Ocean Sci. Discuss.,
https://doi.org/10.5194/os-2020-64-AC3, 2020

Ocean Science
Discussions
Open Access

Interactive comment on "Effect of mesoscale eddy on thermocline depth over the global ocean: deepen and uplift" *by* Xiaoyan Chen and Ge Chen

Xiaoyan Chen and Ge Chen

gechen@ouc.edu.cn

Received and published: 24 August 2020

Dear referee:

We feel great thanks for your professional review work on our manuscript. All of these comments have contributed a lot to improve the quality of our article. And the references tou recommend have been carefully read and are of great help that we will make a careful citation in the final article. According with your advice, we amended the relevant part in manuscript. Some of your questions were answered below.

Q1: You define the thermocline intensity Tz in Section 3.3. Have you shown any results with this parameter?

A: We obtain the position of the thermocline by calculating the maximum gradient of

Printer-friendly version

Discussion paper

the temperature profile data obtained by each Argo float. A schematic diagram of the calculation process of a profile is shown in Supplementary Figure 1. Fig. 1 (a) is a temperature profile measured by Argo and interpolated from 0 to 1000m. Fig. 1 (b) is the result of the gradient profile calculated by the corresponding Fig. 1 (a). It can be seen that there is a position with the fastest temperature change at about 98m which is the position of the thermocline at the corresponding coordinate point obtained from this profile data.

Q2: Lines 148-150. Please try to quantify the results. The temperature shown in Figure 2 is related to not only the eddies but also the background temperature. Could you show the temperature cycle with no eddy for comparison? What does the black line in Fig. 2c and 2d represent? Please add some explanation about the black line in Figure 2 caption.

A: Figure 2 shows the annual and monthly changes of the thermocline depth inside AE, CE and outside eddies in the northern and southern hemispheres from 2002 to 2019. (a) And (b) correspond to the annual change, (c) and (d) correspond to the monthly change. We have added a black curve to indicate the depth of the thermocline which is outside eddies, so as to compare with the depth of the thermocline inside the eddies (that is to say, no eddy for comparison). We also added a black curve in Figure 2 (a-b) and corrected the figure caption, see Supplementary Figure 1. This figure can mainly reflect the following information: Almost the entire time series, the depth inside CE is shallower than AE, and exhibited strong annual, semiannual and seasonal cycles. Quantitatively, from the monthly average of the northern hemisphere, AE can cause the thermocline to sink by nearly 40m around March, while CE can cause uplift of approximately 20m in March and April. As the months go by, the difference between the effects of AE and CE gradually decreases, reaching the minimum in August to September, only about less than 5m. In the southern hemisphere, AE can cause a maximum of about 25m of thermocline deepening during September to October, while CE can cause uplift of less than 10m in September. In March to April, the uplifting effect of CE on the thermocline almost disappeared, and AE can only cause the thermocline displacement of about 2m.

Q3: Are the results shown in Figures 3-5 affected by the uneven distribution of Argo profiles (shown in Figure 1)?

A: We tend to suppose that the results in figures 3-5 are more affected by the property of eddies (such as eddy amplitude, geostrophic velocity, radius, etc.). We added supplementary figure 3 as an illustration. Supplementary Figure 3 shows the displacement in the depth of the thermocline calculated by the Argo profiles that outside the effective boundary of the eddy, but within the boundary corresponding to twice its effective radius. This can be compared with figure 4 (a-b) in the manuscript which is calculated by the Argo profiles that are inside eddies. It can be seen obviously that in areas where Argo is richly distributed, the depth displacement caused by eddy is also very weak. The sampling density of Argo data will affect the accuracy of the results to a certain extent, but this will not be the main effect. And even if the amount of Argo is small in some areas, its density is almost more than 200 for a 5° grid, and the thermocline depth can be calibrated relatively accurately. In addition, in areas with large displacement are generally accompanied by strong eddy activities, such as the Kuroshio area and the North Atlantic area. That is, when the eddy was strong, the thermocline depth shifts greatly.

Q4: In addition to eddy amplitude and eddy radius shown in Figure 6, you may want to show the relationship between eddy-induced thermocline depth and other eddy parameters, e.g., the mean eddy kinetic energy, the mean vorticity, and so on. Line 198: "had an almost linear relationship with". It seems that the relationship shown in Figure 6 is not linear when the amplitude is larger or the radius is smaller. You may want to try the least square fitting with a curve instead of the straight line.

A: We made a modification and supplement to Figure 6 in the manuscript that tried the least squares quadratic function fitting, and the fitting effect was indeed better,

Printer-friendly version

Discussion paper

with R^2 above 0.95. In addition, the two parameters of eddy geostrophic velocity and kinetic energy have been added, as shown in supplement figure 4. After adding these parameters, the relationship between the eddy characteristics and the eddy-induced thermocline displacement can be more fully demonstrated. And we can found the eddy geostrophic velocity and eddy amplitude have the best fitting relationship with a smaller RMSE.

Q5: Line 46: “layer has little to no effect on the exchanges”?

A: This sentence is our statement is not accurate enough. We feel sorry for our carelessness. What this sentence really wants to express is: except during the wintertime convection when the mixed layer deepens significantly, the vertical velocity within the mixed layer that is principally wind-driven does not affect the exchanges between the surface layers and the ocean interior very much. Thank you very much for pointing out, and the manuscript will be revised.

Interactive comment on Ocean Sci. Discuss., https://doi.org/10.5194/os-2020-64, 2020.

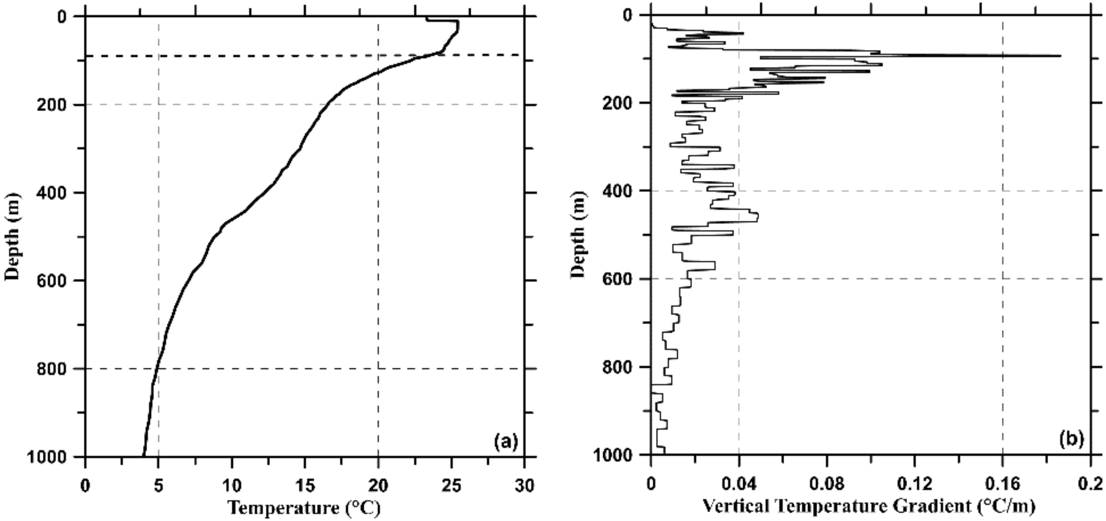

Fig. 1. Procedure for determining the thermocline depth a. Argo temperature profile; b. vertical temperature gradient of the Argo temperature profile.

Printer-friendly version

Discussion paper

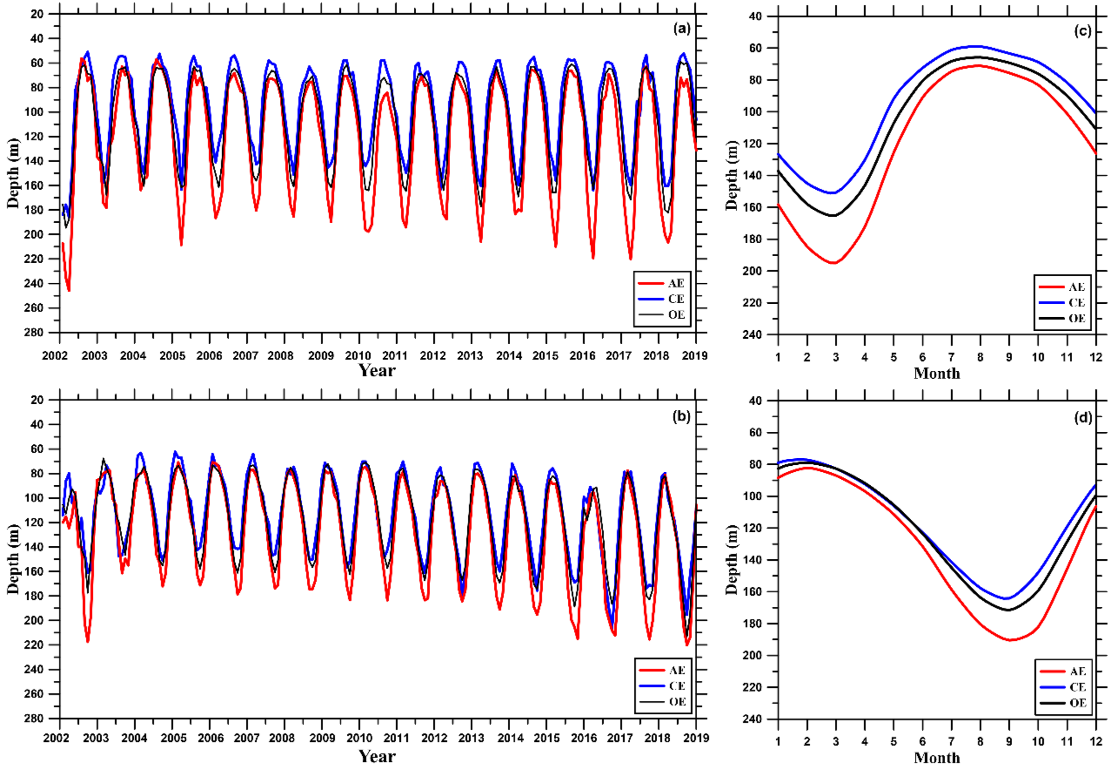

Fig. 2. Monthly time series of DTC inside AE (red lines), CE (blue lines) and OE (black lines) in the (a) Northern and (b) Southern Hemispheres. (c) and (d) show averaged monthly DTC for NH and SH.

Printer-friendly version

Discussion paper

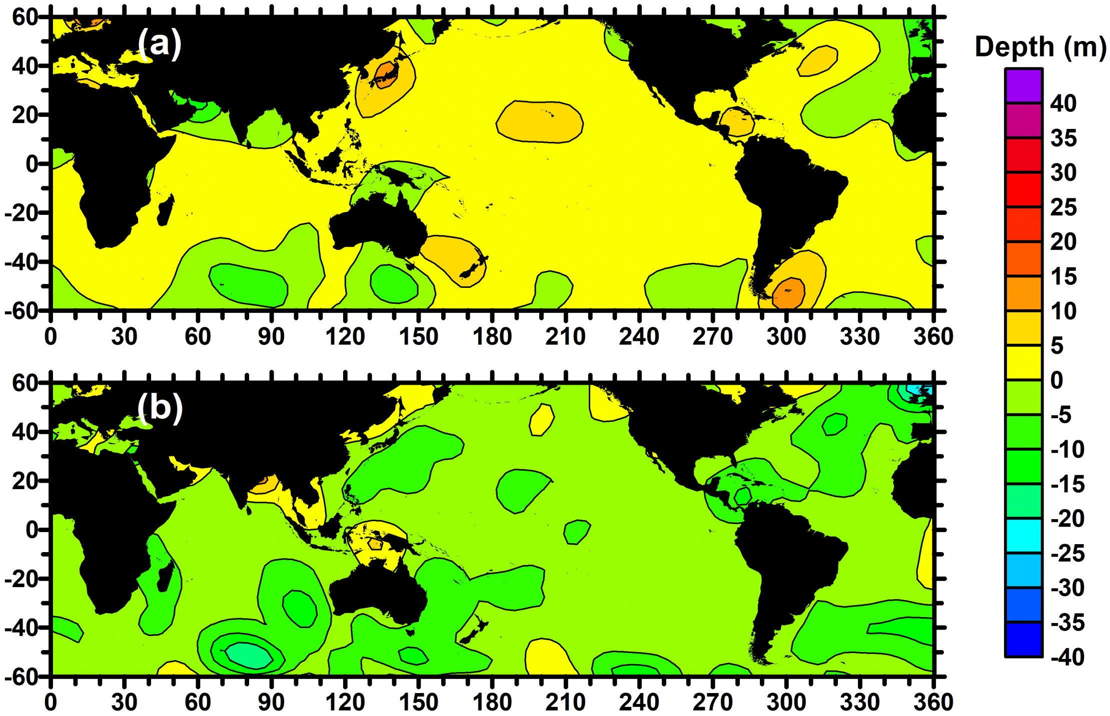

Fig. 3. Maps of outside-eddy-induced depth of thermocline for the global ocean for AE (a) and CE (b).

Printer-friendly version

Discussion paper

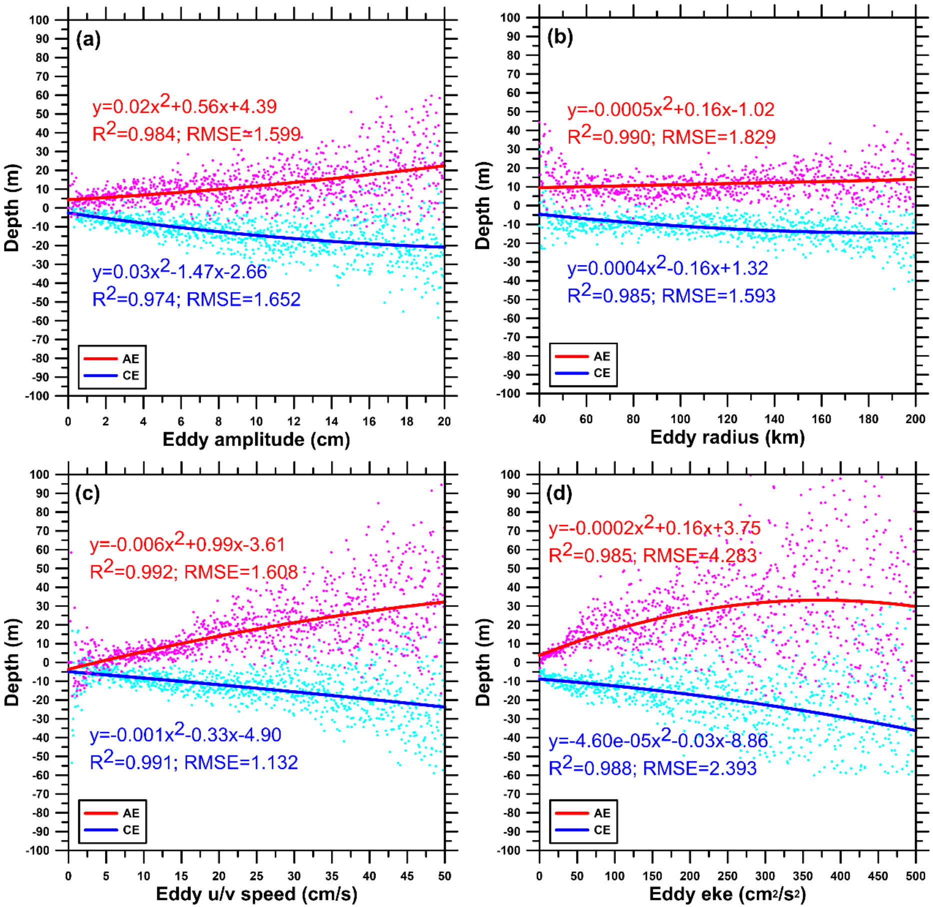

Fig. 4. Eddy amplitude (a), eddy radius (b), eddy u/v speed (c) and eddy kinetic energy (d) plotted against eddy-induced thermocline depth for AE (red lines) and CE (blue lines).

Printer-friendly version

Discussion paper