Our reply to anonymous reviewer 4:

We thank the reviewer for their constructive comments and helpful suggestions, which have greatly improved the quality of our manuscript. We greatly appreciate the time and effort they took to thoroughly go through the manuscript. We also appreciate their willingness to review our revised version.

Marius Buydens (on behalf of all authors)

Please note that the line numbers mentioned in our answers refer to the lines in the 'track changes' document.

(1) Introduction:
A nice review of the issue. Would be stronger if tied more tightly to scientific method – a hypothesis/mechanism is loosely stated (MTG upwelling vs. LTG absence of upwelling), the prediction is intimated but less concrete (percent OC in surface sediments??), the specific testing is mostly absent and it isn't clear how the hypothesis would be falsified. The last paragraph promises "insights," which is appropriate for human behavior/cognition but we want something more concrete for physical sciences. Be specific, tell us exactly what you are going to test and how it will be interpreted. "Insights" is too vague.

We thank the reviewer for the positive comment ("A nice review of the issue") and for the constructive suggestions to clarify the scientific framing of the study. We decided not to build this manuscript around a hypothesis because we only investigated two fjord systems, which does not provide enough replicates to extrapolate our findings toward a general statement on organic carbon burial in MTG- versus LTG-influenced fjords. Our main goal was to examine whether the higher primary production observed in Nuup Kangerlua by Meire et al. (2023) compared to Ameralik is also reflected in the organic carbon content and burial rate in the seabed sediments.

Based on your feedback we rephrased the last paragraph of the introduction to make it more explicit (lines 95 – 103): "This study aims to quantify carbon burial processes in Greenland fjord systems and to evaluate how these fjords contribute to regional carbon storage relative to differences in productivity. To achieve this, we compared two fjords that differ in primary productivity, a contrast linked to the type of glacier discharge (i.e., marine- versus land-terminating glaciers; Meire et al., 2023). We focused on differences in OC and chlorophyll-a (Chl-a) contents, their sources, and OCBRs. This comparison provides a process-based perspective on how glacier influence may affect organic matter deposition and burial efficiency in Greenland fjord sediments, and how these processes connect pelagic production to benthic carbon storage. In addition, spatial gradients in these parameters within each fjord help reveal the extent of glacial influence, as most meltwater discharge occurs in the inner fjord regions."

(2) Discussion:
Ln 323-4 – Again, linking to scientific method, the hypothesis is falsified, and this could be stated as such. The problem with "not supporting" is that it implies that testing could have also "supported," but that is not the goal of scientific method, to support or prove.

Otherwise, it is subject to confirmation bias like religion and politics, and we've seen how well that is working right now. I apologize for the little editorial, but it is what makes me most proud about our discipline, that when done well we will root out the mistakes and errors instead of doubling down on them.

We appreciate the reviewer's comment and agree with the reasoning that the phrasing caused confusion around testing a hypothesis: [*"Our results therefore do not support the hypothesis of higher carbon burial potential of MTG fjords compared to LTG driven systems."]*. We therefore revised the sentence to a formulation that directly reflects our findings: line 358: "Our results show that the fjord receiving input from three MTGs and three LTGs does not have a higher carbon burial rate than the fjord influenced by a single LTG."

(3) Section 4.1: I'm not sure why surface sediment OC content is used as the test of the hypothesis instead of carbon accumulation rate, which incorporates the sediment dilution that is discussed here as a complicating factor for percent OC.

Both OC and Chl-a content as OCBR were used to compare the two fjord systems. Indeed, OCBR incorporates both the burial and the organic carbon content (at depth). However, the along fjord trend in surface OC and Chl-a content is also informative of the short-term effect that glacier discharge may have on the vertical flux of the pelagic production. Although OC and Chl-a content are subject to lithogenic dilution, patterns such as steep, or weak gradients along the fjord-axis or e.g. depositional sites can still be discerned.

(4) Ln 372-3: Say more about how dilution leads to an underestimate. Shouldn't this be accounted for by dating the cores?

OCBRS were calculated by multiplying MAR with OC content of the 9 – 10 cm sediment interval. As this interval, just like the sediment surface layer, has been subject to lithogenic dilution, the OCBR is still biased. At the same time, the faster sediment accumulation rate can compensate for the lower OC% caused by inorganic dilution, but the balance between the two effects cannot be assessed. Therefore, lithogenic dilution could not be accounted for in the OCBRs.

(5) Ln 378-9: I understand that limited data makes it hard to identify and rank controls, but it is also unsatisfying as a reader when the whole process is labeled as "complex" as the parting shot. The next section proceeds to pick apart some of this complexity, so why not make this a more obvious transition into that next section?

Thank you for your constructive comment. You're right, the transition between sections 4.2 and 4.3 currently ends a bit abruptly with "the complexity of carbon burial dynamics," which sounds like an (indeed unsatisfying) conclusion rather than a setup for what follows. We rewrote the last part of the 4.2 paragraph as follows: lines 419-423: "These findings underscore that carbon burial dynamics in glacial fjords arise from multiple interacting factors, and that surface productivity and glacier type alone are insufficient to explain the observed patterns. The following section explores these additional processes, such as fjord morphology, bottom water conditions, and organic matter preservation, that may contribute to the observed variability."

(6) 4.3.1 Stylistically, I don't love the approach of setting up a possible explanation (differences in bottom water temperature) and then proceeding to shoot it down. I appreciated that the text got there eventually, but dangling those small differences in temperature as a possible explanation made me groan, and I don't think you ever want to make your readers groan.

Taking into account your feedback, we rewrote the 4.3.1 paragraph: lines 430-440: "The distinct geomorphology of Ameralik and Nuup Kangerlua, particularly their differing sill depths, shapes bottom water exchange and temperature regimes, which can influence organic matter preservation. Both fjords have no anoxic deep-water masses, and bottom water renewal occurs every one to two years (Mortensen, 2011; Stuart-Lee et al., 2021). However, Ameralik's shallower sill depth (~110 m) compared to Nuup Kangerlua (~200 m) restricts the inflow of warmer, saltier coastal waters (Stuart-Lee et al., 2021), resulting in slightly lower bottom water temperatures (~0.5 °C in Ameralik vs. ~1.3 °C in Nuup Kangerlua during spring sampling). While such temperature differences may contribute to the higher pigment and OC preservation observed in the slightly colder bottom waters of Ameralik, their overall impact is likely modest. Arctic microbial communities are well adapted to low temperatures, and mineralization rates below 10 °C differ only minimally (Thamdrup et al., 2007; Scholze et al., 2020). Nevertheless, the relationship between temperature, water renewal, and preservation remains worth considering, as studies from Svalbard fjords have suggested higher pigment content in sediments associated with colder bottom waters (Krajewska et al., 2020)."

(7) 4.3.2 Doesn't your core dating address lateral transport? The lead profile seems to minimize that possibility. It is absolutely true that resuspension and transport of sediments is a complication, but then you would also have to address why this laterally transported sediment has higher or lower OC content that is decoupled from the original primary productivity idea. You partially do this with cross "contamination" from one fjord to the next, but then again, your surface OC content was similar in both.

The lead profiles do not contradict lateral transport. The persistently elevated mass accumulation rates observed at stations located farther from the glaciers can only be explained by lateral transport of discharged sedimentary material. Furthermore, the $^{210}Pb_{excess}$ activity profiles exhibit subsurface peaks, indicating episodes of sediment reworking. The lower $^{210}Pb_{excess}$ activity between these peaks suggests the input of older sediment, likely resulting from the redistribution of material due to minor slope instabilities or the deposition of small turbidites transported from other locations. The surface OC content in the outer station of Ameralik (AM5) was much higher than any of the stations in Nuup Kangerlua despite the relatively lower primary productivity in this fjord. Therefore, we suggested the possibility of import of suspended organic matter from offshore.

(8)

(8.1) 4.3.3 Do you have data either here or in the literature to compare an annual primary productivity to carbon burial rates in MTGs vs. LTGs? It seems like that would be an important parameter to compare – a carbon burial efficiency number.

Your proposal of reporting a "carbon burial efficiency number" is indeed a good addition to the manuscript. We added the following to the OCBR section (lines 414-418):

"The amount of marine OC buried throughout Nuup Kangerlua ranged from 6 to 28% of the annual primary production as reported by Meire et al. (2023) (90 g C m^{-2} yr^{-1}). These values are comparable to those observed for fjords in Svalbard and northern Norway (Włodarska-Kowalczuk et al., 2019). In contrast, sediments in Ameralik displayed a higher burial efficiency of marine OC, ranging from 25 to 62% of annual primary production (30 g C m^{-2} yr^{-1}; Meire et al., 2023), suggesting more effective OC preservation in this LTG-influenced fjord."

In addition, we added the values to Table 2 and added the following to the M&M section: lines 341-344: "The fraction of marine-derived OC buried relative to total primary production (estimated at 90 g C m^{-2} yr^{-1} for Nuup Kangerlua and 30 g C m^{-2} yr^{-1} for Ameralik; Meire et al., 2023) indicates that a substantial portion of primary production is buried at station NK10 (28%), with the lowest fractions observed at the inner and outer stations (Table 2). In Ameralik, consistently high burial fractions of marine OC were recorded across the fjord, reaching a maximum of 62% at the outer station AM5."

Table 2. Mass sediment accumulation rate (MAR), bulk sediment accumulation rate (SAR), organic carbon burial rate (OCBR), and the fraction of marine OC buried relative to the total primary production per station. The CRS method was applied at stations NK7, NK9, AM5, and AM8, while the CF:CS method was used for stations NK10, NK12, NK13, and AM10. "NK" denotes Nuup Kangerlua and "AM" Ameralik. Results are presented with analytical uncertainties.

Station	MAR (kg m^{-2} yr^{-1})	SAR (mm yr^{-1})	OCBR (g m^{-2} yr^{-1})	marOCBR / PP (%)
NK13	14.1 ± 3.5	15.0 ± 3.7	27.5 ± 8.3	8 ± 2
NK12	5.9 ± 1.0	7.1 ± 1.2	9.6 ± 1.7	8 ± 2
NK10	7.0 ± 0.1	8.3 ± 1.1	29.4 ± 4.0	28 ± 4
NK9	3.1 ± 0.2	4.8 ± 0.3	17.5 ± 0.6	17 ± 5
NK7	2.4 ± 0.2	4.1 ± 0.4	5.9 ± 0.8	6 ± 1
AM10	4.0 ± 2.8	5.2 ± 2.0	9.9 ± 5.0	25 ± 12

AM8	1.1 ± 0.1	2.6 ± 0.2	17.7 ± 0.3	55 ± 1
AM5	1.0 ± 0.1	3.5 ± 0.2	21.0 ± 1.1	62 ± 7

(8.2) Another number to consider is the relative inputs of terrestrial OC vs. marine OC. I know that you use 13C to try to tease this apart, but conceptually, shouldn't it be a higher fraction in the LTGs than MTGs since you actually have a little river flow in the former that can allow more terrestrial carbon loading onto sediment surfaces? It would be informative to know what the weight percent OC is on suspended sediments before they discharge.

We did calculate the relative inputs of terrestrial OC versus marine OC was calculated using the formula of Thornton and McManus (1994) (line 233):

$$OC_{terrestrial} = \frac{\delta^{13}C_i - \delta^{13}C_M}{\delta^{13}C_T - \delta^{13}C_M} \qquad (1)$$

and

$$OC_{marine} = 1 - OC_{terrestrial}, \qquad (2)$$

where $\delta^{13}C_i$ represents the surface sediment values (0 – 2 cm) of $\delta^{13}C_{org}$ of each sample, $\delta^{13}C_M$ is the marine end-member and $\delta^{13}C_T$ is the terrestrial end-member. Only the upper 0 – 2 cm was used to be able to compare with literature.

We compared the fraction of marine OC with the literature in Figure 5 (line 382).

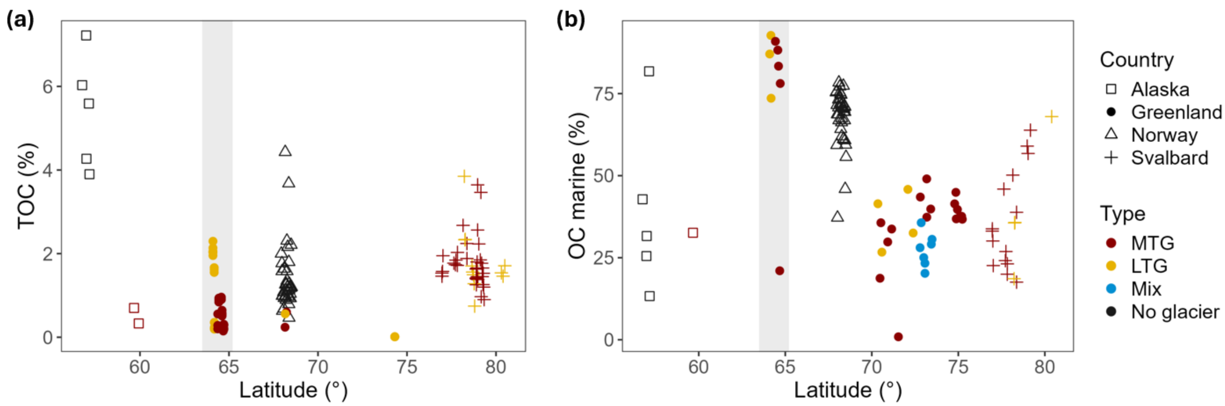

Figure 5. (a) TOC content of surface sediments along latitude. Data compiled from Smith et al. (2002), Thamdrup et al. (2007), Koziorowska et al. (2015), Cui et al. (2016a); Faust and Knies (2019), Włodarska-Kowalczuk et al. (2019), Laufer-Meiser et al. (2021) and this study. **(b)** Fraction of TOC of marine origin along latitude. Data compiled from Koziorowska et al. (2015), Faust and Knies (2019) and this study. Both figures display data from fjords located in high latitude countries: Alaska, Greenland, Norway and Svalbard. The grey band constraints the Greenland fjords investigated in this study. Data indicated in red and yellow represent Marine terminating-glacier (MTG) and land terminating-glacier (LTG)-influenced fjord systems, respectively. The mixed type represents fjords where the dominance of MTG(s) vs LTG(s) on the fjord's hydrology could not be differentiated from literature or satellite images are depicted in blue. Non-glacial fjords are represented in black. Both graphs were created following and updating the example of Faust and Knies (2019).

It is not surprising that we did not find a difference in terrestrial input into the two investigated fjords, since also the MTG-dominated fjord Nuup Kangerlua has terrestrial inputs, fed by three rivers.

We don't have access to data regarding the weight percent OC on suspended sediments before they discharge to complement our observations. We did not sample surface water from the meltwater river to quantify the amount of TOC delivered to Ameralik. However, measurements of $\delta^{13}C$ in the settled sediments indicate that the majority of the organic carbon, even at the head station, originates from marine primary production. We also recommend that future studies should employ sediment traps, as these provide valuable data for assessing food-web dynamics, lateral transport, and mineralization processes in the water column.

(9) Just in general, foodweb dynamics are really hard to tease apart, and I appreciate that this should be raised as a factor, but the section as a whole feels more speculative than helpful. You need vertical flux data, and you don't have it.

Agreeing with your assessment, we removed this paragraph as we recognize that without vertical flux data, this discussion was indeed speculative. Instead we added to the previous section (line 480) "In addition, in Nuup Kangerlua, greater phytoplankton biomass and a larger size class of zooplankton may support a more complex and efficient food web compared to Ameralik (Meire et al., 2023; Stuart-Lee et al., 2023, 2024), resulting in more OC being consumed or remineralized before it reaches the seafloor (Fig. 6)."

(10) Another property you could look at is sediment loading (using percent OC and grain size as a proxy for surface area if you want to get into the weeds more). Do you have any way of distinguishing between discrete OC particles vs. sediment-associated OC?

Distinguishing sediment-associated or petrogenic organic carbon (OC) requires radiocarbon (^{14}C) analysis, which was not conducted in this study. We could only assume that this percentage should be limited as potential sources of petrogenic carbon like meta-sedimentary rocks are rather rare in the catchment areas of both fjords (< 0.1 % of exposed bedrock), which we stated in the M&M section (lines 215-221).

The median grain size d0.5 is very similar along both fjords, which means that the sediment-associated OC will probably be rather constant at the investigated study sites. The difference in OC content between the sites is therefore related to the discrete OC particle content.

(11) 4.4 I appreciate the intent here of providing future direction, but this section comes across as a more complicated "more research is needed" statement, which undermines what you *have* accomplished in this study. It basically says, "what we did isn't good enough, here is how we need to make it better." It would be stronger to pick one or two new hypotheses (i.e. mechanisms) that you think are the most likely alternative hypotheses to your original hypothesis, and then be specific about the prediction and tests that could falsify. As is, there is a vagueness to these around "understanding," which is only earned through concrete and specific data/tests/mechanisms/knowledge.

We rewrote the future research section taking into account your feedback (lines 501-516):

4.4 Recommendations for future research

Our results suggest that factors other than primary production and glacier type, such as sediment accumulation dynamics, lateral carbon transport, and benthic remineralization, play important roles in controlling OC burial in the two fjord systems. We therefore hypothesize that fjord systems influenced by MTGs facilitate greater lateral transport of autochthonous organic material and sustain more extensive carbon transfer through the pelagic food web than those fed by LTGs. To better constrain these mechanisms, future research should combine measurements of pelagic productivity with grazing rates, sediment trap deployments, and carbon isotopic tracing to directly assess the pathways and fate of organic carbon in the entire fjord ecosystem. In addition, benthic OC cycling and remineralization efficiency determine how much organic matter escapes degradation and is ultimately buried. Quantifying benthic oxygen uptake and sediment-water nutrient fluxes along with porewater oxygen and nutrient profiles would therefore help clarify the role of bottom-water and sediment conditions in OC preservation. Finally, MARs and OCBRs should be further investigated in Greenland and other Arctic fjords using standardized dating approaches, ideally the CRS method, to enable robust inter-fjord comparisons. As not all MARs in this study could be determined using the CRS method, these estimates warrant verification in future work. Ultimately, expanding OCBR assessments across a broader range of Greenland fjord systems will be essential to adequately evaluate the proposed hypothesis and improve regional carbon burial estimates.

(12) Conclusions: This section is highly redundant, and I think is unnecessary as long as the abstract captures all the same information. A significant shortcoming of both the abstract and the conclusions is that there is nothing quantitative to make it concrete and memorable. As in the introduction, I don't like the focus on "insights," and I would extend this to the title as well – "exploring" may accurately describe the exercise of carrying out this work, but it gives the impression of insecurity in what is presented here. Consider a bolder title, something like, "Fjords fed by marine- vs. land-terminating glaciers show no significant difference in organic carbon accumulation rate." That would be memorable.

Following your feedback, we decided to drop the conclusion section and we rewrote the abstract as follows:

Abstract. Fjord systems play a crucial role in the burial and long-term storage of organic carbon (OC). Despite their importance, Greenland's fjords remain underrepresented in global carbon budgets, even though accelerated melt of the Ice Sheet alters these ecosystems through increased freshwater discharge and iceberg calving, ultimately driving glacier retreat inland. This study compares sediment total organic carbon (TOC), total nitrogen (TN), and chlorophyll-a (Chl-a) content, as well as $\delta^{13}C$, $\delta^{15}N$, and organic carbon burial rates (OCBRs), in two neighboring Greenland fjords: Nuup Kangerlua, dominated by marine-terminating glaciers (MTGs), and Ameralik, influenced by a land-terminating glacier (LTG). Although subglacial upwelling enhances primary productivity in Nuup Kangerlua, this does not translate into correspondingly elevated surface sediment organic matter content or significantly higher OCBRs compared to Ameralik, where no such upwelling occurs. Instead, the average OCBRs were similar between the two fjords with 18.0 ± 1.6 g C m^{-2} yr^{-1} in Nuup Kangerlua and 16.2 ± 1.7 g C m^{-2} yr^{-1} in Ameralik. In Nuup Kangerlua, sediment Chl-a content in the upper 10 cm ranged from 0.08 to 9.8 μg g^{-1} and TOC from 0.05 to 1.32%, whereas in Ameralik they ranged from 0.35 to 20.1 μg g^{-1} and 0.13 to 2.43%, respectively. The elevated values in Ameralik are linked to a deep depositional basin that promotes OC accumulation and strongly contributes to the relatively high average OCBR. Furthermore, between 8 and 28 % of the annual surface production in Nuup Kangerlua is ultimately buried in the sediments, whereas this proportion is substantially higher in Ameralik: 25 to 62%. The weaker coupling between surface production and sedimentary OC burial in Nuup Kangerlua versus Ameralik underscores the need for further research to disentangle the interactions driving primary production, carbon transfer in the food web, and the lateral and vertical transport, degradation, and preservation of OC in fjord sediments.

In addition, we followed your advice and changed the title of the manuscript to: "Carbon Burial in Two Greenland Fjords Shows No Direct Link to Glacier Type"

Our reply to anonymous reviewer 5:

We thank the reviewer for their careful reading of the manuscript. We particularly appreciate their eye for detail, which helped us improve the clarity and precision of the text.

Marius Buydens (on behalf of all authors)

Please note that the line numbers mentioned in our answers refer to the lines in the 'track changes' document.

(1) Line 73: There are limited data not "is"

Thank you for your comment. We acknowledge that *data* is traditionally treated as a plural noun (i.e., *data are*). However, in contemporary scientific English, *data* is increasingly accepted as a mass noun that takes a singular verb (i.e., *data is*), especially in general and interdisciplinary journals. "Data can be singular or plural. Use the form that best fits your field and your readers' expectations." — *Publication Manual of the American Psychological Association, 7th ed., p. 161*

(2) Line 79: What are "high Arctic fjords?", is something is missing here?

We indeed overlooked this mistake and corrected the spelling: "high-Arctic fjords", in which high-Arctic refers to the northernmost Arctic region, ~75° N. We adjusted and specified this in line 91: "... high-Arctic fjords (i.e. situated above 75°N) ...".

(3) Lines 197-205: It seems that the authors did not indicate the d13C end-member value of terrestrial organic carbon. Furthermore, the referred d13C end-member value of marine organic carbon lacks an uncertainty, which may lead to overestimate/underestimate the calculated results. It is suggestive of considering uncertainties for the organic carbon source apportionment calculation.

We understand that this created confusion. Therefore, we specified the terrestrial end-member starting from line 223: Published $\delta^{13}C$ values for terrestrial plant material in Greenland remain limited, but available data indicate a range of -33.9‰ to -26.9‰ (Thompson et al., 2018). We adopted -26.9‰ as the terrestrial $\delta^{13}C$ end-member, as this value falls within the typical Arctic range of -27.0‰ to -26.8‰ (Ruttenberg and Goñi, 1997; Naidu et al., 2000; Winkelmann and Knies, 2005; Knies and Martinez, 2009; Koziorowska et al., 2015). Due to the scarcity of $\delta^{13}C$ records specific to Greenland's marine organic matter, we used the marine $\delta^{13}C$ end-member value of -20.6‰, which has been reported to be the average Arctic $\delta^{13}C$ value of sedimentary organic matter (Winkelman and Knies, 2005).

(4) For the unit this study used for TOC and TN, I think it should be weight percent (wt.%) rather than %. Please give more information about this.

We appreciate the reviewer's attention to detail. In this study, TOC and TN are expressed as percentages of dry sediment mass. Since this is the conventional and unambiguous way to report concentrations in sediment geochemistry, we used "%" rather than "wt.%." The use of "wt.%" is redundant (as TOC and TN are inherently mass-based) and not consistent with IUPAC recommendations. For clarity, we have specified in the Methods section that TOC and TN are expressed as percent of dry sediment weight (line 187).

(5) Table 2 For the SAR, based on this study, it seems indicative of sedimentation rate.

Both Sediment Accumulation Rate (SAR) and sedimentation rate can be expressed in mm/time unit. Here, we report SAR in mm/year.

(6) Figures A2-A3 are not properly cited in the text

Thank you for noticing this. We have now cited these figures in lines 255 - 260. In addition, we renumbered these figures.