Response to Reviews

In this document the editor's and reviewers' comments are in black, our responses are in brown, and the amended or new text is in blue

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Dear Dr. Guillaume Liniger,

We have received additional comments from the second round of reviews, which are appended below. One remaining major concern is the potential bias in the Chl-a data, and this needs to be addressed before further consideration for publication. I am therefore returning the manuscript to you so that you can make the necessary revisions.

Best regards,
Yuan Shen
Associate Editor

We thank the editor for this comment and request. We address all remaining concerns below.

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Review notes for
Liniger et al., Drivers of phytoplankton bloom interannual variability in the Amundsen and Pine Island Polynyas

Firstly, we apologies for the delay in returning our review.
We thank the authors for preparing the revised manuscript and for their efforts in addressing the comments from both Reviewer #1 and ourselves. Many of our concerns have been satisfactorily resolved, however, we remain somewhat unsatisfied with the response to our concern regarding possible bias in the chl-a data product (see general comment below). In addition, we provide a few very minor comments. Once these issues are resolved, we believe the manuscript would be suitable for publication.

We thank both reviewers for taking the time to review our manuscript once again. We address their final concerns below.

General comments
1) Chl-a data product:
While we appreciate the additional details provided in the revised manuscript, the authors have not addressed the central issue, namely that sediments may impart an optical signature in surface waters that may introduce bias in the Chl-a data product. This concern cannot be dismissed by noting that previous studies have used the same

product. The primary explanation offered for the differing chla–meltwater relationships between ASP and PIP is that ASP is more strongly influenced by sediments. Following the same logic, a stronger influence of sediments in ASP could artificially elevate the retrieved chla relative to PIP not because of alleviation of iron limitation and stimulation of phytoplankton productivity, but due to bias in the chla data product. This would also provide an alternative explanation for the decoupling between chla and NPP in ASP. We understand that an uncertainty analysis is beyond the scope of this manuscript. However, because a possible influence of sediments cannot be ruled out, we request that this be explicitly acknowledged in the limitations section.

In the previous version of the manuscript, we added the following text regarding potential biases in our study, L185-194:
"We note that satellite ocean-colour chla algorithms (including the GlobColour merged product used here) are globally tuned and may underperform in optically complex waters (e.g., with elevated dissolved organic matter or suspended sediments, 'Case 2'). In the ASP, past work (e.g., Park et al. 2017) shows that satellite chlorophyll climatologies reflect broad seasonal patterns that are consistent with in situ measurements of phytoplankton biomass and photophysiology, but there is limited data from regions immediately adjacent to glacier fronts or during times of strong meltwater input. Thus, while we consider satellite chla to be useful for capturing spatial and temporal variability at polynya scale, uncertainty likely increases in optically complex zones near glacier margins or during low-light periods, and needs to be considered while interpreting results.".

In the updated version, we added more text based on the reviewer's comment regarding the influence of sediment and how it could impact the chla estimates, as well as the chla-npp relationship.

New text: "We acknowledge that elevated concentrations of suspended sediments (and non-photosynthetically active particles in general) near the ocean surface can impart optical signatures that bias satellite-derived chla high in coastal waters. Consequently, the higher chla observed in the ASP relative to the PIP, as well as the weak correspondence between chla and NPP in ASP, may reflect some sediment-driven optical effects rather than enhanced phytoplankton biomass or productivity alone. While our results are consistent with known differences in iron supply and mixed-layer dynamics between the two polynyas, the potential contribution of sediment-related bias cannot be ruled out and should be acknowledged when interpreting spatial contrasts in satellite chla on the Antarctic shelf."

Minor comments
L 26: edit "… in both chla and …" to "… in neither chla or…"
Corrected.

L70-74: this needs some clarification. Especially the part about vertical intrusions in PIP. What is meant by vertical intrusions? Do you mean upwelled mCDW?

We apologize for the lack of clarification. By vertical intrusion we intended to distinguish the small-scale upwelling of mCDW onto the shelf and beneath the ice shelf that occur more in the PIP, which would be called 'intrusions', as opposed to larger scale upwelling that would occur more in the ASP.

Updated text: "The PIP and ASP differ in their exposure to CDW and in local circulation: the ASP is more strongly influenced by upwelled modified CDW (mCDW) and glacial meltwater inputs, whereas in the PIP, the deep mCDW retains more of its original offshore characteristics, with vertical exchange only significantly occurring beneath the ice shelves, leading to a more stratified and less directly ventilated surface layer (Assmann et al., 2013; Dutrieux et al., 2014)"

L120-122: The winter mixed layer depth may be a more relevant metric for nutrient entrainment from depth. Furthermore, Fig. 1b shows summer MLD, so it is unclear what is meant by "mean mixed layer depth"
We agree with the reviewer. We have replaced Fig. 1b with the climatological winter mixed-layer depth (averaged for all years that we define as April-Sept, after the growing season and just before the start of the next one). What we meant by 'mean mixed-layer depth' was the climatological summer map (i.e originally all October-March averages from 1998 to 2017). We also accordingly updated the text.

Updated text: "The climatological winter mixed-layer depth (MLD) in the ASP is deeper (Fig. 1b), indicating that it may better entrain deeper sources of nutrients into the upper waters for the following phytoplankton growing season".

L 370: both → either
Corrected.

L 457: sediment → sediment-sourced dFe concentration
Corrected.

L 663: please add a reference
Thank you for pointing it out. We have added one reference that demonstrated that high surface biomass triggered by more iron brought to the surface from the meltwater pump does not necessarily imply high depth-integrated productivity.

Twelves, A. G., Goldberg, D. N., Henley, S. F., Mazloff, M. R., & Jones, D. C. (2021). Self-shading and meltwater spreading control the transition from light to iron limitation in an Antarctic coastal polynya. Journal of Geophysical Research: Oceans, 126, e2020JC016636. https://doi.org/10.1029/2020JC016636

L 748: add "suspected" underlying hydrographic drivers
Added.

L 791-793: this statement goes too far beyond the analysis presented. The results do not suggest long-term changes in the phytoplankton community composition. I suggest to rephrase or omit.
On second thoughts, we agree with the reviewer and decided to remove the sentence completely. Thank you.

L 797: tends → tend
Corrected.

L 802-811: this paragraph presents new results and should therefore be moved to the results section.
We have updated the manuscript as follow:

We added a brief statement in the method section about the ASL:
"Variability in the sea-ice landscape can be influenced by the Amundsen Sea Low in West Antarctica (ASL; Hosking et al., 2013; Turner et al., 2016). We therefore finally looked at the impact of the ASL and its potential influence on sea-ice variability. Monthly ASL indices (latitude, longitude, central and sector pressure) derived from ERA5 reanalysis data were obtained from the ASL climate index page (Hosking et al., 2016)."

We moved the results part in the Results section:
"Finally, we found on average weak spatial negative relationships between SIC and ASL latitude, longitude, mean sector and actual central pressure in both polynyas during the growing season (Supplementary Fig. S7), and only slightly significant in the eastern PIP."

We finally kept the original text in the discussion section:
"The weak relationships between the ASL indices and SIC might be owing to the seasonal variation of the ASL, where its position largely varies during summer, and its impact in shaping coastal sea ice is also greater during winter and autumn in the Amundsen-Bellingshausen region (Hosking et al., 2013). The lack of strong significant relationships overall does not allow us to conclude that the ASL plays an important role in shaping the coastal polynyas landscape and influencing chla variability."

L 851: delete "potential." The results demonstrate a robust and significant relationship between ice shelf melting and surface chla, so "potential" is unnecessary.
Corrected. Thank you.