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Statistical hypothesis test for the detection of very low-frequency earthquakes in southwest Japan

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Very low-frequency earthquakes (VLF) have been observed with deep non-volcanic tremors (NVT) in southwest Japan. In previous studies, it has been shown that the fault strike and dip angles of VLF events reflect the upper boundary geometry of the subducting Philippine Sea plate and the slip angles are consistent with the motion of the subducting plate (Ito et al., 2007, 2009; Takeo et al., 2010). These studies, however, simply applied methods of grid moment-tensor analysis for ordinary earthquakes to the VLF detection, so that a considerable number of small VLF events might be missed. We thus developed a new method specialized to the detection of VLF events.

In our method, VLF events are assumed to occur on the Philippine Sea Plate interface with source mechanisms predetermined from the subducting plate surface geometry and the plate motion. We obtained possible VLF source mechanisms from the plate interface model (Hirose et al., 2008) and the relative plate motion (Miyazaki and Heki, 2001) to calculate VLF synthetic seismograms. Then we detected VLF events by comparing observed seismograms with synthetics using cross correlation and variance reduction (VR). We indicated the availability of this method in the last SSJ fall meeting. However, we did not discuss on validity of the results, which may be artifacts by random noise fitting.

In this study we apply a numerical statistical hypothesis test based on the bootstrap method to check validity of the results. The null hypothesis is ”the obtained VR value is a result from random noise fitting” and the test statistic is VR. In the bootstrap hypothesis test, p value is obtained by

$p = \#\{ t* > t_{obs} \}/N$

where $t*$ is a VR value from an analysis of bootstrap-replication waveforms based on the null hypothesis, t_{obs} is an observed VR value, N is the number of simulations, and ’#’ means the number of simulated values that stratify the condition in the braces. If the p value is less than a given significance level, we reject the null hypothesis. The bootstrap-replication waveforms are calculated from the observed seismograms using a method of frequency domain resampling. In the presentation we will show the result of real data analysis.

Keywords: very low-frequency earthquake, slow earthquake, statistical hypothesis test, bootstrap method