

Physical and mechanical properties of winter first-year ice in the Antarctic marginal ice zone along the Good Hope Line; manuscript ID: tc-2021-209

Report of Editor and Responses by Authors

The authors would like to thank the reviewer for the meticulous reading of the manuscript, the comments and suggestions, which helped to improve the paper. All recommendations are addressed within the manuscript as highlighted in yellow and commented in the following using red font.

The manuscript is much improved and addressed almost all the comments adequately. I think there are two main points that could use some minor improvements.

1. Your results are quite different now that you have used the brine volumes during testing. There is some discussion of why these results might be different in the text, but I would have appreciated a bit more discussion, particularly in the conclusion about why this might be (e.g. differences in structure, potential differences in air volumes, or maybe even differences in the technique, in that prior work tended not to resolve depth variations, etc). One thing you might also try to address is whether the differences you see are real differences, or statistical. E.g. in Figure 14, you see differences between pancake and consolidated ice for Young's modulus, but at least for some brine volumes, I am not sure these are that statistically significant given the spread in your values (the 90% confidence you show is for the line fit, but I believe this does not represent the range that 90% of your values at a given brine volume fall within). Likewise, can you elaborate a little more on the differences in compressive strength with previous work? Is it measurement technique (lab vs insitu)? Is it texture or ice type? Etc. I think just a few sentences in the Results and Discussion and/or Conclusions would help readers better understand what they should take away from your results.

Response:

We have expanded more on results and findings in the conclusion of the revised manuscript. As suggested, we provided more details on the linkages between textural, physical and mechanical properties as well as differences between Arctic and Antarctic sea ice observations.

You are correct. By definition, the 90% confidence interval is not the range that contains 90% of the values but the range of values where one can be 90% certain to contain the true mean of the population.

2. My one comment that was not really addressed was about what conclusions that you can draw about mechanical properties in situ from your lab measurements. Your in situ brine volumes are substantially higher than in the lab, but there is some overlap. i.e., a typical brine volume seems to be about 10% in situ (for a bulk brine volume for the whole core, this seems pretty good, which may be a reasonable number to use for the mechanical properties of a whole floe). In the lab, you have a few values for pancake ice in this range. Do you think then these would provide reasonable values for others to use for the MIZ? Unfortunately, you don't have similar values for consolidated ice, and your curves would extrapolate to

unrealistic values at 10% brine volume. I think some discussion of this is needed in the conclusion.

Response:

We have further discussed in the conclusion of the revised manuscript the found differences of mechanical sea ice properties compared to literature due to differences regarding ice origin, type and texture as well as due to methodological challenges with the mix of in situ/ex situ testing. We also emphasized the importance to relate mechanical sea ice properties not only to its porosity but rather as linked to the combination of ice temperature, bulk salinity and textural characteristics. Lastly, we pointed out that the obtained data indicate a high variability which warrants further studies and confirmation specific to region and season.

Minor comments:

1. Check the formatting of references cited within the text. There seem to be lots of errors generated by your referencing software, and the in-text citation format is not standard for the journal.

Response:

All citation errors have been corrected in the revised manuscript.

2. Figure 1 - this is much improved. The inset is clear enough, I suppose, but think it could be a bit better if the scale was such that you could see more of the coastline of the Antarctic so it was more instantly recognizable to the reader.

Response:

The figure has been further improved as suggested in the revised manuscript.

3. Figure 14 and text - note that the equation you attribute to Langelben and Pounder is actually from Langleben, 1962 for first year ice. In Langelben and Pounder there results fall below this line (though not as much as yours) and are for multiyear sea ice. Note that they measure E in situ, but the paper is not very clear on how they treat brine volume - presumably the in situ value, but it will vary from top to bottom, and their technique gives a bulk value of E, so could help explain why your values do not match theirs?

Response:

As mentioned above, we believe that the textural differences between columnar Arctic sea ice and granular Antarctic sea ice are of significance being partly responsible for the differences regarding the Young's modulus besides the brine loss. Another clarifying sentence has been added, see lines 340 seqq. and also in the conclusion of the revised manuscript.

4. Figure 17 - it would be nice to have a little more discussion of these results, since they appear to be quite different the Kovacs for low brine volume. Maybe it is all due to brine loss (which you could perhaps estimate), but you'd expect that to be less for the lower brine volumes. One possibility is Kovacs used bulk brine volume using a single temperature, and you are using more discrete data (I think). But it could also be different textures and air volumes (particularly for pancake ice).

Response:

Besides loss of brine volume, we believe that the difference regarding the uniaxial compression strength appears to be due to textural differences between columnar Arctic sea ice and granular

Antarctic sea ice which has been already mentioned in the manuscript, see lines 370 seqq., but has been further stressed and discussed in the conclusion of the revised manuscript.

5. I still don't understand what you are trying to show in figure B1. All I see is grey blocks of various lengths, and only M01-US-01D shows different sections labelled, but this is just text on the grey block, so I can't even judge the thickness of these sections. Maybe you'd be better off here with a table that lists the length of the sections and total core lengths for each core?

Response:

There seems to be an issue with certain PDF readers, as the figure shows the core segmentation with appropriate labelling and dimensions. I will upload both figures separately as well for your reference.