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Fast EVP solutions in a high-resolution sea ice model

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The use of elastic-viscous-plastic (EVP) solver to simulate sea ice dynamics is computationally demanding, especially at high resolution when linear kinematic features (leads, cracks) are present in solutions. At such resolutions, numerical stability requires that sub-cycling time steps be sufficiently short, therefore their number increases compared to low-resolution simulations. A modified formulation of the EVP solver changes the EVP algorithm such that its stability is no longer connected to the number of sub-cycles, which only determine convergence to the viscous-plastic rheology. It has been shown in a low-resolution setting (27 km in the Arctic Ocean) that practically appropriate solutions can be obtained with much smaller numbers of sub-cycles. We demonstrate that this conclusion carries over to high resolution when linear kinematic features such as leads emerge.

We show that the computational burden can be dramatically reduced in 4.5 km Arctic Ocean simulations with FESOM2 sea ice-ocean model by using modified and adaptive versions of EVP with the reduced number of sub-cycles. The simulated sea ice fields retain characteristics obtained with more traditional EVP at a large number of sub-cycles. This result is expected to carry over to even higher resolutions; however in each case additional tuning of parameters ensuring stability may be needed.