Reliable numerical models of lithospheric deformation require robust solution methods. The latter should account for a complex and realistic rheological model and should also provide convergent and reproducible results.

Here we present models of crustal-scale deformation that accurately capture the phenomenon of strain localisation in two-dimensions. The use of viscous regularisation yields convergent numerical results. We will compare linearisation methods (consistent tangent, effective viscosity) and discuss the implementation of rheological models (power-law viscous, hardening/softening laws). We will also present three-dimensional models of crustal-scale strain localisation that benefit from both the above-described methods and the computing power of graphical processing units (GPUs).