3D model reveals thermal decomposition as a primary driver of Apennines seismicity
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Earthquakes in the Central Apennines generate extensive and robust aftershock sequences, with high-pressure CO₂ often implicated as an important contributor to seismogenesis. Diffusion of mantle-derived CO₂ trapped in reservoirs at depth is assumed to drive these sequences, yet evidence of diffusion fronts remains elusive. The thermal decomposition of CO₂ imposes numerous additional and isolated sources providing substantial quantities of internally derived high-pressure fluids driving the aftershock sequences. In this work, we analyze a 3-dimensional numerical model of non-linear diffusion with a source term that mimics the generation of additional fluid by thermal decomposition. Model results show strong correlations between the spatial distribution of 50,000 observed hypocenters and calculated fluid pressure fields from the 2009 L’Aquila (Mw 6.3) and the 2016 Amatrice-Visso-Norcia (Mw 6.5) earthquakes. We also show strong correlations with observed temporal aftershock rates, and identify the onset of thermal decomposition correlating with Mw > 4, suggesting a minimum magnitude for generating significant aftershock sequences. The implications of thermal decomposition in seismogenesis are far-reaching because our results suggest this mechanism applies to all carbonate systems, and also in systems containing extensive hydrous minerals, such as within subduction zones.