Modeling injection-induced seismicity

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Abstract

In the continental interior of the US, the rate of M≥3 earthquakes has increased five-fold in just three years. In 2011, five earthquakes with M≥5.0 occurred in the central and eastern US, including an M 5.7 in Oklahoma that destroyed 14 homes and injured two people. This has been attributed to injecting fluids at high pressure. When the pressurized fluid enters a fault, it reduces the resistance to shear failure, causing faults to slip and leading to earthquakes. Due to induced seismicity, state regulators have even ordered the shut-down of injection operations, in states like Arkansas and Ohio. Thus induced seismicity is a near-term threat with a growing public profile and warrants immediate attention.

Models that capture induced earthquake behavior such as spatiotemporal evolution of the events, changes in permeability due to fault slip and pore-pressure, are needed. In this talk, I will describe a parallel simulation tool PFLOTRAN-QK3 that is aimed to capture the complex flow and fault slip coupling. This tool couples multiphase flow using the finite volume method and the dynamics of fault slip based on spectral boundary integral method.

I will also talk about two approaches for evaluating risk-related to injection – one is based on the info-gap theory and the other combines a Bayesian approach with the info-gap theory. These approaches are aimed at aiding decision-making related to injecting pressurized fluids and in answering questions of interest such as “In a given site, where is it safe to inject?” or “Is it safer to inject at site A vs site B?”