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

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Dear referee: Thank you for your nice comments concerning our manuscript. We would like to express our sincere appreciation for your careful reading and invaluable comments. Gaube et al. 2018 (here after Ga2018) has done a great job in mixed layer depth (MLD) displacement (deepen and shoal) modulated by mesoscale eddies. There are some similarities with the results in Ga2018, but there are indeed many differences that need to be elaborated for you. Firstly, the mix layer is located on the surface of the ocean, it is a manifestation of the vigorous turbulent mixing process which is active in the upper ocean. The transfer of mass, momentum, and energy across the mixed layer provides the source of almost all oceanic motions. Therefore, in addition to the mesoscale eddy, the displacement of the mixed layer is more susceptible to the

influence of air-sea interaction (e.g. sea surface wind field or air pressure field abnormal). Ga2018 studied the modulation effect of the eddy on the MLD, which is actually a comprehensive assessment of the MLD migrate that naturally includes the influence of not only eddies but also the air-sea interface interaction, and has not been eliminated. While in our research, we obtain the position of the thermocline by calculating the maximum gradient of the temperature profile data obtained by each Argo float, as shown in Supplementary Figure 1. In fact, we believe that eddies will have an uplift and deepen effect on both the thermocline and the mixed layer. However, what we want to highlight is that the thermocline defined by maximum temperature gradient is a more stable stratification structure, so the displacement of the thermocline is less interfered by other factors while is mainly captured by mesoscale dynamics. Thus, our research on the thermocline depth displacement is closer to the evaluation of deepen and uplift on the ocean stratification by the mesoscale eddies itself. Secondly, comparing with the study of Ga2018, it is found that the seasons of the peaks of eddy-induced depth displacement are different. In their research, the largest displacement is shown in winter, while our research found that the displacement is most significant in spring. This seasonal delayed response indicates the difference in the response of the thermocline and the mixed layer, which highlights our quantitative assessment of eddies' effect on thermocline. What's more, Ga2018 proposed that the magnitude of eddy-induced MLD anomalies is largest during the winter in regions of large eddy amplitude (figure 1 in Ga2018), check this figure we can easily find out only a few grid points near the +50m in AE and -50m in CE at some major strong current regions, however, the values are up to +60m in AE and -70m in CE during the MAM and SON at same regions in our statistics. Meanwhile, the coverage of the high value is large than Ga2018 remarkably (see figure 5 in our manuscript). The magnitude and coverage of the depth anomaly are representing the effect of eddies in ocean stratification. Argo profile data were used in both studies, and the SSH-based automated eddy identification method (Chelton et al. 2011) were used in AVISO multi-altimeter merged SLA data to construct the mesoscale eddy datasets, but different effects were assessed. Last but not least, the letter by Gaube focused on revealing this global feature, but the quantitative evaluation is not detailed enough. Our research shows richer data information and more comprehensive characteristics. For example, we quantified the eddy-induced thermocline displacement in different seasons, and transformed the geographic distributions of thermocline depths into the eddy coordinate system to visualize the distribution of thermocline displacement in the eddy field. What's more, in addition to the eddy amplitude, we give the relationship between eddy radius, geostrophic velocity, eddy kinetic energy and thermocline displacement, and point out the relationship between the eddy lifetime and its displacement distribution which is more comprehensively reveal the relationship between eddy properties and thermocline displacement. In addition, although we all pointed out that the deepening effect of AE is stronger than uplifting of CE is due to the differential current shears in the thermoclines, we pointed out a new explanation for this phenomenon that stem from our recent research findings that there is a higher proportion of abnormal CE, compared to AE. And this unbalanced abnormal eddy ratio may lead to a weaker influence of CE on the displacement of thermocline depth. This has not been pointed out before and could provide a reference for subsequent research.

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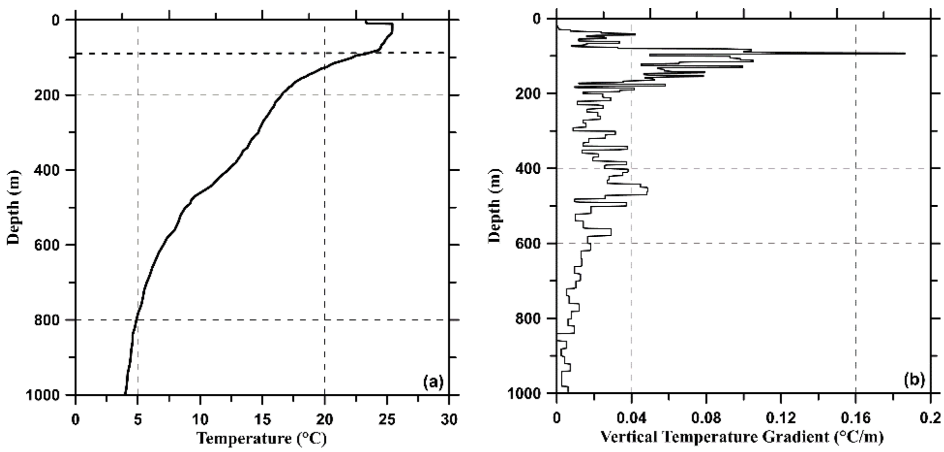

Fig. 1. Procedure for determining the thermocline depth a. Argo temperature profile; b. vertical temperature gradient of the Argo temperature profile.