The sensitivity of primary productivity in Disko Bay, a coastal Arctic ecosystem to changes in freshwater discharge and sea ice cover by Møller et al.

Thank you for the opportunity to further clarify. Please find below our answer to the comment by the reviewer.

Reviewer:
However, I am still surprised that subglacial discharge would have the same effects as surface discharge even on the large spatial scales of the model and the open system in Disko Bay. I agree that the discharge would still reach the surface (or near surface) layer within 10s to 100s of m, but the properties of this water would be very different from surface runoff. It would transport deep water nutrients with it which have been shown to affect nutrient dynamics and primary production on the mesoscale (100km, See Hopwood et al., 2020). The authors mention that surface runoff would create coastal upwelling, but I am not convinced that this would have the same effect as subglacial upwelling as described in numerous studies and fjord systems. If the authors disagree, I suggest adding a reference which shows that the effects of coastal and subglacial upwelling on nutrient concentrations can be comparable in a large open system such as Disko Bay. Is it possible that coastal upwelling is overestimated in the model in order to compensate for the lack of subglacial upwelling? I suggest discussing the source of nutrients in some more detail, or generalize the upwelling in your model as coastal upwelling, including subglacial upwelling. However, if coastal upwleling and subglacial upwelling are not comparable, I am not sure if the model can be generalized to systems with only surface runoff.

Answer: *We acknowledge the concerns of the reviewer and have therefore made a new analysis of the current velocities at the ice edge of the largest marine terminal glacier in the area, Jakobshavn Isbræ. We have plotted vertical profiles of the east-west velocity and the vertical velocity at the ice edge and found that the main outgoing transport from the ice fjord occurs in the bottom waters and that this leads to a coastal upwelling at the ice edge. Hence, even though the ice discharge is at the surface, it is fully mixed in the water column during transport from the release site at the mouth of the glacier to the ice edge. Due to ice cover, the wind driven transport is reduced in the surface layer and the main transport takes place near the bottom of the fjord. Hence, the model can to some extent reproduce the coastal upwelling from subglacial discharge at the edge of the marine terminating glacier and is able to produce realistic results despite the basin scale application and not fine scale modelling around the glacier. We have added a new figure C4 in the appendix showing the velocities and added new text to methods, results and discussion. We hope that the new text and figures clarify the questions raised.*

Below the revised text in the different sections are inserted.

Section 2.6. Surface forcing data

Glacier ice cover was assumed to be present throughout the year in the Jakobshavn Isbræ near Ilulissat with the ice edge located at the mouth of the fjord whereas land- and ice runoff were located at the sub-arms of the fjord (Figure 1).

Section 3.5. Model scenarios with sea ice cover and discharge.

Horizontal (East-West) current velocity profiles at the ice edge (water depth of 241 m) of Jakobshavn Isbræ showed an outgoing westly direction with highest outflow at 150-200 m depth from March to October (Figure C4a). Vertical velocities showed an upward transport with highest values close to the bottom at 190-216 m depth (Figure C4b). The scenario with no runoff (noQNP) showed weaker horizontal transports and less upwelling at the ice edge (Figure C4). When ice run-off was released at *the glacier grounding line instead at the surface, only a small increase of horizontal and vertical velocities was found at 90-200 m depth relative to the baseline. In addition, a small spatial displacement of the primary production was seen (Fig C5). The stratification and vertical distribution of nutrients, Chl a and primary production were not changing much, just establishing a bit further offshore in the late summer months (Fig C3+C6). The effect on the bay primary productivity is only minor (<1%).*

Chapter 4. Discussion. *We do not specifically model the subglacial discharge of freshwater from the marine terminating glaciers or from melting of the numerous large icebergs in the bay. Instead, the freshwater discharge from solid ice was distributed equally across the upper 100 m in the locations where marine terminating glaciers were present. Subglacial discharge that enters at depth, will rise up the ice front within a few 10s to 100s of meters of the ice front (Mankoff et al., 2016), which is within the grid cell size of the model. We therefor inserted ice discharge in the model surface layer that was found to be fully mixed in the water column during transport towards the ice edge. At the ice edge of the Jakobshavn Isbræ, modelled velocity profiles confirmed a bottom upwelling due to higher outgoing water transport at the bottom of the glacier (Figure C4a, b) in accordance with previous studies of marine terminating glaciers (Hopwood et al. 2020). In the scenario with no runoff (noQNP), the outgoing transport and vertical velocities at depths below 100m was severely reduced confirming the importance of ice discharge for the observed dynamic (Hopwood et al. 2020). When the discharge instead was inserted at the grounding line of the marine terminating glaciers, there was a limited increase in the vertical velocity marginal (Figure C5b). Similarly, there was only a slight displacement of the phytoplankton bloom to further offshore and very limited changes in the stratification and vertical distribution of nutrients, Chl a and NPP (Fig C5+C6). The effect of the primary productivity of the Bay was <1%.*

New Figure C4. Vertical profiles of a) East-West velocities and b) vertical velocities at the ice edge in Jakobshavn Isbræ for 2010, the scenario noQNP, and the scenario with subglacial discharge at the glacier grounding line