RESPONSE TO THE REVIEW

of the manuscript No. gmd-2015-112 "Discrete-Element bonded-particle Sea Ice model DESIgn, version 1.3. Model description and implementation"

GENERAL COMMENTS REGARDING MAJOR CHANGES TO THE MANUSCRIPT

Based on the most recent and previous comments of the reviewers, as well as on my own analysis of/reflections on the modeling results, I decided to completely rework the section of the manuscript related to wave-induced sea ice breaking (Section 8.2). Because the majority of objections reported by the reviewers (as well as my own doubts) were related to the concept of the wave-induced breaking model, I decided to extend Section 8.2 by adding the results of one-dimensional (1D) simulations. They are easier to interpret and clearly illustrate some of the important aspects of the model, e.g., changes of the rigid and flexural motion of the floes with their size, as well as distribution of maximum stress within floes of different sizes.
The description of the results of 2D simulations has been shortened accordingly, and now it is limited to those aspects of the model behavior which cannot be deduced from 1D cases and are directly related to the spatial variability of grains' positions and bonds' orientations.

Summary of the changes to the manuscript:

1. Section 8.2 has been completely rewritten. It now contains 2 subsections: 8.2.1 (results of 1D simulations) and 8.2.2 (results of 2D simulations).
2. There have been no changes to the remaining text except two sentences that have been added to Section 2.3 (page 3), so that the review of DEM methods in sea ice modeling remains up to date. These new sentences are marked in green.

My response to the particular comments of the reviewer (below) is rather compact, as most of these issues are addressed in the revised Section 8.2 and the answers can be found there.

RESPONSE TO THE PARTICULAR COMMENTS OF THE REVIEWER

P8, round L685: "*In the following, an assumption is made that the x-components of torque are produced by the unbalanced buoyancy forces acting on a disk if its upper surface is not parallel to the local sea surface, as shown in Fig.4. It is also assumed for simplicity that exactly half of the disk experiences an excess of buoyancy, the other half an excess of gravity (see also Dumont et al., 2011).*"
In my previous review, I proposed the author calculate the stresses in the bonds by considering the locations and orientations of each disc, assuming that they follow the profiles of the waves. The author responded by saying that that is exactly what is done in the paper. The above quote seems to contradict this statement. If a disc is at a wave peak, for example, how can it experience half gravity and half buoyancy (it would only experience gravity in this case)?
The dispersion relation of the wave already has the buoyancy-gravity balance built into them, and if we assume that the ice doesn't change the wave at all, then we are assuming that the ice doesn't change this balance. Consequently it is my opinion that gravity no longer needs to be considered in the balance of forces, and the stresses in the bonds should just be approximated from the elevation and the slope of the discs relative to each other.

But the fact that a disk is exactly at a wave peak does not mean that it has to be in a horizontal position – it still can be tilted relative to the (in this case horizontal) sea surface. And if it is tilted, it experiences a torque trying to restore it to the `untilted' position. The assumption that "exactly half of the disk experiences an excess of buoyancy, the other half an excess of gravity" is related to that situation, not to the net force acting on the disk.

Fig 13: this is still very hard to judge. Its presentation could be improved perhaps with colors for water and different bin sizes of floes, as it is hard to tell whether large areas of white are large floes or large bits of water. Perhaps there could be some indication of the wavelength on the figure too (perhaps the bins for the colorscale could be relative to the wavelength)? Content-wise (also referring to P10, ca L900) can the author confirm that even with very large floes initially it is still impossible to get a simpler pattern like the strips of ice?

(It is Fig. 15 in the revised manuscript). There are no large bits of water in this figure, so all "large areas of white" are large ice floes – these are exactly those floes with unrealistic shapes that are discussed in Section 8.2.2. I indicated that in the caption of this figure. I also added information on wavelength to the caption.
(In fact, the panels have a blue background indicating water, but that background can hardly be seen in between the floes.)
As for the simple pattern of floes, it can be obtained with a regular matrix of identical grains, with a unidirectional wave propagating along one of the matrix' axes. As I state in Section 8.2., this case is fully analogous to the 1D case, as the bonds perpendicular to the wave propagation direction do not experience any stress. With irregular arrangement of grains, this regular striped pattern is not possible to obtain – which is also stated in the paper.

Fig 14: perhaps a more useful quantity to consider would be to subtract the rigid body motions of the floes (hitch, pitch etc) from the total motion, and then the remainder would be the flexural" motion. Then we would probably expect large floes to have more flexural motion (approximately no rigid body motion on average over the whole floe), and smaller ones would have less, since all the discs inside it would be moving more-or-less in phase with each other. However, on the other hand it may not be possible to produce this expected behaviour without a fully coupled 3d model. The other factor in this figure is the damping in the bonds |
perhaps the larger floes having more bonds implies the have more damping, so the velocities are lower? Another quantity which might respond in a similar way would be the stresses in the floes | smaller ones would have low stress, and larger ones higher stress (especially if they were about to break).

As already mentioned, I followed your advice and separated the motion of the floes into the rigid and the flexural components. This analysis is now located in Section 8.2.1, i.e., in the part devoted to 1D simulations – although this aspect of the model is very similar in 1D and 2D. The new Figures 12 and 13 show how the tilt of the grains within a floe, and the stresses acting on the bonds, change with changing floe size. Section 8.2.1 contains a discussion of these results.