<Journal Name> Earth System Science Data

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<MS type> Data description paper

<Manuscript Title> Integrated Observation of an Asymmetric Eddy Dipole in the South China Sea

Dear Editors and Reviewers,

We highly appreciate the detailed and valuable comments of the referees on our manuscript entitled "Integrated Observation of an Asymmetric Eddy Dipole in the South China Sea (MS No. essd-2025-276)". These comments are all valuable and helpful for revising and improving our paper, as well as providing important guidance for our research. In the past few days, we have referred to the comments and improved the paper.

As follows, we would like to clarify some of the points raised by the Associate Editor and Reviewers. The original comments begin with "**Questions and Comments**" and are quoted in normal font, the replies are in blue letters, the revised sentences and phrases are in red letters, and the line number in the revised manuscript is highlighted in yellow. We appreciate the Editors/Reviewers' warm work and taking the time to review the manuscript, and we hope that the corrections will meet with approval.

Yours Sincerely,

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2025-12-01

1. Questions and Comments: This manuscript integrates multiple observations from satellite altimeters, Argo floats, gliders, drifters, and survey vessels to investigate a case of an asymmetric eddy dipole in the South China Sea, with a particular focus on the evolution of its vertical structure. However, two reasons prevent me from recommending it for further consideration in Earth System Science Data.
Answer: Thanks for your comments.

2. Questions and Comments: (1) I cannot identify sufficient novel aspects of this work to match the high impact expected for ESSD. Although the authors provide a dataset collected from multiple observation platforms, it is limited to a single local case of an asymmetric eddy dipole. Therefore, I do not believe this dataset has the potential to attract sufficient interest from the international research community. As noted in the authors' review in the introduction, many previous studies have revealed the vertical structure of asymmetric eddy dipoles using observational data (Line 50-63). In addition, the results of this manuscript mainly offer a simple descriptive analysis of the observations, without presenting any new findings that distinguish this study from previous work. The "gear-like" process has already been proposed in their previous studies based on global analyses. The vertical structures of temperature, salinity, dissolved oxygen, chlorophyll, and zooplankton have already been well documented in numerous previous studies. Although I acknowledge that most of those studies focused on anticyclonic and cyclonic eddies rather than asymmetric eddy dipoles, it remains unclear what new findings this work provides that distinguish it from previous research using the same type of dataset. The authors claim that their observations provide evidence of the impacts of asymmetric eddy dipoles on the vertical transport of water. However, this point has already been well demonstrated by previous numerical and observational studies, such as Guidi et al. (2012).
Answer: Thanks for your comments. We totally agree that many previous studies analyzed the vertical structure or explored the impact of eddy-eddy interaction on ecosystem of asymmetric eddy dipoles. Our previous work revealed the "gear-like" process of asymmetric dipole on the global scale, but it is primarily based on the eddy surface feature. The underwater structure and corresponding evolution of asymmetric dipole on global scale are a challenging task due to a lack of enough underwater information. Therefore, more *in-situ* data regarding asymmetric dipole are needed, and this manuscript provides another typical coupling process in SCS. In addition, this manuscript focuses on the response between changes in surface feature of dipole eddies and changes in vertical structure via eddy-eddy interaction. Since CE keeps steady and AE changes a lot during the coupling process, we concentrated on AE's vertical structure and found it is influenced by vertical transport of water.

3 Questions and Comments: (2) As a manuscript submitted as a data description paper, I believe the current style and format do not provide sufficient details about the dataset. I recommend that the authors pay more attention to thoroughly describing the data collection methods, sensors used, processing procedures, temporal resolution, instructions, and application prospect, especially for the new subsurface observations. In addition, as this is a data description paper, I recommend that the authors share their code for data processing. At present, the manuscript reads more like a research article than a data paper.
Answer: Thanks for your comments. We had revised the related content in the subsection in "2.2 Field observations". Since the data collected by Argo, glider, drifter, RBRmaestro3, and UVP were automatically processed, this manuscript did not introduce processing procedures in details. The code for eddy detection is private since its copyright belongs to the Science and Technology Innovation Project for Laoshan Laboratory (Grant Nos. LSKJ202201406 and LSKJ202204303). The other code in Python for data processing and analysis is now available at https://github.com/Yezi-Yezi/Codes-for-the-Integrated-Observation-of-an-Asymmetric-Eddy-Dipole-in-SCS.

Other comments:

4. Questions and Comments: Line 101 The half-power wavelength cutoffs of 20° in longitude and 10° in latitude appear excessively large. For comparison, Pegliasco et al. (2022) set this value to 700 km.

Answer: Thank you for pointing this out. Figure 1 displays the eddy identification in the study area using the half-power wavelength cutoffs of 20° in longitude and 10° in latitude (Gaussian filter) as well as 700 km (Lanczos filter). As we can see, different filters impact the identification of eddy core and boundary. However, the AE and CE studied here, as larger black stars show, change very little under both cutoffs. We further provide the evolution of eddy kinematic properties in April 2023 (Figure 2). Similarly, although the time series of eddy properties displays modest fluctuations under two cutoffs, their variation exhibits a consistently coherent trend.

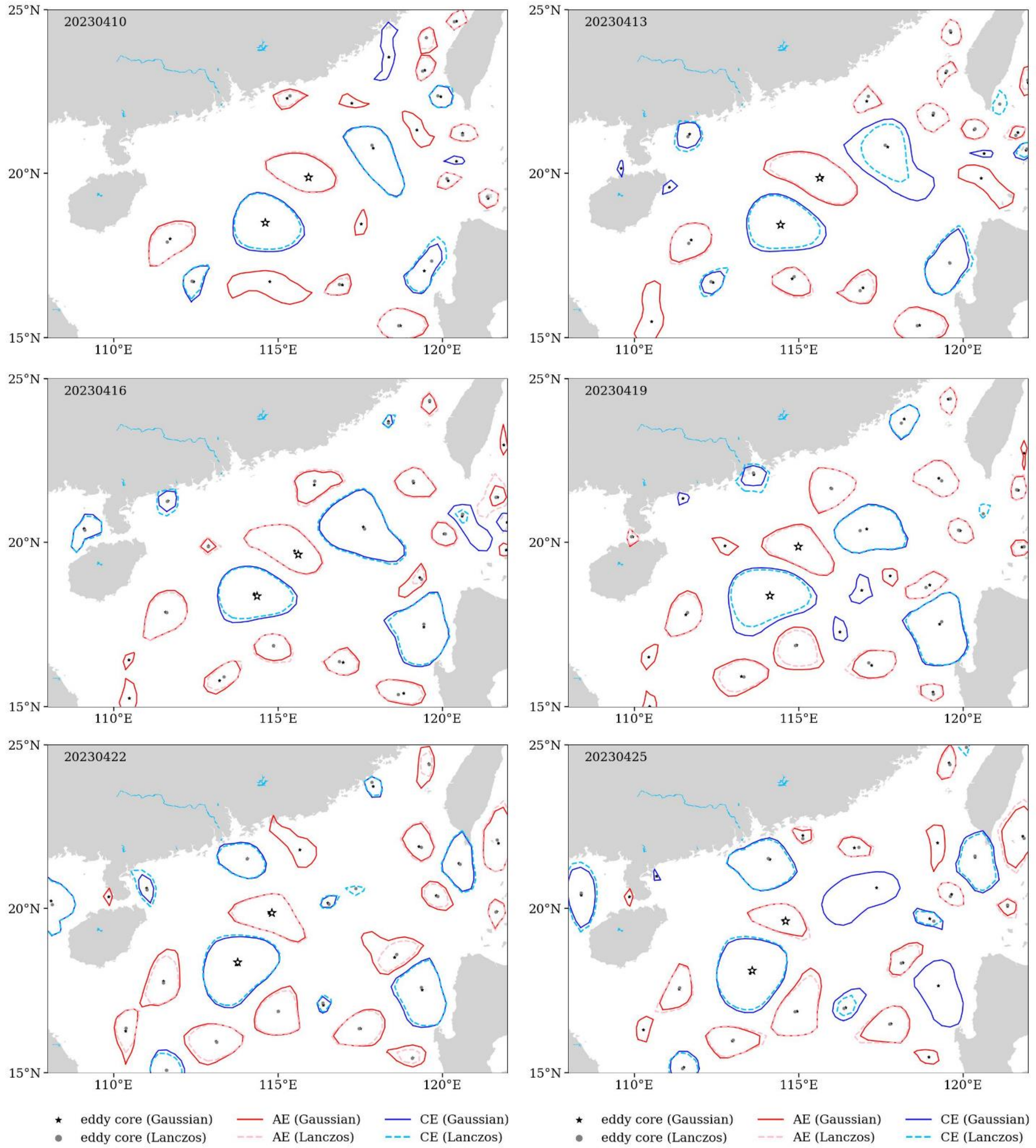

Figure 1. Eddy distribution in April 2023 under two half-power wavelength cutoffs.

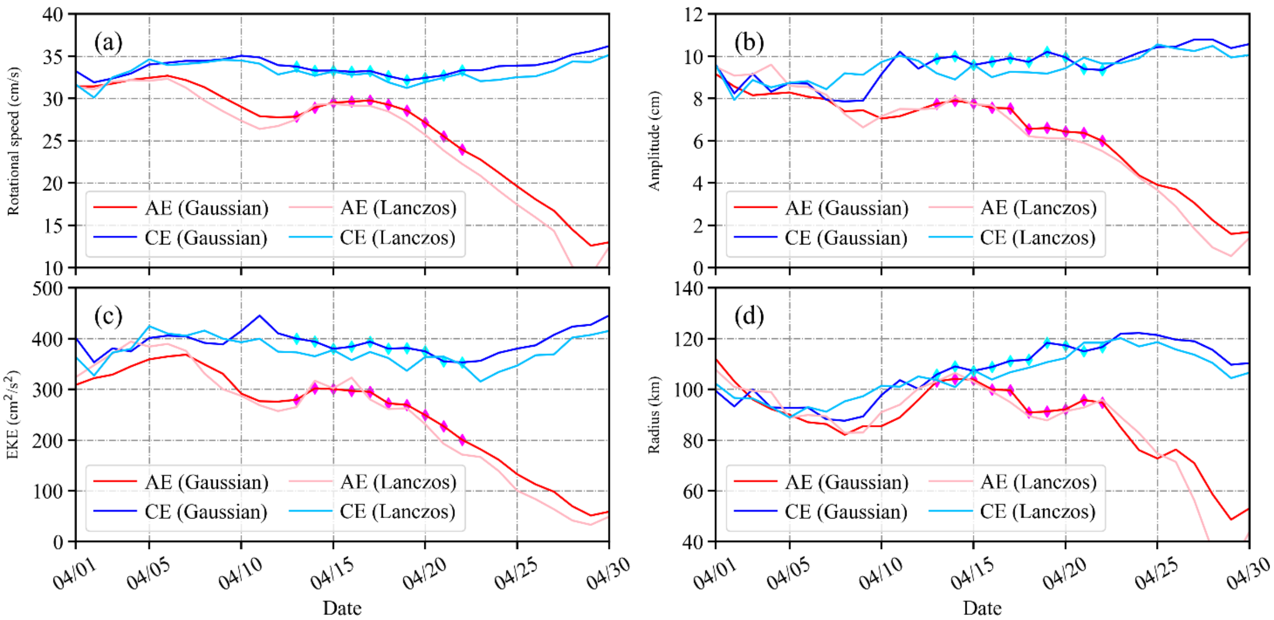

Figure 2. The temporal evolution of (a) rotational speed, (b) amplitude, (c) EKE, and (d) radius for the dipole AE and CE under two filters. The diamonds mark the continuous coupling process from 13 to 22 April.

5. Questions and Comments: Line 171 T/S anomalies are calculated using monthly WOA dataset?
Answer: Thank you for pointing this out. The annual statistics of T/S profiles of WOA23 were used to compute the T/S anomalies. The annual and observed T/S profiles were resampled at the same depth through linear interpolation. The T/S anomalies were then obtained by subtracting climatological T/S profiles from the observed T/S profiles. The related text was added in Line 175-180 as "This work utilized the annual statistics of WOA23 dataset with a grid size of 1/4° to characterize the typical northern SCS water and Kuroshio water and calculate the T/S anomalies from the observations of Argo floats, gliders, and RBRmaestro3. The annual and observed T/S profiles were first resampled at the same depth through linear interpolation. The T/S anomalies were then obtained by subtracting annual T/S profiles from the observed T/S profiles."

6. Questions and Comments: In Figures 8, 9, and 10, it would be better to change the color of the missing values, since white is already used in the colormap.
Answer: Thank you for your helpful comment. We have revised the figures (Fig.8-Fig.12) as suggested. The gray areas now represent missing values in the below figures.

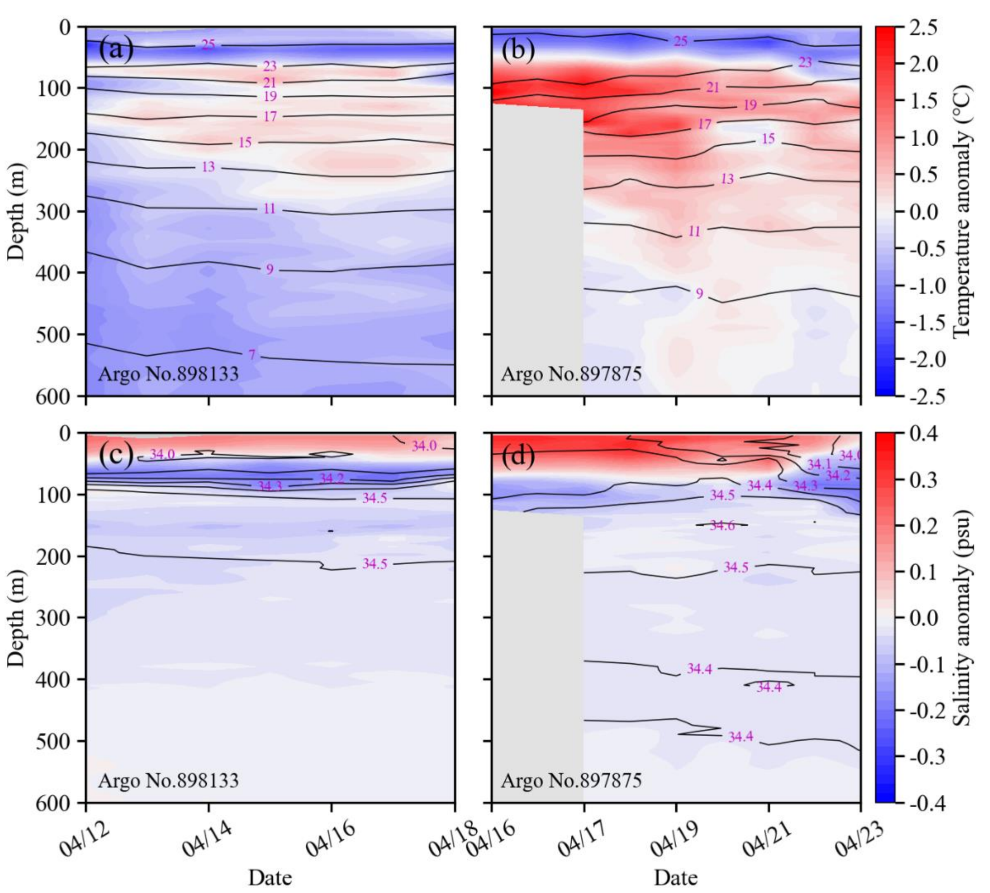

Figure 8: T/S (black lines) and corresponding anomaly (colored shadow) observed by the Argo floats. The gray in each plot indicates missing values. The Video S2 presents the positions of Argo floats and the daily distribution of T/S profiles in detail.

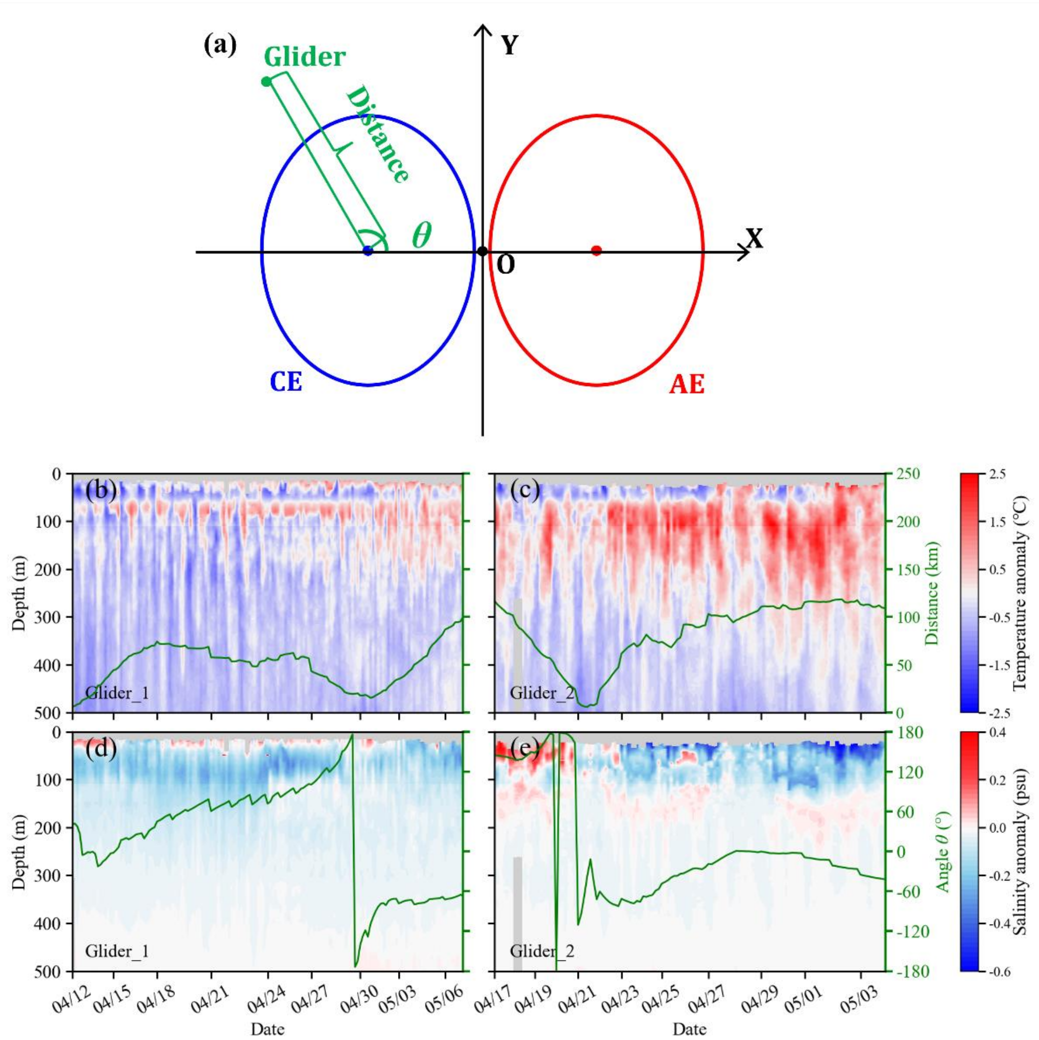

Figure 9: T/S (black lines) and corresponding anomaly (colored shadow) observed by the gliders. The gray in each plot indicates missing values. (a) A diagram of dipole coordinate. The distance is the spatial separation between the CE center and the gliders. The azimuth angle θ is defined as the angle of the ray from the CE center to the glider relative to the ray through dipole eddy centers. The Video S3 presents the glider positions and the daily distribution of T/S profiles in detail.

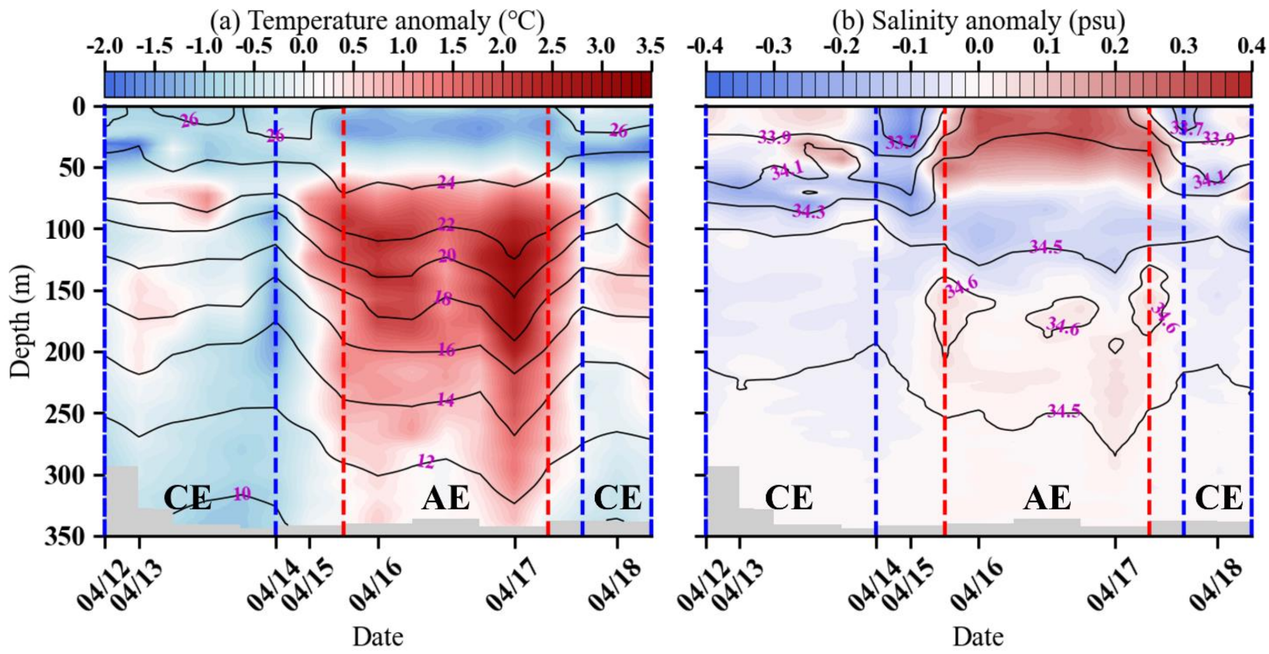

Figure 10: (a) Temperature (black lines) and corresponding temperature anomaly (colored shadow), and (b) salinity (black lines) and corresponding salinity anomaly (colored shadow) crossing the dipole eddy centers. The profiles between two dashed blue (red) lines indicate stations are located within the CE (AE), and the profiles between a dashed red line and a dashed blue line indicate stations are located at the contact zone. The gray in each plot indicates missing values.

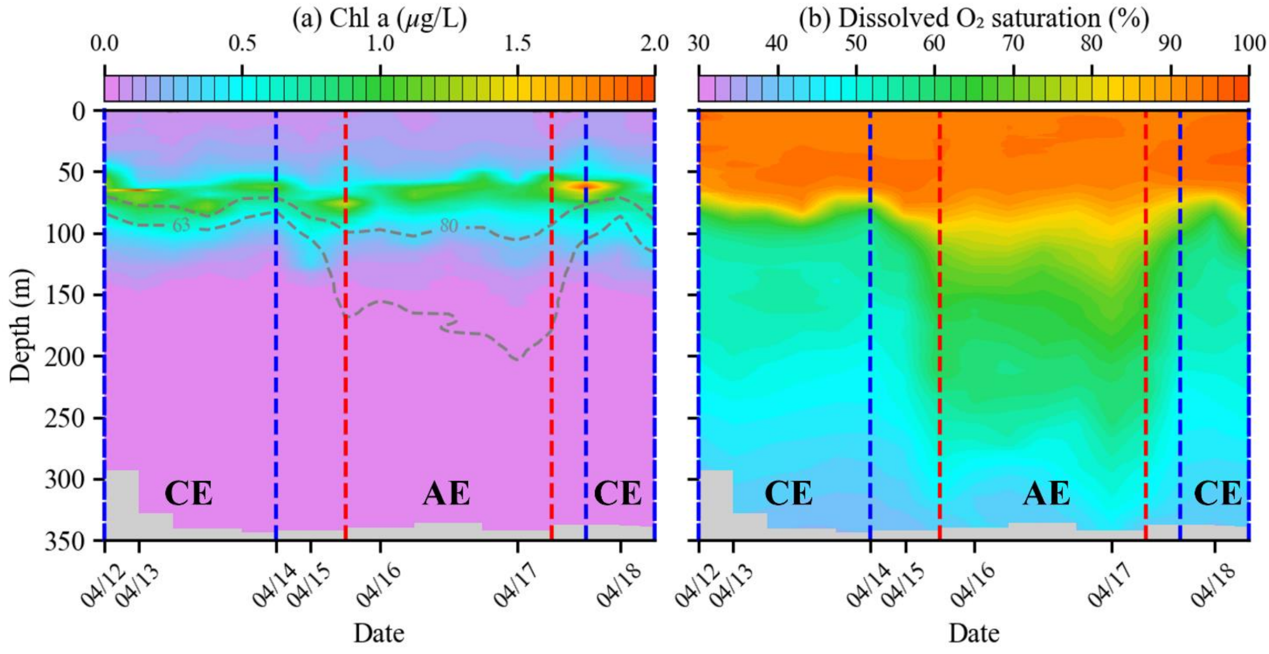

Figure 11: (a) Chl *a* concentration and (b) dissolved O_2 saturation crossing the dipole eddy centers. The dashed gray lines in (a) are the dissolved oxygen (O_2) saturation. The dashed red and blue lines have the same meaning as Fig.8. The gray in each plot indicates missing values. It is noted that the 2.0 μg/L of the color bar is the value exceeding 2.0 μg/L.

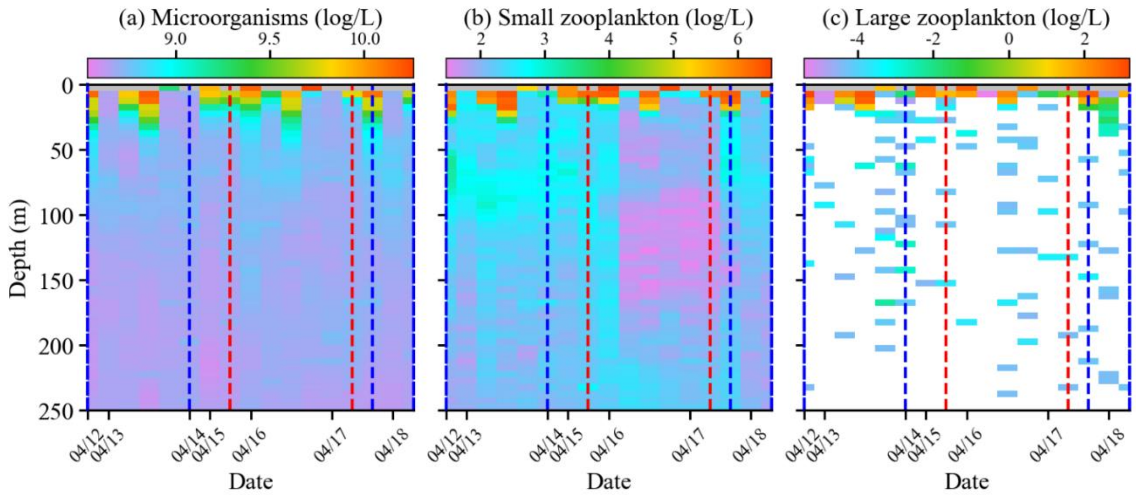

Figure 12: The particle concentrations of (a) microorganisms, (b) small zooplankton, and (c) large zooplankton crossing the dipole eddy centers. The dashed red and blue lines have the same meaning as Fig.8. The gray in each plot indicates missing values. Blanks in (c) mean there is no large zooplankton.

7. Questions and Comments: In Figure 12, I am surprised that diel vertical migration of zooplankton was not observed. It may be more appropriate to plot the results on a logarithmic scale.

Guidi, L., Calil, P. H., Duhamel, S., Björkman, K. M., Doney, S. C., Jackson, G. A., ... & Karl, D. M. (2012). Does eddy-eddy interaction control surface phytoplankton distribution and carbon export in the North Pacific Subtropical Gyre?. Journal of Geophysical Research: Biogeosciences, 117(G2).

Answer: Thanks for your useful suggestions. We have revised the Fig.12 as suggested. Now the diel vertical migration of zooplankton can be observed. The related text was added as "Furthermore, the observed eddies are found to exert a significant influence on the vertical distribution of small zooplankton. A secondary subsurface maximum of small zooplankton occurs at approximately 75 m depth in close proximity to the CE core. In contrast, abundances are significantly suppressed within the AE core, especially at the 80–160 m depth, but exhibit elevated values within the AE–CE transition zone. This finding is consistent with Guidi et al. (2012) that concentrations of buoyant particles increase within the mesoscale frontal zone of AE-CE dipole." Please see Line 405-410 in the revised manuscript.

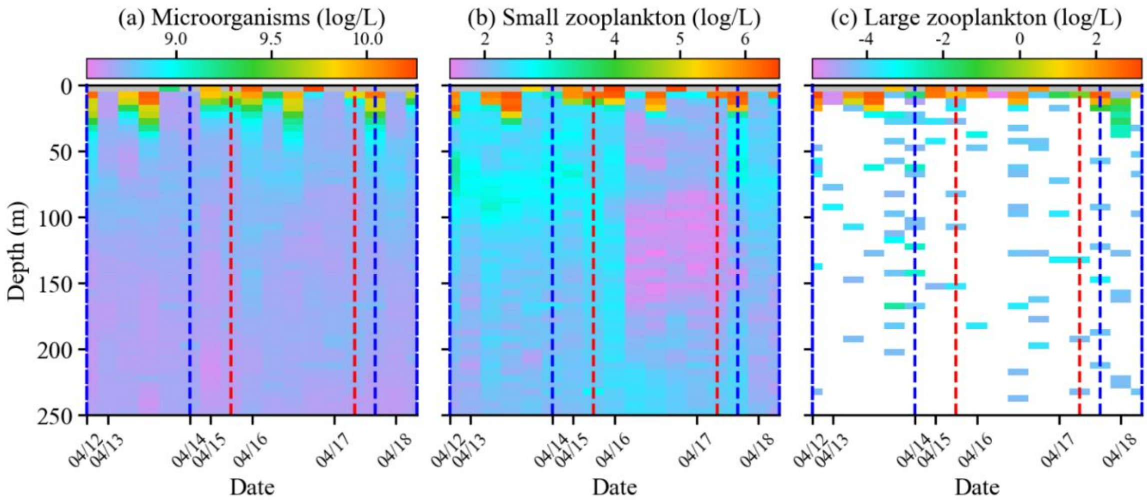

Figure 12: The particle concentrations of (a) microorganisms, (b) small zooplankton, and (c) large zooplankton crossing the dipole eddy centers. The dashed red and blue lines have the same meaning as Fig.8. The gray in each plot indicates missing values. Blanks in (c) mean there is no large zooplankton.