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Interactive comment on "Wave-induced stress and breaking of sea ice in a coupled hydrodynamic–discrete-element wave–ice model" *by* Agnieszka Herman

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1 General Comments

The paper describes 2D discrete element method (DEM) model of sea ice coupled with existing NHWAVE code for solving incompressible dynamics Navier-Stocks equations for water. The DEM uses rectangular grid from NHWAVE discretization to represent ice floes as a set of rectangular cells bonded together. Bonds are represented by a virtual rectangular as well with mechanical properties similar to elastic beams.

The NHWAVE and DEM parts are coupled using the boundary conditions. NHWAVE

uses the ice velocity at the boundary with ice elements using no-slip condition. DEM model uses force and torque caluclated from water pressure at the ice surface.

Closed system of equations is solved with each part using different time steps as characteristic time of DEM model is 2 orders of magnitude smaller. The results show how a single ice floe interact with waves, in particular where the maximum stress appears in the floe and how the floe is breaking under the waves.

The paper is well written although I had some significant problems with all the notations introduced that either are not explained, explained too remote from the equations, or not shown.

I support publishing this manuscript after some corrections. As I am a DEM specialist, I can mostly adress only the DEM part of the publications in my comments.

2 Specific Comments

2.1 Substantial issues

1. My main concern about this work is the lack of verfication of the approach and the code. For example, does discretization step Δx change the outcome of the computations? It is unclear until some scaling tests are done. I would suggest to use different Δx with the same wave input and compare the results. *This can be corrected within this paper by running some tests with Δx being a half of the Δx used in the paper and comparing the results. Maybe a reference that the final results do not change with Δx within the numerical accuracy would be sufficient.*
2. I have some concerns regarding 2D approach to the problem of breaking an ice floe. It is just hard to imagine how to interpret the results of a single ice flow breaking in long (y-dimention) but narrow (x-dimension) fragments as the results

of simulatons show. Actual floe would break along x dimension as well such that it will be easier to break later. I suppose 2D approach is still applicable for testing in channels. *This issue is not to be corrected and just brougt to the discussion at this point.*

2.2 More specific comments

1. I struggled to understand the 2.1 and 2.2 sections with just Figure 1. It would be very useful to add dimensions, indices and more notes to the figure. In this case the reader would see what Δx, l_i, etc. are. Maybe a single cell scheme with forces and torques shown, as well as velocities, constraints ($u_i = 0$) and bonds.
2. Sec. 2.1, p. 5, 0–5. “All bonds are cuboid”. Should it say “All bonds are elastic”?
3. Equations (13) and (14) include terms for the torques and forces imposed from water ($M_{wv,i}$ and $F_{wv,i}$) that are only explained 2 pages later in the coupling section. They should be defined after the equations as well.
4. I have some questions regarding “classical beam theory” equations (18)–(20). First, the length of the bonds is defined generally as $l_{b,i} = \lambda \Delta x$ (page 5, 0–5). Please, verify that $l_{b,i} = h_{b,i}$ for these computations. Moreover, I suggest to introduce a picture showing all the stresses on the bonds.

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