Dear Ken Mankoff,

Many thanks for the review of our manuscript. We have considered each comment carefully and provided an itemized response to the comments as follows. Since there was no option to upload track changes in the system this time, we provided the track changes in the itemized response, in which the changes were marked in blue.

Looking forward to hearing from you soon.

Best Regards,
Ying Chen and other contributors.

**Response to comments**

*This paper has a lot of acronyms. I think it should have a List of Acronyms or Glossary somewhere to help the reader. I note that see "GR" is never defined.*

**Reply:**

We have added a table of abbreviations in the section "Appendix A: Abbreviations". We moved the definition of GR to where it first appeared and gave its full term.

Page 6, Line 154-155, we wrote:

The gradient ratio (GR) is defined as the TB difference with V-polarization between high and low frequencies over the sum of these two TB.

Page 24-25, we wrote:

**Table A1. List of abbreviations used in the paper.**

| Abbreviation | Term |
| --- | --- |
| SIC | Sea ice concentration |
| SIE | Sea ice extent |
| PM | Passive microwave |
| MWRI | Microwave Radiation Imager |
| FY-3 | FengYun-3 |
| SSMI | Special Sensor Microwave Imager series |
| SMMR | Scanning Multichannel Microwave Radiometer |
| SSM/I | Special Sensor Microwave/Imager |
| SSMIS | Special Sensor Microwave Imager Sounder |
| AMSR | Advanced Microwave Scanning Radiometer series |
| AMSR2 | Advanced Microwave Scanning Radiometer 2 |
| AMSR-E | Advanced Microwave Scanning Radiometer-EOS |
| MIZ | Marginal ice zone |
| PIZ | Pack ice zone |
| ASI | Arctic Radiation and Turbulence Interaction Study Sea Ice |
| BST | Bootstrap |

| | |
|---|---|
| NT2 | Enhanced NASA Team |
| NT | NASA Team |
| PMA | Passive microwave algorithm |
| NSMC | Chinese National Satellite Meteorological Center |
| OSI-SAF | Ocean and Sea Ice Satellite Application Facility |
| NSIDC | National Snow and Ice Data Center |
| ICDC | Integrated Climate Data Center |
| GESR | Goddard Earth Science Research |
| TB | Brightness temperature |
| H | Horizontal polarization |
| V | Vertical polarization |
| GR | Gradient ratio |
| Ice Watch/ASSIST | Ice Watch/Arctic Ship-based Sea-Ice Standardization |
| ASPeCt | Antarctic Sea Ice Processes and Climate |
| CHINARE | Chinese National Arctic and Antarctic Research Expedition |
| MAD | Mean absolute deviation |
| RMSD | Root mean standard deviation |
| $R$ | Correlation coefficient |

*Data is provided as Float32 but is only values -2, -1, and 0-100. I assume integer precision is good enough. Therefore, if it were Integer data it would be 1/4th the size. I suggest re-uploading compressed GeoTIFFs of 8-bit signed integer values.*

**Reply:**

We have updated the GeoTIFFs to 8-bit signed integer values. However, this dataset has been accepted for one year. We have tried contacting the editor of data but have not received a response. Therefore, it is difficult to re-uploading the updated data.

*31: Correct "The PM SIC is the most vital data" to "The PM SIC is the most vital dataset".*

**Reply:**

We have corrected it.

Page 1, Line 31-32, we wrote:

The PM SIC is the most vital dataset to initialize the sea ice condition for climate modeling due to its continuous observations (Meier, 2019).

*42: Change "are in planning stage." to "are in planning or concept stage (esastar, accessed 2023-06-10)."*

**Reply:**

We have changed it.

Page 2, Line 40-42, we wrote:

The new missions for successors of these two sensors or the launch plans for other instruments, e.g., the Copernicus Imaging Microwave Radiometer (Jiménez et al., 2021) and Weather Satellite Follow–On–Microwave (Newell et al., 2020), are in planning or concept stage (Esastar, accessed 2023-06-10).

*46ff: Shorten to "SSMIS data have been used to bridge the 2011 to 2012 data gap between Advanced Microwave Scanning Radiometer-EOS (AMSR-E) and AMSR2, to generate a continuou time series (Meier and Ivanoff, 2017)."*

**Reply:**

We have shortened it. However, Meier and Ivanoff, (2017) did not generate a continuous time series. They just used SSMIS data as a bridge to compare AMSR-E total sea ice extent in 2010 with AMSR2 total sea ice extent in 2013. Therefore, we further corrected this sentence.

Page 2, Line 46-48, we wrote:

SSMIS data have been used to bridge the 2011 to 2012 data gap between Advanced Microwave Scanning Radiometer-EOS (AMSR-E) and AMSR2 (Meier and Ivanoff, 2017).

*48ff: Remove "An updated SIC product from the MWRI sensors after systematic assessment may be used to verify the SIC products derived from the next generations of PM sensor."*

**Reply:**

We have removed it.

*55ff: Change "in the melting seasons than in the freezing seasons." to "during sea-ice melt rather than during freezing conditions."*

**Reply:**

We have changed it.

Page 2, Line 54-55, we wrote:

Thus, the uncertainties of SIC and SIE are generally greater during sea-ice melt rather than during freezing conditions.

*79: Correct "were used" to "are used".*

**Reply:**

We have corrected it.

Page 3, Line 77-78, we wrote:

The recently re-calibrated brightness temperature (TB) of the MWRI sensors provided by NSMC are used in this study to ensure the consistency of this new MWRI SIC product.

*88: Correct "More details" to "Further details" and "were given" to "are given".*

**Reply:**

We have corrected it.

Page 3, Line 87, we wrote:

Further details of the MWRI characteristics are given in Zhao et al. (2022).

*86: Correct "in conically scanning mode" to "in conical scanning mode".*

**Reply:**

We have corrected it.

Page 3, Line 85-86, we wrote:

The MWRI sensors measure the radiation of the land, ocean, and atmosphere in conical scanning mode at five frequencies between 10 to 89 GHz at both horizontal (H) and vertical (V) polarization.

**Reply:**

We have removed it.

Page 3, Line 88-89, we wrote:

Although the MWRI sensors onboard the different FY-3 satellites have consistent technical characteristics, the TB data obtained from different MWRI sensors reveal some deviations.

**Reply:**

We have changed them.

Page 3, Line 89-91, we wrote:

Therefore, the MWRI TB data are re-calibrated using the operational algorithm, which focus on the hot load, antenna, and receiver calibration, reducing the TB deviations of different MWRI sensors.

**Reply:**

We have changed and removed them.

Page 3, Line 92-93, we wrote:

This study uses the re-calibrated level 1 swath MWRI TB data from the FY-3B, FY-3C, and FY-3D satellites, provided by the NSMC and available at http://www.richceos.cn (Table 1).

**Reply:**

We have changed them.

Page 3, Line 93-94, we wrote:

Considering the improved performance of the FY-3D MWRI sensor compared to its predecessors, we preferentially selected the MWRI TB from the FY-3D, followed by the FY-3C and FY-3B.

**Reply:**

We have removed it.

Page 4, Line 103-104, we wrote:

This SSMI TB product is projected on 12.5- and 25-km polar stereographic grids at high and low frequencies, respectively.

**Reply:**

We have changed it.

Page 4, Line 105-106, we wrote:

The temporal coverage of these two daily TB products is corresponding to that of the MWRI TB.

**Reply:**

We have removed them.

Page 4, Line 112-115, we wrote:

One is available from the Integrated Climate Data Center (ICDC) of the University of Hamburg, which is derived from the Special Sensor Microwave Imager series projected onto a 12.5-km polar stereographic grid (SSMI-ASI) (Kern et al., 2023). The other is derived from the Advanced Microwave Scanning Radiometer series projected onto a 6.25-km polar stereographic grid (version 5.4, AMSR-ASI) (Melsheimer and Spreen, 2023).

**Reply:**

We have changed it.

Page 5, Line 119-121, we wrote:

To evaluate differences in the uncertainties of SIC between the melting and freezing periods, we use the data of Arctic sea ice surface melt or freeze onset to define the ice melting and freezing periods, which (version 371s, Table 1) are available from the Goddard Earth Science Research (https://earth.gsfc.nasa.gov/index.php/cryo/data).

**Reply:**

We have corrected it.

Page 5, Line 121-123, we wrote:

These data are obtained from the SSMI series sensors using the passive microwave algorithm (PMA) projected onto a 25-km polar stereographic grid, which includes the onsets of the early melt, melt, freeze, and late freeze for the sea ice surface (Markus et al., 2009).

**Reply:**

We have changed them.

Page 5, Line 130-132, we wrote:

To assess the performance of different SIC products in the MIZ, where the accuracy of PM SIC is generally low, the monthly MIZ SIE and MIZ SIE fraction (the ratio between the MIZ SIE and the total SIE) obtained from the three ASI SIC products

are compared.

**Reply:**

We have changed them.

Page 5, Line 132-134, we wrote:

We resample the AMSR-ASI SIC onto a 12.5-km grid to match the MWRI-ASI SIC and SSMI-ASI SIC to compare the SIC for the entire instrument overlap, as well as the winter (Arctic: December – May, Antarctic: June – November) and summer months (Arctic: June – November, Antarctic: December – May), respectively.

**Reply:**

We have changed it.

Page 5, Line 141-142, we wrote:

The fourth SIE product (called as OSI-SAF) is derived from the SIC product described in Lavergne et al. (2020).

**Reply:**

We have changed them. The second change is confusing. As the previous comments "135: Change 'during the entire overlap periods,' to 'for the entire instrument overlap'.", we followed this comment to change this sentence.

Page 5, Line 143-144, we wrote:

The differences between the MWRI-ASI SIE and four existing SIE products are quantified for the entire instrument overlap, as well as the winter and summer months.

**Reply:**

We have changed it

Page 5, Line 144-145, we wrote:

The 2010–2019 trends of the MWRI-ASI SIE and four existing SIE products are compared.

**Reply:**

We have changed it.

Page 6, Line 150-151, we wrote:

In a previous study (Zhao et al., 2022), a TB bias-correction was performed to reduce the bias between daily MWRI TB and AMSR2 TB.

*156: Change "weather filters" to "weather filters [GR(x/y)]".*

**Reply:**

We have changed it.

Page 6, Line 153-154, we wrote:

Two weather filters, i.e., GR(36.5/18.7) and GR(23.8/18.7), and a monthly maximum ice extent mask were utilized to remove the spurious sea ice.

*157: Change "More details" to "Details".*
*157: Change "were given in" to "are given in".*

**Reply:**

We have changed them.

Page 6, Line 155-157, we wrote:

Details about the dynamic tie points ASI algorithm are given in Zhao et al. (2022), and the details about the ASI algorithm can be referred to Svendsen et al. (1987), Kaleschke et al. (2001) and Spreen et al. (2008).

*164/caption Tab.2: Change "Differences in the parameters" to "Parameters".*

**Reply:**

We have changed it.

Page 6, Line 163, we wrote:

Table 2. Parameters or operations used in the previous and modified algorithms.

*166: Change "would cause" to "gives rise".*

**Reply:**

We have changed it.

Page 6, Line 165, we wrote:

Zhao et al. (2022) directly used the tie points from the AMSR series to initiate the SIC derivation, which gives rise large bias in initial SIC due to differences between MWRI and AMSR TB.

*171: Change "referential SIC" to "reference SIC".*

**Reply:**

We have changed it.

Page 6, Line 169-170, we wrote:

We used daily SSMI-ASI SIC in 2018 as the reference SIC and computed the daily average of the MWRI-ASI SIC and SSMI-ASI SIC (SIC > 15%).

*171/172: Change "Then, the linear regression was conducted between" to "The next step involves the linear regression between".*

**Reply:**

We have changed it.

Page 6, Line 170-171, we wrote:

The next step involves the linear regression between the daily average MWRI-ASI SIC and referential SSMI-ASI SIC.

*172/173: Change "As initial tie points we selected the pair satisfying requirements with the slope closer to 1" to "As initial tie point the pair satisfying requirements with the slope closer to 1 was selected".*

**Reply:**

We have changed this sentence.

Page 6, Line 171-173, we wrote:

As initial tie point the pair satisfying requirements with the slope closer to 1, intercept closer to 0, and relatively low standard deviation (Std) was selected from the 6000 samples.

*179: Change "Antarctic tie points were generated by the following procedures." to "process for Antarctic tie points is outlined next."*

**Reply:**

We have changed it.

Page 7, Line 177-178, we wrote:

We adopted the dynamic tie points proposed by Zhao et al. (2022) in Arctic, and process for Antarctic tie points is outlined next.

*179: Shorten "The conditions of sea ice tie-point samples in Antarctic are defined as follows:" to "Antarctic sea ice tie points are derived as".*

*180/181: Shorten "The conditions of open water tie-point samples in Antarctic are defined as follows:" to "Antarctic open water tie points are derived as".*

**Reply:**

We have shortened them.

Page 7, Line 178-181, we wrote:

Antarctic sea ice tie points are derived as: the initial SICs of grids are larger than 95%, and the grids are within the monthly minimum ice extent and 100 km away from the coast. Antarctic open water tie points are derived as: the initial SICs of grids fall within the range [-10%, 10%], and the grids are away from the monthly ice edge by 200–350 km and away from the coast by 100 km.

*182/183: Change "The Section S1.4 of the supplement file illustrates detailed procedures of generating the dynamic tie points." to "Details on generating the dynamic tie points are given in Section S1.4".*

**Reply:**

We have changed it.

Page 7, Line 181, we wrote:

Details on generating the dynamic tie points are given in Section S1.4.

*184: Change "were determined" to "are determined".*

**Reply:**

We have changed it.

Page 7, Line 182-183, we wrote:

The thresholds of the weather filters GR(36.5/18.7) and GR(23.8/18.7) are determined as 0.045 and 0.04 by Zhao et al. (2022), respectively, as the AMSR series sensors.

*186: Remove "can".*

**Reply:**

We have removed it.

Page 7, Line 183-185, we wrote:

In this study, we chose 0.05 and 0.045 as thresholds of GR(36.5/18.7) and GR(23.8/18.7), respectively, as the SSMI series sensors, which generally remove the weather effects (Gloersen and Cavalieri, 1986; Cavalieri et al., 1995).

*188: Replace "against to" with "over".*

**Reply:**

We have replaced it. Due to the comments of "'GR' is never defined" and of "Change 'weather filters' to 'weather filters [GR(x/y)]'.", we moved this sentence about the definition of GR to where it first appeared.

Page 6, Line 154-155, we wrote:

The gradient ratio (GR) is defined as the TB difference with V-polarization between high and low frequencies over the sum of these two TB.

*196/197: Would be good to list the specific databases by DOI from IceWatch and Pangaea.*

**Reply:**

We have listed the specific databases by DOI from Pangaea. However, the specific databases from IceWatch do not give the DOI, so we did not add them.

Page 7, Line 190-195, we wrote:

To validate the accuracy of the MWRI-ASI SIC, we collected the observational SIC from various ship-based measurement programs of the Chinese National Arctic and Antarctic Research Expedition (CHINARE) conducted by the Polar Research Institute of China (Lei et al., 2017) and a standardized ship-based observation dataset (ESA-SICCI) produced by Kern (2019), as well as those available in the IceWatch (https://icewatch.met.no/cruises) and PANGAEA databases (https://www.pangaea.de) (Arndt, 2019; Arndt and van Caspel, 2017; Katlein et al., 2014; Arndt, 2018; Arndt and Castellani, 2019; Hendricks et al., 2012).

Page 26, Line 528-537, we wrote:

Arndt, S.: Sea ice conditions during POLARSTERN cruise PS111 (ANT-XXXIII/2, FROST), Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.887697, 2018.

Arndt, S.: Sea ice conditions during POLARSTERN cruise PS118 (LARSEN), Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.901263, 2019.

Arndt, S. and van Caspel, M.: Sea ice conditions during POLARSTERN cruise PS103 (ANT-XXXII/2), Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.880046, 2017.

Arndt, S. and Castellani, G.: Sea ice conditions during POLARSTERN cruise PS117, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.901279, 2019.

Page 27, Line 573-575, we wrote:

Hendricks, S., Nicolaus, M., and Schwegmann, S.: Sea ice conditions during POLARSTERN cruise ARK-XXVII/3 (IceArc), Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.803221, 2012.

Page 28, Line 587-589, we wrote:

Katlein, C., Arndt, S., and Nicolaus, M.: Sea ice conditions during POLARSTERN cruise PS86 (ARK-XXVIII/3 AURORA), Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.835578, 2014.

*213/Caption Fig.1: Correct "statistical significant" to "statistical significance".*

**Reply:**

We have corrected it.

Page 8, Line 210-212, we wrote:

The statistical significance at 95% and 99% confidence levels are marked by * and **, respectively, and those below 95% confidence level are not marked, the same below.

*216: Correct "Comparisons" to "Comparison".*
*298: Correct "Comparisons" to "Comparison".*

**Reply:**

We have corrected them.

Page 8, Line 214, we wrote:

3.1 Comparison of the ASI SIC products

Page 13, Line 291, we wrote:

3.2 Comparison of the SIE products

*304: Replace "decreasing trend" with "reduction".*
*305: Replace "decreasing trends" with "reductions".*

**Reply:**

We have replaced them.

Page 14, Line 301-303, we wrote:

In the Antarctic, the largest reduction is identified for the MWRI-ASI SIE ($-191,993$ km$^2$ yr$^{-1}$, $P<0.01$), and the difference in trends between the MWRI-ASI SIE and OSI-SAF SIE is the lowest ($-8,928$ km$^2$ yr$^{-1}$ or about 5%).

Page 14, Line 304-305, we wrote:

In the period from 1979 to 2019, the four existing SIE products show significant reductions (about -55,000 km$^2$ yr$^{-1}$, $P$<0.01) in the Arctic and increasing trends (about 7,500 km$^2$ yr$^{-1}$, $P$<0.01) in the Antarctic (Table 4).

*341/Caption Tab.4: Add "The statistically significant at 95% and 99% confidence levels are marked by \* and \*\*, respectively."*

**Reply:**

We have added it. Due to the comment "213/Caption Fig.1: Correct 'statistical significant' to 'statistical significance'.", we further corrected this sentence.

Page 15, Line 337, we wrote:

The statistical significance at 95% and 99% confidence levels are marked by * and **, respectively.

*348: Correct "Comparisons to the" to "Comparison with".*

**Reply:**

We have corrected it.

Page 16, Line 346, we wrote:

3.3 Comparison with ship-based SIC

*356/357: Shorten "This implies that the MWRI-ASI SIC has a better accuracy in winter than in summer, which is due" to "Higher accuracy of the MWRI-ASI SIC during winter compared to during summer is due".*

**Reply:**

We have shortened it.

Page 16, Line 354-356, we wrote:

Higher accuracy of the MWRI-ASI SIC during winter compared to during summer is due to the high sensitivity of PM signal to atmospheric and ice surface melting conditions.

*379/Caption Tab.5: Add "The statistically significant at 95% and 99% confidence levels are marked by \* and \*\*, respectively."*

**Reply:**

We have added it. Due to the comment "213/Caption Fig.1: Correct 'statistical significant' to 'statistical significance'.", we further corrected this sentence.

Page 18, Line 375, we wrote:

The statistical significance at 95% and 99% confidence levels are marked by * and **, respectively.

*390: Replace "more intense." with "stronger".*

**Reply:**

We have replaced it.

Page 19, Line 385-388, we wrote:

In the PIZ, the MADs of polarization difference at 89 GHz between the MWRI TB and SSMI TB are smaller with values of 1.5 and 1.7 K in the Arctic and Antarctic, respectively, compared to those in the MIZ (4.6 and 4.4 K) and over open water (7.6 and 7.6 K), where the atmospheric influence is stronger.

**Reply:**

We have corrected it.

Page 21, Line 423-425 we wrote:

Compared to the SSMI-ASI and AMSR-ASI, the MWRI-ASI reveals more ice along the coasts and around the islands, such as around 72° N from 138° to 144° E in the Arctic and around 78° S from 160° W to 170° E in the Antarctic (Fig. 9).

**Reply:**

We have corrected it.

Page 21, Line 452-454, we wrote:

In the Antarctic, our MWRI-ASI SIE is about two grid cells (25 km) farther south than the Sea Ice Index SIE, and the absolute deviation increases in winter because the SIE is larger in winter than in summer.

**Reply:**

We have corrected it.

Page 23, Line 471-472, we wrote:

This dataset is available from 12 November 2010 to 31 December 2019 with temporal data gaps of 23 days in the Arctic and 82 days in the Antarctic.

**Reply:**

We have changed it.

Page 23, Line 475-476, we wrote:

The values '0-100' are the percentage of SIC, flag of '-1' is the land and of '-2' is the Pole Hole, and 'NoData' for missing data.

**Reply:**

We have replaced it.

Page 23, Line 483-485, we wrote:

To test the skill of the MWRI-ASI as an independent PM SIC dataset, the MWRI-ASI SIC is compared to the existing ASI SIC products of SSMI-ASI and AMSR-ASI, and the MWRI-ASI SIE is compared to the existing SIE products of SSMI-BST, SSMI-NT, OSI-SAF, and Sea Ice Index.

**Reply:**

We have changed it.

Page 24, Line 498-499, we wrote:

Future improvements are aimed to identify and remove the spurious sea ice caused by land spillover and weather effects more accurately by using satellite-based observations with higher resolutions to further improve the MWRI-ASI SIC.

*522: Suggest to acknowledge the input of the reviewers, pls.*

**Reply:**

We have added it.

Page 26, Line 521, we wrote:

In addition, we are grateful to the reviewers and editors for their improvements to this paper.

*References:*

*Add new refence:"esastar, https://esastar-publication-ext.sso.esa.int/ESATenderActions/details/55123, accessed 2023-0610." (Info accessed -- not to be included in your manuscript: "The Copernicus Imaging Microwave Radiometer (CIMR) mission is an Expansion mission of the European Commission to enlarge the Copernicus Space Component. The aim of CIMR is to provide high-spatial resolution microwave imaging radiometry measurements and derived products with global coverage and sub-daily revisit in the polar regions and adjacent seas to address Copernicus user needs. The aim of this activity is to prepare an airborne capability that is required for CIMR calibration and validation activities both prior and post CIMR-A launch expected in 2028/29.")*

**Reply:**

We have added it according to the requirement of references.

Page 27, Line 560, we wrote:

Esastar: https://esastar-publication-ext.sso.esa.int/ESATenderActions/details/55123, last access: 10 June 2023.