

Review of Influences on Chemical Distribution Patterns across the west Greenland Shelf: The Roles of Ocean Currents, Sea Ice Melt, and Freshwater Runoff

The paper investigates the key drivers of chemical distribution patterns on the West Greenland shelf during summer. The study focuses on how ocean currents, sea ice melt, and terrestrial freshwater runoff affect the distribution of macronutrients, carbonate system parameters, and dissolved trace elements based on a cruise with CTD casts, water sampling for nutrients and carbonate chemistry, and trace element analysis. The study area spans across several transects along the Greenland shelf.

We sincerely thank the reviewer for the helpful and constructive comments. These suggestions have significantly improved the revised manuscript, particularly in terms of its overall structure and the presentation of the results. We greatly appreciate the time and effort the reviewer has dedicated to providing this valuable feedback.

While the research aims to provide valuable insights into this complex marine environment, the presentation of the study suffers from significant shortcomings in readability, structure, and data visualization. Sentences are often long, lacking a clear flow of ideas jumping between concepts without sufficient transition or explanation, especially in the result and discussion section.

Thank you for this feedback. We will reorganize the manuscript to improve its structure and readability, summarizing concepts in a more cohesive manner. For the revision, we will consult an external person who is a native English speaker to further enhance the wording and text structure.

Personally I feel the data is not presented effectively. While there are figures in the supplementary material, the main text lacks visuals to illustrate the actual data. Instead, it overuses tables, which don't show the data as clearly as figures would. Also a lot of new data and figures are presented in the discussion which makes readability harder.

In the results section, we will include a figure with multiple panels displaying various parameters (e.g. Sal, Temp, AOU, NO_x, AT, CT, dMn, dFe, dCd, and dPb) for Transect 4. This figure will help visualize the data and introduce general concepts of the study area, highlighting similarities between the parameters (e.g. NO_x and dCd, dMn and dCo).

Additionally, the referencing throughout the manuscript needs improvement. Several citations are inappropriate, not directly supporting the statements they accompany (See below as well). Key references relevant to the specific processes and region under study are also missing. For instance, the manuscript would benefit from including more recent and relevant work on the hydrography of the West Greenland shelf by Rysgaard et al. (2020)

We will correct the citation in the introduction as seen below. We will include the hydrography work by Rysgaard et al. (2020) in chapter 4.1 by comparing this updated view with the categorization system used throughout the rest of the manuscript. We will also reference other work using the same classification system (e.g. Mortensen 2022). The reason for using the older system was that it gives clear boundaries for the water masses that we used to describe and compare the chemical signatures throughout the discussion.

Below some specific comments

L20: sea ice retreat creates nutrient gradients: in general you have to be aware that what you present is just a snapshot of July, so be careful to make statements like this. Yes, there is a gradient in July, but not necessarily for August, September,..

Original sentence: The east-to-west direction of sea ice retreat creates nutrient gradients, with low nutrient levels in highly productive shelf waters and high nutrient levels in areas with prolonged ice cover.

Proposed changes:

- ➔ L15 “during late summer” change to “during July”.
- ➔ During the study period, we were able to capture a distinct nutrient gradient following the east-to-west direction of sea ice retreat, with low nutrient levels in highly productive shelf waters and high nutrient levels in areas with prolonged ice cover.

L 33: This is not supported by paper you cite here AND L34-35: Look at newer circulation paper in West Greenland as well, eg Rysgaard et al. 2020

Original sentence: The circulation across the west Greenland shelf and Baffin Bay is dominated by the opposing direction of the Baffin Island Current (BIC) and West Greenland Current (WGC) (Curry et al., 2011).

Proposed changes:

- ➔ The circulation across the west Greenland shelf and Baffin Bay is dominated by two major currents in the region. The southward-flowing Baffin Island Current (BIC) along the Baffin Island continental slope and the northward-flowing West Greenland Current (WGC) along the west Greenland continental slope (Rysgaard et al., 2020).

L47: suggest to look at more appropriate referencing for sea-ice conditions

Krawczyk et al., 2021 use satellite-derived sea ice concentration as monthly average from 1978–2014, which is an appropriate reference. We will also include a reference that has a more global perspective and one that looks at sea ice in Baffin Bay in October and the changes of the melt period.

Original sentence: In the last two decades, sea ice concentrations in Baffin Bay and the Labrador Sea have decreased significantly due to climate change (Krawczyk et al., 2021).

Proposed changes:

- ➔ In the last two decades, sea ice concentrations in Baffin Bay and the Labrador Sea have decreased significantly due to climate change (Krawczyk et al., 2021), additionally driven by an earlier melt onset and later freeze-up (Stroeve and Notz, 2018; Ballinger et al., 2022).

L49: Do the studies provide evidence of this?

Yes, both do.

Original sentence: Reduced sea ice cover has been correlated with an overall increase in productivity and species richness along the west Greenland shelf (Krawczyk et al., 2021; Møller et al., 2023).

Proposed changes:

- ➔ The reduction in sea ice cover, alongside the additional influx of Atlantic-sourced waters (Krawczyk et al., 2021) and increasing freshwater discharge (Møller et al., 2023), have been correlated with an overall increase in productivity and species richness along the west Greenland shelf (Krawczyk et al., 2021; Møller et al., 2023).

L55: in early-summer

Original sentence: This is why macronutrient distributions (NO_x = nitrate + nitrite; phosphate, PO₄³⁻; silicate, Si(OH)₄) in surface waters of Baffin Bay decrease along a west-to-east gradient as they generally follow the ice coverage (Lafond et al., 2019; Tremblay et al., 2002).

Proposed changes:

- ➔ In early summer, macronutrient distributions (NO_x = nitrate + nitrite; phosphate, PO₄³⁻; silicate, Si(OH)₄) in surface waters of Baffin Bay decrease along a west-to-east gradient as they generally follow the ice coverage (Lafond et al., 2019; Tremblay et al., 2002).

L61: but also dilute due to FW introduction?

Original sentence: The carbonate system of Baffin Bay is influenced by sea ice meltwater, as it has the potential to supply additional alkalinity (AT) (Jones et al., 1983).

Proposed changes:

- ➔ The carbonate system of Baffin Bay is influenced by sea ice meltwater, which has the potential to increase alkalinity (AT) relative to salinity. When the effect of salinity is removed, sea ice meltwater has been shown to supply additional AT in the form of buffering ions such as [CO₃²⁻] (Jones et al., 1983; Fransson et al., 2023).

L 66: The cited studies do not provide any evidence of impact on shelf or slope nor does Hawkings et al. 2015 look at PP

Original sentence: The export of glacial runoff from the GIS alters shelf and slope waters significantly, thus impacting PP in near-coastal regions (Hawkings et al., 2015; Juul-Pedersen et al., 2015).

Proposed changes:

- ➔ The export of glacial runoff from the GIS alters solute and nutrient delivery to near coastal regions (Hawkings et al., 2015) and the continental shelf (Cape et al., 2019).

L71-72: Two of the cited studies do not provide any data on biological productivity

Original sentence: This fertilizes adjacent marine systems and promotes high levels of biological productivity (Bhatia et al., 2013; Hawkings et al., 2020; Oksman et al., 2022).

Proposed changes:

- ➔ This promotes marine production and a prolonged annual productive season (Oksman et al., 2022).
➔ Move Bhatia et al., 2013 to L69

L 109: Were macronutrients filtered?

No, samples for macronutrients were not filtered. The samples were directly frozen after sampling. We will add “without filtration” to the sentence for clarification.

I am not an expert on trace metals but considering the low concentrations expected offshore, how trace-metal clean was the sampling gear?

The Niskin bottles were non-metallic – We will add this information to L104. Comparison with literature values does not suggest any contamination via the sampling gear. LOD and LOQ values also do not suggest contamination via the filtration. The metal-free PFA filtration equipment was acid-washed prior to use as stated in the text.

AOU data is shown but no information is provided on the oxygen calibration?

Two oxygen sensors were part of the CTD system and were calibrated prior to the cruise. By cross-referencing the data of the two sensors, we were able to monitor their drift during the cruise and correct the data accordingly. We will add this information to section 2.2.

Section 3.1. I would show more data in the manuscript instead of tables, potentially transects (not in case there are only 2 stations) or vertical profiles. Now the data is barely presented, or one has to go to supplementary all the time. This does not improve readability.

Please refer to our previous comment. We will include one figure, including ~10 parameters from transect 4. In our opinion, the table holds valuable information, particularly the comparison with literature data.

Generally in discussion, lots of new data and figures are introduced. This should be restructured in my view and moved to results sections. Fe PCA analysis in 4.1.2 and many more figures which follow

Thank you for this recommendation. We had a similar discussion during the writing process and concluded that it is best to present only the “original” data in the results section. This approach provides a general overview for the reader and facilitates future referencing of the data. The PCA analysis was moved to the discussion section because it significantly transforms the data, warranting a detailed discussion. Our aim with Chapter 4.1 was to first introduce the water masses (4.1.1) and then continue with specific characteristics and processes that alter the chemical composition of those water masses (4.1.2). If this aim was not achieved, we will reconsider whether it is reasonable to move Chapter 4.1 to the results section and adjust the discussion accordingly.

L419: July is mid-summer for the arctic

Original sentence: We believe that our sampling near the end of the summer season was crucial for this vast difference in water mass composition.

Proposed changes:

➔ We believe that our sampling during mid-summer season was crucial for this vast difference in water mass composition.

L560: Based on one point in outer part of Disko bay, it is a bit a stretch to make statements on nutrient cycling in Disko bay... In general for section 4.5, very little data is available close to the coast, based on literature it seems many processes are happening inside the fjords, so it seems authors should be very careful to put those much weight on these few observations concerning the impact of FW runoff

Original sentence: Our results highlight that nutrient cycling in Disko Bay is strongly driven by GIS-derived freshwater input, which stimulates PP and creates an important sink for CO₂ long into the summer season.

Proposed changes:

- ➔ Based on the mentioned references and our, albeit, limited data from Disko Bay, we suggest that nutrient cycling in Disko Bay is strongly driven by GIS-derived freshwater input, which stimulates PP and creates an important sink for CO₂ long into the summer season.

Figures & Tables

Fig 1: Maybe good to integrate figure 1 and 5 in some way and show ice extent (fe with contours)

Thank you for this idea. In our opinion, it is easier for the reader to have these separate figures, as the sea ice chapter is further back in the manuscript. This approach emphasizes the decline of sea ice in the study area over the study period.

Table 1: Silicate values (max) are very high, is that an outlier?

No, the max value (35.95) was found in the water mass BBW, where Sherwood *et al.* (2021) have found similar/even higher silicate values (41.6 ± 25.5 ; $n = 31$). This holds true for the other macronutrients as well. We will add a sentence about this in the paragraph for clarification.

Fig 2: it would be good to include recent work in West Greenland eg Rysgaard et al 2020

As the classification system for the water masses was largely adapted from Curry et al. (2011), we will include and discuss the updated hydrograph by Rysgaard et al. (2020) for comparison. Additionally, we could include a more detailed TS diagram for the northern and southern regions of the shelf.

Table S1, I assume that water depth are the sampling depths?

We will change this to “Sampling depth [m]”.

Fig 4: Instead of plotting vs lat/lon, plot against TS or other chemical values to assess drivers

We will switch the axis in 4 a) and put a compass symbol W-E and in the other diagrams S-N. We will evaluate whether it is reasonable to plot against potential density or salinity, but ultimately, we aim to emphasize the geographical distribution.