Thank you for helpful comments that have improved the manuscript. The full content of comments and responses to Anonymous Reviewer #1 are below.

Reviewer Comments in **black** and responses in **red**

Anonymous Reviewer #1

The paper “Characterizing Southeast Greenland fjord surface ice and freshwater flux to support biological applications” is an interesting and topical read. It’s primarily a physical and data analysis paper concerning ice dynamics in the inshore regions of SE Greenland but is written for, and potentially to help, a more biologically orientated research audience. I think this an interesting concept and worthwhile effort. As a more marine/biology orientated reader I hope the following comments are useful. I will defer to other reviewers concerning any technical aspects of data processing because I cannot comment on these in much detail- especially the use of satellite imagery. I think the manuscript is suitable for The Cryosphere and will be a much more interesting read and resource for a broader audience than the raw data products themselves.

Thank you. We also anticipate the paper will be of interest to a multidisciplinary audience.

12 with a focus

Changed

34 Is there a specific reason why Polar Bears are flagged as a species of interest? Perhaps because of the recent highlighting of a population permanently resident in SE Greenland? If I was going to pick one mammal of regional relevance I would probably have picked the narwhal as this region hosts a protected zone specifically for a narwhal population.

Polar bears are flagged as the species of interest because of their significant use of the fjord surface ice and the importance of this physical environment to polar bear life functions. This area is home to a genetically distinct resident subpopulation. A subset of the data in this paper has already been used for comparison with polar bear behavior (Laidre et al., 2022). Narwhals are not a primary species of interest in this region, contrary to the reviewer's suggestion. Narwhals occur further north (around Tasiilaq and the Blosseville coast), but not regularly south of 64N. However, the data are available to combine with any other biological data of a user's choice.

46 ‘primary productivity’ It is important to distinguish between primary and secondary productivity as this seems to be the source of a lot of confusion in the literature in comments about 'highly productive' fjords, e.g. glacier fjords with low primary production can sometimes act as regionally significant hotspots for bird and mammal populations for

reasons other than high primary production driving a disconnection between the two which is often muddled.

We have changed to “primary productivity”.

47 I would not suggest raising Hg as a topical issue, the Hg data from Hawkings et al., 2021 is dubious, other groups report Hg numbers 1000 times lower than claimed in the same location (Jørgensen et al., 2024) and a recent preprint in SE Greenland shows the same low levels (https://www.researchsquare.com/article/rs-3289576/v1). The consensus opinion of the Arctic Hg community is that the Hawkings et al., 2021 values are likely erroneous and, without further verification, the Greenland Ice Sheet does not constitute a major Hg source (Dastoor et al., 2022). I would suggest high turbidity is a much less controversial and more commonly recognized issue of biological relevance to highlight e.g. (Holding et al., 2019; Murray et al., 2015; Sejr et al., 2022)

Thank you for this additional information. We have changed the references to remove the Hawkings et al. 2021 paper and instead include the three suggested references, which we agree do provide useful information on the influence of meltwater in Greenland fjords.

49 Suggest ‘rapid physical changes’ unless providing references also showing time-series effects on biology (I don’t think there are many)

Changed as suggested.

55 Ice presence will also affect light availability, a major driver of primary production, perhaps worth mentioning here

Good point. We have added “Surface ice presence may also alter other factors, such as light availability in the water column, salinity, or ocean water mixing, that may be of interest to other biological researchers.”

3.1 It’s very hard to visualize all this information and assess what is/is not important to data quality. Obviously, there are general issues which the authors’ have worked hard to address and conclude do not impact the conclusions, could a figure, perhaps a supplementary one, show the data availability for each system and better convey this information (e.g. as per Figure 3)?

As suggested, we have added a new figure to the appendix that shows the solid ice discharge observation availability, with a style aligning with Figure 3.

3.2 Could the authors define here (or earlier) what freshwater is and what it does, and does not include? Is it basically the Mankoff definition? And if so, somewhere for clarity could the

authors' clarify what freshwater would be/not be included within these estimates/fluxes e.g. is runoff not originating from the Ice Sheet included and glaciers not connected to the ice sheet? I assume given the topography of the region these are assumed to be a minor freshwater source, is this the case for all of the case studies?

We do use the Mankoff et al. (2020; 2020a) definition for freshwater flux and have added that information to this section. We also clarify that peripheral glaciers may be excluded from this input dataset (because they are not included in the regional climate model ice domain), though these features are scarce within our region of interest.

150- Not an expert on this so forgive a query if it's not the case – is this still affected by cloud cover to some extent and if so how problematic is the interference, is it quantified/quantifiable?

The freshwater flux data are derived from regional atmospheric climate model data, so optical satellite imagery is not an input to this dataset and has no influence on freshwater flux time series.

175- Same query, can the authors give some rough numbers for the loss of data due to cloud cover and over-winter.

Figure 3 gives a visual reference regarding the amount of usable imagery that was available for each fjord across the time period of interest and we believe this is an ideal reference for within the manuscript. Below is also a table showing the number of analyzed images for each fjord and year during January 1 – July 1 (landfast ice; Landsat and MODIS) or the full year (glacial ice; Landsat only). While this time periods might suggest that there are ~182 image days for possible landfast ice analysis, optical imagery is limited not only by cloud cover, but also by polar night, so both influence the number of usable images noted here (also true for glacial ice, but Landsat 8 does not have daily coverage). We also did not analyze images for landfast ice after we observed the arrival of ice-free conditions.

Landfast Ice					
Fjord	**2015**	**2016**	**2017**	**2018**	**2019**
15	51	53	59	38	51
18	55	52	44	43	46
31	30	36	31	27	32
37	59	48	42	48	34
40	62	47	51	47	45
43	61	45	58	59	32
45	65	46	58	71	30
48	59	43	47	63	33
Glacial Ice					
Fjord	**2015**	**2016**	**2017**	**2018**	**2019**
15	17	18	16	21	20
18	15	14	13	17	16
31	8	9	8	3	5
37	9	8	12	10	6
40	10	8	12	8	6
43	15	10	15	16	9
45	17	17	17	19	13
48	15	11	9	12	12

193 To clarify, this was done visually right? The analyst is manually tagging ice cover as bergy bits/glacial ice, landfast and pack ice floes?

This is correct and we have modified to “visual digitization process”.

Figure 3 concerns the raw data or the processed data? e.g. if a MODIS image was available, but had 100% cloud cover, would it be plotted on Fig. 3? Maybe the figure could be improved a little if the dots reflected the quality/usefulness of the data as well e.g. shading out MODIS data with heavy cloud cover?

The figure shows the final data used in analysis, including only quality data. We have modified the caption to make this clear. We do not further distinguish on image quality, as all images included in the figure are used in analysis.

208 The % change might be more useful to quote as it’s hard to understand how large an error this is?

We appreciate the suggestion but have not changed the text. The reason for this is that differences in digitization are all about visual edges and edge resolutions. In other words,

the agreement between a certain area digitized using MODIS vs Landsat will differ not by a percentage of the total fjord area but rather a "fixed" area in regard to the boundaries one could trace in imagery from each source – it is independent of fjord area. We note here that the areas stated represent areas of less than 1% of the individual fjord areas.

337 Just for clarity, I think the authors' implication here is that these areas' bathymetry is poorly mapped because the areas are likely very shallow? Maybe edit accordingly.

The following sentence states: "Comparing landfast ice locations with bathymetric data from BedMachine 5 (Morlighem et al., 2017; Morlighem et al., 2022), for example, landfast ice often occurs in presumably shallow regions that lack any bathymetric detail." So, we feel that the reviewer's request is already addressed within the text.

337-345 Is there potentially a water mass effect here as well? Heat for ice melt comes mainly from the inflow of warm Atlantic water at depth (Straneo & Cenedese, 2015), so shallow areas occupied by a flow of Polar Water and cut off from the main estuarine circulation of a fjord might experience different heat budgets?

We agree that bathymetry influences water mass access within fjords and local heat budgets. The depths we discuss in this section are likely, however, to be on the order of 0-50 meters, much shallower than the expected depth for warm Atlantic inflows, so we expect minimal changes in deeper warm water access for these unmapped areas. We have left the text as is, highlighting surface wave processes and physical bathymetry high points that could ground landfast ice.

351 Reference for seals? My limited understanding was that the evidence for seal-ice associations in glacier fjords is mixed and maybe species specific and regionally dependent (Womble et al., 2021)

The current Laidre et al. 2022 reference does report on predation events with polar bears eating seals in SE Greenland. Due to the difficulty of research in SE Greenland, there are no direct peer-reviewed papers for seals in the region. The Womble et al. 2021 paper focused on Alaska (as does Kelly et al. 2010, which we cite elsewhere in the paper). Another general reference (Lydersen et al. 2014) focuses on Svalbard. There is a grey literature report (Boertmann and Rosing-Asvid, 2014) from a SE Greenland bird and seal survey, but they were not able to survey in ice-covered regions. This led them to conclude: "The relatively high fraction of bearded seals in the water indicates that our route (in open water areas along the coast) did not include the main areas for bearded seals at that time of the year. Bearded seals seek out ice for haul-out in July and they were also seen in the patches of ice

with many hooded seals. Surveys into the densely packed ice-fjords would probably reveal higher concentrations of bearded seals in July."

We have left the text unchanged.

Christian Lydersen, Philipp Assmy, Stig Falk-Petersen, Jack Kohler, Kit M. Kovacs, Marit Reigstad, Harald Steen, Hallvard Strøm, Arild Sundfjord, Øystein Varpe, Waldek Walczowski, Jan Marcin Weslawski, Marek Zajaczkowski (2014), The importance of tidewater glaciers for marine mammals and seabirds in Svalbard, Norway, Journal of Marine Systems, Volume 129, Pages 452-471, ISSN 0924-7963, https://doi.org/10.1016/j.jmarsys.2013.09.006.

David Boertmann, Aqqalu Rosing-Asvid (2014), Seabirds and seals in southeast Greenland: Results from a survey in July 2014, Scientific report from DCE – Danish Centre for Environment and Energy, No. 117, https://dce2.au.dk/pub/SR117.pdf.

358 I assume, maybe the authors can clarify, that wind-based products are simply not available for fjord regions because there's no in situ monitoring and coastal productions cannot be meaningfully extrapolated?

Regional climate models (such as MAR, which we used) can provide gridded wind variables (direction, speed). We have previously done some comparisons between wind products and the few in situ weather stations in Southeast Greenland. While providing reasonable agreements, we ultimately decided not to include wind data within this study. Others may be interested to pursue this idea further.

359-366 Might some overview comments about areas be useful for the reader, what sort of total area and fractional areas of the fjords have each ice type?

The full time series for these metrics are provided within the multi-panel time series that are included for each fjord (one figure within the main text and the other seven figures within the Appendix). Together, these show both area of coverage and percent fjord cover for landfast ice and for all categories of glacier-derived ice. There's high interannual variability, so we prefer that readers refer to these for complete data rather than including a summary in the text.

379 'well underway', a specific statistic and reference to the historical record might be better

We agree that better wording is needed. We now say "With ongoing sea-ice loss along the east coast of Greenland (Stern and Laidre, 2016)…". The reviewer might be interested to know that the sea-ice loss numbers from this paper have actually been updated in 2023

and reported within the Polar Bear Specialist Group Status Table (https://www.iucn-pbsg.org/population-status/) for East Greenland (-5.7 days per decade for change in spring sea-ice retreat and +7.0 days per decade for change in date of fall sea-ice advance), but we don't think this source is an allowable citation for the paper.

Figure A1 I don't understand the dark bars. These values are basically using Mankoff discharge data with glacier grounding line depth from bedmachine right? So I read the dark grey area from 900-1000 m for all years to mean 'no data were available', which would imply to me that there were grounding lines in this depth range with no discharge data. Is this correct, or is it rather the case that there are no grounding lines in this depth range so the value is 0?

We reviewed the various use of zero, near-zero, and NaN values within the Mankoff (2020) and Mankoff et al. (2020a) datasets and stemming from the MAR and RACMO regional climate models. Based on this, we have updated the figure to ensure that light grey regions reflect the presence of discharge outlets but with discharge below our minimum threshold, while dark grey regions indicate that no outlets are present at those depths. The figure and caption are updated accordingly.

References referred to:

Dastoor, A., Angot, H., Bieser, J., Christensen, J. H., Douglas, T. A., Heimbürger-Boavida, L.-E., Jiskra, M., Mason, R. P., McLagan, D. S., Obrist, D., Outridge, P. M., Petrova, M. V, Ryjkov, A., St. Pierre, K. A., Schartup, A. T., Soerensen, A. L., Toyota, K., Travnikov, O., Wilson, S. J., & Zdanowicz, C. (2022). Arctic mercury cycling. *Nature Reviews Earth & Environment*. https://doi.org/10.1038/s43017-022-00269-w

Holding, J. M., Markager, S., Juul-Pedersen, T., Paulsen, M. L., Møller, E. F., Meire, L., & Sejr, M. K. (2019). Seasonal and spatial patterns of primary production in a high-latitude fjord affected by Greenland Ice Sheet run-off. *Biogeosciences*. https://doi.org/10.5194/bg-16-3777-2019

Jørgensen, C. J., Søndergaard, J., Larsen, M. M., Kjeldsen, K. K., Rosa, D., Sapper, S. E., Heimbürger-Boavida, L.-E., Kohler, S. G., Wang, F., Gao, Z., Armstrong, D., & Albers, C. N. (2024). Large mercury release from the Greenland Ice Sheet invalidated. *Science Advances*, *10*(4), eadi7760. https://doi.org/10.1126/sciadv.adi7760

Murray, C., Markager, S., Stedmon, C. A., Juul-Pedersen, T., Sejr, M. K., & Bruhn, A. (2015). The influence of glacial melt water on bio-optical properties in two contrasting Greenlandic fjords. *Estuarine, Coastal and Shelf Science*, *163*(PB), 72–83. https://doi.org/10.1016/j.ecss.2015.05.041

Sejr, M. K., Bruhn, A., Dalsgaard, T., Juul-Pedersen, T., Stedmon, C. A., Blicher, M., Meire, L., Mankoff, K. D., & Thyrring, J. (2022). Glacial meltwater determines the balance between autotrophic and heterotrophic processes in a Greenland fjord. *Proceedings of the National Academy of Sciences*, *119*(52), e2207024119. https://doi.org/10.1073/pnas.2207024119

Straneo, F., & Cenedese, C. (2015). The Dynamics of Greenland's Glacial Fjords and Their Role in Climate. *Annual Review of Marine Science*, *7*, 89–112. https://doi.org/10.1146/annurev-marine-010213-135133

Womble, J. N., Williams, P. J., McNabb, R. W., Prakash, A., Gens, R., Sedinger, B. S., & Acevedo, C. R. (2021). Harbor Seals as Sentinels of Ice Dynamics in Tidewater Glacier Fjords. *Frontiers in Marine Science*, *8*. https://www.frontiersin.org/articles/10.3389/fmars.2021.634541