

Overall comments

A very interesting paper that presents an analytic model for the breaking of an ice floe under uniaxial tension. The paper uses a bonded particle model under idealized conditions to validate the analytic model. Next, the authors use MODIS imagery to generate initial conditions to study landfast ice with the bonded particle model with ocean forcing via a QG model. They run this model for 48 days to show that the breakage properties depend upon the deformation radius and bond strength. The paper represents a significant contribution to our knowledge of the ice dynamics in the context of landfast ice, but requires a major revision. The paper also has numerous typographical errors that require correction.

Major comments/concerns

1. Critical fracture force.

The authors use a method in which the bond is broken when the absolute value of the normal force exceeds a critical value which implies there would be the same threshold for both compression and tension. The author notes that they disable compressive failures, however it is well known that compressive failures are important to ice dynamics. However as authors note ice is much stronger under compression than tension, so they will need to update equation (3) and the their breakage criteria to reflect this.

2. Dominant Balance Assumption

In section 3.1 the authors say for strong enough oceanic forcing, we may assume that the magnitude of the drag force is much larger than the bond force such that the bond force can be ignored in the momentum balance. The authors never give a justification for this, and I wonder how strong the ocean forcing would have to be. When the authors run the models to compare their analytic solution, the bond stiffness they use is so large that given the values they present in the tables at the strongest ocean forcing of 1m/s the bonds would stretch with a relative $1/10^{\text{th}}$ of a millimeter for a 500m radius disk to have the bond and drag forces in balance with each other. For the more realistic forcing the relative displacement is order of microns.

3. Numerical Stability

The authors use very spring stiffnesses, especially in the eddy model. These stiffnesses are accompanied by a large timestep 10s. At these large timesteps, I worry that the authors are not fully resolving the waves propagating through their DEM.

4. Eddy damping scheme

γ_{edge} is chosen by the authors to be 30km and is shown in figure 7. The authors state that the results are not sensitive to the definition of it. However figure 7 seems to show breakage in many of the figures along this line that is plotted. So which results are the author saying do not depend on this definition?

Minor comments and suggestions

Abstract

Line 4: Maybe want to indicate here or somewhere else that the LS stands for level set

Line 7: Power law exponent. Only slope when plotted on a log-log plot

Introduction

Line 28: You introduce FSD in abstract so not sure you need to define it again here.

Line 41: ", than waves that affect smaller scales..." should be "than **by** waves"

Line 54: I'm not sure geometry is the best choice of words here

Line 69: "break mode and the evolution of the pack." Missing comma "break mode, and the evolution of the pack."

The bonded particle method for sea ice

Fig. 2: I would consider moving figure 2b to 2c since the reference to it comes so much later.

Line 95: How are you calculating ocean velocity when the centroid of the ice does not exactly match up with the ocean grid?

Uniaxial bond force

General comment for this section: Missing subscript i on many of these equations

Eqn 7: Does gamma represent anything physically or was this just a mathematical convenience?

Eqn 8: I feel like the symbol epsilon is typically used to represent strain, where here this is a displacement. So not sure this is the best choice of a symbol in the context

Eqn 8: I know for your tests you run later the ocean is set to a specific velocity, but can we generally assume that it is independent of time like you did here?

Breakage length scale under a pulse forcing

Line 146: Say here that $x=0$ is located at the center of the bond

Eqn 12: Missing $\frac{1}{4}$ in the x^c equation, but appears to have been accounted for eqn 13. Also feels strange that this is dependent upon t. So this integration starts from the moment the forcing is applied to move it out of unstretched neutral position?

Eqn 13: Looking at fig 3a, the two parts of the bond force greater than F^c are not continuous, but it seems here are adding them together?

Fig 3b: Something is off with this plot. I^{br} should equal 0 at λ^{cut} . The way λ^{cut} is defined, eqn 13 should have an $\arcsin(1)$, which means the right hand side should equal 0.

Setup

Line 182: How frequently are bonds evaluated to see if they exceed the critical fracture value? This will impact x^c from your analytic solutions for validation. Any significance to 11 hours and how this value was chosen for the duration of the simulation?

Line 184: The way you say you evaluate the simulated breakage length, would this include the central $2x^c$ value shown in figure 3a?

Table 1: include values for ice and ocean density.

Results

Line 188-194: what's the diffuse ocean forcing? 100km or 200km because it is not consistent between the text and the figure.

Fig 4: A video of this simulation would be nice to have in supplemental material. This will allow us to see any leads form and how fractures appear. I assume we would see the fractures appear at $\pm\lambda/8$ first as we see this is the highest bond force in equation 11. I am curious if we see a stress wave propagate out from when the fractures happen. It is this wave of stress in spaghetti that causes it to fracture in multiple places and this is reminiscent of that process.

Fig 5: Given there seems to be issues with figure 3, check to see if analytical solutions

Eddying current properties

239-240: Are these run to quasi-equilibrium with the damping in place or is that added after?

Results

Fig 8: A video of this simulation would be nice to have in supplemental material. This will allow us to see any leads form and how fractures appear. Since we see the large changes to the ice area in 8a, it would be good to see where these losses appear.

Fig 8c-d: These are never specifically mentioned in the text though you definitely talk about them. So put these references in.

Fig 8 caption: Cite the paper with the method used for calculating FSD since there are different methods.

Line 293: What is the bin for your smallest FSD? Since we see fracturing down to the smallest grain, I worry that we might see some edge effects in the power-law you find if you include single grains since those are no longer able to fracture into smaller ones.

Code and data availability:

Line 340: Do you need a zenodo DOI or anything like that?