Toward the accurate stress drop estimation: improve corner frequency estimation with residual evaluation

*Nana Yoshimitsu[1], William Ellsworth[1], Gregory Beroza[1]

1. Stanford University

In the last several years, disposal of wastewater increases the seismic activity in central United States, especially in Oklahoma. The similarity or difference of the source characteristics between induced and natural earthquakes would contribute to hazard assessment. While stress drop is one of the most important source parameter, its difficulty of accurate estimation is well known. The common process in the stress drop estimation need to obtain the corner frequency by comparing the spectral ratio of the co-located event pair and the theoretical model. The accuracy of the corner frequency strongly affects the stress drop estimation since stress drop has proportional relationship to the cube of the corner frequency. In this study, we introduce the residual evaluation to the corner frequency estimation process and select good quality of records toward the better stress drop estimation of potentially induced earthquakes in Oklahoma.

We chose Mw < 4.0 events, and formed co-located (< 2 km) event clusters using the events occurred from 2016 March 1st to August 31 ($1.6 < M_L < 3.5$). The spectral ratios between the smaller events and the larger event in each cluster were calculated to remove path effects. Spectral ratios of the all components of 4 USGS and OGS stations which sampling frequency were 100 Hz were stacked. We analyzed 5.12 seconds from 2.5 times after the *S* wave arrival time after applied the band-pass filter of 0.1 to 40 Hz. Corner frequencies and moment ratio of each event pair were searched by the least square fitting with Brune model.
To improve the quality of the result, we evaluate the residual of the fitted curve to check the existence trade-off between two corner frequencies. We performed grid search between 1 to 30 Hz for a larger event and 1 to 60 Hz for a smaller event, and obtain the residuals (data minus model) on each data point at each trial. We displayed the residual map as a monochrome image, and calculate the distance between the smallest residual point and the centroid of the low residual region. We defined the event pairs which met the threshold distance of eight as a good quality data, and utilized them for the stress drop calculation. Comparing to the results without the selection, stress drops of selected data in the same cluster showed small variation in three clusters; thus, the quality control with residual would be effective. Estimated stress drops were 1-10 MPa for the smaller events and 6-63 MPa for the larger events. This result is consistent with the stress drop estimated in other regions of central United States as well as natural earthquakes.

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