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Climate of the Past
Discussions

Interactive comment on "A reconstruction of warm water inflow to Upernavik Isstrøm since AD 1925 and its relation to glacier retreat" *by* Flor Vermassen et al.

Anonymous Referee #1

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Overall this is a very interesting paper that presents important new information regarding the interaction between ocean circulation and dynamics of a major northwest Greenland tidewater glacier. The paper presents new data from a sediment core reconstructing variations in ocean conditions, specifically the influx of relatively warm Atlantic Water into the fjord. The paper then discusses the possible link between this ocean forcing and variations in ice margin position over the last 100 years. The paper presents results of high scientific significance and quality. I have some questions/suggestions regarding some of the data presented as outlined below.

It is not immediately clear why the sedimentological information referred to (particle

size and IRD) has not been presented in this paper also. This data is often used to interpret glacier retreat rates – I suspect it would make for a much stronger final paper by combining with the faunal data. There may end up being overlap with paper submitted to Journal of Quaternary Science referred to in the manuscript.

A key aspect of this paper is the use for benthic foraminiferal data to interpret changes in bottom water conditions – specifically changes in relative importance of Atlantic Water flux across the shelf. The paper classifies the benthic foraminifera species into groups linked to bottom water conditions based on published studies (Atlantic influenced, Arctic and Indifferent). This is presented in a supplementary table. However, it is not always clear what the rationale for the choice of grouping is as for some species there is more than one potential group designation suggested in the literature. As this is such a key element of the paper I think it would be useful if the groupings and rationale were presented as part of the main paper. Or, alternatively, at least have a table in the main paper with species composition of the three groups stated, then refer to Supp Info for the more detailed rationale.

Presentation of the foraminiferal data. As above this is a fundamental part of the paper and the key interpretation and conclusions are based on the presentation of foraminiferal data. Calcareous foraminifera are presented separately from agglutinated species (Figure 5), however, the % calculation is based on the combined counts of calcareous and agglutinated specimens. As acknowledged in the paper the calcareous species are influenced by dissolution (most severely between 10 and 25 cm). Hence the relative proportions of the various species will be strongly influenced by preservation of the calcareous fauna rather than by bottom water preference. It would make sense to at least present an additional set of graphs showing the % abundance of agglutinated species based on agglutinated counts only. This would remove the influence of dissolution and would make trends in the proportion of Atlantic influenced vs Arctic influenced species clearer to identify. The same could be tried with the calcareous assemblage, though for parts of the core there would not be enough specimens to present a robust % curve. If these plots do not show any clear/useful trends, then they could at least be included in the Supp Info section so that interested readers could see that the analysis had been done.

PCA analysis – linked to the point above, this seems to be largely driven by preservation. Group 1 is composed of entirely calcareous species (including a mix of Atlantic and Arctic water indicators) and Group 2 is entirely agglutinated species (also including a mix of Atlantic and Arctic indicators). This should be made clear in the paper. Based on this surely the PCA results simply show that foraminiferal preservation is a key control, certainly for PC1 at least. It would be interesting to try running PCA on the separated agglutinated fauna alone. This might actually provide more useful ecological information.

The key conclusion based on the faunal data is that bottom water conditions control dissolution – increased dissolution of calcareous fauna during times of colder Arctic Water influence, then reduced dissolution during periods of stronger Atlantic Water influx. This makes sense, but ought to also consider possible influence of sedimentation rate – increased sedimentation rate will lead to improved preservation of calcareous fauna (buried before dissolve). This has been identified from studies immediately in front of Jakobhavns Isbrae in Disko Bay (Lloyd et al 2005 and Lloyd 2006). You may conclude that sedimentation rate does not vary in your core, but I think this possibility ought to be presented.

I don't think these considerations will change the actual interpretation and conclusions of the paper, I think these are valid and generally supported by the data. Some of the points outlined above might help support your conclusions.

Section 5.2. Comparison with climatic records. This discussion is essentially based on the % Calcareous Fauna (ie preservation, Figure 7b). The manuscript suggests warm bottom waters during 1920-1960, but the basal sample from 1925 actually has a very low calcareous abundance (10%). This should be classified as cold water indicating. . .

The high calcareous percentages actually seem to stretch from 1930 – 1970 based on Fig 7b. So based on the data the warm bottom waters seem to be from 1930 – 1970. . . I think the description/discussion ought to reflect this more clearly. The early part of the 20th Century still seems to correlate reasonably well with previous reconstructions (Figure 8f) and the AMO (Figure 8g) – particularly given some error margins in age model generation.

Section 5.3 Retreat of Upernavik Isstrøm and ocean forcing. The record after 2000 seems mixed, seems to be major increase after 2005 for Upernavik 1 and 2 at least, while the ocean forcing is earlier. There is some discussion about the possible role of sea floor topography – it would be useful to provide a little more information here. Have previoius studies identified topographic variability as important in controlling retreat rates for the four different ice streams? Does fjord side wall configuration have an impact on retreat rates? It might also help to put a smoothing line through fig 8f so that it is more directly comparable with your ocean record resolution.

Minor points In the introduction the authors refer to previous research identifying rapid retreat and acceleration of tidewater glaciers in SE and NW Greenland – I think it would be worth making a distinction between NW and central west Greenland. The first studies identified this response from Jakobshavns Isbrae – this is probably better referred to as central west rather than northwest Greenland.

Reference by Ribergaard et al., 2008 does not seem complete.

Figure 8. It would be useful to say what the colours in panels a) to d) represent (times when the glaciers split up?).

Page 9 line 21: '. . .perturb glacier front', I wonder if it might be better to say '. . .reach glacier front'?

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