer is right, we have reformulated the sentence to: “followed by a steady increase until 125 cm (ca. 3.2 ka BP) and rather constant values until the top of the core”. Moreover, we added a mean-line to all four XRF curves in figure 3, in order to make it easier for the reader to see the described changes.

207: I think the variability in Ca/Fe between the core base and c. 340 cm is more than just a "slightly stronger fluctuation". The amplitude is orders of magnitude higher than in the rest of the core!
The reviewer is right about that this sentence was not well formulated. We added a sentence at the beginning of this section to point out that later we are only describing the last 345 cm of the core. Moreover, we added “from 345 cm until ~270 cm” to the mentioned sentence, in order to emphasize that we do not describe the very end of the core here.

212-218: Be more specific and clearly distinguish between modern and extinct species!
Done.

229 and 236: I do not think that it makes sense to give an average percentage in the entire core for the total agglutinated or total calcareous species, especially if (as you write) the relative proportion is changing from the core base to the top. I ask you to calculate % agglutinated of all benthics for each sample and add this record to Fig. 5, also because you refer several times to the aggl/calc ratio later in the text.
We agree that when evaluating percentage data, it needs to be taken into account that the number of agglutinate specimens decrease downwards. This is also, why we have shown the relative frequencies vs. only agglutinated specimens and calcareous only vs. calcareous in figures in the supplementary. However, we now also show the % agglutinated of the total benthic foraminiferal assemblage in Fig. 5. Moreover, in response to a comment by reviewer 2, we have added two figures showing the concentrations (individuals of species per gram sediment) to the supplementary (Fig. A4 and A5).

230: Start new sentence with "However, ..."
Corrected.

238: Again, I cannot see a "steadily decreasing trend towards the top of the core". Values are relatively high near the core base, around 6.5 ka, and near the top. In between they are lower. No trend is visible...
Corrected.

244: Arctic
Corrected.

245: Why is there a period (.) behind the Roman letters for the ecozones? Looks strange...
Corrected.

245-246: It is more common to say "horizonal" and "vertical" axes.

Thank you for your comment. However, after consulting with two English native speakers, we believe that x and y axes are the right terms. We would like to ask the Editor to advise us, whether the journal has some preferences on this topic.

257: Once "on average" is enough…
We agree that the repetition of "on average" seems somewhat obsolete and irritating. However, as we worry that the information could otherwise be misleading or raise questions, we have added the following sentence prior to the foraminiferal zone descriptions: "Unless otherwise specified all relative frequencies are provided as average values for the interval."

294: A trend means that values are changing in one direction, i.e., they become higher or lower. If values are mostly the same, then there is no trend. One would rather say that values remain constant (within a certain range).
Corrected.

298: Wouldn't "cluster" be the proper term?
Thank you for your comment, however, we worry that the term cluster could be misunderstood as derived from cluster analyses. The term "groups" or "groupings" is in fact very commonly used in this context (e.g., Rasmussen and Thomsen, 2004; Perner et al., 2012; Seidenkrantz et al., 2021). Thus, we believe that group is the term that is more fitting to our description.

308: in our interpretation
Corrected.

313: and in fjords
Corrected.

315: I suggest to label the panels/records (a) to (i) and give these labels in the figure caption together with the description of the individual panels/records. This will make it easier for the reader to identify certain records.
Good point, we have added labels.

325-326: How can the bottom waters in these troughs be distinguished?
According to e.g., Budéus et al. (1997) and Schaffer et al. (2017) Atlantic water masses on the bottom of Norske and Westwind Trough differ in their temperature and salinity. We added a sentence in order to explain this topic better.

327: but may also be present due to...
Corrected.

328: shelf break
Corrected.

334-337: Kapp København is a location, not a deposit. Where are such places with Pliocene/early Pleistocene sediments? I cannot find anything on the map (Fig. 1). Is it likely that sediments were transported to your site, and how? Writing that "the breakup and significant retreat of a nearby glacier caused reworking of older sediments" is too general and the example (Seidenkrantz et al. 2019) is from far in the south...

It is actually the Kap København Formation in Peary Land; we by mistake used an abbreviation. The paragraph has now been rewritten to better explain our suggestion, and the location is marked on Fig. 1b.

340: What is the evidence that this was a "cold interval"? You should avoid introducing such a-priori statements before you discuss your own (and published) paleoclimatic evidence.
Corrected. The word “cold” was deleted.

344: "would have characterised" ... if...?
Corrected through rephrasing.

340-348: Stratification and water masses on the NE Greenland shelf are also discussed by Zehnich et al. (2020). You should compare the results - here and in the other subchapters of the discussion.
We have now included more comparisons with Zehnich et al. (2020) in the text.

343**:** Here you say that the area was heavily sea ice covered. Later (l.349 and in the discussion of the Syring et al. 2020 results) you state that planktic foraminifers were abundant and productivity was high. At first sight this sounds contradictory and needs a proper discussion. I am aware that this discussion comes when the relation to the ice margin is discussed, but you may from the beginning say that the results are only apparently contradictory.
Thank you for your comment, we have reformulated this part and added a sentence about the apparent contradiction of the results.

348: A reference is needed when certain elements are ascribed to sources.
Added.

348: I cannot see that the d18O values are particularly low in this section. A potential influence of temperature changes on d18O should be discussed. There is evidence for an enhanced advection of Atlantic Water to the NE Greenland margin (Bauch et al., 2001). As shown in several papers on the W Svalbard margin, this advected AW was relatively warm, even when compared to today, and likely it was still relatively warm when it reached the NE Greenland margin as the RAC. Accordingly, there may be a temperature influence on the isotopic signal. Moreover, how would meltwater (near the surface) influence the d18O of benthic organisms?
We agree that there is no major difference between the d18O in this interval and the following intervals, but still, on average values are a bit lower. We have now added a short discussion on the potential causes, i.e. not just meltwater but also the impact of warmer bottom waters.

In any case, you should compare your isotope results (both d18O and d13C) to the isotope data sets of Zehnich et al. (2020).
We have added more comparisons with Zehnich et al. (2020).

356ff: Try to find better arguments for a linkage of your event with the 8.2 ka event. Can you derive information on the nature of these sediments from the X-ray photos? What about grain sizes? Wouldn't more icebergs leave traces by IRD-rich sediments?
Unfortunately, as mentioned in the text, we don´t have in the presented results other clues that would point to the 8.2 ka event. Our grain size analysis has a quite low resolution and it

doesn´t show any significant changes throughout the top 345 cm of the core. As mentioned in the text, the XRF peak could be only potentially linked to the 8.2 ka cold event. Further analyses are needed to be able to confirm this theory.

357ff: Long sentence. Split into two!
Corrected.

374: appeared around 8 ka BP in the record, after a long absence
Corrected.

378: This refers to the previous sentence and should not start a new paragraph.
Corrected.

384ff: Core numbers are not necessary here and in many other places when references are given.
Thank you for your comment, however, we believe that indicating the core numbers in the text makes it much easier for the reader to find the relevant core positions on Fig. 1.
Müller et al. discuss sea ice coverage and bioproduction, but temperatures only in a semiquantitative way. Werner et al. (2013, 2016) are more appropriate references for near-surface temperatures off W Svalbard and should be used here and in other subchapters of the discussion.
We exchanged Müller et al. 2012 to Werner et al. 2013 and 2016.
They show that strongest AW advection started c. 10.8 ka. On the other hand, Risebrobakken et al. (2011) showed that highest SSTs came only c. 9 ka. Since there is a strong influence of AW at the NE Greenland shelf seea floor, the timing of AW and temperature maxima should be discussed with reference to results from the E Fram Strait. Is there a discrepancy? Can you speculate why?
Thank you for your comment; however, we do discuss this topic later, in the discussion chapter 5.4, where we place our results into a broader context: “The drastic ice recession of the early Holocene produced an extended meltwater surface layer in the Greenland region prior to 8.6 ka BP (Seidenkrantz et al., 2013). The extensive melting of the Greenland Ice Sheet was strong enough to act as negative feedback to the early Holocene warming, and delayed the HTM with 2 kyr at our location compared to the eastern parts of the Nordic Seas (Blaschek and Renssen, 2013).”
One may also ask whether results from SE Greenland are suitable for comparisons. The Nordic Seas are much wider than the Fram Strait and the heat distribution by AW works in a different way there.
We believe that South East Greenland is an important location to mention and to compare to, as we are attempting to reconstruct the strength and the composition of the East Greenland Current, which flows south along the whole East Greenland coast.

403: Foster Bugt is not on the map in Fig. 1.
We changed Foster Bugt to Middle East Greenland shelf in the text.

402-406: Okay, this is interesting information. What kind of conclusion can you draw?
The conclusions of these changes recorded between 6.2 and 4.2 ka BP is mentioned in chapter 5.4, where we place our results in a broader context: “After the Thermal Maximum… The EGC became stronger, with sea-ice loaded surface waters and relatively warm Atlantic-sourced subsurface waters. Coincident with the expansion of the EGC, several studies from the Nordic Seas (e.g., Bauch et al., 2001; Hall et al., 2004; Hald et al., 2007) infer a

weakening of the AMOC, increased water column stratification and less ventilated subsurface during this period. In line with a decreased flux of recirculating AW onto the NE Greenland shelf, the Northeast Greenland Ice Margin started to advance from its mid Holocene minimum around 6 ka BP (Larsen et al., 2018)".

412: <1
Corrected.

414-415: Theoretically, high d18O could also result from stronger AW influence. You should build your arguments on a combination of proxy interpretations. Example: Since the forams point at low bottom water temperatures, we interpret the high d18O valus as indicative of...
Corrected.

420: 4.2 ka
Corrected.

427: What can you conclude from the literature information?
The conclusions of these changes recorded around 3.2 ka BP is mentioned in chapter 5.4, when we place our results in a broader context: "The Neoglacial cold interval started on the East Greenland shelf approx. 3.5-3.2 ka BP, with increased freshwater forcing from the Arctic Ocean and advance of the Greenland Ice Sheet (this study; Andersen et al., 2004; Jennings et al., 2011). According to model simulations of Renssen et al. (2006), the expansion of sea ice may be associated with a cooling triggered by a negative solar irradiance anomaly, which was amplified through a positive oceanic feedback mechanism. The cooling caused temporary relocation of deep-water formation sites in the Nordic Seas, which was accompanied by a distinct reduction in AMOC strength (Hall et al., 2004). The increase in sea-ice extent stratified the water column and hampered the deep-water formation, leading to additional cooling and more sea ice (Renssen et al., 2006)".

432: from ... to ...
Corrected.

433: Atlantic Water
Corrected.

437 to previous times
Corrected.

444: Several papers show that there was a cooling trend after c. 5 ka. However, there is also evidence for some warming in the last 2 ka (e.g., Sarnthein et al., 2003; Werner et al., 2013; Telesinski et al. 2014a,b; Zehnich et al. 2020). Is this expressed in your data? If not, can you speculate why?
Unfortunately, the resolution of the last 2000 years in our data is not high enough to see short term warming events, such as mentioned in e.g., Zehnich et al. 2020.

474: Syring et al., 2020b
Corrected.

501: Also Werner et al., 2013, 2016; Consolaro et al., 2018
Corrected.

523: Hillaire
Corrected.

539: started to resemble
Corrected.

542: Freshening is usually strongest near the sea surface and would thus increase (and not reduce) stratification...
As stated in the sentence, at the same time that the PW increased at the surface of the EGC, the warmer waters in subsurface levels transported by the RAC also decreased. With other words, the subsurface got also cooler, thus, reducing the stratification.

543: and to a (near) perennial
Corrected.

545: What is "possible sea-ice cover"?
Changed to “and possibly, sea-ice cover”.

780: Sarnthein
Corrected.

Fig 1: Orange lettering is difficult to read on greenish background (insert map)
Thank you for your remark. We changed the color to slightly darker; however, we would like to keep the orange color because we would like to show to the readers that we speak about the same water masses on the insert map as the one marked orange on the overview map.