Response to Reviewer 1

General Comments:

The authors have followed the reviewers' comments to modify their manuscript, and hence the quality of the paper is much improved. the authors proofread their paper much more carefully before the paper can be accepted for publication.

Response: We express our gratitude for your thorough review, valuable comments, and constructive suggestions during your second review. Your input has greatly enhanced the clarity of our manuscript. We have meticulously reviewed all comments provided by the reviewer and have made revisions accordingly.

In the subsequent section, we summarize our responses to each comment from the reviewer. We believe that our responses have well addressed all concerns from the reviewer. The changes are shown in the manuscript. Please see below, in blue and black, for a point-by-point response to the reviewer's comments and concerns. All page numbers refer to the revised manuscript file with tracked changes.

Primary comments:

1. The previous primary comment 1 was not addressed properly. Although they have re-organized their rationality for conducting the work in the response letter, there seems no change in their modified manuscript. The authors seem not careful in preparing their response letter (There is even words like "Line xxx")

Response: We sincerely apologize for the notable error like "Line xxx" in our previous version. In this revised manuscript, we are taking our revised manuscript more carefully and conducted a final thorough check to rectify any identified typos and grammar errors. Considering the primary comment 1, we have reworked specific sections of introduction (Lines 88-93) and summary (Lines 536-546) to emphasize the innovations and research motivations. About influence of near-inertial energy, we have incorporated additional sentences at Lines 411-438. Furthermore, the discussion on the influence of background flow field has been expounded upon in the Discussion section (Lines 439-449).

2. There are numerous grammar or tense mistakes, especially in their newly supplemented sentences (e.g., Lines 25-27, 96-98, 321-322, Lines 414-415, Lines 418-431, etc).

Response: Thank you very much! We have carefully reviewed and made necessary corrections, which are shown in the revised manuscript. We have converted the entire manuscript to present tenses, including Lines 25-27, 96-98, 321-322, 414-415, 418-431 as your suggestion in the original manuscript.

Lines 25-26: we have rectified "enhanced" into "enhances".

Lines 408: we have adjusted “will delve” to “delve”.

Lines 428-438: “The EPV is very small before the typhoon, measuring less than 0.5×10^{-5} m s^{-1} in both AE1 and AE2. However, during 15-16 September (Fig. 9c-f), when the typhoon crosses the NSCS, the EPV undergoes significant changes. Its absolute value increases to over 1.5×10^{-4} m s^{-1} within both AE1 and AE2. AE1 consistently exhibits a predominantly negative EPV during most of this period. Consequently, during Typhoon Kalmaegi, the negative EPV facilitates downwelling and convergence (Jaimes and Shay, 2015), leading to a warmer and fresher subsurface layer in AE1 (Fig. 6 a-b). On the other hand, AE2 displays a more fluctuating pattern. It is positive on 14 September, shows both positive and negative values at 0000 UTC on 15 September, and remains mainly negative from 15 to 16 September, and eventually returning to positive, reflecting a continuously fluctuating process. The positive EPV in AE2 contributes to the influx of colder subsurface water into the upper layers, resulting in surface and subsurface water cooling and an increase in salinity in the subsurface (Fig. 6c-d).

All of the co-authors are so grateful to you for the time spent on our manuscript. The comments and suggestions provided by the reviewer are invaluable for us to improve our manuscript. We are so appreciated.

Response to Reviewer 2

General comment:

The authors examined the response of two pre-existing warm eddies to Typhoon Kalmaegi based on observations and reanalysis data. After the typhoon's passage, the two warm eddies presented different changes in terms of amplitude, Rossby number, and kinetic energy. The authors ascribed this difference to the relative positions of warm eddies to the typhoon. I recommend acceptance of the manuscript after a minor revision.

Response: We would like to thank you for your careful reading, helpful comments, and constructive suggestions, which have significantly improved the presentation of our manuscript. We have carefully considered all comments from the reviewer and revised our manuscript accordingly. In the following section, we summarize our responses to each comment from the reviewer. We believe that our responses have well addressed all concerns from the reviewer. The changes are shown in the manuscript. Please see below, in blue and black, for a point-by-point response to the reviewer's comments and concerns. All page numbers refer to the revised manuscript file with tracked changes.

Minor comment:

1. Lines 88-89: The focus of this study is the relative locations of two warm eddies to the typhoon center. Therefore, the maximum wind radius of Typhoon Kalmaegi is an essential metric and must be stated clearly, especially the maximum wind radius when Kalmaegi passed AE1 and AE2.

Response: Your comments have been immensely beneficial, and we sincerely appreciated! Consequently, we have added the marking of the R_{max} of the typhoon and width of typhoon-induced baroclinic geostrophic response in Figure 3. Furthermore, we have provided explanations regarding the maximum wind radius (R_{max}) and when it passed AE1 and AE2 in the revised manuscript. Kindly review the revisions made in Lines 226-229, Lines 230-231, Lines 419-427, Lines 472-476.

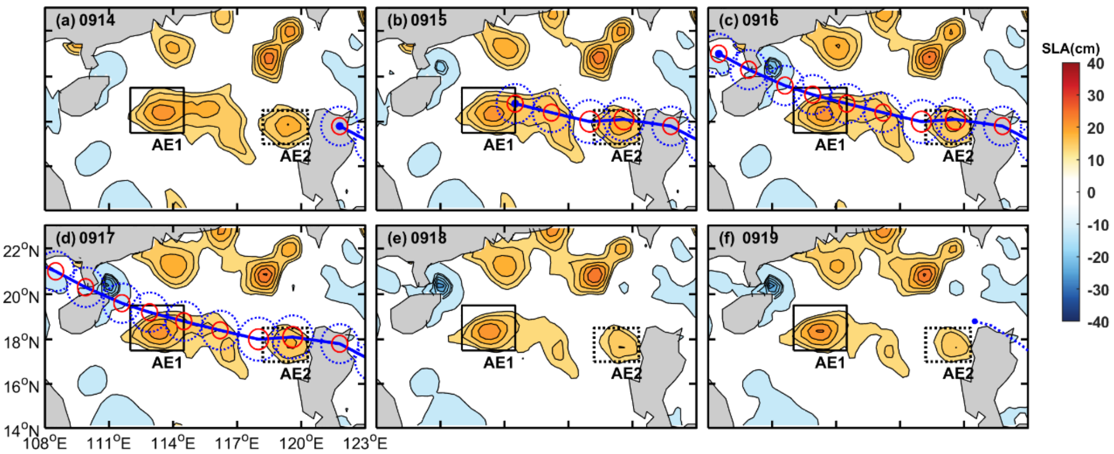

Figure 3. The variations in sea level anomaly before and after Typhoon Kalmaegi moved over the anticyclonic eddies AE1 and AE2 between 14 September and 19 September **(a-f)**. The black solid rectangle represents the area

of AE1, while the black dashed rectangle represents the area of AE2. The blue solid line depicts the path of typhoon Kalmaegi, and the solid red and dashed blue circles are the one-times R_{max} of the typhoon and width of typhoon-induced baroclinic geostrophic response, while the blue dotted line in **(f)** is the path of tropical storm Fung-wong (best-track data sourced from CMA).

Lines 226-229: "Throughout this intensification stage, Kalmaegi encounters two warm eddies: anticyclonic eddy AE1, is positioned to the left of the typhoon's path, with its core situated on the periphery of the typhoon's one-times R_{max} (Fig.3c-d)."

Lines 230-231: "AE2 precisely intersects with the typhoon's trajectory, and its core nearly coincides with the R_{max} of the typhoon (Fig.3b-d)."

Lines 419-427: "Most of the positive wind stress curl exists within R_{max}, leading to strong upwelling, while the weak negative wind stress curl occurs outside R_max, resulting in weak subsidence caused by TCs exist outside the upwelling area (Lu et al., 2020; Lu and Shang, 2024). Typhoon Kalmaegi strengthened after passing through the warm ocean characteristics of AE2, causing a reduction in R_{max}. When passing AE1, R_{max} is 37 km. Notably, the center of AE1 is located outside the R_{max} (Figure 3). Hence, the hypothesis presented here suggests that the observed intensification of AE1 on the left side of the typhoon track is more likely attributed to the negative wind stress curl generated outside the R_{max}, thereby driving the enhancement of downwelling in the pre-existing anticyclonic feature in the ocean."

Lines 472-476: "The response of AE2 differs from that of AE1 mainly because AE2 is quite near the Typhoon Kalmaegi's track. As the typhoon passes through AE2, the R_{max} is 46 km. AE2 is merely 26 km away from the typhoon center (Fig. 3). The significantly positive wind stress curl at the typhoon center induces upwelling and positive vorticity downward into the eddy (Huang and Wang, 2022), and noticeably weakens the eddy, corresponding to the decrease in SLA (Fig. 12a)."

All of the co-authors are so grateful to the reviewer for the time spent on our manuscript. The comments and suggestions provided by the reviewer are invaluable for us to improve our manuscript. We are so appreciated.

Response to Reviewer 3

General comment:
I am not sure about the novelty of the results presented here. The aim of the paper is not presented clearly. As a consequence, it is difficult for the reader can see the value of the manuscript in the context of an already very rich literature on the subject. The manuscript requires a major revision.
Response: We express our heartfelt thanks for your thorough review, valuable comments, and constructive suggestions, all of which have significantly enhanced the quality of our manuscript. We have diligently addressed your comment and made corresponding revisions to improve clarity and accuracy. The manuscript has undergone a meticulous double-check, ensuring that identified typos and grammar errors have been rectified. These changes are shown in the revised manuscript. All page numbers refer to the revised manuscript with tracked changes.

An important issue is that the response made to reviewer 1 does not seem adequate. Reviewer 1 criticizes your interpretation: he says that because the typhoon is moving too fast for the wind stress curl to have a direct influence, all the influence of the typhoon should occur through vertical mixing driven by near-inertial waves, which is different in anticyclones compared with cyclones (see for example Jaimes et al 2011, Journal of Physical Oceanography). If I read correctly your answer to the reviewer, you claim that the wind stress changes, so the Ekman depth changes: but the Ekman depth is a measure of how deep the mixing is, not a measure of the geostrophic response to the wind stress curl. The standard (textbook) definition of the Ekman depth depends on the vertical mixing coefficient and the Coriolis frequency, it does not depend on the wind stress nor on the wind stress curl. Therefore you do not answer the reviewer question. An interesting reference to answer reviewer 1 could be Lu et al (JGR, 2023), who demonstrate the influence of the wind stress curl on the eddies. Or, perhaps, you could make an answer based on Jaimes and Shay (2015), because those authors study the response of warm eddies to a hurricane, just like you do; note that they point out that it is not the hurricane wind stress curl ("undisturbed" Ekman pumping) which is important but rather the "nonlinear" Ekman pumping (second term in their equation 5). You would need to estimate parameters similar to the ones of Lu et al, or Jaimes and Shay, for the specific case of your warm eddies and your typhoon Kalmaegi, to be able to argue that either of these interpretations applies to your case.
Response: Thank you for your suggestions and recommended papers.
The response caused by TCs in the ocean is not only near-inertial response, but also geostrophic response. The near-inertial response influences the large-scale and mesoscale ocean circulation through vertical mixing driven by near-inertial waves. However, geostrophic response is induced by all TCs but near-inertial response only can be done for $U_h > C$, where U_h is the moving speed of a TC and C is the baroclinic mode wave speed (Lu et al., 2023). The potential vorticity injected by typhoon leads to

quasi-geostrophic adjustment of eddy, and the potential vorticity anomalies caused by wind stress curl are generated by geostrophic response (Lu et al., 2020). In addition, the geostrophic response of typhoon is generated within about 0.5 day, and we believe that the wind stress curl of Typhoon Kalmaegi has an impact. The Ekman depth does depend on the vertical mixing coefficient and the Coriolis frequency. In this paper, the Ekman depth is calculated by $D_E = \frac{7.12}{\sqrt{\sin|\varphi|}} U_{10}$(Li et al.,2022), where U_{10} represents the wind speed at 10 m above the sea, and φ is the latitude. Therefore, we removed the discussion on the Ekman depth.

Li, Y., Yang, D., Xu, L., Gao, G., He, Z., Cui, X., et al. (2022). Three types of typhoon-induced upwellings enhance coastal algal blooms: A case study. Journal of Geophysical Research: Oceans, 127, e2022JC018448. https://doi.org/10.1029/2022JC018448

Lu, Z., G. Wang, and X. Shang, 2023: Observable Large-Scale Impacts of Tropical Cyclones on the Subtropical Gyre. *J. Phys. Oceanogr.*, **53**, 2189–2209, https://doi.org/10.1175/JPO-D-22-0230.1.

Regarding the parameters in the relevant papers you mentioned, we get the following results:
TCs influence mesoscale eddies through baroclinic geostrophic response (Lu et al., 2020). The width of this response is generally constrained within the TC orbit, with the transverse diameter length represented as $L_h = L_d + R_{max}$ (Lu and Shang, 2024). Here, L_d is the first mode of Rossby deformation radius, and R_{max} denotes the maximum wind radius. $L_d = \frac{c}{f}$, the phase speed of the first baroclinic mode c was obtained using the method outlined in Jaimes and Shay (2009). Therefore, the width of Typhoon Kalmaegi-induced baroclinic geostrophic response falls within the range of 92 km (Figure 3). Essentially, these geostrophic effects are caused by wind stress curl, and wind stress curl injects disturbance into the ocean through upwelling and downwelling. Most of the positive wind stress curl exists within R_{max}, leading to strong upwelling, while the weak negative wind stress curl occurs outside R_{max}, resulting in weak subsidence caused by TCs exist outside the upwelling area (Lu et al., 2020; Lu and Shang, 2024). Typhoon Kalmaegi strengthened after passing through AE2, causing a reduction in R_{max}. When passing AE1, R_{max} is 37 km. Notably, the center of AE1 is located outside the R_{max} (Figure 3). Hence, the hypothesis presented here suggests that the observed intensification of AE1 on the left side of the typhoon track is more likely attributed to the negative wind stress curl generated outside the R_{max}, thereby driving the enhancement of downwelling in the pre-existing anticyclonic feature in the ocean. (Lines 411-427)

Considering the influence of the background flow field, the pumping rate W is not only related to the wind stress curl (undisturbed Ekman pumping), but also related to the curl of background geostrophic flow (nonlinear Ekman pumping). Therefore, in order to describe the response of upwelling and downwelling more accurately, a parametric TC-driven pumping velocity scale $W_s = W_E - R_o\delta(U_h + U_{OML})$ (Jaimes and Shay, 2015), is derived from the time-dependent vorticity balance in the ocean mixed layer. Here, W_E calculated by Eq. (8), R_o is calculated using Eq. (3), the aspect ratio is calculated by $\delta = \frac{h}{R_{max}}$, here h represents oceanic mixed layer thickness, U_h denotes the translation speed. The oceanic mixed layer Ekman drift is calculated by $U_{OML} = \frac{\tau R_{max}}{\rho h U_h}$. The vertical velocity W_s calculated by Eq. (11) are presented in Figure 10. When Typhoon Kalmaegi passes through AE1, the W_s in AE1 obviously increases, while AE2 experiences minimal change. (Lines 439-449)

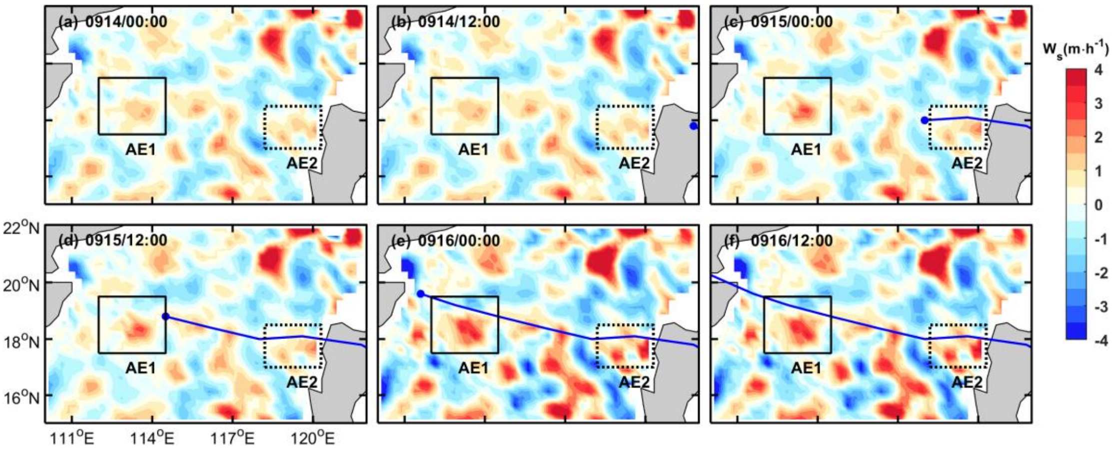

Figure 10. TC-driven pumping velocity (W_s) from 14 September to 16 September (a-f). The color represents the W_s, the blue solid line is the path of Kalmaegi. Negative and positive values are for upwelling and downwelling regimes, respectively.

The introduction could be improved. The literature review is too long and not very easy to read. The lines 96 to 98 are not enough to motivate the paper: reading this sentence, it seems that you just want to add two more eddies to the already rich literature on eddy-cyclone interactions, without asking specific scientific questions, nor pointing out why your study is really original and important.

Response: We are especially grateful for your regarding the clarity of our introduction. In response, we have rewritten the introduction, and strengthened both the introduction (Lines 88-93) and summary (Lines 536-546) sections to provide a clearer elucidate the novelty and purpose of our research.

In the introduction you don't justify at all why you consider typhoon Kalmaegi. How special is this typhoon, relative to other TCs in the area? In the response to the reviewers you mention that Zhang has published 6 other papers about this typhoon and the observations made in 2014, but this is not highlighted in the introduction. You need to explain better why the present paper is different from the work that has already been published, what is new here. Are the observations you show already published elsewhere? If it is the case, why is another paper warranted?

Response: Typhoon Kalmaegi passed over an array of buoys and moorings in the northern South China Sea during September 2014, leaving a set of observations on typhoon-induced dynamical and thermohaline responses of the upper ocean. Therefore, Zhang (2016, 2018) conducted research on the upper ocean's responses to typhoon Kalmaegi. Concurrently, we observed that the typhoon also encountered two warm eddies, each exhibiting distinct responses to the typhoon. Using multi-source data, we investigate how two anticyclonic eddies respond to Typhoon Kalmaegi. Thus, this study forces on understanding the response of eddies to the typhoon, rather than solely examining the upper ocean. This marks the initial effort to characterize the different physical variations induced by TCs within two same polarity eddies, contributing to a better understanding of the role played by mesoscale eddies in modulating interactions between TCs and the ocean.

Zhang H, Wu R, Chen D, Liu X, He H, Tang Y, Ke D, Shen Z, Li J, Xie J, Tian D, Ming J, Liu F, Zhang D, Zhang W. Net Modulation of Upper Ocean Thermal Structure by Typhoon Kalmaegi (2014). Journal of Geophysical Research: Oceans, 2018, 123(10): 7154-7171.

Zhang H, Chen D, Zhou L, Liu X, Ding T, Zhou B. Upper ocean response to typhoon Kalmaegi (2014). Journal of Geophysical Research: Oceans, 2016, 121(8): 6520-6535.

line 417 and following: The discussion is very descriptive and does not discuss what is new in your results compared with the literature. The typhoon has a different effect on the two eddies. Is this just what one would expect based on the different positions of the eddies relative to the typhoon track, based on the existing literature? Or is there a bit of surprise in your observations? The way the manuscript is written, without first laying out hypothesis and more precise scientific questions, it is difficult for the reader to understand whether you just confirm existing theories with additional observations (which is worthy in itself), or whether there is something new (which is more exciting). When you say "The negative wind stress curl induced by the typhoon resulted in favourable surface ocean currents that further enhanced the clockwise rotation of the warm eddy": are you sure this sentence is valid in view of the high translation speed of the typhoon (reviewer 1's remark?)

Response: Thanks to your suggestion, we have rewritten the discussion and proposed a hypothesis based on previous theories. Using multiple observations in the South China Sea, we demonstrate that eddies of the same polarity exhibit different responses to same typhoon. Factors such as the distance between eddies and typhoons, eddies intensity and the background field need to be considered. We are sorry for our misrepresentation, and have removed the sentence "The negative wind stress curl induced by the typhoon resulted in favourable surface ocean currents that further enhanced the clockwise rotation of the warm eddy". Please check Lines 411 to 449.

The summary just repeats the main elements of the discussion (different response of the two eddies) but it lacks perspectives.

Response: We have rewritten the conclusion and stated the purpose and perspectives of this paper. Please check Lines 512 to 546.

A few detailed remarks:

1.Lines 54 to 57: I don't understand this sentence. It does not seem to be grammatically correct.

Response: We apologize for the language problems in Lines 54 to 57. In light of the introduction's revision, we have deleted this sentence. Our intention is to convey that " TCs cause the strengthening of cyclonic eddies, leading to positive potential vorticity anomalies".

2.line 59: "In general, TCs strengthen cold eddies": this statement seems in contradiction with Sun et al 2014, who say "only about 10% of COEs were significantly influenced by these super typhoons". It would be more appropriate to say "In some cases" " rather than "in general".

Response: Thanks for your suggestion. We have amended “In general” to “In some cases” in Lines 55 as your recommendation.

3.line 73: “reduction of warm eddies”: to you mean a reduction in numbers (less eddies)? Or do you mean a weakening of each eddy?

Response: Thanks your for bringing the ambiguity in our original sentence. We have now revised the sentence as follows: “Generally, TCs lead to a weakening of warm eddies” in Lines 68.

4.line 96: "previous studies focused on the interaction of cold cyclonic eddies and TCs: is it true than warm eddies have been overlooked? You refer to many publications about the interaction with warm eddies (lines 73 to 95), how do you assess that the warm eddies have not been focused on? The second part of that sentence is not clear. What are you investigating? The effect of the typhoon on an eddy is not a "feedback", is it?

Response: We sincerely apologize for the inaccuracies in our description. Previous studies have predominantly focused on exploring the interaction between TCs and eddies, often leading to generalized conclusions, such as the weakening (strengthening) effects of cold (warm) eddies on TCs. However, limited researches have been conducted on the divergent responses of same polarity eddies induced by the same typhoon process, particularly in the South China Sea. Based on in-situ datasets, multi-platform satellite measurements, and GLORYS12V1 reanalysis data, we investigate how the upper ocean within two anticyclonic eddies responds to Typhoon Kalmaegi. This marks an initial effort to characterize the different physical variations induced by TCs within two same polarity eddies, contributing to a better understanding of the role played by mesoscale eddies in modulating interactions between TCs and the ocean. Therefore, we have rewritten this section accordingly. Please check Lines 88 to 93.

5.lines 171-173: this is an example of badly constructed sentences. There are many problems with grammar in the manuscript.

Response: We apologize for the language issues present in the original manuscript. This sentence has been revised as following “Since the GLORY.S12V1 data assimilates data from Argo floats, it demonstrates good agreement with Argo profiling floats”. Meanwhile, we have thoroughly reviewed the entire manuscript and enlisted the assistance of a native speaker to aid in revising the manuscript.

6.Figure 2a is not informative at all. If GLORYS assimilated the ARGO data at that time and location, the comparison is not a validation of the product. I suppose that GLORYS did not assimilate the data from the buoys? Then Figure 2b shows a real validation with independant data. It would be better to show profiles at different buoy locations only, and not an ARGO profile, in Figure 2.

Response: The temperature and salinity data of GLORYS12 used for assimilation analysis come from Copernicus Marine CORAv4.1 database. The CORA observations come from many different sources collected by Coriolis data center in collaboration with the In Situ Thematic Centre of the Copernicus Marine Service (CMEMS INSTAC). The observation integrated data from different types of instruments, primarily including Argo floats, XBT, CTD and XCTD, and Moorings. As temperature data was unavailable at S1, we supplemented compared vertical profiles from S2 and S4 with GLORYS12v1. The root mean square (RMS) difference between GLORYS12V1 and Station 2 (Station 4) is 0.14 (0.10), with significant deviations in the mixed layer and thermocline. While the RMS for S2 and S4 is slightly higher compared to S5, it remains within an acceptable range. Please check Lines 156 to 166.

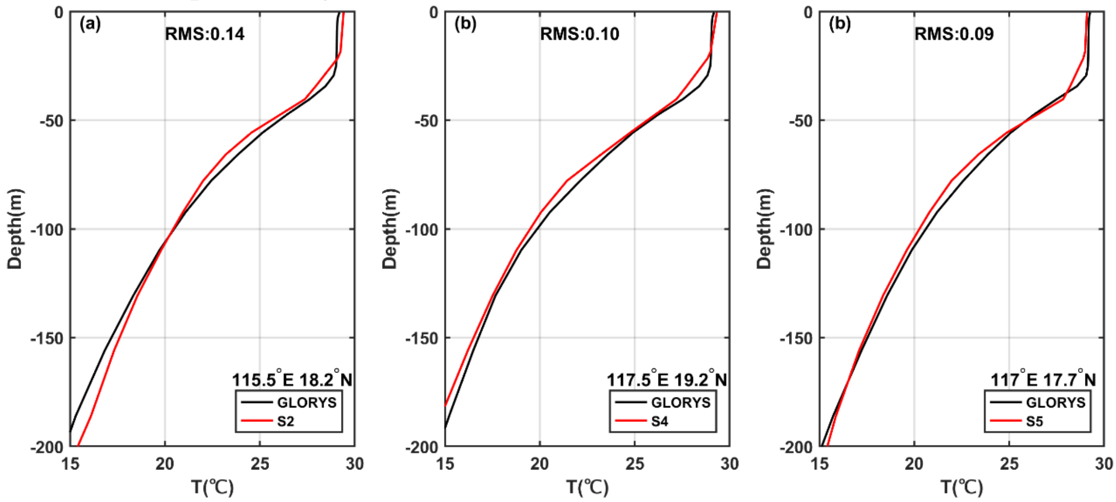

Figure 2. Evaluation of GLORYS12V1 data performance during September 2014. **(a)**, **(b)** and **(c)** are the comparison of vertical monthly mean temperatures recorded at stations 2(115.5°E 18.2°N), Station 4 (117.5°E 19.2°N) and Station 5 (117° E 17.7°N) respectively.

7.lines 195 to 199, EKE definition: you need to say relative to what (time mean? spatial mean?) the anomaly is computed. Also, you should say how you compute the Ekman depth.

Response: Following your suggestion, we have added this sentence “The geostrophic velocity anomalies are referenced to the period of 1993 to 2012.”in Lines 191-192. We also added the formula and explanation for calculating the Ekman depth above as requested.

All of the co-authors are so grateful to the reviewer for the time spent on our manuscript. The comments and suggestions provided by the reviewer are invaluable for us to improve our manuscript. We are so appreciated.