

Interactive comment on “Ice bridges and ridges in the Maxwell-EB sea ice rheology” by Véronique Dansereau et al.

Anonymous Referee #1

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This paper describes numerical experiments with a sea-ice model that uses the "Maxwell Elasto-Brittle" rheology. The details of the Maxwell E-B rheology are described in a previous paper (Dansereau et al, The Cryosphere, 2016). In this paper, two simulations are run: one with idealized geometry of flow through a constriction, and one with the actual geography of Nares Strait. The model reproduces the ice arch across the southern end of Kane Basin that is often observed in satellite imagery, leading to the formation of the North Water polynya to the south. The model also reproduces the presence of landfast ice in small inlets and fjords, sharp gradients in ice velocity across leads, the exponential tail of the sea-ice thickness distribution, and stress states in reasonable agreement with observations.

This paper is clearly written (minor exceptions noted below) and describes results that should be of interest to sea-ice modelers and general circulation modelers. I recom-

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mend publication after minor (mainly technical) revisions noted below. These comments are in page order, not in order of importance.

Minor and Technical Comments

Abstract, first sentence. You need to tell the reader what "EB" is and what the model does before launching into a discussion of its implementation. Like this: "The Maxwell Elasto-Brittle (EB) model uses a sea-ice rheology that allows tensile stress... blah blah [one sentence about the model]. This paper presents a first implementation of the..."

Abstract, lines 6-8. This sentence is a bit awkward. I suggest: "In agreement with observations, the model captures the propagation of damage..." etc. (and delete "are all represented" at the end of the sentence).

Abstract, last sentence. "weakening of the ice cover" and "shorter lifespan of ice bridges" – over what time period? You should add something like "in the 2000s relative to the 1980s and 1990s". And then "with implications in terms of increased ice export" – say that this would be expected because sea ice is expected to continue thinning in the future. In fact, maybe this is a positive feedback on the loss of ice: as it weakens, it drains from the Arctic faster, which weakens it further.

Page 1, line 15. "expenses" should be "expanses"

Page 1, line 21. "May 2005" should be July 2010.

Page 2, line 12. Change "allowed demonstrating" to "demonstrated"

Page 2, lines 18-20. "shorter lifespan of ice arches" and "increased ice export" – over what time period?

Figure 1. The dates on the images are in the format DAY-MONTH-YEAR. Is that standard for The Cryosphere? It might confuse U.S. readers, who often use MONTH-DAY-YEAR.

Figure 1, caption. Put "(MODIS)" before the word "reflectance", not after.

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Page 4, line 10. 0.32 degrees is not 4-10 km.

Page 4, lines 21-24. For the statement about the sea-ice thickness PDF you can cite: Lindsay, R. W. 2013. Unified Sea Ice Thickness Climate Data Record, 1975-2012. Boulder, Colorado USA: National Snow and Ice Data Center. <http://dx.doi.org/10.7265/N5D50JXV>. Web site: <http://nsidc.org/data/docs/noaa/g10006-unified-sea-ice/>

Page 5, line 3. Change "pioneer" to "pioneering"

Page 5, line 9. "dubiously" – Why it is dubious to base the modelling framework on energy conservation?

Page 5, line 18. There is an error in the citation of Hibler's 1980 paper. William D. Hibler III should be "Hibler", not "III". Also on page 23, line 10, the author is Hibler, not III.

Page 5, line 19. "sensible" should be "sensitive"

Page 6, line 5. Instead of "recall", better to write "review"

Page 6, line 7. Instead of "passage", I think "connection" is the intended meaning

Page 6, line 9. After "elastic modulus" write "(E)" because it is used three lines later in the definition of lambda.

Page 6, equations (1) and (2) – you need to say that "mu" is the internal friction coefficient.

Page 6, lines 27-28. About healing: healing allows the level of damage to DECREASE – more healing, less damage. But the damage parameter d INCREASES as healing increases (d=1 is undamaged). So you have to be careful when describing healing. Verbally, healing means a SMALLER AMOUNT of damage. But numerically, healing means a LARGER VALUE of d.

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Page 7, Figure 2, caption. Several things: – It is awkward to have complicated equations in the caption. Furthermore, the components σ_{11} , σ_{12} , and σ_{22} are not used anywhere else in the paper, so I think it would be OK to delete the equations entirely. Otherwise, they should probably go in the main text. That's just a suggestion, there is nothing wrong with the current presentation. – Second sentence: "The thin solid lines represent the damage criterion in the case of $C=0$." To make this clearer, consider: "The thin solid lines radiating from the origin represent the damage criterion in the case of no cohesion ($C=0$)." – What is the shaded region in the figure?

Page 8, line 7. Change "assimilated to" to "simulated as"

Page 8, line 27. I think $\max[0, (1-A)]$ should be $\max[0, A-1]$. This is supposed to describe "the excess concentration" when $A > 1$. If $A > 1$ then $\max[0, 1-A] = 0$, which doesn't make sense. The excess concentration should be $\max[0, A-1]$.

Page 9, equation 7. This equation doesn't make sense either. When $A > 1$, $h_+ = 0$. I think this equation should be $h_+ = \max[0, A-1]h$.

Page 9, line 18. Change "of being" to "to be". Change "sturdy" to "steady"

Page 9, line 19. Capitalize "Lincoln Sea"

Page 10, line 27. Acceleration and advection terms are neglected in equation 3. Does this mean the solution is steady state, with no time dependence?

Page 11, Figure 3 caption. Delete the first "(a)" because the caption later refers to (a) and (b).

Page 11, line 11. "quenched disorder" – this needs a reference.

Page 11, line 16. Beaufort SEA. Also, Weiss et al (2007) is cited in connection with Figure 8(a), but the figure caption cites Weiss and Schulson (2009).

Page 12, line 10. Delete "the upstream part of", so the sentence reads, "...prescribed on GAMMAin and GAMMAout..."

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Page 12, lines 14-15. "The equations of motion... Galerkin methods are used to handle advective processes" – but the advection terms in equation 3 are neglected. So I don't understand this. Does it refer to advection in equations 4 and 5?

Page 14, line 2. "deformation rates" – I think this should be "high deformation rates"

Page 14, line 3. "downstream of the channel" should be "downstream of the constriction"

Page 14, Figure 4. This figure should be bigger, so that it fills the full width of the page. It's a bit difficult to see the peaks of wind stress in panel (a) – bigger would be better.

Page 15, line 23. I think "Fig 4b and 4c" should be "Fig 5b and 5c"

Page 15, line 27. I think "Fig 4b" should be "Fig 5b"

Page 16, line 24. The text says "Weiss et al (2007)" but the Figure 8 caption says "Weiss and Schulson (2009)"

Page 18, line 2. "ice landfast" should be "landfast ice"

Page 18, line 8-9. How does the ice become weaker without thinning? Is it because the ice strength is temperature-dependent, so increasing the temperature would make it weaker? Is it because the composition of the ice could change, such as increased salinity?

Page 23, line 10. The first author is Hibler, W.D. III

Page 25, line 27. Weiss and Dansereau 2016 – is the DOI correct?

Page 26, Figure 5 caption. At the end of the last sentence, "red arrows on (a)" should be "red arrows on 4(a)"

Page 27, Figure 6 caption. Delete the first "(a)" because the caption later refers to (a) and (b).

Page 29, Figure 8 caption. Delete the first "(a)". Capitalize "Beaufort Sea"

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Page 31, Figure 10 caption:

– line 2: "is of 10" should be "is 10"

– lines 5 and 6: "insert" should be "inset"

– I recommend deleting these two sentences: "The tail of the distribution..." and "The temporal evolution..." because the last sentence of the caption explains the same thing as these sentences.

Page 31, Figure 11 caption:

– line 2: "is of 10" should be "is 10"

– line 5: "insert" should be "inset"

Please note: I have not flagged all the minor grammatical corrections that should be made by an editor, for example:

Page 9, line 10. "is of 100%" – delete "of"

Page 9, line 26. such AN ice bridge

Page 10, line 8. "in Cartesian" should be "to Cartesian"

Page 10, line 9. Delete "is"

Page 11, line 8. employed IN the simulations

Page 11, line 12. "by randomly by" – delete second "by"

...and so on...

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