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The Cryosphere Discussions

Interactive comment on "Brief communication: Pancake ice floe size distribution during the winter expansion of the Antarctic marginal ice zone" *by* Alberto Alberello et al.

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CH: This manuscript uses shipboard camera images taken over a transect of the Antarctic MIZ to describe the pancake floe size distribution in that region. The manuscript is sets out its goals, and accomplishes them concisely and straightforwardly, and so I recommend its publication in short order: this information is valuable and interesting to those who are trying to evaluate and understand sea ice models that incorporate the physics of small floes. I do have some relatively minor issues, mainly related to presentation and data processing, that I would like to see improved upon before publication. These are listed below - if any comments are unclear please contact

me with questions.

AA: We thank the referee for his very positive comments. Below we provide answers to all the comments.

CH: Page 1 Line 10 - I believe the paper of yours truly you mean to cite is H+T 2015, as that is the model paper.

AA: We agree that H+T 2015 is the better reference and thus we added it in the revised manuscript.

CH: Page 1 Line 11 - While it is true early results show the importance of the FSD at the edge, only floe breaking by waves and floe melting has been put in models, so it isn't true that this is the place where floes are most important as we don't have a handle on their evolution deeper into the pack.

AA: We have changed the statement.

CH: Page 1 Line 12 - Please cite either Steele, 1992, or Horvat et al, 2016 when making the statement about floe melting.

AA: Reference to Steele 1992 has been added.

CH: Page 1 Line 13 - I would delete "formed ... currents" as you also mention the importance of waves for pancake formation, and winds and currents can significantly alter the formation mechanism of sea ice in the MIZ.

AA: The phrase has been deleted.

CH: Page 1 Line 15 - change "exhibits" to "resembles" as you argue below the inapplicability of fractal scaling.

AA: The change has been made.

CH: Page 2 Line 3 - add citations to Herman 2014, 2017 here as it is important for readers to know there is really not much evidence of a multi-decadal power law.

AA: The section has been rewritten and clarified to provide a better overview of previous literature, including the papers by Herman (noting that Herman 2014 should be Herman 2010).

CH: Page 2 Line 5 - Both papers cited here really argue *against* the adoption of FSD power laws, not for them!

AA: We agree with the reviewer. We rephrased this section and added a reference to Herman et al. 2017 to make this statement clearer.

CH: Page 2 Line 16 - "the *Antarctic* sea ice annual mass budget".

AA: Added.

CH: Page 2 Line 18 - I'm not sure the statement about pancakes being more common is supported by the Roach et al paper as it is a point measurement.

AA: We changed "common" to "frequent than in the past". We added a reference to Wadhams et al. (2018) where such a claim is made explicitly. We have kept the reference Roach et al. (2018), which specifically focusses on pancakes and where this statement, supported by a number of references, appears at the end of the first paragraph of the Introduction.

CH: Page 3 Fig 1 - I would like to see this visualization improved, and the caption more descriptive. For example, it isn't clear that (a-b) and (c) are on different axes immediately, and isn't mentioned that (c) is the cutout in (a-b). Also, are the measurements you are making the dark line in (c)? Could you add the green dash to (a-b) as well?

AA: We now indicate explicitly in the caption that (c) is a subdomain of (a) and (b) where it is indicated by a white frame. We also added that the black part of the track in (c) indicates where cameras were operational and measurements undertaken. The green mark in (a) and (b) is superfluous as the area of interest is already framed in white and would clutter the figure.

CH: Page 3 Line 8 - explain what you mean about statistical independence.

AA: We now added that this means that the sampled area in two subsequent images is different (i.e. no overlap) thus all the floes are only measured once.

CH: Page 3 Line 8-15 - generally, please explain the operation used to compute the pancakes as this is very important information for reproducing or building from this work.

AA: A brief description has been added. The procedure is fairly standard and only uses a series of MatLab built-in functions. We point out that development of the algorithm is not the focus of this communication. Details are now given in the supplementary material. The algorithm and data are available upon request.

CH: Page 4 Line 5 - please explain why one might decline an image.

AA: Visual inspection of the processed images quickly reveals images to be disregarded, e.g. when the reconstructed floes didn't match the greyscale image in a macroscopic way. In general, images where discarded when a large number of separated floes were merged together (i.e. only one identified floe by the algorithm, we define such instance artificial welding) or when single floes were split in a number of smaller floes by the algorithm.

CH: Page 4 Line 8 you explain why AMSR might *overestimate* concentration, but for many points along the track it underestimates concentration - explain.

AA: AMSR2 averages two daily swaths. During the measurements the intense storm conditions induced an ice drift of the order of 100km Eastward. In this circumstance it is likely than one or even both swaths occurred over open water thus leading to underestimation the instantaneous observed ice concentration (e.g. at the beginning of the recording). A comment has been added in the revised manuscript.

CH: Line 18 - "prone to error" - what kind of error? why?

AA: The extent of these floes is only few pixels. Higher resolution (i.e. px/m) would be required to reliably reconstruct the shape of these floes. A comment has been added in the revised manuscript.

CH: Line 19 - why were the welded floes excluded? Isn't this the process by which these pancakes are said to form? What criteria is used to pick floes to exclude, and how does this affect the tail of your distributions in Fig 3?

AA: Only artificially welded floes are excluded, i.e. those that are made by two separated floes but the algorithm returns as one single floe. Real welded floes are still included. A comment has been added in the revised manuscript to clarify the concept of artificially welded floes.

CH: Line 20 - area = 1.55 kmËĘ2 - I thought the swath was 28 m, which would mean you traveled 55 km into the ice, not close to 100 km.

AA: The swath itself would be 55km by 28m but this is distributed over a ship track of 100km. Two subsequent images are not contiguous in space to avoid overlap and guarantee statistic independence of the sampled floes. A comment has been added in the revised manuscript.

CH: Page 5 Figure 3 - You have extra space in this figure - could you please also plot the area weighted FSD rather than the number size distribution? The area size distribution is what appears in the Roach et al model and so would be good to see. You can estimate how much spread there is in (a) by taking D_1 and adding white noise to it and calling that D_2, then re-sorting in the instances D_2 > D_1. the magnitude of the white noise that is required to get the fit line would tell you how much error there is in assuming a circle.

AA: Figure 3 has been revised, with additional subplots and insets. The area distribution is presented in 3b (cumulative) and 3e (pdf, previously in 3b).

In response to this comment we show the empirical distribution of the D2/D1 ratio in

figure 3a which provides information on the scatter of D2/D1. To better describe the shape of the floes we added the scatter plot of the circularity as a function of the diameter (figure 3d in the revised manuscript). We believe this to be a better way to describe the shape of the floes and is more commonly used than the method suggested by the referee.

CH: Line 2 - why the mode = peak probability? Why not the mean, and could you report the "roundness" of the floes?

AA: The mode is extracted from the floe area distribution (i.e. the FSD expressed in terms of area instead of floe number as shown in Fig 3b and 3e in the revised manuscript). Mean and median are also reported in the revised manuscript noting that in terms of area distribution mode, median and mean are all about 3.1m.

CH: Line 4 - That the probability of exceedence hides the fact of a non-power-law distribution is extremely interesting and while some have discussed this in model papers, to my knowledge this is the first time this has been evidenced *on purpose* in an observational paper. I would like to see this highlighted!

AA: We added a statement to highlight this concept in the conclusions.

CH: Line 12 - I don't think you can say that there is a different physical mechanism to make larger floes as you only have a point observation of welding.

AA: Visual inspection of a large number of the images reveals that a considerable number of the larger floes are formed by smaller floes welded together. The line of welding is clearly visible from the images (see video in the supplementary material). These relatively large floes contribute the most in shaping the tail of the FSD. It is very likely then that welding process (for which importance has been shown by Roach et al., 2018), is the physical process that mostly affects the FSD in this regime, but this conjecture has to be further verified. The statement in the manuscript has been modified.

CH: Line 25 - The point about dropping a priori assumptions is good, I would add that using a KDE is in some ways equivalent to fitting distributions to power laws: both are not derived from first principles and so both give little insight into the actual physics governing the distribution.

AA: We made no change in response to this comment, as the point we were trying to make is that using a KDE involves no assumptions about the shape of the FSD.

Please also note the supplement to this comment:
https://www.the-cryosphere-discuss.net/tc-2018-155/tc-2018-155-AC1-supplement.zip

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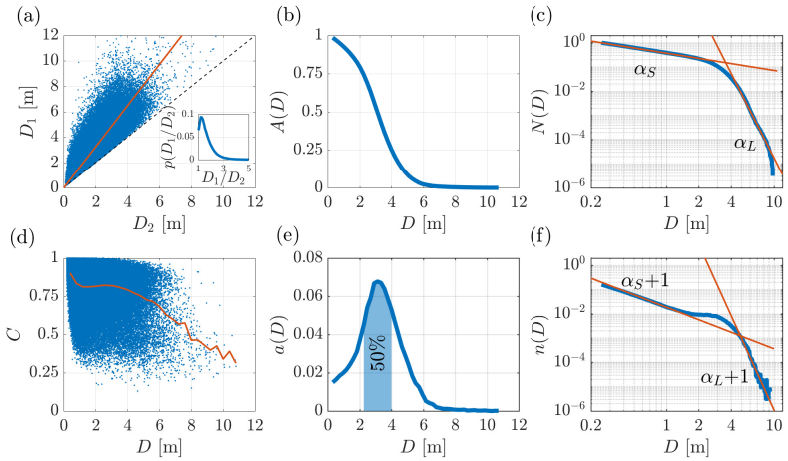

Fig. 1.