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Possibility of apparent velocity fluctuation caused by changes of the Hi-net instrument response

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Continuous seismograms recorded by Hi-net have been contributed to successful developments and applications of seismic interferometry analyses in which the temporal change of statistical properties of the seismograms are detected as a fractional change of subsurface structure. Because more than 10 years has passed since the Hi-net established, the instrument response could slightly change. The present study thoroughly analyzed the stability of the instrumental response for each Hi-net station and examine whether the change of the instrumental response can cause an artificial error in seismic interferometry analyses.

A record of instrument response by a calibration coil test is found at 9:00 a.m. in Hi-net. We determined the natural frequency f0 and damping parameter h by a grid search for the best fit between a theoretical instrument response and the observed one in time domain. The resolutions of this method for f0 and h were 0.05 Hz and 0.05, respectively. We obtained a temporal change of the f0 and h for about 10 years for each station. The variations were within the resolution of the grid search method. We obtained small f0 shifts approximately 0.02 Hz at KMIH (Kamaishi, a station located near the coast in Iwate) seismic station at the 2011 Tohoku-oki earthquake. A very small and long term trend of instrument response is also recognized for the period.

In order to investigate influences of the changes of instrument responses on seismic interferometry analysis, we calculated various waveforms using the f0 and h with a range of 0.9 - 1.1 Hz and 0.6 - 0.8, respectively. A velocity fluctuation corresponding to these instrumental response variation, or apparent velocity fluctuation, was estimated by a stretching method of auto-correlation-function (ACF) after a band-pass filter of 1 - 3 Hz and 1 bit normalization were adapted, where reference ACF was calculated with f0 = 1 Hz and h = 0.7 as typical Hi-net instrument parameters. As a result, small apparent velocity changes less than 0.1 % were obtained corresponding to the shifts of the instrument responses. Because this change is significantly smaller than those typically reported as a subsurface velocity change (for example, more than 0.3 % velocity decrease was found by Ueno et al., 2012), we concluded that the Hi-net instrument responses are stable enough to detect subsurface velocity change $>$ 0.1 % by seismic interferometry analyses.

Keywords: Hi-net, instrument response, seismic interferometry, apparent velocity change