A dynamic identification of *continuous discontinuities* in geodynamic numerical models

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Discontinuities affect the Earth's dynamics, yet the Earth is often represented in geodynamical models as a continuous material. The challenge of representing discontinuities in numerical models has been addressed in several ways in literature. The split node method, originally introduced by Jungels (1973) and Jungels and Frazier (1973) for elastic rheology and then modified by Melosh and Raefsky (1981) to simplify its implementation, allows the introduction of discontinuity into a finite element model by imposing an a-priori slip at a designated node, where the displacement depends on the element which the node is referred to. Originally, this method requires that the discontinuity's geometry and slip are pre-established.

More recently, Marotta et al. (2020) modify this approach by introducing a coupling factor that indicates the percentage difference between the velocities of the element to which the slip node belongs, while the velocity consistently derives from the dynamic evolution of the system. However, this method still requires the pre-establishment of the discontinuity's geometry.

We here present a new technique that enables the dynamic identification of the discontinuity's during the thermomechanical evolution of the system, based on physical parameters and without predefining the slip or the geometry.

We have implemented a new algorithm that identifies one or more discontinuities in a finite-element scheme operating through two phases: nucleation and propagation. Nucleation involves selecting a yield physical property and identifying the potential slip nodes, i.e., nodes on which the chosen physical property exceeds a yield value. The nucleus is then identified as the potential slip node where the chosen property most exceeds the yield. Propagation can be performed by choosing between three approaches of propagation: single simple fault, multiple simple fault and single double fault; and three schemes for the identification of neighboring nodes: grid-bounded, pseudo-free and free. The resulting discontinuity is the line connecting the nucleus and the propagation nodes. Once the discontinuity has been identified, a coupling factor is introduced and the algorithm continues to operate following the Marotta et al., (2020)'s scheme.

The results of several benchmark tests, performed through both simple and complex finite-elements models, confirm the success of the algorithm in recognizing yield conditions and introducing a discontinuity into a finite-element model and demonstrate the correctness of the propagation's geometry.

References

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