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Multiple Seismic Array Observations of Non-volcanic Deep Tremor in Western Shikoku (Part2)

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Deep non-volcanic tremors become very active during episodic slow-slip events in western Japan and Cascadia. Detailed tremor activity are important to understand the mechanism of tremor and the relationship between tremor and SSEs. However it is difficult to determine the location of tremors with high accuracy because tremors show faint signals and make the identification of P/S-wave arrivals difficult. The Envelope Correlation method (Obara, 2002) and the Hybrid method (Maeda and Obara, 2009), which are focusing on energy temporal change and excluding phase information, were developed. Seismic array analysis (e.g. Ueno et al., 2010, Ghosh et al., 2010), which is focusing on phase information, is also useful to evaluate tremor activity, especially to estimate the arrival direction of seismic energy, as it can distinguish multiple tremor sources occurring simultaneously. Here, we have conducted seismic array observation and analyzed seismic data during tremor activity by applying the MUSIC method to trace tremor location and its migration in western Shikoku.

We have installed five seismic arrays in western Shikoku since January 2011. One of the arrays contains 30 stations with 3-component seismometers with a natural frequency of 2 Hz (Type-L array). The array aperture size is 2 km and the mean interval between stations is approximately 200 m. Each of the other arrays (Type-S array) contains 9 seismic stations with the same type of seismometers of the Type-L array, and is deployed surrounding the Type-L array. The small array aperture size is 800 m and its mean station interval is approximately 150 m. All array stations have recorded continuous waveform data at a sampling of 200Hz.

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In May 2011, an episodic tremor and a short-term slip event occurred for the first time during the observation period. We could retrieve the array seismic data during the whole tremor episode. The analysis of data from the type-L array confirms concentrated seismic energy arriving from the anticipated direction of tremor which is located by the Hybrid (Maeda and Obara, 2009; Obara et al., 2010). Most of the arrays could detect the arrival direction; the Type-L array could also estimate the slowness with an adequate accuracy. We converted from slowness to location (latitude and longitude) in MUSIC spectrum by assuming tremor occurs on the plate boundary and compared with results of the Hybrid method. The MUSIC spectrum peak approximately is consistent with the epicenter of the Hybrid method. But spectrum peak concentration that the Hybrid method cannot detect is also observed. This is an advantage of the seismic array analysis that also uses phase information.

Keywords: Low frequency tremor, Multiple seismic array