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Two-phase aggregates under simple shear: assessing numerical issues

Arthur Bauville (1), Thibault Duretz (1), Philippe Yamato (2), and Stefan Schmalholz (1)
(1) Lausanne, Lausanne, Switzerland, (2) Université Rennes 1, France

One of the main challenge in geodynamic modeling resides in the treatment of large deformation of heterogeneous media. Geological materials are generally characterized by sharply varying physical properties. Sharp interfaces tend to focus deformation, and therefore numerical errors.
In this study we utilize popular implementations of the finite difference and finite element methods for solving viscous flow and advection. We implemented finite difference method coupled with a Lagrangian marker-in-cell (FD/MIC) technique to represent the deforming media. With this method the flow solver has restricted geometric flexibility, it is however characterized by a light and stable discretization. Additionally, we employ the Lagrangian finite element method with an unstructured mesh which offers full geometric flexibility at the cost of relatively heavier discretization.
We test the accuracy of the FD/MIC scheme by running periodic simple shear deformation of aggregates containing weak circular inclusions (1e6 viscosity ratio). Finite difference simulations were computed for variable grid and marker-mesh resolutions. These results are compared to those obtained using Lagrangian finite element, which we consider as a reference solution. We use several criteria (volume conservation, discretization errors, symmetry) to evaluate the quality of the solutions. These results are used to assess the numerical stability and accuracy of the finite difference/marker-in-cell method under large deformation.