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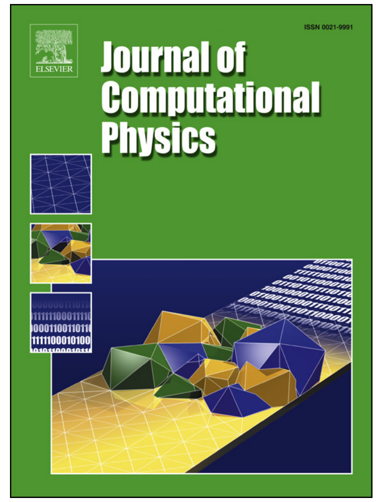

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A Meshfree Approach to Non-Newtonian Free Surface Ice Flow: Application to the Haut Glacier d'Arolla

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Abstract

Numerical models of glacier and ice sheet dynamics traditionally employ finite difference or finite element methods. Although these are highly developed and mature methods, they suffer from some drawbacks, such as inability to handle complex geometries (finite differences) or a costly assembly procedure for nonlinear problems (finite elements). Additionally, they are mesh-based, and therefore moving domains become a challenge. In this paper, we introduce a novel meshfree approach based on a radial basis function (RBF) method. The meshfree nature of RBF methods enables efficient handling of moving margins and free ice surface. RBF methods are also accurate, easy to implement, and allow for reduction the computational cost associated with the linear system assembly, since stated in strong form. To demonstrate the global RBF method we model the velocity field of ice flow in the Haut Glacier d'Arolla, which is governed by the nonlinear Stokes equations. We test the method for different basal conditions and for a free moving surface. We also compare the global RBF method with its localized counterpart—the RBF partition of unity method (RBF-PUM)—that allows for a significant gain in the computational efficiency. Both RBF methods are compared with the classical finite element method in terms of accuracy and efficiency. We find that the RBF methods are more efficient than the finite element method and well suited for ice dynamics modeling, especially the partition of unity approach.

Keywords: Ice sheet modeling, Non-Newtonian fluid, Free surface flow,

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