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The application of real-time induced seismicity forecasting as a risk management system

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Stress changes due to subsurface fluid injection in oil and gas operations may induce seismic activity. The size and distribution of such events are a function of local geology, in situ stress conditions, and treatment parameters. Not all fluid injection operations exhibit seismicity, but when they do it is vital to monitor the on-going induced seismic activity for an evaluation of the invoked risk mitigation plans. The majority of regulatory traffic light protocols introduced to date are based on staged magnitude thresholds, which increase the need for an estimation of the potential largest magnitude event that may occur during operations. Forecasting the maximum magnitude in real-time is a subject of significant interest to many operators. This allows operators to proactively optimize and adjust their stimulation plans in a way to prevent regulatory shutdowns.
In this study, we discuss different published seismicity forecasting models and evaluate their performance via real-time monitoring playback 30+ diverse datasets acquired during hydraulic fracturing operations to simulate real-time monitoring conditions. We use three prediction models to estimate the maximum magnitude and one model to evaluate the number of events stronger than a given threshold magnitude. Our findings show that, in general, maximum magnitude estimates from different models are nearly identical and in good agreement with the observed seismicity. We show that over time, the forecasts lose their sensitivity to the injection volume. The study also highlights the limitations of this approach when a large event occurs in early stages of a sequence. One of the most important takeaways is the impact that the quality of seismic data has on the system performance. High-quality data recorded by a local array combined with advanced processing techniques designed to generate “research grade” seismic catalogues automatically in near real-time is a key requirement.