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The Cryosphere Discussions

Interactive comment on "Initial sea-ice growth in open water: properties of grease ice and nilas" *by* A. K. Naumann et al.

Anonymous Referee #1

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Review - The Cryosphere - Naumann et al. - TCD-6-125-2012 (tc-2011-108)

Naumann et al. present a interesting data set from a set of tank experiments, on new ice growth in different conditions, in a manuscript draft that is concise and well written. However, I find that there are significant flaws in the description of the experiments, and especially how the walls in the relatively small tank that is used, will affect the results. Such a small tank will not be representative of open ocean conditions, and the accumulation of ice during growth in dynamic conditions may be severely impacted by the small size of the tank. This needs to be better described. Also the wind fetch will be very different than in the open ocean.

I also feel that they could have done a more thorough job to set the scene for this work, based on a more quantitative summary of earlier work in the subject matter. This would

aid the reader to see if the justification and motivation for this work is as sound as the authors argue.

Nevertheless, such experiments are an important step to better understand the initial growth processes, however the representativeness of such a small tank need to be much better discussed in the manuscript.

Therefore I recommend that this manuscript needs a major revision and re-review.

Specific comments

p. refers to page, and l. to line number in the pdf at TCD.

p. 126 - Title - given the size of the tank- I am not convinced that the experiment is representative of open water conditions - given that with this you mean the open ocean? I think the title should rather show that this was a tank experiment, from the title one can be misled to think that this was based on observations in the open ocean.

p. 126 - Abstract- Generally well written. First paragraph could be made a bit shorter "Initial sea-ice growth was investigated in a tank study with three different setups; .... " Some more details could be given to aid the reader, such as size of tank, thicknesses of the ice that is formed in the different experiments, and solid fraction values for nilas. Maybe also note that your experiments are done with a NaCL solution, not seawater.

p. 126 l. 7 - delete "We find that the"

p. 126 l 18 - delete "We find that"

p. 126 l 22 - Do you mean the volume of ice produced is the same? You would think if part of the tank is kept open, freezing rates are higher and more ice is formed (therefore the ice htat is formed would be thicker?) - would be maybe possible to mention the amount of ice that is formed as well. IS the double thickness a result of a"wall-effect", i.e. piling against the wall of the tank?

p. 127 - Introduction. Generally well written. Would expect to see some more citations

in the first paragraph, i.e. to seminal work by Weeks, Ackley, et co.

p. 127 - second paragraph. Paper by Skogseth & Smedsrud (field study) is mentioned later in the draft, why are results from this paper not discussed here? Also the authors should have found the time to shortly give some of the results to the paper by Maus and de la Rosa that is submitted, would be vital for the reader to see, what their results (experimental or field?) have contributed to the knowledge of initial ice formation.

p. 128 l- 9-10. You cite a masters thesis, this is not readily available for the reader (at least the reference does not give a link to an electrenoc version), further it is in German, and therefore it is basically irrelevant to cite here, as it won't help (most of) the readers to find out anything more about the experiment. Remove citation in the Introduction.

p. 128 l. 7-8. See above. No excuse to show briefly what results this paper has come out with, does it undermine or duplicate results presented in this paper? Why is this not in the reference list? You list Håvik et al (in prep) there - smells like an urge for self-citation. Be consistent in this, and give credit where it is due.

p. 128 - l. 11-19. Most of the sentences start with "In Sect. X we" .. please improvethe text flow by using variable wording at the start of the senteces, such as "following with xxx in Sect. X", "thereafter in Sect.", "Finally in Sect. ..."

p. 128 - Experimental setup General. What was the material of the tank? Was it made of transparent material of any if the sides? How high was the tank? I think the authors should add a schematic of the tank and instrument setup, and a photo of the experimental setup, to aid in understanding how it looked like. (For later: Also adding photos at the end of the three different types of experiments would be useful).

p. 128 l. 26 - "experimental processing" - unclear to me what this means

p. 129 l. 3 - how large where the heating plates, I assume they also covered the part of the tank above the water level?

p. 129 l. 6-7. IN the abstract you list three types of experiments "quiescent", "with

waves" and "current and wind" - here you list "quiescent", "waves" and "current" - I assume the alst one means "current and wind" - be consistent through out how you name the different types of experiments.

p. 129 l. 12 - show the "oblonged circular track" of the current in the schematic of the tank setup or photo.

p. 129 l. 15 - what kind of wind system? What kind of wind does it produce, evenly on the whole surface, fetch?

p. 129 l. 26-27 - Again, citation to Naumann not needed, if details need to be shown, give them in the paper or as supplementary material.

p. 130 l.1-2. Type of thermistors and accuracy?

p. 130 l. 3-5. Here you cite work in prep, but do not cite Maus & de la Rosa which is submitted. Please be consistent. If none of the results in Håvik are presented here, omit this paragraph.

p. 130. l.6-7. Delete paragraph.

p. 130 l. 9 "with waves" "with current" -please be consistent in the terms you use for the different experiments (in abstract you also mention wind).

p. 130. l. 10 should this be "solid fraction (by mass)"? Maybe specify it here.

p. 130 l. 24. Salinity of true "pure ice" is 0.0, but does the consolidated ice chunks/pieces in grease possibly contain some salt between crystals? Since you have used error propagation, how senstitive is the estimate if Si would range from 0.0 to 0.2?

p. 131 l.1 "gauge" is this is a conductivity probe or sensor (haven't seen gauge used before)? Accuracy?

p. 131 l. 2 Why cannot the salinity of the interstitial water be measured directly in the samples, immediately after it has been collected? I am sure measure could be made

to try to do this measurement, was it tried at all during experiment?

p. 131 l. 7. Simply write "the salinity of the interstitial water therefore increases during ice formation"

p. 131 l. 15 What values are used for pure ice density, and how is water density calculated?

p. 131 l. 16-25. Would need to say how this measurement is performed in practice. Is heat also lost to the surroundings, not only to ice melt? IS the sample stirred to assure heat is evenly mixed into the sample and no stratification occur? How accurately is temperature before and after measured, and should that also be an error term? Give units for U, I, delta-t and delta-T?

p. 132 l. 2 - are the errors significantly different? does it pay off to do the more time consuming (?)calorimeter method, if you have almost same error as with the salinity method? I assume this discussion will follow.

p. 132 l. 10 - "two samples" - was the spatial variability in the tank studied beyond these two samples? How close to each other where these two samples taken? Exactly the same time?

p. 132 l. 14 - Accumulation at the end of the tank is a clear sign that the wall has an accumulating effect. Was there any effort to study the spatial variability in the thickness and compactness of the accumulating ice layer in the experiments with current (and wind?)?

p. 132 l. 15 "sampling there" - at the end of the tank?

p. 132 l. 18 how does the piece inside the tube affect the grease ice layer when it is pushed through the ice?

p. 132 26-27 - how does the ration between the grease ice layer and weater below affect the solid fraction estimates? You say that thin layers were not measured, so for

thicker layer how does to error propagate to the solid fraction estimates?

p. 133 l. 10 how did you measure the bulk salinity of the ice if you did not collect any samples?

p. 133 l. 13 "visible evolution" - example photos would help here.

p. 133 l. 19 you state "uniformly thick" - was this measured? or simply assumed?

p. 133 l. 21 "ice crystal layer" how does this compare or differ from grease ice?

p. 133 l. 21 Size of pancakes formed?

p. 133 l. 23 - "roughly spatially uniform thickness" - again was this measured, or simply assumed?

p. 133 l. 27 "end of the tank" and "considerably thicker" - how much thicker, again was this measured, or how was this evaluated? Is this not a sign of accumulation against the wall and therefore also compaction of the grease ice will happen sooner than in an "open water" condition? Did you examine the spatially varying solid fraction of the grease ice?

p. 134 l. 2 "track" - not sure this is the right term to use, flow pattern, or the like maybe?

p. 134 l. 5 - you claim that this is more representative of a wind driven situation, to a degree yes, but if the ice is accumulated against a wall, this more like grease ice accumulation towards an ice edge.

p. 134 l. 7 - "experiment with current" did this include the wind as well?

p. 134 l. 8 Figure 2 - Would be informative to show the evolution of TS also from different type of experiment, one from each type.

p. 134 l. 14 - the gain of salt, was that similar in the different experiment types? was the same amount of ice form in the same time?

p. 134 l. 20 simply say "strong near-surface stratification in"

p. 135 l. 6 - Figure 3 - would be clearer if you can also show the points of data as circles or the like, with a range or standard deviation. Looks tome there is a trend for decrease in solid fraction of the salinity method with time - a sign of increasing interstitial salinity perhaps?

p. 135 l. 7 - and this means that the two different samples are in fact comparable?

p. 136 l. 2 - perhaps add the "corrected" salinity derived solid fraction line also into Figure 3

p. 136 l. 6 - Figure 4. SHow descriptive statistics for the distributions. If you look at the two methods separately, is there any difference in the spread of the values?

p. 136 l. 12 "over time" - rather during first 3.5 hr as shown in Figure 3.

p. 136 l. 18 first time the term "turbulent experiments" is used, please be consistent in the use of terminology for the different types of experiments

p. 136 l. 17-25. Is this not an inherent result of the experimental setup, one more evidence that more grease ice accumulates in the current/wind experiment at the ends of the tanks, and therefore it is quite clear that in a thicker grease layer the solid fraction is lower at the time surface consolidation starts? Need to be clear of this possibility as well.

p. 136 l. 26 to p. 138 l. 7 - interesting results

p. 138 l. 17. Figure 6. Why is Sbu higher in the in the experiments with current?

p. 138 l. 25-26 - How was ice thickness measured? Many points in the tank? You earlier mentioned that there was stratification in the tank during nilas formation, how can you then be sure that the salinity measured by the CTDs in the under-ice water can be used to calculate average salinity with sufficient accuracy? Would be interesting to see actual salinity profiles beneath the ice in the nilas tanks.. Can you asses the impact of the error in calculating the amount of salt in the underlying water from possible

stratification at the surface? How does this propagate to estimation of solid fraction?

p. 139 l.12 Eq 7. give units to all used parameters. What is "h" in equation 7? What values are used for the constants, source of data?

p. 139 - l. 20 - Ra numbers are less than 10, so critical value in sea ice is less tahn 10?

p. 139 l. 26 - Ra number in Figure 7b, is this for the surface of the ice, or some average for the ice whole ice layer? For loss of brine, shouldn't one follow e.g. the bottom cm of the ice with time, as the layers above have already strated to consolidate and have lost most of the brine already?

p. 140 l. 5 - how accurately is the bulk salinity actually estimated? (see above)

p. 140 l. 21 - Perhaps section 4.4. could be divided into 3 sections; salinity, solid fraction and thickness.

p. 140 l. 25 start new section here 4.4.1

p. 141, l. 16 start new subsection here 4.4.2

p. 142, l- 25 start new subsection here 4.4.3

p. 142, l. 1-3. "turbulent experiments" what do you mean by this? Was this solid fraction due to accumulation f grease-ice againts the wall of the tank? After how many hours was this solid fraction calculated?

p. 142 l. 14-24. Again a sign that the ice in this experiment was packed against the wall of the tank. Lower values measured in the "nature" had likely free-floating grease-ice. Need to consider this wall-effect.

p. 142 l. 14-24 You mention a paper submitted by Maus and De la Rosa - since you apparently know this paper, how are their results linked to these presented in this paper? What were their results?

p. 142. l. 22 Of course not comparable, if you measured it in a layer at rest = layer that is pushed against a wall and accumulates due to wall-effect.

p. 142 l . 28 first time the method of ice thickness measurement is described, should have been noted in the Methods part. Only one point in the tank where this was measured? "Very homogeneous" - is based on what?

p. 143 l. 1 - now you mention that the ice thickness was very unhomogeneous. Should ahve been noted on earlier. How representative are the two samples taken from one tank if there are such variations in thickness?

p. 143 l. 2 Rather than "measured" the salinity increased was "estimated", especially if there was any vertical layering in salinity. Error associated with this in estiamtes of ice thickness?

p. 143 l. 11-18. The ice thickness in the current experiment, is this the thickness of the actual layer accumulating at the end of the tank, or some idealized average thickness over the tank based on the salinity increase in the tank and the solid fraction? How large portion of the tank was in fact ice free? Should have been described earlier in Section 3.

p. 143 l. 20. "with a current" - do you mean with the experiment with waves?

p. 144 l. 4 "grease-ice model" confusing, does this mean that this applies for both wave and current experiments, as grease ice was formed in both? Or does this relate to the current with wind experiment only? Please clarify.

p. 144. l.9. Citation of Naumann again, please omit. Perhaps replace with (not shown). How does this C value compare to other studies?

p. 144 l. 15 do you mean surface temperature for the quiescent and wave experiment, and grease-ice model for the current experiment? Please clarify and be consistent in use of terms for the experiments.

p. 145 Summary- No critical assessment of the drawbacks and deficiencies of this experimental setup. It is hardly easy to directly compare the conditions, as the dimensions of the tank seem to clearly affect the accumulation of grease-ice in the current/wind experiment.

Small edits p. 129 l. 18 - "at different depths" p. 130 l. 2 "at 12 cm" p. 131 l. 7. Simply write "the salinity of the interstitial water therefore increases during ice formation" p. 132 l.7 delete "an" p. 133 l. 6 "collection" instead of "taking" p. 133 l. 8 "collection" instead of "taking" p. 135 l. 26 sentence starting "However, ..." this could be written much shorter - like "However, assuming interstitial salinity of 35 leads to a mean solid fraction of 0.25". Simple as that. p. 135 l. 13 & 16 "is forming" "is decreasing" . simply use forms or decreases p. 142 l. 9 - measureD

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