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M2Di: MATLAB 2D Stokes solvers using the Finite Difference method

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The study of coupled processes in Earth Sciences leads to the development of multiphysics modelling tools. Mechanical solvers represent the essential ingredient of any of these tools such that their performance and robustness is generally dictated by that of the mechanical solver.

Here, we present M2Di, a collection of MATLAB routines designed for studying 2D linear and power law incompressible viscous flow using Finite Difference discretisation. The scripts are written in a concise vectorised MATLAB fashion and rely on fast and robust linear and non-linear solvers (Picard and Newton iterations). As a result, time to solution of 22 seconds for linear viscous flow with 10^4 viscosity jump on 1000^2 grid points can be achieved on a standard personal computer.

We will present a numerous example of applications that span from high resolution crystal-melt dynamics, deformation of heterogeneous power law viscous fluids, instantaneous mantle flow patterns in cylindrical coordinates, and calculation of pressure gradients around inclusions using variable grid spacing.

We use analytical solution for linear viscous flow with highly variable viscosity to validate the linear flow solver. Validation of the non-linear solver is achieved by comparing numerical solution to analytic and benchmark solutions of power law viscous folding and necking. The M2Di codes are open source and can hence be used for research or educational purposes.