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Modelling Coulomb stress changes due to fluid injection and withdrawal: relations to induced seismicity

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Fluid injection and withdrawal in deep wells is a basic procedure in a series of mining and deep resources exploitation, i.e. oil and gas extraction, geothermal exploitation, EGS permeability enhancement and waste fluid disposal. All these activities have the potential to induce seismicity. EGS activities, in the last years, have been the focus of particular attention for the risk of induced seismicity, as dramatically demonstrated by the 2007 Basilea earthquake (ML=3.4). The crucial significance ascribed to the Basilea induced seismicity and related EGS activities, however, basically depends on the fact that such activities were conducted in the very center of a large city. More in general, all the activities implying fluid injection and withdrawal have the potential to induce seismicity, whose tolerable level of magnitude depends essentially from the closeness to dense urban settlements. The mechanism of induced seismicity, despite several decades of experience, is not known in details, preventing an effective assessment and/or mitigation. In this work, we use a modeling approach to the general problem consisting in the simulation of fluid injection/withdrawal at depth, in a given reservoir model, and computing the resulting changes in the Coulomb stress on fractures of given orientation, pre-loaded by a background tectonic regional stress. A fluid-dynamical approach in porous media based on the THOUGH2 algorithm is used. The changes in Coulomb stress are related to the potential of occurrence of induced seismic swarms, higher values indicating higher probability of events.