Response to comments by Reviewers #1

We deeply thank you for your constructive suggestions on the early version of the manuscript numbered "os-2021-7" (hereinafter named old manuscript). We have addressed all the comments formulated by the replying (in red) to your remarks (in black and blue) and the changes in manuscript (*in red italic*).

Anonymous Referee #1

Overall comments:

This paper presents a very interesting study. The authors have excellent overall knowledge regarding the MLD, and this is clear in this work. It provides critical new data of T & S and MLD estimations of the area.

I found it very interesting to compare the MLD and MLDt and also the use of the stratification index.

As the scientific work is very good and the information that comes out of it is of great importance, I believe that the text needs to be written better to present these nice results. And also, a more robust discussion of the results is required. First, I would suggest expanding and rewriting the discussion/conclusion sessions and proceeding with professional Editing for better results.

I would also recommend using abbreviations (like the ones you have been set in Figure 1). For example, try to replace in the text the Bering Sea basin with BSb and the Bering Sea shelf with BSs or something similar (it will make it easier to for the reader).

Also, I'm not pretty sure how important it is to keep a decimal in the MLD. I don't believe that gives extra info if the MLD is 65m or 65.21m. I would round the MLDs as they are not providing any significant scientific input differences minor like that. The international references on MLDs are in meters.

Maybe Figure 11 could be left aside and just use the ADT information only in the text.
Comments regarding the Figures are following.

I would suggest that this work should be published after major revisions.

Reply:
Thanks a lot for the positive assessment and constructive comments of our paper.

The use of the stratification index was improved within the mixed layer other than within the depth of

60 m.

The result was rewrote to place the hydrographic data into the context of previous work. The discussion was expanded and rewrote by citing more references to a make it more robust. The discussion was improved to demonstrate what is new in this research.

I replaced in the text the Bering Sea basin with BSb, the Bering Sea shelf with BSs, the Bering Sea slope with BSp, Chukchi Sea shelf with CSs, Chukchi Sea slope with CSp and Bering Slope Current with BSC, as you suggested.

I round the MLDs in meters as you suggested.

Figure 11 (numbered Figure 11 in the early version of the manuscript) was left aside and I just used the ADT information only in the text.

The 4.5 Section was supplemented in the revised manuscript to compare the temperature, salinity and MLD along the BL (Bering Sea) and R (Chukchi) sections in 2019 with previous years. The shoaling and warming of the mixed layer were found in 2019 than previous years and the climatology. And this was accompanied by the warming of the Cold Intermediate Water in the Bering Sea.

Especially for Sectors

2.2 Data

171… and dissolved oxygen: You refer to oxygen measurements, but you are not using them anywhere in this work, so you need to make that clear or remove it from the data sector. (else the reader is waiting to see some oxygen data)

Reply:
Thank you for pointing this out. I am not using oxygen measurements in this work, and I have removed the description about oxygen measurements from the data sector in the revised manuscript.

Does the data from the shipborne meteorological station were used for cross-validation of the CCMP model? Please explain to this sector why you are presenting each dataset and how you will use it (Data and methods).
This is also valid for the fluxes and wave data etc. You are slightly presenting them in this section, but you are not making any comment regarding their use. So, we arrive at the discussion-conclusion, and we find results of correlations that have not been mentioned before. This section is the place that you'll explain your methodology:
For example: "To investigate the reasons of the spatial MLD variability, different cross-correlations and lagged (maybe) correlations have been done. First, with the wind regime ….bla bla bla. Then we have investigated the correlation of the MLD with the wave data…blabla bla". Also, regarding the wave data, maybe it is worth it to run a Lagged Correlation to see if you obtain different results.

Reply:

Thank you for your kind suggestions. The data from the shipborne meteorological station were used to evaluate the CCMP reanalysis wind data. The wind speed bias, wind speed root-mean-square error (RMSE hereafter) of the CCMP was 1.29m, 2.37m, respectively. The temperature, salinity and pressure obtained by CTD were used to calculate MLD. The current observed from the ADCP and the sea level were used to detected eddies that might affect MLD. The wind stress and momentum flux derived from the CCMP wind data, the sea surface heat flux and water flux obtained from the CFSv2 were considered as important factors that deepen the MLD. And the detailed explanation was supplemented in the revised manuscript as following:

The wind observed by the shipborne automatic meteorological station were used to evaluate the Version 2 Cross-Calibrated Multi-Platform (CCMP) Wind Vector Analysis Product over the period from 24 Aug. to 6 Sep.. The wind speed bias, wind speed root-mean-square error (RMSE hereafter), wind direction RMSE of the CCMP wind product was 1.29m, 2.37m, and 27.46° *, respectively. The correlation coefficients of the zonal wind between the CCMP wind and the measured wind by the ship were 0.92. The correlation coefficients of the meridional wind between the CCMP wind and the measured wind by the ship were 0.91. The mean difference of the zonal wind between the CCMP wind and the wind measured by the ship was 0.51 m/s. And the mean difference of the meridional wind between the CCMP wind and the wind measured by the ship was 0.29 m/s. That meant the CCMP wind product behaved well in the target region.*

To investigate the reasons of the spatial MLD variability, different cross-correlations have been done. First, the sea level from the satellites and the ADCP observation were used to detect eddies and major ocean currents that may largely determine the MLD. The Bering Sea level was obtained by the combined measurements of several altimeters from the COPERNICUS MARINE SERVICE (The Copernicus Programme is the European Union's Earth Observation Programme, available online at https://resources.marine.copernicus.eu/?option=com_csw&view=details&product_id=SEALEVEL_GLO_PHY_L4_NRT_OBSERVATIONS_008_046). Second, with the wind regime, the correlation between wind speed and the MLD was explored. The relationship between the MLD and the buoyancy flux as well as the momentum flux was estimated through Multiple Linear Regression. The wind speed at the height of 10 m above the sea level and momentum flux were extracted and derived from the Version 2 CCMP (Cross-Calibrated Multi-Platform) Wind Vector Analysis Product offered by the Remote Sensing Systems (Wentz et al, 2015). The spatial resolution of CCMP dataset was 0.25°*, and the temporal resolution was 6 hours. The sea surface heat flux and water flux were obtained from the National Centers for Environmental Prediction (NCEP) Climate Forecast System Version 2 (CFSv2) (Saha et al., 2011). Then we have investigated the correlation between the MLD and the wave data. The significant wave height was obtained from the COPERNICUS MARINE SERVICE (available online at https://resources.marine.copernicus.eu/?option=com_csw&view=details&product_id=WAVE_GLO_WAV_L4_SWH_NRT_OBSERVATIONS_014_003). The bathymetric dataset used in plotting the CTD profiles was from ETOPO1 (Amante & Eakins, 2009).*

Also, there is an extend paragraph on this sector regarding the ADCPs, but the data and a discussion on these data is minimum in the rest of the manuscript. It looks like they belong to auxiliary data but they are really expanded in this sector. Thus, depending the use and the importance of each dataset, dedicate an appropriate paragraph in this section.

Reply:

Thank you for your excellent advice. The sector regarding the ADCPs was condensed as following:

*CTD and lowered ADCP observations were carried out to get profiles of temperature, salinity, and velocity at these stations. The model of the CTD and ADCP were SBE 911 Plus and Teledyne RDI WHMariner 300kHz respectively (**错误!未找到引用源。** and **错误!未找到引用源。** in Supporting Information). The Lamont-Doherty Earth Observatory (LDEO) software based on the inverse method (Visbeck, 2002) was used to calculate the ocean current by processing the data from the Lowered ADCP. Ship-borne ADCP measurement was carried out while the ship was in motion to get the current profile of the upper ocean along the track. The surface temperature and salinity measurements were made as well in the underway observations. The SeaBird FerryBox (**Table 1** in Supporting Information), Teledyne RDI OS 38kHz, and Teledyne RDI WHSentinel 300kHz (**Table 2** in Supporting Information) were used in the underway observations.*

3.1. The salinity and temperature

To make it more robust, I would suggest the authors to add a small part (as you have already start doing, just extend it a bit) more dedicated to this area's water masses. There have been some studies for the Bering Sea, so a reference to these studies, regarding the water masses of the area and a comparison with the new dataset (that the authors collected in 2019) will make the manuscript more robust and complete.

Reply:

Thank you for your comments. A small part was added in the revised manuscript to introduce this area's water mass with more references in the revised manuscript as following:

In the northwestern Bering Sea shelf, there was a cold and salt water mass called the Anadyr Water (AW hereafter) (Wang et al., 2020; Liu et al., 2016). The Alaska Coastal Water (ACW hereafter) was located on the northeastern Bering Sea shelf with the feature of high temperature and low salinity (Wang et al., 2020; Liu et al., 2016). The layer below the surface layer was called the cold intermediate layer (CIL) in the Bering Sea basin, and it forms as a result of two processes: cooling of the water in autumn and winter and its warming in the spring and summer (Luchin et al., 1999).

The comparison between the new dataset and previous studies was supplemented in Section 4.5 in the revised manuscript as following:

4.5 The inter-annual variation

To explore the inter-annual variation of the MLD in the Bering Sea and Chukchi Sea, the observations along the BL section and R section from the World Ocean Atlas 2018 (WOA2018) and previous Chinese National Arctic Research Expeditions were compared.

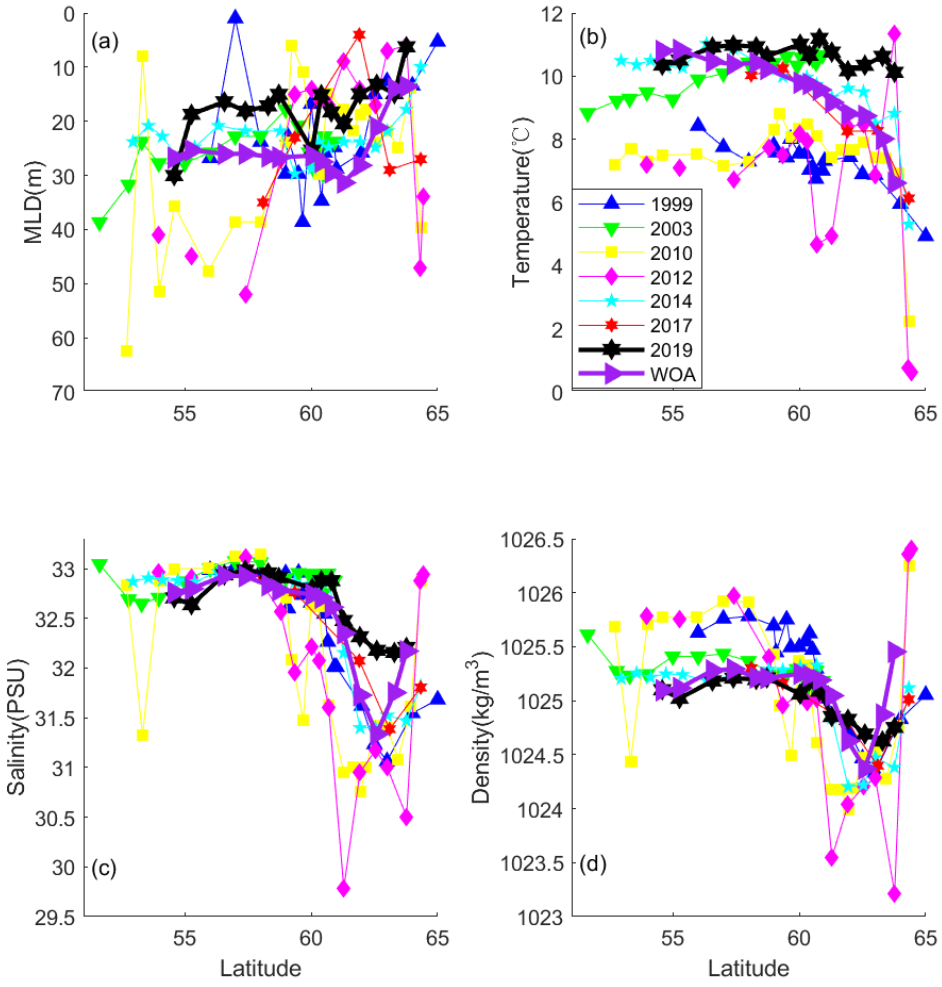

Figure 1 The inter-annual variation of the MLD, temperature, salinity, and density of the mixed layer from the Chinese National Arctic Research Expeditions and the climatological MLD from WOA along the BL section in the Bering Sea.

*The MLD in 2019 was obviously shallower and the temperature of the mixed layer was higher than those in the other five years along the BL section in the Bering Sea (Figure 1 (a) and (b)). This shallower MLD was accompanied by the warming of the surface layer (**错误!未找到引用源。** (c) and (d)) and cold intermediate layer (CIL) (Figure 2 (a) ~ (f)). The minimum temperature of the CIL water mass in the Bering Sea basin showed a trend of increase: it was* 0.54℃, 0.94℃, 0.82℃, 0.69℃, 1.99℃, *and* 2.50℃ *for the year of 1999, 2003, 2010, 2012, 2014, and 2019, respectively (Figure 2 (a)~(f)). The warming of the CIL may be related to the air temperature warming in the previous winter and the processes in the north pacific (Overland et al., 2012).*

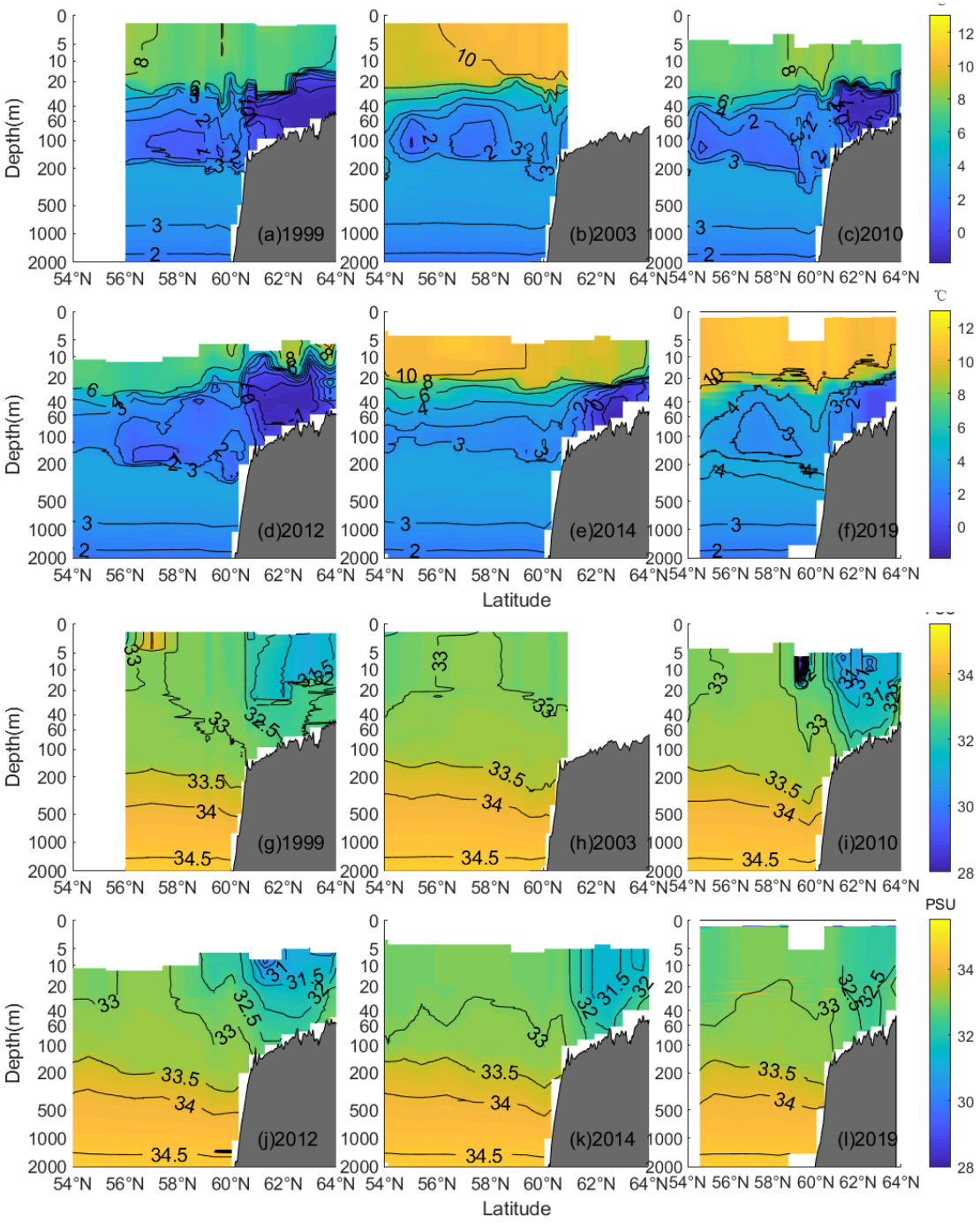

Figure 2 The temperature ((a)~(f)) and salinity ((g)~(l)) profiles along the BL section in the Bering Sea from the Chinese National Arctic Research Expeditions and WOA. These expeditions were all carried out in summer.

The MLD in 2019 was shallower than those in 1999, 2003, 2010, 2012, 2014, and 2017 along the R section in the Chukchi Sea (Figure 3 (a)). And this was accompanied by the warming of the mixed layer (Figure 3 (b), ***错误!未找到引用源。*** *(a) and Figure 4). This surface warming was related with to the regional air-sea heat flux and the Arctic amplification (Danielson et al., 2020). Chronologically, the salinity and density was consistent with the WOA climatological fields (Figure 3 (c) and (d)), while the*

*MLD was shallower and the temperature was higher than the WOA climatological fields in the summer of 2019 (Figure 3 (a) and (b)). But salinity dominated the spatial fluctuation of the density for most of the year (Figure 3 (c) and (d)). It should be noticed that the salinity of the water in the Bering Sea shelf was larger than the climatology (**错误!未找到引用源。** (d) and (f), Figure 1 (c)) while it was not so in the Chukchi Sea shelf (Figure 3 (c)). This may be linked to the increasing net glacial ablation in the Gulf of Alaska watershed (Danielson et al., 2020).*

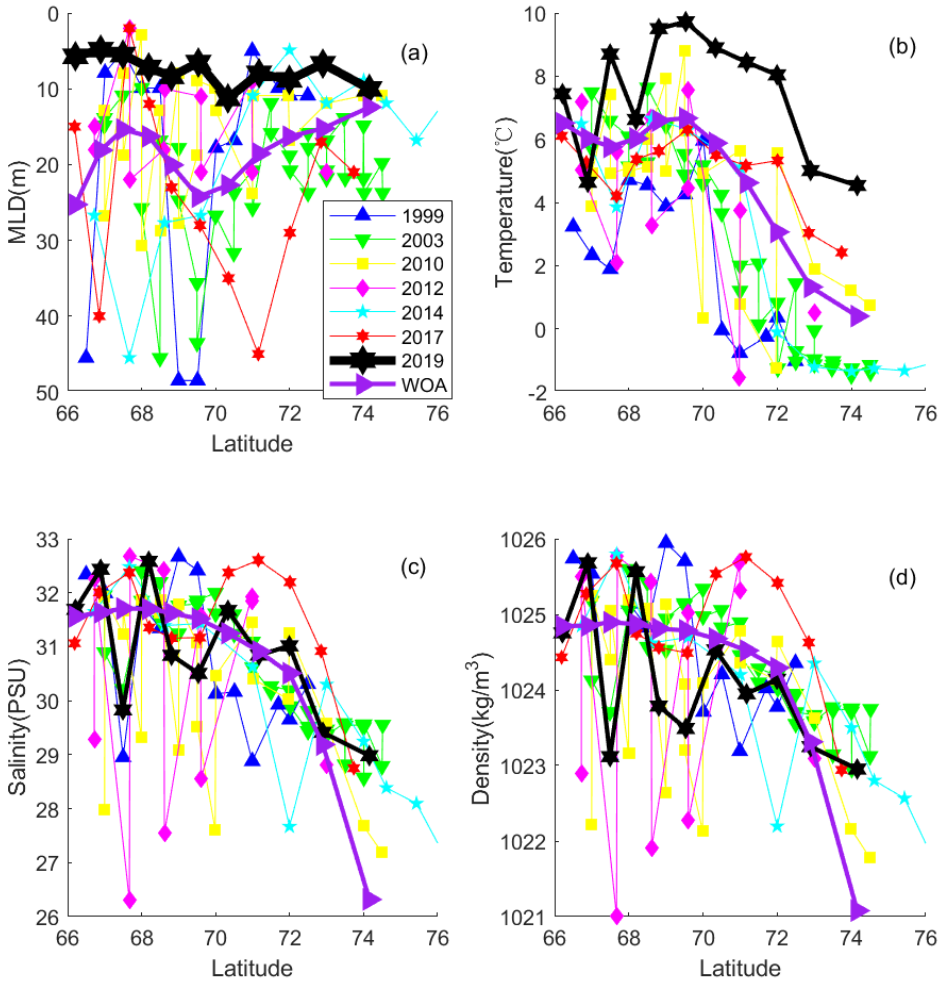

Figure 3 The inter-annual variation of the MLD, temperature, salinity, and density of the mixed layer from the Chinese National Arctic Research Expeditions and the climatological MLD from WOA along the R section in the Chukchi Sea.

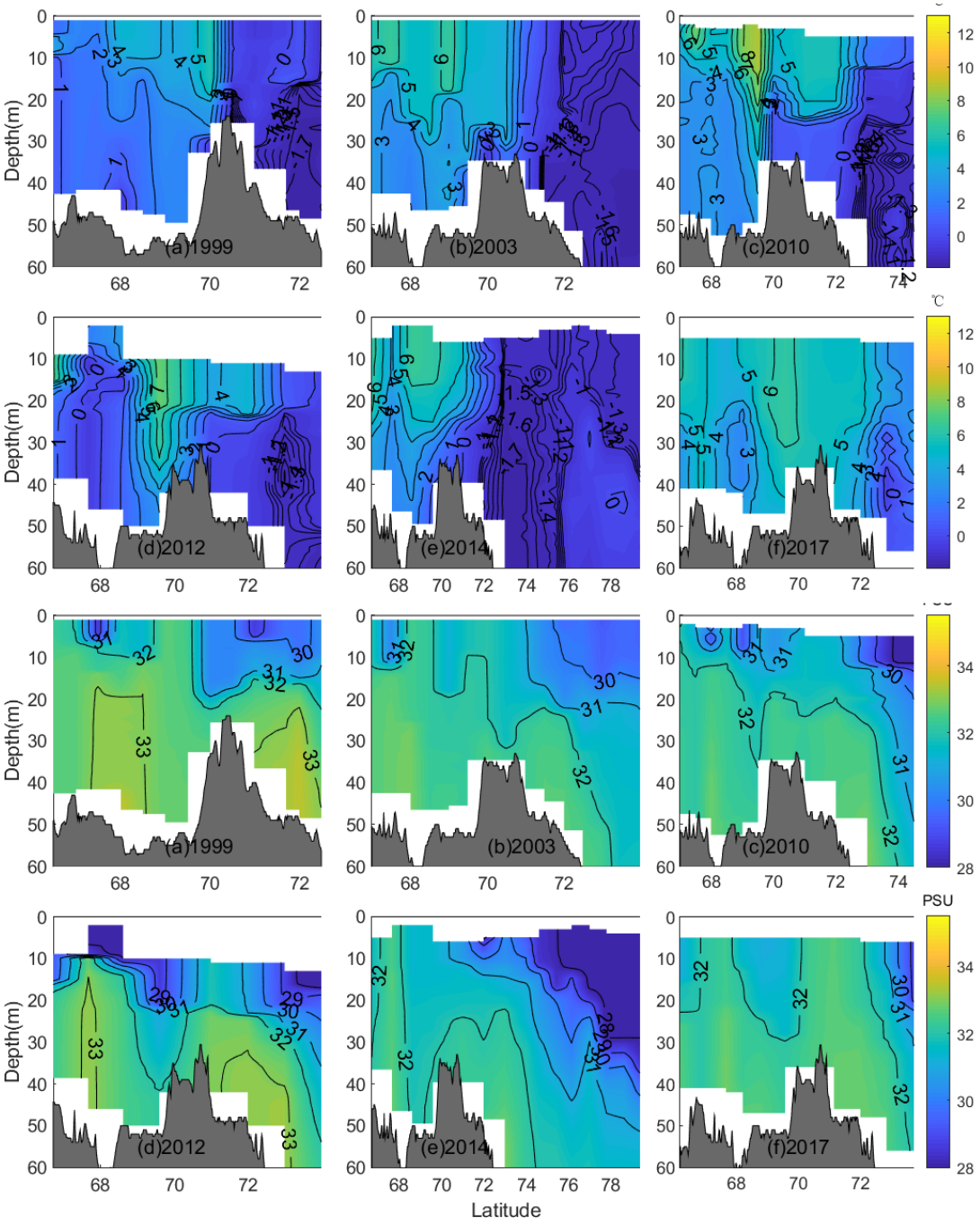

Figure 4 The temperature ((a)~(f)) and salinity ((g)~(l)) profiles along the R section in the Chukchi Sea from the Chinese National Arctic Research Expeditions and WOA. These expeditions were all carried out in summer.

3.4. The relation of temperature, salinity, and MLD

The first half of this sector, as it is written, is not providing any necessary information as it is not explaining precisely the relationship between the MLD and the T/S. Part of this info is already existing in the results. The second half (lines 447 and beyond) is written much better.

Thank you for your comments. The first half of this sector was rewritten to explain precisely the relationship between the MLD and the T/S and the info already existing in the results was deleted:

*In the southern Bering Sea shelf, the MLD at the stations BL07~BL14 and BR01~BR09 fluctuated with the topography (**错误!未找到引用源。** (a) and (b)). In the north Bering Sea shelf, due to the significant difference in density between the Anadyr Water and the Alaska Coastal Water, advection occurred and the seawater was stratified in the transition zone. As a result, The MLD in the transition zone was shallower than that in the northeastern and northwestern Bering Sea shelf (**错误!未找到引用源。** (c)). The northward increase of the MLD in the Chukchi Sea was accompanied by the high meridional gradient of the salinity and temperature. That might be the result of the advection of the low-salinity water generated from the melting of sea ice in summer in the Chukchi Sea. The larger MLD at R05 and R07 stations might be related to the ACW appearing within the range of 68.5 - 70.5°N on the bottom.*

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More detailed comments line by line:

What is the CCMP reanalysis? Please add reference and link

Reply:
Thank you. The full name of the CCMP reanalysis data, reference and link was supplemented in the revised manuscript:
The wind observed by the shipborne automatic meteorological station were used to evaluate the Version 2 ***Cross-Calibrated Multi-Platform (CCMP) Wind Vector Analysis Product*** *(Wentz et al, 2015) over the period from 24 Aug. to 6 Sep..*
The wind speed at the height of 10 m above the sea level and momentum flux were extracted and derived from the Version 2 ***CCMP (Cross-Calibrated Multi-Platform) Wind Vector Analysis Product*** *offered by the Remote Sensing Systems (Wentz et al, 2015).*
Version 2 CCMP Wind Vector Analysis Product produced by Remote Sensing Systems *is available online at* ***http://www.remss.com/measurements/ccmp/****.*
Wentz, F.J., J. Scott, R. Hoffman, M. Leidner, R. Atlas, J. Ardizzone, 2015: Remote Sensing Systems Cross-Calibrated Multi-Platform (CCMP) 6-hourly ocean vector wind analysis product on 0.25 deg grid, Version 2.0. Remote Sensing Systems, Santa Rosa, CA. Available online at www.remss.com/measurements/ccmp.

200…obtained from the CFSv2 (Saha et al., 2011).: …what is the CFSv2, add info as you have for the Copernicus

Reply:
Thank you. The information for the CFSv2 was added in the revised manuscript:
The sea surface heat flux and water flux were obtained from the National Centers for Environmental Prediction (NCEP) Climate Forecast System Version 2 (CFSv2) (Saha et al., 2011).
The sea surface heat flux and water flux obtained from the National Centers for Environmental Prediction (NCEP) Climate Forecast System Version 2 (CFSv2) are available online at https://rda.ucar.edu/datasets/ds094.0/.

214-228: This paragraph, as it is, is more like an Introduction part or, if better connected to the text, could be a part of the discussion regarding the paper results of estimating the MLD using different criteria, so I believe it must be or removed from the data and methods sector or rephrased in a way that will underline and explain the selected MLD estimation method of this work.

Reply:
Thank you. This paragraph has been moved to the Introduction part.

264-266: If you are referring to Kara et al. (2000), the reference depth was set at 10m, and the criterion is set as: <the depth at the base of an isothermal (isopycnal) layer, where the temperature (density) has changed by a fixed amount of $\Delta\sigma\ \theta = \sigma\ \theta(T + \Delta T, S) - \sigma\ \theta(T, S)$, where P - 0) from the temperature (density) at a reference depth of 10 m. (with $\Delta T = 0.8°C$)>
You may want to refer also for the $\Delta\sigma\ \theta = 0.125$ kg m-3 criterion to Monterey and Levitus [1997], Global Ocean (reference level 0m), Suga et al. [2004], North Pacific (ref level 10m),

- Monterey, G., and S. Levitus (1997), Seasonal Variability of Mixed Layer Depth for the World Ocean, NOAA Atlas NESDIS 14, 100 pp., U. S. Gov. Print. Off., Washington, D. C.
- Suga, T., K. Motoki, Y. Aoki, and A. M. Macdonald (2004), The North Pacific climatology of winter mixed layer and mode waters, J. Phys. Oceanogr., 34, 3– 22.

Reply:
Thank you for your advice. This paragraph has been rephrased to explain the reference depth and the suggested reference was added:

The criterion for the MLDd was $\Delta\sigma = 0.125 kg / m^3$ *, and the reference depth was 5m. The criterion was the same as some previous studies, such as Monterey and Levitus (1997) for the Global Ocean, Suga et al. (2004) for the North Pacific. But inconsistent with the reference depth of 10 m in their study, a reference depth of 5 m was adopted because the MLDd in some area was shallower than 10 m.*

296 …the Bering Sea basin had the characteristics of high temperature and low: … the Bering Sea basin had a high temperature and low…

Reply:
Thank you. I have changed the expression as following:
The upper ocean above 30 m in the Bering Sea basin had a high temperature and low salinity pattern.

300: Are you referring to the Bering Sea basin?

Reply:
Yes, sorry for my ambiguous sentence. I have changed it into:
There was a cold water mass with a depth range of 50-200m and a core temperature slightly lower than 3 ℃ in the Bering Sea basin. It was called the Bering Sea Basin Intermediate Water in some studies (Liu et al., 2016).

301: In the middle layer of the layer 50-200m? please rephrase it and give the depth that you are referring to

Reply:
I rephrased it as following in the revised manuscript:
There was a cold water mass with a depth range of 50-200m and a core temperature slightly lower than 3 ℃ in the Bering Sea basin.

309-311: In the east, the density of high-temperature and low-salinity water was smaller, which had the characteristics of the Alaska Coastal Water.: High temperature and lower salinity results to lower density, so wordy writing. Do you mean that this water mass was similar to Alaska's Coastal Water? (do they have similar T, S)?.
The same also for the following lines.
Also, there is no reference to Anadyr Water. But it appears in the results without having any reference in the Introduction. Give some info for this water mass and maybe the other water masses of that area (see my previous comments regarding sector 3.1)
Please find another way to characterize the water masses that you are referring to. It's not so nice repeatedly referring to 'high-temperature and low-salinity water masses.'

Reply:
Thank you for your comments. An introduction to the Anadyr Water and Alaska Coastal Water was supplemented in the revised manuscript:
In the northwestern Bering Sea shelf, there was a cold and salt water mass called the Anadyr Water (AW hereafter) (Wang et al., 2020; Liu et al., 2016). The Alaska Coastal Water (ACW hereafter) was located on the northeastern Bering Sea shelf with the feature of high temperature and low salinity (Wang et al., 2020; Liu et al., 2016).
And the way to characterize the water masses was changed as well in the following manuscript:
In the northwestern Bering Sea shelf, the core temperature of the AW was about 2℃*, and the core salinity of the AW was higher than 32.5. In the northeastern Bering Sea shelf, the core temperature of the ACW was higher than* 9℃*, and the salinity was significantly lower than that of AW.*

354-356: Thus, the BS section represented the MLD under the influence of the advection of these two water masses: That's very interesting, so maybe you need to add some info in the Introduction section regarding the water masses in the area.

Reply:
Thank you for your comments. Some information was added in the revised manuscript to introduce this area's water mass with more references in the revised manuscript as following:
In the northwestern Bering Sea shelf, there was a cold and salt water mass called the Anadyr Water (AW hereafter) (Wang et al., 2020; Liu et al., 2016). The Alaska Coastal Water (ACW hereafter) was located on the northeastern Bering Sea shelf with the feature of high temperature and low salinity (Wang et al., 2020; Liu et al., 2016). The layer below the surface layer was called the cold intermediate layer (CIL) in the Bering Sea basin, and it forms as a result of two processes: cooling of the water in autumn and winter and its warming in the spring and summer (Luchin et al., 1999).

357 … On the contrary, the MLDt was zero there: How is that possible? I don't think it is zero. I believe that MLD and MLDt are similar because the water column looks to me (from Figure5) homogeneous. You can check that if you plot the temperature by depth. If that's so, you'll need to change it through the whole text, discussion, con conclusions, etc.

Reply:
Thank you for your comments. I agreed to your suggestions and changed it through the whole text, discussion, conclusions, etc.

428 …Therefore, the shallower MLD in the Bering Sea shelf might be due to the terrain constraints and the bottom friction… please explain more or give some reference

Reply:
Thank you for your insightful comment. I deleted this assumption in the revised manuscript. I need to do sensitivity experiment by numerical modeling to explore the evidence and the physical process in my following research.

460-461… The average difference between MLDd and MLDt was-3.25m in the northern Bering Sea and the Chukchi Sea, the absolute value of which was much greater than the 0.51 m… The absolute value what, of the MLD in the Chukchi Sea? Please refer to the station. Also, if the MLDd and MLDt difference is more or less half a meter, I'm not sure how accurate it is to tell that this demonstrated that salinity changes drive the mld. Every calculation method has an accuracy range (+-); thus, I believe the 0.51m is in the buffer of the accuracy of the method.

Reply:
Thank you. The absolute value of the average difference between MLDd and MLDt in the southern Bering Sea. And I rephrased it in the revised manuscript:
The average difference between MLDd and MLDt was -3.25 m in the northern Bering Sea and the Chukchi Sea, and the difference was only 0.51m in the southern Bering Sea (Including BL01~BL06, BR00).
I removed the conclusion when the difference between the MLDd and MLDt was smaller than 1 m, in consideration of the accuracy range as you suggested.

491: when you are referring to the eddy, it is better to say if it cyclonic or anticyclonic

Reply:
Thank you. I have improved my expression to say if it cyclonic or anticyclonic throughout the revised manuscript.

523 .. between them:…between the ccmp and the measured by the ship??

Reply:

Yes. The purpose was to evaluate the CCMP wind using the measured wind by the ship. I rephrased the expression and the evaluation was supplemented with more details in the revised manuscript:

The wind speed bias, wind speed root-mean-square error (RMSE hereafter), wind direction RMSE of the CCMP wind product was 1.29m, 2.37m, and 27.46°*, respectively. The correlation coefficients of the zonal wind between the CCMP wind and the measured wind by the ship were 0.92. The correlation coefficients of the meridional wind between the CCMP wind and the measured wind by the ship were 0.91. The mean difference of the zonal wind between the CCMP wind and the wind measured by the ship was 0.51 m/s. And the mean difference of the meridional wind between the CCMP wind and the wind measured by the ship was 0.29 m/s. That meant the CCMP wind product behaved well in the target region.*

522-523…And the mean difference of the zonal wind and meridional wind between them were 0.51 m/s and 0.29m/s respectively…The mean difference between the meridional and zonal wind was 0.51….? is that what you mean?

Reply:

Sorry for my ambiguity expression. I have rephrased these sentences:

The mean difference of the zonal wind between the CCMP wind and the wind measured by the ship was 0.51 m/s. And the mean difference of the meridional wind between the CCMP wind and the wind measured by the ship was 0.29 m/s.

532…It had been known that the MLD at BL01and BL07 was mainly due to the influence of the continental slope current... Please explain better what you mean by that and try to expand it using the appropriate references.

Reply:

Thank you for your suggestion. The deepening the MLD at BL01 and BL07 had been discussed in Section 4.2 based on the measured current velocity and references:

*The deepening of the MLD in the Bering Sea slope might be related to the strengthening of the turbulent mixing caused by the BSC and the strong vorticity along the BSC (**错误!未找到引用源。** and **错误!未找到引用源。**(b)). As shown in **错误!未找到引用源。**, the absolute dynamic topography showed a high gradient along the Bering Sea slope. And the current velocity along the Bering Sea slope was about 0.1 m/s, which was significantly larger than that in the Bering Sea basin and the Bering Sea shelf. The large MLD at BL01 in the northern continental slope of the Aleutian Islands was related to the anticyclonic eddies along the Aleutian Islands (**错误!未找到引用源。**). The MLD at BL01 was 30.04 m, significantly larger than that at BL02, which was 18.72 m (**错误!未找到引用源。** (a)). The current velocity at BL01was about 0.2m/s, while in the basin was measured less than 0.1m/s according to the ADCP observations. The spiral of the current became irregular at the base of the mixed layer (**错误!未找到引用源。** (c). And this confirm the conclusion that anticyclones deepen the MLD in the research of Gaube et al., 2019.*

Some examples of editing language issues

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196: The sampling interval is 1 minute. : …was 1 minute (try to keep the same time through the text)

Reply:
Thank you. I rephrased it and checked that issue to keep the same time through the text.

197 …The CCMP reanalysis wind data at the height of 10 m above the sea level was also used: ….were also used (it's plural the data), or if you preferer: the CCMP reanalysis wind dataset …was also…

Reply:
Thank you for your patience. I corrected it as plural form: The wind speed at the height of 10 m above the sea level and momentum flux **were** extracted and derived from the Version 2 CCMP Wind Vector Analysis Product. And the whole text was checked as well.

198 …spatial resolution of CCMP data is: …of CCMP dataset.

Reply:
Thank you. Your suggestion was adopted. The revised sentence was:
The spatial resolution of CCMP dataset was 0.25°, and the temporal resolution was 6 hours.

208…bathymetric data used in this paper was from: … if you are referring to data is plural, so you use were, if you refer to a dataset you can use was

Reply:
Thank you. I corrected it into the following: The bathymetric dataset used in the CTD profiles was from ETOPO1.

264: In what previous research are you referring to? Please specify and insert the reference.

Reply:
Thank you. I have inserted the references and supplemented reasonable explanation:

The criterion for the MLDd was $\Delta\sigma=0.125 kg/m^3$ *, and the reference depth was 5m.*

The criterion was the same as some previous studies, such as Monterey and Levitus (1997) for the Global Ocean, Suga et al. (2004) for the North Pacific. But inconsistent with the reference depth of 10 m in their study, a reference depth of 5 m was adopted because the MLDd in some area was shallower than 10 m.

300-304: Try to write clearer these sentences

Reply:
Thank you for your suggestion. I have rewritten these sentences clearer as following:
There was a cold water mass with in the CIL and a core temperature slightly lower than

3 ℃ in the Bering Sea basin. The temperature of the bottom cold water mass in the southern continental shelf was similar to that of the CIL in the basin, but the bottom cold water mass was shallower due to terrain constraints on the shelf.

As for the CIL, I have added a reference as following:
The layer below the surface layer was called the cold intermediate layer (CIL) in the Bering Sea basin, and it forms as a result of two processes: cooling of the water in autumn and winter and its warming in the spring and summer (Luchin et al., 1999).

308 …and the salinity was significantly lower than that in the west. In the east, the density of high-temperature and low-salinity water was smaller, which had the characteristics of the Alaska Coastal Water: …. In the east, the (high-temperature and low-salinity water) density was smaller, which had the Alaska Coastal Water characteristics.

Reply:
Thank you. I rephrased it as following:
In the northwestern Bering Sea shelf, the core temperature of the AW was about 2℃*, and the core salinity of the AW was higher than 32.5. In the northeastern Bering Sea shelf, the core temperature of the ACW was higher than* 9℃*, and the salinity was significantly lower than that of AW.*

314-316: There were…. If you are describing the data in Figure 8, then you need to be more precise; for example: at stations BL… (or at latitude…) of the Chukchi Sea shelf and the continental slope, low-density waters were present in the upper layer, with a temperature range of….

Reply:
Thank you. I rewrote them as following:
At stations BR, M and BT of the Chukchi Sea shelf and the continental slope, low-density waters were present in the upper layer, with a temperature range of 1℃～10℃ *and salinity of* 28~30 *(**错误!未找到引用源。**).*

Try to write the sentence the less wordy possible.
Example for 316-322:
The temperature and salinity were gradually decreased, moving from the south to the north. At the surface, the temperature drops from 10 to 1 °C and salinity from 30 to 28. While in the bottom layers, the temperature decreased from 4 to -1.8°C and the salinity from 32 to 30….
318 … The temperature of the bottom water decreased from 4 to -1.3 °C from south to north, while the salinity also decreased from 32 to 30...: The bottom water temperature decreased from 4 to -1.3 °C from south to north, while the salinity also decreased from 32 to 30

321-322: There was a middle cold-water mass with a core temperature of -1.8 °Cin the depth range of 40m ~ 150m below the surface warm water in the Chukchi Sea slope. What was the salinity of this water mass? If you can, please give a more exact position.

Reply:
Thank you for your kindness. I rewrote them as following:
*The temperature and salinity were gradually decreased, moving from the south to the north. At the surface, the temperature drops from 10 to 2 °C and salinity from 30 to 28. The bottom water temperature decreased from 4 to -1.3 °C from south to north, while the salinity also decreased from 32 to 30 (**错误!未找到引用源。**). There was a cold water mass in the depth range of 40m ~ 150m below the surface warm water in the Chukchi Sea slope within the latitude* 74.5°N~76°N *(**错误!未找到引用源。** (b) and (c)) . It's core temperature was about* -1.8℃*, and it's salinity were increased from 32 to 34.5 downward.*

333 ….was shallower than 15 m. And the minimum…: Moreover, the minimum…

Reply:
Thank you for your advice. I rewrote it as following:
Moreover, the minimum of the MLD at the BL section was 6.23 m, which was observed at BL14 station.

335 …BL14 station was located in the northwestern Bering Sea: …located on the…

Reply:
Thank you. I rewrote it as following as you suggested:
The BL14 station was located on the northwestern Bering Sea shelf.

338 …which was located in the continental slope: … on the continental slope

Reply:
Thank you. I rewrote it as following as you suggested:
It occurred at the BL01 station, which was located on the continental slope on the north of the Aleutian Island.

344 …than all the MLD in the Bering Sea shelf: …on the Bering…

Reply:
Thank you. I rewrote it as following as you suggested:
The minimum MLD was 16.32 m at these stations and almost larger than all the MLD on the Bering Sea shelf, including the stations BR04 - BR10.

350 …stations in the Bering Sea shelf:…on the Bering…

Reply:
Thank you. I rewrote it as following as you suggested:
Corresponding to that, the MLD at BR10 and BR11 stations were dramatically greater than those at other BR stations on the Bering Sea shelf.

352-353: The western BS section was under the influence of the water mass named Anadyr Water … The western BS section was under the influence of the Anadyr Water

Reply:
Thank you. I rewrote it as following as you suggested:
The western BS section was under the influence of **the Anadyr Water** in the northwestern Bering Sea, and the eastern BS section was under the influence of the Alaska Coastal Water in the northeastern Bering Sea.

355 … the MLD were all larger:…the MLDs were larger..

Reply:
Thank you. I rewrote it as following as you suggested:
As the water column at BS01 - BS03 was well-mixed, the MLDs were larger than 35 m.

362 …The MLD in the continental slope of the Bering Sea was significantly:… The MLD in the Bering Sea's continental slope was significant…

Reply:
Thank you. I rewrote it as following as you suggested:
*The MLD in the **Bering Sea's continental slope** was significantly greater than those in the basin and the continental shelf.*

384 … The Chukchi Sea is on the north of the Bering Strait:… is north of the Bering Strait:…

Reply:
Thank you. I rewrote it as following as you suggested:
The Chukchi Sea is north of the Bering Strait.

388 … 4.5x10-6 m

Reply:
Thank you. I rewrote it as following as you suggested:

In general, the MLD increased at a rate of $4.5\times10^{-6}\,\mathrm{m}$ *per meter northward along the R section (**错误!未找到引用源。** (a), The rate equals* $\Delta MLD(m)$ *divided by distance (m). So, the rate was dimensionless because both the units of the MLD and*

distance was meter.).

390 … The MLD at stations BT13-BT16 was all greater than:… BT13-BT16 was greater than

Reply:
Thank you. I rewrote it as following as you suggested:
The MLD at stations BT13-BT16 was greater than 15 m and was also greater than the MLD in the Chukchi Sea shelf (Figure 9 (c)).

430 …The isothermal and the isohaline showed a trend of deepening:… The isothermal and the isohaline showed a deepening trend in the Bering Sea slope,

Reply:
Thank you. I rewrote it as following as you suggested:
The isothermal and the isohaline showed a deepening trend in the Bering Sea slope, and the cold water mass in the middle layer also showed a deepening trend (Figure 5 (a)).

431 … than that in the Bering… than in the Bering

Reply:
Thank you. I rewrote it as following as you suggested:
As a result, the MLD in the Bering Sea slope was larger ***than in the Bering Sea*** *basin (Figure 7 (a)).*

444 … advection of the low salinity water:…In what low salinity water are you referring to?

Reply:
Thank you. I rewrote it to make it clear:
That might be the result of the advection of the low-salinity water generated from the melting of sea ice in summer in the Chukchi Sea.

452 … The changes of MLD in the Chukchi Sea slope: …MLD changes in the….

Reply:
Thank you.
Thank you. I rewrote it as following as you suggested:
The MLD changes in the Chukchi Sea slope might be related to the low-salinity water generated from the melting of sea ice in summer and topographical constraints.

459 … caused by the change in temperature.:…caused by temperature changes

Reply:

Thank you. I rewrote it as following as you suggested:
In other words, the change in density was mainly caused by temperature changes.

468 … The contribution from salinity to:…The salinity contribution…

Reply:
Thank you. I rewrote it as following as you suggested:
*The **salinity and the temperature contribution** to the MLD was explored by studying the stratification index.*

479 … research (Johnson et al., 2012): … research of Johnson et al. (2012),

Reply:
Thank you. I rewrote it as following as you suggested:
*This was consistent with the **research of Johnson et al. (2012)**, which showed that the seasonal variation of the mixed layer in the Arctic was dominated by salinity.*

500-501 … The current velocity at BL01was about 0.2m/s and was larger than that in the basin, which was smaller than 0.1m/s, according to our ADCP observations:… The current velocity at BL01was about 0.2m/s, while in the basin was measured less than 0.1m/s according to the ADCP observations.

Reply:
Thank you. I rewrote it as following as you suggested:
The current velocity at BL01was about 0.2m/s, while in the basin was measured less than 0.1m/s according to the ADCP observations.

503-505…On the basin scale, the dominant cyclonic circulation might lead to the MLD in the central part of the Bering Sea basin smaller than that in the continental slope in the rim of the basin… might lead to a smaller MLD in the central part of the Bering Sea basin, than that in the continental slope in the rim of the basin

Reply:
Thank you. I rewrote it as following as you suggested:
On the basin scale, the dominant cyclonic circulation might lead to a smaller MLD in the central part of the Bering Sea basin, than that in the continental slope in the rim of the basin.

520-521:The wind observed by the shipborne automatic meteorological station was used to assess the CCMP wind product -> this is not to be here

Reply:
Thank you. I moved this to section 2.2.

527 …and the north:…and in the north

Reply:
Thank you. I have added the correct preposition as you suggested:
*In the west of the Bering Sea basin, in the northeast of the Bering Sea, and **in the north** of the Chukchi Sea (BL, BS, BT, and M stations), the MLD had a positive correlation with the wind speed, and the correlation coefficient was 0.6 (the red line in **错误!未找到引用源。**).*

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Figures-Tables

Figure 1 or 2: It would be helpful for the reader to show in one of these figures (probably the second) the areas of the Bering Sea shelf & basin, Chukchi Sea self & slope, and the transition zone that you are referring to later in the text.
Also, please show the Anadyr Water in the Figure.

Reply:
Thank you. I have modified Figure 2(a) (Figure 6 in this reply letter) to show the areas of the Bering Sea shelf & basin, Chukchi Sea shelf $ slope. Figure 2(b) was modified to show the Anadyr Water, Alaska Coastal Water and the transition zone that I was referring to later in the text.

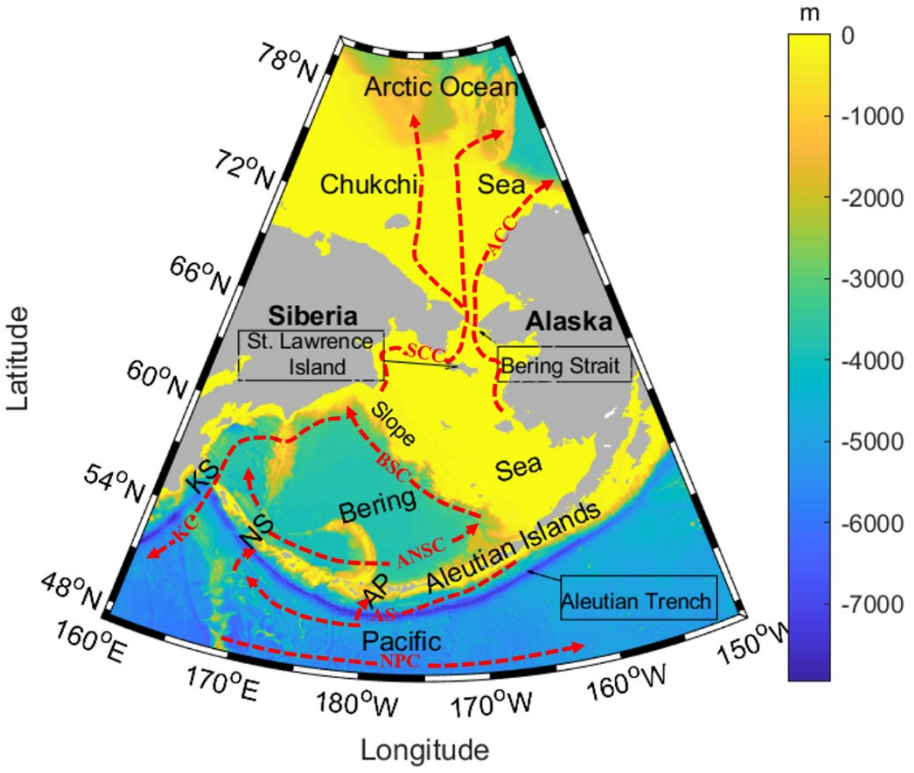

Figure 5 *Figure 1 Topography, bathymetry, and circulation in the Bering Sea, Chukchi Sea, and adjacent region. Abbreviations include: ACC = Alaskan Coastal Current; SCC = Siberian Coastal Current; KC = Kamchatka Current; BSC = Bering Slope Current; ANSC = Aleutian North Slope Current; AS =*

Alaskan Stream; NPC = North Pacific Current; KS=Kamchatka Strait; NS=Near Strait; AP=Amchitka Pass. (Danielson et al., 2014; Kawaguchi & Nishioka, 2020; Johnson and Stabeno, 2017)

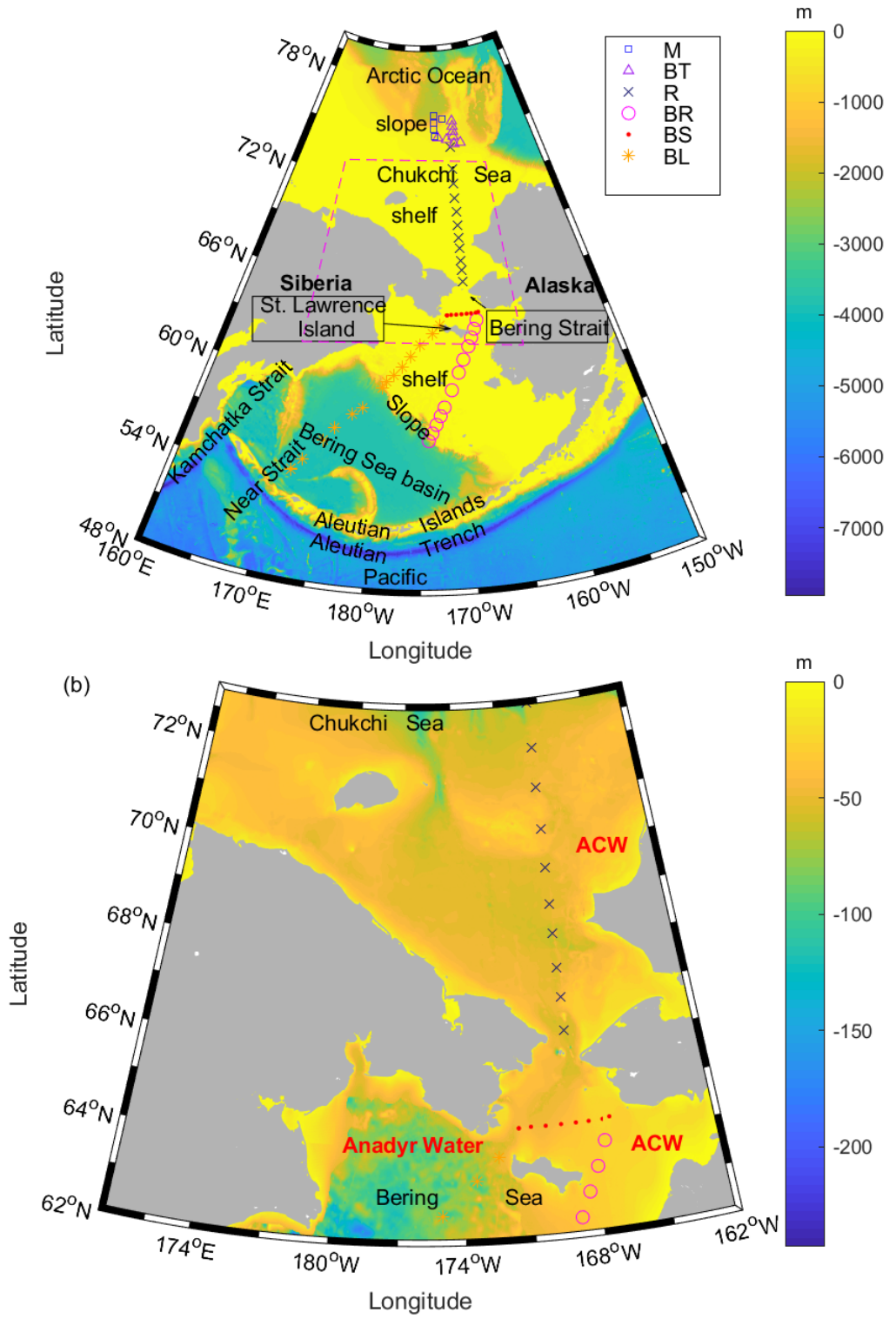

Figure 6 *Figure 2. (a) showed the distribution of the 58 observation stations. The asterisks, dots, circles, crosses, triangle, and squares represented the BL, BS, BR, R, BT, and M section, respectively. (b) showed*

the bathymetry and topography in the dashed line rectangle in (a). ACW was the abbreviation of Alaska Coastal Water.

Figure 3: panel c: what are the two red boxes? Please write it to the caption.

Reply:
I have written the meaning of the red boxes in the caption: The local extremum in the red boxes might lead to smaller MLD than the real MLD.
And more specific quote of the red box was added in the text as well:
BR00 was a station of type B, where the temperature of the mixed layer had local extremum, as shown by the red boxes in Figure 3(b).

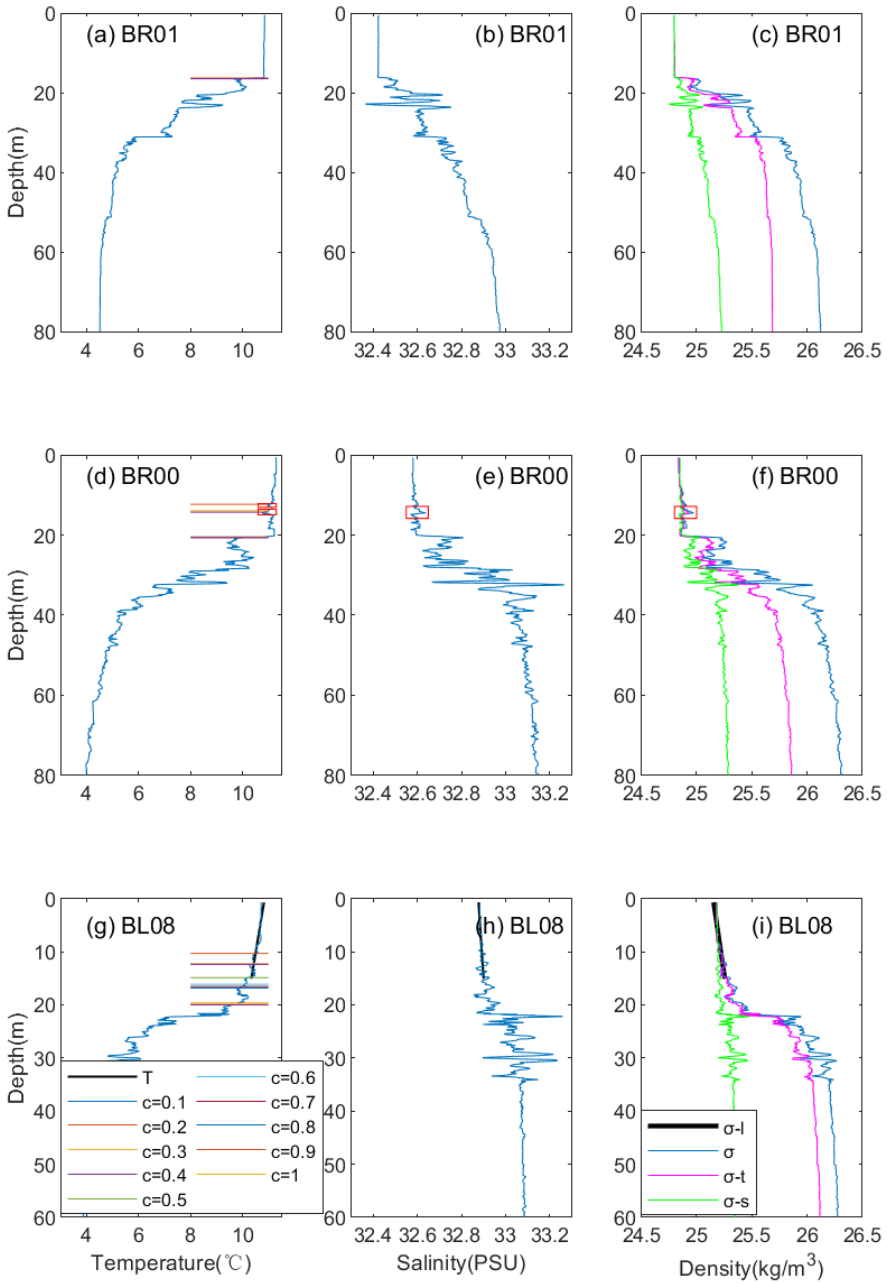

Figure 7 *Figure 3 Three types of temperature, salinity, and density profiles. (a), (b), and (c) showed the type A temperature, salinity, and density profiles, which had almost the same MLDt using different criteria. (d), (e), and (f) showed the type B temperature, salinity, and density profiles, and the MLDt calculated from this temperature profile using different temperature criteria was distributed around the local extremum. The local extremum in the red boxes might lead to smaller MLDt than the real MLDt. (g), (h), and (i) showed the type C temperature, salinity, and density profile; the MLDt calculated from type C temperature profile using different temperature criteria had more difference, and the distributions were more dispersed. Horizontal lines in different colors showed different MLDt responding to a group*

of temperature criteria in (a), (d), and (g). The variable c in the legend represented the temperature criteria which ranged from 0.1 to 1 ℃. The black solid lines in (g), (h), and (i) showed the linear regression of the temperature, salinity, and density profiles within the mixed layer. The magenta (green) solid line in (i) showed density profile calculated from the depth-related temperature (salinity) and the fixed salinity (temperature) at the depth of 5 m.

Figure 4: Does this Figure includes all the stations? If not, it should. I suggest making one panel only, including all the stations (maybe on the vertical axis) and all the MLDts (on the horizontal axis). Also, I don't see the MLDt equal to 0 for the stations BS01-03.

Reply:
Thank you for your suggestions. I modified the figure to include all the stations (on the vertical axis) and all the MLDts. The left panels for MLDt and the right panels for MLDd. The new figure 4 was shown as following:

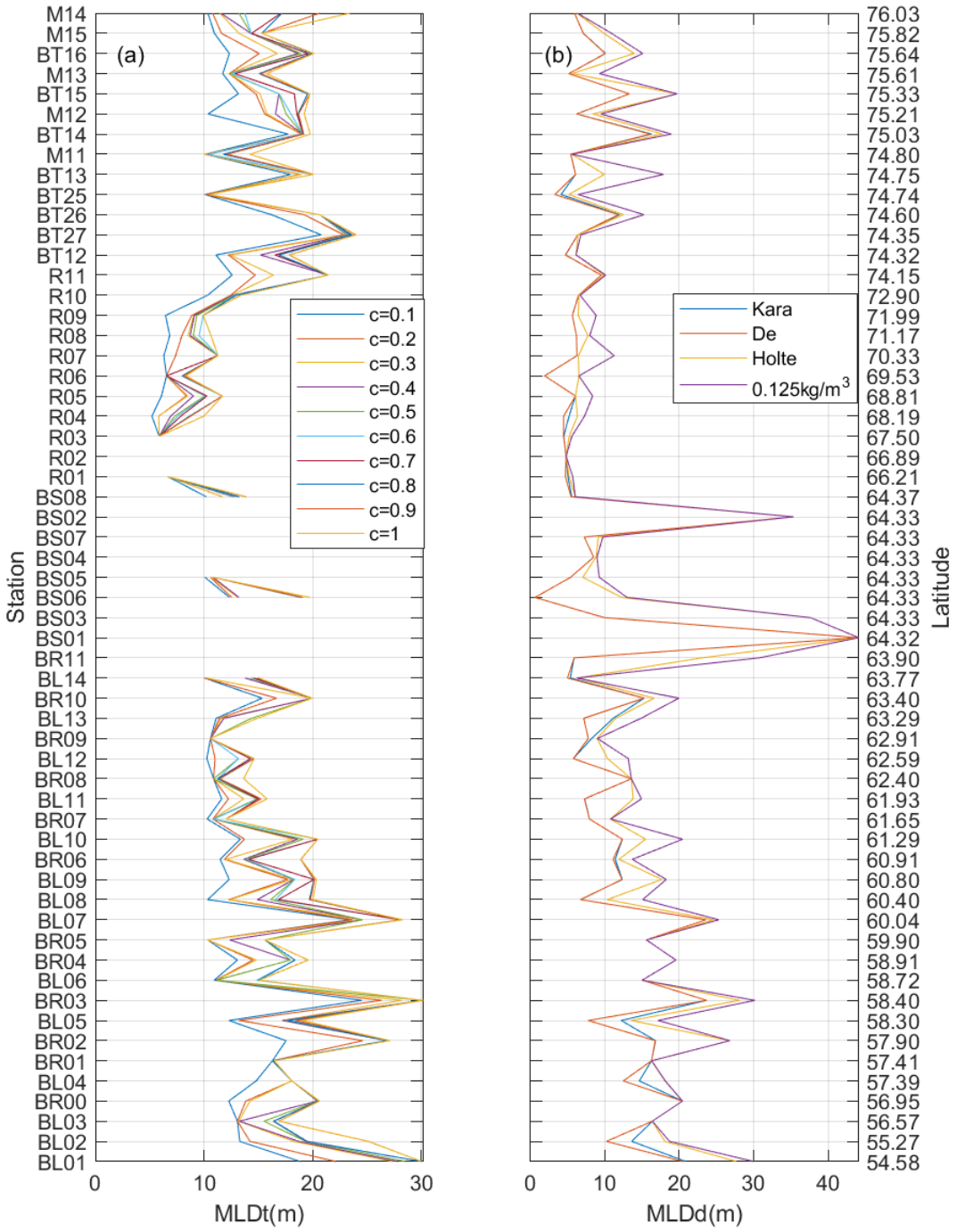

Figure 8 *Figure 4. (a) The MLDt corresponding to a group of temperature criteria. The variable c in the legend represented the temperature criteria which ranged from 0.1 to 1 ℃. (b) The MLDd corresponding to the criteria from the Kara et al. (2000), de Boyer Montégut et al. (2004), Holte et al (2009), and* $\Delta\sigma$=0.125kg / m^3 *, respectively. Both the left and right panels were in ascending order of the latitude.*

Figures 5 and 9: every panel has a different depth, so please clarify the Labels for the depth (m) in each panel. Also, I would recommend adding the MLD line in every plot in these figures to make it easier for the reader to understand the MLD variability in each station.

Reply:

Does your "clarify the Labels for the depth(m)" mean the string "Depth(m)" near the y-axis? If so, as you have mentioned "every panel has a different depth", I changed the figure so every panel had the same depth. I used log scale y-axis. As for your "adding the MLD line in every plot", I added the MLD line as Figures bellow:

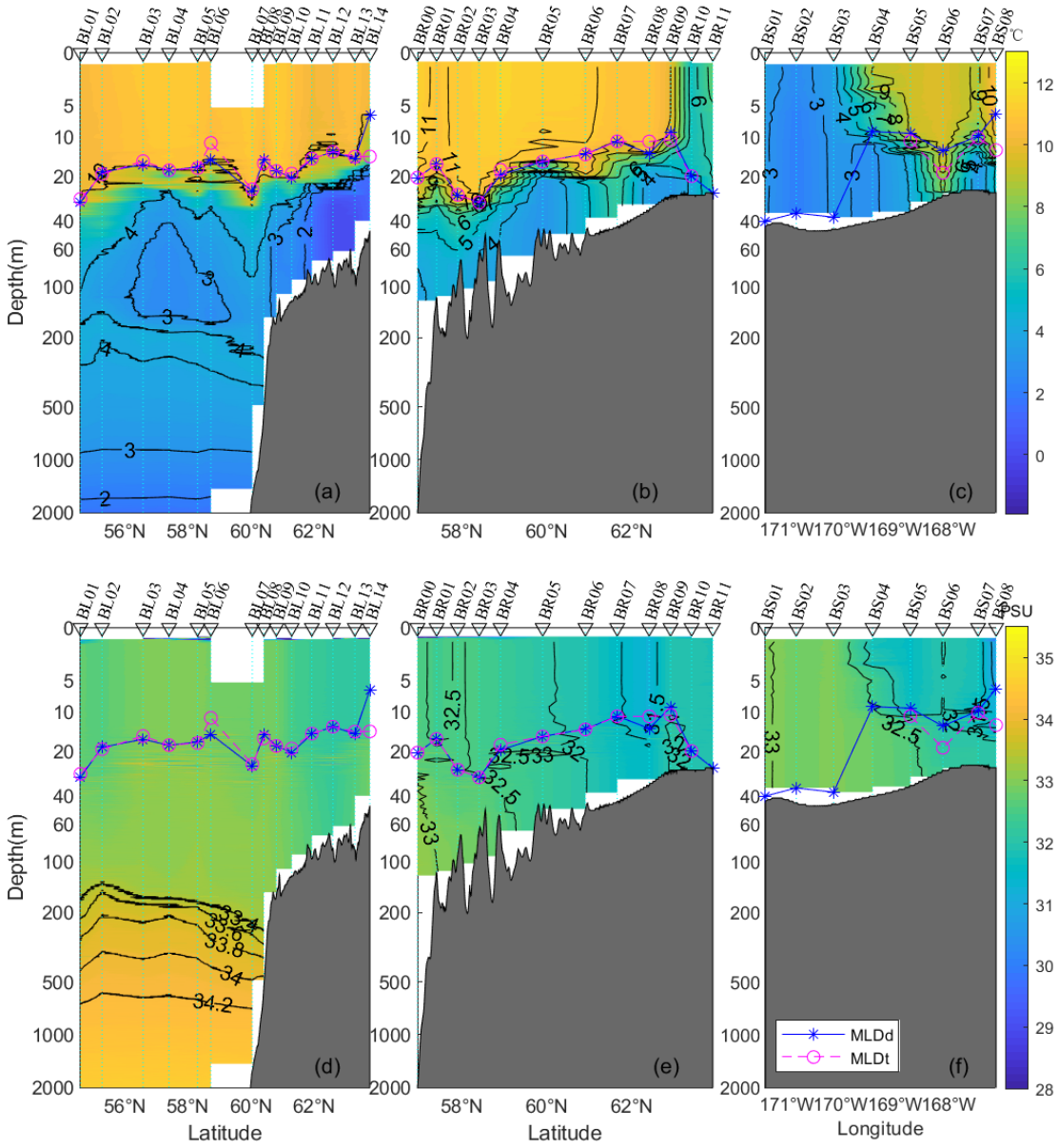

Figure 9 *Figure 5 The upper panels and the lower panels represented the temperature and salinity profiles, respectively. The left (a, d), middle (b, e), and right (c, f) column represented the section of*

BL, BR, and BS, respectively. The blue solid line represented the MLDd. The magenta dashed line represented the MLDt.

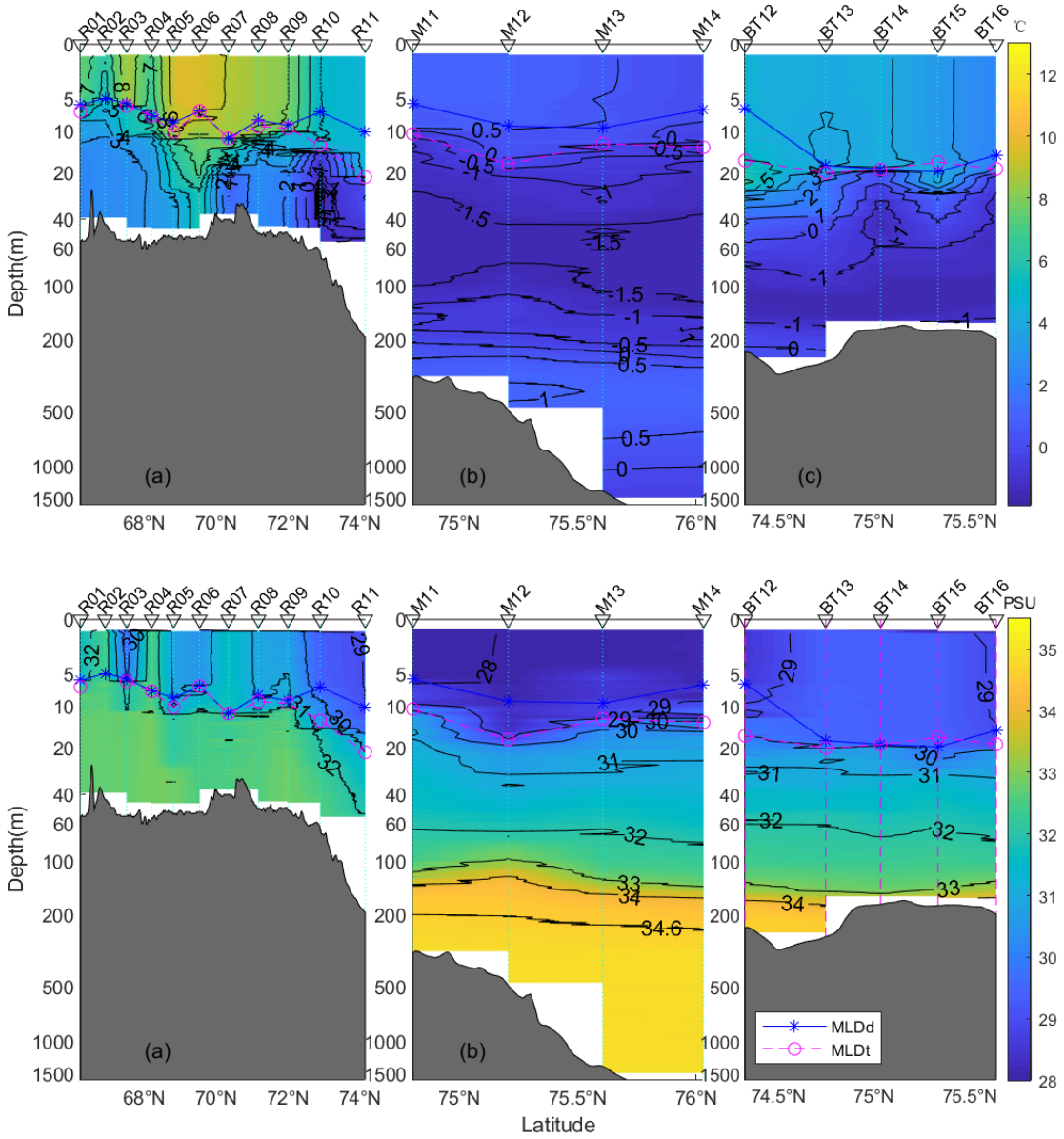

Figure 10 *Figure 8 The upper panels and the lower panels showed temperature and salinity profiles, respectively. The left (a, d), middle (b, e), and right (c, f) column represented the section of R, M, and BT, respectively. The blue solid line represented the MLDd. The magenta dashed line represented the MLDt.*

Figure 10: it is challenging to follow. The axes' colors are mixed; in one panel the left is blue and in the next panel is black. There are the two magenta lines (explained under), but there is a red dashed line in panel a and another dashed line (probably blue) in the rest of the panels without explanation. Please make the Figure better and the captions complete.

Reply:

Thank you for your advice. I changed the left axes' colors to black and the right axes'

colors to blue. I uniformed the color of the lines and completed the captions as well. The Figure 10 in the revised manuscript was in the following (**错误!未找到引用源。**):

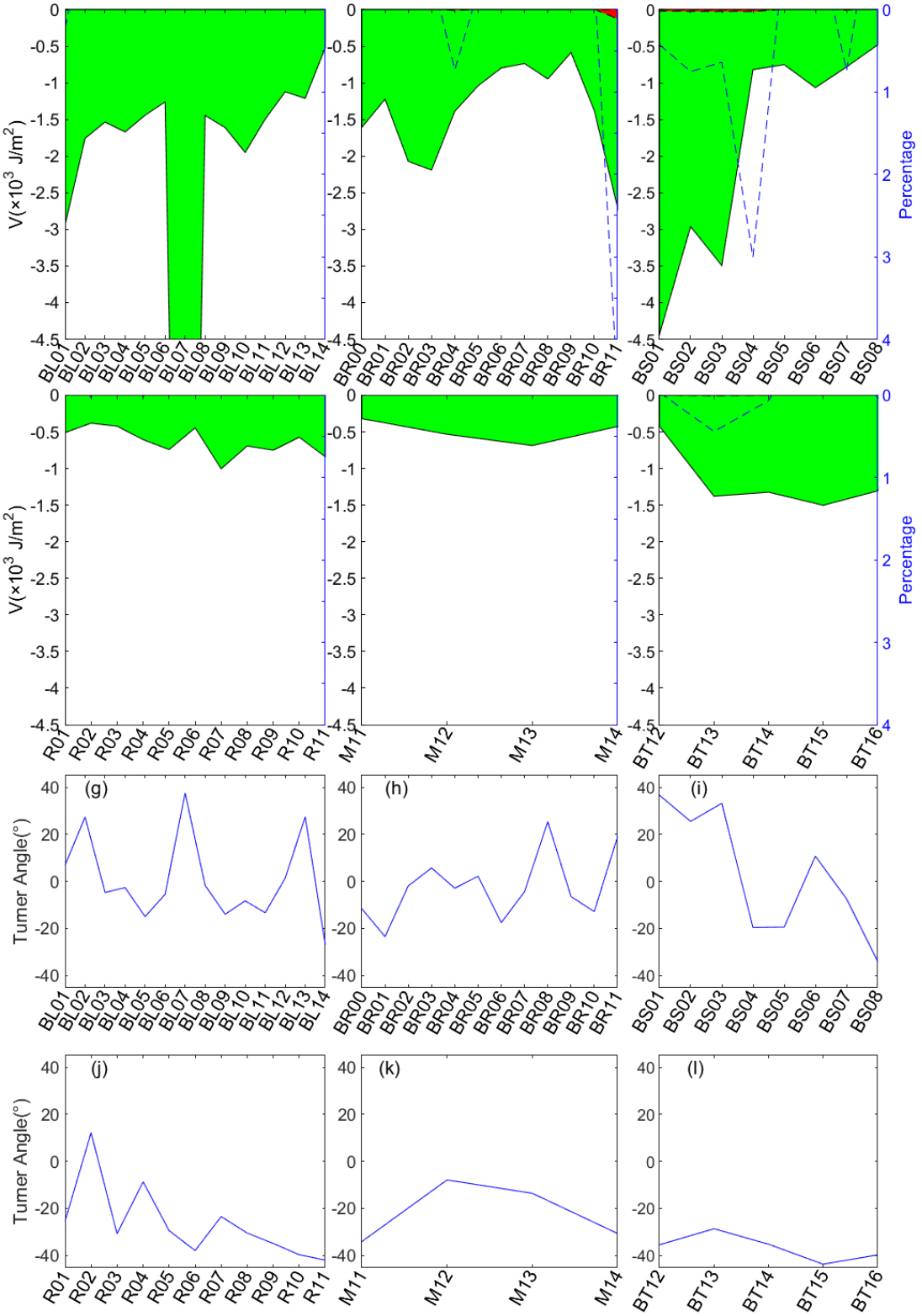

Figure 11 *Figure 10 (a)~(f) The left axis represented the stratification index. Red was the proportion of stratification due to temperature. Green was the proportion due to salinity. The right axis represented the percentage of the contribution of the temperature. The blue dashed line represented the proportion of the contribution of the temperature to the stratification at different stations. (g)~(l) The mean Turner*

Angle (Ruddick, 1983; Clement et al, 2020) within the mixed layer.

Figure 13: …Scatter plot of the wind speed and the MLD in all the stations. …The solid blue line is the regression line of? And the red solid line? Please rewrite the caption

Reply:
Thank you. I rewrote the caption to clarify the meaning the blue solid line and the red solid line. The new caption was:
Scatter plot of wind speed and MLD of all the stations. The red solid line was the regression line between the wind speed and the MLDD in the BL (except BL01), BR, BT, and M stations. The blue solid line was the regression line between the wind speed and the MLDD of all the stations.
The modified Figure 13 was showed in following:

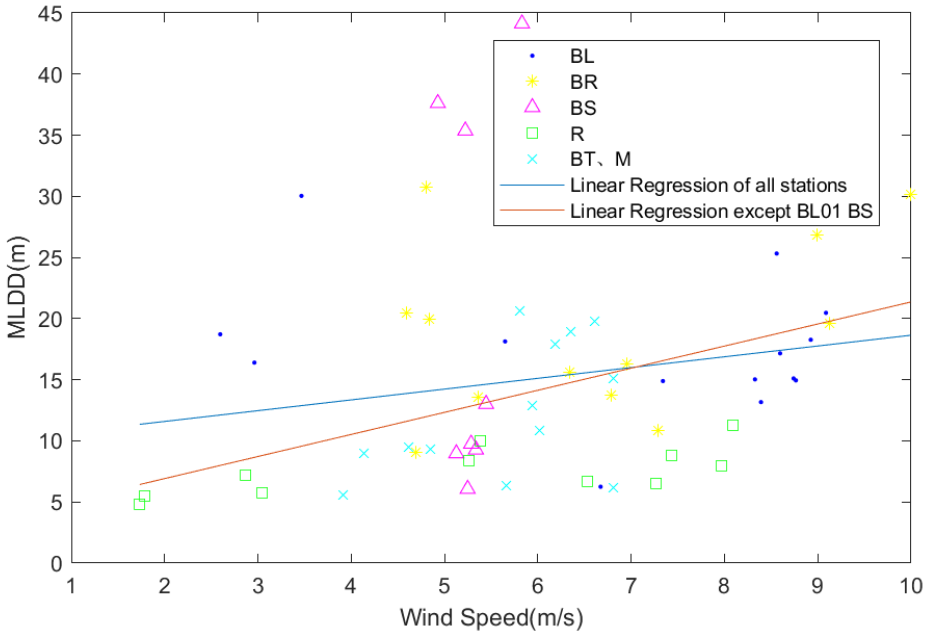

Figure 12 *Figure 13 Scatter plot of wind speed and MLD of all the stations. The red solid line was the regression line between the wind speed and the MLDD in the BL (except BL01), BR, BT, and M stations. The blue solid line was the regression line between the wind speed and the MLDD of all the stations.*

Figure 12: the figure and the caption are confusing, try to make them clearer.

Reply:
Sorry for my fault (The title "m" in the colorbar). I corrected the figure and the caption as well. The new caption was:
(a) The anticyclonic eddy next to station BL01 (The red rectangle in subplot (b)). The contours denoted the sea surface height from satellite observations. The yellow line denoted the track of the ship. The red vectors denoted the surface oceanic current velocity observed by ADCP. (b) The surface eddy street along the Bering Sea slope from the 16-day averaged SLA. The vectors represented the surface

geostrophic flow anomaly. The color denoted the vertical relative vorticity (normalized by the local planetary vorticity, f, i.e., Rossby number) at the sea surface. The red, yellow, and blue solid lines denoted the 200m, 2000m, and 3000m isobaths, respectively. The red rectangle denoted the location of the region in (a). (c) The vertical distribution of the current direction and vertical current shear at the BL01.

The revised Figure was as following:

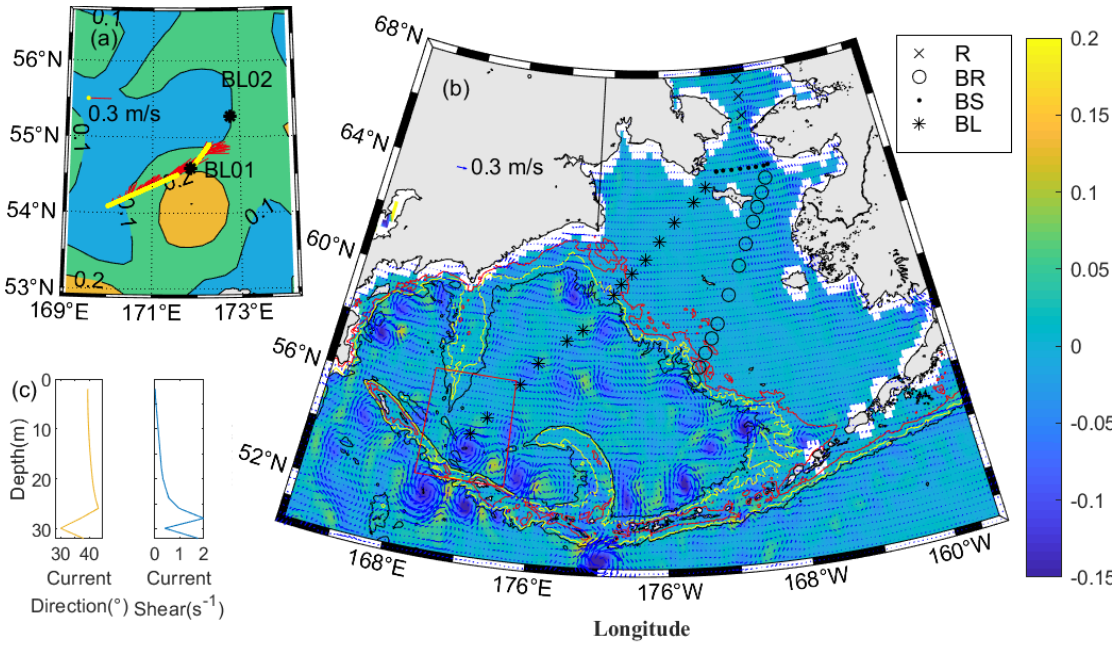

Figure 13 *Figure 12 (a) The anticyclonic eddy next to station BL01 (The red rectangle in subplot (b)). The contours denoted the sea surface height from satellite observations. The yellow line denoted the track of the ship. The red vectors denoted the surface oceanic current velocity observed by ADCP. (b) The surface eddy street along the Bering Sea slope from the 16-day averaged SLA. The vectors represented the surface geostrophic flow anomaly. The color denoted the vertical relative vorticity (normalized by the local planetary vorticity, f, i.e., Rossby number) at the sea surface. The red, yellow, and blue solid lines denoted the 200m, 2000m, and 3000m isobaths, respectively. The red rectangle denoted the location of the region in (a). (c) The vertical distribution of the current direction and vertical current shear at the BL01.*

Figure 14: explain in the caption of the Figure what is the yellow box

Reply:

As you mentioned above, it was unreasonable to say MLDt was zero. So I deleted the similar description here and the yellow box as well. The new Figure 14 in the revised manuscript was as following:

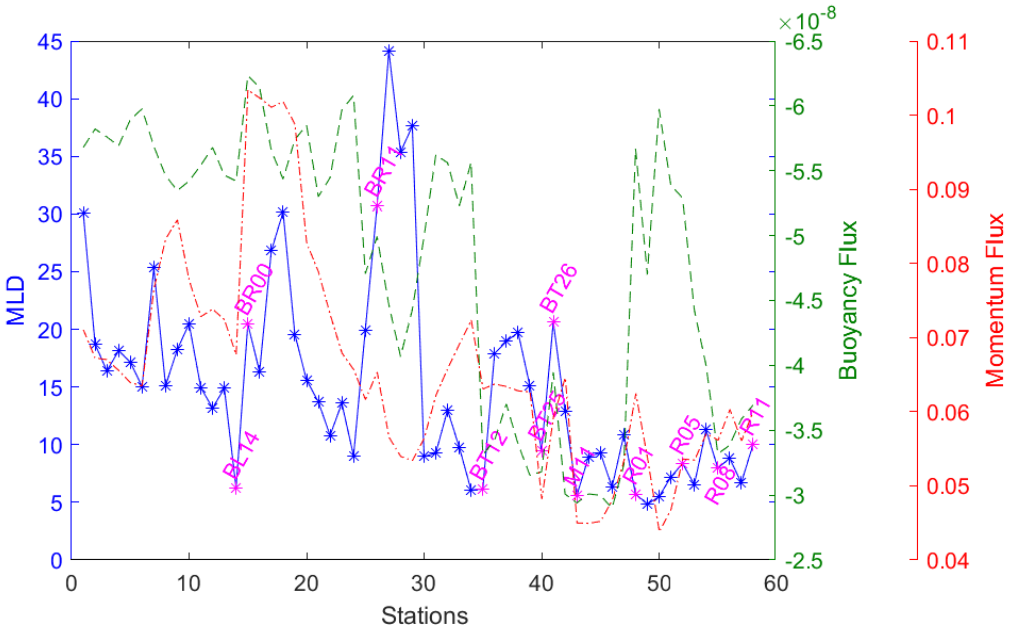

Figure 14 *Figure 13 The buoyancy flux, momentum flux, and MLD of all stations. The buoyancy flux was one-month averaged, and the momentum flux was 10-day averaged. The order of stations is the same was Table 3.*