The effect of correlated permeability on spatiotemporal
distribution of microseismic events in a conceptual model of fluid-induced seismicity

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Seismic hazard due to fluid invasion in hydraulic fracturing, wastewater disposal, and enhanced geothermal systems has become a concern for industry and nearby residents. One of the challenges associated with this seismic hazard is the estimation of the spatial effects of these industry operations. Based on a large set of real-world fluid-induced seismicity catalogs, it was recently found that the spatial decay of seismic activity with distance from injection wells exhibits two typical behaviors: short-range decay and long-range decay. The distinction between the two groups can be captured by the exponent in the seismicity density but the underlying origin remains unknown. Here, we introduce a novel conceptual model that not only can capture the observed frequency magnitude distribution of fluid-induced seismic events but also explains different spatial decay exponents observed. In particular, previous models of fluid-induced seismicity have assumed that the permeability and porosity field is either uniform or random and spatially uncorrelated. However, power-law scaling in the spatial frequency power spectrum of well-logs, $S(k)\sim 1/k^\beta$, has been observed for many different physical properties of rocks such as sonic velocity, porosity, and log(permeability). Our model takes advantage of this by introducing a spatially correlated field for porosity and permeability. Our analysis shows that increasing $\beta$ can decrease the spatial decay exponent, leading to more seismic activity at larger distances from the injection site. In particular, our model explains the two different types of behavior in the spatial distribution of fluid-induced microseismic events as a consequence of different correlations in permeability.