REVIEW OF 'EXPERIMENTAL EVIDENCE FOR A UNIVERSAL THRESHOLD CHARACTERIZING WAVE-INDUCED SEA ICE BREAK-UP'

VOERMANS ET AL

1. General comments

This is a very nice collection of observations and the main result of figure 8 is surprising, but convincing with quite a few events included that represent many different scales and seem to have been careful with uncertainties. I recommend publication with minor revisions. I have a small suggestion about the definition of the I_{br} threshold to make it more intuitive.

2. Specific comments

(1) p3: section about I_{br} could be improved - I have never heard the term "similitude" or of the "Pi-theorem" before - can you think of a better name? Using ka (steepness) and kh instead of converting k to λ would get rid of many factors of 2π, and I_{br} could become a stress relative to the flexural strength or a strain relative to the breaking strain for a beam. (The critical value would be about $4\pi^2 \times 0.014 = .55$ I guess). Since the relationship looks like it could have some universality it is worth presenting it somewhat more intuitively.

(2) "sheet as an elastice plate" — "sheet as a thin elastic plate" (or maybe simply an elastic beam, since you are using the $\sigma = Y\varepsilon$ relation below).

(3) p16: "infinitely thin ice sheet becomes numerically unbreakable" — the opposite problem is that the strain as $kh \to \infty$ (shorter waves/thicker ice) also becomes infinite. In that case including reflection by ice edges is one way to reduce the strain inside the ice [1, 2]. Using the ice wavelength instead of the open water one could also make a difference here too. For both points the ice sheet example of Cathles et al jumps to mind.

References

[1] Guillaume Boutin, Fabrice Ardhuin, Dany Dumont, Caroline Sévigny, Fanny Girard-Ardhuin, and Mickael Accensi. Floe size effect on wave-ice interactions: Possible effects, implementation in wave model, and evaluation. *Journal of Geophysical Research: Oceans*, 123(7):4779–4805, 2018.

[2] T. D. Williams, L. G. Bennetts, V. A. Squire, D. Dumont, and L. Bertino. Wave-ice interactions in the marginal ice zone. Part 1: Theoretical foundations. *Ocean Modelling*, 71:81–91, 2013.

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The Cryosphere
Discussions

Interactive comment on "Experimental evidence for a universal threshold characterizing wave-induced sea ice break-up" *by* Joey Voermans et al.

Anonymous Referee #1

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This paper presents an analysis of recent field campaigns in which the wave conditions and simultaneous sea ice break up were measured. This data is compared with data from previous observations to determine a threshold for breaking. Such a threshold will be useful provided it is accurate. Even if it is not entirely accurate, I believe it will serve as a valuable benchmark for comparison. I am supportive of the publication.

The fundamental difficulty in this from a theoretical point of view is that the sea state is random with a range of periods. It is therefore difficult to assign to any break-up event a single value for λ unless it is for a wave tank experiment. This point should be discussed.

The equations for Young's modulus etc. are essential and summarise literature which is not well known. Multiple authors, mostly those associate with Squire, have used 6GPa for the Youngs modulus, which is an overestimate. However, it should be explained clearly what the units in the formulae are, and the units should be made consistent is possible (e.g. the units of brine volume).

The breaking model, in fact, contains two contradictions/paradoxes. One is that in the limit of small thickness ice is unbreakable, and the other is that short-wavelength waves will break any ice. The second point seems to have been missed by the authors. However, the model assumes that the ice is moving compliantly with the sea surface and the wavelengths are so long that the sea ice can be modelled as a negligible surface. Some discussion of this point and the regime in which it is valid would be useful.

The literature review is mostly complete. However, the first coupled attenuation and breaking model appeared in Kohout AL, Meylan MH. An elastic plate model for wave attenuation and ice floe breaking in the marginal ice zone. *Journal of Geophysical Research: Oceans*. 2008 Sep;113(C9). The authors concluded that their attenuation model was failing because of the overprediction of the break-up.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-201, 2020.