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...What We Know, What We Don't Know, and What We Need to Learn

Off-fault Triggered Swarms after L'Aquila 2009 and Central Italy 2016-2017 seismic sequences

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Abstract
Earthquake swarms, a series of seismic events occurring in a local area lasting from days to years, have recently been the subject of intense study. The primary causes of these swarms are believed to be transient aseismic fault slip and slow or sudden pulses in hydraulic pore pressure. A combination of these features is frequently suggested to explain complex seismicity patterns. This study delves into the intricacies of off-fault swarms, likely triggered by large seismic sequences. We focus on two significant seismic events in the Central Apennines: the L'Aquila event in 2009 and the Central Italy sequence in 2016-2017. These powerful seismic sequences activated a high level of off-fault lower magnitude seismicity in an area of approximately 400 km² from 2009 to the end of 2017. This region, close to Campotosto, experienced several earthquakes with magnitudes greater than 5 and a persistent and long-lasting high level of lower magnitude seismicity.
High-resolution earthquake catalogs provide a rich dataset for analysis and offer unique insights into the mechanisms driving earthquake swarms. From these catalogs, clusters of events were selected for further study and classified based on migration velocity, duration, and total moment released. The swarms that followed the two primary sequences did not overlap in space. The seismicity activated after L'Aquila 2009 is prevalent in the western sector, while after Central Italy 2016-2017, many swarms are observed in the easternmost part. The analysis revealed variable durations ranging from a few days to months and migration velocities from kilometers to meters per day. These findings suggest an interplay between fluids, aseismic, and seismic slip affecting minor faults. Interestingly, swarms are generally located at depths of less than 10 km and have multiple events with M<3.5. In some cases, these swarms anticipated M>5 foreshock-mainshock sequences. We compare observations with well-known natural and anthropogenic swarms, providing new case studies and insights into their mechanisms and evolutionary styles.

Preferred section:
1) *Analysis of seismicity from waveform to catalogs and beyond*