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Numerical investigation of a seasonally loaded water reservoir: poroelastic and hydraulic response to loading and induced seismicty

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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 seismic events, with maximum magnitudes ranging from -1.0 and below up to magnitude 6.3, as recorded in the largest confirmed case of reservoir induced seismicity (RIS), that took place at the Konya reservoir in India.
During a 13 months observation campaign at the Pertusillo water reservoir, located in Southern Italy, 2000 events have been recorded, with magnitude ranging from -0.2 up to 2.7.
Statistical analysis and spatio-temporal seismicity patterns allows to identify two distinct RIS behaviors, as they have been reported in other RIS cases: seismicity associated with a short-term load effect and due to a longer term diffusion and movement of fluids.
To discriminate between the undrained and the drained response and to correctly pinpoint the exact triggering mechanism, a forward numerical model (finite element) is presented here. The 3-dimensional model presented here allows including heterogeneous elastic and hydraulic parameters. The numerical solution for a homogeneous elastic model has been verified against the analytical solution.
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 influence on the nearby fault system.