Review of "Wave-Triggered breakup in the marginal ice zone generates lognormal floe size distribution" by Mokus & Montiel (2021)

This very well written paper presents a 2-D hydrodynamic model for wave-induced sea ice breakup which combines linear wave theory and viscoelastic sea ice rheology in order to compute the scattering of wave by sea ice floes. By using an empirical strain threshold to define the floe size resulting from breakup, the FSD resulting from breakup follows a lognormal distribution under realistic wave forcings thus demonstrating that a preferential size is indeed generated by the process. They also show that the median floe size evolves with both wave period and ice thickness, a result that partly contrasts with the findings of Fox and Squire (1991) and Herman (2017) in which the FSD is independent of the sea state. I'd recommend a consideration of the comments below before the article is published.

Introduction :

- This section is a very good review of the FSD topic that gives the reader a broad view of the subject and helps understand what the challenges related to its observation and its inclusion in models are. Lines 35 to 40 sum up the problem with the power-law very efficiently.

Preliminaries :

- This section poses the framework very clearly and efficiently. Figure 1 is great and really contributes to the understanding of the model throughout the reading of the paper.

Methods :

- The description of the scattering model is clear and exceptionally well made.
- Regarding the breakup parametrization, using argmax ε_j as the position of fracture is in a sense arbitrary since the floe could break anywhere between the positions where ε_c and $\varepsilon_{\max}$ are reached. How sensitive is the resulting FSD and its statistical moments to the position of the breakup ?
- What is the relationship between the fracture position and sea ice properties (h, Y, γ) ? And what about wave properties (a, T, λ) ? Say x^* is the position where breakup happens, is it possible to obtain functional relationships $x^* = f(h, Y, \gamma, a, T, \lambda)$ with your data? Such information would be helpful for the translation of your results into larger scale models. Knowing the shape of the FSD is a great step but being able to circumscribe it with physical properties would bring an even more complete physically-based parametrization.

- Figure 2 illustrates well and concisely the algorithm.
- In table 1, a value of 6 GPa for sea ice Young's modulus is displayed. Where does this value come from and how is the FSD affected by it ?

Monochromatic forcing :

- Figure 3 is great to get grasp the physics of the problem as it is formulated in the paper but one key aspect regarding strain is missing in my opinion. To be more specific, how is the strain distributed spatially in floes and how does that evolve in time ?

Main comment : The principal concern I have with this paper is on how the FSD is built since this could have heavy repercussions on its shape and thus on the title of the paper. There are indeed many ways to compute the FSD, which are toroughly analyzed by Stern et al. (2018), and none is really better than another. But, depending on what it the goal of the paper is, which seems here to be "[aimed] at being a step towards parametrization of wave-action in FSD-evolving models", a particular way of computing the FSD can be advantageous. The mention of "histogram of the length" in the caption of figure 3 makes me believe that the probabilities of each floes are computed using the frequency of observation in the model. Dumas-Lefebvre and Dumont (2021) have shown that using the frequency of observation of the floes to build the FSD may lead to a bias on the estimation of the modal size and incidentally on the shape of the FSD. We have proposed using the partial concentration, which is the definition of both the ITD (Hunke and Lipscomb, 2010) and more recently the FSD (Bateson et al., 2020) used in global sea ice models, rather than the frequency of observation to compute the probability densities of each floe size category. With this framework, we have obtained a FSD that i) has a significantly different shape than with the frequency of observation approach, ii) a distribution mode that better corresponds with what can be seen visually in observations and iii) a FSD that is directly translatable to larger scale models.

With that in mind, could you describe how the FSD is obtained ? Secondly, I strongly suggest to re-compute your FSDs with the partial concentration approach since it could have an impact on the shape of the distribution and would then alter the title of the paper. For the mathematical details of the computation, I refer you to Dumas-Lefebvre and Dumont (2021) and if you have any questions, do not hesitate to reach out to me.

Forecast based on fitted parameters

- Figure 7 does a great job at showing how the parameter vector and modal floe size evolve relative to wave height, ice thickness and strain threshold. Can your model give insight on how are the waves and sea ice properties respectively responsible of the modal floe size, minimal and maximal sizes as well as the spread of the distribution ?

Discussion and conclusions :

- The discussion at lines 405 to 413 is good but to be more complete, line 414 should include Dumas-Lefebvre and Dumont (2021) since we provide data on a ”post wave-induced breakup” FSD.

References

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