Amplitude evaluation of stacked waveforms of LFEs at Parkfield: Toward estimating focal mechanisms

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Tectonic low frequency earthquakes (LFEs) are observable using short-period seismometers, and have been found at plate boundaries worldwide. The focal mechanisms of LFEs have been determined as low-angle thrust-type at the subduction zones, such as southwest Japan, Mexico, and Cascadia [Ide et al., 2007; Royer and Bostock 2014; Frank et al.,2013]. However, the focal mechanisms of LFEs at transform faults have not been studied yet. We investigate the focal mechanisms of LFEs at the Parkfield section of the San Andreas fault, based on the LFE catalog of Shelly (2017).

LFEs are generally observable in 2–8 Hz, with a poor S/N ratio. Therefore, the improvement of signals is essential for the determination of focal mechanism. Given that the focal mechanisms are always the same, we can stack waveforms of all events to obtain better waveforms with clear P wave polarity and other phases. P wave polarities and amplitude ratios of P to S wave [Hardebeck and Shearer, 2002] are useful to estimate focal mechanisms. In addition, the amplitude information of P and S wave enables waveform inversion to better constrain the focal mechanisms and the physical size of LFEs. Therefore, we try to obtain stacked waveforms with amplitude information.

We use seismic networks of HRSN, NCSN, and BDSN near Parkfield, most of which are located along the San Andreas fault. The quality of seismograms in these networks is not homogeneous in space and time [e.g., Shelly, 2017], with some stations eliminated, changed, and installed during the study period. The absolute amplitude of each component is usually recovered using the amplitude of original waveforms or the dot product of the original waveforms and the normalized stacked waveforms [e.g., Ide et al., 2007]. However, available stations at Parkfiled are largely different among events and the ordinary methods do not work. Therefore, we obtain stacked waveform with amplitude information as follows.

First we prepare normalized stacked waveforms for each station, by simply stacking all available waveforms normalized by its maximum amplitude. The dot product of the normalized stacked waveform and an event waveform is regarded as “the amplitude of each event at each station”, which is used as data to estimate “the magnitude of each event” and “the relative amplitude of each station” in a linear inverse problem. This information is used to resize the normalized stacked waveforms.

The relative amplitude is a key information to investigate the focal mechanisms. We present stacked waveforms with recovered absolute amplitude for some families, and compare with synthetic waveforms. The magnitude of events is also useful to find characteristic behavior of seismicity depending on event size.

Keywords: Low frequency earthquake (LFE), Slow earthquake, Stacked waveform, Amplitude evaluation, Parkfield, San Andreas fault