Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS027-11 Room:105 Time:May 22 14:45-15:00

Time reversal of seismic waves in Izu peninsula

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The time-reversal process is performed to the seismic wave that occurred in Izu peninsula central part on December 18, 2009, and vibration on the hypocenter is obtained. There are many difficulties that should be solved for the application of the time-reversal process to the seismic wave. Acquisition of detailed propagation environment in underground is difficult, and the number of elements of the array is limited. To obtain the propagation environment that is the most important factor on the application of the time reversal, we proposed an inverse problem method using robustness of the time reversal. First of all, velocity of seismic wave was obtained from the relation between the range and the propagation time from the hypocenter to the observation station. The velocity of the P wave was 5633 m/s. This value is the average velocity from the hypocenter to the observation station, and the average value is insufficient for the time-reversal process. The time reversal pulse formed on the hypocenter is theoretically shown by the product of Green function from the hypocenter to the observation station, the conjugate Green function from the observation station to the hypocenter, and the spectrum of the hypocenter vibration. The product of Green function from the hypocenter to the observation station and the spectrum of the hypocenter vibration are reflected in the signal received at the observation station. On the other hand, the product of the signal to which the received signal is time-reversed and the conjugate Green function from the observation station to the hypocenter is reflected in the pulse formed on the hypocenter. However, Green function from the observation station to the hypocenter is unknown. Then, the robustness of the time reversal is used. First, the pressure fluctuation on the hypocenter is obtained by assuming the propagation environment to be a uniform layer that consists of the average velocity, and using the propagation model for Green function. Parabolic equation method is used here for the propagation model. The rise time of the formed pulse approaches time axis 0 as it approaches the hypocenter. That is, the principle of the time reversal has been obviously approved. However, a systematic change in the time reversal pulse was not seen for the change in the velocity structure. That is, it is necessary to grasp a more detailed propagation environment. The contributing parameter is pressure in the same in all sea areas though the sound speed structure in the sea changes by the temperature, salinity, and the current. Underground velocity is assumed to subject the effect of pressure, and the velocity is increased monotonously in depth from surface of the earth to 7000 m. The velocity gradient is assumed to be a parameter, the propagation environment is changed, and the amplitude change of the time reversal pulse is obtained. The amplitude of the pulse became the greatest at a certain gradient. When the velocity gradient is 0.14 in observation station Shimoda, the amplitude became the greatest. The transmission path from the hypocenter to the observation station was obtained by the propagation environment with this velocity gradient. The wave horizontally radiated from the hypocenter reaches the surface of the earth of the range 17 km. The wave radiated from the horizontal up reaches the surface of the earth at the range that is shorter than 17 km. From the results, future tasks are obtaining the detailed propagation environment corresponding to the range between the hypocenter and the observation station. In this paper, data from Hi-net of National Research Institute for Disaster Prevention was used. We express our gratitude.

Keywords: Time reversal, Phase conjugation, hypocenter vibration, Seismic wave propagation, Underwater acoustics