EGU22-13215
https://doi.org/10.5194/egusphere-egu22-13215
EGU General Assembly 2022

New i3elvis: Robust visco-elasto-plastic geodynamic modelling code based on staggered finite differences and marker in cell

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In the recent decade, numerical modelling approaches based on combination of staggered finite differences with marker in cell techniques became increasingly popular in geodynamics due to their simplicity, flexibility and computational efficiency. Here, I present new version of popular 3D thermomechanical code i3ilvis, which has been fundamentally revised to include the following methodological advances (Gerya, 2019 and references therein):

- Full thermomechanical coupling (through global Picard iteration) including compressible time-dependent mass conservation equation and adiabatic and shear heating effects in the energy conservation equation.
- Regularized visco-elasto-viscoplastic rheological model with/without dilation. (Duretz et al., 2019) based on global thermomechanical Picard iteration.
- Accurate continuity-based velocity interpolation for marker advection applicable for both compressible and incompressible flows.
- Free surface stabilization against “drunken sailor” instability.
- Accurate 3D rotation of elastic stresses on markers.
- Dislocation-diffusion creep rheology with grainsize evolution(Bercovici and Ricard, 2012) including newton iteration for dislocation creep to compute effective viscosity for markers.

The new code is OpenMP parallel and has already been successfully tested for cases of realistic 3D geodynamic modeling including tectono-magmatic model of continental breakup to oceanic spreading transition and spontaneous subduction initiation scenario associated with slab bending and normal faulting.

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