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Alternative viscous-plastic rheologies for the representation of fracture lines in high-resolution sea ice models

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Fracture lines dominate the dynamics of sea ice. They affect the ice mass balance and the heat transfer between the atmosphere and the ocean. Therefore, climate modeling and sea ice prediction require an accurate fracture representation. Most sea ice models use viscous-plastic (VP) rheologies to simulate sea ice internal stresses. One of the issues with these rheologies is that they overestimate the intersection angles between fracture lines, with consequences for the subsequent sea ice drift. In idealized experiments, we investigate the mechanisms linking VP rheologies and fracture angles and assess alternative rheologies for high-resolution modeling. Results show that the definition of the transition between viscous and plastic states is essential for the creation of sharp fracture lines. The fracture angles with Mohr-Coulomb yield curves agree with the Arthur fault orientation theory. Further, rheologies with Mohr-Coulomb yield curves or teardrop yield curves appear to reduce intersection angles. Finally, experiments show that these results are reproduced for different sea ice initial conditions. With rheologies that favor smaller intersection angles, sea ice models move a step closer to accurate sea ice dynamics at high-resolution.