EGUsphere, referee comment RC2
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Comment on egusphere-2022-916

Anonymous Referee #2

Referee comment on "The sensitivity of primary productivity in Disko Bay, a coastal Arctic ecosystem, to changes in freshwater discharge and sea ice cover" by Eva Friis Møller et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-916-RC2, 2022

The paper presents an interesting modelling exercise on the drivers and sensitivity of primary production to sea ice and freshwater runoff changes. Both in situ and remote sensing data are used to validation. The overall approach and the aim of the paper would be an important contribution to model primary production along the Greenland coast. However, there are two major issues that need to be addressed before the paper can be published. Firstly, I am very skeptical about the approach to not differentiate subglacial and surface runoff, since the effects for primary producers are very different. Secondly, most of the in situ data are not available and therefore the study is not reproducible. Some of the cited papers do not supply their raw data, and the GEM database only has CTD data available, but none of the biogeochemical or sea ice data mentioned in the manuscript.

Subglacial upwelling: The authors do not differentiate between surface freshwater inputs and subglacial inputs. Their effects on coastal ecosystem and NPP are very different. Surface runoff introduces only few nutrients and leads to low surface salinity and strong stratification. Subglacial discharge introduces large amounts of NOx via subglacial upwelling, but the freshwater is highly diluted once it reaches the surface, if it reaches the surface at all. Consequently subglacial discharge leads to substantially weaker stratification. It is unclear if the model considers subglacial upwelling. The different sources should be considered separately, both in the discussion making clear what the effects of subglacial vs surface runoff are, in the model, and in the selection of reference stations. Currently there is no reference station or transect where surface runoff is the major freshwater source. Does this mean the manuscript focusses on the effects of subglacial discharge and upwelling? In this case this has to become clearer.

Data availability: The authors refer to validation data from MarinBasis Disko of the GEM programme. However, only CTD data between 2011 and 2019 are available in the GEM database. No data for plankton communities or nutrients are reported. These data need to be publicly available to allow reproducibility of the study, either via updating the GEM database, or by achieving the data on another open access platform (e.g. PANGAEA).

Other data are mentioned via citing earlier publications. However, many of these publications do not supply their raw data either. Consequently, the study is currently not reproducible. I highly recommend a data availability statement after making sure the raw data are publicly available. Ideally the model code should also be achieved (e.g. github, zenodo).

Other comments:

L29: Fresh water should be written together as Freshwater

L30: A single productive hot spot needs an article “a” productive hot spot. OR productive hot spot”s”

L60: wind-induced mixing needs a hyphen.

L67: deep subglacial upwelling would be mixed with large amounts of ambient seawater on the way up often not even reaching the surface. Thus, the effect if subglacially released freshwater on surface stratification is minor.

L78: their impacts in plural.

L85: a pronounced decrease needs an article.

L87: There do not seem to be any sea ice data in the GEM database. Please refer to the respective subprogram where the data are available.

L133: there are issues with fixed elemental ratios in phytoplankton, especially under high light- low nutrient conditions (e.g. See Ross and Geider, 2009). This needs to be added to the discussion.

L148: the GEM database has does not show this relationship. Please refer to the specific report showing it or show the relationship in this manuscript in the supplement.

L167f: I see some issues with the assumption that all subglacial discharge will reach the surface layer in the fjord. Often the discharge reaches neutral buoyancy at depth. Also the resulting surface salinity and stratification is substantially lower compared to surface runoff due to the entrainment of saline bottom water. Overall, I am very skeptical to use the same model formulation for surface runoff (->low surface salinity, strong stratification, low nutrient inputs) and subglacial discharge (higher surface salinity, weak stratification, large amount of nutrient (mostly NOx) input by subglacial upwelling). See Hopwood et al. 2021. I recommend at least a model exercise separating these two different freshwater sources and check if the results differ substantially. One approach would be to add a reference station with high subglacial inputs and another station with high surface runoff. I would expect a larger positive effect on NPP with subglacial runoff (due to subglacial upwelling).

L202: There are no sea ice data in the GEM database. Please refer to the respective subprogram where the data are available, or make sure they are publicly available elsewhere.

L233f: Many of these validation data do not seem to be publicly available which makes the study not reproducible. The GEM database has only CTD data between 2011 and 2019. No data for nutrients, plankton biomass and communities, Chlorophyll are available in the GEM database. Please make sure the data are available and refer to the source. I recommend a data availability statement in the manuscript. Also the paper by Møller and Nielsen only shows the data in in plots and there seems to be no reference to the raw data.

L287 and L289f: Here I see issues with the assumption that subglacial and surface runoff have the same effects on surface salinity (See comments above). Especially the station close to the Icefjord is very likely heavily influenced by subglacial upwelling of nutrients. I recommend adding a third reference station with high surface runoff and no subglacial inputs to check if the higher production is related to subglacial upwelling or the freshwater runoff.

L343: Would it be the same for surface runoff, or is the higher production with higher freshwater runoff from the glacier related to subglacial upwelling?

L400: Wind tides, but also subglacial upwelling are important nutrient sources in the described system. E.g. Juul-Pedersen et al. 2015 describes subglacial upwelling in Godthåbsfjord as the key driver for high late summer/autumn production in the entrance of the fjord system (ca 120 km distance from the glacier terminus).

L433: Please add more details about the upwelling being enhanced by freshwater discharge. Do you refer to subglacial upwelling?

L434f: Higher nutrient concentrations in the surface water compared to the discharge is expected if subglacial upwelling is the source of nutrient inputs by bottom water entrainment. This shows that subglacial upwelling needs to be considered in the model.

L464: I highly recommend excluding the 1996/1997 data. Without information about the method or access to the data it is not possible to reproduce the study or even judge the quality and limitations of the data. In situ bottle incubations can have a variety of issues and need a variety of metadata to calculate NPP in the fjord (e.g. light data, attenuation, Chlorophyll).

L512f: I am glad this issue is discussed, but I think that the main conclusion of this paper remain very speculative and poorly supported if subglacial and surface discharge are not treated separately. At the moment it is unclear if the positive effects of freshwater runoff are due to subglacial upwelling (subglacial discharge), or due to increased stratification (mainly surface discharge). I suggest checking if a reference station at a site with only surface runoff shows the same results as the current icefjord reference station. If yes, the conclusion of freshwater runoff as main driver (instead of subglacial upwelling), would be supported.

L515: The effects of subglacial upwelling can reach quite far (e.g. 120 km in Godthåbsfjord, where the tidewater glacier is smaller than in Illulisat, Juul-Pedersen et al., 2015).

L537: Freshwater is one word.

References:

Hopwood, M. J., Carroll, D., Dunse, T., Hodson, A., Holding, J. M., Iriarte, J. L., ... & Meire, L. (2020). How does glacier discharge affect marine biogeochemistry and primary production in the Arctic?. *The Cryosphere*, *14*(4), 1347-1383.

Juul-Pedersen, T., Arendt, K. E., Mortensen, J., Blicher, M. E., Søgaard, D. H., & Rysgaard, S. (2015). Seasonal and interannual phytoplankton production in a sub-Arctic tidewater outlet glacier fjord, SW Greenland. *Marine Ecology Progress Series*, *524*, 27-38.

Ross, O. N., & Geider, R. J. (2009). New cell-based model of photosynthesis and photo-acclimation: accumulation and mobilisation of energy reserves in phytoplankton. *Marine ecology progress series*, *383*, 53-71.