Response to Referee#2 comments:

We thank Referee#2 for the positive and constructive comments and suggestions, and for understanding the challenge of interpreting these complex results. We have addressed all the comments and will modify our manuscript accordingly. Our responses to Referee#2 comments are written (in blue) after each comment.

General Comments

This is a good paper that attempts to interpret a complex data set that at first glance is not easy to understand. I commend the authors for their efforts in interpreting these records cohesively. The age models are reasonable, although in Site 17 it is more difficult to recognize where the unsupported Pb reaches supported Pb levels and the Cs peak is hard to see. Nonetheless, the authors interpretation of the likely age model is sound. The geochemistry is clear and interpreted appropriately. The authors should be commended for including detailed diatom ecological information and references to back up their interpretations. This should be universal in diatom papers but is often missing. I have some concerns and questions about the grain size data and diatom data, but overall, the paper is a great contribution to our understanding of freshwater discharge from Greenland and primary productivity.

Specific Comments

The figures are quite hard to read in many cases. The font is exceptionally small. In some cases, it is the equivalent of 2 or 3 points—nearly impossible to read even when zoomed way in on the pdf! In Figure 1, please increase the font size of the numbered fjords. Figures 3 and 4 are the most problematic for the reader to investigate. It's nearly impossible to read the axes because of the small font size. In addition, the authors compare productivity levels between sites, but the x-axes are different for each site. It would be helpful if the x-axes were identical between sites in Figure 3. It's possible that this will be difficult for some measurements, like BSi, but it would be helpful if possible. For Figure 4, it is inappropriate to plot diatom relative percent data with varying axes. The length of 10% on the x-axis for Sea Ice Associated species should be the same length for 10% on the x-axis for *Detonula confervacea* and for every other taxa. This is the only way to evaluate relative percent. In rare cases, it's okay to break an axis for taxa that overwhelm the assemblage, but I don't think this is an issue with this data. It needs to be clear to the reader that the assemblage is dominated by cold-water species and freshwater species are a small percentage. These axes lengths should also be the same for all three sites. In addition, the length of the axes for diatom concentration should be consistent between sites in Fig. 4. I noticed that for all of these figures, although they take up the full vertical space on the page, there is ample space for the figures to stretch horizontally to accommodate these changes in axis length. Please also increase the font size on all the axes so that they're easy to read.

We completely agree that the figures ended up too small, and that font sizes were too small. We have enlarged all figures and increased the font sizes.

We understand the principle of having similar scaling of x-axis in the figures to aid comparison, however, in this case the assemblages have many minor contributors that are important ecological indicators. By scaling the x-axes for all species, the most abundant would make it very difficult to visually discern any trends/changes in the abundance of less abundant species. Plotting different x-axes is a common practice when showing microfossil data. Therefore, we would like to maintain the x-axes in Figure 3 as originally submitted.

It's concerning that there isn't agreement between the two different grain size methods (Malvern Mastersizer and wet sieving). Shouldn't they both show increases in the coarse fraction at the same times? The authors should address this in the result section.

In this study, we used two different methods to study variations in the sediment grain sizes. These methods use different sample volumes; wet-sieving method uses larger volumes of sediment (ca. 2 grams) than the method with Malvern (ca. 0.2 grams) and is thus more sensitive to detect larger grain sizes. Malvern was specifically used to distinguish size fractions below 63 µm. Results from the two methods do not perfectly align but are complementary. We have clarified this in methods and results sections.

Please be cautious about how you interpret "productivity." In section 4.1 you discuss productivity in terms of TOC, diatoms, and BSi, which is appropriate. However, in section 4.3, you discuss productivity only in terms of BSi. It seems important that the three productivity indicators are not correlated at all sites and in some cases are anticorrelated (site 20). There should be a discussion of these differences and potentially interpretations of why they are different. This could be in Section 4.1 or a new section between 4.2 and 4.3. Please also be specific in section 4.3 that there is an increase in BSi, but not necessarily an increase in "productivity."

We have clarified throughout the manuscript which productivity proxy is discussed and added speculation why different proxies give various signals.

There is discussion about sub-glacial sediment plumes drawing nutrients from deep water to the surface. However, all these sites are at about 500 m water depth. Are the nutrients sourced from this depth (intermediate water depths) or are they somehow drawn from the deeper ocean and in over the fjord sill to upwell at the sites? I see the references here, but I'm having trouble understanding how this mechanism works. Perhaps a sentence or two more in section 4.3 would elucidate this.

We have added more text elucidating this mechanism presented in the referenced papers.

In section 4.4, I'm having a really hard time seeing the association between late summer species and freshwater discharge. I'd be more easily convinced that species like *Synedra* and benthics were responding to the freshwater increase than *T. antarctica* and *Detonula*.

At site 17 late-summer blooming cold-water species are more abundant between 1930´s and 1970´s and from mid-90´s onwards, when freshwater discharge was higher and have a positive correlation with freshwater runoff. Whereas *Synedra* spp. and benthic species do show increased abundances after the 90´s but not between 30´s and 70´s, and thus the link between the abundance of these species and freshwater runoff is not so obvious. At site 6, benthic species have a statistically significant negative correlation with inner fjord freshwater runoff.

Technical Corrections

Table 3: Please either include p-values or the significance level for the correlations.

We have added p-value ($p < 0.05$) in text.

Line 358: Which site are you referring to in this sentence? Site 8? This is confusing because in the first part of the sentence you refer to the Outer fjord, then say that there are frequent low-amplitude fluctuations, but I can only see one fluctuation in TOC at Site 8. Please clarify this.

Yes, here we discuss fluctuations in BSi content and diatom productions at site 8. We have made this clearer in the text.

Line 378: Please provide references for the $\delta^{13}C$ values.

We added reference to Meyers (1994).

Lines 365-371: It's striking that Site 17's BSi is similar to the other sites, but there are no diatoms at this site. It would be helpful if the authors mentioned this and perhaps addressed why this might be.

Referee#2 must refer to site 20 (and not 17) where diatoms were found to be very sparse and mainly just fragments. The BSi content at site 20 has a similar trend as BSi content at site 17, but site 20 has biogenic silica content varying between 5.3-14.3 mg/g^{-1} (mean 8.0 mg/g^{-1}) which is lower than in sites 8, 6, and 17 where mean biogenic silica contents are 27.5, 22.2, and 12.6 mg/g^{-1} (respectively). This points that site 20 has significantly lower productivity than the other sites. We have added more discussion of the missing diatom record on site 20.

Lines 385-390: It's quite easy to check and see if there is a significant amount of land-derived inorganic nitrogen. You just need to plot TOC vs. TN and check if the y-intercept is 0. If it is, then there is no clay bound nitrogen. I suggest the authors do this so they know whether or not it is present. See Schubert and Calvert (2001) for more information.

We plotted our TOC values against TN as suggested and can confirm that there is no clay bound nitrogen. We have added this to the manuscript.

Lines 416-421: Are you referring only to the inner fjord in this sentence? Please clarify. This statement doesn't hold true for Site 6.

Yes, here we discuss about diatoms in the site 17 record, and we have better clarified this in the text.

Line 528: I noticed a typo, this phrase should read, "…summer blooms become larger…" not "becomes."

We have corrected this typo. Thank you.

References

Schubert, C. J., & Calvert, S. E. (2001). Nitrogen and carbon isotopic composition of marine and terrestrial organic matter in Arctic Ocean sediments: implications for nutrient utilization and organic matter composition. *Deep Sea Research I* 48:789-810.