Unveiling the roots of seismogenic faults in central southern Apennines

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Transient aseismic processes, driven by fluid movement, fault creep, and slow slip events, can further influence earthquake distribution, primarily due to tectonic loading. Analyzing seismicity clusters induced by these transient processes is highly valuable for understanding fluid circulation dynamics (Danré et al., 2021) and unraveling the geological complexities of tectonic structures that influence the spatiotemporal evolution of seismicity within complex fault systems (Ross et al., 2020).

To perform such analysis, it is essential to utilize a more comprehensive and accurate seismic catalog with higher spatiotemporal resolution than standard catalogs.

From this perspective, we analyzed seismic activity from 1981 to 2018 in a high-seismic-risk area of the central-southern Apennines in Italy, characterized by a complex fault network. This region, which has experienced large earthquakes in the past, has remained relatively quiet in recent years.

To explore the spatial relationships between background seismicity, clustered seismicity, and Quaternary geological structures, we examined seismic activity over 43 years (1981–2024) across various crustal depths. The dataset was divided into three periods with consistent magnitude completeness (1980–2005, 2005–2011, and 2012–2024). For the 2012–2024 period, during which the seismic network configuration was stable, we applied a filter-matching technique to refine the catalog. This analysis identified 72 spatiotemporal clusters and established a baseline seismicity rate. Seismic sequences and swarm activities were distinguished, and their spatial distribution was analyzed concerning active faults, Vp/Vs ratios, and CO2 anomalies.

A noteworthy finding is the absence of significant seismicity at depths < 10 km, which could suggest strong coupling of the more superficial faults. These faults remain locked, preventing fluid ascent and instead triggering seismic clusters at greater depths.

These findings have helped constrain certain segments of active seismogenic structures at depth, enhancing our understanding of the area's seismogenic potential and seismic hazard, which remains high due to the occurrence of strong seismic sequences in the past.