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The accuracy evaluation of sampling clock of Hi-net and data correction for precise measurement of travel time

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Recently, attempts have been made to detect of seismic travel time change with the use of Hi-net data by various approaches. For example, one to tens of msec of delay in seismic travel time associated with the 2011 M9.0 Tohoku-Oki earthquake were detected by the methods of ACROSS, seismic interferometry, repeating earthquake and so on. For precise measurement of slight change of seismic travel time, synchronization of clock between sources and receivers or receivers and receivers is absolutely essential, but accuracy estimation of sampling clock of Hi-net is not always sufficient so far.

In this study, sensor check signal is used to evaluation and correction of sampling clock of Hi-net data acquisition system. The sensor check signal is a response waveform of seismometer for applied square-wave voltage with 5 seconds in duration to calibration coil. The square-wave voltage is generated by ON/OFF action of DC voltage source by a mechanical relay with 1pps timing of a GPS clock. That's timing is independent of sampling clock, therefore we can potentially check accuracy of the sampling clock on the basis of the GPS clock by using the sensor check signal. The important things here are stability of mechanical relay action and seismometer phase characteristics. The timing of sensor check signal was researched by cross-spectral method at 24 Hi-net stations for the eight years from 2004 to 2012.

Consequently it was revealed that OFF timing of mechanical relay is stable at all stations and there is little variation of temporal change of phase characteristics for high frequency band at a distant from natural frequency ~ 1Hz. Delay time of sensor check signal, starting at 5 seconds past 9 a.m. every day, was analyzed by cross-spectral method. Reference waveform is a month stacked data, Dec. 2012. Delay time of sensor check signal, that is to say sampling clock timing, changes like a stepwise function overlapped with random fluctuate related to data noise level. These results applied to travel time change data Hi-net Yaotsu (11.3km) and Hi-net Hourai(56.9km). Stepwise travel time change disappeared without change in the event of large earthquake, and annual and secular travel time change became clear.

The precision of clock is a foundation of modern science. For seismic measurement to be modern science, explicit information of precision of sampling clock is absolutely needed at a very least. Hereafter, I hope to get and circulate the information of clock correction of all Hi-net stations, and replaced data logger with accurate sampling clock.

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Keywords: seismic velocity change, sensor check signal, cross-spectrum, seismic ACROSS