In the following reply, you may find your own comments marked in **gray** and the replies by the authors of the manuscript indented and in **black**.

General Reply:

Based on the definition of this type of polynya, open water is obvious indicator of the polynya. Thin ice is an indirect indicator that shows open happened here but now thin ice and will soon become thick ice if the warm water upward does not appear again in a later date. In my opinion, the open water is better mapped by the ASI ice concentration map (6.5km resolution) as indicated in the paper and prior studies. The new thin ice thickness product is 45km and is not a good indicator of the small opening; also there is publication about thin ice thickness retrieval from passive microwave remote sensing such as the AMSE-E/2, that could be up to 6.5km in spatial resolution (see paper Dai et al., 2020, Remote Sens. 2020, 12(9), 1484; https://doi.org/10.3390/rs12091484). However, this paper did not mention this method in their paper at all, indicating some lack in literature review. To confirm and validate their thin ice method for mapping polynya, Sentinel-1 SAR image is a much better approach than the ASI concentration since the Sentinel-1 has much higher spatial resolution (also in Dai et al., 2020 paper and other papers).

> Thank you very much for your comments and clarifications which have led to the improvement of the manuscript. Your concerns on the specific data product chosen for this research are noted. Reading up on the suggested literature on AMSR-E/2 sea ice thickness (SIT) products (Nihashi et al. 2017, Dai et al. 2020) was informative and as a result, it will definitely be mentioned in the finalized manuscript. This manuscript, like the Master's thesis that inspired it, began first and foremost as an application of SMOS sea ice thickness: a retrieval which was mainly developed at the Institute of Environmental Physics (IUP) in Bremen. All the authors of this manuscript are affiliated with IUP and thus SMOS and SMOS-SMAP SIT data products were the most logical choice. In addition, the mentioned retrievals have publicly available datasets with manuscripts dedicated solely to their validation (Huntemann et al. 2014, Paţilea et al. 2019). The theory behind both retrievals is that at L band (1.4 GHz) the radiation is sensitive to SIT up to 50 cm which is reported on and discussed in Kaleschke et al., 2010, 2012 prior to the development of the SIT data products. As such, although this method has plenty of its own uncertainties, these uncertainties have been studied and we can trust in the validity of the retrieved signal.
>
> In terms of quality and validity of the retrieved SIT, it is difficult to compare the SMOS and SMOS-SMAP SIT data products with the AMSR-E/2 SIT algorithm developed by Nihashi et al. 2017 and used by Dai et al. 2020. However, due to

more extensive literature on the former as well as the above-mentioned reasons, we opt to stay with SMOS and SMOS-SMAP SIT analysis. Keeping in line with the topic of the manuscript, it is also beneficial to be able to discern sea ice thicknesses beyond just 20 cm like in the AMSR-E/2 SIT algorithm (Nihashi et al. 2017, Hwang et al. 2007) as during polynya years, ice thicknesses up to 20 cm are closely confined to the rim of the polynya. Simply put, the laid-out goal of this research was more to apply SMOS and SMOS-SMAP SIT retrieval to the Maud Rise region rather than the thin SIT study of the Maud Rise Region for which the data product was chosen after the formulation of the hypothesis. Accordingly, no effort was made to develop our own AMSR-E/2 SIT retrieval algorithm for the purposes of this study, and we decided to stick with established data products.

Specific Comments Reply:

In the paper, authors made it clear that their SMOS-SMAP retrieval algorithm assumes ~100% SIC, while there is low SIC with polynya. This causes a concern on their results.For example, in their text line 108-110, “Thin ice thickness is … a combined ice area and thickness anomaly and not be used to calculate... ice volume…”.

Due to concerns expressed by all 3 reviewers, we have opted to switch the approach of our SIT analysis to apparent SIT. While we know that the SMOS-signal is associated with thin sea ice, due to the conditions posed by the dynamically changing polynya and Maud Rise anomalies as a mix of older ice with newly formed ice, we cannot take the SIT retrieval at face value. As such computing any ice volume from it would include high levels of spatially inhomogeneous uncertainties that cannot be quantified.

This paper claimed that it is the first time to confirm that wind is a major factor for the Weddell Sea polynya, although I am not sure if they have enough data to confirm this finding from these polynya events 4o years ago. Otherwise, are you so confident that the results from these two years of data can apply to other times?

With regard to the polynya events, we simply corroborate past studies on the topic. Thanks to reviewers 2 and 3, more of the appropriate studies (i.e. McPhee et al. 1996, McPhee 1999, Goosse and Fichefet 2000) could be rightfully attributed with first insights into wind-driven openings above Maud Rise. As for the 2018 sea ice anomaly, we build off of those studies and speculate based on ERA5 atmospheric reanalysis whether wind-driven forcing could have played a part in the anomaly. Wording that implies all anomalies are wind-driven will be corrected.

they conclude various different factors must occur simultaneously for the polynya to occur. But this statement is not an approved statement. the paper writing needs to improve, I have listed a few in the details below, but many can be found throughout the

paper. One big comment is the section 4 (conclusions). Most of the content in this section should be in the discussion not in the conclusions

Noted. We will see what we can transfer from the Conclusions to the Discussion.

L2, “fully opened again on …2107”, but figure 1 and text shows 2016 opened.

Noted and corrected.

L3, “lasted until melt” is not clear and confused. Maybe change to “lasted until the summer melting season”? “80 days, 2017,” should be “80 days in 2017.”, right? are you sure it reached early December before all surrounding ice melted?

Changed to approximately 80 days (in reality it’s more like 81 days before the polynya open water area is integrated into the Southern Ocean). “Lasted until melt” has been clarified as well.

L4, “actually was not the…”, what is the subject of this sentence? You missed it.

The subject was meant to be 2017 itself. We will clarify this part of the abstract in accordance with some suggestions from reviewer3.

L59-61, I have question for this purpose of the study: “we aim to ….”, why you want to using the thin ice thickness which is not already existing and will be much coarse resolution as compared with the exiting ASI ice concentration data. AMSR-E/2 can also be used to derive thin ice thickness. Is this your thickness compatible with the AMSR-E/2 Derived?

To our knowledge there was no comparison study between the AMSR-E/2 derived ice thicknesses and SMOS/SMAP sea ice thickness product. We also could not find the said AMSR-E/2 sea ice thickness product online, so that no comparison could be performed.

L85: a root mean square difference (RMSD)

Corrected.

L92, “growing sea ice”, do you mean “sea ice growing season”?

Yes, we will modify the text accordingly.

L110-111, I am not sure how long this thin ice would last once the upward of warm deep water stops or weaken, since most of the time the Weddell Sea polynya is an open water area as indicated (for 80 days in 2017). Once the upward of warm deep water stops, thin ice would form and would thicker, also thicker ice from surrounding would come to fill the open and thin ice area soon as I can imagine.

Noted. Will elaborate on this further.

L141: Can you explain why 2017 and 2018 are chosen?

Reasons behind the choice were clarified. Sentence was changed to: “For a detailed analysis of the Weddell Sea polynya, 2017, the year in which the largest Weddell Sea polynya of this century occurred, and 2018, the year that followed which as will be shown exhibits anomalous thin ice behaviour, have been chosen.”

L143-144: Can you clarify the strength of SMOS-SMAP SIT compared to the SIC datasets?

Changed to: “Here the advantage of the SMOS-SMAP ice thickness retrieval shows its strength by detecting anomalous sea ice behaviour where traditional sea ice concentration datasets cannot”

L149: Can you mention this spatial resolution of ASI SIC in section 2.2?

Yes, the spatial resolution as well as more information on the ASI SIC data product will be included.

L169, “….area that is classified as open water”. I have question. this means it was 0% open water before Sept 13? if this is the case, then 100% ice covered, then ice thickness should be higher but why it was actually lower compared with after Sept 13? this is not possible. am i wrong?

On September 12 there was a bit of open water area left (below 80% class in Fig. 4b) while the entire area is ice covered on Sep 13. Technically this means that this area could be refrozen, i.e., it should be detected in the thin ice class (<10cm). However, because of the difference in Resolution of the two products this is not an enforced causality. The reduction of open water area in the footprint of SMOS/SMAP could just increase the retrieved ice thickness. The latter is consistent with what is shown in Fig. 4c as reduction of low SIT area across all SIT classes.

L170, 0% open water should come with high SIC and SIT, right?

Yes, this is correct, see also the previous answer.

L175: There is no section 3.2. Please check it. Should it be “4. Discussion”?

Corrected.

L180: Can you add any references here?

We added the following references…

L191: Can you present any statistical parameters, such as correlation coefficient (R)?

We will add the following statistical parameters: …

L193-194: I guess the higher resolution of ASI SIC can affect this result. In Figure 3 and Figure 6, it seems that ASI SIC (6.25 km) has a much finer spatial resolution than SMOS SIT (45 km?). If so, the ASI SIC data should underestimate the thin-ice (or open water) area compared to the SMOS SIT data. Maybe you need to discuss the effect of different spatial resolution.

Since ASI retrieval is estimating open water as a percentage on a sub-footprint scale, as is SMOS and SMAP-SMOS but with SIT, we do not think any sizeable under(or over)-estimation will occur in either data product.

L201-203, sentence “we see… freeze up”, please break up…

This sentence as well as paragraph will be rewritten also due to concerns from reviewer 3.

L213, “east and southeast directions”, but the figure 4 does not show these directions.

Figure 7 referenced for the direction specifications.

L216-219, Figure 7: Can you mark the extent of sea ice anomaly area in Figure 7?

Thank you for the suggestion. While the exact shape of the polynya, and the anomaly even more so, is difficult to establish. A reference cylinder will be included in the wind charts to guide the viewer.

L226-227, “therefore also…”, please cite papers here since it is your finding.

We will add the following references.

L 237-238: I just wonder if there is any possibility of sea ice advection (e.g. drift of thin sea ice from other regions?). By seeing the time-series video of SIT, you may be able to confirm if those thin ice events are all really “polynya-type” events or they are advection of thin ice from surrounding area.

More generally, literature on the topic attributes this thinning to melting from below. This is partly confirmed for the 2017 polynya (e.g. Campbell et al. 2019) with in-situ data and the situation can be assumed to be similar for 2018 since the region is prone to such events (Wilson et al. 2019, Holland 2001). The maps chosen were those that best depicted the initial expansion of 2017 as well the wide-scale thinning in 2018, however longer time periods were studied and the videos you are referring to were analysed. As such we can confirm that this is not simply the advected thin ice.

L268-269, the last sentence “Moreover, it is the combination….”. this sentence is suspicious, since your paper did not approve it.

Here we try to corroborate past studies on the topic rather than claim it as our finding, the wording will be fixed and references will be added.

L281, “…low SIC (most likely minor lead openings) is recorded”. I really hope the paper use the Sentinel-1 SAR data to validate or confirm…

In the end, we decided this is beyond the scope of this manuscript and we’ll stick with MODIS blue marble imaging for high-resolution comparisons. However we will mention this point in the outlook.

Figure 1: Can you briefly explain how to define/distinguish “polynya events” and “ice thinning anomalies”?

Done.

Figure 3. what are the resolutions for them? it is really not easy to match the two sets.

The SMOS/SMAP product is oversampled in a resolution of 12.5km while the size of footprint is about 45km on average (hence the soft contours). The ASI resolution is about 5km and it is resampled into a 6.25km grid.

Figure 4 and Figure 5: I am just curious why you mention 2017 (Figure 5) first, and then 2018 (Figure 4). Would it better to mention 2017 first prior to 2018? In Discussion, you describe 2017 first and then 2018, so it is somehow confusing to read the text and figure together. And same for Figure 7 (2018) and Figure 8 (2017). Also Figure 4b, if 0% SIC for open water, should be 100% sea ice, but figure 4c shows 0% ice from August 11-Sept 4, please explain?

First point will be addressed, and the flow of the text will be switched to consistently be 2017 discussed first and then 2018. Thank you for that insight; it should improve the structure of the manuscript.

Fig4c shows the area of the different sea ice thickness classes where the thick ice class (>50 cm) is not shown in the plot. This means that entire area was covered by thick ice beyond the thickness sensitivity of the SMOS/SMAP retrieval.

Figure 6, really the SIC and SIT do not match much, except the 2016 and 2017.

No and they are not meant to, that is partly what this manuscript aims to show that areas of thin ice, in this setting where a lot of the melting is from below, need not be low in terms of sea ice concentration.

Figure 8: Same to Figure 7, can you mark the extent of sea ice anomaly area in Figure 8?

A reference cylinder indicating the location of the polynya will be included.

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