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Interactive comment on "Floe-size distributions in laboratory ice broken by waves" *by* Agnieszka Herman et al.

Anonymous Referee #2

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General comments: This paper aims at improving the understanding of the FSD observed so far by examining the properties of the floe size distribution (FSD) produced by wave-induced fracturing through laboratory tank experiments. The major purpose of this study is to show what kind of FSD is formed under as simplistic a situation as possible with regular waves and thin uniform ice, and then to check the applicability of a power-law function which has widely been used. Resultantly, they found that even in such a simple configuration, the FSD produced is far from simple. Based on the results, they proposed that a summation of two functions, the upper incomplete gamma function and the normal distribution, would represent the real FSD rather than two regimes of power-law functions with different exponents. Overall, I feel that this paper is a good and interesting work, and this approach is indispensable to improve our understanding

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of FSD of sea ice. Therefore, I believe this work will contribute to the development of sea ice dynamics, especially for the formation processes of FSD, related to the wave-ice interaction. Even so, I consider this paper needs somewhat more insight about physical interpretation of the results. My major comments are as follows:

1) Regarding the fitting functions, could you explain why you consider these two types of functions (the gamma function and the normal distribution) are appropriate for representing the wave-induced FSD? I could understand from the description in Discussion section that there seems to be two different processes and it would be appropriate to represent the FSD by a summation of two different functions. I can understand one should be the normal distribution if there is a representative length. But how do you explain physically about the gamma function? Since this issue seems to be the key of this paper, it might be better to add some brief explanation earlier, e.g. when the two functions were defined in section 3.2. 2) Besides, how do you explain the representative size of the normal distribution? The value of about 0.5 m observed in the tank is clearly different from the wavelength. As the value of 0.5 m is almost common for all the experiments, it might be related to the ice property such as minimum buckling size determined by the stiffness of the material (Mellor, 1986). Please try to find a reasonable explanation. I think this is important to apply the result to the real FSD in sea ice. 3) Regarding the description “scale-invariance of floe size distribution is assumed a priori” (P2L3), and “In many cases, no convincing arguments for assuming power-law FSDs exist” (P2L7-8), I do not agree. Although I might be wrong, to my understanding, this is not necessarily true. I understand researchers did not assume scale-invariance a priori, but examined it by showing how well a power-law function fits the FSD observed. Personally, I consider there is a good reason for thinking of a power-law as a candidate of PDF function. In nature, it would be natural that size distribution (for any material) tends to become scale invariant without any external forcing that determines the scale. Historically, it has been well known that there is a scale invariant property in the process of sea ice breakup (Weiss, 2001 Engineering Fracture Mechanics Vol.68). In this experiment, a scale given by external forcing would be wavelength. Therefore,

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it might be possible that the FSD for floes smaller than the wavelength becomes scale invariant through the breakup process and follows a power-law function. Also in your results, there is a possibility that floe size may have a scale invariance property, judging from Fig.2, although you asserted “do not look fractal” in P9L22. (For example, I recommend you plot long-axis against short-axis of the ellipse for individual floes. It might show almost linear relationship.)

Besides, it should be kept in mind that in reality the FSD formation process is not limited to the wave-induced breakup of sea ice. The herding and other processes that do not have specific scales, which is induced by winds and/or currents, can also contribute to the FSD formation as pointed out by Toyota et al. (2011). Therefore, when the controlling scale is unclear, I do not think it is unreasonable to try to use a power-law function for fitting to test the scale invariance. What do you think? (But as far as this experiment is concerned, I agree that the normal distribution should be used because regular waves with a fixed wavelength can determine the dominant scale.) Thus, I recommend you reconsider about this matter.

Specific comments: *(P2L8-9) “no alternative pdfs are considered” This is not necessarily true. For example, Lu et al. (2008) used the Weibull distribution for fitting. *(Section 2) Please describe whether you used pure ice or sea ice in the experiment. It would provide useful information to consider the ice flexural strength. *(Table 1) How did you obtain the wavelength? Was it measured directly or estimated from the theory of deep water approximation? *(Table 2) Please add the explanation of Nf and Nf,all in the caption rather than in the text. *(Section 4) It would be desirable if you include some description about how these results can be applied to the real FSD of sea ice.

That is all. Faithfully yours.

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