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Searching for seismic precursors in southern California with phase coherence

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We search for tremor-like seismic precursors to M3-6 earthquakes in southern California. We examine the seconds to minutes before each earthquake with a frequency-domain phase coherence approach. We look for precursory signals that have high phase coherence with the earthquake seismograms—after cross-correlating between two stations. This inter-station correlation eliminates much of the complexity of the source-time functions. It allows the phase coherence technique to identify signals that originate in the same location as the earthquake, even if those signals have extended source-time functions. To demonstrate this approach, we use it to analyze an emergent precursor detected by Tape et. al., 2013, prior to a M3.9 earthquake in central Alaska.

In southern California, we have thus far examined 1000 earthquakes. The method successfully detects many of the previously identified foreshocks, as well as several foreshocks that are not in the catalog. However, it reveals no tremor-like seismic precursors. For most of the earthquakes, error estimates indicate that any precursors still hidden in the data should be smaller than a signal with a duration of 5 seconds and energy equivalent to a M1 earthquake.

We could reduce this upper bound further by averaging the phase coherence over multiple potential precursors. However, that reduced noise floor reveals a bias that results from temporal variations in noise sources. The phase coherence of two seismograms including only noise is usually higher if the seismograms are more closely spaced in time. This causes a bias because the template earthquake seismogram includes some noise. In order to avoid this problem, we also consider an alternative template: the seismogram of an earthquake that occurs nearby but at a different time. However, this analysis is more complicated because the new template earthquake may not be entirely coherent with the earthquake with the potential precursor.