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## **Poro-visco-elasto-plastic seismo-hydro-thermomechanical geodynamic models for subduction zones and induced seismicity**

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Natural and induced seismicity is widely investigated, and extensive knowledge has been acquired in the last years, but exact earthquake mechanisms remain elusive and poorly understood. The high impact of earthquakes on human society emphasizes that a deeper understanding of earthquake processes must be a priority in order to improve seismic hazard assessment and mitigate associated risks. Pervasive fluid flow is a key process significantly influencing rock physics and mechanics, and thus has a crucial impact on natural and induced earthquakes. Seismo-hydro-thermo-mechanical (SHTM) modelling is an important nascent branch of geodynamic modelling, which investigates evolution of coupled fluid-solid systems under conditions of both slow tectonic and fast seismic deformation rates. Here, we present a new fully coupled two-dimensional seismo-hydro-mechanical numerical code, with a poro-visco-elasto-plastic rheology, based on fully staggered finite differences with marker-in-cell technique, adaptive time stepping and global Picard iterations. The presented numerical code combines inertial mechanical deformation with pervasive fluid flow. The adaptive time stepping allows the resolution of co-seismic and interseismic phases with time steps ranging from milliseconds to years.

First, we demonstrate how fluid-bearing subducting rocks are intrinsically seismic and how seismic events in the form of highly localized ruptures spontaneously nucleate along the subduction interface. Nucleation and propagation of such events are driven by rapid fluid pressurization caused by visco-plastic compaction, counterbalanced by a nearly simultaneous and equivalent poroelastic decompaction inside the propagating and rupturing fault. Successive post and interseismic fluid pressure release, generated by poroelastic compaction along the fault, allows strength recovery of the megathrust. The model reproduces the broad range of seismic events present at the subduction interface, including slower events, regular earthquakes, and earthquakes that rupture the entire megathrust and reach velocities on the order of m/s, without employing slip rate dependent frictional properties.

Next, we show how our approach can be successfully adapted for fluid injection setups to model induced seismicity phenomena. The numerical code successfully modelled fluid induced seismic events and the resulting seismic wave propagation. Preliminary results show that faults can form spontaneously and grow aseismically at the injection site thereby creating favorable conditions for the development of broad induced seismicity region where different faults can be activated

seismically at different time.

Finally, we outline in short future SHTM modeling directions that should account for fracture-induced dilatation and dynamic permeability variations, thermal effects and three-dimensionality.