Extreme Fault Connectivity and What It Means for Seismic Hazard Models

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How connected are fault systems in shallow continental crust? Seismic hazard models in California have evolved from simple segmented prescriptive models to much more complex representations of multi-fault and multi-segment earthquakes in an interconnected fault network. During the development of the 3rd Uniform California Earthquake Rupture Forecast (UCERF3), the prevalence of multi-fault ruptures in the modeling was controversial. Yet recent earthquakes, for example, the 2016 M7.8 Kaikoura earthquake – have validated this approach. If anything, connectivity in the UCERF3 may be underestimated, although clustering in the model may mitigate some modeling simplifications.

Seismicity also provides a probe of underlying fault connectivity in Southern California. We find no correlation between proximity to major mapped faults and earthquake size. Similarly, aftershocks sequences are not more productive when they occur closer to major faults. Our results support the view that the fault system in California is characterized by extreme connectivity; i.e., that an earthquake that nucleates within this fault network is equally likely to grow large regardless of whether it starts on a fast-moving, relatively simple structure or on a small secondary fault strand. This connectivity is not necessarily an actual geometric connectivity; it could be an effective one driven by rupture dynamics and the propensity for fault-to-fault jumps.

What is the proper way to model earthquakes in a highly connected fault network? Future iterations of hazard models should continue to model more accurately the true connectivity of the fault system and include the largest, rarest events. The goal should not be to predict the exact rupture process likely to happen in a future Kaikoura-like rupture, but to capture enough connectivity so that the modeled magnitude distribution – including the maximum magnitude – is accurate.