The Cryosphere Discussions

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Interactive comment on "A Network Model for Characterizing Brine Channels in Sea Ice" *by* Ross M. Lieblappen et al.

Anonymous Referee #1

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General Comments:

This paper presents a topological and statistical analysis of novel three dimensional images of sea ice microstructure. In this paper, a directed graph is mapped to the microstructure of the sea ice and a throat size assigned to each node from the semi-minor axis of a best fit ellipse around a brine pocket viewed from a horizontal slice. Edges are assigned when moving though the ice if a brine pocket continues immediately below the previous elevation. Edges themselves can represent a splitting or joining of a brine channel depending on the overlap of the pockets being compared. Using this network model, statistical analysis is carried out relating morphological characteristics to depth and temperature. The results of the analysis are consistent with observed characteristics of sea ice microstructure for both columnar and frazil ice. The analysis presented

here is then to be used as a basis for model development.

This paper presents an extensive analysis of rare and difficult to obtain microstructural data. Sea ice microstructure moderates a broad range of physical processes in both the Arctic and Antarctic. As a result, this statistical analysis should be of broad interest to polar science community. Overall, the analysis is well thought out, and well executed. I recommend this paper for publication with the following specific issues being addressed and or considered. I might also suggest the authors carefully read through the manuscript, there are sporadic minor grammatical errors.

Specific Comments:

Page 1

Line 1: "The brine network in sea ice is a complex labyrinth whose..."

I understand what you are trying to get at here but the description is not completely accurate. A labyrinth would imply that there is no order to the channel development, this is not the case.

It might be better to say something like, " The brine pore space in sea ice can form complex connected structures whose geometry is critical in the governance of important physical transport processes between the ocean, sea ice and surface."

Page 2.

Line 32: "since viewed in two-dimensional slices"

I think it would be prudent to add the fact that these are horizontal slices for clarity.

Page 3 Line 4: "This definition captures both the location and the size of the brine phase at any point..."

I'm not sure I understand this. The brine phase refers to the whole of the brine pore space. I think you might mean that it captures the location and size of a brine pocket

at any point. However, this is a 2d slice so you may want to find some other type of phrasing.

Near Line 25: The probability of remaining notation is a bit awkward and phrasing confusing. Saying you are counting the number of connections made me think of the total number of connections that can trace back to that pocket.

How about: For example, to calculate the probability that brine pockets of a given size remain we simply divide the number of pockets for a fixed throat size r that connect once from z_i^* to $z_i^* - 1$ by the total number of pockets of that size.

Markov chain: I agree that the network model is representing a Markov chain, and that seems to make sense, it should be that way physically I think. But is there a physical justification that this is true? I believe it would strengthen the paper.

Section 3 Results: You might want to add a reference with definitions of the some of the quantities listed in Figure 2.

Page 4 Line 7: " but instead produces a slush that has x-ray attenuating properties between ice and brine".

Is the slush in the pore space? The wording makes it sounds as if the whole thing is slush, that of course would not make sense at -7 C. It becomes clear later, but saying that the slush is in the pore space immediately would make things clearer.

Could it also be that at the bottom of the core you had more brine leakage at the time of extraction? In this case ,what was in the brine space may have been less saline and thus slushy at the in-situ temperatures.

Line 11: It would be helpful to describe what is meant by "as best as possible".

Line 27: "Salinity Values Measured in the Field"

Were these bulk salinity measurements from adjacent cores? That should be stated if so.

Page 5

Line 13: "This is an important observation since we did not record the vertical orientation of the samples during cutting"

Can't you tell by the direction of splitting, or are the samples too small to see that structure?

Line 21: Change maximize to maximum.

Line 22: The description of Figures 8 and 9 should be rethought and made more clear. It is not clear to me what the unsorted figures represent. I assume node index is just a way to label each node and to me it seems arbitrary. Ordering them by size makes sense but what gives the unsorted part of the figure any relevance? I think a description of how each node is labeled in the unsorted figure is needed to understand what it is meant to represent. Is it done by physical distance from the node with the largest throat size? It was not clear to me. This may all be fixed by clearly defining "node index" which I did not see in the figure.

Page 10

Line 22 "The probability distributions shown represent a sampling of the various possibilities..."

Consider rephrasing, maybe change possibilities to microstructural behaviors?

For your future model development, you might want to consider the effect salinity might have on the statistics you consider. It is encouraging to see that the other two previous cores you use do follow the most recent though. However, in the Arctic summer snow melt can get into the pore space decreasing salinity and reducing permeability. Just a thought.

Figures: Figure 1: A figure showing how a split or join is assigned would be nice but is not completely necessary.

Figure 2. Rename object volume to brine volume fraction?

Figure 14: Just a comment, the up and down motion might be able to be captured if you had someway to include horizontal edges in your network model.

Figure 15: Connecting the dots with thin lines may make the figure easier to read, not sure, it is ok as is though.

Technical Corrections

Page 1

Line 25: produces should be produce. "Since different growth rates in natural sea ice produce…"

Page 4

Line 4: Remove the word "sufficiently"

Line 6: change "this ambient cooling" to "the ambient temperature".

Page 5 Line 21: Change maximize to maximum.

Figures

Figure 10: X-axis title is cut off a bit.

Figure 11: In the caption "black squares" should be "blue squares".

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