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Modeling of poroelastic and hydraulic response of a seasonally loaded water reservoir and implications for Reservoir-Induced Seismicity

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Water level reservoir affects the underlying crust stress state through the poroelastic response to the weight of the water volume stored and by the consequent fluid movement.
The perturbation of crustal stress state has been associated in some cases with small to large seismic events, with maximum magnitudes up to 6.3, as recorded in the largest confirmed case of Reservoir-Induced Seismicity (RIS), that took place at the Konya reservoir in India.
In this work, we present results of forward numerical modeling (finite element) in order to properly understand the triggering processes and to discriminate between the undrained and the drained response. The 3-dimensional model presented here allows inclusion of heterogeneous elastic and hydraulic parameters. Stress and strain are calculated for a transient evolution of the water level, and the calculation allows to compute dCFS (change in Coulomb failure stress) and to identify promotion of failure on different planes at different time of reservoir activities.
The short-term undrained response strongly depends on the elastic properties and can be amplified in a heterogeneous layered elastic media, especially for a media being stiffer with increasing depth. The long-term response depends on the hydraulic properties and it can play a role even if the reservoir is hydraulically isolated from the underlying units. The calculated perturbation of stresses and pressure in space and time can be provided as an input to a statistical model to investigate the evolution of seismicity and the earthquake triggering potential for nearby fault system.
As example application we closely model the Pertusillo water impoundment, located in Southern Italy, where about 2000 events with magnitude between -0.2 and 2.7 were located nearby the artificial lake in between 2005 and 2006 by an experiment-specific temporary network.