Dear Editors and Reviewers,

The authors, above all, would like to thank the editor and the reviewers for their comments to help to improve the manuscript. We have now carefully reviewed and addressed all of comments which we hope meet with approval, with revisions to the manuscript shown in red. The primary corrections in the paper and the responds to the reviewer's comments are as flowing:

Responses to Reviewer's Comments:

Reviewer #1:

I'd once again like to thank the authors for their diligent response to all the reviews. This is my third time reviewing this paper, and I am happy to see that many of my concerns have been addressed in the current version of the manuscript.

The authors have now included statistics (cumulative probability) on how many points are used pr grid cell, clearly highlighting the limited coverage of HY-2B with the re-tracker provided in higher level products. They have also provided statistics (cumulative probability) on how often 25 km segments include 15 points or more. They have also included a discussion on their uncertainty estimates in relation to other studies, as well as provided a distinction in uncertainty estimates from multi-year ice and first-year ice.

Overall, I am happy with the changes that the authors have made based on my comments and within the scope of their study. I have a few comments, which are minor, but nonetheless should be considered by the authors to strengthen their publication in comparison to recently published studies.

General comments

During the review process of this paper, it has come to my attention that a new paper (Jiang et al., 2023) with similar motivation/objectives and with a, to a large degree, similar processing chain has been published, although they have included more products in their comparison. I think this study now requires a short section or paragraph on how this study differs from the already published study. Here, I especially encourage a discussion on how they use the lowest 3 points in their study to estimate the SSHA with the argumentation that one other study on Envisat observation has been published using this and how this is often applied to laser altimetry, as well as their use of a different re-tracker and geophysical corrections (maybe, the results on DTU21 MSS represented in an earlier response to the reviewers of this study could be included to aid this discussion). You might want to have a look at their reviewer reports/response, where this has also been questioned. However, I believe it is imperative that the authors clearly highlight the differences, and present why the results of this study are still relevant.

Response: Thank you for the valuable comments. We have supplied the description of Jiang et al. (2023) in the intruduction. 'Therefore, Jiang et al. (2023) used the AWI CS-2 sea ice thickness products to calibrate the HY-2B thickness estimates.' (Line 73-74)
We have supplied the description of the difference between this study and Jiang et al. (2023), as well as the relevance of this study in the discussion. 'The discrepancies between this study and Jiang et al. (2023) are mainly due to retrieval methods and data sources. The discrepancies of the methods are reflected in the re-tracking method, the estimation method of SSHA and whether the subsequent results need to be calibrated with AWI CS-2. The discrepancies of the datas are reflected in product levels of HY-2B and DTU MSS models. Jiang et al. (2023) used the lowest 3 points per 25 km to estimate SSHA with HY-2B L1 product, resulting the retrieval of sea ice thickness is thicker than AWI CS-2. So the retrieval of sea ice thickness need to be calibrated with AWI CS-2. It is worth noting that this study uses SGDR data, which only includes the SMLE re-tracking data. We don't deny that the L1 data Jiang et al. (2023) used is much more extensive in the Arctic. In this study, we try to explore the application of SGDR data released to the public in polar sea ice, but it can be seen from our study that it seems difficult to obtain reasonable results by using conventional methods. So we use 15 lowest points per 25 km to estimate SSHA to retrieve more reasonable Arctic radar freeboard and thickness. Through this study, we can see that the relative surface height after substracting MSS is relatively low compared with CS-2, which may be caused by the re-tracking algorithm and precision orbit determination. This is what we need to avoid when reprocessing HY-2B L1 data, which also provides reference for reprocessing L1 data.' (Line 491-503)
We have also revised 'We will reprocess the HY-2B L1 data to obtain more reliable polar sea ice thickness products.' to 'We hope to release products that are more reasonable and suitable for polar sea ice thickness retrieval, so as to better evaluate the potential application of HY-2B in polar sea ice'. (Line 512-513)

The authors mention in response to the reviewers, that their estimation method of 15 points within the segment yielding one lead point does not necessitate that there is only one lead along the segment. This is inherently clear, however that was not the concern raised in that question. What is important here - especially considering that the interpolation of lead points into floes are done by nearest neighbor-is the accuracy of that lead estimation point every 25 km segment. This has already been partly discussed with the cumulative probability statistics and the analysis you made with using a combination of numbers of points used to estimate SSHA. But, what was questioned previously was: is one point pr. 25 km enough to represent the SSHA, especially if that point could be affected by floe points in the estimation? Showing the distance between leads identified for other missions was to feed into the discussion of whether the estimation method of SSHA seems reasonable, and whether one SSHA pr. 25 km (since this is your estimation method) is accurate enough. I'll leave it up to the authors to consider if more discussion is relevant here, but I strongly suggest the authors to reflect upon this-especially in relation to the recently published study, that used 3 points along the segment.
Response: Thank you for the valuable comments. Actually, one point per 25 km isn't

enough to represent the SSHA, but currently we have tried other methods to retrieve radar freeboard, and we didn't obtain a satifactory result. This is the best result we can get so far. As the reviewer noted in his previous comments, Tilling et al. (2019) saw that a lead-to-floe echo distance for EnviSat ranged from 0-20 km (average 11.3 km). So there might be two or three leads within 25 km segment according to Tilling et al. (2019). However, it should be made clear that SGDR products have been re-tracking by Brown model, as well as the error of precision orbit determination, resulting in the relative surface elevations obtained by SGDR are lower than AWI CS-2 (Table 2, Figure 3 and Figure 4). The average of 3 lowest points within 25 km segment are lower than the average of 15 lowest points within 25 km segment, resulting in a higher radar freeboard retrieval. So we use the average of 15 lowest points within 25 km segment to estimate the SSHA. Although it is inconsistent with Tilling et al. (2019), the average of 15 lowest points within 25 km segment is more suitable to obtain reasonable radar freeboard than the average of 3 lowest points for the lower relative surface elevations. This method in this study is maybe only applicable to SGDR data and is not the mainstream method. We also pointed out in the paper that we hope to use HY-2B L1 data in the future to classify lead and floe to obtain more reasonable radar freeboard and sea ice thickness.

With the introduction of new sentences, there are several places where a read-through would be beneficial. I am aware that this comment was also given the last time, but it is simply to ensure the readability of the manuscript, and since there have been a significant number of new/edited sentences, I encourage the authors to have a look at them again and see if they can improve on this.

Response: Thank you for the valuable comments. We have read and checked the whole manuscript. We have added the reference of Jiang et al. (2023). (Line 605-606)

Specific comments

Line 24: "we will …" -> I suggest rephrasing this sentence. Somehow it sounds like your not happy with your results. Perhaps mention that future work will include reprocessing the data with a dedicated sea ice re-tracker, and that a further investigation of using the radar waveforms directly to identify leads will be the next steps.

Response: Thank you for the valuable comments. We have revised 'We will reprocess the HY-2B L1 data to obtain more reliable polar sea ice thickness products' to 'The future work will include reprocessing the HY-2B L1 data with a dedicated sea ice re-tracker, and using the radar waveforms to directly identify leads to release products that are more reasonable and suitable for polar sea ice thickness retrieval' (Line 24-26).

Line 254: In the review comments you mention that the satellites passes with about 3 hour difference, but the way it is written here sounds like almost 2 weeks of difference. Could you please clarify that you are comparison two instances, and that for each date denote the time differences between HY-2B and CS-2 acquisition.

Response: Thank you for the valuable comments. We have revised 'Fig. 4 (a) and (e) show the orbit positions of HY-2B and CS-2 obtained on April 4, 2020, and March 13,

2020, covering the Beaufort Sea and the northern Canadian Archipelago, respectively, to compare the relative surface elevation, SSHA, and radar freeboard estimates' to 'We selected two instances of different time for comparison acquired on April 4, 2020 and March 13, 2020, respectively, as shown in Fig.4 (a) and (e). For each date denote the time of CS-2 and HY-2B tracks. Both of them cover the Beaufort Sea and the northern Canadian Archipelago'(Line 255-257).

References

Jiang, M.; Zhong, W.; Xu, K.; Jia, Y. Estimation of Arctic Sea Ice Thickness from Chinese HY-2B Radar Altimetry Data. Remote Sens. 2023, 15, 1180. https://doi.org/10.3390/rs15051180