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DOUAR, a new 3D creeping flow model for the solution of geological problems: some applications.

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We present a new finite element code for the solution of the Stokes and energy equations that has been purposely designed to address crustal-scale to mantle-scale flow problems in three dimensions. Although it is based on an Eulerian description of deformation and flow, the code, DOUAR, has the ability to track interfaces and, in particular, the free surface. The finite element discretization is based on a non-uniform, yet regular octree division of space that allows to adapt the finite element discretization at will, i.e. in regions of strong velocity gradient or high interface curvature, with efficiency. A variety of rheologies have been implemented including linear, non-linear and thermally activated creep and brittle (or plastic) frictional deformation. The large system of algebraic equations that results from the finite element discretization and linearization of the basic partial differential equations is solved using a multi-frontal massively parallel direct solver that can efficiently factorize poorly conditioned systems resulting from the highly non-linear rheology and the presence of the free surface. The code is almost entirely parallelized. We present a few results and applications of the code to geological problems, such as grid adaptivity in the vicinity of regions of localised deformation.