Earthquake-earthquake triggering in natural swarms and fluid-induced seismicity

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Aftershock cascades and aftershock zones play an important role in forecasting seismic activity in both natural and human-made situations. While their behavior including the spatial aftershock zone scaling has been the focus of many studies in tectonic settings finding, for example, long-range earthquake-earthquake triggering in the near-field, this is not the case in situations where the seismic activity is primarily driven by fluids and the diffusion of excessive pore pressure. Here, we probe three different seismic settings that are believed to be influenced by fluid diffusion. The natural swarm in i) the Long Valley Caldera and the suspected swarms in ii) the Yuha Desert, both located in California, and associated earthquake-earthquake triggering behavior are compared against induced seismicity related to large scale wastewater disposal in iii) Oklahoma and southern Kansas. All settings exhibit a significant amount of event-event triggering highlighting the importance of secondary processes for the overall seismicity. We find an almost identical temporal event-event triggering behavior including the Omori-Utsu relation and the associated productivity relation. In terms of the spatial triggering density, both cases i) and iii) show a rapid decay beyond their rupture length. This proves that narrow spatial “aftershock” zones are not specific to induced seismicity but also occur in natural settings. Typical of most tectonic settings, a relatively long-range behavior is observed in case ii) suggesting that fluid migration might not be the dominant driving mechanism of the seismic activity and/or that the underlying structure of the fault network may control the secondary earthquake-earthquake triggering and its spatial evolution.