Response to comments by reviewer 2 on cp-2024-60

We would like to thank Reviewer 2 for the constructive suggestions, which helped us improve the quality of this manuscript. Below, the reviewer's comments are presented in blue, and our responses to each point are in black.

Summary

This paper presents organic geochemical proxies used to distinguish the source of organic matter (OM) in two 17-18 kyr records from the Laptev sea. The data is integrated with pan-Arctic records in an attempt to investigate local versus global drivers of enhanced OM flux during deglaciation. It is a very nice study and paper that fits well within the scope of Climate of the Past. However, I also think there is some room for improvement in he presentation and discussion of the data. Specifically, 1) a clearer presentation of sedimentation rate changes in the studied cores (and how they impact the mass accumulation rate estimates) is important, 2) a more in-depth discussion about the timing and link to OM flux/source changes associated with previously identified meltwater events in the Laptev Sea between MWP-1A and MWP1B. These are discussed further in the points below:

Specific comments

Line 25: "Additional terrOM MAR peaks coincided with periods of enhanced inland warming, prolonged ice-free conditions, and freshwater flooding, which varied between regions.". I wonder if this sentence could be more specific, for instance, be specific about what periods evidence for coastal erosion in response to sea-level rise are identified, and at what periods are inland warming and freshwater flooding seen? Also - maybe the last sentence could be re-written so that the expression 'regional terrOM fluxes' only occurs once.

We thank Reviewer 2's suggestion to enhance the clarity of the abstract. We will revise the last section of the abstract (line 25) as follows: "Additional terrOM MAR peaks varied regionally. Peaks from the Beaufort Sea during the Bølling-Allerød coincided with a freshwater flooding event, while peaks from the Laptev Sea and the Fram Strait during the Preboreal/early Holocene coincided with periods of enhanced inland warming and prolonged ice-free conditions. Our results highlight the influence of regional environmental conditions, in addition to global drivers, which can either promote or preclude regional terrOM fluxes."

Could the authors add a bit more information on how a dR value of -95 +/- 65 years for the Marine20 calibration curve was derived from Bauch et al, 2001? It is good to describe the conversion of old dR values when making them compatible with the Marine20 calibration curve, it is good bookkeeping.

We thank Reviewer 2's suggestion to provide more details about the updated ΔR values for cores PS51/154 and PS51/159, this helps improving the clarity of the calibration process. We will modify the method section to "We used the Marine20 curve for calibration (Heaton et al., 2020), with a time constant ΔR =−95±61 yrs calculated using the Marine20 database (http://calib.org/marine/). This ΔR value was derived from the average reservoir ages of 5 modern bivalve shells from the Laptev Sea (Bauch et al., 2001). The rationale for using an updated ΔR is the ~150 yr shift in the global marine reservoir age between the Marine13 curve used in the previous age model (Hörner et al., 2016) and the Marine20 curve used in this study (Heaton et al., 2023; Heaton et al., 2020)."

Result, Section 4.1 chronology: "The mass accumulation rates (MARs) of all biomarkers were largely affected by the pronounced sedimentation rate changes and thus, showed similar temporal changes in all terrestrial biomarkers, including HMW n-alkanes, HMW fatty acids, and lignin phenols (Fig S3, contents of each biomarker in Fig S4). Fig 2a and Fig 5 i, j show the mass accumulation rate of HMW fatty acids as a representation.". Mass accumulation rates play a very important role in the environmental interpretations presented in this paper. In a number of areas the author's highlight how important the number of age-depth control points, and more generally changes in sedimentation rate, can impact these calculations. Furthermore, one of the most general questions about how offshore sedimentary processes responded to regional and global climate changes, concerns how the mass accumulation of sediments (sedimentation rate) changed. If there is an influx of material from land, one would expect that there would be enhanced deposition of sediments offshore. One question not answered in the current paper is - do we see this? I think it would be great if the authors added a 'sedimentation rate', or 'mass accumulation rate of sediments' panel in Figures 2 and potentially 5. The age depth models in the supplementary material do not really show the changes in sedimentation rate through time (not in enough detail), and it would be nice to clearly see how this impacting the calculated MAR's of other components (like TerrOM).

We appreciate Reviewer 2's suggestion to incorporate sedimentation rate changes for cores PS51/154 and PS51/159 in Figure S3. This high correlation between elevated terrOM MAR and sedimentation rates is also evident in other pan-Arctic sediment core records (Figure A2-1). We will include this figure in the supplementary as Figure S6.

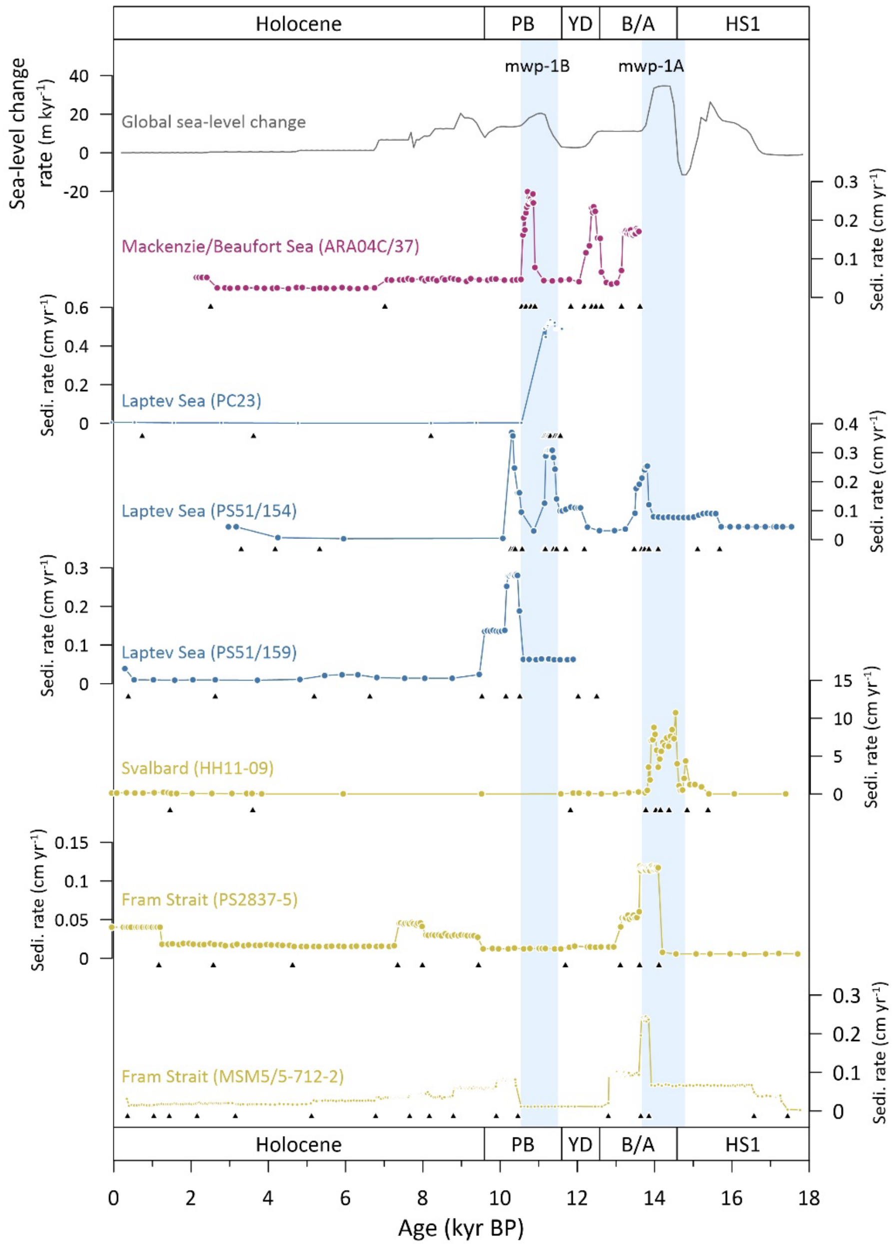

Fig A2-1. Rate of global sea-level change (Lambeck et al., 2014) and sedimentation rate changes for cores ARA04C/37, Beaufort Sea (Wu et al., 2020); PC23, Laptev Sea (Tesi et al., 2016); PS51/154, Laptev Sea (this study); PS51/159, Laptev Sea (this study); HH11-09, northern Svalbard continental margin (Nogarotto et al., 2023); PS2837-5, Fram Strait (Birgel and Hass, 2004); MSM05/5-712-2, Fram Strait (Müller and Stein, 2014; Aagaard-Sørensen et al., 2014; Zamelczyk et al., 2014). Black triangles indicate the age control points for each record. The blue bars highlight periods of rapid sea-level rise. Meltwater pulses are denoted as mwp-1A and mwp-1B. Paleoclimate periods are abbreviated as HS1: Heinrich Stadial 1, B/A: Bølling-Allerød, YD: Younger Dryas, and PB: Preboreal.

Line 253: "remained rather constant despite the periods of peak MAR (Fig S5)." I think you should specify what MARs you are discussing.

We thank Reviewer 2 for pointing out the ambiguity in the original text. We will revise the sentence as follows: "The values of $\delta^{13}C$ and TOC in cores PS51/154 (–25.6‰ and 0.79%) and PS51/159 (–25.8‰ and 0.99%) remained rather constant between 16.2 and 9.5 kyr BP, despite the three periods of peak MAR of terrestrial biomarkers (Fig S5).".

Line 375: "Before the Bering Strait opened at around 11 kyr BP (Jakobsson et al., 2017), the coastlines of the Beaufort Sea and the Chukchi Sea were connected, allowing the potential westward transport of terrOM from North America. Therefore, we consider the record before 11 kyr BP from the Chukchi Sea (4-PC1) as a representation of terrOM signal from the North American Arctic.". I am not sure that I buy this argument. On one hand this paper is trying to disentangle regional from global climate drivers for TerrOM delivery to the Arctic, but then wants to use a record from the Herald Canyon in the Chukchi Sea as a proxy for deglacial processes operating across Arctic North America? Even when we look at the basic sedimentology, the deglacial records that have been published from the Canadian Beaufort Sea have a very high detrital carbonate content, which is not mirrored in the Chukchi Sea records. Maybe there is something I have misinterpreted, in which case it would be good to clarify what is meant in this sentence.

We agree that linking the Chukchi Sea record to the Canadian Beaufort Sea record is debatable, also the core 4-PC1 record only covers the period between mwp-1A and mwp-1B and the mid-Holocene, rather than the full last deglaciation period. To maintain focus, we will remove the Chukchi Sea record from the discussion.

Line 385: "Age-depth models for these records were recalibrated against the Marine20 calibration curve (Heaton et al., 2020) or a combination of Intcal20 (Reimer et al., 2020) and Marine20 curves, depending on the original studies to achieve congruent age control across all records. Reservoir ages were taken from the original publications." Is this accurate? or were reservoir corrections taken from the original publications and updated to fit with the Marine20 calibration curve by . . . and then specify how this was done.

We thank Reviewer 2 for pointing out the need to update ΔR for the Marine20 calibration curve. This adjustment significantly improves the comparability of terrOM MAR peaks in marine sediment cores to periods of rapid sea-level rise. In Table A2-1, we have compiled the R or ΔR values previously used for each record, and the updated ΔR values for calibration against the Marine20 curve. Following Heaton et al. (2020), we use the Marine20 database to derive updated ΔR values except for core ARA04C/37. For this core, as there are no available ΔR values for the Beaufort Sea or nearby in Marine20 database, we subtract 150 yrs from the ΔR values from the previous age model (Keigwin et al., 2018), as suggested by Heaton et al. (2023). For studies using constant ΔR, we keep the same principle and use the constant updated ΔR for calibration. Three studies are using varying ΔR in their previously published age models: cores ARA04C/37, PC23, and HH11-09. For core ARA04C/37, the new ΔR values for each dating point were calculated by subtracting 150 yrs from the previous ΔR for each dating point (Keigwin et al., 2018). And we referenced the updated Marine20-calibrated age models from Sabino et al. (2024) for core PC23, and from Nogarotto et al. (2023) for core HH11-09, respectively. Table A2-1 will be included in the supplement as Table S3, and we will expand the discussion paragraph about the use of new ΔR. Figure 5 in the manuscript will also be updated accordingly.

Table A2-1. Comparison of previous calibration and updating calibration methods on the core used in this study.

Core ID	Reference of previous age model	Previous calibration curve	Previous R or ΔR	Updated ΔR for Marine 20	Method to updated ΔR
ARA04C/37 JPC15	Keigwin et al. (2018); Wu et al. (2022)	Marine13	ΔR=200±100 during younger dryas, 0±100 for the other periods	Variable ΔR, ΔR=50±100 during younger dryas, ΔR=-150±100 for the other periods	Update ΔR from Keigwin et al. (2018) by minus 150 year (Heaton et al., 2023)
PC23	Tesi et al. (2016)	Marine13 for marine samples /Intcal13 for plant samples	ΔR=400 during early Holocene, 67 during mid and late Holocene	ΔR=411±56 during early Holocene, ΔR=−95±91 during mid and late Holocene	Adopted from Sabino et al. (2024)
PS51/154	Taldenkova et al. (2010)	Fairbanks 0107	R=370, constant	ΔR=−95±61	From Marine20 database, average of 5 adjacent available datapoints
PS51/159	Taldenkova et al. (2010)	Fairbanks 0107	R=370, constant	ΔR=−95±61	From Marine20 database, average of 5 adjacent available datapoints
HH11-09	Nogarotto et al. (2023)	Marine20	Variable ΔR between each datapoints	Variable ΔR	Adopted from Nogarotto et al. (2023)
PS2837-5	Nørgaard-Pedersen et al. (2003)	CALIB 4.1.2	R=0±400, constant	ΔR=−41±30	From Marine20 database, average of 10 adjacent available datapoints
MSM5/5-712-2	Müller and Stein (2014); Aagaard-Sørensen et al. (2014); Zamelczyk et al. (2014)	Marine09	ΔR=151±51, constant	ΔR=−65±33	From Marine20 database, average of 7 adjacent available datapoints (distance <620 km)
PS2458	Nicolas et al. (2024)	Marine20	ΔR=345±60, constant	ΔR=345±60, constant	Adopted from Nicolas et al. (2024)

Line 407-409:"The rapid global sea-level rise during meltwater pulse 1A (mwp-1A) was an important process in terrOM mobilization across the pan-Arctic region. TerrOM MAR peaks during this period are observed widely in records from the Eurasian Arctic and the Bering Sea". The title of this section is 'Pan-Arctic factor: sea-level rise' but no mention is made here of the Canadian Arctic/Beaufort Sea. I think it is hard to argue this without data from the Canadian Arctic, and it does not seem like that data exists (i.e in Fig 5, the Beaufort Sea records do not extend that far back in time). I can imagine that there may be a difference in glaciated versus non-glaciated margins etc. I at least think that this needs to be discussed in the text, as I am not at all convinced that the Chukchi Sea record is representative of North America. A core from the Herald canyon cannot tell us about all the processes operating across the northern coast of Canada.

We appreciate Reviewer 2's comment. Indeed, the Canadian Arctic suffers from the lack of available records extending before mwp-1A. We agree that the Bering Sea record may not reflect the environmental conditions in the Arctic Ocean, as terrOM sources in the Bering Sea likely originate from Beringia rather than North America. We will exclude the Bering Sea record from the discussion to maintain focus on the Arctic Ocean and modify the section title to "Regionally recurrent factor: sea-level rise" to better align with the scope of the available data.

Lines 431-435: "In the North American Arctic, terrOM MAR peaks appeared during the interval between mwp-1A and mwp-1B (Fig 5d, e). Inland warming in North American began at approximately 13.5 kyr BP, while the Eurasian Arctic remained cold (Brosius et al., 2021). This regional temperature discrepancy possibly explains the exclusive terrOM MAR peaks observed in the North American Arctic during the interval between mwp-1A and mwp-1B (Fig 5c, g)". I think one of the most important observations that is not picked up in this paper is the link between TerrOM fluxes in the Beaufort and Chukchi seas and the d18O excursion reported by Spielhagen et al., 2005 in the outer Laptev Sea. All of these events appear to occur between MWP-1A and MWP-1B and there seems to be a coincidence in timing, even with some of the HMV Mar's in the Laptev Sea (PS51/154) and Fram Strait. However, this is hardly discussed in the paper and I wonder if it deserves more attention (see next comment)

As this comment is directly related to the next comment, we reply to the two comments together below.

Lines 465-470: "However, freshwater events were less likely to be the cause for terrOM MAR in the western Laptev Sea. While freshwater flooding events were recorded in an icedammed lake upstream of the Lena River (14.9 ± 2.0 kyr BP) and in a sediment record from the Laptev Sea (PS2458, at 12.7 ky BP) (Spielhagen et al., 2005; Margold et al., 2018), the timing of these events did not 470 correspond with any of the terrOM MAR peaks in cores PS51/154 and PS51/159. This temporal mismatch suggests that Siberian freshwater pulses had little impact on the increase in terrestrial biomarker MAR in the western Laptev Sea.". The d18O peak in foraminfera from PS2458 (Fig 7 in Spielhagen et al 2005) does seem to overlap or is very close to some of the increased terrigenous biomarkers MAR's shown in figure 5 of this paper. I think it would add a lot to recalibrate the ages of PS2458, and plot this data on one of the summary figures. It seems to be an extremely complementary dataset to the goals of this study (looking at processes impacting terrigenous OC mobilization to the Arctic). The current arguments that it is not correlated to any of the documented periods of enhanced TerrOM flux is not really supported by the current presentation of data. It may be true – but can it be shown more clearly?

We thank Reviewer 2 for the suggestion to recalibrate records from core JPC15 (Beaufort Sea) and core PS2458 (Laptev Sea). The freshwater event identified in the Beaufort Sea (planktic foraminifera $\delta^{18}O$ drop in core JPC15)(Keigwin et al., 2018) aligns with terrOM MAR in core ARA04C/37 (Wu et al., 2022; Wu et al., 2020) (Figure A2-2, upper panel). However, in the Laptev Sea, the timing of the freshwater event in core PS2458 did not match the MAR peak in core PS51/154 (Figure A2-2, lower panel). This mismatch suggests that the freshwater event in the Laptev Sea likely did not trigger elevated MAR peaks. We will include a discussion in the revised manuscript and include Figure A2-2 to the supplement as Figure S7.

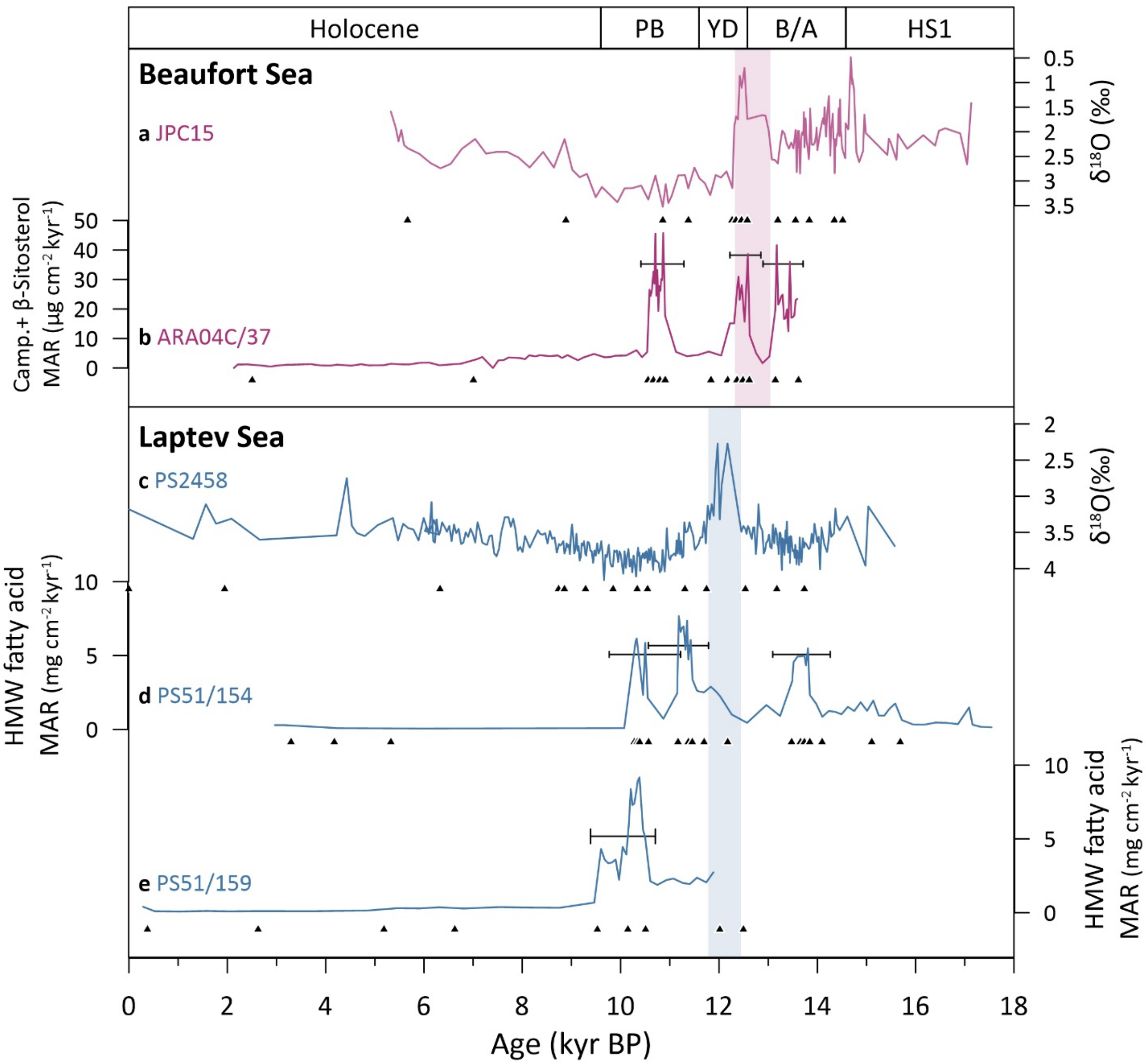

Figure A2-2. Comparison of freshwater event and terrestrial organic matter (terrOM) mass accumulation rate (MAR) in the Beaufort Sea: (a) $\delta^{18}O$ values of *Neogloboquadrina pachyderma* from core JPC15 (Keigwin et al., 2018). (b) Campestreol + β-sitosterol MAR from core ARA04C/37 (Wu et al., 2020). Laptev Sea: (c) $\delta^{18}O$ values of *Neogloboquadrina pachyderma* from core PS2458 (Spielhagen et al., 2005)(d) high molecular weight (HMW) fatty acid MAR from core PS51/154 (this study). (e) HMW fatty acid MAR from core PS51/159 (this study). Black triangles denote age control points. Black intervals under MAR peaks indicate age uncertainty ranges. Purple and blue bars highlight freshwater events in the Beaufort Sea and the Laptev Sea, respectively.

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