Statistical analysis of earthquake event correlations in Virtual California

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The combination of advanced computer simulation tools and statistical analysis methods has yielded promising improvements in our understanding of the earthquake process. The Virtual California simulation tool can be used to study fault and stress interaction scenarios for realistic California earthquakes. The simulation generates a synthetic earthquake catalog of events with a minimum size of M 5.0 that can be evaluated using statistical analysis methods. Virtual California is a Monte Carlo based simulation code that utilizes realistic fault geometries and a rate and state friction model in order to drive the earthquake process by means of stress interactions between and slip deficits on faults within the model.

We have developed a statistical method to analyze the interaction between Virtual California fault elements and thereby determine whether events on any given fault elements show correlated behavior. Our method examines events on one fault element and then determines whether there is an associated event within a specified time window on a second fault element. Results are then tabulated and then differenced with an expected correlation (calculated by assuming either 1) a uniform distribution of events in time or 2) a random distribution of events in time). We generate a correlation score matrix, which indicates how weakly or strongly correlated each fault element is to every other in the course of the VC simulation. Correlation scores are calculated by taking the integral of the difference between the actual and expected correlations over all time window lengths. The correlation score matrix can focus attention on the most interesting areas for more in-depth analysis of event correlation vs. time.

We have performed this analysis on 59 faults (639 elements) in the model, which includes all the faults save the creeping section of the San Andreas. The analysis spans 40,000 yrs of Virtual California- generated earthquake data. Preliminary statistical analysis of the data indicates promising insights into the interactions between fault elements, including long-range interaction between faults in different geographical regions (i.e. fault elements in northern California interacting with those in southern California).