CELLULAR SEISMOLOGY PREDICTABILITY AS A MEASURE OF ASSOCIATION BETWEEN WASTEWATER INJECTION WELLS AND EARTHQUAKES: A 2018 UPDATE

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Discerning the interrelated effects of space and time on the potential for wastewater well injection to induce earthquakes in Oklahoma is important for accurately mapping seismic hazards. This study explores how distance from wells and time after initiation of injection affect the possibility that injection activity might induce earthquakes under different conditions of operational lifetime length, injection volume, and well depth. The method used here is a modified version of "Cellular Seismology", which we call "Modified Cellular Seismology" (CS, MCS, e.g., Kafka, 2007; Chambless, 2015; Chambless and Kafka, 2017). We use "CS Predictability" (CSP) as an operational definition of the extent to which injection wells are associated with earthquakes. Using this method, analyses were designed to test the hypotheses that earthquakes associated with injection are more likely to occur close to (i.e., conservatively within about 15 km of) wells and within the same year as active injection, depending on various operational conditions. We find evidence that the potential for inducing earthquakes does extend to about 15 km from injection wells, although we also find that earthquakes are most likely to be between 2-3 km from any given well and second most likely to be between 9-10 km for any given well. Regression analyses suggest that CSP decreases by an average of about 5% over a period of 5-7 years for any given well, though there exists a great deal of scatter in this relationship. This change, if it exists at all, is quite slow and also variable across wells of different conditions, ranging from a decrease of 26% to an increase of 8%. Additionally, analyses on wells active for only a single year show that the relationship between CSP and time may not be linear, as CSP tended to stay constant at first and then peak at least a year after injection. This suggests that there may be, on average, at least a year of lag before any given well is likely to induce earthquakes.

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