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# Correction of the near-source vibration instability in ACROSS analysis

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http://www.eps.nagoya-u.ac.jp/across/index.html

Seismic velocities are continuously measured for 15 months using a newly developed vibration sources named ACROSS. In the experiment it is revealed that most of the temporal variations are attributed to that of the near-source region. In this study we corrected this effect from the temporal variation estimated in Ikuta et al (2002).

We are developing a new system for seismic exploration. The name ACROSS stands for Accurately Controlled Routine Operated Signal System. The purpose of the study is monitoring the temporal variations of propagation properties of seismic waves in the crust. The primary feature of the system is to generate sinusoidal waves by rotating an eccentric mass around an axis. The mass position as well as digitization is accurately controlled with reference to the GPS clock. This system enables us to make a continuous monitoring of the seismic wave propagation without destroying the surrounding ground. It also gained high signal-to-noise ratio by stacking the records repeatedly.

An ACROSS source is deployed near Nojima fault, which ruptured at the 1995 Kobe earthquake. We ran the system from January 2000 to April 2001 and monitored temporal variation of travel time. The emitted elastic wave from the source is received with seismometers deployed at the bottom of 800m and 1700m deep boreholes under the sources. The observed records were stacked 36 times with the interval of 100 seconds and stored every one hour. The signals generated from the ACROSS sources were extracted from the stacked data in the frequency domain for the range is between 10 and 22 Hz. The extracted series of spectral signals was converted into a transfer function by a deconvolution with the spectra of the theoretical force generated by the source. P, S and some later phases are identified in them in the time domain. During the experiment, the transfer functions were calculated for every hour. To detect a faint temporal variation in this transfer function, we calculated the cross-spectral densities (CSD) among the traces for the parts including P or S. The relative variation in travel time is obtained by averaging the relative phase delays of the available spectral components.

The long-term variations of about 2 ms for both the P and S waves were observed during the 15 months. The variations of near-source vibrations are, however, similar to that of the travel time variations of the P and S waves observed at the 800m and the 1700m boreholes. Therefore, most of the temporal variations are attributed to that of the near-source region. 4 seismometers, each of which has 3 components, are deployed on the surface and at the bottom of the 10m-deep borehole in the source room. Though the position of the eccentric mass is accurately controlled, the phase variation in the source vibration is governed by the rigidity of the surrounding rock.

We tried to remove the influence of this source-region instability from the observation records and estimated the temporal variation of the seismic velocity in the deeper portion. We used the method proposed by Yamaoka et al (2001) in which the observed records of the seismometer at 800m depth are expressed with linear combination of the near-source records. The combination coefficients through the experiment period were estimated with the maximum likelihood method. We applied the method for each frequency component and calculated the temporal variation of travel times for P and S, in the same method used in Ikuta et al (2002). Changes in S-wave travel time attributed rain are almost removed, and total variance of travel time is reduced to about 1/3 of the previous one.

Reference

Ikuta, R., K. Yamaoka, K. Miyakawa, T. Kunitomo M. Kumazawa, Continuous Monitoring of Propagation Velocity of Seismic Wave Using ACROSS, GRL accepted

Yamaoka, K., T. Kunitomo, K. Miyakawa, K. Kobayashi, M. Kumazawa, A Trial for Monitoring temporal variation of seismic velocity with ACROSS system, The Island Arc, 10, 336-347, 2001