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Real-time Ground Motion Prediction Method Using Observed Waveform Data at Front Site

(前線波形情報を用いたリアルタイム地震動予測手法について)

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1. Introduction

The authors have tackled with development of a regional earthquake early warning system based on the accurate real-time ground motion prediction against the approaching Miyagi-ken Oki earthquake. For Earthquake Early Warning for one million city Sendai and other inland cities, the real-time earthquake observation systems have been installed at 5 sites, namely two Pacific Ocean Coast sites (Oshika and Ogatsu) and two intermediate locations of the propagation pass, Ishinomaki and Schichigahama, and Tohoku University in Sendai (Figure 1). The Shichigahama site is located at the Sendai Basin edge. The real-time observation data from the 5 sites is transformed to a data server of DCRC of Tohoku University, Sendai. As for real-time ground motion forecasting using front-site waveform data, a methodology using ANN has been proposed and verified its applicability for earthquakes in Miyagi-ken Oki area[1].

In EEW, non-stationary of ground motions like later phase due to basin induced surface wave is meaningful considering available time. The authors have investigated real-time ground motion prediction method for Sendai basin by using the waveform data from Pacific Ocean Coast sites and intermediate observation point at the Sendai basin edge including an investigating method focused on the non-stationary ground motion based on wavelet analysis.

2. Non-stationary ground characteristics based on wavelet analysis

When we assume the front site located along Pacific coast to be input, and target site located inland like Sendai to be output, non-stationary transfer function can be developed between front site and target site. Transfer function can be estimated using observed data of front site and target site. Transfer function is the kind of system matrix. So, it is important to estimate the system matrix by optimization method. Once transfer function is successfully developed, ground motion of target site can be predicted by use of observed earthquake data of front site and transfer function when strong earthquake occurs. We define the non-stationary transfer function by wavelet coefficients of observed data at front site and target site. Conceptual figure of non-stationary transfer function is shown in Figure 2. Figure 3 shows deep underground structure of Sendai[2)3)] together with locations of about 30 earthquake observation points[4]. The clear later phase observed in Sendai basin especially Nagamachi area during 2008/08/16 Miyagi-ken Oki earthquake (M7.2) and its epicenter locaion is shown in Figure 1. The time history data and the corresponding wavelet coefficients are shown in Figure 4 for the observation point within the basin (Ryutakuji) and basin edge (Shichigahama). In this analysis, complex continuous Morlet wavelet is adopted as mother wavelet[5]. The Ryutakuji site is on thick sedimentary layers (ref. to Figure 3). Athough Shichigahama record shows wavelet coefficients only for peaks caused by body waves, outstanding later phase with peak period of about 2.3 sec is recognized in the Ryutakuji record. It is noted that the arrival time of later phase at Ryutakuji delays 35 second from P wave arrival at Shichigahama and 15 seconds from S wave arrival at the basin edge site. An accurate ground motion prediction not only S wave but also later phase is requested for the warning information for tall building's earthquake countermeasure.

3. Future discussion

We are investigating the applicability of non-stationary transfer function developed by small earthquake data to strong earthquake. The definition of transfer function by wavelet is also being verified based on numerical and analytical calculations. Parameters related to ground motion prediction should be classified from the view points of source effect, path effect and site effect. Results are expected to come up soon.

The above-mentioned methodology with focused on non-stationary ground motion characteristics would be investigated for earthquake from different directions.

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Figure 1: Location of real-time observation sites

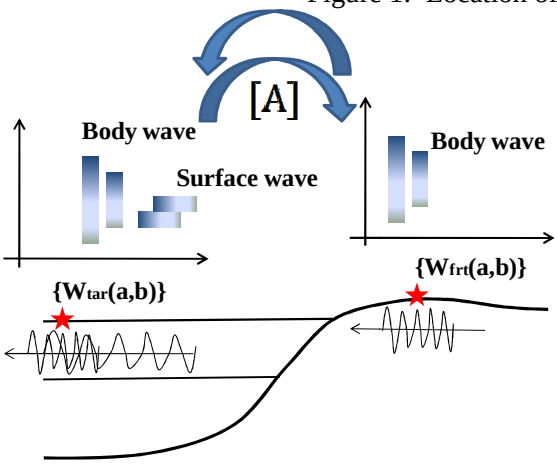

Figure 2: Conceptional figure of non-stationary transfer function

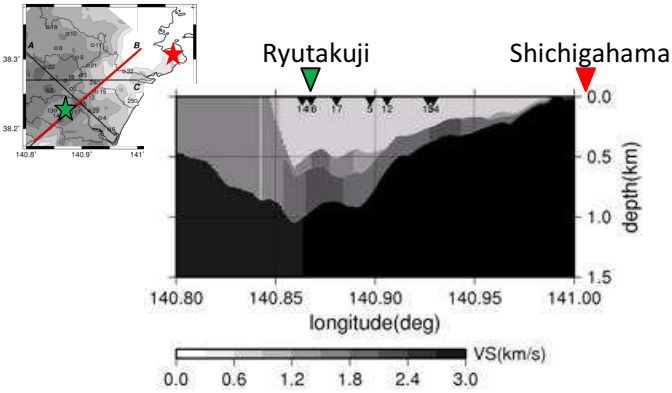

Figure 3: Deep underground structure of Sendai basin

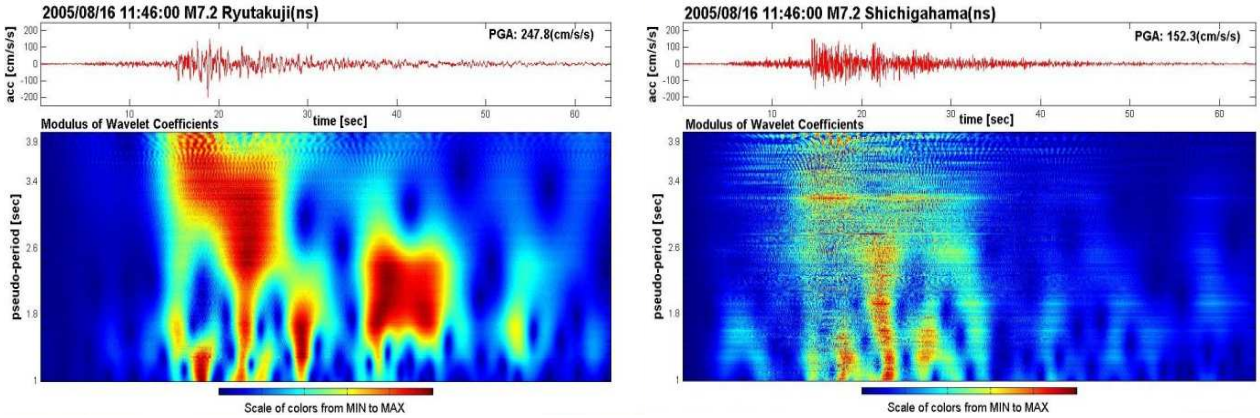

Figure 4: Time history of observed earthquake data and wavelet coefficient
(Left: Ryutakuji, Right: Shichigahama)

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