

The authors would like to thank the editor and the second round review of our revised manuscript. Following the comments for minor revisions, we have made changes accordingly. This document records all the revisions we have made, listed below. The original comments are in *blue italic*, with our reply following each item of the comments. Moreover, in the marked version of the revised manuscript, the revisions are highlighted with 'REV1'. Additionally, the extra revisions for Language edits are marked out by 'REVLang'.

*Editor Comments:*

*Novel approach to derive the MIZ width of the Atlantic sector in the Arctic from the CryoSat-2 delay-Doppler radar altimeter.*

*Dear authors.*

*Thank you for addressing the reviewers' and editor's comments from the preceding round.*

*Your revised manuscript has been re-reviewed. Pls address the set of comments received from reviewers in response to your revised ms. In additioa, pls also address my comments (below).*

*Editor's Comments:*

*General comments:*

*Figure 1: The top panel does not adequately depict the changes in the wavelength or wave height correctly. Also the ice floes in the MIZ are incorrect, while the sea ice in the Ice Pack is shown as one huge floe on either side of the lead.*

Reply: The author appreciates the reviewer's feedback. We have reviewed and corrected the depiction of the wavelength, wave height, and sea ice representation in Figure 1 to ensure accuracy and clarity.

*I69: Wingham et al. [2006] do not refer to the "sea ice mass balance". Suggest to explore, for example, Ricker et al. [2018; <https://doi.org/10.5194/tc-12-3017-2018>].*

Reply: The author appreciates the reviewer's suggestion regarding the inappropriate references. We have already added the references here: [Ricker et al., 2018].

*I128L Chnage "Other satellites for the MIZ retrieval" to "Other satellites assisting in the MIZ retrieval"*

Reply: The author appreciates the reviewer's suggestion. The title has been revised to:"Other satellites assisting in the MIZ retrieval"

*I152: Add info as to how long typical Cryo2Ice sampling intervals last.*

Reply: The author appreciates the reviewer's suggestion regarding the addition of information about the typical Cryo2Ice sampling intervals. Accordingly, we have updated the manuscript with the following description:

"Consequently, the ground track of CS2 coincides with that of IS2 at the interval of 19 orbits (about 30 hours), and the average visit interval of the two satellites is within 3 hours(ESA)."

*I185-186: Rewrite "As shown in Figure 1" to describe what is shown in Fig 1 that demonstrates that "larger SSD (...) corresponds to less power drop in the slant looks".*

Reply: The author appreciates the reviewer's suggestion. We have revised the following sentence as follows:

"In the bottom row of Figure 1 and the typical retrieval scenarios in Figure 3 and 4, we show the fitted value of TES from the multilooked waveform and the SSD. SSD is the standard deviation of the Range Integrated Power waveform, with larger values corresponding to slower power decay of the increase in the incidence angle."

*I215: Location names to be capitalized: Change "Greenland sea," to "Greenland Sea,"*

Reply: The author appreciates the reviewer's suggestion. Accordingly, we have revised the location name to "Greenland Sea" and have also reviewed and verified the accuracy of other location names throughout the manuscript.

*I480: The argument "through wave-ice interaction (ice floe breaking, rafting, thermodynamic feedbacks, etc)." holds only if the later MIZ width is larger than the former. Can you show this?*

Reply: The author appreciates the reviewer's suggestion. A brief description of the relevant processes in the MIZ has been added as follows:

"Ice floe breaking, rafting, and thermodynamic feedback collectively accelerate the melting and dynamically expand the MIZ through ice fragmentation and altered ice dynamics (Collins III et al., 2015; Arduin et al., 2020)."

*I510: Rewrite "at: <https://zenodo.org/record/8176585> (last access: 24 July 2023)" to be completely in brackets. No need for the URL to be in the main sentence.*

Reply: The author appreciates the reviewer's suggestion. We have revised the sentence as follows:

“ We provide the MIZ dataset, containing the wintertime MIZs in the Atlantic Arctic region from 2010 to 2022 [<https://zenodo.org/record/8176585> (last access: 24 July 2023)].”

*Table 2: Suggest to add information for CS2 retrieval as to how many CS2 tracks were used for each calculation for each region.*

Reply: The author is grateful for the reviewer's suggestion. Accordingly, we have included the number of CS2 tracks utilized for each region in the manuscript.

*Minor comments:*

*\* Correct spelling of "in situ" is without hyphen but in italics. (line 2 and all other uses in this ms)*

Reply: The author appreciates the reviewer's suggestion. We have revised the term “in-situ” to “*in situ*” and formatted it in italics throughout the manuscript.

*15: Change "ice cover" to "sea ice" or "sea-ice cover".*

Reply: The author appreciates the reviewer's suggestion and has accordingly revised the term “ice cover” to “sea-ice cover”.

*18: Replace "MIZs" with "MIZ events".*

Reply: The author appreciates the reviewer's suggestion and has accordingly revised “MIZs” to “MIZ events”.

*19: Replace "MIZs" with "MIZ events".*

Reply: The author appreciates the reviewer's suggestion. We have revised 'MIZs' to 'MIZ events' and have reviewed the entire manuscript to ensure the accuracy and appropriateness of this description.

*l13-14: Sharpen the statement in "Besides CS2, the proposed retrieval algorithm can be adapted for various historical and future radar altimetry campaigns." -> This is one of the key outcomes of your work described in this ms.*

Reply: The author appreciates the reviewer's suggestion. We have revised the sentence as follows: “Beyond its application to CS2, the proposed retrieval algorithm can be adapted for historical and future radar altimetry campaigns.”

I18: Add "The" to read "The MIZ is...".

Reply: The author appreciates the reviewer's suggestion and has added "The" to the sentence as recommended.

I18: "MIZ" has been defined and used in abstract already, suggest to remove here.

Reply: The author appreciates the reviewer's suggestion and has accordingly removed "marginal ice zone" from the sentence.

I18: The opening sentence is not informative, as you define MIZ with an undefined concept, the "sea ice edge". I also beg to disagree that the MIZ is deeper than the sea-ice edge.

Reply: The author appreciates the reviewer's suggestion. We have revised the following sentence as: "The MIZ is on the boundary of the sea-ice covered area that is affected by the open ocean."

I19: "swells" - Correct to "swell". The noun swell can be countable or uncountable. In more general, commonly used, contexts, the plural form will also be swell.

Reply: The author appreciates the reviewer's suggestion. We have corrected the "swells" to "swell" in this sentence.

I25: Add "the" and correct "MIZs" to read "the MIZ plays ... role".

Reply: The author appreciates the reviewer's suggestion. We have added "the" in this sentence.

I25: Replace "potentially" with "the likely process" or just cut "potentially".

Reply: The author appreciates the reviewer's suggestion. We have replaced "potentially" with "the likely process" in the sentence.

I27: Plural for "ecosystem"??

Reply: The author appreciates the reviewer's suggestion. We have revised "ecosystem" to "ecosystems" in this sentence.

I29: Singular for "MIZs", correct to "the MIZ is".

Reply: The author appreciates the reviewer's suggestion. We have revised "MIZs" to "the MIZ is" in this sentence.

*I30-31: Correct "of the wave's propagation and attenuation in the sea ice cover" to read "of wave propagation into and attenuation by the sea ice".*

Reply: The author appreciates the reviewer's suggestion. We have corrected the sentence to "In situ campaigns in MIZs, in spite of the great challenges, provide us with the direct evidence of wave propagation into and attenuation by the sea ice."

*I31: Remove "mainly".*

Reply: The author appreciates the reviewer's suggestion. We have removed "mainly" in this sentence.

*p34-35: Correct "Passive Microwave Imaging (PMI) satellite payloads' to "satellite-borne Passive Microwave Imagers (PMI)".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "Passive Microwave Imaging (PMI) satellite payloads" to "satellite-borne Passive Microwave Imagers (PMI)" in this sentence.

*I36: Correct "ocean's" to "ocean".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "ocean's" to "ocean" in this sentence.

*I37: Correct "fully-packed ice cover" to "compacted sea ice".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "fully-packed ice cover" to "compacted sea ice" in this sentence.

*I38: Correct "close to" to "up to".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "close to" to "up to" in this sentence.

*I41: To be correct add "by satellite-borne instruments" to read "To resolve waves in the MIZ by satellite-borne instruments,"*

Reply: The author appreciates the reviewer's suggestion. We have added "by satellite-borne instruments" in this sentence.

*I41: Rewrite "high-resolution satellite payloads are typically required," to read "satellite payloads providing high spatial resolution are typically required,".*

Reply: The author appreciates the reviewer's suggestion. We have rewritten this sentence to "To resolve waves in the MIZ by satellite-borne instruments, satellite payloads providing high spatial resolution are typically required, including optical sensors, Synthetic Aperture Radar (SAR), and laser altimetry of ICESat2."

*I41: Remove "various".*

Reply: The author appreciates the reviewer's suggestion. We have removed "various".

*I43: Remove "These".*

Reply: The author appreciates the reviewer's suggestion. We have removed "These".

*I45: Rewrite "The effective footprint should be at least finer than half of the wavelength, which is no more than a few hundred meters." to "The spatial resolution of these sensors needs to resolve wavelength in the order of few hundred meters, so in the order of 100 meter."*

Reply: The author appreciates the reviewer's suggestion. We have rewritten the sentence to "The spatial resolution of these sensors needs to resolve wavelength in the order of few hundred meters, so in the order of 100 meter".

*I46: Correct "MIZs" to "MIZ".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "MIZs" to "MIZ".

*I47: Correct "MIZs" to "MIZ".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "MIZs" to "MIZ".

*I47: Change "mainly due to their highly variant nature" to "largely due to its high temporal variability".*

Reply: The author appreciates the reviewer's suggestion. We have changed "mainly due to their highly variant nature" to "largely due to its high temporal variability".

*I48: Correct "MIZs" to "MIZ".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "MIZs" to "MIZ".

*I48: Correct "observation is" to "observations are".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "observation is" to "observations are".

*I49: Remove "potential".*

Reply: The author appreciates the reviewer's suggestion. We have removed "potential".

*I49: Correct "MIZs" to "MIZ".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "MIZs" to "MIZ".

*I50: Correct "MIZs" to "MIZ".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "MIZs" to "MIZ".

*I51: Remove "the region of".*

Reply: The author appreciates the reviewer's suggestion. We have removed "the region of".

*I52: Replace "including" to "which encompasses the".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "including" to "which encompasses the".

*I52-53: Correct "there exist a variety of sea ice conditions" to "a variety of sea ice conditions exist".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "there exist a variety of sea ice conditions" to "a variety of sea ice conditions exist".

*I53: Remove "the" from "such as the".*

Reply: The author appreciates the reviewer's suggestion. We have removed "the" in this sentence.

*I54: Correct "pass through" to "".*

Reply: The author appreciates the reviewer's suggestion, we have corrected the "pass through" to "develop and enter"

*I55: Correct "Besides.. 2017)." to "Notably, the Atlantic Arctic is rich with human activities, all highly variable due to a numerous dependencies, including those arising from the Atlantification of the region (Polyakov et al., 2017)."*

Reply: The author appreciates the reviewer's suggestion, we have revised the sentence to "Notably, the Atlantic Arctic is rich with human activities, all highly variable due to a numerous dependencies, including those arising from the Atlantification of the region (Polyakov et al., 2017)".

*I57-58" Change "and ... 2022." to read "and derived a 12-winter (2010 - 2022) record for the MIZ in the Atlantic Arctic based on CryoSat-2."*

Reply: The author appreciates the reviewer's suggestion, we have revised the sentence to "and derived a 12-winter (2010 - 2022) record for the MIZ in the Atlantic Arctic based on CryoSat-2".

*I58: Suggest to cut "The paper is organized as follows."*

Reply: The author appreciates the reviewer's suggestion; we have removed "The paper is organized as follows" from the text.

*I60: Replace "typical cases of retrieval" to "case studies".*

Reply: The author appreciates the reviewer's suggestion, we have replaced "typical cases of retrieval" with "case studies" in the manuscript.

*I60: Shorten by removing "Further".*

Reply: The author appreciates the reviewer's suggestion and has removed "Further" from the text.

*I62: Remove "and carries out related analysis".*

Reply: The author appreciates the reviewer's suggestion and has removed "and carries out related analysis".

*I63-64: Remove "Specifically, as shown through intercomparisons, the traditional SIC-based MIZ definition yields much narrower MIZs than our retrieval."*

Reply: The author appreciates the reviewer's suggestion and has accordingly removed the sentence: "Specifically, as shown through intercomparisons, the traditional SIC-based MIZ definition yields much narrower MIZs than our retrieval."

*I64-65: Shorten "Finally, in Section 6 we summarise the paper and discuss related topics of the satellite-based observations of the MIZ." by connecting with the previous sentence.*

Reply: The author appreciates the reviewer's suggestion. We have revised the sentence to read: "Section 5 introduces the 12-year record of the wintertime MIZs in the Atlantic Arctic, while Section 6 discusses related issues of satellite-based observations of the MIZ. Finally, Section 7 includes a brief summary of the dataset and its potential applications."

*I68: Remove "constantly".*

Reply: The author appreciates the reviewer's suggestion, we have removed "constantly".

*I68: Correct "earth's" to "Earth's".*

Reply: The author appreciates the reviewer's suggestion, we have corrected "earth's" to "Earth's".

*I68: Remove "for over 12 years".*

Reply: The author appreciates the reviewer's suggestion, we have removed "for over 12 years".

*As discussed with the authors, from here on language issues are not longer listed, instead the authors are referred to a (professional) service for improvements to the text.*

Reply: The author appreciates the reviewer's suggestion. We understand and appreciate the importance of clear and professional language in our manuscript. We had sought the assistance of a professional service to address and improve the language issues as recommended. And the revisions for Language edits are marked out by 'REVLang'.

*I102: Need to specify which "elevation".*

Reply: The author appreciates the reviewer's suggestion, we have revised it as "surface elevation".

*I103-104: Correct style in "Rapley (Rapley, 1984)".*

Reply: The author appreciates the reviewer's suggestion, we have corrected the style to "in Rapley (1984)" in the manuscript.

*I142: Add space " " to read "wavelengths (Collard".*

Reply: The author appreciates the reviewer's suggestion, we have added the space in this sentence.

*I149: Remove "the" to read "Over sea ice,"*

Reply: The author appreciates the reviewer's suggestion, we have removed "the".

*I148: Remove "Compared with the CS2 radar altimeter,".*

Reply: The author appreciates the reviewer's suggestion, we have removed "Compared with the CS2 radar altimeter,".

*I232: Ensure consistent format for dates, i.e., "2015-Feb-17".*

Reply: The author appreciates the reviewer's suggestion, we have checked the format for dates, including in the figure and table, to confirm they are with consistent format.

*I277: Avoid two "back to back" section/subsection headers. Provide a brief statement about using data from other satellites for MIZ validation.*

Reply: The author appreciates the reviewer's suggestion, we have included the following description:

"We validated the MIZ retrieval based on CS2 by conducting a comparative analysis with that derived from the IS2 laser altimeters and the SAR imagery from S1. IS2 and S1 attain high-resolution sampling of the sea ice cover and the MIZ. However, the MIZ retrieval with IS2 is based on its capability to resolve the height signature of waves in the MIZ, whereas that with S1 relies on the wave-modulated backscatter. These methods differ from the proposed CS2-based retrieval methods; hence, they also provide us with complementary perspectives of the processes in the MIZ."

*I375: Remove "We would like to note that,".*

Reply: The author appreciates the reviewer's suggestion. We have removed "We would like to note that,".

*I426: "Summary and discussions": Rename to "Discussion".*

Reply: The author appreciates the reviewer's suggestion. We have renamed "Summary and discussions" to "Discussion".

*I460: Change "More study is needed" to read "Further scientific studies are needed".*

Reply: The author appreciates the reviewer's suggestion. We have corrected "More study is needed" to "Further scientific studies are needed".

*I509: Split of the final sub-section "Summary of the dataset and outlook" into "Conclusions".*

Reply: The author appreciates the reviewer's suggestion, we have split the "Summary of the dataset and outlook" into "Conclusions".

*I571: Correct "between 80 m and 800 m" to "between 80 and 800 m".*

Reply: The author appreciates the reviewer's suggestion, we have corrected "between 80 m and 800 m" to "between 80 and 800 m".

*I591: Consider to acknowledge the contribution of the two reviewers.*

Reply: The author appreciates the reviewer's suggestion. We have now included an acknowledgment in our manuscript to recognize the valuable contributions of the editor and two reviewers. Their insights have significantly enriched our work.