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Earthquake rupture Along Fractal Fault Surfaces

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Earthquake rupture occurs along non-planar fault surfaces whose geometric complexity exhibits fractal characteristics over a wide range of spatial scales (<mm to >km). Here, we investigate in a numerical framework how this fractal character affects earthquake rupture.
First, we show that the fractal geometry of a rupture surface may be deterministically approximated via sufficiently fine parameterization. Roughness expressions at smaller length-scales (smaller then this parameterization level) do not significantly affect the rupture process. The importance here lies in "rupture surface" as opposed to "fault surface". That is, an earthquake with small rupture area requires the same level of parameterization as an earthquake with a large rupture area, which implies that small earthquakes are sensitive to small-scale roughness features. As a rupture grows, it becomes less sensitive to small-scale roughness features.
Second, the earthquake stress drop that is associated with a certain amount of slip along a non-planar, geometrically rough surface is distinctly larger than its planar-fault equivalent. Earthquake stress drop is inversely proportional to fault roughness. Current stress drop estimates for real earthquake ruptures all assume a planar rupture surface, implying that these stress drop estimates are consistently and significantly too low. In fact, proper consideration of a fault geometry's fractal character (as well as consideration of an earthquake rupture's non-uniform distribution of slip) largely removes the apparent discrepancy between current stress drop estimates from real earthquakes and stress drop values that are implied by high-speed friction experiments (which are about one magnitude higher).