REVIEW OF 'DISCRETE-ELEMENT BONDED-PARTICLE SEA ICE MODEL'

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1. General comments

1.1. **Bonded elements response to tension, compression and shearing.**

(1) The results look very nice — my main question is about the reproducibility of results with smaller grain sizes: eg how much do macroscopic quantities like the area of unbonded grains or integrated stresses change? As the author points out in the results section, under compression the unbonded grains transmit a lot of the stress.
(2) Perhaps randomisation/variation of properties instead of having constant properties might make a difference? (I will return to this point when I discuss the waves part.)

1.2. **Waves causing ice breakage.**

(1) Around eq 31, p5500: There are some big assumptions here — mostly relating to assuming that the wave is unaffected by the ice. Local effects at the edges/corners of each floe are neglected, but when the floe is small enough compared to the wave it might be reasonable to make this assumption. (This should be mentioned at least in the paper.) Alternatively if the floe is very large compared to the wave, it might be reasonable to modify the dispersion relation (DR: relates ω and k) — eg use the thin elastic plate DR.
(2) Assuming one wavelength is long enough to fit enough discs (perhaps about 10?), the discs could be placed along the profile of the wave and could follow the 3d orbital motion of the wave. Eqn (31) would give the horizontal motions ($\boldsymbol{u}_{\mathrm{wv},i}$) and vertical motions ξ_i of the discs. Also the tilts of the discs could be calculated from the gradient of the wave $\nabla\xi = a\boldsymbol{k}\cos(\varphi)$. The relative motions of the discs should surely be enough to compute the forces due to the connecting springs. This requires high spatial resolution but I think this is needed to model the break-up of individual floes due to waves as the author proposes.
(3) Following on from the previous point, I don't think the model shown in Fig 4 would be able to resolve a wave.
(4) It was very hard to judge the results shown. Perhaps these "interesting results" presented (range of floe sizes) correspond to cases where the waves are not resolved, and the boring ones are when they are? Maybe a simpler case could be presented eg a plane wave coming in with breaking being expected in parallel lines every half wavelength or so. It would be very interesting to then see if other forces could break

the floes in the other direction — ie long strips seem quite rare in the field, and one question is how do they end up as rectangles or other shapes? One explanation could be pre-existing weaknesses, but another could be that forces like drag combined with some heterogeneity in drag coefficient or bond strength make these long strips very prone to further break-up. In other words, it could be very interesting to investigate the interaction between waves and other forces to see if the "sharp" FSD produced by swell waves could be turned into something resembling a power-law like FSD. Perhaps check the video of Dany Dumont (https://vimeo.com/106835989) for a potential simulation (swell waves plus a shearing current).

2. Specific comments

(1) p5491, L4: "new bonds may be created" — this is quite interesting. Perhaps there should be a minimum time that 2 floes should be next to each other — maybe enough frazil ice or something like that that could act as a glue between floes. It would be interesting if the "herding" of small floes into larger ones could be reproduced somehow.
(2) Perhaps it would be easier to understand the differential forms of (14-17)?
(3) p5508 L1-5: I would expect the opposite: large floes to flex with the wave, while smaller ones should behave as rigid bodies - moving with it without bending very much. Note that the "stress breaking criteria" of [1] was removed by [2] for the reason that it became easier for longer waves to cause breaking than short ones (when in fact the slope becomes smaller as they get longer).

3. Typographical errors

(1) eg title → "A discrete-element bonded-particle sea ice model" (there are other mistakes with missing/incorrect articles also).

References

[1] D. Dumont, A. L. Kohout, and L. Bertino. A wave-based model for the marginal ice zone including a floe breaking parameterization. *J. Geophys. Res.*, 116(C4):1–12, 2011.
[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.