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Sophistication of microtremor methods to survey shallow structures, Part2 : Application of automatic reading algorithms

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We have been seeking an efficient way to maximize the potential of the microtremor methods for shallow surveys. It is considered that a practical approach has been gained in the observation by the development of portable seismometers (Senna, 2006, 2012) and by the finding of the full usability of the data obtainable by a miniature array (radius less than 1m), optionally together with a small irregular-shaped array (radius less than 10 m) consisting of three seismometers (Cho et al., 2013a).

As an efficient way to infer an S-wave velocity structure, we consider that a classical, simple profiling method (SPM), where a dispersion curve is directly converted into an S-wave velocity structure (e.g., Heukelom and Foster, 1960), is a good scheme from a view point of simplicity, thus, the balance between the efforts and the information to be extracted. It is true, however, that we frequently like to increase to resolution. Facing this dilemma, we suggested a simple tool 'H/V depth conversion' (Cho et al., 2013). We found that the use of an H/V depth conversion followed by a simplified inversion method (SIM) of Pelekis and Athanasopoulos (2011) can in fact increase the resolutions (e.g., Senna et al., 2013; Yoshida et al., 2013).

The current challenge is to further promote the efficiency in the data processing procedure. A visual reading of analysis results, which we take at the current time, is time consuming to deal with a vast mount of microtremor data, now obtainable by a streamlined observational procedure. The reproducibility and biases depending on analyst constitute other kinds of problem of visual reading.

To address this problem, Cho et al. (2014, thismeeting) invented automatic-reading algorithms. In this study we test their algorithm by applying it to observed data to compare the results with those obtained with visual readings. Our method of observation and analysis is described in the following.

1. Observation

Observation duration is set to 15 minutes irrespective of the array shape, where either miniature arrays with a radius of 60 cm or irregular-shaped arrays with radii about 3 to 10 m are used.

2. Automatic analyses and readings of phase velocities and H/V spectra

The selectin of the data portions and the spectral analysis are automatically executed by using the software BIDO. Cho et al. (2014)'s algorithms are used for automatic readings of phase velocities and H/V spectra.

3. Inferring 1D S-wave velocity structures and constructing 2D sections

A dispersion diagram, represented by the relation between the wavelength, L, and phase velocity, Vr, is converted into a 1D S-wave structure having the relation between the depth, D, and S-wave velocity, Vs, where relations Vs= Vr/0.92 and D=0.375L are used (SPM). The resulting 1D structures are spatially interpolated to obtain a 2D section, where H/V depth conversions are overdrawn.

The above procedure from 1 to 3 is fully automatically executed. Incidentally, this study include no examination on SIM because no automatic algorithm has been developed yet because of the robustness problem.

We applied the above procedure to microtermor data obtained along survey lines in four different areas with variable geological environments (e.g., Itako City, Hadano City, Kashiwa City, Urayasu City). As the results, natural views of 2D S-wave velocity sections are obtained in all cases, similar to those obtained by visual readings. Furthermore, resulting velocity sections are consistent with other kinds of subsurface structural data (i.e., geological sections, N-value distributions, the 3D soil model of Senna et al. (2013)). We consider that, needing further improvement, Cho et al. (2014)'s algorithms can provide us with acceptable results at the first stage of automating the analysis procedure.

Keywords: Microtremor, velocity structure, surface waves, phase velocity, array, underground structure model