LONG-TERM INFLUENCE OF FAULT ZONE DAMAGE ON FULLY DYNAMIC EARTHQUAKE CYCLES: CONSTRAINTS ON HYPOCENTER LOCATION AND MAGNITUDE-FREQUENCY DISTRIBUTION

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Mechanical modeling of fault-slip over long timescales is of fundamental importance for understanding earthquake physics and assessing seismic hazard. Mature strike-slip faults are usually surrounded by a narrow zone of damaged rocks characterized by low seismic wave velocities. Observations of earthquakes along such faults indicate that seismicity is highly concentrated within this damaged fault zone. However, the long-term influence of this damaged zone, i.e., decades to hundreds of years, is not well understood. We model aseismic slip and fully dynamic earthquake rupture propagation on a vertical strike-slip fault surrounded by a damaged fault zone for a thousand-year timescale. We use observations along major strike-slip faults, e.g., San Andreas and Calico faults, to constrain the material properties and geometry of the damaged fault zone. These simulations address the effect of fault zone structure and its damage over multiple earthquake cycles along strike-slip faults. We use a spectral-element method in two dimensions with a rate-state dependent friction along the fault to solve the elastostatic and elastodynamic equations of motion. We have implemented shared memory parallelism in Julia to speed up the simulations. Our results show that the presence of the damaged fault zone produces earthquakes with variable magnitudes manifesting a log-linear relationship between the number and magnitudes of earthquakes, i.e., magnitude-frequency distribution. The depth extent of the damaged zone has a pronounced effect on constraining the hypocenter of earthquakes. We also explore the effects of the different damaged fault zone geometries on the magnitude-frequency distribution and hypocenter depths.