# Reply to reviewers: "The next generation sea-ice model, neXtSIM, version 2"

(Reviewer Comments are in black, and Author Responses are in blue)

**RC:** The manuscript is improved, and I only have several minor remarks listed below. I would recommend it after they are taken into account.

**AR:** We are happy that the reviewer sees improvement in the latest version of the manuscript. We have done our best to address the remaining concerns. We must note that the numbering of lines and figures is not quite consistent with the latest version, but we don't think this will cause any issues.

## Minor points

**line 4** ... to capture sea ice deformation features ... I still do not fully see why one needs this on coarse meshes.

**AR:** This is explained in more detail in the introduction, and there is little room for extra details in the abstract, beyond the current "fails to capture sea ice deformation features and the resulting localised changes in thickness and concentration, which likely play an essential role in ice-atmosphere-ocean interactions". Most of the first paragraph of the introduction now addresses this question.

**lines 22, 29, 37** 'for ten days', 'for four days', 'for an entire year', 'over several years' – I would suggest that this information is omitted, as for any potential user such limitations tell that model was not mature enough at that time. Why to write about this? A sea-ice model should not have such limitations at the resolutions the authors are aiming.

**AR:** We included this information to provide some historical context; neXtSIM has been around for a while now, but only with the version described here have these limitations been overcome. In fact, the reason we are releasing version 2 to the community and writing this paper is that the model no longer has these limitations and can therefore be used by people not intimately familiar with it.

**line 60** omit 'an EVP implementation as'; 'This was then ... ' It was then modified to act as ...

**AR:** Agreed. The text now reads

In version 2 of neXtSIM, we also include implementations of the elasto-viscous-plastic (EVP) Hunke and Dukowicz (1997) and modified elasto-viscous-plastic (mEVP) (Lemieux et al., 2012; Bouillon et al., 2013) rheologies for comparison and testing.

**line 64** remove 'any'

**AR:** Reworded to read "... for completeness, focusing on aspects relevant to neXtSIM."

**line 73** 'd is then reduced ..' Do you mean that d becomes negative? Also, please rephrase the next sentence, it is unreadable.

**AR:** It should have said "increased", not "reduced". We have corrected this. The following sentences now read:

> A local increase in $d$ represents damaging of the ice, which is modelled as a reduction in elasticity. The reduction in elasticity in an element means that this element deforms more easily than before, and so the distribution of stresses in the neighbouring elements must change. This causes a stress redistribution ...

**147** 'donates' ? Do you mean 'contains'?

**AR:** It should have been "denotes". We have substantially rewritten this section and changed the notation.

**432, 434** 'vertices'? Do you mean edges of triangles? Vertices is the same as nodes.

**AR:** Yes, it should say "edges". We've fixed this in several locations.

**459, 460** I would be of interest to see a comment on incurring errors.

**AR:** The errors incurred here are primarily displacement errors, which we estimate to be no larger than 1/3 of the model resolution. This is discussed in the following paragraph.

**464, 465** – this is an obvious problem, and a question arises to what an extent the use of Lagrangian advection is the only solution?

**AR:** Lagrangian advection is, of course, not the only solution, and it is clear that we would greatly benefit from a holistic comparison between the Lagrangian approach and others. This is, however, very challenging, since all approaches have their drawbacks and require substantial detailed knowledge and expertise to implement properly. A model comparison study is probably the best approach here, but that is clearly outside the current scope.

**499** Why the time step is so small? Please comment on it. Also for realistic case please give information on time step and the number of substeps.

**AR:** We used a short model time step so that we could have high-frequency outputs to better inspect the processes involved. This is now noted in the manuscript. Information on the time-step length and number of sub-steps is now included in the section on the realistic case (1800 s and 120, respectively).

**Panel c in Fig. 5 and panel a in Fig. 7** are patchy, and, as in my previous review, I would rather consider this a disadvantage of the model. A numerical model should not show noise on grid scales. I understand that the Lagrangian scheme allows to integrate such patchy fields, but how can you then compute divergence of h*sigma? I do not see that emphasizing heterogeneity at grid scale is a good approach, as all discrete differential operators are not accurate at such scales. Please comment on this in the paper.

**AR:** The "patchiness" of figure 5c (now figure 7c) was partly due to a processing mistake; it's multi-year climatology, and should, therefore, be inherently smooth. We have corrected this figure. The patchiness of figure 7 (now 11) is due to repeated fracturing of the ice cover over several years. It is the result of the physical model and bears a striking resemblance to high-resolution satellite images of the ice (e.g. figure 1). Reproducing this heterogeneity should be considered a feature of the model. Such heterogeneity is evident in every iteration of the brittle rheologies in Girard et al. (2011); Bouillon and Rampal (2015); Rampal et al. (2016, 2019); Ólason et al. (2022). We have added the following to the relevant section: "The neXtSIM results also demonstrate how the model reproduces the strong heterogeneity that characterises sea-ice dynamics (e.g. Rampal et al., 2008)".

# References


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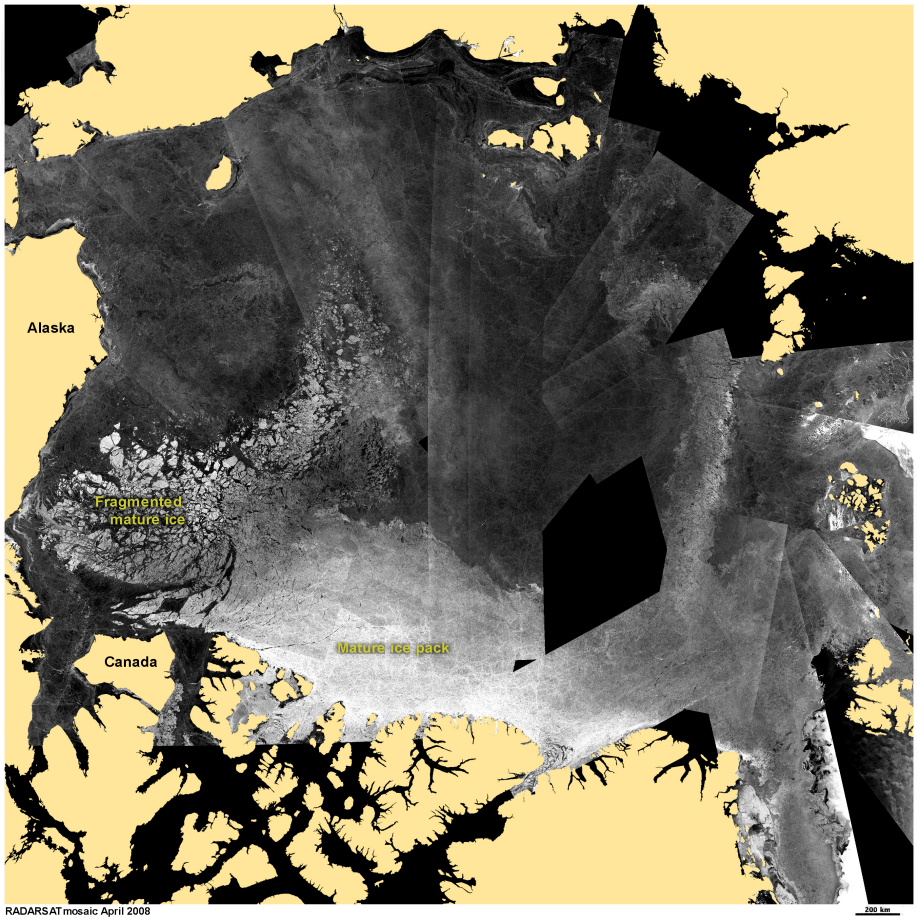


Figure 1: A mosaic of RADARSAT SAR images originally created by NASA, but not available on their website any more.

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