

Hypocenter determination of deep low frequency tremors beneath the Kii Peninsula by backprojection of seismic array data

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A seismic array analysis enables us to detect weak signals if they are coherent. In Cascadia, a high accuracy hypocenter determination of tremors has been carried out by using dense seismic arrays (e.g., Ghosh et al., 2012). In Southwest Japan, previous studies (e.g., Ueno et al., 2010) applied the **M**ultiple **S**ignal **C**lassification (MUSIC) method (Schmidt, 1986) to data of surface seismic arrays at Western Shikoku and carried out the hypocenter determination. However, a quantitative threshold for event detection was not considered. Sagae et al. (2018 SSJ) introduced an event detection threshold based on the coherence of waveforms among stations, and improved tremor detection by using a surface seismic array installed by AIST at the Kii Peninsula. We applied the MUSIC method to this data in times when tremor events were detected and estimated slownesses and arrival azimuths of tremor signals. Their temporal variations suggested tremor migration. However, we did not carry out hypocenter determination. In this study, we determine hypocenters of tremors by backprojection using the estimated slownesses and arrival azimuths. The surface seismic array installed by AIST at the Kii Peninsula was composed of 39 three component velocity sensors with a natural frequency of 2.0 Hz and a sampling frequency of 200 Hz. This array had an aperture of about 1.5 km and the sensors were arranged in a cross shape with interval spacings of 50~100 m. We analyze data for 1 year (between July 7, 2013 and July 7, 2014), because the number of sensors is stable in this period.

We focus on a frequency of 3 Hz, which is within the tremor's dominant frequency band of 2-10 Hz. Data processing is described as follows. (1) We calculate averaged coherence of waveforms for all station's pairs. (2) We detect tremor events by setting a detection threshold based on the averaged coherence. (3) We estimate slownesses and arrival azimuths by applying the MUSIC method to the data when tremors are detected. (4) We project them back to the plate boundary (Hirose et al., 2008) and determine source locations by using S wave velocity model JMA2001 (Ueno et al., 2002).

We detected 5 periods of high tremor activities during the 1 year period. We compared the hypocenter distributions determined by our method and those of AIST tremor catalogue which were determined from an envelope cross correlation method. Temporal variation of tremors in this study were almost consistent with the AIST catalogue. We were also able to detect about 2.5 times as many events as the AIST catalogue. It is easier to identify temporal variation of tremors in more detail because our study improved temporal resolution up to 10 sec.

We projected temporal variations of tremor distributions into along-strike and along-dip directions. The results show tremors tend to migrate along the strike in time scales of several days with migration velocities of 6.0~9.3 km/day. Along-dip migrations of tremors with a short timescale of several hours are also detected. When we focused on the initial part of tremor activities, tremors tend to start in deeper parts and gradually migrate to shallow parts. These migration velocities were estimated to be about 1.0 km/hr (24 km/day) in the up-dip direction.

In this study, we were able to improve tremor detection by setting the event detection threshold based on the coherence of seismograms for stations pairs in a surface seismic array. Thanks to this, we were able to locate 2.5 times more tremors than the conventional method. We made it easier to keep track of tremor migrations by improving the temporal resolution of hypocenter determination to 10 sec.

We used the plate boundary model (Hirose et al., 2008). We downloaded the AIST catalogue from Slow

Earthquake Database (Kano et al.,2018).

Keywords: Deep low frequency tremor, Seismic array analysis, Backprojection, MUSIC method, Kii Peninsula, Hypocenter determination