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Differentiating induced and natural seismicity using space-time-magnitude statistics applied to the Coso Geothermal Field

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A remarkable characteristic of earthquakes is their clustering in time and space, displaying their self-similarity. It remains to be tested if natural and induced earthquakes share the same behavior. The Coso Geothermal Field is one of the most seismically active areas in California and features an abundance of natural seismicity due to active tectonics and a large number of induced earthquakes resulting from geothermal power production since 1987. We study natural and induced earthquakes comparatively in the same tectonic setting at the Coso Geothermal Field. Covering the pre- and co-production periods from 1981 to 2013, we analyze inter-event times, spatial dimension, and frequency-size distributions for natural and induced earthquakes. Individually, these distributions are statistically indistinguishable.

Determining the distribution of nearest-neighbor distances in a combined space-time-magnitude metric lets us identify the triggering relationship of an earthquake pair. Nearest-neighbors pairs naturally fall into two populations that categorize it as either clustered (triggered) or background (independent) events.

Compared to natural earthquakes, induced earthquakes feature a larger fraction of background seismicity. Furthermore, they contain a population of independent pairs at large magnitude-rescaled times and small magnitude-rescaled distances. Unlike tectonic processes, stress changes by the field operations occur on much smaller time scale and appear strong enough to drive small-scale faults through several seismic cycles. As a result, we record seismicity close to previous hypocenters after a period on the order of a year.