ESC2016-338-1, 2016
35th General Assembly of the European Seismological Commission

How well can we explain reservoir-induced seismicity by mean of simplified semi-analytical models? Use of a combined poroelastic and earthquake nucleation approach applied to the Val d'Agri (Italy)

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The artificial lake of Pertusillo in Val d'Agri (Italy) is one of the known water reservoirs showing protracted seismic activity for several years after the initial filling in 1963. More than 800 small-magnitude events (ML < 3; Mc=1.1) were located between 2001 and 2013 by a monitoring network of a local industry operator supplemented by permanent and temporary stations of the Istituto Nazionale di Geofisica e Vulcanologia. Hypocenters concentrate at a shallow depth (< 5 km) to the south of the lake. During the same period the reservoir water level fluctuated in average of tens of meters between summer and winter periods. The observed seismicity rate positively correlates with these seasonal oscillations.
Reservoir-induced seismicity might occur as the response to the crustal stress caused by the poroelastic response to the weight of the water volume as well as pore-pressure redistribution.
We model stress and time-dependent pore-pressure due to water level variations associated with the Pertusillo lake. The solutions are given for a homogeneous, porous-elastic half-space and considering the decoupled approximation when solving the governing partial differential equations (i.e. elastic stresses influence the pore pressure but not vice versa). Calculated effective stresses are used to compute seismicity rate changes through the rate-and-state nucleation model.
Results show that the proposed model reproduces consistently the time behavior of seismicity and its positive correlation to the water level fluctuations; it allows also for understanding the relative importance of the driving forces. However, our approach is a generalization of the problem of reservoir-induced earthquakes because we are not considering information of the crustal structure in the study area, such as for example the presence of different layers with different physical characteristics. Discrepancies between forecasted and observed seismicity may suggest that some parameters of the modelling need a better fit and/or that the simplicity of some assumptions needs to be revised, allowing for a better understanding of the phenomena at play.