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# Fault geometry, a source of complexity in earthquake cycles

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Earthquake are known to be a complex phenomena, varying over several lengthscales in space (from micro-seismicity to big megathrust earthquake) and also in time (decades of loading for few second of rupture). The rate and state framework [Dieterich, J. (1979). Modeling of rock friction: 1. Experimental results and constitutive equations. *Journal of Geophysical Research*, 84(B5), p.2161.], that is an empirical law allowing for the restrengthening of the fault resistance after a rupture, has helped a lot to understand the temporal evolution of seismic cycle. It made possible modeling of earthquakes over several cycles and allowed us to reproduce sequences of earthquakes. However, one cannot probably summarize all the complexity of earthquakes in the friction. Another appealing source of complexity is the geometry, and networks of faults.

This is known from observation that the geometry has a strong impact on the dynamic of earthquakes. Despite this importance of geometry, very few studies have tried to incorporate the geometry in model of earthquake cycles. This is mainly due to computational reasons that make non-planar geometries out of reach because of computational time. To overcome this issue, we develop a new quasi dynamic model of earthquakes, with rate and state friction law, that is accelerated through the use of Hierarchical matrices [Chaillat, S., et al., Theory and implementation of H-matrix based iterative and direct solvers for oscillatory kernels, Journal of Computational Physics,351, p.165–186]. We showed that geometry alone can perturb a lot the seismic cycle, changing the recurrence time of earthquakes making it more chaotic. Another big challenge of seismic cycles models would be to catch scaling laws such as Omori or Gutenberg. We show that the interaction of faults may resolve some of these scaling law issues (Fig. 1).

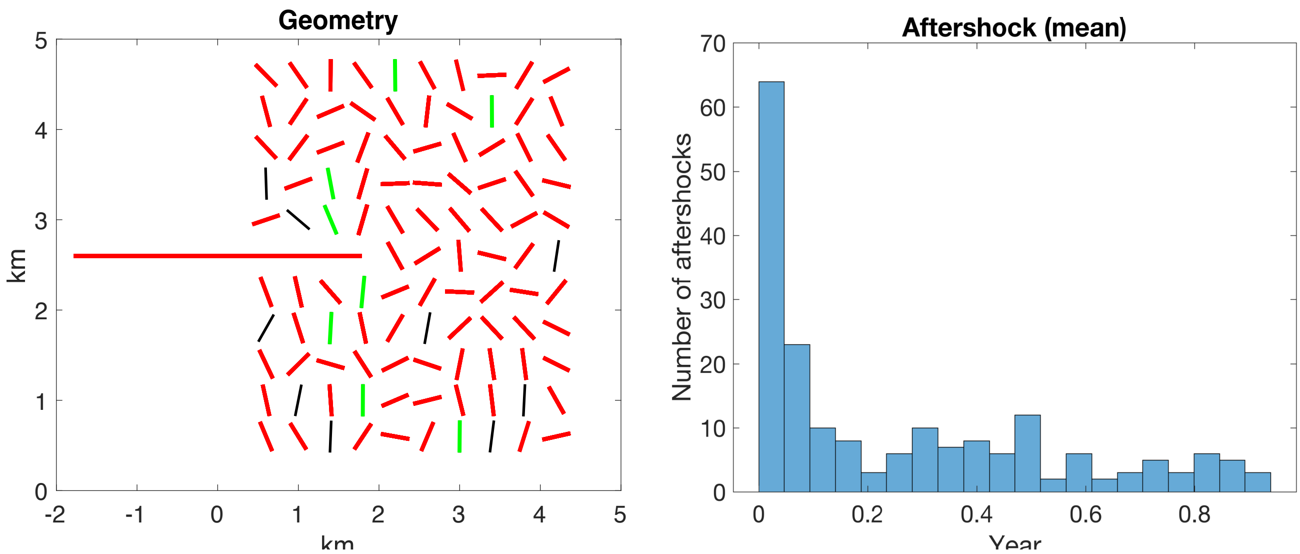


**Figure 1. Left: geometry of a network of 107 faults, modeled with rate and state. Red faults indicate that faults had ruptured during the simulation, green faults are blocked faults (no longer rupturing). Right: aftershock distribution after the main fault ruptured.**