

2nd Review of: “Implementation of a brittle sea-ice rheology in an Eulerian, finite-difference, C-grid modeling framework: Impact on the simulated deformation of sea-ice in the Arctic” by Laurent Brodeau, Pierre Rampal, Einar Ólason, and Véronique Dansereau.

This manuscript presents the implementation of the Brittle Bringham Maxwell (BBM) rheology in the SI3 community sea ice model, which uses a C-Grid Finite Difference framework. In particular, the authors present their use of the E-Grid discretization scheme to avoid difficulties with the staggered velocity and stress components in the C-Grid. The performance of their BBM implementation is then assessed first using a benchmark simulation from Mehlmann et al., 2021, then in pan-Arctic context, both compared to the same SI3 simulations repeated using the standard SI3 rheology configuration (the aEVP rheology). Results demonstrate the adequacy of the BBM implementation and its good performance in representing LKFs.

I find that the manuscript is interesting, important and has potential for publication in GMD. In particular, it provides detailed discussions on difficulties implementing the BBM rheology in the SI3 sea ice model, and presents the numerical tools used by the authors to overcome them. This is an important step for the rheology to be more thoroughly investigated and used by the community.

I commend the work made by the authors to clarify the manuscript and genuinely address all of my (and other reviewers) comments. Many useful explanations have been added to the implementation description, and some changes to the methods largely clarify the analysis and allow for a more detailed presentation and interpretation of the results. I find this version of the manuscript to be very clear, useful and interesting, making for a strong manuscript that will open the door for a wider use of the BBM rheology in the sea ice modelling community.

I therefore recommend its publication, after addressing the following minor edits/clarifications.

Best regards,

Mathieu Plante

Minor comments:

- Title: perhaps indicating E-augmented C-grid?
- L287: “for the term of the divergence of the stress tensor” --> either : for the stress divergence term, or : for the rheology term?
- L288-293: Please clarify, I have difficulty understanding what you try to say. Are you referring to the 1/h form of the last terms in Eq. 16? Also, I am not sure what errors you are referring to.
- L294-295: Please clarify. Also, I may be missing something but according to the equation, the nudging intensity is modulated by γ_{ns}/N_s ... So why would it be less sensitive to N_s than to γ_{cn} ?
- L296: remove coma after (Eq.9). Also, I would introduce (CN) earlier, at L280, and use it thereafter.

- L296 “before any potential upcoming correction is applied following the Mohr-Coulomb test” :: Rewrite, as this sounds as if the nudging is made between the MC test and the correction. I believe, according to your answers to my last review, that you rather apply the nudging before applying the MC test (i.e. before calculating d_{crit})? Perhaps something along the lines of: “Due to the strong damage-stress interdependence, we apply the CN after solving the constitutive equation but before computing d_{crit} and applying the stress correction”.
- L297-298: “then we may propagate [...]”:: Too many comas, this sentence needs to be clarified. I get that you mean that it would introduce a discrepancy between the damage and the corrected stress values. This is very helpful, thanks for adding this explanation to the manuscript.
- L303: remove come after γ_{cn}
- L323-324: This precision may not be needed, and confuses me as “the sum of Ns successive displacement vectors” sounds too much like making a Lagrangian track out of the Eulerian vectors. But I do not think it is the case here: I assume that the mean is applied on the Eulerian U,V, hence defined at a specific grid location and not building into a track.
- L325: I am not sure, but I would remove the dash between order and moment.
- L342: “yields the so-called” -> change to “is the”
- Add point at end of L395.
- Section 2.5: I find a bit awkward the miss-match between the subsections (2.5.1--2.5.4) and the use of “as a first step”, “as a second step”, “a final step”. I think it would be clearer if you distinguished between the trajectory selection (L388-395, which could be 2.5.1), from the quadrangle selection (L403-409), instead of describing both as steps in an overall “selection process”.
- L411-412: repetition of quadrangles: → “based on their position #1 and #2 using [...]”
- L413-414: “Similarly to [...]” → This sentence is confusing, and may not be needed, as the following sentence is clear enough by itself.
- L420: no need for indent (keep in 1 paragraph)
- L442: “somewhat very different” → not clear. I suggest going directly into the differences for conciseness.
- L498: remove shown and put “figure 7” in parentheses.
- Section 3.3.1. Looking at the curves, it looks to me that in terms of power law, the standard simulations have a similar slope in the tail of the PDFs, although with under-represented large deformations. This is worth mentioning, although I understand that it is not the focus. E.g., perhaps something on the lines of “Our results suggest a propensity for SI3-default to exhibit somewhat similar power-law behaviour (similar exponents, except in convergence) but yet to underestimate the extreme values of the deformation rates. [...]”).?