Title: Intraseasonal variability of North Pacific Intermediate Water induced by mesoscale eddies

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Responses to Reviewers' comments

The authors appreciate the constructive comments from the anonymous reviewers, which greatly improved the content of the article. The comments have been fully considered and adapted in the revised manuscript accordingly.

Response to reviewer1:

Dear reviewer, I am very shocked that you read every sentence of my paper so carefully and then gave me so many useful comments, which must have taken you a lot of time, and I have hardly ever received such detailed and informative review comments.

Thank you very much for your review, I have carefully thought about each of your comments, and I have corrected some of the major issues you raised and I have made substantial changes in line with the comments. But I may not have corrected them very well, and I hope to discuss some of them with you further to improve my manuscript.

Thank you again for your careful examination of my manuscripts.

Major comments

This manuscript presented data analyses from the three specific moorings located in different places of the North Pacific. The water mass, North Pacific Intermediate Water (NPIW), is the focus of this study. The manuscript showed results of the underwater thermohaline measurements. The authors argued that the observed intrasasonal variability shown in the data can be attributed to mesoscale eddies. This is the central theme throughout the manuscript.

Overall, I found the content was difficult to follow and felt that the authors did not convey strong enough evidence guiding the readers. The scientific story is also weak. My major comments will be elucidated in the following paragraphs.

Major comments 1: Poor English.

The English writing is very poor and there are many obvious grammatical errors shown in the manuscript. Word usages are confusing which makes the reading difficult. For example: the authors wrote "…and in some cases even thousands of meters of the seafloor…" (Lines 165 – 166). I do not understand at all this sentence. Another example is "…Multi Observation Global Ocean 3D Temperature Salinity Height Geostrophic

Currents and Mixed Layer Depth (MLD)…" (Lines 226 – 228). It looked like the authors seemed to copy and paste these text from a table from the CMEMS, this is obvious that this sentence is not written in formal English. Sometimes the authors used a symbol for sigma theta and describe a sentence like "the isopycnals of 26.2 – 26.7 sigma_thata…" (Lines 349) and "…26.8sigma_theta isopycnal…" (Line 255). I believe there must be a more proper and consistent way describing an isopycnal. I would suggest the authors consult with a native English editor first before submitting their work.

Response: It's true that I didn't check the expression of some sentences carefully, as you said, and these inaccuracies affected the fluency of the reading. Based on your suggestion, I carefully combed through the whole manuscripts, focusing on including those sentences you pointed out.

Regarding this formulation of the isopycnals, as you suggested I revisited some of the literature and they express it in a variety of ways. In this paper, I have corrected the expressions based on the literature and harmonized them into a similar sentence "26.2-27 σ_θ isopycnals".

Major comments 2: Incoherent introduction.

The introduction is poorly written. The first paragraph of the introduction listed points and previous studies, but in a superficial way. I was expecting that the authors would provide the state of the arts in the NPIW. For example, what is the spatial distribution of the NPIW and what are they related to the three deployed moorings? Why do we care about the NPIW? Are the depths of the NPIW the same at the three deployed moorings? Why do we care about the variability at a time scale of < 100 days? Why does the time scale of < 100 days be associate with mesoscale eddies? Without these information and the latest status of the NPIW research, the introduction is just like a memo listing old papers.

One important argument connecting eddies to the observed T/S variability is that eddies can influence at deeper depths. How can an eddy influence the water layers at deeper depths (via observations or numerical simulations)? However, the readers cannot understand how eddies make a contribution at the ocean interior. Following this argument, how can this eddy-driven change at deeper depths link to the mooring data? There are too many oceanic phenomena causing interior T/S changes from mooring data. Low-frequency internal waves can be also a natural candidate, can't they? The linkage between observed T/S variability and eddies is not convincing. The authors used satellite SLA data and inferred these SLA data as eddies. Note that you are directly relating surface signatures with underwater mooring data. There are no qualitative (or quantitative) explanations (or showing some previous studies that had linked SLA to underwater T/S data) how you can proceed such an analysis in the introduction.

Response: Thank you very much for your good advice, I did not write my summary clearly enough. In this paper the main focus is on the intra-seasonal variability of NPIW, why do this study? Because there is quite a lot of knowledge on the seasonal variation as well as the inter-decadal variation of NPIW in the existing studies, and there is a lack of knowledge on its higher frequency variation such as the intraseasonal scale. And the current challenge of long-term measurements for NPIW has always existed, while the data source for studies on the intraseasonal scale relies mainly on measured data. Only a few localized studies of its variability have been conducted, so the intraseasonal variability of NPIW deserves more in-depth analysis.

Based on your comments, I have reorganized some of the new evidence in the abstract and rewritten that section. It is written as follows:

The North Pacific Intermediate Water (NPIW) is a pivotal component of the North Pacific's water mass and extensively studied due to its significant role in climate dynamics and oceanic processes. This water mass, forming in the northwestern subtropical gyre, specifically in the mixed region between the Kuroshio Extension and Oyashio front, is characterized by its low salinity and relatively cooler temperatures at depths of approximately 400 to 1200 meters, also its density is centered around 26.8 σ_θ isopycnal, with a salinity minimum about 34.0 to 34.3. (Talley, 1993, 1995; Yasuda et al., 1997; You et al., 2003; Masujima et al., 2009). NPIW is an important intermediate water mass connecting the upper and deeper layers of the ocean, and has important implications for physical, biological, chemical, and ecological processes such as dissolved oxygen, nutrient distribution, and thermohaline transport (Nishioka et al., 2020; Talley et al., 1993; Hansell et al., 2002; Auad et al., 2003; Tsunogai et al., 2002; Ohkushi et al., 2003). NPIW also plays an important role in global biogeochemical fluxes such as carbon and nutrient cycling (Tsunogai et al., 2002; Ohkushi et al., 2003).

The distribution and transport pathways of NPIW have been a focal point of oceanographic research, many studies have shown that the NPIW is widely distributed in the North Pacific Ocean, and that it is transported by complex water masses and circulation (Qiu, 1995; Ueno & Yasuda, 2004; Yasuda, 2004; Gordon and Fine, 1996; Kashino et al., 1996; Kashino et al., 1999). You (2003) found that NPIW originates from the subpolar regions of the North Pacific and propagates through the eastern subtropical gyre towards the Indonesian Through flow. As a result, NPIW can be found in eastern Japan, eastern Taiwan, the West Philippine Basin, and the intermediate region of the North Pacific Ocean (You. 2003; Fujii et al., 2013). Based on previous studies, we determined the approximate distribution of the NPIW from the WOA13 showed in Fig. 1, and this figure is similar to the results of You. (2003), we reproduce the depth distribution characteristics of NPIW in different regions. The NPIW was found to have different depths in different regions, with shallower depths in the western boundary region and deeper depths in the middle of the North Pacific Ocean. Since NPIW is one of the most important water masses in the global ocean, most of studies focus on its seasonal, interannual or interdecadal variations in different regions, and this variability is largely influenced by multi-scale ocean-atmosphere interactions (Masuda et al., 2003; Ohshima et al., 2010; Bingham& Lukas., 1995; Solomon et al., 2003; Qiu et al., 2011; Van et al., 1993). However, the majority of the studies mentioned above focus on time scales exceeding a few hundred days, and also the NPIW are located in the deep layers below the subsurface, where direct and long-term observations are difficult. More than that, there is often a large bias in the salinity representation of the water masses in the intermediate layer of the model data, there are very few studies of intraseasonal variations in the NPIW.

Mesoscale eddies are widely found in the oceans, with survival periods ranging from a few days to several hundreds of days, and radii of up to several hundreds of kilometers (Wyrtki et al., 1976; Richardson, 1983; Robinson, 1985; Chelton et al., 2007; Chelton et al., 2011; Zhang et al., 2014; Wunsch et al., 2007; Martínez-Moreno et al., 2021). A large number of observational studies have shown that eddies can affect depths of up to kilometres, that there are significant differences in the three-dimensional structural features within anticyclonic and cyclonic eddies, and that mesoscale eddies produce different temperature and salinity anomalies by causing uplift or subsidence of the isopycnic. (Zhang et al., 2015; Thoppil et al., 2011; Zhang et al., 2016; Zhang et al., 2015; George et al., 2021; Waite et al., 2016; Hausmann et al., 2017). Within the range of NPIW generation, propagation and distribution, there is also a high incidence of mesoscale eddies, it is therefore of great interest to investigate whether mesoscale eddies have an impact on the NPIW in different regions and with different thermohaline characteristics. In a localized area along the western boundary, Mensah et al. (2015) examines the intraseasonal to seasonal variability of intermediate water east of Luzon and Taiwan by hydrographic data from several cruises, it deduced a possible relationship between the eddies and the intermediate water from SLA data. Also, Wang et al. (2016) revealed that the semiannual variability of water masses at the northern and southern hemispheric convergence near 8° N related to mesoscale eddies. Next, Ren et al. (2022) found an intraseasonal variability of the IW of ~80 days from direct observations of the subsurface moorings east of Taiwan, and that this variability is associated with mesoscale eddies. These studies can illustrate some of the effects of eddies on IW, but they are insufficient to demonstrate the widespread and persistent existence of NPIW's intraseasonal variability characteristics, which is one of the most important links between high-frequency variability and medium- to long-term cyclic variability.

Nakanowatari et al. (2015) pointed out that there are currently many shortcomings in relying on model data to study the characteristics and distribution of NPIW due to the lack of observational data support. In this study, we utilize a long time series of high-resolution observations of the NPIW from three subsurface mooring deployed at different spatial and temporal scales in the North Pacific Ocean to study the intraseasonal variability of the NPIW, is essential for understanding the intricate relationship between ocean processes, climate change and marine ecosystems.

Major comments 3: Loosely defined NPIW.

Definition of the NPIW is not clear nor consistent in the manuscript.

The authors declared that the sigma theta raging 26.7 – 26.9 kg m^{-3}. But later terminologies “Kuroshio Intermediate Water (KIW)”, “Intermediate Water”, and South “China Sea Intermediate Water (SCSIW)” also appeared in the manuscript. As these water masses should have their own T/S ranges, a further explanation is needed.

There should be more precise definitions for NPIW rather than sigma theta. However, “low salinity” later becomes a criterion for the appearance of NPIW. The choice of this low salinity criterion was not clearly explained in the manuscript (in what value of the salinity can be called “low”?). The moorings are located in three different places. How can be a criterion (either sigma theta, or low salinity) applied to these different places without additional considerations? All of these drawbacks largely reduce the convincingness.

Also, some figures shown in the manuscript are depth-averaged values at the depth range 500 – 800 m depth. This is another criterion using a depth-averaged value that has not been gone through a clear definition. I don't know why averaged values within 500 – 800 m depth can represent NPIW at the all of the three mooring locations. No evidence or explanation are given.

Response: In this paper, we mainly talk about the changes of NPIW, for the Kuroshio Intermediate Water (KIW) and South China Sea Intermediate Water (SCSIW) which appear in the paper, they exist around the Luzon Strait at the western boundary, and they are capable of influencing the local circulation under the influence of mesoscale eddies, and their properties are significantly different from NPIW. and thus affect the properties of the NPIW. Their properties are significantly different from the NPIW, and although they are not the focus of this paper, I have described their water mass properties in the manuscript based on your suggestion.

Based on your suggestion, I carefully combed through the paper and removed most of the claims of a low salinity criterion, and in fact there were differences in depth and salinity characteristics of the NPIW at all three measurement points. Therefore, during the analysis, we did not uniformly take the interval of 500-800 m, but selected different ranges according to the depth at which the salinity minimum of the NPIW is located, and the selected depth ranges encompassed the currently defined interval of salinity variation of the NPIW. I have corrected the expression of how to select different depth intervals as follows:
In order to reveal this potential periodicity, we performed a wavelet analysis of the salinity in the intermediate layer. The NPIW is defined as a water mass with salinity between 34.0 ~ 34.3 psu and depth between 300 ~ 800 m according to You et al. (2003) and Tally et al. (1993), combined with Fig. 2, the average minimum salinity values of M1, M2 and M3 are located at depths of 600 m to 700 m, 600 m and 550 m, respectively. In this paper, we take the average salinity value within 100 m of the depth where the minimum salinity value is located for wavelet analysis, specifically in M1, M2 and M3, which are taken as 500 m to 800 m, 500 m to 700 m and 450 m to 650 m, respectively. In fact, the salinity value in this depth interval is basically lower than 34.3, which corresponds to the typical salinity characteristics of the NPIW.

Major comments 4: SLA and eddies.

The authors applied a passed band of 20 – 100 day to SLAs and tried to connect the correlation of SLA to band-passed T/S fields shown in the mooring data. I don't see any words or evidence that can guide me why SLAs with energy at 20 – 100 day (e.g., Figure 6) are related to underwater salinities with energy at 40 – 100 day (e.g., Figure 5).

As an eddy passes by the mooring site, it is expected to observe long-lived, short-lived, fast-propagating and slow-propagating eddies. Some eddies are quite big, several times the size of the local Rossby radius, while other eddies can be quite small. As these different types of eddies can have particular effects on the observed mooring data, I don't see the manuscript carefully differentiate these issues, but simply relate everything to eddies. I am not convinced.

Again, why are only eddies with energy at 40 – 100 day important? Aren't those with energy at < 40 days not important? Perhaps the authors made this decision of a passed band by Figure 4. Again, as my other question, why does the spectrum need to be calculated using depth-averaged salinities within 500 – 800 m depth?

SLAs with energy at 20 – 100 days could be also signatures of westward propagating Rossby waves. This part is not even discussed at all. This question makes me wonder that "how can you really make sure that an eddy indeed passed by the mooring site?"

Response: To link the SLA and salinity changes, I rewrote this section as follows:

In the Western Pacific region, mesoscale eddies are an important source of intraseasonal signals (Zhou et al., 2021). In order to establish a link between them, we first confirmed whether the mesoscale eddy induced SLAs is characterized by a typical intraseasonal signal. The results reveal a 60-80 days period in the SLA across mooring locations M1 to M3 showed in Fig. 4g to 4l. This period aligns closely with the salinity variation measured by the moorings, indicating a possible correlation between SLA and salinity variations in this region.
To further clarify their relationship, we analyzed the average temperature and salinity at intermediate layer after applying a 20-120 days band-pass filter to discuss the potential correlation between the SLA and these parameters, with the results presented in Fig. 6. At the M1 mooring location, the SLA with correlation coefficients of 0.55 and 0.45 with temperature and salinity, respectively. This pattern is further supported by the T-S diagram at M1 shown in Fig. 7a, where water characteristics of relatively lower temperature and salinity (or higher temperature and salinity) correspond to negative (or positive) SLA. For the mooring M2, Fig. 6b shows correlation coefficients of 0.4 and 0.3 between SLA and temperature and salinity, respectively, indicating a slightly weaker correlation compared to M1. Nonetheless, both Fig. 6b and Fig. 7b demonstrate a positive correlation between SLA and temperature-salinity variables. At the mooring M3, temperature-salinity variations and their correlation with SLA are weaker during the observation period, with lower correlation coefficients. However, similar to M1 and M2, Fig. 6c and Fig. 7c show that periods with significant negative SLA, such as between April-May 2017, correspond to relatively lower salinity and temperature, with salinity values reaching as low as 34.2 psu. Conversely, periods of significant positive SLA, such as between April 2016 and May-June 2017 at M3, correspond to higher temperature and salinity, with salinity reaching up to 34.3 psu. These findings in Fig. 6 and Fig. 7 indicate that higher (lower) temperatures and salinities correspond to periods of positive (negative) SLA, which regardless of observation location and time, suggesting that there is a relationship between NPIW and mesoscale eddies.

Your second question is very insightful, and it is indeed true that there may be differences in the effect that various types of eddies may have on the water mass as they pass over the mooring location. There may be differences in the effects of different eddies on the

NPIW, and given that this paper is a qualitative analysis of the different thermohaline variations due to the effects of anticyclonic and cyclonic eddies on the NPIW, the analysis of this part of the manuscript to which you refer may be underdeveloped. I think your question may be more appropriate for us to consider in future studies, for example, the long-lived eddies you mentioned may have a longer effect on NPIW, so the thermohaline transport that may be induced may be greater, and how to measure the magnitude of this effect is very meaningful.

The reason why we chose a scale of 40-100 days is because this time scale is considered to be a typical scale of intraseasonal variability, and this time is a typical mesoscale eddy time. Also eddies within 40 days may be weaker and too small in size to have a limited depth of vertical influence and thus may not affect the NPIW. Thus we did not consider this time period in our bandpass filtering.

It is true, as you say, that Rossby waves may also cause changes in this period of the SLA. In general, mesoscale eddies in the inter oceanic region are also manifestations of first-mode baroclinic Rossby waves. In our observations we cannot guarantee that the eddies pass through the mooring site, and thus we have demonstrated the effect of the eddies on the NPIW by a number of case studies. For example, the different characteristics of the NPIW in the presence of anticyclonic and cyclonic eddies around the mooring site were chosen to illustrate the effect of the eddies on the NPIW.

Major comments 5: Low and high salinity events. (Line 559)

This part is very confusing. The addressed low and high salinity events are relative, no arguments are provided why such a salinity change has to be eddy-driven. There are also no definitions showing how these low/high salinity events are defined.

Response: I read my manuscript carefully after you asked this question and you are very logical and indeed as you said there are many factors that cause salinity anomalies, not just eddies. I think I should have got my logic wrong, because to prove whether the eddy has an effect on salinity or not, I should first find out the characteristics of the salinity distribution at the moment of the eddy, so that I can show the effect of the eddy on salinity. Instead, I went about it in the manuscript in a poor way by first basing it on high and low salinity events before finding the reason.

So based on your suggestion, this section has been rewritten as follows, including the figure has been redrawn and corrected.

As the changes in NPIW are mainly in response to changes in salinity, we chose typical cyclonic and anticyclonic eddies events to analyze the salinity changes as they pass through the moorings. An intraseasonal signal with inverse phase characteristics at a depth of 700 m at M1, as shown in Fig. 5. The averages of the current field and salinity distribution at depths ranging from 500 m to 700 m and 700 m to 900 m at the moment of the anticyclonic and cyclonic eddies, respectively, with results displayed in Fig. 11a to 11d. The completely different salinity distributions in the anticyclonic and cyclonic eddy events can be seen in Figure 11. From the average salinity and current of 500-700 m in Fig. 11a and Fig. 11b, the salinity within the anticyclonic eddies is significantly higher than that of the cyclonic eddies, and this high salinity is not only manifested in the mooring measurement points, but also in the salinity within the other eddies distributed in Fig. 11a and 11b, which are also consistent with this characteristic. Within the deeper 700-900 m layer, anticyclonic eddies are able to induce lower salinity characteristics compared to cyclonic eddies, in contrast to the upper layer.

These distinct salinity changes during anticyclonic (cyclonic) eddy periods are related to the eddies' internal vertical transport. In the North Pacific region, the salinity profile structure is inversely *S*-shaped, with two peaks indicating high salinity features in the subsurface layer about 200 m and low salinity about 600 m. Thus, the downward movement of water masses within the anticyclonic eddy causes subsurface high temperature and salinity water to mix into the intermediate layer, leading to increased temperature and salinity at intermediate layer. Similarly, this downward movement causes low salinity intermediate layer water to mix downwards, resulting in relatively lower temperature and salinity characteristics in the deeper layer. Conversely, when cyclonic eddies occur, their upward movement of lower salinity water in NPIW to mix upwards, resulting in lower temperature and salinity characteristics above the intermediate layer, while the upward mixing of deeper higher salinity water masses leads to positive temperature and salinity anomalies in the intermediate layer. These phenomena demonstrate how the eddies' internal relative movements can alter local temperature and salinity, causing thermohaline mixing.

Major comments 6: The literature seems to be out of date.

There is only one paper regarding NPIW published after 2021, Ren et al. (2022). This is very surprising because this paper is the first-author’s paper. I don’t think this kind of literature review can help the readers.

Response: Based on your comments I have carefully reviewed some of the literature and made some additions. Still some studies on a class of literature on long-term changes in NPIW.

Zhou, Y. T., Gong, H.J., Zhou, F., 2022. Responses of Horizontally Expanding Oceanic Oxygen Minimum Zones to Climate Change Based on Observations. Geophysical Research Letters, 49(6): e2022GL097724.

Sugimoto,S., 2022. Decreasing Wintertime Mixed Layer Depth in the Northwestern North Pacific Subtropical Gyre. Geophysical Research Letters, 49(2): 2021GL095091.

Yuan, D.L., Yin, X.L.,Li, X., et al., 2022. A Maluku Sea Intermediate Western Boundary Current Connecting Pacific Ocean Circulation to the Indonesian Through flow. Nature Communications, 13(1): 2093-2100.

Li,Z., England,M.H., Groeskamp,S., 2023. Recent Acceleration in Global Ocean Heat Accumulation by Mode and Intermediate Waters. Nature Communications, 14(1): 6888-6901.

Finally, I feel the manuscript is confusing and is also not well written at this stage. The whole content needs to be re-arranged thoroughly. To summarize what I have read so far, NPIW, eddies, SLA, and low salinity, and various depth ranges for NPIW are not presented in a coherent and clear story. The authors kept using vague sentences without providing definitive values or evidence. The term "variability" should reflect important aspects of the NPIW, such as its volume, its layer thickness, at which depth ranges it distributed, strength of stratification, …etc, and the manuscript did not discuss how these variabilities change with eddies in an intraseasonal time scale. The manuscript, however, only told the readers that eddies can result in salinity change by 0.3 and the low-salinity core can situate in a depth range of hundreds of meters. Can these statements apply to different seasons or different locations? What kind of eddies can cause a meaningful or a statistically-significant impact on NPIW? I do not see a broader and scientific story from the current version of the manuscript, unfortunately.

I don't think a major revision can be a viable option because there are many issues needed to be clarified and examined, and it will take a lot of time. There should be a better version of the manuscript based on these unique data sets. To my conclusion, I think the current manuscript should be rejected without further considerations. The editorial office may ask the authors to resubmit their work once the major comments and issues are revised.

Response： Thank you again for your careful reading and very many useful suggestions, based on which I have reorganized the whole manuscripts and removed some ambiguous expressions. The thesis has been reorganized.

This manuscript mainly focuses on the intraseasonal variation of NPIW and its influencing factors. In the current existing research, some understanding has been achieved on the long-term variation and seasonal variation of NPIW. Due to the deep location of NPIW, the scarcity of long-term observations and the insufficient reflection of NPIW changes in model data, the understanding of its intraseasonal changes is lacking. The intraseasonal signal is a key link connecting high-frequency variability and long-term variability, so we qualitatively analyses the characteristics of NPIW variability in this paper and reveals the eddy as one of the factors contributing to the variability. It is hoped that the findings will expand the understanding of NPIW.

Some other important issues

Line 60: What is “low-salt”? I believe this is not a formal English writing.

Response: Indeed it is, I have corrected it in manuscripts, it should be “low salinity”.

Line 99 – 104: The text describe variabilities of NPIW, but did not make it clear what these variabilities actually are.

Response: I have reorganized the introduction section based on the suggestions you mentioned earlier, please review it again.

Lines 131 – 138: It is not clear why salinity anomalies in the Kuroshio Extension have something to do at the mooring sites.

Response: Indeed, and our observation point is still some distance away from the Kuroshio Extension area, so I've deleted the relevant statement.

Lines 157 – 158: not always. This is for mid-latitude, but eddies at high-latitudes will be much smallers.

Response: Yes, the radius of the mesoscale eddies gets smaller with increasing latitude, and the general current thinking is that the mesoscale eddies is a manifestation of the first mode baroclinic Rossby, whose radius is inversely proportional to latitude.

Lines 169 – 170. I don’t understand what you tried to say.

Response: I have been delete this sentence.

Line 206. Since WOA 2023 has been announced. WOA13 is very out of date.

Response: You are right, since in this paper we are plotting the distribution of climate state-averaged NPIW, we consider WOA13 to be sufficient. Of course we will certainly be analysing it with the new database in the future.

Lines 238 – 242: This part looks like introduction.

Response: This part has been integrated into the introductory section, so please review it again.

Line 258: How can we see NPIW disperse southward and westward from Fig. 1?

Response: You're right, it really doesn't show the diffusion process of NPIW. I didn't phrase it correctly, it should be the distribution of NPIW. It has been changed to the following sentence: NPIW in the western and southern parts of the distribution, the minimum salinity of the NPIW increases and its depth is relatively shallow.

Line 261: No definition for the “edge” of the NPIW.

Response: It has been changed to the following sentence: Based on the NPIW range determined by the 34.3 psu contour of the salinity definition, M3 near 18°N, which can be seen in Fig. 1 to be located close to the south edge of the NPIW distribution, has a salinity minimum value close to that at M2, but the depth of the low salinity core becomes further shallower to ~550 meters.

Lines 272 – 275: This interpretation comes from nowhere, right? Please provide more evidence.

Response: After careful consideration, this sentence doesn't make a lot of sense and I've removed it.

Line 281: What is “discontinuities”.

Response: It should be “apart”.

Lines 309 – 311: Why do we need to care about KIW and SCSIW? And what are their relationships with NPIW?

Response: In fact this is a localized water mass in the western boundary region, and NPIW may be altered somewhat by mixing with them in this region.

Line 346: Here you defined NPIW sign salinity and depth range. But your Figure 1 emphasized sigma theta.

Response: Figure 1 distinguishes the NPIW mainly on the basis of the most representative isopycnals. The NPIW is also variable, so I refer to their values for it for subsequent analyses in order to study the variation.

Line 349: But here you used signa theta again but using "intermediate waters". Is this the same as NPIW? The depth range is also different here.

Response: It is indeed true that different regions correspond to different depths of NPIW, to avoid distress therefore I have rewritten the paragraph.

The observations not only show the typical distribution characteristics of the NPIW at different locations, but also the observed up and down fluctuation characteristics of the salinity with the isopycnals are found in Fig. 2. In order to reveal this potential periodicity, we performed a wavelet analysis of the salinity in the intermediate layer. The NPIW is defined as a water mass with salinity between 34.0 ~ 34.3 psu and depth between 300 ~ 800 m according to You et al. (2003) and Tally et al. (1993), combined with Fig. 2, the average minimum salinity values of M1, M2 and M3 are located at depths of 600 m to 700 m, 600 m and 550 m, respectively. In this paper, we take the average salinity value within 100 m of the depth where the minimum salinity value is located for wavelet analysis, specifically in M1, M2 and M3, which are taken as 500 m to 800 m, 500 m to 700 m and 450 m to 650 m, respectively. In fact, the salinity value in this depth interval is basically lower than 34.3, which corresponds to the typical salinity characteristics of the NPIW.

Lines 358 – 359: …"…relatively faster". I don't understand at all.

Response: I have been rewrite this sentence: During the observation period from September 2019 to August 2020, the variability period appears to be longer about 80 days showing in Fig. 4c, while the variability period after September 2020 is about 60 days.

Lines 369 – 370: stronger signals, weaker signals, these text are very vague.

Response: Thanks to your suggestion, I've rewritten this paragraph:

To more clearly observe the periodic variations in salinity, we calculated the anomalies of the salinity at each depth for each mooring during the observation period and used a 40-100 day band-pass filter. Fig. 5a shows that intraseasonal signals are present from 400-900 m for the M1 mooring, and these signals strength gradually weakened after April 2018, which is consistent with the results of the wavelet analysis in Figure 4a.. The band-pass filtering of salinity for the M2 and M3 mooring also showed the intraseasonal signal, the strongest intraseasonal signals were found around 550 m for M3, corresponding to the core of the NPIW. Additionally in Fig. 5c, the larger intraseasonal signals are observed during two periods: April to July 2016 and January to April 2017, with weaker intraseasonal signals from August to December 2016, as reflected in the wavelet spectrum in Fig. 4e. Combining the wavelet analysis and the corresponding band-pass filtering results from the three moorings reveals that within the extensive distribution range of the NPIW in the Western Pacific, observations at different times and locations consistently indicate the presence of typical intraseasonal variation in the NPIW.

Line 374: "inverse phase change", what is this?

Response: I corrected the expression of the sentence in question.

Lines 363 – 365, and Figure 5: The salinity anomalies have to be related to NPIW, why?

Response: You are absolutely right, it is true that the measured salinity in the 400-900 m depth range is not all NPIW, but for example, the water mass in the range of 500-800 m at the M1 position belongs to NPIW, so the measured salinity change can basically represent the change of NPIW.

Figures 6 – 7: They should be in the result section.

Response: The order has been adjusted in the new manuscript.

Lines 477 – 482: Why?

Response: This sentence is really illogical, I have removed it and rewritten the paragraph.

Lines 491 – 493: SLA and geostrophic currents are daily data. But your analyses on mooring data have been low-passed. How can they be comparable with other?

Response: Since eddies move slowly and take some time to pass near the moorings, it is possible to influence the thermohaline during this time. The properties of the measured temperature and salinity data will not be changed after low-pass filtering.

Some figures (Figures 9, 11 – 13) are hard to see the shading and vectors.

Response: I've redrawn these Figures.