

Response to rebuttal:

General response:

I would like to commend the authors for their thorough efforts in revising the manuscript and for the detailed responses provided to each referee comment. The manuscript has benefited substantially from these revisions. My primary concerns during the initial review centred on three key areas: (1) the study's focus on SIC uncertainty and the use of inconsistent terminology, (2) the treatment of spatial heterogeneity, and (3) a lack of clarity regarding certain methodological choices. I am pleased to see that these issues, along with several minor concerns, have been addressed satisfactorily.

In light of the revisions made, I recommend the manuscript for publication, subject to minor revisions. Below, I provide a small number of remaining comments for the authors' and editor's consideration. These include both new observations and follow-up remarks related to my original concerns, which are identified using the corresponding rebuttal numbering for ease of reference.

Title: refocusing the study to a sensitivity study specifically using the bootstrap algorithm has significantly improved the clarity of the of the study and avoids many of the initial methodological concerns.

Kindly consider revising the title to "Sensitivity of the Bootstrap sea ice concentration **algorithm** to surface parameters in the Antarctic marginal ice zone using passive microwave retrievals" since you're testing the algorithm's sensitivity and not a concentration product derived with the bootstrap.

RC3.2: Thank you for the clarification regarding the increments, I reserve my response to another comment below. On a different note, I find that having different ranges for figures 6-10 for "Retrieved SIC" is confusing, some are 0-100%, some less and some more, why not fix it to 0-100%? If it is a visual issue, consider for figures 6-8 for example, setting the legend columns to 4, that way they will likely occupy less vertical space, allowing you to fix the range, if that fails, you can place the legend outside the figure using `insert_axes` in python. But I'll leave this to the authors to decide. The same trick can be used for figure 10. I'm not sure what restricts figure 9. But regardless of the increments, the range should be the same throughout.

RC3.3: Thank you for this clarification. I appreciate the use of a schematic to explain this and fully agree with the authors about the additivity property of the radiance. Indeed, the relative vertical and horizontal extends mean that the lateral fluxes are negligible.

While I am now convinced that the spatial heterogeneity is not a major factor for the study, I believe the authors should acknowledge that spatially aggregating the sectors creates somewhat pseudo conditions that may not be representative of the true Antarctic conditions, I say it is not major because I still believe that the major contribution of this work is providing a novel approach to testing the sensitivity of the SIC retrieval algorithms and not to truly assess it against "real" conditions, doing so requires significant work that can be refined in later studies but these shortcomings should be acknowledged. At the very least it should be said somewhere that Antarctic sea ice varies significantly within the sectors and aggregating them may not represent the true sensitivity. This does not take away from how informative the results are about the probable sensitivity to the broad characteristics in my opinion.

RC3.18: Alright, this makes sense. I assume that a 15% increment in the TB space is not sufficient then? If yes, then okay, otherwise I still do not understand why for example for figure 4

it would not be better to have the same increments on the left and right columns (i.e. 15%), unless indeed a 15% is insufficient to show the impact due to wind speed on the left column.

RC3.23: I concede that that inclusion of multiple ice types does represent the diversity of conditions around the Antarctic sea ice. However, I am not convinced that a circumpolar aggregation informs us about the "true" nature of Antarctic sea ice, the focus on the broad characteristics and sensitivity of the bootstrap to these broad features is sufficient for an initial research pathway, extrapolations can be made in later studies so I no longer deem this a major concern, it only needs acknowledgement. I also note that the tie points are done circumpolarly and not sector specific, perhaps commenting this somewhere in the manuscript may be better. Either way, I leave this decision to the authors and editor.

Lastly, I have a general recommendation for **figures 2 and 3**. Please consider using shared x and y axis, since the subplots display the same variables, only differing in the shaded variable.

For **Figures 9 and 11**, Please explain why the sea ice does not have liquid water fraction. I would have also expected that the algorithm is sensitive to ice salinity given that it is sensitive to the liquid water fraction, at least as shown in Figures 6 to 8. This is because the salinity is somewhat indicative of liquid water fraction (i.e. high LWF, higher bulk salinity).

I commend the authors once more for their dedication to improving the manuscript and thank them for the detailed responses and actions taken.