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Presumption of Hypocenter Vibration of Earthquake by Time Reversal

タイムリバーサルによる地震の震源震動の推定

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1. Introduction

Recently, the asperity has become a matter of great concern in the field of earthquake. There is a possibility that a severe earthquake may be foreseen if many earthquakes that occur in a certain specific source region are analyzed in detail in relation to it. Therefore, more observations are necessary. We have examined the application of the result concerning a time reversal in the ocean to an underground seismic wave[1-4]. However, there are many problems in a time-reversal process in the earth. This time, the time-reversal process is applied to the observation of the earthquake that occurred in Izu peninsula central part on December 19, 2009 and the vibration in a hypocenter is presumed. As a result, the convergence of the pulse that converged in the hypocenter is examined.

2. Propagation environment and convergence

Earthquake often occur at the vicinity of Ito in Izu peninsula. Many seismometers are set up as shown in **Fig.1** for an observation. However, there are many problems in the time-reversal process in this region unlike in the sea. First, the grasp of a propagation environment is difficult. The hypocenter waveform of the earthquake that occurs at 3800m in depth of Izu peninsula is presumed from waveforms received by the seismometer distributed in the whole area of Izu peninsula here.

Fig.1 Seismometer disposed in Izu peninsula.

Figure 2 shows the time of arrival of the seismic wave to the range from the hypocenter to the reception point. Both P waves (o) and S waves (x) are distributed on a straight line. Therefore, propagation environment can be considered to be almost homogeneous. And, the propagation speed of the P wave and the S wave becomes 5633 and 3433 m/s from the inclination of these straight lines, respectively.

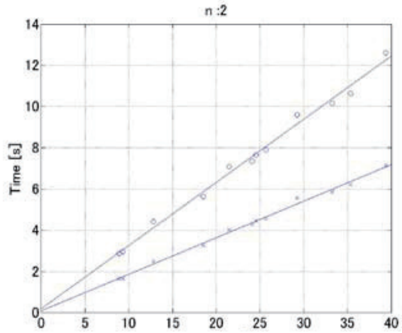

Fig.2 Propagation time of seismic waves to range.

Next, the sensor is a hydrophone in the sea, and the seismometer in the earth. The seismometer receives vertical and horizontal velocity though the hydrophone receives the pressure fluctuation. Moreover, making the seismometer an array is difficult though the hydrophone can easily construct the array. In the time reversal with small number of array elements, the suppression of reflected waves decreases. Processing that uses the array with one element is important to utilize the data of the seismometer. The compressibility of the pulse that converges in the hypocenter to confirm the effectiveness of the processing is examined.

3. Time reversal of seismic waves

In the propagation environment with the dispersibility like shallow water, the propagation pulse elongates gradually with the propagation range. The same pulse as the radiated pulse is formed at the source location when radiating from the array after the time-reversal process is given to the elongated pulse. On the other hand, the radiation pulse from the hypocenter is unknown in case of the seismic wave. And, it is the purpose of this report to presume it. Then, the time-reversal process is given to the P wave component of the signal that receives by the seismometer, and the pulse (Hereafter, it is called TRP) formed at the hypocenter is examined as a function of the range. In this case, a parabolic equation method is used for calculating Green function. The frequency range used is from 0.3 to 16 Hz. First, the TRP of Itonaka that exists in the shortest range (4.0 km) from the hypocenter is shown in **Fig.3**. The seismometer observes three velocity components in east

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and west, the south north, and the vertical direction. Those pulsewidths are almost equal though the shape of those TRP is somewhat different. Figure.3 is the TRP to the south north velocity component. The TRP to Shuzenji is shown in **Fig.4.** The pulse stands up from almost time base 0 as well as Fig.3. That is, the time convergence that is one of the effectiveness of the time-reversal process is filled enough. However, the pulsewidth increases compared with Fig.3, and there are reflected pulses from three seconds after. The reflected pulse can be disregarded if there is a time difference in an original pulse and the reflected pulse though the reflected pulse is caused when the number of array elements is little. Similarly, the TRP to Shimoda is shown in **Fig.5.** The pulses after two seconds in time are the reflected pulse. The pulsewidth of the original pulse becomes small though the reflected pulse increases compared with Fig.4, and the pulsewidth is near Fig.3. The relation between the range and the pulsewidth for each reception point is given in **Table 1**. The TRP doesn't subject the effect of the propagation environment easily when the reception point is near the hypocenter. It is assumed that the TRP of Itonaka that is the nearest the hypocenter is the pulse at the hypocenter. The pulsewidth of the TRP for other observation points is wider and the compressibility of the pulse is inferior. However, the pulsewidth of the TRP of furthest Shimoda is the nearest that of Itonaka in 2.3ms. On the other hand, the pulsewidth of the TRP of Kawazu that is nearer than Shimoda is larger than the value of Shimoda in 2.6ms from the hypocenter in the same direction. Moreover, the difference is caused in the pulsewidth though the range of Nirayama and Kan'nami is almost equal. The reason for these results is that the propagation environment was assumed to be a uniform propagation environment based on Fig.1.

4. Summary

To verify the effectiveness of the time-reversal process to the signal received by one seismometer, the convergence of the time reversal pulse was examined. The degradation of converging by the inhomogeneity of the propagation environment was seen though there was no problem in a time convergence. It will be thought that a detailed examination of the propagation model is necessary in the future.

Acknowledgement

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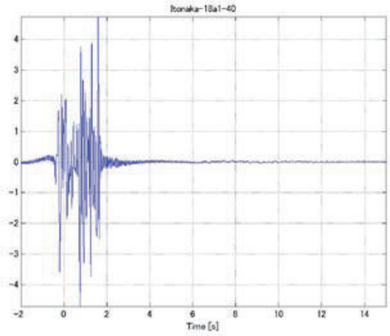

Fig.3 Time reversal pulse for Itonaka site.

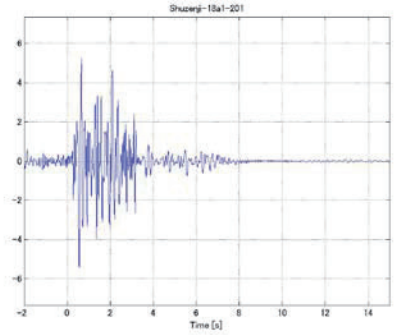

Fig.4 Time reversal pulse for Shuzenji site.

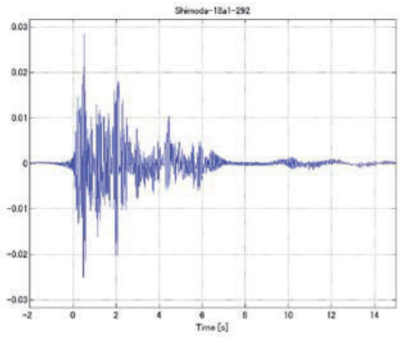

Fig.5 Time reversal pulse for Shimoda site.

Table 1 Pulse width of time reversal to range from hypocenter.

	Range [km]	Pulse Width [ms]
Itonaka	4.0	2.1
Shuzenji	20.0	2.8
Nirayama	20.2	2.8
Kannami	20.7	2.5
Kawazu	23.3	2.6
Manazuru	22.1	2.9
Shimoda	29.2	2.3

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