Geophysical Research Abstracts
Vol. 21, EGU2019-3012, 2019
EGU General Assembly 2019

Source complexity of an injection induced event: the 2016 Mw 5.1 Fairview, Oklahoma earthquake

Jose Angel Lopez-Comino (1,2) and Simone Cesca (2)

(1) KAUST, King Abdullah University of Science and Technology, Computational Earthquake Seismology, Thuwal, Saudi Arabia (jose.lopezcomino@kaust.edu.sa), (2) GFZ German Research Centre for Geosciences, Potsdam, Germany

Complex rupture processes for moderate-to-small earthquakes may reveal a dominant direction of the rupture propagation and the presence and geometry of one or more main slip patches. Finding and characterizing such properties is crucial to understand the nucleation and growth of induced earthquakes. We analyze one of the largest earthquakes linked to wastewater injection, the 2016 Mw 5.1 Fairview, Oklahoma earthquake using empirical Green's function (EGF) techniques and decipher its source complexity. The earthquake source for the mainshock can be isolated from seismograms through a deconvolution procedure between the mainshock and EGF waveforms, thus obtaining the Apparent Source Time Functions (ASTFs). We use 16 foreshocks and aftershocks as EGFs (Mw between 4.4 and 3.4), having depths (±3 km) and faulting geometries (±13° for the strike of the preferred plane) similar to the ones found for the main event. ASTFs robustly obtained from EGFs analysis help to infer rupture directivity and complexity during the rupture growth. To obtain the ASTF, frequency domain deconvolution is performed through spectral division using S wave windows. Stable ASTFs are observed for different EGFs revealing the source complexity of the target earthquake. Two source pulses slightly separated are easily identified at NE azimuths, while stations located toward SW record single pulses of overall shorter durations. Resulting apparent durations range from 1.05 to 2.45 s. These durations exceed empirical values and durations resolved for Mw 5.1 earthquakes, which are typically about 1 s. This fact suggests that the ASTF complexity could be due to the presence of two subevents separated in space and time. A new approach based on relative hypocenter-centroid location is developed in order to infer the relative location for the two subevents identified from the ASTF analysis. The first subevent has a magnitude of Mw 5.0 showing the main rupture propagation toward NE, in direction of the higher pore pressure perturbation due to wastewater injection. The second subevent appears as an early aftershock with lower magnitude Mw 4.7. It is located SW of the mainshock in a region of increased Coulomb stress, where most aftershocks were relocated. These results have important implications to discuss the role of anthropogenic stress perturbation in controlling the direction and extent of the earthquake rupture growth.