

Editor assessment of revised manuscript: Krause et al. Icebergs

Dear authors,

Thank you for your thorough revision of the manuscript and response to the reviewers' requests. I find the manuscript much improved, but would like to request some further amendments to improve clarity, slightly reduce the length, and ensure it is suitable for the journal's audience.

The requested changes are listed below, and refer to the line numbers in the tracked changes manuscript uploaded. My main criticism is in the use of 'atmospheric origin' as an explanation of NO₃ and PO₄ sources. I understand that you can argue that these compounds only reach the icebergs' base via incorporation into the ice matrix, either as snow or via cryoconite or supraglacial sediment. However, in the nomenclature of glacial literature it is rather misleading, since atmospheric tends to denote transport from the upper atmosphere to ice/snow surfaces, rather than anything from the air (which could include wind-blown debris). Instead, I request that they are labelled as sourced from ice sheet or glacier surfaces. The origin may then be from chemical or biological scavenging from supraglacial sediment (which may be windblown, and thus technically atmospheric, although not strictly from the atmosphere), or from aerosol deposition (N species), or from precipitation (N species). I give specific suggestions below. Thank you for your contribution to the Cryosphere, I look forward to reading the next iteration of the manuscript.

Editor, Dr Liz Bagshaw.

R: We thank the Editor for their time, consideration and especially for their comments to help prove readability for The Cryosphere's readers. We have adjusted the terminology throughout as requested.

Requested amendments

L19: add 'low' prior to availability of Fe and Mn

R: Added.

L29-30: rewritten sentence does not make sense 'whilst total dissolvable Fe and Mn retained a strong relationship with sediment load, where weaker relationships were observed...' Please correct (could just remove 'whilst'). Suggest also removing 'retained' – not necessary.

R: Rewritten as "Total dissolvable Fe and Mn had a strong relationship with sediment load, whereas..."

L34: remove 'however' and unclear what you mean by meltwater flux here. Suggest removing from abstract since it is a minor component of your work.

R: Rewritten as "Dissolved Mn was present at higher dMn:dFe ratios, with fluxes from melting ice..."

L41 and throughout manuscript: I don't like the use of 'atmospheric origin'. P is not sourced from the atmosphere – I see that you argue that it is from cryoconite thus 'atmosphere' but I think this is too confusing. Instead, can you note that N and P are likely from glacier and ice sheet surfaces, where Fe, Mn and occasionally Si are from en- or subglacial sources.

R: Rephrased as suggested for clarity. We have used the term as suggested above "the ice matrix" in contrast to additions associated with englacial sediment. Based on the editor's suggestion, we have edited the text to: "Our results suggest that NO_x⁻ and PO₄³⁻ concentrations measured in calved icebergs originate from glacier and ice sheet surface processes which determined the ice matrix. Conversely, high Fe and Mn, and occasionally high dSi concentrations, are associated with englacial sediment, which experiences limited biogeochemical processing prior to release into the ocean."

L61: arguably the polar oceans are the cryosphere, so please change to 'interface between glaciers and ice sheets and the ocean' or further simplify to 'marine-terminating ice'. This whole section could be

simplified to 'Icebergs are reported to be sources of fertilizing nutrients to low productivity zones of the ocean, particularly in the southern ocean (Refs). Fe is thought to be the main nutrient limiting phytoplankton growth, so changes to regional Fe supply can have widespread ecosystem impacts. Whilst icebergs are recognized as important sources of Fe (Refs), the sensitivity of this source to climatic impacts (IF YOU ACTUALLY DO THIS?? IF NOT, CUT) and the relative importance of delivery of other critical micro- and macro-nutrients remains to be analysed. Recent work has suggested that low dissolved manganese concentrations....'

R: Rephrased as "At the interface between the marine-terminating ice and ocean". We agree the revised Introduction can be shortened for brevity and have done so following the Editor's helpful suggestion following the above structure suggestion to trim parts of the text.

L96-109: I dislike the argument that nutrients are atmospheric in origin. Whilst this link can be tenuously proven, I think it can be simplified as 'nutrients in icebergs are either sourced from the ice crystal structure (Fischer) or from sediments either deposited on the ice surface or entrained in the interior or basal structure. Internal cycling may redistribute these nutrients and affect their relative abundances....'

R: As above, we agree that this would be confusing to The Cryosphere readership and have edited throughout referring instead to incorporation into the ice matrix structure.

L148: cut the first sentence and ensure these references are incorporated elsewhere if they are critical to your narrative. The paper is too long to include 'commented on' – this is a paper not a PhD thesis.

R: As suggested, we have trimmed the introduction using the suggested structure by the editor to make the text of the first part shorter and more to the point (changes are tracked, the Introduction is now 1/5 shorter than the R2 version).

Figure 1: very nice, thank you for this addition. Can you plot one above the other so we can resolve some of the detail?

R: Figure orientation changed as suggested.

L392: I think rather than 'runoff-sediment interaction is limited' you could explicitly state that there is unlikely to be significant subglacial chemical weathering, since this is a cryosphere journal.

R: Edited to read: "such that subglacial chemical weathering is probably limited".

L450: this sentence is very awkwardly expressed. Would recommend simplifying: 'the similarity between nutrient ratios in sea ice (Henley et al) and some of our samples suggest seawater is an important contributor to iceberg nutrients, albeit unevenly distributed because of the differing structure of sea ice and glacial ice (refs).'

R: We have rephrased the sentence, as this is not what we intended to communicate. The nutrient ratios and concentrations in these cases suggest a seawater source, but the salinity data does not. Sentence re-written as: "The ratio of NO_x : PO_4^{3-} :dSi in sea ice is strong evidence that nutrients in sea ice have a primarily saline origin (Henley et al., 2023)."

Recommend cutting L453-460.

R: We are aware of some new (unpublished) work from Greenland which suggests marine ice formation is much more common than presently thought (it is not presently thought to be formed anywhere in south Greenland). If it was formed in some Greenland fjords over winter, it might would explain the above issue with nutrients, so we prefer to keep sentence 453, but we have cut 455–460 as suggested.

Figure 5: can you note the distance that defines 'inshore' and 'offshore' in your caption?

R: Edited as suggested: "Inshore samples within 1 km of the coastline, whereas offshore values were all >15 km away from the coastline". For consistency we added the same detail to the methods section.

L534: once again, I request removing 'atmospheric' origin of P. Suggest just cutting L534-535.

R: Sentence removed as suggested.

Figure 6a: not quite sure what this is showing. Could remove to make more space for 6b which is arguably more interesting.

R: We have modified the figure to include just 6b as requested.

L533: remove 'when approaching ice fragments'.

R: Edited as requested.

L562: misnumbered figure? Is there where you use 6a?

R: Correct, as this is no longer in the Figure 6, now edited to read: "It should be noted that randomly collected samples had much lower sediment loads"

L569: remove 'atmospheric deposition of NO₃ and PO₄ varies regionally' and 'reported concentrations of PO₄ are more sensitive to the method used due to universally low concentrations' – neither are required for your argument and rather muddy the water. The statement of PO₄ concentrations in ice cores from Kjaer et al is sufficient.

R: Lines 569–572 Deleted as suggested.

L582: I don't think it can be argued that no PO₄ can be released from subglacial weathering. It may be that PO₄ is taken up prior to measurement, so all remains bound in organic phases. Regardless, I don't think this affects your argument and I suggest just removing L582-584 ('in contrast, no, or very limited release of NO₃ or PO₄ is expected from weathering, which is supported by the correlations').

R: We agree with this and for brevity have deleted 582–584 as suggested.

L605: suggest adding 'some basal layers are lost prior to...' since not all layers will be scoured

R: Edited to: "that basal layers are largely lost prior to, or rapidly following, iceberg calving"

L613: 'glacial origin' rather atmospheric? Or cut this sentence again.

R: We now use the phrase suggested by the Editor, "ice matrix" .

L639: latter not later. Can just stick with 'the former generally having higher sediment loads'

R: Edited to read: "with the former generally having higher sediment loads."

L641: overlong correction here. Keep it simple: 'Arctic icebergs are generally smaller because they are typically sourced from tidewater glacier fronts rather than calved from larger ice shelves. They are also logistically easier to observe and access than Antarctic icebergs.'

R: Edited as suggested.

L657: misnumbered figure?

R: We have corrected this to reference Fig. 6.

L667: I think this is cool, but you've already discussed it so I think this paragraph can be cut
R: Removed as suggested.

L691: not sure the cryoconite explanation helps here. Suggest just leaving with 'the mechanism of this process remains unclear'.
R: Edited to read: "The mechanism of this process is unclear."

L746: other N 'phases' rather than 'sources'. I also wonder about adding P to this sentence, since a survey of organic P fascinating. Thus it would become 'considering the universally low concentrations present in icebergs, other phases of N or P (e.g. DON, NH₄, DOP) may be important'
R: Yes, this is correct, edited to read: "NO_x⁻ and PO₄³⁻ as sources of bioaccessible nitrogen and phosphorous, but considering the universally low concentrations present in icebergs, other N and P sources (e.g. DON- Dissolved Organic Nitrogen, DOP- Dissolved Organic Phosphorous, and NH₄) may be relatively important (Parker et al., 1978)." We think "sources" is a correct term as we are phrasing "sources of N and P to biota".

L759: 'below or at the standard analytical detection limit for PO₄ and NO₃' – to make it clear to readers who are just skimming your conclusions which macronutrients you assessed

R: Edited for clarity to read: "below the standard analytical detection limit- especially for PO₄³⁻ and dSi"