Estimates of source parameters by Multi-Window Spectral Ratio (MWSR) method

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Source parameters of microearthquakes are important to understand the physics of earthquakes, investigate seismic source scaling relationships, and infer the local stress level in the crust. Most previous studies assumed a frequency independent Q operator to model crustal attenuation, although the assumption has not been fully confirmed for high frequencies. Recent work by Ide et al. [2003] indicates that the assumption of a frequency independent Q introduce an artificial size dependence in source parameter measurements even in the relatively clean recording environment of a deep borehole. One approach that avoids this assumption is the spectral ratio method, which removes the propagation effects as common mode noise for co-located earthquakes. However, the spectral ratio procedure as it is usually implemented is subject to inexact cancellation of path effects due to small location differences between the events. If their ruptures do not overlap, they will almost always be outside of a common Fresnel zone at the corner frequency of the smaller event, leading to instability in the estimations of source parameters.

In this study, we propose a method to determine a stable spectral ratio by stacking the ratios calculated from the multi-window taken along the record following the direct waves. We name the method as Multi-Window Spectral Ratio method (MWSR method). In order to confirm the applicability of the approach, we analyzed seismograms of microearthquakes occurring at Parkfield, CA, recorded by the SAFOD Pilot Hole seismic array. We succeeded in obtaining stable spectral ratios by the MWSR method. These spectral ratios were modeled to determine seismic moments and corner frequencies using the multiple empirical Green's function approach [Hough, 1997; Ide et al., 2003]. Static stress drops and apparent stresses of microearthquakes at Parkfield display moment-independent scaling in agreement with scaling laws reported for moderate and large earthquakes. It is likely that the dynamics of microearthquakes at Parkfield is similar to that of natural tectonic earthquakes in a macroscopic viewpoint.