Response to reviewers

Dear Reviewers:

We would like to thank you for carefully reading our manuscript. We appreciate the comments and suggestions, your crucial comments helped us solve a lot of problems. In the following, we include a point-by-point response to the comments from each reviewer. In the revised manuscript, all the changes have been highlighted in red.

Comment 1: Page 3, line 76: What do you mean with "polar eddies"? Do you mean eddies of different polarity?

Response: Thanks for your suggestion. Yes, it mean eddies of different polarity (AE/CE), and we have revised grammar issues： "… and the distribution of sea surface Chl concentration in eddies of different polarity was investigated"

Comment 2: Page 3, lines79-89: It is unusual to place the results at the end of the introduction. I would rather formulate specific scientific questions to be answered in this study and/or describe the structure of the paper (data, methods, results, discussion…)

Response: Thanks for your crucial comment, we delete these results and rephrased these sentence. "Our study indicate that the characteristics of Chl profiles and their influencing factors vary across different depths in seawater. The contribution of phytoplankton biomass and physiological regulation to Chl concentration is different at different depths. Therefore, it is not sufficient and can not provide complete information to study the effect of eddies on Chl only using remote sensing data. This study filled this gap, and will have significant implications for enhancing our understanding of the biogeochemical processes and carbon cycle associated with eddies." (Page 3, lines 79-83).

Comment 3: Page 4, line 95: In the introduction, the authors state that "winter mixing enhances the productivity of AEs and CEs". I was wondering, whether the dataset from "January 2000 to August 2021" might be imbalanced in terms of seasonality. It is worth to analyse, whether the the interaction between dynamic processes of mesoscale eddies and chlorophyll is related to seasonal variability (at least summer and winter condition). Also, I am missing some general information

about mesoscale eddies such as the generation mechanisms and formation regions.

Response:

Thanks for your suggestion. The sentence “winter mixing enhances the productivity of AEs and CEs” was cited from previous research, and we have add a reference afeter the sentence. We read the article again carefully and find that, in South Pacific Ocean, whether in winter or summer, chlorophyll concentration in AEs is higher than CEs, chlorophyll concentration in AEs is higher than CEs. In winter, the difference of chlorophyll concentration between AEs and CEs is more obvious. SO, the change of seasons did not affect the results of the experiment.

The generation mechanism of eddies is complex, with factors such as wind, ocean currents, changes in submarine topography, and geostrophic effects. In the nearshore area, eddies are more prevalent and can move both eastward and westward. In the open ocean, our study did not take into account he generation mechanisms and formation regions of eddies, so we did not provide a detailed description of these characteristics of eddies. We also referred Chelton's article, he described the detail characteristics of eddies, and the AVISO data we used is from Chelton’s arithmetic.

Comment 4: Page 5, line 119-121: Please rephrase the sentence, as it is hard to understand.

Reponse: Thanks for your suggestion. We rephrased the sentence: “The dataset provided by AVISO for identifying and tracking eddies from January 2000 to August has been selected. The eddies obtained through the interpolation algorithm and amplitude exceeding less than 1cm and lifetime less than 10 days have been excluded to reduce errors.” (Page 5, lines 119-121).

Comment 5: Page 5, line 125-128: What vertical resolution do the float profiles have (before interpolation). Are there any criteria to omit profiles with a coarse vertical resolution?

Response: Thanks for your suggestion. There are significant uncertainty in the vertical resolution of these float profiles. In the process of these floats floating up, they will constantly measure the surrounding physical parameters. It may be a few meters to measure a value, and it may be tens of centimeters to measure a value, and the resolution decreases with the depth increased. To facilitate data processing, we interpolate these data according to the depth at where they were measured, so that each profile has a vertical resolution of 1m. We rephrased the sentence: “Preprocessing are

performed before BGC-Argo data being used. There are significant differences in the vertical resolution of these float profiles. To facilitate data processing, we interpolated these data according to the depth at where they were measured, the interpolated profile data exhibits an accuracy of 1 meter. In the end, these profile data was smoothed with a 15-point moving mean filter and median filter to remove noises."(Page 5, lines 126-128).

Comment 6: Page 5, line 135-145: Please give some explanations on the significance/meaning of Cphyto and equation (1) as it would be easier to understand.

Response: Thanks for your suggestion. Cphyto (phytoplankton carbon) can represent the quantity of biomass, and was calculated from BBP which is defined as: Cphyto = 0.19 × (53607 × BBP700 × (700/550) + 2.5). Equation (1) means relative differences of Chl between AEs and CEs, the higher the value of Chl', means the greater the Chl concentration in AEs compared to CEs. We added more description of Cphyto and equation (1): "CPhyto (phytoplankton carbon) was calculated from BBP which is defined as: CPhyto = 0.19 × (53607× BBP700 × (700/550) + 2.5), it represents the quantity of phytoplankton biomass." ; "the higher the value of Chl', means the greater the Chl concentration in AEs compared to CEs. $\overline{Chl_{AE}}$ indicates the mean Chl concentration in AEs, and $\overline{Chl_{CE}}$ represents the mean Chl concentration in CEs, while $\overline{Chl_{OE}}$ means Chl mean values outside eddies. " (Page 5, lines 134-137, 141-146).

Comment 7: Page 6, line 152: Why exactly is this area (16°S-24°S, 160°W-144°W) used for this study.

Response: Thanks for your suggestion. The area belongs to the central location of the South Pacific Ocean, and the marine environment is relatively stable. On the other hand, the BGC-Argo floats is more concentrated in this region, and these floats have more kinds of data, so we choosed the area in this study.

Comment 8: Page 7, line 171: The higher Chl concentration in AEs than in CEs is impossible to see in Figure 2. I would suggest to split up Figure 2 into three depth section: 0-50m, 50-150m, 150-300m depth with different x-axis to better resolve the small changes at depth. Same with

Figure 3 and 4.

Response: Thanks for your suggestion. We are quite agree with you, and we have added these pictures in supporting information. We added reference of table 1, the relationship of Chl concentration in AEs and CEs can also be seen in Table 1. We rephrased the sentence: "In MLD, the Chl concentration in AEs was slightly higher than that in CEs" (Page 7, line 174).

Comment 9: Page 10, line 236-237: I don't understand the sentence, please rephrase.

Response: Thanks for your suggestion. We rephrased the sentence: "In general, the phytoplankton biomass was mainly affected by nitrate concentration (Sukigara, 2022). This is also illustrated by the fact that the nitrate and CPhyto profiles exhibited high correlations. With the rapid decline of phytoplankton biomass, the nitrate concentration increases rapidly at around 150m." (Page 10, lines 239-242).

Comment 10: Page 10, line 237-239: Do you mean anticorrelation between Cphyto and nitrate? Anyway, the relationship between these two parameters is hard to see in the upper 120m as the decrease of the nitrate is very weak.

Response: Thank you for your important comment, and we are quite agree with you. Our original meaning is that, with the rapid decline of phytoplankton biomass, the nitrate concentration increases rapidly at around 150m. On the other hand, the nitrate concentration in AEs is higher than in CEs, the result is consistent with the distribution of Cphyto concentration (Cphyto in AEs is higher than in CEs). Therefore, there is a strong correlation between nitrate concentrations and phytoplankton biomass. In the upper 120m, when the light conditions can meet the needs of phytoplankton growth, phytoplankton will grow and consume nitrate, the phytoplankton biomass and nitrate concentration will eventually reach a balance state. So, in the upper 120m the decrease of the nitrate is not obvious. In the end, we rephrased the sentence："This is also illustrated by the fact that the nitrate and CPhyto profiles exhibited high correlations. With the rapid decline of phytoplankton biomass, the nitrate concentration increases rapidly at around 150m."

Comment 11: Page 10, line 242-244: In case this is common knowledge a reference is missing.

Response: Thanks for your suggestion. We add a reference.

Comment 12: Page 11, line 253-258: Reference is missing for the statement.

Response: Thanks for your suggestion. We added a reference.

Comment 13: Page 11, line 256-258: Please rephrase.

Response: Thanks for your suggestion. Due to data modification, we rephrased the second section of part4: "In MLD, our research showed that the higher Chl concentration in AEs compared to CEs is driven by both biomass and physiological adjustment of phytoplankton. Whether biomass or pigment concentration is responsible for the difference in Chl concentration between AEs and CEs, is ultimately relies on the influence of eddies on nutrients, temperature and light (Poppeschi et al., 2022). Due to the modulation mechanism of the eddies on the MLD (AEs deepen the MLD and CEs make it shallower), AEs can contact deeper nutrient lines, the mixing of turbulent flow enables AEs to have higher nutrient concentrations and promotes phytoplankton growth. Meanwhile, because of the function of the eddy pump, AEs have a higher temperature relative to the CEs (temperature′=1.8%). On the one hand, the higher temperature in AEs promotes the metabolic capacity of phytoplankton and promotes the growth of phytoplankton, increasing the biomass. On the other hand, higher temperature will also reduce the concentration of pigment in phytoplankton cells, and finally weaken the Chl concentration within AEs, making the Chl' lower than ${C_{Phyto}}'$. However, the opposite situation has emerged currently, the Chl' is higher than ${C_{Phyto}}'$ in MLD. This suggests that temperature may not be the primary determinant influencing phytoplankton's physiological adjustment in MLD, but the light. The deepened MLD in AEs increased the vertical migration of subsurface phytoplankton, resulting in a reduction in light exposure, and thus contributing to an increase in cellular pigment due to light adaption (He et al., 2021)."

Comment 14: Page 11, line 258-261: Do you refer to this study or to previous studies? Please give a reference.

Response: Thanks for your suggestion. We have rephrased the sentence to make it clear what we mean, the sentence continues the previous sentence, we added a reference in Response 11.

Comment 15: Page 12, line 300-301: This sentence is hard to understand, please rephrase.

Response: Thanks for your suggestion. We rephrased the sentence: "Therefore, it's difficult for CEs to carry the eutrophic water to surface from the deep ocean through eddy pumping, however, AEs can contact more nutrients because of the deepening MLD."(Page 12, lines 301-302).

Comment 16: Figure 3 and 4: Same scale of the y-axis would be helpful for comparison.

Response: Thank you very much for your advice, and we are quite agree with you. We have replotted figure 3 and 4. We also added pictures with depth section: 0-50m, 50-150m, 150-300m for Figure3 and 4 in supporting information.

Technical comments:

Comment 17: Page 1, line 16: Please explain the acronym "BGC"

Response: Thanks for your suggestion. We rephrased the sentence: "In this study, we mainly utilized biogeochemical-argo (BGC-Argo) data to investigate the relationships between Chl levels…" (Page 1, line 16).

Comment 18: Page 1, line 17: "…Nitrate, Temperature and Light…" – Should be written in lower case.

Response: Thanks for your suggestion. We rephrased the sentence: "and environmental factors (CPhyto, nitrate, temperature and light) and the underlying dynamic mechanisms of mesoscale eddies in SPO." (Page 1, line 17).

Comment 19: Page 1, line 18: "Our findings showed that, …" – Incorrect comma, please delete.

Response: Thanks for your suggestion. We deleted the comma, and rephrased the sentence. (Page 1, line 18)

Comment 20: Page 1, line 24: "(…euphotic zone) ," – Incorrect blank, please delete.

Response: Thanks for your suggestion. We deleted the blank (Page 1, line 24).

Comment 21: Page 3, line 71: “driver” – Should it say “drive”?

Response: Thanks for your suggestion. Yes, and we corrected the word (Page 3, line 71).

Comment 22: Page 4, line 103: Please explain the acronyms “ZEU/BBP” and why ZEU and BBP are used for this study.

Response: Thanks for your suggestion. We rephrased the sentence (Page 4, line3 99-100). The data ZEU/BBP we used from BGC-Argo data are explained in part 2.3. “The adjusted data of Chl (has been optimized for non-photo-chemical quenching effects), BBP (particulate backscattering coefficients), temperature, PAR (photosynthetic available radiation) and nitrate produced by BGC-Argo were used”

Comment 23: Page 9, line 208: Please either delete “although” or “while”.

Response: Thanks for your suggestion. Word “while” was deleted (Page 9, line 210).

Comment 24: Page 9, line 212: Do you mean “lower rate”?

Response: Thanks for your suggestion.

Comment 25: Page 11, line 249: Blank missing.

Response: Thanks for your suggestion. We added a blank (Page 11, line 250).

Comment 26: Page 12, line 292, 293: Should say “feeds” and “attracts”

Response: Thanks for your suggestion. We rephrased the sentence (Page 12, lines 291-293).

Supplement:

We updated the algorithm for Cphyto and added references: Cphyto = 0.19 × (53607× BBP700 × (700/550) + 2.5) (Page5, lines 135-136).