Flow of Scattered Waves' Energy From the Fore-Arc to the Back-Arc in Eastern Japan Revealed From the Cross-Correlation Analysis of Coda Waves

Nobumasa Takagi, Haruo Sato and Takeshi Nishimura
Graduate School of Science, Tohoku University, Sendai, 980-8578, JAPAN
E-mail: takagi@zisin.geophys.tohoku.ac.jp

Recently, a new method using multiple scattering waves in heterogeneous media to retrieve Green's function is proposed. Camplillo and Paul (2003) showed that Rayleigh waves were retrieved from the cross-correlation analysis of coda waves in Mexico. Snieder (2004) proved that the cross-correlation function calculated from the wave fields recorded at two different points well coincides with Green's function between the two points. He also showed that this cross-correlation function in a positive lag time and that in a negative lag time are related to waves propagating to opposite directions. If heterogeneities of the Earth's interior were homogeneous, cross-correlation function would be symmetrical with respect to lag time zero. In the present study, we practice the cross-correlation analysis of coda waves recorded in eastern Japan to show asymmetric characteristics.

We used seismograms of the earthquakes with magnitude larger than or equal to 5.0, which are large enough to excite long coda waves. We analyzed vertical component velocity seismograms recorded by F-net (NIED). Eliminating direct waves, we only used coda waves whose lapse time was larger than two times of S-wave travel time and whose amplitude was larger than twice the background noise level. Coda waves were divided into 360s-length time windows and amplitude attenuation was corrected in each time window for the calculation of cross-correlation function. Then, we stacked cross-correlation functions weighting with cross-correlation coefficients.

Figure 1 shows examples of the stacked cross-correlation functions calculated in eastern Japan. Cross-correlation functions in a positive lag time correspond to Green's functions from a reference point, which is TYS, to other stations, and those in a negative lag time do inversely. Wavelets having a predominant period of 10s is found to propagate to opposite directions with a group velocity of about 3km/s. From the predominant period and group velocity, we interpret them as Rayleigh waves.

Asymmetry is found in cross-correlation function for some pairs of stations. Wavelets appear in both positive and negative lag times for cross-correlations between TYS and KSN or between TYS and IYG., but wavelets do not clearly appear in cross-correlations between TYS and the other stations. This suggests that propagation of scattering waves' energy has strong directivety. Comparing peak values in positive and negative lag times, we estimate the direction and strength of scatted waves' energy: the energy flow is in the direction that the larger peak value appears. In this study, we presented the ratio of a large peak value to a small peak value as the vector length illustrating the strength of energy flow. Energy flow from the forearc side of the volcanic front to the back arc side is observed systematically as illustrated in Figure 2. Predominant flow is northwestward in Hokkaido (Figure 2b), and westward in Tohoku and Kanto (Figure 2c and 2d). Our results suggest that the forearc side is more heterogeneous and has more scatterers which can serve as second sources, or that waves attenuate more rapidly in the back arc side.

Acknowledgement: We thank the National Research Institute for Earth Science and Disaster Prevention for providing F-net seismograms, and the Japan Meteorological Agency and the Ministry of Education, Culture, Sports, Science and Technology for processing hypocenter locations.

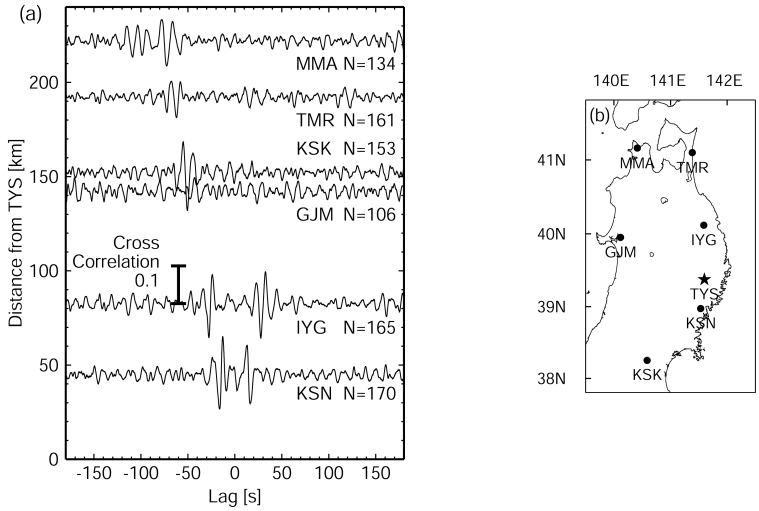

Figure 1. (a) Cross-correlation functions between TYS and stations in eastern Hoshu, Japan. Value N on the right side of each station' name shows the number of stacks. (b) Configuration of F-net station used.

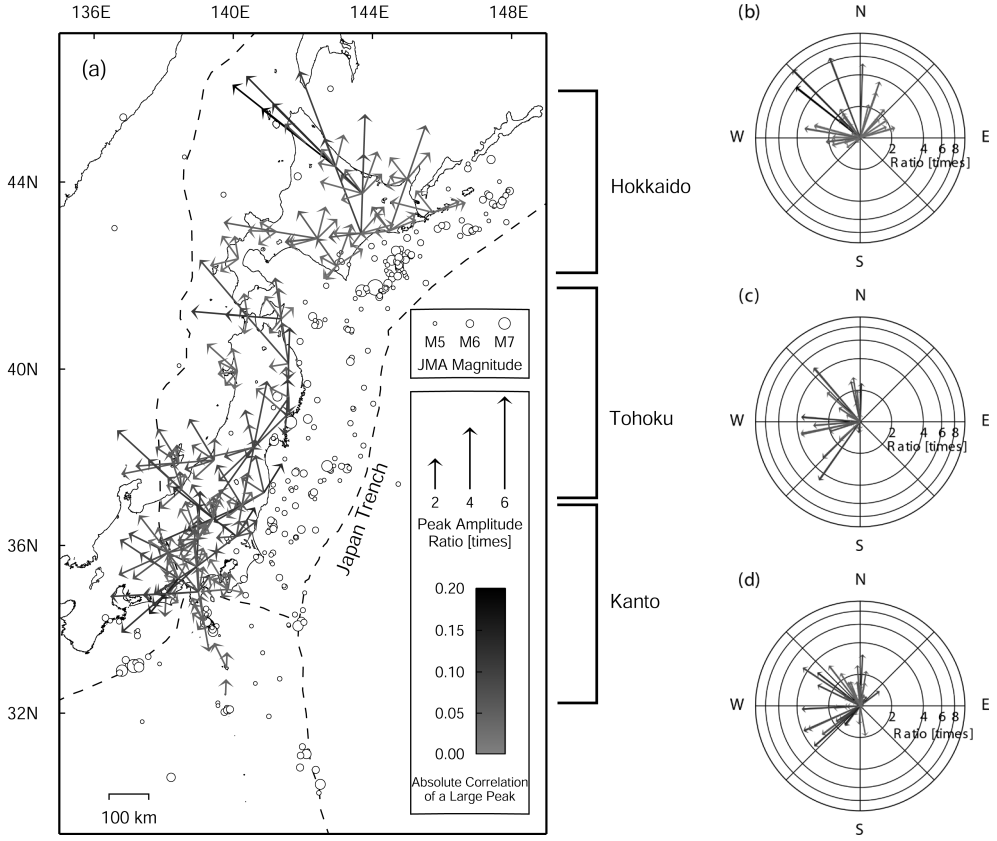

Figure 2. (a) Flow strength and direction about scattered waves estimated from the stacked cross-correlation function of F-net station pairs. Each vector indicates the direction of larger flow between two stations and its length represents the peak amplitude ratio. Gray scale means the absolute correlation of a large peak. Circles represent the epicenters of the earthquakes we analyzed. Totally 339 events of M >=5.0 are analyzed. Dashed curves show plate boundaries. (b), (c) and (d) are distributions of flow vectors in Hokkaido, Tohoku, and Kanto area, respectively. Scales of the strength (length of the vector) are plotted with log scale.