Ocean Science Discussions

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Comment on os-2022-15

Anonymous Referee #1

Referee comment on "Impact of a long-lived anticyclonic mesoscale eddy on seawater anomalies in the northeastern tropical Pacific Ocean: a composite analysis from hydrographic measurements, sea level altimetry data, and reanalysis model products" by Kaveh Purkiani et al., Ocean Sci. Discuss., https://doi.org/10.5194/os-2022-15-RC1, 2022

General notes

Manuscript presents results of a rare, in recent times, direct investigation of the impact induced by typical mesoscale eddy structure on material transport in low latitudes of the North-Eastern Tropical Pacific using comprehensive analysis of new in-situ measurements. That was combined with the remote sensing data and eddy-resolving hydrodynamic modelling. It is known that eddies are responsible for up to the third of total heat transport in oceans (i.e. Sun et al 2019). This paper help to answer important scientific questions by using appropriate methods and with adequate accuracy. Therefore, the article is within the scopes of *Ocean Science* and satisfies its major requirements.

The comments below raise few questions to be addressed and suggest minor technical improvements. I believe those small corrections will contribute to the quality of presentation of the results and make the manuscript perfectly suitable for publication in *Ocean Science.*

Specific Comments

The aim, objectives and research context are specified in the Introduction. The main subject of the study is to reveal and quantify the impact of self-propagating relatively large structure (extended by ~100 kms in horizontal and 100s of meters in vertical directions) on the transport of heat, salt and other physical and chemical parameters and their distribution in the particular part of the ocean. The research has practical implication for sustainability studies focused on the mitigation of the consequences expected from the perspectives of metals’ extraction in the deep sea in observable future.

In the *Abstract* authors presented the major outcome of this research – quantified anomalies, associated with one of the eddies, which authors remotely traced since June 2018 from its origin site in Tehuantepec Gulf over 2000 km away to the location of their in-situ survey in April-May 2019. Alongside the anomalies values authors should include here the time-span period over which the mean was evaluated and the anomalies standard deviations. In the last sentence about the implications, the authors should clarify why an eddy 'traceable down to 1500 m' (Page 1, line 7) is important for the expected mining activity at a depths of 4-5 km in the area. Perhaps bringing in the ideas from lines 97-105 (Page 3) or from Conclusions could be helpful.

In the *Methods* section authors briefly described the approach, however &2.4 requires stronger justification of the 'climatology' chosen to estimate the anomalies, since the suggested source is different from more traditional $1/4^{o}$ fixed depths decadal WOA (Boyer, Levitus et al, 2019), isopycnal WAGHC (Gouretski, 2019) or several other monthly ocean climate products.

It is not very clear whether the authors used (a) an annual mean over whole 27-years reanalysis period (1993-2019) or (b) the multi-year monthly mean values at each grid cell (p.6, L. 150-151) derived from certain CMEMS GLORYS12 dataset. Authors applied individual daily reanalysis snapshots of the T,S etc properties interpolated/ or derived/ from the nearest grid cells to the location of their CTD stations in R/V Sonne 268 cruise. How were the reanalysis T,S profiles 'validated against them' (versa CTDs)? What bias ranges at what levels were detected (and exposed as shadows at Figure 4)?

It seems appropriate to use the reference to relevant peer-reviewed papers (in addition to Tech. reports, i.e. Lellouche et al. 2021, https://doi.org/10.3389/feart.2021.698876). The latter could assure audience in the reproducibility of the results and increase the confidence in the quality of the products being used, which has its known uncertainty and well defined biases.

Results section provide convincing evidence of substantial differences induced by eddy transition into ambient ocean properties. Indication of which criterion (potential density or thermal) and which thresholds value were chosen to determine the mixed layer depth in &3.3, L.233 is required. Referenced Montegut et al 2004 shows wide spread in results with different threshold values applied (ΔT=0.1, 0.2 ^{o}C, $\Delta\sigma_{\theta}$ = 0.03-0.055 kg m^{3} etc).
What was the contribution in the uncertainty induced by barotropic motion (tidal, inertial) on vertical fluctuations of the thermocline and other isolines depths derived from CTD casts at the eddy centre and its opposite edges (L.234-236)?

Measured enhanced swirl/transition velocities ratio (Chelton, 2011) exceed 3 (L.274), therefore this particular eddy was capable in the net volume transport. Original author's method (subtraction of climatology / reanalysis profiles from the measured CTD values) enables to produce and to analyze the required estimates with adequate confidence and with known limitations. These results are well presented with good illustrations in paragraphs 3.5 and 3.6. The only exception is the clarity in description of the Aquadrop (current meter, mounted on CTD frame) horizontal velocity measurements (P.11, L.321-328) and Figure 9. More informative and consistent picture could be revealed with either (a) similar (quiver plot) vectors averaged over 2-5 minutes intervals or/& (b) its replacement with i.e. 'wind rose' diagram. The later will provide a percentage of the currents flowing toward each directional segment and the bar lengths proportional to velocity magnitude - at each depths level. It would be beneficial to re-arrange all 6 plots vertically for three (west, central and eastern) stations for better visualization.

In the *Discussion* section authors put the main findings of this research into essentially wider context. Promising advantage of the chosen method is an enabling to filter out the impact of a long-term oscillations such as ENSO. However, in parallel, provision of local anomaly values may be useful for comparison with eddies known from the literature. Abnormally large thermal anomaly (+7.8 ^{o}C) here was similar to only one reported occasion elsewhere - in the South Chinese Sea, Chu et al 2014, who also used climatology instead of nearby background station(s). Authors reasonably explained their exaggerated T anomaly with several factors, including the longer than usual residence time of given eddy at the origin site, confirmed by the satellite data analysis. Coincidently that overlapped with positive (warm) ENSO phase in 2018-19 and with the downward descending of the warmer surface water due to anticyclone clockwise rotation within the eddy.

The high practical value of the study is in confirming the possibility of remote detection well in advance the arrival of mesoscale eddies at the target areas. Study proves the importance of eddies dynamics in enhancing the transport of heat, salt, dissolved and suspended matter in a belt overlaying the perspective mining sites in the NETP.

Technical corrections

Page 1, line 11. Is there word missing: salt transport [anomalies] or the given value is 'absolute' transport with the eddy?

Page 1, line 19. Is there word missing:' long distance [horizontal]'.

Page 2, line 27. Better replace the word 'hydrography' with "dynamics" or similar, as term 'hydrography' is the definition of the mapping, surveying and charting the water bodies, rather than changing the sea-water properties or ocean motion.

Page 4, lines 99-100. Replacement one of two 'potentially' occasions with 'perhaps' or similar.

Page 8, lines 190-210, &3.2 and Figure 4 (Page 23). Adding the Water Mass indices (with small symbols or bounding lines) on top of the T, S profiles and/or T,S diagram (Figure 4a,b) will provide the reader with better context about where-in the given eddy's profiles are embedded. Changing the axes of T,S diagram with equal size could help to avoid WM indexes overlaps. Adding dashed grid to Fig.4a and depths marks (0.2, 0.4,1 – 4 km) at Fig.4b could be helpful.

Page 12, line 365. Replace 'these' with 'the' at: 'in these other regions'.

Page 14, line 420. The eddy-induced variations in the depth-integrated heat transport profile order of O (+10-100 TW) here contrast with the values +26÷150TW included elsewhere in the text (Page 12, L.363) and in the Abstract +85 TW (L.10). It seems reasonable to complete integration calculus and provide a volume integral value as well, i.e. using a formula for tilted conus volume (Fig. 11, or other approximations) and with the STD spread due to eddy shape uncertainty. Similar is applicable to Salt volume transport.

Page 14, line 421. How did authors obtain the value of 'the annual meridional heat at 10°N'? That needs description or reference to the source.

Page 22, Figure 3, include position of CTD stations at Fig. 3b,c,d

Page 23-24 Figures 4a and 5 could become much more informative if the different vertical and horizontal axes limits and un-even stretching would be applied to the upper and to the deeper layers, i.e. below 0.5 km. That is possible in the same manner as authors did on Figures 6, 10, 12 (pages 25, 29, 31).

Page 27, Figure 8. Increase the font size of the tick marks (colorbars, axes) will make it visible (size 14-16 points). It is sufficient to show once the value of tick-marks on geographical axes here. Colour scheme could be unified for all layers and shown once – if it's log-stretched at both ends (i.e. as shown at Fig.4 in Chu et al 2014, referenced here).

Page 28, Figure 9 – see the notes in Specific comments on wind-rose diagram and/or vectors averaging over 2-5 minutes intervals.