Response to Review Comments
for

“The response of sea ice and high salinity shelf water in the Ross Ice Shelf Polynya to cyclonic atmosphere circulations”

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Note: Reviewers’ comments are highlighted by blue color; authors’ responses are in black color. Revisions in the revised manuscript are highlighted by blue color.

Reviewer comments:

Anonymous Referee #2:

Using a regional ocean-sea ice-ice shelf model they investigate the role of meso and synoptic scale cyclones in sea ice production, HSSW formation and export from the Ross Ice Shelf polynya. The authors found that the Cyclone caused an increase in the sea ice production rate due to changes in offshore winds and a consequently Enhancement of HSSW formation and export.

While I think that this paper could potentially give an important contribution to the understanding of the processes involved in the dense water formation in the Ross Sea, there are several issues that still need to be addressed before publication.

We thank the reviewer for his/her efforts in reviewing this manuscript and providing useful comments that significantly improved our manuscript.

Overview Comments:

1. The main results of the manuscript are based on the HSSW salinity and volume increase in the RISP, in response to the increase of sea ice production due to the strengthening of off-shore winds during cyclone events. While the increase of SIP occurs in the RISP (Figures 5 and 9), the increase of HSSW salinity and volume takes place in the region west of Ross Island (Figures 6 and 10), which is not in the RISP polynya, but in what is called the McMurdo polynya. Moreover, in this region there is no increase in SIP, so how do you explain the increase in Salinity there?
I suggest setting the western limit of the RISP at Ross Island (approximately 169.5° E; see Tamura et al., 2008; Orsi and Wiederwohl 2009; Drucker et al., 2011) and recalculating the HSSW salinity and volume. In this case, I suspect that you will not observe anymore a significant increase in HSSW salinity and volume during the cyclones events.
Moreover, from the TS diagram in Figures 6 and 10 is not easy to see the change in salinity of the RISP except for the end-members (higher salinity values), it would be easier to make salinity time-series of the surface, intermediate and the bottom layer at a different location along the RISP.

Sorry for the confusion in the RISP definition. As the reviewer suggested, we redefined the boundary of RISP to make a better separation between the McMurdo polynya and RISP. The western boundary has been changed close to the Ross Island as shown in Fig. 2a in the revised manuscript. In addition, HSSW is redefined as the water mass with neutral density (γ^n) above 28.27 kg m^{-3}, salinity (S) $>$ 34.62 and potential temperature (θ) $<$ -1.85° C (Orsi and Wiederwohl, 2009; Castagno et al., 2019) following

Comment #7. All of the related figures and statements have been updated based on this newly defined RISP and HSSW.

As shown in the updated Fig. 6a, HSSW was still mainly formed in the western section of RISP (167°E–176°E) where the increase in SIP can be observed in revised Figs. 5 and 9. In addition, we reproduced the T-S diagrams for selected cyclone events (SYNO1, SYNO2 and MESO) based on the redefined RISP and HSSW in Figs. R1, R2 and R3, which also reveal an increase of HSSW formation in the RISP region (around 167–174°E). The reason why HSSW accumulated in the western RISP may be related to the continuous westward flow along the coastline (at approximately 78°S, 175°E–165°W), which can be observed by Fig. 15 and Fig. S6 in the revised manuscript (particularly prominent in Figs. S6d, e, g, h, f and k). Following the reviewer's suggestion, the T-S diagrams have been modified to the time series of HSSW salinity (Figs. 6, 10 and S3 in the revised version), which still presented similar features to previous T-S diagrams. The relevant statements have been updated based on these time series plots.

References:
Orsi, A. H. and Wiederwohl, C. L.: A recount of Ross Sea waters, Deep. Res. Part II Top. Stud. Oceanogr., 56, 778–795, https://doi.org/10.1016/j.dsr2.2008.10.033, 2009.
Castagno, P., Capozzi, V., DiTullio, G. R., Falco, P., Fusco, G., Rintoul, S. R., Spezie, G., and Budillon, G.: Rebound of shelf water salinity in the Ross Sea, 10, 1–6, https://doi.org/10.1038/s41467-019-13083-8, 2019.

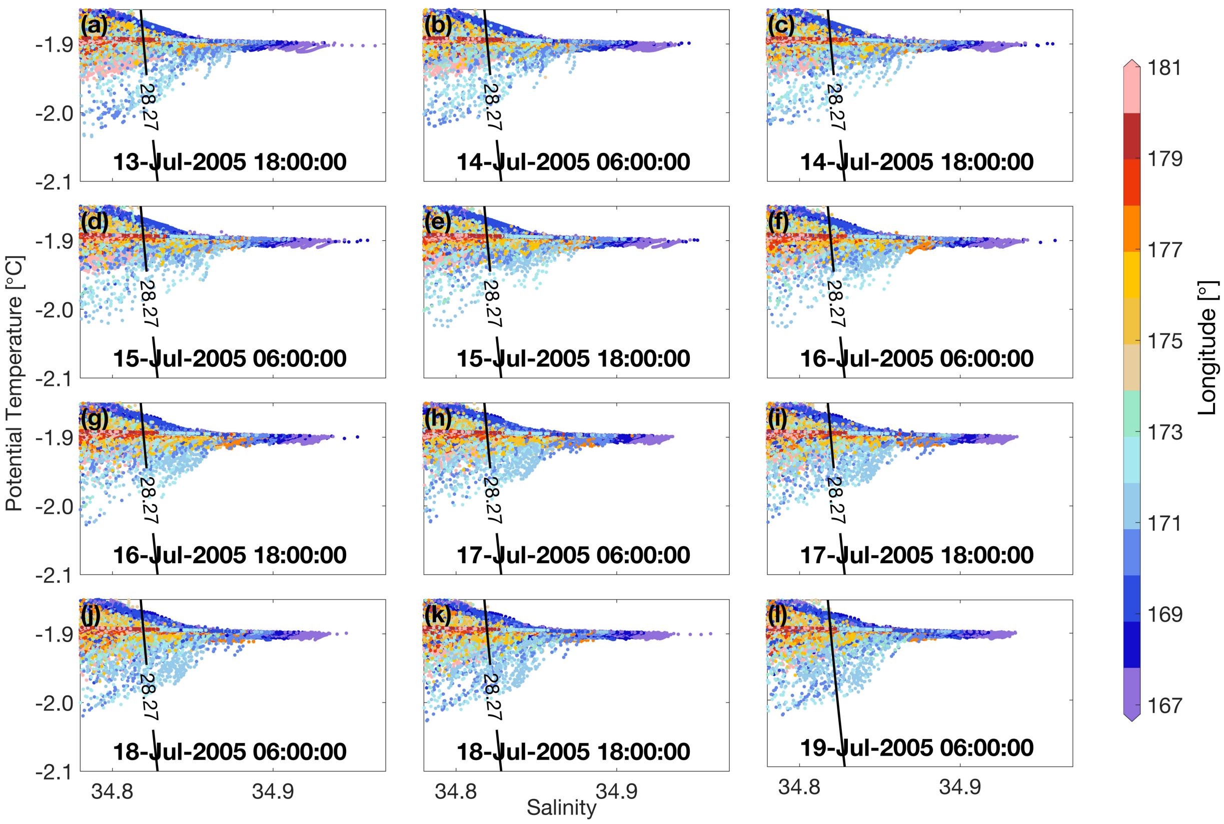

Fig. R1 (a–l) Temperature–salinity (T–S) diagrams for the RISP region shown in revised Fig. 2a during the SYNO1 event from July 13 to July 19 of 2005. The T–S dots are color-coded with longitude. The black isoline denotes the neutral density contour of 28.27 kg m^{-3}.

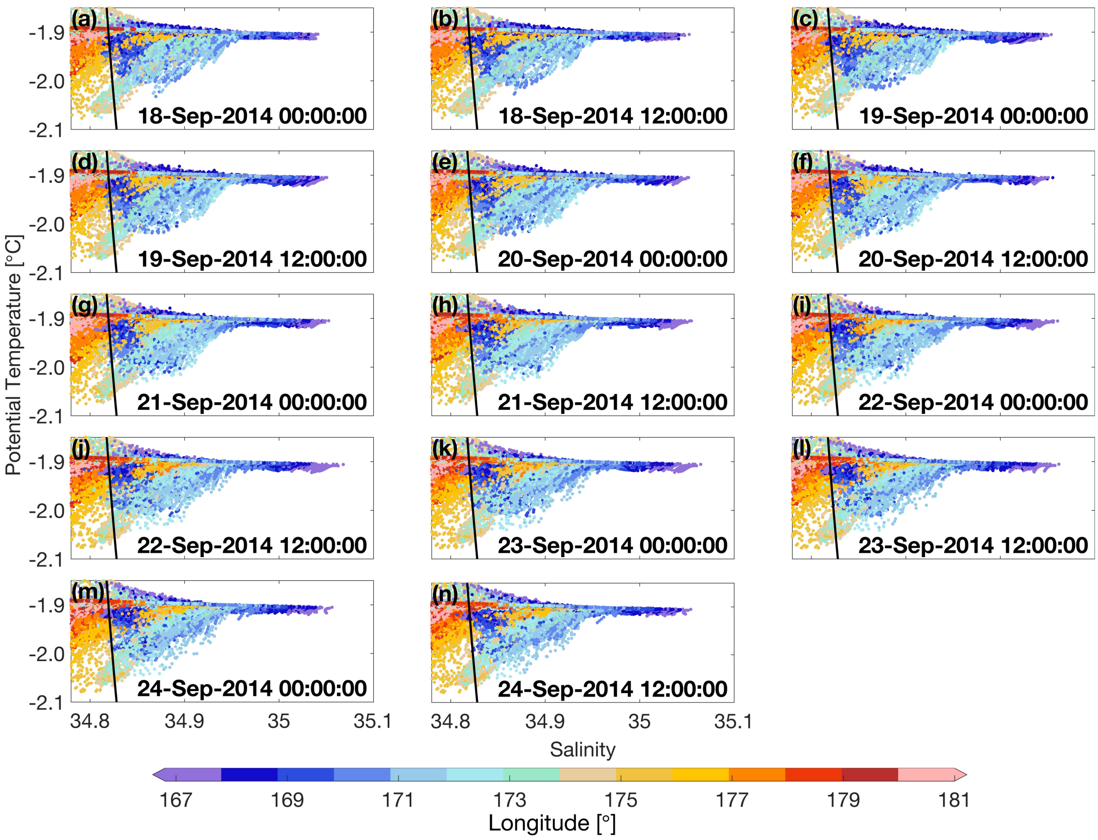

Fig. R2 (a–n) Same as Fig. R1 but for the SYNO2 event from September 18 to September 24 of 2014.

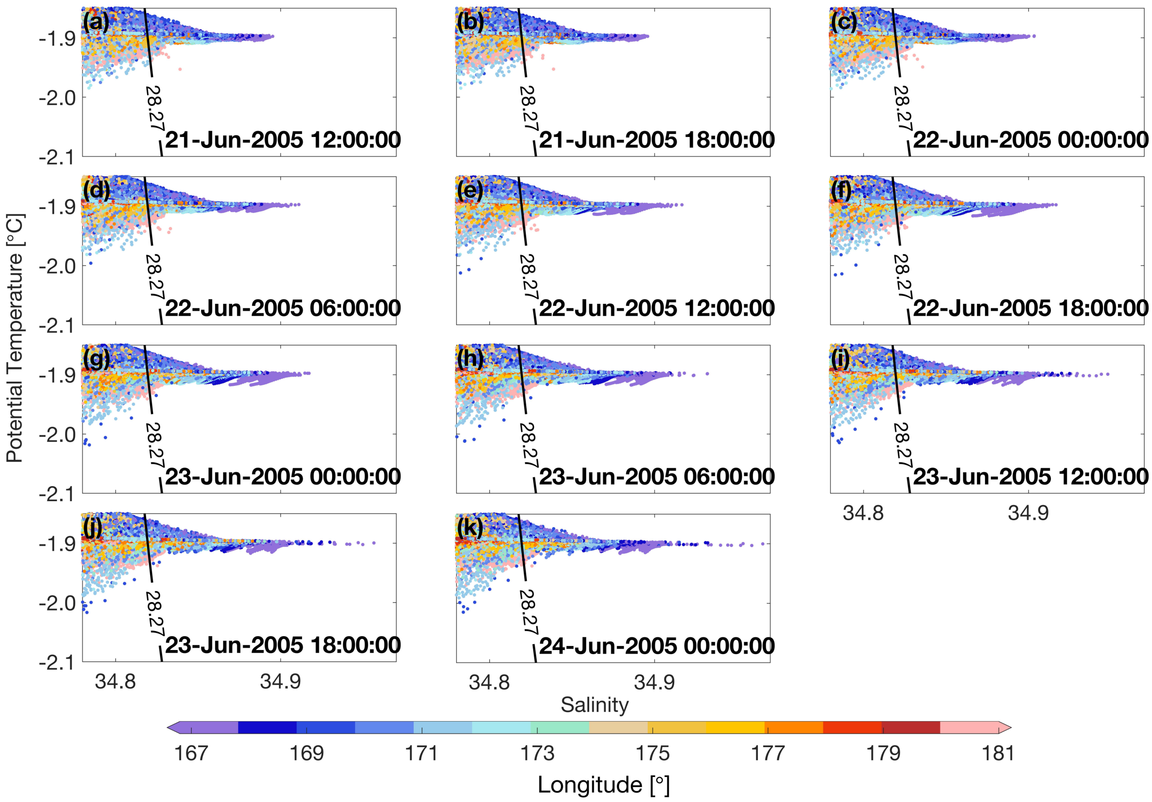

Fig. R3 (a–n) Same as Fig. R1 but for the MESO event from June 21 to June 24 of 2005.

2. One of the main focuses of this work is to estimate the export of HSSW from RISP. If you considered the RISP from 163° to 187° E, why do you draw a meridional transect (S1) in the middle of the polynya? Where the water in S1 is exported from?

Thanks for pointing this out. As mentioned in our reply to Comment #1, the extent of RISP has been revised. For the updated RISP, the meridional transect S1 is located outside the RISP, which makes the calculation of HSSW export reasonable.

3. Because the modelled ocean currents data are crucial to the paper discussion, it would be appropriate to validate those data with in-situ observations. You could use in-situ mooring data in a few areas of the Ross Sea. In the Ross Sea, mooring observations are available from different National programmes (USA, NZ and Italy).

Thanks for this suggestion. It is difficult to conduct point-to-point comparisons, so we have to look at mean pictures of the transport. In Dinniman et al. (2018) with the same model, we mentioned that the pathways were accurate and did look at one mean CDW transport estimate along the western slope of Pennell Bank: "The Ross Sea circulation model accurately simulates the locations of the CDW intrusions [e.g., Fig. 7 in Dinniman et al. (2011); see Fig. S2 in the supplemental material]. Observation-based estimates of total CDW transport onto the Ross Sea continental shelf are limited to a few locations and short periods. The simulated MCDW transport along the western slope of Pennell Bank over a 2-week period in the summer of 2011 [0.22 ± 0.03 Sv (1 Sv ≡ 106 m^3 s^{-1}); McGillicuddy et al. 2015, see their supplemental material] matched observations made at this location over the same period (0.24 Sv; Kohut et al. 2013), suggesting that the volume input is realistically captured in the simulations.".

References:
Dinniman, M. S., Klinck, J. M., and Smith, W. O.: A model study of Circumpolar Deep Water on the West Antarctic Peninsula and Ross Sea continental shelves, Deep. Res. Part II Top. Stud. Oceanogr., 58, 1508–1523, https://doi.org/10.1016/j.dsr2.2010.11.013, 2011.
Dinniman, M. S., Klinck, J. M., Hofmann, E. E., and Smith, W. O.: Effects of projected changes in wind, atmospheric temperature, and freshwater inflow on the Ross Sea, J. Clim., 31, 1619–1635, https://doi.org/10.1175/JCLI-D-17-0351.1, 2018.
Kohut, J., E. Hunter, and B. Huber, 2013: Small-scale variability of the cross-shelf flow over the outer shelf of the Ross Sea. J. Geophys. Res. Oceans, 118, 1863–1876, https://doi.org/ 10.1002/jgrc.20090.
McGillicuddy, D. J., and Coauthors, 2015: Iron supply and demand in an Antarctic shelf ecosystem. Geophys. Res. Lett., 42, 8088– 8097, https://doi.org/10.1002/2015GL065727.

4. The proposed mechanisms in paragraphs 3.4 and 3.5 are not convincing (in other words, too speculative). I think that the discussions need solid improvements. See below.

Following the reviewer's suggestions, much more calculations and discussions have been conducted to improve the credibility of our study. Please see more detailed information in Comments #17–22.

5. Many works have shown the direct role of the winds on the DSW formation, and because the cyclone influences the local wind dynamics, it is obvious that changes in the position and scale of a cyclone may have slightly different effects on the dense water formation. A more interesting work would be to statistical analysis of the cumulative effect of cyclones on the HSSW formation during the winter season and on the HSSW salinity trends and interannual variability.

It is true that many previous studies have already revealed the effects of winds on water mass formation processes including HSSW and AABW (for instance Mathiot et al., 2010; Barthélemy et al., 2012). The majority of these studies are focused on the seasonal scale or longer time scales. In reality, there are more high-frequency strong wind events (i.e., cyclones) occurring in the Ross Sea and East Antarctica (Uotila et al., 2011; Turner et al., 2009; Chenoli et al., 2015), and the main purpose of this study is to elucidate the impacts of typical cyclone events on sea ice and HSSW in RISP on a shorter time scale (i.e., synoptic-scale influences) by quantifying the variations and response time for different variables. In our previous study targeted on the Prydz Bay and Shackleton polynyas (Wang et al., 2021), the seasonal effects of strong wind events related to cyclones on HSSW formation have been identified, showing that the duration of strong wind events over the winter season could significantly affect the HSSW formation in the deep ocean. Such investigations are also important for the Ross Sea, but considering the length of the current manuscript (particularly the number of figures), we decided to put such analysis in a future work, and we thank the review for this suggestion.

References:
Barthélemy, A., Goosse, H., Mathiot, P., and Fichefet, T.: Inclusion of a katabatic wind correction in a coarse-resolution global coupled climate model, Ocean Model., 48, 45–54, https://doi.org/10.1016/j.ocemod.2012.03.002, 2012.
Chenoli, S. N., Turner, J., and Samah, A. A.: A strong wind event on the ross ice shelf, antarctica: A case study of scale interactions, Mon. Weather Rev., 143, 4163–4180, https://doi.org/10.1175/MWR-D-15-0002.1, 2015.
Mathiot, P., Barnier, B., Gallée, H., Molines, J. M., Sommer, J. Le, Juza, M., and Penduff, T.: Introducing katabatic winds in global ERA40 fields to simulate their impacts on the Southern Ocean and sea-ice, Ocean Model., 35, 146–160, https://doi.org/10.1016/j.ocemod.2010.07.001, 2010.
Turner, J., Chenoli, S. N., Abu Samah, A., Marshall, G., Phillips, T., and Orr, A.: Strong wind events in the Antarctic, J. Geophys. Res. Atmos., 114, https://doi.org/10.1029/2008JD011642, 2009.
Uotila, P., Vihma, T., Pezza, A. B., Simmonds, I., Keay, K., and Lynch, A. H.: Relationships between Antarctic cyclones and surface conditions as derived from high-resolution numerical weather prediction data, J. Geophys. Res. Atmos., 116, 1–14, https://doi.org/10.1029/2010JD015358, 2011.
Wang, X., Zhang, Z., Wang, X., Vihma, T., Zhou, M., Yu, L., Uotila, P., and Sein, D. V.: Impacts of strong wind events on sea ice and water mass properties in Antarctic coastal polynyas, Clim. Dyn., 57, 3505–3528, https://doi.org/10.1007/s00382-021-05878-7, 2021.

Specific Comments:

6. Line 28-30: in this paper, you have chosen to represent positive along shelf velocity with a westward current, but in general in Oceanography a positive zonal component is considered to be positive in the eastward direction, so it is a bit confusing. Therefore, here I suggest explicit the direction of the correlation: transport direction (eastward or westward) with the wind direction (northward or southward).

The definition of along-shelf velocity sign in the original manuscript is indeed not common in the oceanography community, though we wanted to define the direction of HSSW export toward the slope (westward) as positive. As the reviewer suggested, we changed the definition and now the eastward direction is defined positive in the revised manuscript. All related texts and figures (revised Figs. 7 and 11) have been updated using this new definition.

7. Line 190-191: In order to define and identify HSSW in the Ross Sea I suggest using the definition proposed by Orsi and Wiederwohl (2009) that is more commonly used by the Ross Sea community. This definition uses both traditional thermohaline parameters (potential temperature and salinity S) and neutral density.

The definition of HSSW has been revised according to the reviewer's suggestion. Please see our detailed response to Comment #1.

8. Line 216-221: The sentence "three-dimensional along-shelf and cross-shelf momentum equations are..., where $\frac{\partial u}{\partial t}$ and $\frac{\partial v}{\partial t}$ are the alongshore and cross-shore components of velocity," is a bit confusing. it is not clear if the currents are along-shelf (parallel to the shelf-break?) or along-shore (along the Ross Ice shelf?). I suggest to use along and across the Ice shelf.

The original sentence has been revised to "The three-dimensional along-ice-shelf and across-ice-shelf (defined by local acceleration terms) momentum equations are…where u and v are the along-ice-shelf and across-ice-shelf components of velocity…" to make the direction clear (Lines 224–229 in the revised version). Furthermore, the model girds have been shown in Fig. 1b to illustrate the along- and across-ice-shelf directions.

9. Lines 236-237: looking to figure 3a I can see the lowest density in the western ross sea (dark blue), lower than the eastern Ross Sea (light blue) and the highest density outside the Ross Sea, west of Cape Adare.

Sorry for the inaccurate expression. The original sentence "The high track density of synoptic-scale cyclones extends to the continental shelf and coastal regions in the western Ross Sea (Fig. 3a)." has been revised to "The high track density of synoptic-scale cyclones extends to the continental slope regions of the western Ross Sea (at around 65°S, Fig. 3a)" (Lines 246–247 in the revised version).

10. Lines 237-238: you should change the wording to explain the figure better. I see a higher density at 180° outside the continental shelf and not close to the RIS.

The original sentence "For mesoscale cyclones, a large number of track densities appear at the center of the Ross Sea (at about 180° meridional) in front of the RIS central region (Fig. 3b), which…" has been revised to "For mesoscale cyclones, on the Ross Sea continental shelf a large number of track densities appear in front of the RIS central region (near the ~180° meridian, Fig. 3b), which…" to make a clearer statement (Lines 247–248 in the revised version).

11. Line 294: Salinity is overestimated (See Orsi and Wiederwohl 2009; Jacobs et al., 2022). The region 163°E–164°E is not in the RISP (Tamura et al., 2008; Orsi and Wiederwohl 2009; Drucker et al., 2011).

As mentioned in our response to Comment #1, the western boundary of RISP has been revised. The updated salinity values are more reasonable and lower than previous ones (Figs. 6, 10 and S3 in the revised version).

12. Lines 294-296: Here you suggest that the increase in salinity occurs in the region 163°E–164°E, when is observed an increase in SIP. From figure 5, I can see the increase in SIP in the region east of Ross Island (169.5), how the increase in salinity in the region 163°-164° E (that is outside the RISP) is explained by the increase in SIP west of 169.5 at about the same time (The distance between these 2 regions is not less than 150 Km)?

The initial idea was that the SIP change in the region east of the Ross Island can affect the HSSW on the west by the westward coastal current along the RIS, which could be seen in the upper layers in Fig. 15 and Fig. S7 (particularly eminent in Figs. S7d, e, g, h, f and k). Meanwhile, we apologize for the misunderstanding here. What we were trying to demonstrate was that SIP can regulate changes in the salinity of HSSW on the western RISP, but did not emphasize the instantaneous correlation between these two variables. Instead, the persistence of the increase in HSSW salinity indicates that there is a lagging or cumulative effect of the HSSW response to SIP. Anyway, in summary, the T-S diagrams have been modified into time series plots to facilitate a better interpretation of the changes in HSSW salinity (Figs. 6, 10 and S3 in the revised version).

13. Lines 319-321: I think this expression is misleading. In this paper, the positive velocity is considered westward, whilst usually, the positive zonal velocity is considered to be eastward.

Please see our response to Comment #6. The related sentences have been revised to "Meanwhile, there was notable change in the cross-transect current velocity: the positive (eastward) velocity in the upper layer between 76.7°S and 76.5°S decreased significantly, while the negative (westward) velocity in the bottom layer increased (Figs. 8f to i and l). Both features could lead to reduced eastward exports when the wind speed decreased." (Lines 345–348 in the revised version).

14. Line 368: Also in SYNO2 the salinity increases mostly west of RI, and not in the RISP.

Please see our response to Comment #1.

15. Lines 369-371: I do not think that the HSSW salinity decreased in relation to the decrease in SIP on the eastern side of the RISP. During stage I of SYNO2 (Figure S3) the salinity increases mostly west of Ross island, therefore most probably, HSSW salinity is not affected by the SIP decrease in the eastern Ross Sea. Moreover, In the Eastern RIS, the salinity is much lower compared to the western Ross Sea and there is no HSSW production (Orsi and Wiederwohl 2009), therefore is not clear how the SIP reduction in the eastern RISP helps to decrease the salinity of the HSSW.

Based on the updated results in the revised version, the related statements in this part have been modified to "For the water mass response, HSSW volume variability in the RISP increased significantly until 00:00 on 21 September and then remained positive values for at least 60 hours (Fig. S3a). The salinity of newly formed HSSW increased to 34.84 psu at 00:00 of September 21 after Stage I and II of the SYNO2 cyclone (Figs. S3b). Afterwards, the volume and salinity of HSSW kept increasing for 36 hours when the coastal SIP was already decreasing (Figs. S2 and S3)." (Lines 386–390 in the revised version).

16. Lines 465-466: you haven't mentioned before that at S1 in Syno1 there is a 12 hours lag between HSSW export and the wind.

Sorry for this typo. S1 should be changed to S3 based on the previous results. The original sentence has been revised to "As there are lag correlations between wind speed and current velocity both for S1 and S3, such a relationship can explain why the HSSW export also exhibited lag responses to the wind speed." according to the updated results (Lines 483–485 in the revised version).

17. Lines 489-490: I suggest showing the figure in the supplementary material.

Following the reviewer's suggestion, the momentum analysis results for SYNO1 are shown in Figs. S4 and S5 in the revised supplementary material, and these figures are also mentioned in the text as "For SYNO1 (Figs. S4 and S5), the momentum balance presents similar results to those of MESO." (Lines 514–515 in the revised version).

18. Line 491: "are displayed in the cross-shelf (Fig. 12) and along-shelf (Fig. 13) directions respectively." Is along-shelf in figure 12 (Transect S1) and cross-shelf in Figure 13 (transect S3)?

No, the momentum equation used for the meridional transect S1 is for the across-ice-shelf component ($\frac{\partial v}{\partial t} = -fu$..., which defined by local acceleration terms). For the zonal transect S3, the across-transect velocity is regulated by the along-ice-shelf equation ($\frac{\partial u}{\partial t} = fv$...). To make a clearer statement, related sentences have been added in the revised version as we mentioned in Comment #8.

19. Lines 504-507: In Figure S4, I can't see the intensified westward Ekman transport in the region 74°-76.5° S and 163°-167° E. Moreover, Why the increase in the off-shore winds intensify the westward Ekman transport only in that region of the Ross Sea? Please explain.
In addition, in case there is an increase in the pressure gradient between 74°-76.5° region and the RIS, why do we observe the increase in the eastward transport only in a part of transect S1 and not in the whole transect?
Furthermore, the geostrophic flow due to a tilt in the sea surface slope should be mostly barotropic. In figure 7 (and 11) does not look like the transport is barotropic.
You should also consider that the pressure gradients depend both on the sea surface slope and the density gradient between the RIS and the outer shelf. During cyclones, the increase in SIP and salinity close to the RIS should enhance the geostrophic flow due to the salinity differences.

The region bounded by 74°–76.5°S and 163°–167°E has been highlighted for better revealing of the westward Ekman transport (marked by the blue boxes in Figs.15d and 15j in the revised manuscript). An explanation as to why enhanced westward Ekman transport was only observed in this region is actually given in the original version, but may not be clear enough. The first reason is that during the MESO event, only the west section of RISP (approximately west of 180°) was dominated by offshore winds (updated Fig. 8), which leads to the westward Ekman transport. Moreover, a southeastward flow persisted close to the Ross Island, which was captured over the entire depth (Fig. 15 in the revised version). The water transport carried by this southeastward flow could result in a consistent lower sea surface elevation in this region near S1 (revised Fig. 14), then inducing a continuous pressure gradient force that plays a dominant role on the local currents. Therefore, the Ekman transport would not work in this region. The detailed information about "the southeastward flow" has been addressed in Comment #20. So to conclude, the intensified Ekman transport is only observed in the northwest region of the Ross Sea.

To give a better interpretation of this part. The sentence "These features suggest that the increased offshore winds induced intensified westward Ekman transports in the upper layer over 74–76.5°S and 163–173°E just north of S1 (Fig. S4), eventually resulting in the higher sea surface elevation in this region (Figs. 14b and 14d). Meanwhile, the relatively strong vertical shear in the upper layer suggests that the Ekman transport could dominate on top of the interior geostrophic current (Figs. 12j and 12t). However, near the RIS over 163–173°E where offshore winds also prevailed, the increase in surface elevation could barely be detected." has been revised to "These features suggest that the increased offshore winds induced intensified westward Ekman transports in the upper layer in the area bounded by 74–76.5°S and 163–176°E just north of S1 (marked by the blue box in Figs. 15d and 15j), eventually resulting in the higher sea surface in this region (Figs. 14b and 14d). Meanwhile, the relatively strong vertical shear in the upper layer suggests that the Ekman transport could dominate on top of the interior geostrophic current (Figs. 13j and 13t), which contributed to the variation of SSH over S1. However, near the RIS between 163°E and 176°E where offshore winds also prevailed, the increase in surface elevation (i.e., the enhanced westward Ekman transport) could barely be detected (Fig. 15)." (Lines 534–542 in the revised version).

Following the reviewers' suggestions, we further calculated the barotropic and baroclinic components of the geostrophic currents to make more solid discussions. A As shown in the revised Fig.14, the barotropic flow over S1 is similar to the ocean currents in the upper layer (revised Figs.15a, d, g and j), which presents a southeastward flow across S1. To further identify the dominant flow component on the defined transects (S1, S2 and S3), the vertical sections of cross-transect velocity for barotropic and baroclinic geostrophic flow during SYNO1 and MESO were presented by Figs. S8–S11 in the revised supplementary material. The related features for S1 have been added as "In addition, we further examined the barotropic and baroclinic components for this geostrophic flow along S1 (Figs. S8 and S9). The positive (eastward) velocity in the upper layer in the area bounded by 77.1–76.9°S and 76.7–76.5°S (Figs. 11c, f, i and l) is regulated by the barotropic current (Figs. S8a, d, g and j), while the negative (westward) velocity in the deeper layer (Figs. 11c, f, i and l) is related to the baroclinic component resulting from the density differences across S1 (Figs. S9a, d, g and j)." (Lines 551–556 in the revised manuscript). For S3, the updated findings have been added as "Such barotropic currents could be identified on S3 in Fig. S8. Meanwhile, the baroclinic geostrophic flow also plays an important role in HSSW export across S3 (Figs. S9c, f, i and l). Therefore, the northward flow is regulated by both barotropic and baroclinic components. These features for MESO are consistent with that we found for SYNO1 (Figs. S10 and S11)." (Lines 570–574 in the revised manuscript).

20. Lines 511-516: In Figure S4, I can barely see the eastward flow in the upper layer. Looking at the figure all I can see is a very chaotic circulation with currents directed in the opposite direction at close nodes, especially close to the RIS and Ross Island. Moreover, along the RIS, a strong coastal current has been observed that flows westward and not eastward (Pillsbury & Jacobs 1985; Jacobs & Giulivi 1998; Smith et al., 2012; Porter et al., 2019).
Could it be useful to show a figure with the mean surface circulation across S1? Furthermore, I do not think that in the upper layer (50 m) the HSSW can flow underneath the RIS. The RIS thickness at the front is no less than 150-200 m thick, well below the depth of 50 m.
Moreover, both Budillon et al. (2003) and Jendersie et al. (2018) show an inflow of HSSW underneath the RIS in the deep layer and not in the upper 50 m layer as observed here.

We are sorry that we found a mistake over the RIS region when producing the original Fig. S4, and the current patterns outside the ice shelf region were correct. In the revised figures, there are no flows at 50 m over the RIS region (see revised Fig. 15 and R4), which is reasonable now. Meanwhile, the spatial pattern of averaged circulation for the surface, intermediate, and bottom layers has been presented in Fig. R4 as the reviewer suggested. By comparing the features between Fig. R4 and original Fig. S4 (now revised as Fig. 15 in the main text), there are no big differences and still some chaotic currents over S1. Therefore, to more clearly demonstrate the eastward flow mentioned in the main text, we have marked the relevant area with yellow boxes near S1 (updated Fig. 15). By examining the current patterns within the boxed area over S1, there was a southeastward flow that could be observed at depths of 300 and 500 m and can further flow underneath the RIS reach around 78°S. The components of this southeastward flow in different directions can be clearly shown in the revised Fig. S6 and Fig. S7 respectively. So generally, this flow is consistent with the HSSW inflow mentioned by Budillon et al. (2003) and Jendersie et al. (2018). In addition, the strong westward flow along the RIS mentioned by the reviewer could also be found in Fig. S6 (indicated in blue along coastlines).

The related statement "After examining the horizontal pattern of currents over the Ross Sea, we found a current flowing from west to east across S1 located north of the Ross Island, which further flowed southward below the RIS (Fig. S4) in the upper layer." has been modified to "After examining the horizontal pattern of currents over the Ross Sea, we found a southeastward flow across S1 located north of the Ross Island (within the yellow boxed area near S1 in Fig. 15), which can also be detected in Fig. 14, suggesting that it can be regarded as the barotropic flow resulting from sea surface change. Furthermore, this southeastward current further flowed southward below the RIS in the deeper layer (Figs. 15b, c, e, f, h, i, k and l), and the zonal and meridional components of this southeast flow can be observed more clearly in Fig. S6 and Fig. S7 respectively." to better explain this phenomenon (Lines 542–547 in the revised version).

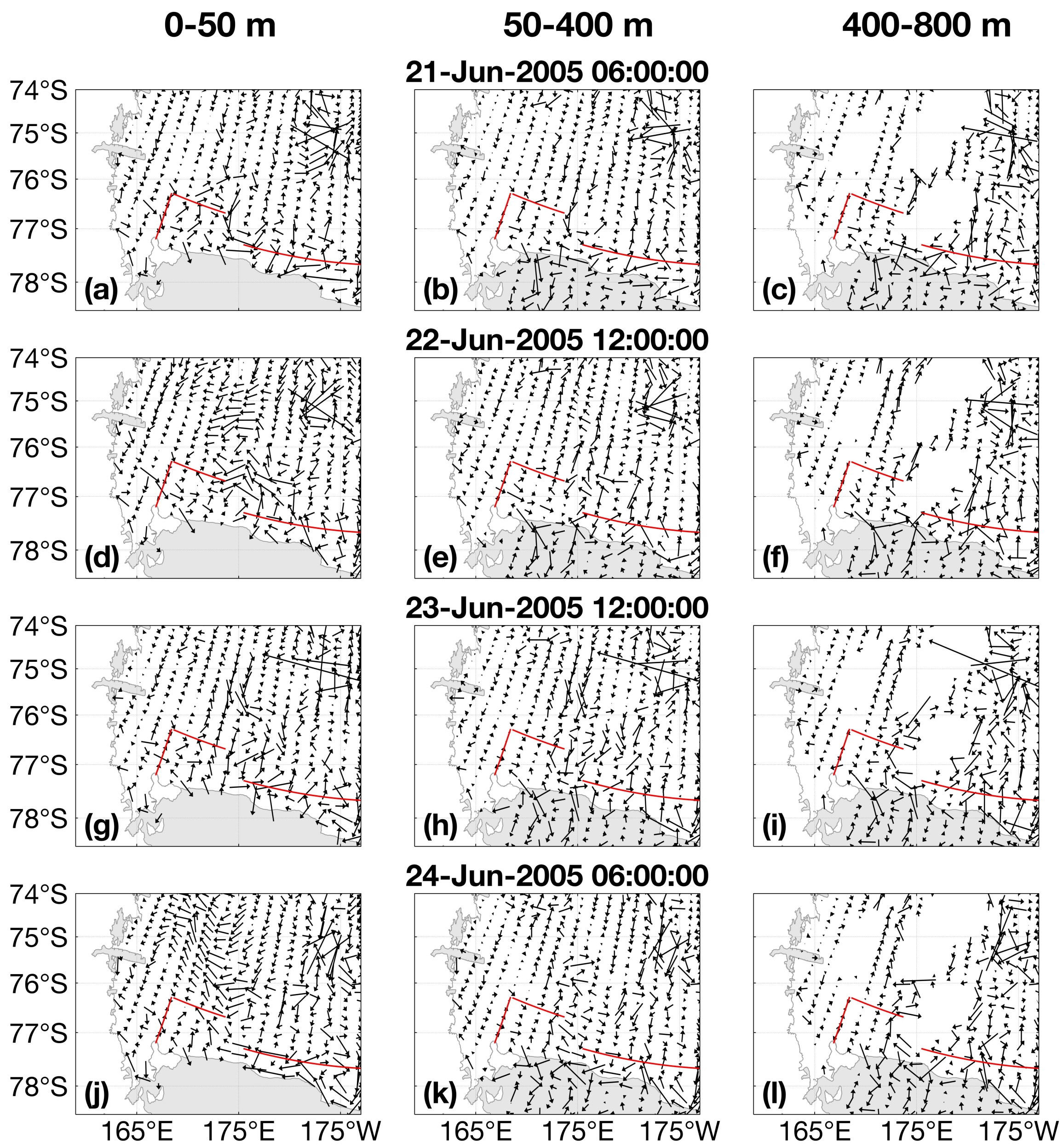

Figure R4. Spatial distributions of depth-averaged ocean currents over (a, d, g and j) 0–50 m, (b, e, h and k) 50–400 m and (c, f, i and l) 400–800 m at four selected time points (06:00 am of June 21, 12:00 am of June 22, 12:00 of June 23 and 06:00 of June 24). The red lines are the S1, S2, and S3 sections defined in Fig. 1b

21. Lines 545-552: I do not agree with the sentence "The HSSW formation in the RISP demonstrated a near-instantaneous response to the wind change during the synoptic- and meso-scale cyclone events". Here, the increase of HSSW salinity and volume is observed west of Ross Island and not in the RISP polynya where the SIP increases during the Cyclones. This is clear from Figures 6 and 10. Looking at the TS diagram confirms that the HSSW salinity increase occurs west of Ross Island, where there is no increase in SIP. Therefore, the discussion below is pointless.

Based on the redefined HSSW and RISP, the updated results suggest that the HSSW is mainly formed within the RISP region (around 167°E–174°E). Please see more detailed information in our response to Comment #1. Meanwhile, the HSSW volume also showed instantaneous increase when the wind was increasing (Figs. 6b in the revised version).

22. Lines 553-568: Following Morrison et al., 2020 the CDW intrusion and HSSW outflow are correlated, but close to the shelf break and not close to the RIS. In addition, it is the HSSW outflow that modulates the CDW intrusion and not the contrary as stated here. While it is true that the CDW may affect the DSW formation rate in the Ross Sea, the time scales are very different. The response of the RISP and therefore of the HSSW formation to a cyclone (strong winds) is much shorter than the response of the dense water formation to the CDW intrusion onto the shelf. Moreover, the spatial scales are completely different: the continental shelf in the Amundsen Sea is smaller and the ice shelf is much closer to the shelf break than in the Ross Sea. In addition, the continental shelf water properties in the Amundsen Sea are completely different from the Ross Sea, in the Amundsen Sea, there is no DSW formation.
Finally, I don't understand why you compare the time lag registered in your study (related to the local ocean dynamics response to the northward wind increase during a cyclone, with Mathiot et al., (2012) work that looks at the lag between the cumulative HSSW production during summer and export from the Ross Sea. These are processes happening at different time scales.

We agree with the reviewer's comments, and the original sentence mentioning the role of CDW inflow in HSSW flow has been deleted and revised to "Another factor might be the local circulation system like the outflow of basal melting water and the local gyre over these coastal regions. Herraiz-Borreguero et al. (2016) highlight the role of ice shelf water in controlling the HSSW formation rate and its thermohaline properties in East Antarctica. Formation of HSSW could be hindered by the freshwater input from ice shelves (Williams et al., 2016). Meanwhile, the increased freshwater from ice shelf melting could reduce the transport of CDW onto the continental shelf region (Dinniman et al. 2018), which can further affect the formation of dense shelf water." (Lines 591–597 in the revised version).

As the reviewer suggested, the findings of Mathiot et al. (2012) and our study do focus on different time scales, so it does not make much sense to make lag time comparisons. Instead, we tried to address the linkage of this study to our study, and reorganized the statements as "Mathiot et al. (2012) documented a 6-month time lag between the HSSW formation in polynyas (TNB and RISP) and the HSSW transport across the topographic sills in the Ross Sea, i.e., the maximum HSSW transport occurred during summer (February/March) while the maximum of polynya activity occurs in winter (August/September). The defined sections across the Drygalski Trough and the Joides Trough in their study were located around 74°S, which is about 330 km further north than the sections we selected. This study provided a baseline for us to estimate the timescale for the cyclone-induced sea ice and HSSW change to influence bottom water properties at the slope." (Lines 602–608 in the revised version).

23. Figure 3: I suggest adding the trajectory of the cyclones in the figures.
Figure S4: Because this figure is important for the discussion, I suggest including it in the main text. I also suggest highlighting the region 74°-76.5° S and 163°-167° E.

The cyclone tracks of three typical cases (SYNO1, SYNO2 and MESO) are added to Fig. 3 as the reviewer suggested, and descriptions of the tracks and cyclone evolutions are added in the revised version (Lines 251–263).

Figure S4 in the original supplementary material has been added to the revised main text as Fig. 15. In addition, the region 74°–76.5°S and 163°–167°E has been highlighted as the reviewer suggested. Please see the detailed response in Comment #19 and #20.

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