Identifying and Mitigating Induced Seismicity: The Role of a California Earthquake Center

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The 21st century saw a sharp increase in human-induced earthquakes in the US and around the world (Ellsworth, 2013; Rubinstein & Mahani, 2015). The unexpected spike in earthquakes fundamentally changed the conversation around earthquake hazard. Unlike tectonic events, this hazard is in principle avoidable and therefore invites a new set of scientific and societal questions. What practices promote earthquakes and how can they be avoided? How do the induced earthquakes interact with the tectonic systems and, most importantly, under what circumstances can they trigger an even bigger catastrophe? These questions should be central to any earthquake center's activity both because of their societal impact and because of the intrinsic scientific value of the relatively tractable problem that induced seismicity provides. Induced seismicity is the closest thing to a controlled experiment earthquake science has ever had.

Answering the questions requires robust identification of induced seismicity and an ability to separate it from tectonic earthquakes. Techniques for performing this separation rely on either identifying anomalous aspects of the sequence of earthquakes or correlation with known human industrial activities. In either case, the identification has specific data requirements. To identify anomalous sequences, it is critical to measure the smallest earthquakes possible as they are the most abundant events and their detection greatly improves statistical robustness (Brodsky, 2019). To correlate with known industrial activities, public release of the relevant industrial data is required, which is surprisingly rare.

Induced seismicity has been documented in California from a wide variety of anthropogenic forcings including geothermal production, oil extraction, waste water disposal and groundwater extraction (Allis, 1982; Amos et al., 2014; Brodsky & Lajoie, 2013; Goebel et al., 2016; Segall, 1989). This large portfolio of induced earthquakes can be identified in California in part because of its unique combination of dense seismic instrumentation and a regulatory environment that ensures public access of industrial data such as fluid injection and production volumes. No other similarly sized region in the world has both of these features.

The California dataset is sufficiently rich that it can be used to address the critical issues of induced seismicity. The presence of multiple sources of induced earthquakes allows meaningful comparison of processes that promote, or mitigate, earthquakes. The abundance of tectonic seismicity allows empirical assessment of the tectonic interactions with multiples examples available. Both of these activities are greatly advanced by the recent improvement in processing techniques that increased the identified earthquakes in Southern California by an order of magnitude (Ross et al., 2019). As similar computationally-intensive techniques are applied to the rest of the Californian data, induced seismicity is one of the first targets that can benefit.

A California-wide focus therefore appears to an appropriate approach for investigating induced seismicity. The region is uniquely capable of allowing progress on the most controlled experiments available to our field.

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