EGU23-5229, updated on 20 Apr 2024
https://doi.org/10.5194/egusphere-egu23-5229
EGU General Assembly 2023

Modeling fluid-driven seismic cycles in subduction zones

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Various geological and geophysical observations from different subduction zones attest to the importance of pore pressure fluctuations and fluid flow in triggering regular earthquakes, slow slip events and tectonic tremors. We use the Hydro-Mechanical Earthquake Cycle (H-MEC) code to model fluid-driven earthquake cycles in a subduction megathrust environment. The code uses a finite differences-marker in cell method, and couples solid rock deformation with fluid flow. The code solves the mass and momentum conservation equations for both solid and fluid phases, with the addition of gravity and temperature-dependent viscosity. The brittle/plastic deformation is resolved through a rate-dependent strength formulation and the development of slip instabilities is governed by compaction-induced pore fluid pressurization. With such code we can demonstrate how the fluid pressurization can lead to localisation of deformation with slip rates up to m/s in a fully compressible poro-visco-elasto-plastic media. The models can reproduce all slip modes observed in nature from regular earthquakes to transient slow slip phenomena to aseismic creep. Here we investigate various controls on dominant slip mode and their expected distributions and interactions along a subduction interface model setup. Our initial results show that the dominant slip mode depends on porosity, permeability, plastic dilatation and viscosity of the matrix. An increase in the porosity will lead to aseismic deformation in the form of slow slip events and creep. We also investigate the effects of inclusions (clasts) along the subduction channel, acting as stress heterogeneities, with physical properties different from the subduction channel. We attempt to understand the role of inclusions with different viscosities and permeabilities embedded in the matrix. With this numerical framework, we can better understand fluid-driven seismicity, and the effects of fluids on long-term geodynamic processes. Our study also contributes to better understand the role of fluid pressure cycling in seismic and aseismic deformation in subduction zone environments, as well as provides new insights in the role of stress heterogeneities within the frictional-viscous shear zone.