Identifying repeating earthquakes on the Hayward and Calaveras faults using an automated search code

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In this study we identify repeating earthquakes on creeping faults in northern California. Repeating earthquakes ("repeaters") are collocated earthquakes with almost identical waveforms. Commonly found on creeping faults, repeaters can be used to identify creeping (and by their absence, locked) segments on a fault. Repeaters can be identified through waveform correlation and hypocenter proximity. We expect events in a repeating sequence to have highly similar waveforms, with a high cross-correlation coefficient (e.g. ≥ 0.9). Earthquake relocations, such as double-difference relocation, can confirm that the rupture areas of proposed repeaters overlap.

The Full Automated Repeating Earthquake Search (FARESearch) code automates the labor-intensive task of repeater detection, with the added benefit of accounting for a changing seismic network configuration. FARESearch requires phase arrival information and seismic waveforms as input. Waveforms are first cross-correlated using the Super Efficient Cross-Correlation (SEC-C) code. The next step is to cluster events with high cross-correlation coefficients (CCC) for each station. If different stations share a common event, their clusters are merged to form "multi-station clusters" (MSCs). An average CCC matrix is constructed from the top six CCC values for each event pair. Finally, a hierarchical algorithm (MATLAB's *linkage*) is used to group events into repeating earthquake clusters ("families") based on the average CCC matrix.

Here, we apply FARESearch to identify and classify repeater sequences on California's Hayward and Calaveras faults over a 38 year time period (1984-2022). We identify over 5,000 and 10,000 candidate repeaters on the Hayward and Calaveras faults, respectively. These repeaters were grouped into ~1,000 and ~2,000 families. We find elevated repeater occurrence on both faults following the 1984 M6.2 Morgan Hill earthquake. We are currently working to verify the hypocentral location of the candidate repeaters.

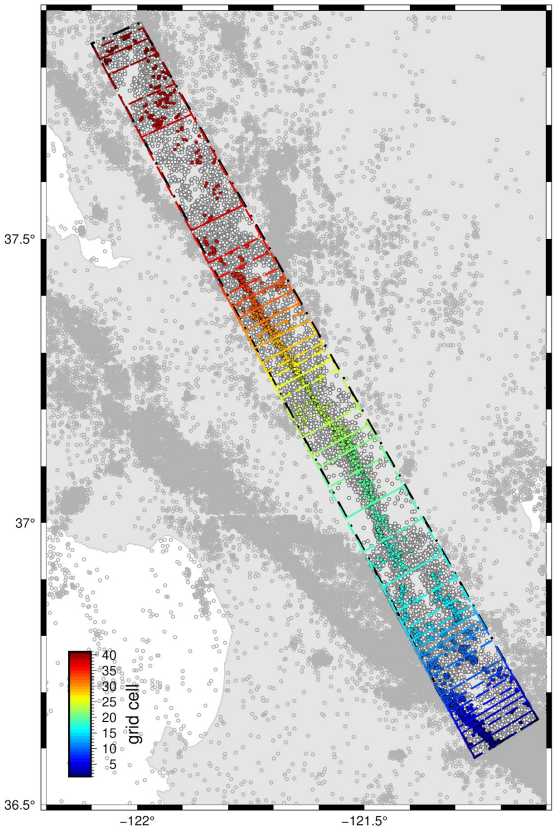

Fig. 1: Candidate repeating earthquakes on the Calaveras Fault.