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Constraining potential triggering stress amplitudes on receiver faults using the Large-n Seismic Survey in Oklahoma

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Recent increases in the rate of earthquake occurrence in Oklahoma have been linked to disposal of large volumes of saltwater, a byproduct of oil and gas production, into deep wells. Some work has shown that areas with active fluid injection and induced seismicity, such as Oklahoma, may also be susceptible to dynamic triggering during the passage of seismic waves from large, remote earthquakes. In Spring 2016, the 1833-station LArge-n Seismic Survey in Oklahoma (LASSO) array was deployed for ~30 days to examine an area containing both active wastewater injection and seismicity in Grant County, located in northern Oklahoma. Here we use the LASSO array to look for dynamic triggering caused by teleseismic earthquakes with magnitudes Mw 6-8 that produced Peak-Ground-Velocities (PGVs) exceeding 10 μm/s at the LASSO array, consistent with PGV values seen to have triggered seismicity at other locations. We focus on examining seismicity that occurred around the time of a shallow Mw 7.8 event in Ecuador on 04/16/2016, which generated the largest PGV at LASSO (250 μm/s).

To establish if earthquake rates change during or following the passage of the teleseismic surface waves in a systematic way, we develop a catalog of earthquakes around the time of each teleseismic event. We first create a preliminary catalogue using a Short-Term Average/Long-Term Average (STA/LTA) detection algorithm in a window spanning +/- 24 hours around the P-wave arrival of each teleseismic earthquake, requiring detection at a minimum of 110 LASSO stations to declare an event. We then enhance the STA/LTA catalogue with manual detections in the 3 hours surrounding the P-phase arrival of the Ecuador earthquake. Results from the application of various statistical tests (e.g., Z-test, beta-test) suggest an increase in the seismicity rate a few hours after the surface wave arrivals. Specifically, while we observe no significant increase in events within the surface wave train, the results suggest delayed triggering may occur 4 hours after the passage of teleseismic surface waves. For example, in the 24 hours prior to the mainshock P-wave arrival, the number of events in 1-hour time bins ranges from 0-5, while starting four hours after the P-phase arrival, the seismicity rate increase to 10-25 events per hour, persisting at the sustained elevated rate for approximately 5 hours. Resolving the transient dynamic stresses measured from observed particle velocities imposed by the Love and Rayleigh waves from the Ecuador mainshock onto the fault planes of hypothetical receiver faults inferred to have optimal orientations (left-lateral and reverse faults) suggests imposed stress changes from the mainshock of approximately 800 Pa.