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Modelling earthquake interaction and seismicity statistics

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The effects of earthquake interaction and fault complexity on seismicity statistics are investigated in a 3D model composed of a number of cellular automata (each representing an individual fault) distributed in a volume. Each automaton is assigned a fractal distribution of strength. Failure occurs when the 3D Coulomb stress on any cell exceeds its strength and stress transfer during simulated earthquake rupture is via nearest-neighbor rules formulated to give realistic stress concentrations. An event continues until all neighboring cells whose stresses exceed their strengths have ruptured and the size of the event is determined from its area and stress drop. Long-range stress interactions are computed following the termination of simulated ruptures using a boundary element code. In practice, these stress perturbations are only computed for events above a certain size (e.g. a threshold length of 10 km) and stresses are updated on nearby structures. Events which occur as a result of these stress interactions are considered to be "triggered" earthquakes and they, in turn, can trigger further seismic activity. The threshold length for computing interaction stresses is a free parameter and hence interaction can be "turned off" by setting this to an unrealistically high value.

We consider 3 synthetic fault networks of increasing degrees of complexity – modelled on the North Anatolian fault system, the structures in the San Francisco Bay Area, and the Southern California fault network. We find that the effect of interaction is dramatically different in networks of differing complexity. In the North Anatolian analogue, for example, interaction leads to a decreased number of events, increased b-values, and an increase in recurrence intervals. In the Bay Area model, by contrast, we observe that interaction increases the number of events, decreases the b-values, and has little effect on recurrence intervals. For all networks, we find that interaction can activate mis-aligned structures and that it tends to decrease the number of tectonic (i.e. non-triggered) events.