EGU2020-11655
https://doi.org/10.5194/egusphere-egu2020-11655
EGU General Assembly 2020


# Direct fault states assessment from wavefield properties: application to the 2009 L'Aquila earthquake

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Monitoring and investigating the physical states of active faults is essential to understand how earthquakes begin and the physical processes involved. Traditionally, fault-state investigation strategies use seismic catalogs whose completeness and accuracy may be limited. We propose to take benefit of the information encoded in the continuous seismograms in order to fully extract information about the fault physics. We calculate the covariance matrix spectrum of continuous seismograms at an array of stations and extract features (e.g. entropy, spectral width, variance and coherency) from the covariance matrix eigenvalue spectrum. Those features are related to seismic source characteristics (e.g. source localization, spectral content, duration...) in the time scale of analysis, and can be used to reveal different physical states of faults. The dominant frequency band of the seismic wavefield changes at different stages of fault activities. Therefore, we perform clustering to characterize the physical states of fault based on the extracted frequency-dependent features. We apply this approach to investigate the 2009 L'Aquila earthquake. At preparation phase of the L'Aquila earthquake, foreshocks are localized around the main active fault. In contrast, the aftershocks disperse in a more broaden area where the faults have been activated by the mainshock. The extracted features and corresponding clustering results are able to capture and distinguish those patterns of earthquake distribution. In addition, the locations of the seismic sources are encoded in the covariance matrix eigenvectors. Through clustering and migration of eigenvectors, we are able to reveal the spatial and temporal variation of the different seismic sources. The method is here applied to study recent earthquakes in Italy as the L'Aquila 2009, Emilia 2012 and Norcia 2016.