

Point-by-point responses to the associate editor

Biogeochemical controls on the concentrations and stable isotope compositions of sea-ice particulate organic matters in the Southern Ocean

Keigo D. Takahashi, Ryosuke Makabe, Masayoshi Sano, Kazuki Nakata, Noriaki Kimura, Daiki Nomura, Michiyo Yamamoto-Kawai, Ryo Matsuda, Natsumi Nojima, Masato Ito, Shintaro Takao, Naho Horimoto-Miyazaki, Aiko Tachibana, Norio Kurosawa, Takeshi Tamura, Mizuki Komatsu, Kay I. Ohshima, Kohei Mizobata, Shigeru Aoki, and Masato Moteki

We greatly appreciate your time and review for our manuscript. The responses and revised text in this file (circled by quotation marks "") are written with the line numbers (L.###) which correspond to the manuscript with track changes 'Author's track-changes file'.

Both reviewers find that your revisions have adequately addressed their concerns. I also went through the revised manuscript carefully and see substantial improvement in this version. There are, however, a few remaining minor issues and inconsistencies that should be corrected before publication.

Changes in the manuscript not mentioned in the review

We found that POC_{VWM} and Chl_{VWM} needed slight revision, which should be $1137.2 \mu\text{g L}^{-1}$ and $12.4 \mu\text{g L}^{-1}$, respectively ($1137.6 \mu\text{g L}^{-1}$ for POC_{VWM} and $12.0 \mu\text{g L}^{-1}$ for Chl_{VWM} in the original manuscript). We also checked the statistics and values in Tables and text again. The revisions can be found in the track-changes file although they did not change significantly the results and conclusion of our manuscript.

Title: I agree with the reviewer that the title reads a bit long, even in its revised form. Please consider a more concise title, which would be more effective.

The title is shortened as follows;

"Biogeochemical controls on the concentrations and stable isotope compositions of sea-ice particulate organic matters in the Southern Ocean"

Minor corrections and consistency checks:

1) POC flux and contribution estimates: Please carefully reconcile the values reported in different parts of the manuscript. The Abstract reports $4.1 \pm 0.3 \text{ Tg C yr}^{-1}$ and $>12\%$, whereas Sect. 3.5 reports $4.6 \pm 0.3 \text{ Tg yr}^{-1}$ and $16.5 \pm 3.1\%$; Table 2 reports $4.1 \pm 0.3 \text{ Tg yr}^{-1}$ and $14.7 \pm 2.8\%$; and the Conclusions again report $4.6 \pm 0.3 \text{ Tg C yr}^{-1}$ and $16.5 \pm 3.1\%$. Please verify the calculations and use the appropriate values consistently throughout. The value in Table 2 was correct; we unified those in the Abstract, Section 3.5., and Conclusions (L.34–36, 430–431, 668–669);

"Using freshwater flux from sea ice melt and the measured sea-ice POC concentrations, this supply was estimated to be $4.1 \pm 0.3 \text{ Tg C year}^{-1}$, equivalent to $14.7 \pm 2.8\%$ of primary production in the marginal ice zone of the studied region."

"Assuming the primary production at the MIZ in this sector to be $27.9 \pm 5.0 \text{ Tg year}^{-1}$ (Arrigo et al., 2008), sea ice-derived carbon was found to account for $14.7 \pm 2.8\%$ of this production."

“Furthermore, we estimated the carbon supply from sea ice to be $4.1 \pm 0.3 \text{ Tg C year}^{-1}$, equivalent to $14.7 \pm 2.8\%$ of primary production in the MIZ.”

2) Stable-isotope summary values: Please also check the consistency of the mean $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values reported in the Abstract, Sect. 3.2, and Sect. 4.2. In particular, please make clear whether the reported values include or exclude newly formed ice.

We revised the sentences so that they clearly state if the reported values include all sea-ice samples or those excluding newly formed ice (L.30–32, 372–373, 507–508);

“The $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of all sea-ice particulate matter samples were $-24.6 \pm 3.2\text{‰}$ and $+1.5 \pm 2.2\text{‰}$ (mean $\pm$ standard deviation), respectively, showing greater variability compared to those in seawater ($-28.8 \pm 1.0\text{‰}$ for $\delta^{13}\text{C}$ and $-0.5 \pm 1.4\text{‰}$ for $\delta^{15}\text{N}$).”

“The mean ($\pm$ SD) $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for sea ice excluding newly formed ice were $-24.4 \pm 3.2\text{‰}$ and $+1.6 \pm 2.2\text{‰}$, respectively ($-24.6 \pm 3.2\text{‰}$ and $+1.5 \pm 2.2\text{‰}$ for all sea ice).”

“The $\delta^{13}\text{C}$ of POC was $-24.6 \pm 3.2\text{‰}$ for all sea ice samples, which was higher than the previously reported $\delta^{13}\text{C}$ of surface seawater in the SIJ (-31‰ to -24‰ , Espinasse et al., 2019).”

3) Sect. 3.3: The text states that Chl a showed no significant monthly differences ($p = 0.26$), but the following sentence says that POC showed a similar trend to Chl a, “with both significantly higher in February.” Please correct this apparent contradiction.

We corrected the statement on POC in Section 3.3 (L.384–386);

“The mean monthly POC concentrations increased from December to February, with significantly higher concentration found in February than in other months.”

4) Table 2: The expression for “POC Input from ice per area ($a \times b$)” appears incomplete relative to Eq. (6), which also includes sea-ice density (ρ_i). Please check the notation/calculation and revise as needed. Also correct “Volume-Weightd Mean” to “Volume-Weighted Mean” and check the clarity of the superscript/footnote labels.

We added ρ_i in the equation. Table footnote now has explanation of ρ_i . We also corrected the spell of VWM (L.437–438);

“... ρ_i is the sea-ice density (0.90)”

5) Section heading: The manuscript proceeds directly from the Introduction/Fig. 1 to Sect. 2.1. Please check whether an overarching Sect. 2 heading (e.g., “Materials and methods”) is missing.

We added the title for section 2 “Materials and methods” (L.175).

6) Figure captions: Please double check the description of the panels/regions. E.g., the caption of Fig 1 should also account clearly for panel (f).

We added explanation on Fig. 1f (L.173). We checked and conducted slight revisions for the rest of figure captions.

“...seawater sampling sites around 110°E conducted during the cruise UM18-08 (f).”

7) Figure 2: Please check the reported $\delta^{13}\text{C}$ – $\delta^{15}\text{N}$ correlation statistics. Sect. 3.1 gives $r = 0.24$, $p < 0.01$, whereas the value displayed in Fig. 2b appears different. Please make the figure and text consistent.

The value in Fig. 2b was correct. We revised the value in Section 3.1 (L.330–331);

“...showing a significant positive correlation with each other (Spearman’s rank test, $r=0.34$, $p<0.05$), although the correlation coefficient was low (Fig. 2b).”