Multiple seismic array analysis of low frequency tremors in western Shikoku, Japan

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Introduction

In southwest Japan, low frequency tremors (LFTs) have been detected at deeper part of the seismogenic zone on the subducting Philippine Sea plate interface by high sensitivity seismograph network Hi-net operated by NIED. The tremor source area migrates during each episode along the strike of the subducting plate with a migration velocity of roughly 10 km/day, which was referred from source locations obtained by the envelope correlation method. Obara and Hirose (2006) has shown that the tremor episode is accompanied by a short-term slow slip event. In order to investigate characteristics of the wave field propagation from the tremors and migration of the tremor sources in detailed scale, we carried out a temporary seismic observation in western Shikoku, where the active tremor associated with the short-term slow slip event occurs with a recurrence interval of approximately six months.

Observation

In this observation, we deployed three seismic arrays above the belt-like LFT area with a spacing of about 20 km among arrays, during the period from February to May in 2007 because we anticipated the coming LFT episode to occur on March or April, 2007. Each array was composed of 32-channel receivers which mainly consist of vertical-component with natural frequency of 2 Hz. The average spacing between receivers is approximately 30 m. Waveform data were recorded continuously with a sampling interval of 0.01 s.

Method

The active tremor episode with the short-term slow slip event was recorded by Hi-net stations from 13 to 15 on March 2007 in western Shikoku as anticipated. Since the arrays also recorded relatively high coherent signals, tremor, we performed frequency-wavenumber power spectrum analysis for each array recordings by the MUltiple SIgnal Classification (MUSIC) method to determine the arrival direction and apparent slowness of the signals. In order to project the source areas of signals recorded by the three arrays into map, we made angular spectrum with a constant slowness including a peak vale of the power spectrum for each array. Assuming the angular spectrum as a probability of arrival direction from the tremor source, we obtained a probability of area of one tremor source by multiplying the spectrum for each array. Due to verification of the source migration of tremors, we located the sources by grid search method for backazimuth and apparent slowness estimated at each array at each time window.

Result

At two seismic arrays, the apparent slowness was continuously low during the tremor episode. At the other array, the slowness was relatively high, and the arrival direction of the waves slightly changed with increasing time. Since the probabilities of areas were obtained in each time window by multiplying angular spectrum of each array, the daily and total probabilities were obtained by stacking them. Very low frequency earthquakes having dominant period of 20-50 s, seem to occur at the edge of the daily high probability area. Relatively high probability distribution in active tremor period was consistent with a fault plane of short-term slow slip event.

We successfully determined the precise source locations of tremors by grid search method, and detected the migration of the sources clearly with a velocity approximately 10 km/day. The distribution of tremors concentrated around the two arrays located in north-west Shikoku, and it gradually spread at the end of the tremor episode. This expanded distribution is consistent with the probability of the tremor source. We recognized that there were many arrival directions within short time window. This might indicate that the tremors occur simultaneously at different places because of complex slipping on the plate interface.