Reviewer's comments

Reviewer #1

This paper is well-written and structured. It presents a novel dataset from three multicores along a transect in Kongsfjorden (Svalbard) and provides relative contributions of organic matter sources. To qualify the organic matter, the paper uses bulk parameters (carbon and nitrogen) and lignin phenols. The relative age of the cores is constructed using 210Pb geochronology. I highly enjoyed reading the manuscript and the ideas were easy to follow. The introduction clearly laid out the importance of this study and the methods were succinct and well described. I would have enjoyed a slightly more detailed discussion in section 4.5 about increase surface runoff and impacts on the fjord. The paper suggests important influence from river discharge at the middle site, but does not support/compare with the existing literature on terrestrial OM inputs. Here are some key points that I would like clarification on, followed by minor changes.

Reply: We sincerely thank Reviewer #1 for the thoughtful and constructive feedback. We are pleased that the manuscript was found to be well-structured, with clearly presented ideas and a novel and informative dataset. The reviewer's comments have been invaluable in enhancing the clarity and depth of our work. We have carefully addressed all points in a detailed, point-by-point response below. As suggested, we expanded Section 4.5 (now Section 5.5 in the revised manuscript) to provide a more comprehensive discussion of increasing surface runoff and its implications for the fjord system. This includes a broader comparison with the existing literature on terrestrial organic carbon (OC) inputs, particularly in relation to the riverine influence observed at the middle core site. These additions were made to strengthen the interpretation of our results and to situate them more firmly within a broader environmental and climatic context. All changes in the manuscript have been clearly marked and referenced in our responses.

Main recommendations

- Clarifying how this manuscript builds on from the published work in Kim et al., (2023)

This paper builds on finding from previously published work by the authors (Kim et al., 2023). Due to the similarities in analysis and research location – the present study would benefit from presenting how it builds on the previous findings. I would recommend adding 1-2 sentences in the introduction to present the findings of Kim et al., 2023 and specify how this new manuscript differs and expands from the previous work.

Reply: In the revised manuscript, we added 1–2 sentences to the Introduction to summarize the key findings of Kim et al. (2023), which examined the sources and characteristics of surface sedimentary organic matter across eight fjords in Svalbard, including Kongsfjorden. That study focused on the spatial distribution of recent OC dynamics based on surface sediments. In contrast, the present study builds upon those findings by analyzing multiple sediment cores along a transect in Kongsfjorden, providing a higher-resolution reconstruction of temporal changes in OC sources and burial over the past centuries. This expanded spatial and temporal framework allows for a more comprehensive understanding of long-term carbon cycling in the context of ongoing climate change.

- Extrapolating N_{org} from N_{tot}

I recommend that the authors further justify extrapolating N_{org} from N_{tot}. How precise is this correlation? The authors describe different sources of OM in the fjord system. Wouldn't these different sources also differ in partition of N? I think it is misleading to present both N_{org} and N_{tot} since N_{org} is just offset by a correction factor (as I understood it). I think this part in the paper deserved a bit more explanation. Also, couldn't the age of the sediment affect the partitioning of N (i.e. is using a correction factor from surface sediment accurate)?

Reply: Previous studies conducted in various Svalbard fjords showed that surface sediments contained a substantial proportion of inorganic nitrogen, reaching up to 70% of the total nitrogen (N_{tot}) content (Fig. S1A), with a significant correlation between inorganic nitrogen and clay mineral content (Schubert and Calvert, 2001; Winkelmann and Knies, 2005; Knies et al., 2007; Knies and Martinez, 2009; Kumar et al., 2016; Kim et al., 2023). Consistent with the strong linear relationship (R^2 = 0.89, Fig. S1A) between N_{tot} and organic nitrogen (N_{org}) contents reported in surface sediments from multiple Svalbard fjords (Kim et al., 2023), our subdataset from Kongsfjorden and Krossfjorden exhibited an even stronger correlation (R^2 = 0.96, Fig. S1B). This strong correlation enabled us to estimate N_{org} from N_{tot} using the derived regression equation: $N_{org} = 0.7863 \times N_{tot} - 0.0096$. However, as noted by Reviewer #1, it is important to acknowledge that inorganic nitrogen content can vary with sediment type and depth, potentially influencing the accuracy of the estimated N_{org}. Therefore, while this regression-based method provided a practical and data-supported approximation, caution is warranted when interpreting the estimated N_{org} values, particularly in sediments with heterogeneous stratigraphy or mineralogical composition. This consideration has been incorporated into the revised manuscript.

- Describing the study sites in greater detail

I believe section 2.1 could be made into its own section 2 and methods could be section 3. Would it be possible to showcase the biogeochemistry of Kongsfjorden in more details here? Otherwise, Krossfjorden is discussed quite heavily in the discussion. The study site section would benefit from having 2-3 more sentences describing how Kongsfjorden and Krossfjorden are similar/different.

Reply: In the revised manuscript, we followed Reviewer #1's suggestion and presented the original Section 2.1 as a standalone Section 2, with the Material and Methods moved to Section 3. We expanded the regional setting section to include a more detailed description of both Kongsfjorden and Krossfjorden. In particular, we added 2–3 sentences highlighting the key similarities and differences between the two fjords, as these are important for contextualizing our findings. These additions aim to provide a stronger foundation for interpreting the results within a broader regional and environmental framework.

- Discussing the historical/spatial dynamics

Section 4.5 begins to explore the potential OM dynamics at the middle site in a historical context. I think this section would benefit from being expanded a bit. This is the main objective

of the manuscript. Why is the middle core seeing the largest changes in OM source. If it because it is more influenced by surface runoff, and therefore glacier dynamics, then perhaps citing sources of increase river discharge is more relevant than just temperature changes. The argument could be made more convincingly while citing the existing literature. Also, a comment on which change is more significant in Kongfjorden (more surface runoff or Atlantification? Or both and why?) would make a more impactful conclusion. The manuscript only mentions greater terrestrial input and then focuses on Atlantification.

Reply: Unfortunately, to the best of our knowledge, the available literature does not provide direct evidence of increased river discharge to Kongsfjorden beginning in the 1970s, which is the most relevant period for our study. Most existing studies focus on more recent decades, particularly from the 1990s onward, when systematic hydrological and oceanographic observations became more widespread. In Kongsfjorden, meltwater from marine-terminating glaciers remains the dominant sediment delivery mechanism. Even at the middle site, which also receives some fluvial input, glacial meltwater prevails, as indicated by the relatively small proportion of EM3 (18.2 ± 14.9%) compared to EM1a and EM1b (81.8 ± 14.9%). In addition to glacial and fluvial sources, variability in Atlantic Water (AW) inflow plays a key role in shaping marine OC burial, as AW delivers nutrients that stimulate marine productivity. This influence appears more pronounced at the middle site, which is more sensitive to AW variability, compared to the outermost site where AW input remains relatively stable. These considerations were reflected in the expanded Section 4.5 (now Section 5.5) of the revised manuscript.

Minor recommendations

Abstract: Perhaps omit the use of acronyms in the abstract for ease of read.

Reply: To improve readability, we wrote out full terms upon their first mention in the abstract and use acronyms thereafter. Given the strict word limit, we aimed to balance clarity and conciseness by minimizing acronym use where possible, while still adhering to formatting and length constraints.

Lines 32-34: Please elaborate on this positive feedback loop. How would a greater contribution of AW further amplify AW inflow in fjordal system?

Reply: The growing influence of AW inflow observed in our record highlights the potential for continued Atlantification under ongoing Arctic warming. As sea-ice loss and glacier retreat diminish physical barriers, AW can penetrate more deeply and persistently into fjords. This increased inflow can further accelerate ice melt, reinforcing AW intrusion through positive feedbacks. As a result, such processes may substantially alter carbon cycling and ecosystem dynamics in Arctic fjord systems. We elaborated on this point in the revised manuscript.

Introduction: Since the scope of study is similar to Kim et al 2023 – perhaps define in the introduction how the present study builds on the previous paper.

Reply: In the revised introduction, we clearly defined how the present study builds on the findings of Kim et al. (2023). While the previous study provided a pan-Svalbard synthesis based on surface sediments from eight fjords to assess spatial variability in recent OC cycling, the current study focuses specifically on Kongsfjorden and employs a high-resolution sediment core approach to reconstruct changes in OC sources over the past several centuries. This temporal perspective allows for a more detailed investigation of the fjord's sedimentary response to recent Atlantification. By combining bulk geochemistry, lignin biomarkers, and radiocarbon signatures, this study provides deeper insight into the mechanisms driving carbon cycle shifts in one of the most extensively studied Arctic fjord systems.

Lines 52-53: "While modern observations have clear limitations in providing long-term datasets" – perhaps reword "datasets" to make this statement more meaningful (i.e. of course modern data isn't old data…)

Reply: In the revised text, we rephrased the sentence to clarify that modern observational records are limited in their ability to capture long-term historical trends and environmental variability.

Line 57: Change "high-Arctic Svalbard archipelago" to High Arctic Svalbard archipelago

Reply: As suggested, we revised the phrase to "The high Arctic Svalbard archipelago" in the revised manuscript.

Methods: I would recommend adding a sentence at the beginning of each subsection to establish why these analyses were undertaken. This way, readers without prior knowledge of certain methods can understand why certain analyses were done. (i.e. to understand the source of carbon in the fjordal system, we…). Please also describe the indices used in for phenol composition analysis (S/V, C/V and 3,5-Bd/V, (Ad/Al)v).

Reply: As suggested, we added brief introductory sentences at the beginning of each Methods subsection to clarify the objective of each analytical approach and help guide readers who may be unfamiliar with the techniques. Additionally, we included descriptions of the lignin phenol indices (S/V, C/V, 3,5-Bd/V, and (Ad/Al)v) in the revised manuscript to ensure their interpretation is clear.

Line 100: AW acronym has already been defined.

Reply: As suggested, we removed the repeated definition of the AW acronym to avoid

redundancy.

Lines 107-109: Perhaps the types of terrestrial inputs to Kongfjorden could be expanded a bit.

Reply: As suggested, we expanded the description of terrestrial OC sources delivered to Kongsfjorden. Specifically, glacial runoff contributes large volumes of sediment to the seabed, forming turbid plumes that reduce light penetration and suppress primary productivity, particularly in areas close to glacier termini (Ito and Kudoh, 1997; Svendsen et al., 2002). In addition to sediment, glacial runoff transports a variety of terrestrial OC, including petrogenic and soil-derived OC. These additions were incorporated into the revised discussion to provide a more comprehensive overview of terrestrial inputs into the fjord system.

Line 128: Define KOPRI for readers that are not aware of this facility.

Reply: As suggested, we defined the acronym KOPRI (Korea Polar Research Institute) upon its first mention in the revised manuscript to ensure clarity for all readers.

Line 139: samples were heated to what temperature?

Reply: As suggested, we included the temperature information in the revised manuscript to enhance clarity.

Line 150: Define HPGe and KBSI.

Reply: As suggested, we defined the acronym HPGe (High-Purity Germanium) and KBSI upon its first mention in the revised manuscript to ensure clarity for the reader.

Line 173: Replace “carbon isotopes” with “$\delta^{13}C_{org}$” for uniformity

Reply: As suggested, we replaced “carbon isotopes” with “$\delta^{13}C_{org}$” for consistency and clarity throughout the manuscript.

Results: Why was the radioisotope analysis not performed at the inner site? This needs to be addressed somewhere in the manuscript.

Reply: As suggested, we added a statement to the results section, explaining that the inner fjord multicore was excluded from ^{210}Pb dating due to the high sedimentation rates and intense

sediment mixing typically observed near glacier fronts. These conditions are known to limit the applicability of radioisotopic dating by disturbing sedimentary stratigraphy and reducing the resolution of age-depth models (e.g., López et al., 2020; Schirone et al., 2022).

Lines 227-230: What about the inner site? Also, where is the sedimentation rate reported by Zaborska in relation to the present study?

Reply: The sediment core analyzed by Zaborska et al. (2006) was collected in 2000 from a site in the inner part of Kongsfjorden, geographically close to our HH23-1058MUC core. In their study, a sedimentation rate of approximately 0.15 cm/yr was determined using ^{210}Pb dating. While this provides useful context for sedimentation conditions in the inner fjord, we did not perform ^{210}Pb dating on HH23-1058MUC due to extensive sediment mixing, which prevented the development of a reliable age model, as noted above. We clarified this point in the revised manuscript.

Line 243: Please state what is the significant correlation between N_{tot} and N_{org} derived from previous studies. (see comment in main recommendations)

Reply: As suggested, we mentioned that a previous study (Kim et al., 2023) reported a strong linear correlation ($R^2 = 0.89$) between N_{tot} and N_{org} in surface sediments of various Svalbard fjords, which supported the use of N_{tot}-based corrections for estimating N_{org} content as mentioned earlier.

Discussion:

Lines 392-394: "The poor sorting observed across all morphological zones highlights fluctuating energy conditions during deposition, likely driven by episodic glacial advances and retreats. These variations suggest that the prevailing climatic conditions in Kongsfjorden were neither stable nor persistent over extended periods" – I am not sure that this conclusion can be drawn from the lack of correlation between TOC and grain-size and poor-sorting. The present study doesn't link specific advance/retreat events to sedimentary behaviour – so I would avoid overinterpretation and just state that poor sorting and lack of correlation between grain-size and TOC are indicative of a glacier-fed system.

Reply: As suggested, we revised the statement to avoid overinterpretation by simply noting that the poor sorting and lack of correlation between grain size and TOC are indicative of a glacier-fed system, without attributing these characteristics to specific glacial advance or retreat events.

Lines 492-499: This section could be developed further. Why do the river systems deliver soil-derived OM to the middle site more than the inner site? If this is due to surface runoff – then a

map indicating where the river systems are in Kongsfjorden would be highly relevant. There is also a large body of literature on the biogeochemical signature of surface runoff in Kongsfjorden. Perhaps it would be interesting to compare to some of these studies?

Reply: As noted, the main river systems delivering soil-derived OC to Kongsfjorden are located closer to the middle fjord area, rather than the inner site. In the revised manuscript, we enhanced the map in Figure 1 to more clearly show the locations of these river inflows and their proximity to the middle core site. Furthermore, we incorporated previous studies, which have shown that surface runoff significantly influences the biogeochemical composition of particulate and dissolved matter in Kongsfjorden.

Lines 502-517: These equations could be placed in the methods section. The discussion loses a bit of momentum when you have to read through how the AR were calculated.

Reply: As suggested, we moved this section to the Material and methods section.

Figures:

Figure 1: It would be nice to show the elements discussed in section 2.1 on this map. Adding a third panel with labels of the different glaciers and river systems could be helpful to readers that don't have prior knowledge of Kongsfjorden.

Reply: As suggested, we updated Figure 1 by adding labels for the major glaciers (Blomstrandbreen, Kongsbreen, Kronebreen, and Kongsvegen) and river systems (Bayelva River) in Kongsfjorden to help readers better understand the geographic context.

Figure 2: Change "Water contents (%)" to "Water content (%)" both in caption and in axis title.

Reply: As suggested, we changed the term.

Figure 3: The figure caption states 3 sites (A-C) – but only two are presented (A-B). Please explain in text why inner site is not present here. Add a note in the figure caption to explain the different symbols used in the slopes in the Pb_{ex} panels.

Reply: We thank the reviewer for pointing out this error. We corrected the Figure 3 caption to accurately reflect that only two sites (A and B) are presented. Additionally, we clarified that open circles indicate the data points used in the linear regressions (yellow and blue dotted lines) of the natural log-transformed $^{210}Pb_{ex}$ versus depth to estimate sedimentation rates.

Figure 6: Having a color key, instead of textual annotations, would make the EM identification easier at first glance.

Reply: In the revised figure, we added a color key to represent each end member (EM), enhancing visual clarity and making EM identification more intuitive at first glance.

Figure 7: The key states that surface sediments have been taken for this study. However, the methods only states multi cores. Please clarify either in the key or in text where the square samples come from. I think that it would be beneficial to differentiate symbols here for the Konsfjorden multicores samples (the present manuscript) over the rest of the dataset to highlight the novelty of this paper of Kim et al., 2023. (see comment in main recommendation)

Reply: In the revised manuscript, we clarified the origin of the surface sediment samples by using a hashed square symbol to indicate the samples newly analyzed in this study, in addition to the multicores, and by adding corresponding details in the Material and methods section

Figure 8: See comment for figure 7.

Reply: As mentioned above, in the revised manuscript, we clarified the origin of the surface sediment samples by using a hashed square symbol to indicate the samples newly analyzed in this study, in addition to the multicores, and by adding corresponding details in the Material and methods section.

Reviewer #2

The manuscript by Kim et al provides a detailed study of 3 sediment cores from Kongsfjorden, Svalbard, with the aim to improve our understanding of the relationship between organic carbon (OC) deposition in the fjord, its different sources and climatic/oceanographic changes. The authors combined sedimentological data, bulk parameters, biomarkers and a robust geochronology based on 210Pb to estimate the relative contributions of sedimentary OC sources to different coring sites in Kongsfjorden. The manuscript is very well written and very clear, and the described dataset represents an important addition to our knowledge of the organic carbon cycle in Svalbard. I have just a few general comments and suggestions, and some minor comments.

Reply: We sincerely appreciate Reviewer #2's thoughtful comments, which have greatly contributed to improving the quality of our manuscript. We will incorporate the suggestions into the final version wherever appropriate.

General comments:

It is unclear in the introduction which knowledge gaps you are trying to fill: is it the lack of observational data on AW inflow before the recent warming or during it? Or both? A few more words could be spent to underline and make clear the main aim of the work

Reply: As suggested, we have revised the introduction to clearly emphasize the main aim of this work.

Since the aim of the work is strongly related to the inflow of AW in the fjord, I think a section briefly explaining the mechanisms of AW intrusions in the fjord, mentioning also its effects, should be included. With it, a better representation of WSC-ESC dynamics could be included in Fig. 1 (for example, like in De Rovere et al 2022).

Reply: We appreciate this suggestion. In the revised manuscript, we added information on the mechanisms of AW intrusions into the fjord, mentioning also its effects in the Section 2 Regional setting. In addition, we modified Fig. 1 for a better representation of WSC-ESC dynamics like in De Rovere et al., 2022.

The EM modeling for grain size seems an excellent tool to study grain size distribution with a more accurate approach, but I do not understand why EM3, as you presented it, can not be simply a combination of EM1 and EM2. Could you further explain how the procedure for establishing the different end members work?

Reply: In this study, endmember modelling of grain size data from sediment cores was conducted using the AnalySize program with a non-parametric approach, following the methodology of Ahn et al. (2024). This analysis resulted in the extraction of four endmembers (EMs). Based on the nature of their modal characteristics and principal mode values, two of the EMs were grouped as EM1a and EM1b, while the remaining two were defined as EM2 and

EM3, respectively. EM1 (a + b) and EM2 were characterized by unimodal grain size distribution curves. EM1 had fine-grained mode values ranging from 8.2 to 9.3 μm, whereas EM2 was characterized by a relatively coarser mode at 29.3 μm. In this context, EM3, which exhibits a bimodal distribution, initially appears to result from a simple combination of EM1 and EM2. However, the coarse mode of EM3 reaches 81.2 μm, which is significantly larger than the principal mode of EM2. Therefore, EM3 cannot be regarded as a simple combination of EM1 and EM2.

S/V and C/V ratios, both in core and surface sediments, seem to point towards a quite strong contribution of gymnosperms, despite the major presence of angiosperm species in Svalbard archipelago (see for example https://npolar.no/en/themes/vegetation-svalbard/ and references therein). How does this compare to other lignin datasets from similar Arctic areas?

Reply: The strong gymnosperm signal observed in the surface and core sediments, despite the current prevalence of angiosperm species in the Svalbard archipelago, suggests a significant contribution of OC from older sources, such as permafrost deposits. This indicates that the OC preserved in the sediments may originate from vegetation that grew during earlier time periods, rather than solely reflecting present-day plant communities. We added this aspect in the revised manuscript.

You present really interesting results on the change of OC sources in the latest decades, especially the increased marine OC accumulation rates in the middle fjord, but why do you think the same pattern is not present in the outermost core also? I think in general that this entire section of the discussion could be expanded, elaborating further the interpretation of the changes in sedimentary OC deposition, both in time and between coring sites.

Reply: Thank you for your valuable feedback. The observed increase in marine OC ARs at the middle fjord site (core HH22-1161MUC), but not at the outermost site (core HH22-1159MUC), likely reflects differences in hydrographic and sedimentary dynamics between these locations. The middle core site located closer to tidewater glaciers thus appears more sensitive to AW variability, as AW delivers nutrients that stimulate marine productivity, thereby increasing marine OC burial. In contrast, the outer site experiences more consistent AW influence, leading to relatively stable marine OC burial over time. Additionally, lower SRs at the outer site due to its greater distance from the glacier front, may obscure short-term variations in OC deposition. We incorporated this aspect into the revised manuscript to provide a more comprehensive understanding of the spatial and temporal variability in sedimentary OC deposition.

Detailed comments:

Line 32-33: this sentence is a bit confusing; it reads as if the increased influence of AW underscores the potential future amplification of AW inflow itself. I think what you meant is

that the increased influence of AW underscores the likely important effects of an even stronger AW inflow

Reply: Thank you for pointing this out. We agree that the original phrasing was unclear and could lead to misinterpretation. In the revised manuscript, we have rephrased the sentence to clarify our intended meaning. It now states that the growing influence of Atlantic Water (AW) observed in our record highlights the potential for continued Atlantification to significantly affect carbon cycling and Arctic fjord ecosystems.

Line 71-72: I am not sure what "long-term changes" are when referring to post 1990 effects, do you mean also changes that will happen in the future?

Reply: Thank you for this helpful comment. We agree that the term 'long-term changes' may be interpreted differently depending on the context. We rephrased the sentence in the revised manuscript.

Line 88: I would add past changes to present and future changes

Reply: As suggested, we revised the sentence in the revised manuscript by adding the aspect of the past changes.

Line 93: refer to Fig. 1 in this instance

Reply: As suggested, we referred Fig. 1 for that sentence in the revised manuscript.

Line 102-104: change position of this sentence before the previous one, in line 99

Reply: As mentioned earlier, in the revised manuscript, we separated this subsection into a standalone Section 2 on the regional setting, restructuring the content and providing more detailed information on the study area.

Line 174: the procedure for sample preparation before 14C analysis of TOC is missing

Reply: Thank you for pointing this out. We added a detailed description of the sample preparation procedure for radiocarbon (^{14}C) analysis of TOC in the revised manuscript (Lines 200–204). Briefly, sediment samples were pretreated with HCl to remove carbonates and with NaOH to eliminate humic acids, then dried at 60 °C. The alkali-insoluble fraction was combusted at 900 °C in sealed ampoules with CuO to generate CO_2, which was subsequently

purified and converted to graphite following the method of Vogel et al. (1984). Radiocarbon ($^{14}C/^{13}C$) measurements were conducted using accelerator mass spectrometry (AMS).

Line 180: remove “the” before CuO oxidation

Reply: As suggested, we removed “the” in the revised manuscript.

Line 190: change “precision” to “uncertainty”

Reply: As suggested, we changed the term in the revised manuscript.

Line 223: why were only 2 cores analyzed for geochronology? Besides, this would agree with fig. 3 where only the depth profiles of cores 1161MUC and 1159MUC are displayed, but the caption of the figure states that all 3 cores have depth profiles (line 891-892)

Reply: Thank you for pointing this out. In the revised manuscript, we clarified in the Material and methods section that the inner fjord core (HH23-1058MUC) was excluded from ^{210}Pb dating, as previously mentioned. Additionally, we corrected the caption of Figure 3 to accurately reflect that only two sites (HH22-1161MUC and HH22-1159MUC) are shown.

Line 274-276: judging by the ranges and average values, it is dubious if the middle core or the outer core have different lignin phenols concentrations

Reply: Thank you for the observation. In the revised manuscript, we removed the statement suggesting a difference in lignin phenol concentrations between the middle and outer cores, as the reported ranges and mean values do not support a statistically meaningful distinction.

Line 325: change “located closest” to “the closest one”
Reply: As suggested, we changed the sentence in the revised manuscript.

Line 331: why does the settling of fine particles contribute to the formation of EM2 near the glacier front? EM2 was described as an EM mainly constituted by coarser particles

Reply: Thank you for the insightful comment. We acknowledge that the original wording may have been unclear. To clarify, the presence of coarser-grained sediments associated with EM2 near the glacier front is interpreted as the result of energetic bottom currents generated by subglacial meltwater discharge. Specifically, the release of meltwater initiates buoyant

upwelling plumes that enhance localized hydrodynamic activity in glacier-proximal environments. This circulation promotes strong bottom currents capable of winnowing finer particles and facilitating the preferential deposition of coarser material, which characterizes EM2. We revised the manuscript accordingly to more clearly articulate this sedimentary mechanism and prevent potential misinterpretation.

Line 334-339: could it be that the mixed (fine + coarse) distribution that you observe in the middle of the fjord is generated by the combination of different (marine, fluvial and glacial) processes? This is one of the things which brings me to think that EM3 could be a combination of EM1 and EM2 (see also the 3rd general comment).

Reply: We thank the reviewer once again for this thoughtful comment. We agree that the mixed (fine + coarse) grain-size distribution observed in the middle of the fjord likely reflects the combined influence of glacial and fluvial processes. As noted in response to the general comment, EM1 primarily represents the settling of fine particles from suspension, largely driven by glacial meltwater, while EM2 reflects the deposition of coarser sediments likely resulting from bottom-current winnowing. EM3 displays a distinctly bimodal grain-size distribution, which may initially appear a simple combination of EM1 and EM2. However, the coarse mode of EM3 is significantly coarser than the principal mode of EM2, indicating that EM3 is not a straightforward mixture of the two. We clarified this point in the revised manuscript.

Line 349: remove the comma after 0.4

Reply: As suggested, we removed the comma in the revised manuscript.

Line 362-364: please include in the text the range of values, or average values, for surface sediments, IRDs and coal to make it easier for the reader

Reply: As suggested, we added the relevant range and/or average values for surface sediments, IRDs, and coal in the revised manuscript to facilitate comparison and improve clarity for the reader.

Line 369-370: as for the previous comment, please include the δ13C values for surface sediments, IRDs and coal in the discussion

Reply: As suggested, we included the $\delta^{13}C$ values for surface sediments, IRDs, and coal in the revised manuscript to enhance the discussion and provide more clarity to the reader.

Line 390-392: this statement, which I fully agree with, also partly contrasts with the previous interpretation of EM3 in the middle fjord, where you stated that fluvial processes were the possible source of the bimodal distribution, while here it is stated that glacial processes were the key factor for the general lack of sorting of the sediments

Reply: We thank the reviewer for this thoughtful comment. To clarify, our interpretation of EM3 emphasized a fluvial origin for both the fine and coarse fractions. The fine particles were likely derived from suspended sediments transported by river input, while the coarse fraction was attributed to denser underflows originating from the same fluvial source. Therefore, rather than representing a mixture of glacial and fluvial inputs, EM3 was interpreted as the product of a distinct fluvial depositional regime capable of delivering a wide range of grain sizes. However, at the middle site, the proportion of EM3 was relatively low compared to EM1a and EM1b, suggesting that glacial meltwater remains the dominant sediment delivery mechanism at this site, with only a minor influence from surface runoff processes. We revised the manuscript to more clearly highlight this mixed contribution to the middle site.

Line 392-396: I am not sure I agree with this interpretation. Of course, it is likely that the fjord experienced changes in the energy of the depositional environments, but the poor sorting in all cores could be simply due to the always present glacial activity, that even in stable conditions will provide poorly sorted sediments, just as you stated in the previous sentence citing Singh et al. 2019.

Reply: As mentioned above, poor sorting observed across all cores can reasonably be attributed to the persistent influence of glacial activity, which delivers poorly sorted sediments even under stable environmental conditions. All core sites were primarily influenced by glacial processes, resulting in poor sorting. We also note that at the middle site, EM3 constituted only a small fraction of the overall grain size distribution, and therefore its sorting signal would be largely overprinted by EM1. Thus, even at the middle site, the overall grain size distribution reflected poor sorting. We acknowledge that our initial wording may have caused some confusion and thus revised the manuscript accordingly to clarify this point.

Line 428: remove “The”

Reply: As suggested, we removed “The” in the revised manuscript.

Line 436-438: how do you explain a higher contribution of degraded OC in the middle and outer fjord, when supposedly the major source of old and reworked (and thus also degraded) OC in the fjord should be the Kongsbreen/Kronebreen (as it is also suggested by radiocarbon data)?

Reply: While radiocarbon data indicate that Kongsbreen/Kronebreen is a significant source of old and reworked OC, the higher 3,5-Bd/V and (Ad/Al)v ratios observed in the middle and

outer fjord likely reflect additional degradation processes that occur during transport and post-depositional modification. As OC is transported seaward from glacial sources, it undergoes oxidation, microbial degradation, and hydrodynamic reworking, particularly in areas where sediment residence times are longer, such as in the middle and outer fjord, and where exposure to oxygen is more prolonged. Therefore, the observed increase in lignin degradation indicators offshore is not necessarily in conflict with the radiocarbon-based source attribution but instead reflects the combined effects of provenance and degradation processes along the transport pathway. We clarified this aspect in the revised manuscript.

Line 481-485: while describing the results from Method 1, you used the range of % for each EM. Here instead you used the average values with SDs. Change one of the two descriptions for better uniformity

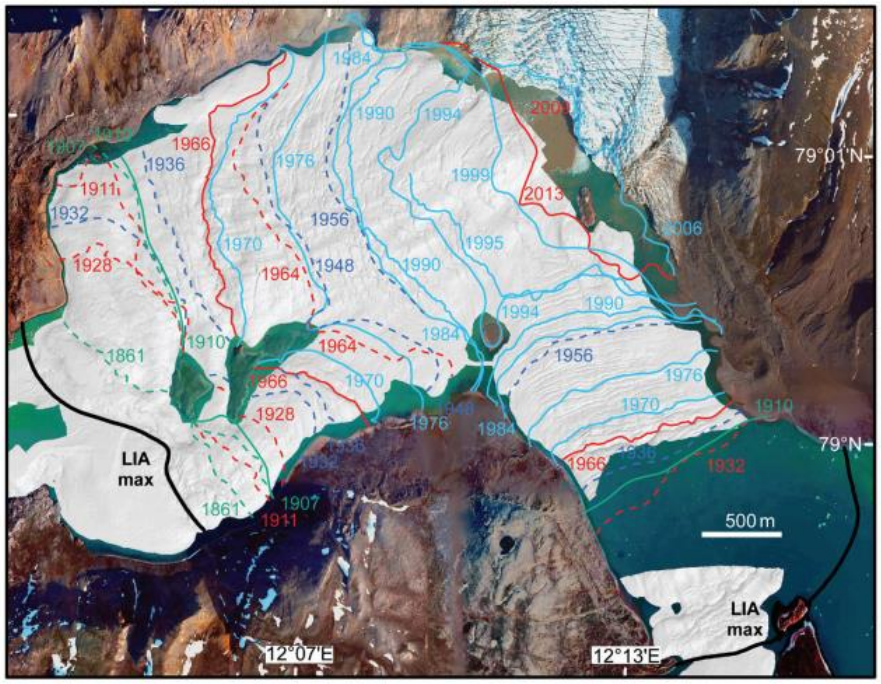
Reply: To ensure consistency and avoid redundancy in reporting, we will use the average values and standard deviations in this section, as they provide a clearer representation of the characteristic features of each end member. We will revise the manuscript accordingly (Lines 528–531).

Line 581: explain further what you mean with "two-step process", this point is not clear from the discussion

Reply: Our study highlights ongoing and significant shifts in carbon dynamics in the Svalbard region, driven by a combination of increased Atlantic Water (AW) inflow and glacier melting. Building on the findings of Tesi et al. (2022) and our results, we propose that the marked increase in AW inflow to Kongsfjorden during the 20th century likely occurred in two distinct phases, governed by complex and not yet fully understood mechanisms. To better constrain the timing, drivers, and consequences of AW variability, we emphasize the need for future research that integrates high-resolution climate modeling with sediment core records from Svalbard. This integrated approach will be essential for refining projections of climate and carbon cycle feedbacks in the rapidly warming Arctic. These aspects were more thoroughly addressed and incorporated in the revised manuscript.

Fig. 11D: the axis label states "Distance from Blomstrandbreen front in 2006 (m)", but it is not clear from where this distance was measured. A figure in the Supplementary Materials showing the position of this glacier would also be useful for the readers

Reply: The distance shown in Fig. 11D was measured from the position of the Blomstrandbreen glacier front in 2006, based on data from Liestøl (1988), Landsat imagery, and aerial photographs. Glacier margin fluctuations have been well documented in Burton et al. (2016; see figure below), with solid lines indicating glacier margins determined with higher certainty. To help readers better understand the location of the glacier front, we have added the position of Blomstrandbreen to Figure 1 in the revised manuscript.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