Answers to reviewer 2

This study aims to provide an insight of primary productivity variation and its drivers in the Amundsen Sea Embayment using a bioregion approach based on cluster analysis. Such study could highlight the main physical and biogeochemical difference that drives the biology across the longitudinal and latitudinal gradient of the whole area. However, as mentionned by RC1, such difference can only be compared with consistency in the analysis method and report of full results, which is lacking here. On the other hand, the authors only describe their findings, without trying to explain the processes behind the variation of parameters leading to changes in phytoplankton primary production. As suggested, I concur with RC1 that this study needs major revision and improvment before being considered for publication. Specific comments are listed below:

Answer: We greatly appreciate the referee for spending time on reviewing our manuscript and for the constructive comments. We have made careful considerations on the referee's comments, and have implemented most of the referee's suggestions. We hope to fulfill the requirements given by your review. Please see our responses in detail below.

We have added the correlation between and environmental factors in Table 3. We also added some discussions to explain the processes behind the variation of parameters leading to changes in phytoplankton primary production in the manuscript this time. Including how environmental controls differ in different bioregions and what caused the variation of nutrients and how it could have affected the PP.

In section 3.3

"The environmental controls of primary productivity of 6 and 7 showed some differences with that of bioregions 8 and 9. These differences may be caused by the differences of the dissolved iron concentrations. The dissolved iron concentrations in bioregions 8 and 9 were the highest in the Amundsen Sea area (Figure 5), so dissolved iron was not the limiting factor for primary productivity in these two bioregions. So in bioregion 8 and 9 the decadal and long-term changes

of primary productivity were more correlated with the SST and sea ice. In bioregion 6 and 7, the dissolved iron concentrations were much smaller than that of bioregion 8 and 9. The primary productions were also positive correlated with SSTs and negative correlated with sea ice thickness, but the effects of changes of SSTs and sea ice thickness were relatively smaller than that of dissolved iron. So the primary production was mainly controlled by dissolved iron concentrations in bioregions 6 and 7. The spatial differences in the limitation of dissolved iron on the primary productivity of the Amundsen Sea were consistent with previous results (Gerringa et al., 2012; Yager et al., 2012; Alderkamp et al., 2015).”

“The variation of these nutrients was caused by changes of the seasonal cycle of the sea ice in the offshore area in the Amundsen Sea. Stammerjohn et al. (2015) found that the winter ice season duration showed a rapid decrease since 2000 and the summer open duration showed a rapid increase since 2000 in the offshore area in the Amundsen Sea. Previous studies have shown that sea ice coverage in west Antarctica water and in the Amundsen Sea has decreased drastically over the last few decades (Stammerjohn et al., 2015; Randall-Goodwin et al., 2015). On the one hand, the melting sea ice is a potentially important source of dissolved iron, nitrate, phosphate, and silicate (Lannuzel et al., 2010). On the other hand, the melting sea ice can lead to salinity-driven vertical stratification (the “meltwater pump”), it can transport sediment-derived nutrients to the upper water column (St-Laurent et al., 2017; Twelves et al., 2021). Throughout much of the Southern Ocean, macronutrients are abundant and low Fe concentrations limit productivity (Tagliabue et al., 2014). Also, Alderkamp et al. (2015) showed that the primary production is stressed by limited iron availability while macronutrients are generally abundant in the Amundsen Sea. Alderkamp et al. (2015) indicated that primary productivity would be stressed by low iron concentrations during December and January in the Amundsen Sea. So the changes in dissolved iron resulted in increased primary production in November and December after 2000. Kwon et al. (2021) also found that the increase in iron can lead to a shift in the bloom peak

timing to earlier than January in the Amundsen Sea continental shelf water (mostly in bioregion 5) using a 1-D pelagic ecosystem model."

Table 3. Correlation between primary production and environmental factors of bioregion 6, 7, 8 and 9.

	SST (Nov-Mar)	Hice	Fe	nitrate	phosphate	silicate	mlp
Bioregion 6	0.12	-0.10	0.96	0.86	0.87	0.94	-0.18
Bioregion 7	0.07	-0.18	0.59	0.78	0.81	0.61	0.11
Bioregion 8	0.45	-0.54	0.11	0.08	0.13	0.07	-0.02
Bioregion 9	0.46	-0.24	-0.25	-0.15	0.20	-0.05	-0.15

Trends with significant at the 95% confidence level are underlined

1. Be careful about the use of the word "Significant". One can only use this term when it refers to statistical analysis, which is often not done. Changing the wording of perfoming the analysis is highly recommended.

Answer: We have tested the significances of the trends and correlations in the work. We are sorry for mot making it clear in the manuscript. We have added this in the section 2.2.

"The significance of the correlations and trends identified in this study was checked using t-tests and Mann–Kendall tests (von Storch and Zwiers, 1999; Feng et al., 2015), respectively. The pre-whitening method was used to avoid autocorrelations in the work (Kulkarni and von Storch 1995)."

2. Figures 7 to 10 should be centered around Austral summer (June to July or July to August) to ease the figures reading.

Answer: We have modified these figures this time.

3. Figure 2: Bioregion should be listed according to a latitudinal gradient to ease the comprehension in you result description. Unless you justify your number listing, the bioregion number attribution seems random.

Answer: We have modified the bioregion numbers in Figure 4 according to a latitudinal gradient this time.

4. Figure 3 should have indication on the X axis if possible to understand were the coast/offshore areas are.

Answer: We are sorry for this. There were about 21416 points used in the hierarchical clustering, which will result in too many points on the X axis, so we did not show the points number in the X axis.

5. Colorbars are missing on some plots

Answer: We have modified the figure 9 and 10 this time.

6. Do you obtain the same result if you integrate your primary productivty (in TgC y) across the whole time period for your bioregion ? (e.g sum instead of mean). For Figure 11 for example.

Answer: We checked the results this time, it is the same. In addition, according to reviewer 1, we calculated the annual NPP using July-June, and have modified the figure 11.

7. Overall discussion is lacking, especially line 355 - 356. You argue the variation of nutrients result in primary production increase in some bioregion, but you do not explain what caused the variation of these nutrients and how it could have affected the PP.

Answer: The variation of these nutrients was caused by changes of the seasonal cycle of the sea ice in the offshore area in the Amundsen Sea. Stammerjohn et al. (2015) found that the winter ice season duration showed a rapid decrease since 2000 and the summer open duration showed a rapid increase since 2000 in the

offshore area in the Amundsen Sea. Previous studies have shown that sea ice coverage in west Antarctica water and in the Amundsen Sea has decreased drastically over the last few decades (Stammerjohn et al., 2015; Randall-Goodwin et al., 2015). On the one hand, the melting sea ice is a potentially important source of dissolved iron, nitrate, phosphate, and silicate (Lannuzel et al., 2010). On the other hand, the melting sea ice can lead to salinity-driven vertical stratification (the “meltwater pump”), it can transport sediment-derived nutrients to the upper water column (St-Laurent et al., 2017; Twelves et al., 2021). Throughout much of the Southern Ocean, macronutrients are abundant and low Fe concentrations limit productivity (Tagliabue et al., 2014). Also, Alderkamp et al. (2015) showed that the primary production is stressed by limited iron availability while macronutrients are generally abundant in the Amundsen Sea. Alderkamp et al. (2015) indicated that primary productivity would be stressed by low iron concentrations during December and January in the Amundsen Sea. So the changes in dissolved iron resulted in increased primary production in November and December after 2000. Kwon et al. (2021) also found that the increase in iron can lead to a shift in the bloom peak timing to earlier than January in the Amundsen Sea continental shelf water (mostly in bioregion 5) using a 1-D pelagic ecosystem model.

We have added this in the section 3.3.