The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-25

Anonymous Referee #1

Referee comment on "Holocene sea-ice dynamics in Petermann Fjord in relation to ice tongue stability and Nares Strait ice arch formation" by Henrieka Detlef et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-25-RC1, 2021

This study presents a multi-proxy record from a marine core collected from outer Petermann Fjord (PF), NW Greenland, to reconstruct Holocene sea-ice dynamics in this region. This reconstruction builds upon previously published geochronology and sedimentological analysis conducted on the same core (Reilly et al 2019) and provides new insight into regional sea-ice dynamics and the influence sea ice likely had on the presence/absence of an ice tongue fronting the Petermann Glacier (PG). By comparing this new record with existing records in the region, Holocene sea-ice reconstruction in Nares Strait has been produced. The results indicate the important role sea ice and ice arches located in the north and south of the Nares Strait had on landfast sea ice within the PF and therefore on the presence or absence of the stabilising ice tongue of the PG. The results and discussion add an important perspective on the role of the marine cryosphere in stabilising local ice tongues in NW Greenland, which in turn has implications for modelling future behaviour of marine-terminating glaciers and dynamics of the Greenland Ice Sheet.

Overall, the article is well written and presented. The results and discussion are robust and support the interpretation and conclusions made. It is evident that a significant amount of analytical work has been conducted and the results are carefully considered. The conclusion that landfast sea ice is an important control on ice-tongue presence/absence, although not unexpected, is an important outcome and is within the scope of The Cryosphere. I do not have any major comments, and I would recommend publication after addressing some minor points listed below:

Specific comments (intermediate). Numbers link to the manuscript line number.

I do like the short title, but I think you could expand upon this to include the broader regional implication of the study with regards to Nares Strait sea-ice dynamics. I suggest you adapt this to indicate the wider reach of this study.

Figure 1a: can you add /label the deeper Atlantic water circulations on the map?

Section 2: Water depth and the location of sills appears to be an important control on the AW, but it is not clear where these sills are, in particular the 220 m deep sill in Kane Basin. Can you add either a bathymetric contour or sill on your Fig 1 b? or if that looks cluttered add a little bit more detail in the text.

115: can you add the current temperature of the modified AW and where it is located in the water column?

117: in this sentence you state 'This sill impedes the throughflow of the densest AW…' do you mean it prevents AW from the south altogether or is there a density gradient in the AW? If the former I suggest you rephrase to '…impedes the throughflow of the dense AW…'

137-140: Can you add a bit more detail for Fig. 2 in this section, such as years where landfast sea ice formation in PF acts independently to Nares Strait, and the sea-ice conditions at the time of the ice-tongue calving events?

140: add reference and detail on how productivity changes with sea-ice conditions. Also, how does Supplementary Figure 1 show PF with ice edge conditions in spring/summer? Can you add an example year in the text in line 142 '…during years (e.g.,).

Section 3.1, pg 7: I would like to see a bit more detail for the core description added in this section. In line 179 and 180, can you add more detail on the '…coarser particles. ' and '...coarse material…' respectively, such as rough grain size? Also, can you add where the core is laminated in this section rather than in the results?

Section 3.3 Sea-ice biomarker methodology is very detailed. Does all this information need to be in the main text? Can some of it be moved into the supplementary section e.g., Table 2?

Section 3.3: Foraminifera abundances are interesting and provide potential information on productivity, but assemblage data would also be very insightful with regards to the sea-ice or ice tongue presence in the PF as well as the presence of AW (e.g., presence of the foraminifera *Cassidulina neoteritis*). Is there a reason assemblage counts have not been included here?

366-375: this section describes the DIP_{25} results, but this is in the Supp info. Is there a reason for this or can this data set be moved into the main text?

General results section comment. The core stratigraphy and environmental interpretations are sporadically included within the results section. In doing so there is some repetition e.g., line 332 and 349 and new information on the core is added intermittently (e.g., lines 353-354). I would suggest removing the interpretation and sedimentology detail out of the results section unless it is needed to justify why data has not been included (e.g., lines 329-331). Instead, I would like to see this detail added to the methods section (3.1) when the core is initially described and within the discussion section where the multi-proxy results can be linked to the core interpretation.

Lines 470-475: could another explanation for the lower terrestrial input during the re-establishment of the ice tongue be related to grounding-line proximity to the core location?

Figure 5h: the reconstructed ice-tongue extent (km) at ~590-600 cm doesn't seem to match that produced in Figure 5 of Reilley et al (2019). I also suggest 5h extends back to 555 cm to match the datasets for this study.

518: The author state that increased meltwater runoff may have led to sea-ice instability. Can they add a bit more detail on the process and/or reference?

Section 5.3, line 593-595: an assumption made is that dependent on ice arch configuration PF and Kane Basin will have opposing sea-ice conditions. What is this assumption based upon? The 4 satellite images in Supplementary figure 1 or published observations? If the latter then can you add the reference to the text? If this is based on the authors' observations, it would be worth adding a figure like Fig 2 that includes Kane2b sea-ice conditions to show this modern relationship and that there is indeed opposing sea-ice conditions to strengthen this assumption. This could be added to the Supp info.

640: This is the first time that 'The arrival of little auk colonies…' have been mentioned. Can you add their significance with regards to understanding sea-ice conditions?

654-662: Enhanced seasonality is an interesting outcome. Are there any other records (marine/terrestrial) that also indicates enhance seasonality to support this interpretation? Why would seasonality be enhanced during this period? You also start the sentence 'Possible reasons…' what other potential reasons are there for this and why is seasonality your preference?

661: What historical records are you referring to?

731-732: Here the authors proposed the formation of seasonal ice melange in the fjord shortened the calving season. What is the evidence of this? Can you refer to the appropriate results?

741-743-: I found the sentence starting 'Thus, this scenario…' hard to follow. Can you rephrase this?

Specific comments (technical).

41: add a, after Historically.

Figure 1A: there are purple currents that have not been labelled. Can you state what these are in the caption?

108: remove 'the' before Baffin Bay

109: capital C for Robeson Channel

134: remove 'vast'

195-197: add ref to end of the sentence

Section 3.3 Planktonic and benthic foraminiferal abundances: change to 3.4

298 and 300: add ref to end of sentences.

Line 391: change to 'These become especially apparent in the dinosterol and campesterol concentrations between 400-500 cm and the β-sitosterol concentrations (add core depth)

447: Add Washington and Hall Land onto Figure 1c

544: I suggest you change the wording '…bear witness of…' to suggest prolonged

560: I suggest you do not start the sentence 'Especially…'. Also, it is not clear from this sentence whether both declines in IP_{25} fluxes are accompanied by a decrease in TOC but the second is more significant, or only the second IP_{25} decline is accompanied by a decrease in TOC.

602 and 603: be consistent with landfast or fast.

613- 615: I suggest you rephrase this sentence to 'Thus, abundant driftwood delivery to Ellesmere Island/northeastern Greenland together with the formation of beach ridges is indicative of seasonally open waters along the coast (Fig. 6A).

Figure 8: A simplified version of Fig. 6 is not needed. I suggest you remove Fig. 8 and add the ages to each panel in Fig. 6

Supplementary Figure 1: can you include what ice arch state each image is showing in the caption and label each satellite image a), b), c) and d)?

Figures: overall the figures are nicely presented. My only minor criticism is that the y-axis does not line up to the graphs. Whilst I appreciate this is done to enable the graphs to fit on one page, it does make it harder to see the values and which axis relates to which graph. In some cases, the lower axis overlaps with the overlying graph and the overlying graph is covering some of the data points e.g., Fig 4e. Can the authors find a way to make this easier for the reader to view?