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FEM-modelling of ice dynamics without remeshing

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The Finite Element Method (FEM) has become a popular method for numerical ice sheet modelling, partly due to its capability of representing complex geometries. However, there is a limit to just how complicated these geometries can be. In the presence of irregular geometries and moving boundaries like those appearing in glaciology, costly remeshing and low mesh quality may become issues. To overcome these problems, new unfitted sharp interface methods such as CutFEM are being developed by the FEM community. The CutFEM method allows for the boundary to cut through a mesh, without requiring the element nodes to be located on the boundary. In this way simple structured meshes can be used and remeshing is avoided while accuracy and stability is retained. We develop a CutFEM method for the full Stokes equations and apply it to a transient simulation of the Arolla Glacier with both no slip and partial slip conditions at the bed, using a level-set function to track the moving ice surface. We demonstrate accuracy of the method and discuss extensions to modelling ice shelves and moving grounding lines.

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