

Response to reviewers after second review

September 16, 2025

We thank the reviewer for his/her second review. Our responses below are in blue.

Reviewer 1:

The authors have shifted the emphasis from a strong focus on intersection angles to highlighting the broader benefits of introducing a non-normal flow rule. They argue that the plastic potential offers an interesting and useful modeling capability: it allows optimization of deformations while maintaining the same yield curve, and conversely, it permits adjustments of the yield curve to improve simulations of landfast ice and sea-ice drift with little impact on deformation patterns.

Overall, the manuscript has been improved compared to the previous version. The most important criticism, the missing validation of the implementation of the non-normal flow rule, has been convincingly addressed: the supplement now includes a uniaxial compression test (after Ringeisen et al. 2021). Methodological differences from earlier studies (Hutter and Losch 2020; Hutter et al. 2022) are also explained more clearly, and the quantitative analysis provides new insights into the relationship between the computational grid and LKF orientations.

Nevertheless, some issues remain. The central discrepancy, why pan-Arctic simulations continue to produce intersection angles peaking at 90° instead of 45° , is acknowledged but not resolved. This limits the general validity of the conclusions. In addition, it is not correct to state that the intersection angles are “partly caused by the alignment of LKFs with the computational grid”; the results demonstrate correlation rather than a proven causal mechanism.

Explaining why intersection angles are still at 90° instead of 45° is a difficult problem that would require a lot of work. This is discussed in the conclusion of the manuscript.

We agree about the correlation rather than a complete explanation of the mechanism. We have rephrased some sentences to reflect this.

Finally, the manuscript remains highly technical in places. Requests for explanatory sketches or schematics were not implemented; instead, references are made to other papers. This does not resolve the issue, especially when the sections in question concern the authors' own newly developed methodology in python. It raises the question of why such material is included in the manuscript if, in its current form, it remains difficult for readers to follow. This should clearly be improved before publication. I recommend acceptance after minor revisions.

We have clarified the text in Appendix A and added a figure to better explain the algorithm for calculating the width of LKFs. For the rest, in order to keep this manuscript relatively short, we prefer not to include similar schematics as the ones already presented in other articles.

Minor comments:

1) 1.20: Please add a citation to “for example to optimize landfast ice.”

We have cited Lemieux et al. 2016.

2) 1.14: “We show that these frequent 90° angles are partly caused by the alignment of LKFs with the computational grid.” What is shown is rather a correlation, not clearly a causal mechanism.

We agree. It is written in the revised manuscript: ‘Results suggest that these frequent 90° angles are partly caused by the alignment of LKFs with the computational grid.’

3) 1.93: You are probably referring to the appendix here, please clarify.

No, as stated we are referring to the supplement.

4) 1.280–288 (Numerical convergence): It would be helpful to test at least one run with substantially more Picard iterations to rule out that insufficient convergence affects the results.

The results with the implicit solver are really a small complement to the main results. We do not want to put more emphasis on this. Furthermore, simulations with 10 Picard iterations with a time step of 3 minutes are already quite demanding in terms of computational resources.

5) Fig. 1: The notation “ $i=100, j=100$ ” in the caption is unclear, please explain what i and j stand for.

It is already written in the caption that the grid indices are i and j . We don't think more detail is needed.

6) p.8, l.176–190: This section remains very technical. Since it introduces the new analysis tool, the description should be made more accessible to readers. A sketch showing an LKF, grid lines, and the angles under discussion would be very helpful.

We have notably improved the text in Appendix A to better explain our new tool. We have also included a new schematic for explaining the calculation of the LKF width.

7) l.309: Please explain what N_{min} means.

We have clarified this. It is now written in the revised manuscript: 'Increasing the minimum number of points required (N_{min}) from 10 to 20 or 30 (i.e., analysing only longer and longer LKFs) does not change, qualitatively, our conclusions...'

8) Fig. 12: Please also include the standard VP model to make the differences visible.

Unfortunately, our simulations with the implicit solver (VP) do not cover the full period of the time series. Anyway, we would expect small differences and don't think this would be useful.

9) Appendix A: Please add i/j axes to the figure.

We added the x-y axes on Fig.(A1).

10) l.423–434: A sketch would help illustrate the contour lines under discussion.

We agree that Appendix A needed to be reworked. We have therefore added Fig.(A2) that explains the procedure for calculating the half width. We have also modified and reorganized some of the text.

Thank you very much for your help in improving this article.

Jean-Francois Lemieux