Response to Reviews of:
"Laboratory study of frazil ice accumulation under wave conditions"
by De la Rosa and Maus, submitted to the Cryosphere Discussions:

We thank the three Anonymous reviewers for their feedback on our manuscript and for the constructive comments and suggestions which will improve the flow and presentation of the manuscript. In the following, we have replied to each comment and provided extended explanations and/or changes that will be or have already been made in a revised manuscript. Reviewer comments are given below with our response in red italic.

A summary of our major changes include the following:

-We split Table 1 into two tables and reduced numbers given to two decimal places.

-We removed Figure 10 from the paper and replaced Figure 4 with a contour plot of all out data for Experiment 1 (both tanks) to illustrate the spatio-temporal variability of a) frazil ice thickness, b) frazil salinity and c) frazil ice solid volume fraction.

-Considerable work is being carried out to improve the text and remove repetitions. It is clarified that ice conditions for Experiments E2 and E4 evolved similar to E1 and E3, however water was already close enough to freezing so that ice formation started much earlier than during E1 and E3. Sampling for the early hours of these two experiments could not be obtained, so the presented values 'miss out' Mode 1, as the light grey shading in the histograms of Figure 6 illustrate.

Reply to Reviewer 1

The authors describe the results of four experimental runs that studied the properties of frazil ice generated by waves done at the Hamburg cold wave tank facility, in 2007- 2008 under the acronym RECARO (Reduced Ice Cover in the Arctic Ocean). This is new work that according to the authors, was described briefly by Wilkinson et al. (2009). Some of the data from these experiments has been published by Wang and Shen (2010a) on wave attenuation, (by De la Rosa et al. (2011) on frazil ice properties, and in a submitted paper by Maus and De la Rosa (2011), so that the present authors are working on ground that has been heavily ploughed.

Answer: *The ground has been heavily ploughed, from different sides and perspectives, indeed. The RECARO experiments were a fruitful success.*

The current paper studies the change in bulk frazil ice properties during the transition from open water to pancake formation under wave conditions, where bulk refers to averages over the entire tank. This is useful information, but presented in a way that is not easily understandable. There is only one figure that shows the variation in ice properties with distance down the tank, the rest refer to bulk properties. Given the change of frazil ice properties that occur with distance due to wave attenuation both in the lab and in the field, I find their bulk averages approach bewildering.

Answer: *Also another reviewer requested more information about property distribution with distance. We supply this now in Figure 4 in a contour plot, as suggested by one of the reviewers. Please note, as we had mentioned in the text, that only frazil thickness varies strongly with distance. Salinity and*

solid fraction do so with time, but to a lesser degree with distance. Figure 4 now shows this clearly, for E1 where we had most observations.

I also dont have a very good feel for the experiment; the addition of some photographs of the apparatus and ice layers would help.
Answer: *Our given reference Wilkinson et al. 2009 shows pictures of the apparatus.*

Because the size of the font in Table 1 and the size of many of the figures are too small, a major problem with the paper is that it difficult is to read. This means that my review was done using a combination of a printout for the text, and the pdf enlarged by 2 to 4 times for the figures. Specifically, the Table is written in what I estimate to be a 4-point font (a 4 point font), which I find really hard to read. This use of such a small font would not be permitted at JGR. I suggest that the authors break the table into two parts, and redo it with the 10-pt font used in the rest of the paper. A similar problem occurs with some of the figures; these are also difficult to understand because of their small size; when they are enlarged by 200-400\% so that I can read them, the symbols and labels lose their resolution.
Answer: *We agree the table was typeset very small in the online Discussions version. We improved this.*

There are also problems with the experiments: The authors carried out four experiments (E1-E4) but only two of them started with completely ice-free conditions. According to Section 3.3 in the paper, Experiments E2 and E4 began with a 3-4 cm ice thickness, where this ice was left over from melting the ice of previous experiments (E1, E3). The authors do not provide an explanation as to why they began the so-called open water experiments with a layer of old ice crystals, and do not explain why data from these runs is included in the analysis. Regarding old ice crystals, as Peter Hobbs discusses in his book Ice Physics, this aging ice has different properties than young frazil, because its crystal shapes tend more to the spherical than the flat young frazil crystals. Given the problems with E2 and E4, and the confusion on the graphs described below, I strongly suggest that they drop E2 and E4 from the discussion, and focus their discussion on E1 and E3.

Answer: *We considered the possibility of old, of course different left-over frazil, but do no longer think that much ice was left over (we remove sentence lines 15-17, p.1855 in Sect. 5.1 and modify lines 11-12 in p. 1857, Sect. 5.2). We started measuring at a later stage, because we had no access to the lab during the night. This is stated now in the text. The onset of ice growth is thus not well known.*
However, since we later discuss results in terms of thickness dependence, not time, this does not affect our results. The histograms in Fig. 6 are shown to illustrate that despite E2 and E4 lacking the young ice peaks, they still show similar distributions to E1 and E3. The four experiments are thus comparable.

Figure 2. Suggestion to add some discussion of the long period oscillations in (b).

Answer: *During E1 the ice cover became thick enough for waves to get damped. Possibly the long-period oscillation seen in the T_w record (Fig 2d) is due to heating through the tank bottom, as surface cooling no longer mixes downward and the whole water mass warms, coupled to the tank circulation. This is now summarized in the text (p. 1842, end of Sect. 3.1), and reference is made to the heat flux calculation which is mentioned in following section.*

Figure 3. The closed and open circles are not identified, and data taken at a number of different times are identified by the same open circles. Because of the scatter in the data, this reviewer cannot

associate the open circles at each distance with a specific time. The inability to distinguish among different times, plus the small size of these sub-figures, makes them near worthless.

Answer: We modified the symbols. The symbols now sort observations in 5 hour and 10 hour bins and illustrate the temporal and spatial distribution (The 10 hour bin was selected for over-night hours, when very few measurements were possible). The 3 lines are exponential fits of the thickness distribution along the tank at respective centered times 5, 15 and 25 hours. This is now clarified within the text and Figure legend too.

Figure 4. Needs lots more discussion; let's look at the blue dashed line; this is the mean of an exponential fit at three different times with the observed data; why does it fall off so dramatically with time? Why is such a confusing figure important? And, why don't you discuss the anomalous behavior described in this figure?

Answer: As this was also suggested by other reviewers we removed this figure. Instead we now show a contour plot of H_i, S_i and v_s, but just for Experiment one, to illustrate the spatio-temporal variability.

Figure 5. Given that the old ice (E2 and E4) is not representative of new frazil, why include it in the figure?

Answer: We change l. 20-21 on p. 1847. We clarify that the experiments do not present less clarity, but reflect only the later stage of frazil evolution 5-10 hours after onset of growth.

Figure 6. Since E2 and E4 are your worst experiments, why break them out separately? Why not break out your "good" experiments, E1 and E3?

Answer: As noted above, the histogram shows well that experiments E2 and E4 lack the low salinity mode, but are otherwise similar to E1 and E3. To show this we treat them separately. We added this clarification to the Discussion text that refers to Figure 6.

Figure 7. Your experiment E2 (thin green line) in panel b is really strange, with the unexplained and undiscussed fall-off at the end, another reason for eliminating E2 and E4.

Answer: This is experimental scatter due to variability in v_s and H_i. Also other experiments deviate by 0.5 cm from the linear fits in Fig. 7a and b. There is no reason to remove the experiment with one large deviation, only because it appears to have a fall-off at the end.

Figure 9. I've spent a fair bit of time staring at these three sub-figures, and I don't understand them. Your definition of an e-folding length based on the length of the tank seems completely arbitrary. I'd be very happy if you would drop this figure.

Answer: We now use the expression "natural scale of the tank" instead of "e-folding". However,the figure shows at which thickness wave damping becomes significant and there is almost no such information from other work. We think it is important.

Figure 10. Again, I find these figures of ice thickness averaged over the length of the tank not to be very valuable. Also, how to you handle the cases where you change the paddle wave amplitude or turn it off? How does this figure help me in understanding frazil ice? And, you refer in the text to histogram distributions grouped in time (not shown), that show the ice thickness is still increasing and had not reached a limiting value in the times

covered by the figure. If this is the case, why show the figure?

Answer: There are several model studies (i.e. Bauer and Martin, 1983) that indicate that frazil ice thickness is limited by wave height. The Figure shows in which regime the experiments took place. However, we agree that the Figure does not allow to determine when the limiting value would have been reached. We therefore removed it, and also removed the corresponding text referring to this figure: l.6-16, p.1851. We now write instead: "By the end of E1 to E3, the normalized grease ice thickness was between $1.5 < H_i/w_{h0} < 2$ and still increasing, not having reached a limiting value. By the end of E4 however, H_i/w_{h0} values close to 3 were reached and ice consolidation had clearly initiated."

Figure 11: Again, much too small to read, I need to use a 400\% enlargement to see the figures. This is one of the critical figures in the manuscript, since it shows (I think) the maximum packing that occurs before pancake ice formation. There is also a great deal of scatter in this figure. If this figure is critical, and I think it is, why not display it in a way that the casual reader can understand it?

Answer: The figure was rescaled automatically during production of the discussion paper. The original submitted Fig. 11 meets the resolution requirements. We will however re-submit the three sub-plots(panels a, b and c) as separates files to allow the editors to adjust the scalings and/or panel positions.

In summary, the authors need to resize the Table and Figures so that they can be read from the printout, and seriously consider dropping Experiments E2 and E4 from the discussion, because of their contamination by old ice. The resizing has to be done, otherwise no one is going to read the paper.

Answer: We agree with most of the Figure resizing. As explained above we do not drop E2 and E4.

Reply to Reviewer 2:

Reply to general comments:

Regarding improvement of flow of text suggested by the reviewer:

The two authors are working together to improve the disjointed reading as the reviewer suggests.

Reply to specific comments:

2. Experimental setup:
P1838, Line24. Please use NaCl solution instead of NaCl water.
Answer: Has been changed.

P1839,Line 5-17. This description of conditions between experiments is not needed, simply state the water depth for each experiment. However it is worrying that this description implies that all experiments start off ice free whereas discussion later in the paper clearly describes two experiments starting with ice cover. Please clarify.
Answer: We agree. We now note in the text that 'E2 and E4 also start ice free, but that our measurements could just be started 5-10 hours after the start of ice formation'.

2.1 Air and water temperature and salinity
P1840, Line 16-22. This is the first mention of the quiescent tank. Is it important? If

yes, please mention it in the first part of section2. If not please remove this paragraph.

Answer: We mention the tank earlier in the text as suggested. The quiescent tank is the place where the temperature chains were installed, and it indeed is important that they were not in the wave tank.

3 Observations
3.1 Air and water temperature and water salinity
P1842, Line 6. Please say what the temperature difference is between. Also, is Tf calculated for the initial tank salinity or for the evolving tank salinity?

Answer: Yes, Freezing minus water temperature, thus T_f is calculated for the evolving tank salinity and plotted in Fig. 2c and 2d.

3.2 Heat flux from surface
Please rewrite first paragraph and equations as it is confusing to refer to the right hand side of an equation when you have two equals signs. It could be along the lines of "The bulk heat flux : : :. can be approximated as the sum of the heat flux due to cooling before ice growth (Qs) and the heat flux during frazil ice growth (Qi) Q=Qs+Qi " Then explain each term and put full equation.

Answer: We agree. We now write the bulk heat flux Q from the tank as Q=HwCpw...+ dHe/dt... (excluding Qs and Qi) where the first term on the right hand side refers to cooling before ice growth (Qs) and the second (Qi) to latent heat release once frazil ice growth has started"

3.3 Ice thickness
P1844, Line2. Please change figure 3 as described below so that the figure really does indicate how the ice thickness varied in time. I cant judge whether the first paragraph is accurate until the data is plotted more clearly.

Answer: We use now different symbols for different sampling time ranges (see reply to Reviewer I).

P1844, Line 14. Please define the symbols used for the model functions. If the equation has time dependency included please show where. How were the coefficients chosen?

Answer: We removed the mention of the power law fit, as it is not further discussed in the paper. We reformulated lines 15-17: "We fitted the measured ice thickness distribution Hi(X) along the tank axis X with an exponential fit (Hi=a*(1-exp(bX)), a and b being constants obtained by nonlinear regression."

P1844, Line 18. Should this read "The mean modelled ice thickness was obtained by integrating in each case the modelled ice thickness ..."

Answer: We reformulate l.18-27 and l.1-3 next page 1845: "Comparing the fits with the observations we found the exponential to perform much better (mean standard deviation of residuals of 0.49 cm) than the power law (1.25 cm), for which no stable exponent was found."

3.4 Frazil ice solid fraction.
P1845, Line 7. Is Maus and De la Rosa published yet? If not, the details of the derivation of Eq. 2 should be included here.

Answer: The paper is under review. We have updated this.

P1845, Line 9. Please say that Vg is the measured grease/frazil ice volume fraction (instead of the ice volume)

Answer: V_g is indeed the measured grease/frazil ice volume, not a fraction.

3.5 Frazil ice salinity

P1846 Line6. we assume Sb=Sw. This assumes that the brine has the same salinity as the water measured at the CTD. Please explain why this is a valid assumption. Many other results reported within the paper rely on this assumption.

Answer: We refer now to Maus and De la Rosa where this assumption is discussed.

P1846, Line 7. Please reference the density approximation.

Answer: Now clarified in text: "...obtained from an analysis of standard references (Maus, 2007)"

P1846, Line 21. Hence the value of Swo of 33 was used in equation (3). Equation 3 does not use Swo, it uses Sb which you assume is Sw (which is different from Swo). I dont know whether this is a typo or whether the wrong values have been used in the analysis. If Swo has been used then I suggest everything that depends on it should be recalculated or it should be justified.
Answer: It is a typo. We rewrite "...and S_{wo}=33 was used for E3."

4. Results If the results from E2 and E4 were compromised due to a different initial set up, remove them from these results or discuss them separately later. The text would flow better.
Answer: E2 and E4 are not compromised - it was just not sampled during the first 5-10 hours (please see extended reply to this below).

P1847, Line 19. Consider changing to Figure 5c, d shows the weighted mean volume fraction of frazil ice (vs).

Answer: Accepted.

P1847, Line 22. From figure 5 it appears that there was a decrease in the number of observations between hours 10 and 20. Is this reflected in the low histogram counts between initial frazil formation and pancake formation? If so, the discussion about the bimodal distribution is not valid and discussion of it should be removed from the paper.
Answer: We add "Note that the early mode is not present in E2 and E4 where measurements started late, yet the pre-pancake mode is similar".

4.1 Equivalent ice thickness
4.2 Wave height and ice thickness
P1849. Line 26. We normalize the wave height and the ice thickness ... From figure 9 it looks like only the ice thickness is normalised.
Answer: Correct, we changed this in the text.

4.3 Frazil ice compaction rate
P1852, Line 23. Change figure 6c to figure 11c.
Answer: Has been changed.

4.4 Pancake P1853, Line 18. Without a figure we have no way of knowing how good this relationship is. Please justify it or remove it.
Answer: We now write "20-40 percent lower than the average frazil thickness".

5 Summary and discussion
P 1853.Line 24. we measured these properties. Were these properties measured or estimated from other observations?
Answer: Reformulated: "To do so we estimated..."

Table 1 Too small. Give it a title before explaining the symbols.
Answer: Has been changed.

Figure 2. In label for d) it should be 'solid lines in (d) are the water freezing temperature'
Answer: Has been corrected.

Figure 3. This figure is very unclear. There is no way of knowing what time each dot corresponds to. Please consider replotting these as contour plots of ice thickness (with time and distance as the x and y axes). If the author believes it is important to leave the figure in the existing format, it is essential that different symbols (corresponding to different times) are used for all observations corresponding to each growth model. Otherwise we are unable to see how well each model represents the data.

Answer: We now use different symbols sorted for data falling within 5-hour time bins. To illustrate spatio-temporal change, we now show a contour plot instead of figure 4 (see replies further below).

Figure 4. Consider replotting as mean observed ice thickness against mean modelled ice thickness.

Answer: We dropped this plot as it does not tell much. Instead we show a contour plot of thickness, salinity and solid volume fraction in a time-distance diagram of the tank.

Figure 8. A rather confusion figure. Consider using different symbols for tank A and B (or filled and open) and have error bars in the same colour as the symbol. I like the continuity of colour between the plots. Need to define heavy dashed black line in the figure caption.

Answer: Heavy dashed line is now defined. However, the figure caption explains what line-style refers to tank A and B, and the legend also does so.

Figure 9. Add description of symbols i.e. blue squares show results from tank A etc.

Answer: Agreed. Has been done.

Comment: We clarify that the results from E2 and E4 were not compromised due to a different initial set up, as the reviewer suggests. The values preserve the same accuracy as the other two experiments and also show the same tendencies in the modal distributions contained within Figure 6. This is also observed when plotting E2 and E4 data alone, splitted into experimental run time (i.e the first 0-5 hous, hours 5 to 10 and hours 10 to 15). Removing these experiments from the results would remove variability due to the reduced amount of observations from these two runs. However we do not think it is justifiable to ignore these results.

Data from E2 and E4 have therefore not been removed from the results as suggested. Instead, the text was rewritten to clarify that the early ice formation stage was not measured for these experiments.

Reply to Reviewer 3:

General Comments:

Section 2.1, Page 1840: What is the accuracy of the CTD? In order to decide whether or not the water becomes supercooled, the accuracy of the calibration of the salinity and temperature measurements are needed. Please quote errors in the water salinity and temperature measurements.

Answer: Agreed. We add after line 15, p.1840: "The accuracy of the CTD measurements is better than 0.005 K in terms of temperature and 0.05 in terms of salinity."

Maus and De la Rosa (2011): Details of the derivation of equations and the discussion depend on this paper. At the time of submission this was under review. Unless Maus and De la Rosa is now in press then I suggest that some dependence between the papers be removed, particularly in section 5 where the dependence reduces the impact of the discussion. Depending on status, throughout the manuscript it should say Maus and De la Rosa (under review).

Answer: We have updated throughout the text the mention of the paper and now define it as being '(under review)'. We shorten the text in Sect. 5.

Fig 6c: This is referred to on p. 1852, line 23 but I did not have a Fig 6c in the version of the paper that I have. Please correct.

Answer: Corrected to "Fig 11c".

Section 5.1: I felt section 5.1 was longer than it needed to be. Perhaps the comparison could be put in a table? The authors need to emphasise the point of section 5.1 because some of the background information regarding the difference between in situ and drained samples seems to be the subject of Maus and De la Rosa (under reveiw).

Answer: We do consider adding a table and shorten the description to the main points that (i) drained samples span a wide range in salinities and (ii) undrained salinities are physically more relevant, yet have seldomly been documented.
Section 5: I suggest that the authors could increase the impact of their paper by reducing the length of the discussion. Some material is repeated, some is given in detail that would be better delivered in a table, while some is very dependent on Maus and De la Rosa (under review) and might be better described in their follow-up paper. In particular I wonder about the necessity of including sections 5.5 and 5.6, both of which seem to conclude that more measurements are necessary.

Answer: We considered the text in connection with the ongoing review of Maus and De la Rosa. and will shorten sections 5.5 and 5.6.

Specific and technical comments :

Page 1839; Line 26: Replace "less" with "lesser"
Answer: Has been replaced.

Page 1840; Line 4: Replace "placed stationary" with "placed at fixed locations"
Answer: Has been replaced.

Page 1840; Line 11: You cannot use an "approximation" to derive a temperature to 1 mK precision. Please round the temperature to a number of decimal figures that is appropriate to the approximation used.

Answer: *Reformulated as follows: "The freezing temperature (T_f) was calculated based on equation A15 from Maus (2007). It gives -2.105 ^oC for an NaCl solution with 35 g kg^{-1} salt content at atmospheric pressure".*

Page 1840; Line 16: I do not understand "Two thermistor chains of platinum resistance thermometer (Pico Pt-100) sensors", since a thermistor and a platinum resistance thermometer are different types of temperature sensors. Do you mean "Two temperature chains of platinum resistance thermometer (Pico Pt-100) sensors"?

Answer: *Appologies for this confusion. Yes, we do mean 'temperature chains of platinum resistance thermometer (Pico Pt-100) sensors'*

Page 1840; Line 17: I don't know what you mean by "covered air temperatures" Do you mean that air temperatures were measured up to 16 cm above the ice?
Answer: *Yes we do. We changed this in text.*

Page 1840; Line 26: Insert "temperature" before "sensors"
Answer: *Ok*

Page 1840; Line 26: Insert "frazil" before "ice"
Answer: *Ok*

Page 1842; Line 9: In order to make statements about supercooling we need to be told the accuracy of the temperature and salinity measurements. Please quote these.
Answer: *Mentioned now as written above.*

Page 1843; Line 2: I think you mean "perfectly insulated" on all sides but the upper surface?
Answer: *Yes, we rewrote this.*

Page 1843; Eqn 1: This assumes uniform properties throughout the tank, in particular the rate of change of temperature in the water. Please comment on assumptions.

Answer: *We now write: "Assuming a uniform rate of change in the tank water temperature".*
As derived estimates for Tank A and B were very close the assumption seems to be justified under wave-induced mixing.

Page 1843; Line 8 & 9: Were Cpw and ρw calculated from the salinity of the water? Please explain.

Answer: *We agree that we should have calculated C_{pw} and ρ_w at the same reference (Sw=33.3, Tf=-2.0 C) as the mentioned latent heat Lf, as this reference values roughly coincide with the start of freezing of E1. We changed this and now calculate ρ_w =1025.9 (kg m^{-3}) and C_{pw} =4009 J kg^{-1} K^1, with reference to Sw=33.3, Tf=-2.0 ^oC (according to equations from Maus, 2007). Note that the derived(corrected) heat flux changes from 81.6/81.5 to 81.3/81.2 Wm^2, and does not affect our results.*

Page 1843; Line 23: Does Qs become 0 when Qi becomes non zero?

Answer: We add "This neglects the small Q_s due to lowering the freezing temperature that may be estimated as < 0.1 W/m^2 (Fig. 2d)".

Page 1844; Line 4: "We see that the along-tank ice thickness distribution becomes approximately uniform with time, for all experiments in tank A, and experiments E2, E3 and E4 in tank B." I don't think I am reading Fig 3 correctly because E1(A) does not look any more uniform with time than E1(B). However it is difficult to tell because we are not told the times of the measurements (see comment on Fig 3). Please clarify.

Answer: This is a mistyping. We interchange A and B.

Page 1844; Line 8: "Ice accumulation at the end of the tanks only noticeably occurred during experiments E1 and E3 correctly because there seems to be ice accumulation at the end of the tank in E2(B) early in this experiment. Please clarify.

Answer: We reformulate this sentence: "In E1 and E3 it took more than 5h of freezing until ice accumulated at the end of the tank".

Page 1844; Line 16: Where is the time dependence in these functions? Is there a physical explanation for choosing these forms?

Answer: There is no time dependence and the fit was done for any instance of time. There is no physical explanation - we just carried this out to find the most successful fit. We shortened this paragraph and removed any confusion with time dependence from text.

Page 1844; Line 25: *h2* is not an exponential function. I assume you mean expression 2? Does h2 have an exponential time dependence? Please clarify how time enters your fit.

Answer: This has been corrected. Time does not enter our fit.

Page 1847; Line 13: I felt that this comment should also be in the figure caption of Fig 5. "Note that all salinities in E4 that started with a 2gkg^{-1} higher salinity, are shown normalised by 33/35.38."
Answer: Has been added.

Page 1848; Line 3: "The first group (not shown) presents two peaks in.." I assume that this is the difference between the dark bars and the light bars? Thus I would not agree that this group is not shown.
Answer: Ok

Page 1848; Lines 8 & 9: Replace "show if" with "examine whether". Insert "show before "how". Put brackets around Sect 4.1 and Sect 4.2.
Answer: Ok

Page 1848; Line 10: I suggest introducing this paragraph with a sentence from p. 1849 "In laboratory conditions, with relatively constant air ventilation and radiation, the heat flux leading to ice growth may be approximated by the empirical growth law Qa(Ta -Ts), where Ta is the air temperature at a

fixed reference level above the ice, and Ts the ice or water surface temperature.” In fact you might consider inserting the first paragraph of p. 1849 at the start of the section on Equivalent ice thickness.

Answer: *Yes, we agree this is a good suggestion. We moved L. 1-6 from p. 1849 to the beginning of this paragraph.*

Page 1848; Line 12: Please comment on the fact that the equivalent ice thickness varies linearly with time. Is this to be expected?

Answer: *We reformulate slightly "For the freezing period, in case of a constant heat flux, the latter may be obtained from a fit of the equivalent ice thickness against time, ($H_e = H_{e0} + qht$). We apply this..."*

Page 1848; Line 23: “We may consider the difference between the mean water and air temperatures as an indicator of the possible changes observed in Qi, derived from the procedure explained above, we see a small decrease in Qi.” is not a sentence. Please amend.

Answer: *We remove this sentence.*

Page 1849; Line 21: Insert “et al” after “Wadhams”
Answer: *Ok*

Page 1850; Line 13: Replace “considerably” with “considerable”
C: Ok

Page 1851; Line 6: This does not appear consistent with E1(A) in Fig 3 which seems to get thicker as you go further from the wave paddle? Please clarify.
Answer: *We modified this section accordingly. Please refer to our reply to Reviewer I.*

Page 1851; Line 22: Please define v S(t) and vSo when they first appear. The latter is defined on p. 1852.
Answer: *We added after Equation (7): "where v_{s0} is the solid fraction at t=0".*

Page 1852; Line 25: Insert “,” after “fall”
Answer: *Ok*

Page 1852; Line 27: There are too many significant figures in the error. That is, I suggest 0.27±0.03. I also then suggest replacing “a slightly higher estimate than” with “within error of”
Answer: *Agreed, we changed this.*

Page 1853; Line 15: Remove “already”
Answer: *Ok*

Page 1853; Line 16: There is no E5. Please correct.
Answer: *Ok*

Page 1854; Line 7: Replace “Once” with “once”
Answer: *Ok*

Page 1854; Line 13: Replace "further increase in thickness remained rather uniform over the tank" with "thickness increased uniformly over the tank"
***Answer*:** *Ok*

Page 1854; Line 20: Replace "Experiments" with "experiments"
***Answer*:** *Ok*

Page 1854; Line 26: Please give the error in 0.01 K measurement.
***Answer*:** *Done, please see comment response to Table 1 below.*

Page 1855; Line 13: Remove "already"
***Answer*:** *Ok*

Page 1856; Line 1: Replace "we report here" with "here we report"
***Answer*:** *Ok*

Page 1856; Line 21: Replace "also Onstott et al. (1998)" with "Onstott et al. (1998) also"
***Answer*:** *Ok*

Page 1857; Line 6: Insert "ice" after "low"
***Answer*:** *Ok*

Page 1857; Line 23: I did not understand the sentence after "i.e."
***Answer*:** *We reformulate: "As long ice accumulates strongly at the end of the tank, the remaining tank contains younger ice, weakening a possible frazil-time relationship".*

Page 1857; Line 27: Replace "it" with " this"
***Answer*:** *Ok*

Page 1859; Line 1: Replace "evens out" with "becomes uniform"
***Answer*:** *Ok*

Page 1859; Line 11: Insert "of" after "height"
***Answer*:** *Ok*

Page 1859; Line 24: Will turbulence not also act to keep frazil in suspension?
***Answer*:** *Yes it will, but not beyond a certain concentration.*

Page 1860; Line 14 to 1861; Line 9: Here you are describing the time dependence of the solid fraction. However Fig 6 is the data for all times (I assume). Do you have enough data to be able to examine the time dependence?
***Answer*:** *We describe more clearly now: Page 1860; Line 29 to 1861; Line 1: "As the average values are influenced by accumulation of loose frazil from below, one may also interpret the surface values as the packing modes."*
We also removed "(up to v_s~0.15) " in line 3 p. 1861.

Page 1861; Line 26: Replace "considerable" with "a considerable amount"
***Answer*:** *Ok*

Page 1863; Line 5: Replace "indentified" with "identified" Page 1863; Line 20: Replace "the top, we used in our earlier study of the second phase of E2 (De la Rosa et al., 2011) additional infrared

surface temperature observations to distinguish between pancake and frazil/grease ice." with "the top, in our earlier study of the second phase of E2 (De la Rosa et al., 2011) we used additional infrared surface temperature observations to distinguish between pancake and frazil/grease ice."
Answer: *Ok*

Page 1863; Line 25: Replace "to" with "at"
Answer: *Ok*

Page 1864; Line 6: Replace "periodical" with "periodic"
Answer: *Ok*

Page 1864; Line 16: "appears to scale"? Do you mean "appears to scale linearly"?
Answer: *We changed to "increases".*

Page 1864; Line 25: Again I am not sure what you mean by "scale"?
Answer: *Also changed to "increases".*

Page 1865; Line 15: Replace "The question from which levels the heat lost through the surface is derived," with "The question of the depths from which heat is lost through the surface"
Answer: *Ok*

Page 1865; Line 21: Why does the tank receive this heat through the bottom and sides? Please explain.
Answer: *There is a heated room just below the tank, therefore transfer from the bottom was considered and mentioned here. Hayley Shen and Kalle-Evers (from HSVA facility), noted this additional flux (personal communication).*

Page 1867; Line 3: Why is heat entering the tank at the surface? I thought it would be leaving. Please explain.
Answer: *Agreed, the heat is not entering, we change the text to: "being lost through the surface".*

Page 1868; Line 23: Replace "emphasize" with "recommend"
Answer: *Has been replaced.*

Page 1868; Line 19 on: It is a pity that the first paragraph of your conclusion depends on the not-yet-published paper. Page 1869; Line 1: Please modify the statement about supercooling once consideration has been given to the error in this measurement.
Answer: *Agreed. We remove "presented in more detail in a follow-up paper (Maus and De la Rosa, 2011)"*

Pages 1869 & 1870: I found the conclusions drawn from your observations regarding the relations between solid fraction and thickness very interesting.
Answer: *Thank you!*

Table 1: I think many of the quantities on Table 1 are quoted to too many decimal places. I doubt that freezing point is know to 10 mK given t hat it is "approximated" from Maus (2007). I doubt that wave height is known to ±10 µm. Please think carefully about the error in the quantities you have measured.

Answer: *We went through the table and removed some decimal places. Freezing point is not "estimated" (we removed this) yet "calculated" after Maus (2007) based on several references. We note that the values from the latter equations are within 0.01 K of predictions from the FREZCHEM model (frezchem.dri.edu)*

Fig 1: Are the temperature sensors thermistors or platinum resistance thermometers.
Answer: *Answered above already, in page 1840, line 16.*

Fig 3: Generally thickness increases with time, but clearly not always. Could the symbols be colour-coded so that the times could be identified?
Answer: *Symbols have been changed, but not colour-coded. Instead we now binned the measurements into 5 hour bins, and used a different symbol for data falling within each time bin.*

Fig 4: It is difficult to distinguish between the blue colours in this figure.
Answer: *We replaced Fig. 4 and now show a contour plot showing the evolution in both time and space, as was suggested by one of the reviewers.*

Fig 5: I think that a capitol Vs has been used on the axes when lower case vs is used in the text. There is something wrong with the caption. It does not mention (c).
Answer: *Vs has been changed to lower case vs and (c) is now mentioned. We also changed the line styles to 'dash-dot' and increased line and symbol thickness, to improve clarity if this figure.*

Fig 6: I assume that this histogram is for data collected at all times. Do you have enough data to consider the time dependence? Could some sort of shading be used to include time information in the plot? Because of the different ice conditions at the start of the experiments, this may not possible.
Answer: *Yes,histogram is for data collected at all times. Data are sparse in time for all experiments but E1, for which we show time dependence in Figure 11c. However the present plot highlights the difference in the histograms between E1+E3 and E2+E4. The latter two experiments lack observations from the first 5-10 hours after onset of freezing. It thus underlines the two modes that we discuss We note that in Maus and de la Rosa (in review) we elaborate the age dependence in more detail, by sorting after equivalent thickness and estimating solid fraction profiles.*

Fig 8: Q_s is not marked on either axis of the figure. Is the mean a spatial or temporal average?
Answer: *It is a temporal average, we note this now.*

Fig 9: Replace "meaned" with "averaged".
Answer: *Has been done.*

Fig 10: I was confused by the caption since I was expecting wave height to be one of the axes. I suggest you replace "against" with "by"
Answer: *We now removed this figure, as was suggested by Reviewer I, and adjusted/shortened text in p. 1851, lines 6-16 accordingly (please see reply to Reviewer I).*