Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS24-P01 Room:Convention Hall Time:May 20 18:15-19:30

Envelope broadening of S-wave seismograms from earthquakes near the hypocenter of the 2011 Tohoku-Oki earthquake

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It is reported that the seismograms of the earthquakes in the forearc of the northeastern Japan show clear difference in their S-wave envelope shapes according to difference in their focal depths [Gamage et al, 2007; Koga 2010]. The seismograms of interplate earthquakes tend to have broader S-wave envelopes than those of intraplate earthquakes. We investigated the envelope broadening by measuring peak delay times of the S waves of earthquakes occurred beneath the landward slope of the Japan Trench. By including the aftershocks of the 2011 Tohoku-Oki earthquakes, we could analyze a number of intraplate earthquakes, both in the downgoing slab and in the overriding plate, as well as interplate earthquakes.

As a result, we noticed that interplate earthquakes are not always associated with significantly large peak delay times showing remarkable envelope broadening. In the trenchward half, up to ~ 130 km from the trench axis, of the landward slope area, the earthquakes near the plate interface tend to have evidently broadened S-wave envelope whereas those in the landward area are characterized by moderate peak delay times. We also confirmed that intraslab earthquakes have small peak delay times indicating less S-wave envelope broadening. Peak delay times of the earthquakes with considerable waveform broadening tend to increase rapidly in the small hypocentral distance range. This observation suggests strong short wavelength heterogeneity along the plate boundary in the trenchward zone. In contrast, increase rate of peak delay times of intraslab earthquakes are smaller than the averaged values. This reflects less heterogeneity in the Pacific slab in terms of short wavelength perturbation of material properties.

Keywords: S-coda wave, interplate earthquake, intraplate earthquake

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Time-lapse change in seismic velocity after the 2011 Tohoku-Oki earthquake estimated using ambient noise record

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We detected temporal velocity change after the 2011 Tohoku-Oki earthquake using ambient noise interferometry. We used a seismic array in Iwate prefecture, which is equipped by Tohoku University. The array consists of 10 broadband sensors. Minimum and maximum separations of the array are 2.4 km and 18 km, respectively. Vertical component data of nine stations from January 2010 to December 2011 are used. After removing earthquake according to data amplitude, we computed normalized cross spectra for each day.

In the case of isotropic incidence of ambient noise, normalized cross spectra can be modeled by the Bessel function $J_0(kr)$, where k is the wavenumber and r is the separation distance [Aki 1957]. By fitting the Bessel function, we measured average phase velocity for each frequency. From average cross spectra before the earthquake, the phase velocities at 0.4, 0.8, 1.2 Hz are estimated as 3.183, 2.985, 2.878 km/s, respectively. After the earthquake, they are 3.176, 2.978, 2.863 km/s. Therefore, velocity decreases at 0.4, 0.8, 1.2 Hz are 0.22, 0.22, 0.52%, respectively. The phase velocities at other frequencies also show decrease after the earthquake. Especially, in the frequency range of 0.4-1.2 Hz, velocity decrease tends to be proportional to frequency.

The cross spectra for the case of anisotropic incidence of ambient noise also can be modeled by expanding the azimuthal distribution of incident wave amplitude in a Fourier series [Harmon et al., 2010]. When we modeled the noise source distribution by the fourth order expansion, the phase velocities at 0.4, 0.8, 1.2 Hz before the earthquake are 3.181, 2.980, 2.855 km/s, respectively. After the earthquake, the phase velocities are estimated as 3.173, 2.972, 2.842 km/s, which means velocity decrease by 0.24, 0.27, 0.46%.

Keywords: Seismic velocity change, Seismic interferometry, The 2011 Tohoku-Oki earthquake

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Ambient noise analysis using short-period seismometers and hydrophones

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In the interferometry, the wavefield propagating between two positions can be retrieved by correlating ambient noise recorded on the two positions. This approach is useful for applying to various kinds of wavefield, such as ultrasonic, acoustic (ocean acoustic), and seismology. Off the Kii Peninsula, more than 150 short-period (4.5 Hz) seismometers, in which hydrophone is also cosited, had been deployed for ˜2 months on 2012 by Japan Agency for Marine-Earth Science and Technology (JAMSTEC) as a part of "Research concerning Interaction Between the Tokai, Tonankai and Nankai Earthquakes" funded by Ministry of Education, Culture, Sports, Science and Technology, Japan. In this study, correlating ambient noise recorded on the sensors and hydrophones, we attempt to investigate characteristics of wavefield in the ocean, subseafloor, and its solid-fluid interface.

The observation period is from Sep. 2012 to Dec. 2012. Station spacing is around 5 km. For 5 lines off the Kii Peninsula, the 30-40 seismometers are distributed at each line. Sampling interval is 200 Hz for both seismometer and hydrophone. The vertical component is just used in this study for correlation analysis. The instruments are located at 100-4800 m in water depth. In the processing for the both records, we applied a bandpass filter of 1-3 Hz, replaced the amplitude to zero if it exceeds a value that was set in this study, and took one-bit normalization. We calculated cross-correlation function (CCF) by using continuous records with a time length of 600 s, stacked the CCFs over the whole observation period.

As a result of the analysis for hydrophone, a peak can be seen in the CCF for pairs of stations where the separation distance is ˜5 km. Although the peak emerges in the CCFs for the separation distance up to 10 km, it disappears in the case that two stations are greater than 15 km separated. As a next approach, along a line off the Kii Peninsula, we aligned CCFs for two stations with the separation distance of ˜5 km, the peak emerged in the CCFs clearly shows a travel time variation as a function of water depth. The velocity of the signal is approximately estimated to be 1.2 km/s and 0.7 km/s at water depths of 2000 m, 4000m, respectively, and the velocity seems to gradually change between the two depths. In addition to the wave, a relatively weak signal can be seen, which shows a velocity of 1.4-1.5 km/s with no depth dependency.

As a result of the analysis for seismometer, a peak can be seen in the CCFs for two stations with a separation distance of ˜5 km, which shows the water-depth dependent travel time as well as the analysis for hydrophone. However, the amplitude of the signal with a velocity of 0.7-1.2 km/s was weaker than those obtained in the analysis for hydrophone. In contrast, the signal with a velocity of 1.4-1.5 km/s emerged clearly compared to those using records of hydrophone. At present, no remarkable signals cannot be seen in the CCFs using horizontal components.

These signals obtained would be explained by the Stoneley wave, which has the largest amplitude at seafloor, the T-phase, which has the largest amplitude at the center of the SOFAR channel, the Rayleigh wave, which has the large amplitude within seawater and marine sediments, and also the superposition or coupling of these waves.

Keywords: Interferometry, Seafloor observation

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Cross terms of ground transfer function -generalization of Normalized Energy Density-

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Normalized energy density (NED: Goto et al., 2011) is one of the essential quantities for a ground transfer function of a 1D layered structure model. This quantity is regarded as a type of norm for the power of the ground transfer function. The cross term of the functions is defined as an extension of the NED. The cross term is physically defined as the correlation coefficient between the two ground transfer functions. The cross term detects the harmony of two transfer functions; a finite value is obtained only in the case where peak frequencies coincide. The properties of the cross term is analytically proved for a two-layered case and numerically shown for three- and four-layered cases.

Reference

Goto et al., Conserved quantity of elastic waves in multi-layered media: 2D SH case -Normalized Energy Density-, Wave Motion, 48, 602-612, 2011.

Goto, Fundamental property of cross terms of ground transfer function, Wave Motion, submitted.

Keywords: Normalized Energy Density, Ground transfer function, Cross term, Complex integration

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Improvement of SPAC method by taking the ratio of power spectra between two sites

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Since Aki proposed a new approach to estimate phase velocities of surface waves, spatial auto-correlation (SPAC) method has been a very useful tool to estimate ground structure because of its simple post-process. After that, many reseachers both in and out of Japan continued to publish papers on practical adaption of Aki's theory to microtremor exploration. However, in all those improved methods, the layers under surface can only be assumed to be horizontal through the SPAC method while in fact, the layers are likely to be inclined slightly with certain angle. Hence, it is expected to obtain more detailed information of ground structure such as inclination by making better use of the records.

In recent years, the seismic interferometry theory has also been widely used to estimate ground structure. It is proved that in an elastic medium the Fourier transform of azimuthal average of the cross correlation of motion between two sites is proportional to the imaginary part of the exact Green's function between these sites. Hence, it becomes possible to calculate the ratio of imaginary part of different Green's function by taking the ratio of corresponding cross correlation to analyze ground

structure more particularly because Green's function indicates intrinsic property of the medium. Actually, seismic interferometry is conditionally consistent with the SPAC method which offers the base of introducing seismic interferometry to SPAC method.

SPAC method requires the multiplification calculation of Fourier transformation of records at two sites of center of an array and a one site on the circular array. By taking the ratio of power spectral between two different sites, it is hoped to obtain the ratio of imaginary part of Green's function according to seismic interferometry theory correspondingly and analyze the difference of ground structure through the ratio. More information such as the inclination of layers could be obtained.

Since this new concept has been proposed, some problems has been pointed out and the availablity of the combination remains to be proved. Firstly, the ratio of power spectra is used to calculate the ratio of imaginary

part of Green's function whicn means the wavefield is supposed to consist of mainly body wave. However, the SPAC method requires the wavefield to be dominated by microtremors. It seems to be paradox but it is believed

that seismic interferometry theory itself satisfies wavefield of full wave. It is hoped that by taking the ratio of power spectra between two sites, the surface wave content will be extinguished and the body wave content remains.

Secondly, under the assumption of body wave being dominating, it is said that power spectra itself of each site could be used to analyze out the peak frequency of the ground structure (in simple case, the first layer) which tend to say that there is no need to take the ratio of them. Nevertheless, in wavefield dominated by microtremor and with the inclination of layers small enough, it is hard to extract useful information from each power spectra alone and to compare between them.

In this paper, the concept of SPAC method, interferometry and the combination of them are firstly proposed comprehensively. Then, in order to solve the two problems mentioned above, we use finite-difference method to

simulate some 2-layered simple layered medium under the wavefield dominated by microtrmors. Next, SPAC method is applied to certain array of observation sites to examine if this wavefield is effective for SPAC method. Finally, the availability of seismic interferometry would be analyzed and the need to take the ratio of power spectra will be shown.

Keywords: Power spectra, seismic interferometry, SPAC method, Green's function, layered medium

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Seismic interferometry imaging of seismograms observed in the Fujikawa-kako fault zone - ISTL seismic reflection survey

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Seismic interferometry synthesizes the pseudo seismic response between receivers by cross-correlating records observed at the receivers, which corresponds to the seismic response observed at one receiver from the other receiver as a seismic source. The method enables us to obtain a subsurface structure using seismic records without using arti?cial sources.

The Fujikawa-kako fault system - Itoigawa-Shizuoka Tectonic line (ISTL) seismic reflection survey was conducted from April 2 to April 15, 2012. The survey line crosses the Fujigawa-kako fault zone, the Minobu fault system, and the ISTL. This survey aimed to elucidate the sedimentary structure of the lower Fujikawa River region, the deep structure of the fault system and the Philippine Sea Plate.

In this study, we applied the auto-correlation analysis and the cross-correlation analysis of seismic interferometry to the seismogram of natural earthquakes observed by the survey line. We compared the results obtained by seismic interferometry with the seismic reflection profile and evaluated the validity and the applicability of the methods.

We selected 24 earthquake records among the earthquake records observed during the re?ection survey. The records of 8 arti?cial sources used for the wide-angle re?ection survey were also used in this analysis. We extracted the P-wave of natural earthquake from the first arrival to S-wave arrival. For the analysis of the artificial source records, a time windows of 10 seconds from first arrival was applied. We applied the band pass filter between 4 and 16 Hz, and then, manually removed the traces with indistinct first arrival of P-wave before correlating each seismic record. Moreover, we applied the static correction, a technique often used in the analysis of a land reflection survey, to the reflection record to remove the effect of receiver elevation and shallow layers.

The result of the interferometry analysis using natural earthquakes and that using arti?cial sources shows good agreement. The profile is consistent with that of the seismic reflection survey. This indicated that seismic interferometry works as an effective exploration method. However, the deep structure, such as the plate boundary, was not well imaged in the profile. One of the reason is that the number of earthquake records used in this study was insuf?cient due to the short observation period.

Keywords: seismic interferometry, seismic reflection survey, subsurface structure, Fujikawa-kako fault zone, Itoigawa-Shizuoka tectonic line

SSS24-P07 Room:Convention Hall Time:May 20 18:15-19:30

Seismic interferometry imaging of crustal structure using deep earthquakes in Tokai region

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Seismic reflection survey using artificial sources is generally used as an imaging method of subsurface structure. By using the theory of interferometry, a subsurface structure can be imaged from seismic wave records of natural earthquakes as well as those of artificial sources. Imaging deeper structures is expected by using the natural earthquakes because the energy is larger than the energy from artificial sources.

This study aims to image the structures in the crust and the plate under the Tokai region by applying autocorrelation analysis (Claerbout, 1968) of seismic interferometry to the natural earthquake records observed by Tokai Array observation (Kato et al., 2010) from April to August, 2008. Records of the 8 Hi-net stations near the Tokai Array were also added.

Auto-correlation analysis assumes that the wave is at normal incidence since it stands in one-dimensional wave field. Therefore deep earthquake records (about 200 - 300 km) occurred in Pacific plate slab under the Tokai region were used. According to Kato et al. (2010), the deepest depth of Philippine Sea plate boundary is about 40 km under the Tokai region. From the theory of the Fresnel zone, it is estimated that the angle of incidence up to about 10 degree can be considered as normal incidence in the frequencies used for analysis. Therefore, deep earthquakes whose incident angle of 10 degrees or less in all stations were selected.

From the deep earthquake records of Tokai Array Observationthat satisfy the condition of incidenct angle, we selected 11 events (Mj2.2 - 3.6) for the analysis. For Hi-net records, 40 events (Mj3.0 -) of the deep earthquakes were extracted during 2004 - 2012. We used waves after P-wave arrival to S-wave arrival of the UD component as P-wave record and waves after S-wave arrival in the NS and EW components as S-wave. In prior to auto-correlation, pre-processing such as correction of the frequency response of seismometer, band-pass filter (pass band : 0.5 - 1.0 Hz) and deconvolution of source wave were applied.

In the result of analysis, we found continuous reflectors dipping NW near the depth of plate boundary shown in Kato et al. (2010). The reflectors were also found in the result of Hi-net data. Our preliminary interpretation is that the reflectors correspond to the plate boundary. The continuous reflectors were clear in the NW side of the array. However, it became obscure in the SE side. This may be due to the effect of sedimentary layers and the man-made noise in the SE side of the array. Also, this may be due to the regional geology because it seemed that the lateral change in the section locates near Median Tectonic Line and Butsuzo Tectonic Line.

We will apply the crosscorrelation analysis to the record in order to improve S/N ratio, and then, apply the same processes to teleseismic records.

Keywords: seismic interferometry, autocorrelation analysis, crustal structure, subsurface imaging, deep earthquake

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A split in the subducting Philippine Sea slab beneath the Izu-western Nankai collision zone

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On July 5, 2011, an earthquake with a magnitude of 5.5 occurred off the Kii Peninsula in the northern Wakayama Prefecture in southwest Japan within the subducting Philippine Sea (PHS) plate at a depth of around 10 km. The earthquake caused strong shaking in the area near the epicenter. We analyzed the waveforms from this earthquake recorded at Hi-net and F-net stations in Japan. Such waveform analyses exhibit most of the earlier observations like dominance of low-frequency ($f < 0.25$Hz) onset and following high-frequency ($f > 2$ Hz) energy with long coda due to the stochastic waveguide effect of the subducting plate, proposed earlier by Furumura and Kennett (2005). Interestingly, we observed a clear difference in wave propagation pattern between east and west of the epicenter. For example, the waveforms for eastern part show S-coda are depleted with high frequency energy as compared to the western part. The duration of S-coda varies alternatively between high and low from east to west through center of the epicenter. The central stations show loss of low-frequency precursor to P-waves and presence of converted phases in P-coda. Such complexities in the observed waveforms are difficult to explain due to the radiation pattern of P- and S-waves and/or by anomalous propagation of seismic waves in existing plate model, indicating sudden lateral change in the wave guiding properties of the subducting slab, such as caused by the splitting of the slab as proposed by Ide et al. (2010).

To explain the observations, we employ two-dimensional finite-difference method (FDM) simulations of complete high-frequency P-SV wave propagation taking thinning of the PHS slab into account. In the plate model we included stochastic random heterogeneities described by exponential distribution function with a longer correlation length of 10 km in horizontal direction and much shorter correlation length of 0.5 km in depth and standard deviation from background P- and S-wave velocities of 5 % following the study of Furumura and Kennett (2007). We expect that the observed guided wave energy decouples from the waveguide where the slab is split. Low frequency energy leaks out of the slab in the low velocity mantle surrounding the slab. Taking into account the distribution of seismicity and focal mechanisms (Ide et al., 2010), and receiver function analyses (Shiomi et al., 2004) in the PHS plate, we expect a local velocity discontinuity or splitting of the plate at least to a depth of 30 km. Such a split in the PHS plate structure could also be manifested as non-volcanic tremor sources in the southwest Japan (Obara, 2002). The preliminary results, which suggest that the Philippine Sea slab is strongly split or partitioned beneath the Izu-western Nankai Trough in southwestern Japan, is the cause of the complicated waves from shallow inslab events. These effects need to be tested further with a 3-D FDM simulation employing high-performance computers with a variety of possible slab geometries. We finally discuss the implications of the new split plate model on the seismogenic potential of the area and the dynamics of the Nankai subduction in southwest Japan.

Keywords: Philippine Sea Plate, Scattering, Plate Tear, Wave Propagation

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T-waves from the nuclear test in North Korea

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North Korea conducted 3rd nuclear test on 12 February 2013. P-waves from the explosion were observed widely in the Japanese Island. We examined seismic T-waves observed by the seismometers of Hi-net stations because T-waves have been effectively used to detect explosions in the context of the Comprehensive Nuclear Test Ban Treaty (CTBT). We found that the T-waves were clearly observed in the Japan Sea side of northern Japan, while the waves are obscure along the coast from Yamagata to Fukuoka prefectures. This is probably due to the topography of ocean bottom. Along the paths of T-waves from the source to northern Japan the depth of ocean bottom is almost deeper then 3000 m. Thus there is few topographic high to prevent the propagation of sonic waves in the SOFAR channel. On the other hand, shallower and complex bathymetry causes incoherent arrival of T-wave energy along the paths to the southern Tohoku to Kyushu. We investigated the characteristics of T-waves by seismograms, envelopes, and spectrograms. At some stations in Hokkaido and northern Tohoku the amplitude of T-waves is much larger than P-wave. The peak frequency of T-waves reaches about 4 Hz. The most notable feature is the duration of T-waves; the duration is longer at stations in Hokkaido than at stations in northern Tohoku. Longer duration in Hokkaido is attributed to the contribution of reflected/scattered T-waves from the northern edge of the Yamato Bank situated at the middle part of the Japan Sea. Thus the T-waves from the nuclear test provide unique opportunity to investigate the lateral variation of the SOFAR channel and scattering characteristics of sonic waves in the Japan Sea.

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Keywords: T-wave, nuclear test, Japan Sea, topography, scattering, SOFAR channel

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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

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An attempt to detect seismic velocity change due to tidal strain based on autocorrelation analysis of ambient noise

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Recent studies using noise correlation method report temporal changes in seismic velocity associated with occurrence of large earthquakes and volcanic activities or seasonal variations (e.g. Titi et al., 2012; Hobiger et al., 2012). These temporal changes of the structure can be interpreted as the damage in near surface due to strong motion or the static stress change due to coseismic slip on the fault or volcanic crustal deformation. A few field experiments of in situ seismic velocity measurements detected seismic velocity changes of 0.1%˜0.5% due to tidal strain (e.g. Reasenberg & Aki, 1974; Yamamura et al., 2003). In frequency band, these active experiments using piezoelectric transducer or air gun as sources with dominant frequency of 1kHz or 30 Hz are not always consistent with seismic interferometry which have reported temporal changes. Using dilation and compression by tidal force as an external force, we examine seismic velocity changes due to applied stress based on autocorrelation function (ACF) analysis of ambient noise.

We use the vertical component of continuous seismic data (100Hz sampling) at 118 Hi-net stations in the northeastern Japan from 1 January to 31 December 2010. To remove signals from natural earthquakes, we use data with amplitudes less than a threshold value, which is set to be five times the median of 1 year RMS calculated every 10 min, and apply one-bit normalization. The data is filtered at frequency band of 1-2Hz, 2-4Hz. ACFs are calculated every 10 minutes.

To detect small velocity changes due to tidal stress in 103 Pa order, we need to select data in relatively calm day. We measure time delays by applying cross correlation analysis for the mean ACF in 2010 and daily ACFs. Correlation coefficients and time delays are calculated by shifting a time window of 2.56 s during the lag time of 1.28-10 s. For a homogeneous medium in which seismic velocity constantly increases or decreases, we estimated daily seismic velocity changes from the relation between lag time and delay time. In order to enhance the temporal resolution of the CCF, we interpolate with a sampling frequency of 800 Hz.

We compute tidal synthetic volumetric strain at each station using GOTIC2 program (Matsumoto et al., 2001) in estimated calm days. We define tidal strain with a value more than 5.0x10-9 and less than -5.0x10-9 as dilational and compressional episodes respectively, and we stack ACFs in each period. We call the ACF stacked in dilational episode DACF and that in compressional episodes CACF. We estimate the time delay of DACF for CACF only when the correlation coefficient is larger than 0.99.

Focusing on seismic velocity changes obtained stably, we select stations which estimated error of seismic velocity changes is smaller than 0.01%. At the frequency band of 2-4 Hz, we measure seismic velocity changes at 27 stations, and summarize them in a histogram. Velocity changes are distributed in -0.06±0.06%, and the peak shows -0.01%. It can be thought that seismic velocity decrease in dilation, our result may show velocity changes due to tidal strain. However the weighted average of seismic velocity changes is estimated -0.006±0.005%, which show our methods cannot always give meaningful result. On the other hand, at the frequency band of 1-2 Hz, we measure velocity changes at 45 stations. At this frequency band, velocity changes are distributed in -0.14±0.09%, and the weighted average of seismic velocity changes is estimated 0.0±0.004%. These results may show that our method cannot detect seismic velocity changes due to tidal stress.

In comparison with previous studies, we cannot detect clear seismic velocity changes corresponding to tides. There may be difference of frequency band between previous study and our study as a cause, so we will analyze at higher frequency band.

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I thank NIED for making continuous data of the Hi-net available.

Keywords: seismic interferometry, autocorrelation function, ambient noise, earth tide, temporal seismic velocity change

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Validation of S-wave velocity structure in the southern Kanto based on Green's functions with seismic interferometry

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Seismic interferometry is known to provide Green's functions between the stations pairs by using the long-term microtremors obtained at both stations. Surface-waves are expected to be dominant in the Green's functions from microtremors observations on the earth surface. Since surface-waves provide the information about the near surface structures, we use Green's functions estimated with seismic interferometry for validation of the S-wave velocity structures in the southern Kanto.

We have constructed the network for long-term microtremors observation in the southern Kanto, and applied it to seismic interferometry. We have also estimated the S-wave velocity structures with tomographic inversion based on the slowness of the cross correlation functions. Recently, the amplitudes of cross correlation functions are also studied to reconstruct the amplitude of Green's function (e.g. Tsai, 2011; Prieto et al., 2009). Seismic interferometry is often applied to the microtremors of which amplitudes are normalized to 1 bit (Campillo and Paul, 2003) or with threshold clipping (Shapiro and Campillo, 2003). However, these procedures distort the amplitudes of microtremors and the distortion of the amplitudes of reconstructed Green's functions, accordingly. Chimoto and Yamanaka (2012) used the data processing by Prieto et al. (2011), which applies no normalization for microtremors, and showed the possibility in the use of the information about the amplitudes. They also demonstrated to obtain the appropriate signals of Green's functions from the cross correlation with the data processing.

In this study, we also used the data processing denoted by Chimoto and Yamanaka (2012) to use the information about the amplitude of Green's functions. Since surface-waves of Green's functions of which amplitudes preserved provide the useful information about the near surface structure, we use them to validate the S-wave velocity structures in the southern Kanto. We compare the estimated Green's functions with seismic interferometry and the theoretical Green's functions from the empirical S-wave velocity models proposed by Yamanaka and Yamada (2006) to validate it.

In the southern Kanto plane, where the dense microtremor array observation has been conducted, the appropriate S-wave velocity structures would have been estimated, because both Green's functions show the similarity. However, there also existed the difference in the later phases due to the scattering in the short period range, indicating that the further modification of the models is needed. We then focus on Sagami bay and Tokyo bay, because the model is still unknown due to the difficulty of conducting the geophysical exploration. We found that both Green's functions had difference and show the complexity due to the complexity of the subsurface structures in such areas. The difference in Green's functions was not only in direct wave but also in later phases. The difference was significant in the short period range. This suggests that the further modification of the models is required in such areas.

Keywords: Seismic interferometry, Green's function, S-wave velocity structure, Southern Kanto, Cross correlation function, Microtremor