New insights into the Pertusillo Lake reservoir induced seismicity (Italy) from a high-resolution matched-filter earthquake catalogue

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The southern Apennines range hosts a well documented case of protracted Reservoir Induced Seismicity (RIS) associated to the Pertusillo artificial lake. Since the deployment of a local monitoring network in 2001, M3+ swarms were recorded to the south of this medium-sized water reservoir. Interpretation in terms of RIS relies on the positive correlation found between seasonal water level changes and earthquake rate that increases during the winter-spring refill. We present a new high-resolution catalogue of RIS obtained by running a matched-filter (MF) detection technique on data recorded during a dense passive survey between 2005-2006. We aim at producing a very-high quality catalogue in terms of completeness magnitude (Mc) and hypocenter location accuracy to precisely track the spatio-temporal distribution of seismicity, pinpoint the activated faults, investigate the rupture mechanisms and the role played by crustal fluids in triggering RIS. All these issues are critical to improve understanding of the physical mechanism behind the RIS.

Our initial catalogue includes 406 handpicked templates recorded by 3C 24-stations temporary network run by INGV. Local magnitudes range between 0.06 and 2.63, with a MC of 0.4. Templates are correlated to the 13-month-long data streams by the MF algorithm. A matched event is declared when the average value of cross-correlation function (CC) computed over all stations exceeds 0.65. The procedure furnishes 10056 matched events with associated P- and S-phase automatic picks, weighted according to the uncertainties of template event picks and the CC values of each trace. Matched events are preliminary located in a 1-D model using the NonLinLoc software and then selected based on quality criteria. The final catalog has MC=0.1 and includes 6012 high-quality events with ML > -0.9 that are then relocated through the high-precision double-difference relative technique. We recognize four main clusters confined at 2-6 km depth within a fractured, liquid-bearing carbonate antiform characterized by high-Vp (>6.0 km/s) and very-high Vp/Vs ratio (>2.0) that indicates high-pressure pore fluids. Hypocentral alignments delineate NW-trending high-angle faults dipping to the NE or SW that measure up to 2 km along strike and dip. Prevailing extensional focal mechanisms are coherent with the fault geometry and local stress field. These results suggest re-activation of inherited thrust-faults with associated back-thrusts optimally oriented in the present extensional stress field.
The spatiotemporal seismicity distribution indicates a positive correlation between the seasonal oscillation of the lake level and the progressive activation of the 4 clusters of seismicity. Distant clusters from the PWR are delayed with respect to the closer ones, suggesting that seismicity migrates away from the reservoir following a pore fluid pressure triggering process. The b-value is high and it also varies with time between 1.2 and 1.8 with a trend anti-correlated to the lake level. Therefore, the proportion of large earthquakes to small ones increases during the re-fill stage characterized by intense earthquake production and vice-versa. The two southern clusters, more distant from the lake, with events that delineate clear fault-zones, share the lower b-values (1.4).