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Estimation of velocity change depth from wave-propagation simulation and interferometric analysis of Hi-net and KiK-net

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Since Hi-net and KiK-net sites are co-located, we can detect the depth dependence of seismic velocity change by applying the interferometric analysis to seismograms recorded by these two types of seismograph networks. In this study, we measure autocorrelation function (ACF) of ambient noise record obtained by Hi-net, and measure deconvolution function (DCF) of the surface and the borehole-bottom seismograms obtained by KiK-net for the Myoko-Kogen station (N.MKGH/NIGH17). By comparing these two functions, we detect the depth dependence of seismic velocity change associated with the M_W6.3 earthquake occurring on November 22, 2014 at northern part of Nagano-prefecture, Japan. By applying the interferometric analyses, we detect velocity reduction ratios of 1-2 % and 3-4 % for the ACF of Hi-net record and for the DCF of KiK-net records, respectively, within the time period of one week after the mainshock. This difference in the velocity reduction ratios could be attributed to difference in sensitivity of the two functions; the DCF is sensitive to change in the medium above the borehole-bottom receiver (0-150 m depths), while the ACF is sensitive to wider zone. Next, we perform a two-dimensional finite-difference wave propagation simulation and examine the change of ACF associated with the 3 % velocity reduction at 0-150 m depths considering the result revealed from the DCF of KiK-net records. The reference velocity structure used in this simulation is created by adding random fractional fluctuations to the depth-averaged velocity structure obtained from the seismic tomography data around the target region. The velocities of the top layer are set to V_P = 4.0 km/s and V_S = 2.0 km/s for model 1, and V_P = 3.0 km/s and V_S = 1.0 km/s for model 2. The velocities between the top layer and the 2.5 km depth are smoothly interpolated and connected to the tomography data. The positions of source and receiver are co-located at the 150 m depth. Applying the stretching technique to the simulated waveforms, we obtain 0.7 % and 1.2 % velocity reduction ratios in average for the models 1 and 2, respectively. According to the well-logging data at Myoko-Kogen station, the average velocities at 0-150 m depths are V_P = 1.8 km/s and V_S = 0.6 km/s, which are slower than the velocities of the top layer adopted for the model 2. Therefore, the true velocity reduction ratio would be larger than 1.2 % if a realistic velocity structure is available for the finite-difference simulation. This result indicates that over half of the observed velocity reduction ratio detected by the ACF of Hi-net record is attributed to the velocity reduction at the top 150 m depths.

Keywords: Hi-net, KiK-net, interferometry, velocity change, finite-difference simulation