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Interactive comment on "Wave-ice interactions in the neXtSIM sea-ice model" *by* Timothy D. Williams et al.

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We thank the reviewer for their comments.

1 Major comments

1. *I have problems with understanding the concept of the damage parameter d in relation to ice concentration c and maximum floe size D_{max}. Equation (9c) states that (without thermodynamic effects) d can change (or, more precisely, increase) only if stress falls outside the prescribed envelope. That is, d is not in any direct way related to other quantities characterizing the ice (although, I suppose,*

in longer simulations the model would by itself evolve into a state in which d, c and D_{max} are related). This makes d quite mysterious to me. For example, how should one imagine ice with $c = 70\%$ and $d = 0$, which is used as an initial condition in the simulations? We have relatively dispersed ice, with 30% open water, floes with power-law size distribution (which makes sense only if the number of floes per grid cell is large), but the ice is "undamaged" — how realistic is that? What motivated this choice of initial conditions and how does it influence the results? A more general question: What does "damaged" and "undamaged" mean in physical terms? The authors should include some discussion/explanation before they proceed to describing details of their model, otherwise some parts of it seem rather obscure. d, c and D_{max} are quantities describing the state of the ice cover, and by being shaped by wave-ice interactions they act as a signature of those interactions — so sufficient space should be given to relationships between them. Are all combinations of d, c and D_{max} realistic? If not, does the model allow for those combinations or are there some mechanisms that relate one variable to the other?

   (a) With regard to the unfamiliarity of the reviewer (and probably other readers) with the damage variable d we have added a new section (now §2.3) with an example simulation showing its role, which is usually to produce localised damage and linear kinematic features.

   (b) (i) With regard to the initial conditions, one of the main results of the paper was that the WRS had relatively little effect in most situations, but we still wanted to give a demonstration of situations where it did do something, even if those situations were relatively rare. This led to the choice of $c = 0.7$ initially, because for higher concentrations ($\gtrsim 0.9$) the internal stress could balance the WRS without failing (ie the WRS did nothing for higher concentrations) — see the formulae for $Y_*(c, d)$ and P.

   (ii) Not being an observable variable, d is difficult to initialise so we initialise it to zero usually and let it evolve according to the different forcings, given the other variables which are observable. In general, there is no explicit relationship between it and c. However, we can make some generalisations about it — eg. it is only increased if c is high, when the internal stress becomes large enough to cause the ice to fail. Thus initially having $c = 0.7$ and $d = 0$ is not an unrealistic combination.

(iii) We assumed the ice was initially unbroken — ie we initialised $D_{\max}$ to its default “large" value of 300 m for simplicity mainly, but we note that it is not incompatible with the initial value of c, since in summer it is possible to have large floes with large gaps between them (smaller floes melt faster). In general, d and $D_{\max}$ are not related, but in some simulations we employed a rudimentary MIZ “rheology" where we set the damage to a high value when it was broken — this lowers the effective elastic stiffness Y_* to near zero, putting the ice nearly in free drift, although P provides some resistance to compaction.

(iv) We have added some extra descriptions/justifications of our initial conditions.

2. *The authors do not describe how D_{max} is modified if the breaking criteria (section 3.4) are fulfilled. I know this information can be found in previous papers, but it should be given here for completeness (presumably in section 3.3, together with the description of FSD).* A new section with this information is added now (section 3.4.4)

2 Minor comments

1. *I'd suggest to replace the word “movement" with “displacement" (or something similar) in the context of the changing position of the ice edge. Especially in the*

abstract, it is not clear what the sentence “. . . wind waves can produce noticeable movement in loose ice" really means, as no reference to ice edge is made. It wrongly suggests that some analysis of ice motion is made in the paper We have clarified that we only looked at the displacement of the ice edge in the abstract and elsewhere.

2. *The authors should check if all symbols are explained in the text. In most cases (e.g., wave number and amplitude in section 3.4.1) it is obvious what the symbols mean, but still, they should be defined.* We have checked that all symbols are defined now.

3. *In the list of references, some papers have missing volume/page numbers, e.g., Meylan et al. 2014 or Rabatel et al. 2015.* These have been fixed.

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