

The Cryosphere Discuss., referee comment RC1  
<https://doi.org/10.5194/tc-2020-354-RC1>, 2021  
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## Review of tc-2020-354

Anonymous Referee #1

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Referee comment on "A generalized stress correction scheme for the MEB rheology: impact on the fracture angles and deformations" by Mathieu Plante and L. Bruno Tremblay, The Cryosphere Discuss., <https://doi.org/10.5194/tc-2020-354-RC1>, 2021

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Review of "A generalized stress correction scheme for the MEB rheology: impact on the fracture angles and deformations" by Plante and Tremblay (tc-2020-354).

This manuscript is a generally well written and easy to follow description of an extension to the MEB model of Plante et al (2020), but also has implications for other MEB implementations. This extension addresses two problems of the original model: large (numerical) error growth, which may be model-code specific) and too large fracture angles (which is probably not model-code specific. The new scheme allows to specify a more general correction of stress states that exceed the Mohr-Coulomb failure criterion. Sensitivity experiments in uniaxial compression illustrate that the parameterization indeed reduces the error growth and also reduces the fracture angles towards more realistic values. From the sensitivity experiments a preferred parameter set is determined. This is a very useful addition to the development of MEB rheology (and code) and should be published subject to minor revisions.

My main point of critique is that the manuscript is missing a bit of general introduction and a clear problem statement. To my mind, the manuscript can be improved by taking the reader more by the hand than is done. This only requires a few sentences here and there or maybe an additional paragraph, e.g.

(1) what do we expect from a "brittle" model in contrast to a "granular material". The concept of "granular material/flow" is used often in the text, but it is not clear (from the text) how the brittle part of the model relates to that. Do we expect that a brittle model represents a granular material properly?

(2) state the issues with sea models and MEB in particular that are addressed in this paper in separate paragraphs. Now the angle-issue is mentioned in the middle of a paragraph that is introduced by: "The damage parameterization is relatively new, ..."

(3) discuss if the new scheme can be also useful for other implementations of MEB (e.g. neXtSim)

There are some technical issues (figure referencing and captions) detailed below.

The points below sometimes repeat my main points.

page 1

Abstract: General background and (more importantly) a clear problem statement is missing from the abstract. E.g., the problem of too large angles is not stated and the error growth is also only mentioned as the target of the new parameterization. It would help to have more context here already (1-2 extra sentences).

l3: any correction path: unclear "any"

l18: significantly: repetition

l22: the presence of and deformations along LKFs

page 2

l30: Hunke, 2001: not sure if this is an appropriate reference (for what)?

l44: "The fracture angle simulated by the MEB and standard VP models" It will be easier to follow, if you dedicate a separate paragraph (or at least an introductory sentence to this paragraph) to the fracture angles as a problem statement before describing what VP and MEB models do wrong.

l60 I think that the problem statement is not clear enough. Unless you are very familiar with the details of the implementation of MEB models, it's not clear where Plante et al (2020) had numerical difficulties and if this is specific to their implementation. It should be clear if this will also be of value for, e.g. neXtSIM, or Dansereau et al.

Also the fracture angle problem is somewhat buried in the introduction and should be more prominent, because the paper devotes a large part to this.

page 3

l62: (Sulsky and Peterson, 2011) fix parentheses

l81: (Plante et al., 2020) fix parentheses

page 4

l96: is -> in

l104: "resulting in dominant elastic component"? not clear, something missing?

page 5

l117: maybe put  $\mu$ ,  $\phi$ ,  $c$  into Fig1 for better illustration?

page 6

eq 16: where does the "some algebra" start from? Maybe add a little more explanation here to guide the reader.

l148: "something that is not possible in the standard parameterization otherwise  $\Psi$  ..." please rephrase.

page 7

l166: on -> of

page 8

l208: asymmetry factor: not immediately clear why this measures error. I assume that you expect perfectly symmetric solutions about the center line, but I think that this needs to be explained.

The same is true for "damage activity", what do you want to use this for and how does this diagnostic achieve that.

page 8

eq.26/27. the notation is a bit unusual and looks a little like (pseudo-) code. Why not use standard indexing as one would expect in a maths text?, e.g.  
 $\left(\sigma_{II}\right)_{n_x-i,j}$

page 9

l235: 0.29 N/m? units?

l243: "mostly elastic with divergence along the fracture line" Where do we see that divergence? In Fig3 I mostly see negative divergence = convergence.

l248/9 The references to figure 4 are not correct. There is no Fig 4i, then it's not clear from the caption, what we are seeing in color (damage?). It would help to add the timing in the plot (maybe top right or bottom left of rhs column).

page 10

l251: here and everywhere else: Units should NOT be in italics).

l254:  $10^{-6} \text{ Nm}^{-2}$  (unit not in italics): in 4.1 it was  $1e-8$ !! In Fig5 it seems to be  $1e-8$  as well.

l254:are -> is

l254: "damage error amplification ratio R" maybe refer to equation 23 here?

l258: indicate -> indicates

In Figure 6 the panels for  $\epsilon_{ps\_asym}$  and  $R_{max}$  are exchanged wrt to Figure 5. Why confuse the reader?

l263: "the production of" could be removed

l264: I would argue for  $\gamma \geq 0$  the improvement is significant (including 0). But the asymmetry also grows for  $\gamma > 0$  and only for values  $> 45$  it seem to stay low. Why not discuss that here?

page 11

l286: "Based on these results, we suggest the use of a correction path that is normal to the yield criterion ( $\gamma = \arctan \mu$ , see black points in Fig. 9)."

my say,  $\gamma = \phi$  in this case, (isn't it)?

page 12

l331: "are robust to the exact" -> are not sensitive to the exact, are robust with respect to the exact ...

l335: reach -> reaches

l335: elastic wave are however no-longer -> elastic waves, however, are no longer ...

l344: in -> is

page 13

l349: the uniaxial -> a uniaxial

l351: not sure if "post-fracture" (or pre-fracture) is grammatically correct. I would use "after (and before) fracture" in most places in this manuscript

l352: "contrary to laboratory experiments of granular materials and satellite observations of sea ice." A short discussion about to what extent we expect granular behavior in an MEB model seems in place (not here in the conclusions but somewhere in the introduction?), in order to understand if this is an encouraging or a discouraging result

l361: "the production of" remove, see above

page 21

Figure3: miximum -> maximum/minimum?

page 22

Figure 4. What are the meaning and the units of the color scale? Is this for the control simulation only?

page 27

Fig9: "The theoretical fracture angle from the Mohr-Coulomb and Roscoe theories are indicated by dashed and dash-dotted lines for reference." something like this, could also be useful in Fig7.