Response to reviewers

Dear Reviewer:

Thank you very much for your crucial and constructive suggestions, which let us find the shortcomings in our study, and we also learned more knowledge from your comments. Your comments helped us a lot, and solved the problem where we were confused (the chlorophyll level measured by BGC-Argo does not meet our expectations in the ocean surface layer). We answered your comments in the following pages, and revised the manuscript, all the changes are highlighted in red.

General comments:

Comment 1: In part 2.3 the authors mentioned that they are using BGC-Argo delayed mode data for their study. Presently, the chlorophyll-A has not been qualified in delayed mode in the South Pacific area. So a very important comment, the authors should really improve the description of the dataset first.

Response: Thanks for your extremely professional suggestion. For the data usage problem mentioned in part 2.3, we found that we mistakenly believed that 'Quality controlled data' was equivalent to 'delayed mode data' by reading relevant articles and websites where the data came from (https://www.seanoe.org/data/00311/42182/#96562). The chlorophyll-a data we used produced by BGC-Argo were 'Quality controlled data'.

In the downloaded dataset (Quality controlled data), there are two types of chlorophyll-a data, one labeled 'CHLA' and another labeled 'CHLA_ADJUSTED'. The chlorophyll-a data we used originally is labeled 'CHLA', and this data has not been optimized for non-photo-chemical quenching (NPQ) effects. The chlorophyll-a data labeled 'CHLA_ADJUSTED' is adjusted data and has been optimized for NPQ effects. So, we used the adjusted data of chlorophyll-a redone the experiment. We rephrased the description of the data we used in this paper (Page 4, line 114).

We rephrased these sentences: “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 2: The BGC-Argo chlorophyll-A qualification is very heterogeneous presently from a float to another and it is not mentioned in the manuscript. Moreover, there is no mention in the manuscript of the major feature of the Chlorophyll-A measurements, based on fluorescence. According to me it requires careful use of this Chlorophyll-A dataset without ignoring this feature. I think that dealing with this issue is a prerequisite before trying to compare BGC-Argo Chlorophyll-A profiles with satellite data.

The chlorophyll-a measured by BGC-Argo, based on fluorescence data, is affected by the non-photochemical quenching and this can have a huge impact on the Chlorophyll-a estimation mainly at the surface. It is not clear in the manuscript whether the authors are using raw data from the BGC-Argo dataset or the adjusted fields (corrected in real-time of the quenching); this should be mentioned as a first step.

Then, depending on the option chosen (raw vs. adjusted), the authors must describe their treatment of the data and explain in details the quality control that they are applying on the data (it is mentioned, but there is no details).

Response:

Thanks for your suggestion. The ratio of chlorophyll-a fluorescence (measured by the sensors) to chlorophyll-a concentration varies as a function of non-photo-chemical quenching (NPQ) [1]. Chlorophyll fluorescence of phytoplankton decreases when exposed to ambient light. The chlorophyll-a data labeled 'CHLA_ADJUSTED' we used has been optimized for NPQ effects [2]. (Page 4, line114).

The temperature data we used is labeled 'TEMP_ADJUSTED'. Some times, the data labeled 'DATA_ADJUSTED' is lacked in some floats, then we will use data labeled 'DATA' with mode 'A'. For nitrate data, according to the manual, the data we used is labeled 'NITRATE' with mode 'A'[3]. Similarly, bbp, and PAR data with mode 'A' were used. The data labeled 'DATA_ADJUSTED' or with mode 'A' are adjusetd data. (Page 4, line115).

Then, we converted the adjusted profile data into vertical profile data with an accuracy of 1m according to PRES (sea water pressure) data, and then smoothed them with a 15-point moving mean filter and median filter to remove noises. Finally, we plotted the profiles in eddies of different polarity (Page 5, line 128).

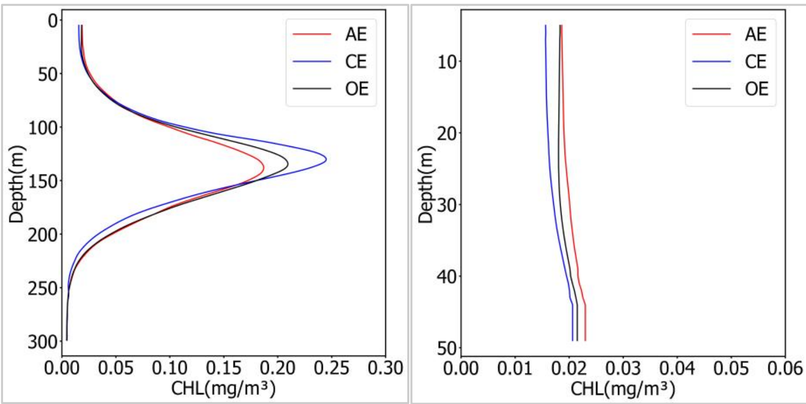
In the end, **we redone the experiment** using adjusted data, and all the tables and figures are updated. The variation of the experimental results is mainly concentrated in the Mixed Layer Depth, the second paragraph of part 3.3 and the second paragraph of part 4.

We rephrased these sentences, and added references: "The adjusted data of Chl (has been optimized for non-photo-chemical quenching effects...)(Page4 line114)"; "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. (Page4 lines125-129)"

Comments on the Figures:

Comment 1: Considering that the MLD is close to 50m, it is hard to see that the figure 2 highlights any difference between AEs and CEs in CHL concentration as mentioned in the text, a zoom of the figure could be added.

Response: Thanks for your suggestion. We added a zoom of figure 2 from 0-50m in supporting information, and the relationship of Chl concentration in AEs and CEs can also be seen in Table 1.



Comment 2: Still on the BGC-Argo dataset, the figure 4c. is not obviously illustrating an increase of nutrients in the area of 50m to 110m as mentioned by the authors, from AEs to CEs. If the BGC-Argo data nitrate profiles are qualified in delayed mode as mentioned by the authors, they are provided with uncertainties and these uncertainties are within +-1 micromol per kg. I think that the authors should also consider carefully the uncertainties of the dataset before concluding.

Based on these different remarks, to further evaluate whether this study is relevant, as it is presently difficult to check exactly what data are used, how they are qualified and whether the data are used correctly, the authors should consider revisiting deeply their "data" part (http://www.argodatamgt.org/). It could be also useful to mention the Argo WMO of the floats that they are using in their study.

Response:

Thanks for your suggestion. As mentioned previously, the data we used is labeled 'NITRATE' with mode 'A'. The small difference of nitrate concentrations between AEs and CEs in the South Pacific Ocean (SPO) is due mainly to the oligotrophic nature of the SPO, where nitrate concentrations are inherently low. On the other hand, according to statistics, there are more than 400 nitrate profiles in this area. Therefore, we believe that these nitrate data with mode 'A' are reliable. The nitrate data was also used in other paper [4].

We added BGC-Argo's ID number in this manuscript (6901659，6901660，6901687，6902701), as the unique identifier that they can be found on the website: https://biogeochemical-argo.org/data-access.php (Page 4, line 113)

We rephrased these sentences: “There are 4 BGC-Argo floats were used in our study (ID: 6901659，6901660，6901687 and 6902701), they can be found on the website: https://biogeochemical-argo.org/data-access.php.”

Supplement:

We updated the algorithm for Cphyto and added references: Cphyto = 0.19 × (53607× BBP700 × (700/550) + 2.5) (Page 5, lines 135-136).

We also rephrased the second paragraph of part 3.3, the second paragraph of part 4 and the second paragraph of part 5 due to the modulation of data (chlorophyll, BBP).

The second paragraph of part 3.3: “In MLD, the concentration of CPhyto in AEs was found to be higher compared to CEs, which was consistent with the Chl results. The Chl′=21% and the Cphyto′=5.1% in MLD, suggest that although the Chl in AEs was much higher than in CEs, the biomass was not significantly higher (Figure 3, Table 1). The θ profile precisely explains this phenomenon, θ′=15.6% in this layer, indicating that the pigment concentration per individual phytoplankton cell in AEs is higher than in CEs. That is, in MLD, the higher Chl concentration in

AEs compared to CEs is driven by both biomass and physiological adjustment of phytoplankton, and induced the higher of Chl′ than Cphyto′. ”

The second paragraph of part 4: “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. 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 (Figure 4c). Meanwhile, because of the function of the eddy pump, AEs have a higher temperature relative to the CEs (Figure 4a) (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 Cphyto′. However, the opposite situation has emerged currently, the Chl′ is higher than Cphyto′ in MLD (Table 1). 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 (Table 1).”

The second paragraph of part 5: “In MLD, AEs have a higher Chl concentration than CEs, is driven by both biomass and physiological adjustment of phytoplankton, and the physiological adjustment plays a predominate role. As a result of the convergent subsidence, AEs deepened MLD and can contact deeper nutrient lines, the mixing of turbulent flow enables AEs to have higher nutrient concentrations and promotes phytoplankton growth. The deepening 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, and the higher temperature in AEs plays a little negative contribution.”

References:

[1] Bittig, Henry C., et al. "A BGC-Argo guide: Planning, deployment, data handling and usage." Frontiers in Marine Science 6 (2019): 502.

[2] Schmechtig, C., et al. "Bio-Argo quality control manual for the Chlorophyll-A concentration, Ifremer." (2018).

[3] Johnson, Kenneth, et al. "BGC-Argo quality control manual for nitrate concentration." (2021).

[4] Xiu, P., & Chai, F. (2020). Eddies affect subsurface phytoplankton and oxygen distributions in the North Pacific Subtropical Gyre. Geophysical Research Letters, 47, e2020GL087037. https://doi. org/10.1029/2020GL087037