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Improvement in the accuracy of GPS/Acoustic measurement using a multi-purpose moored buoy

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In 2011 Tohoku-oki earthquake (Mw 9.0), seafloor geodetic observation using GPS/Acoustic measurement revealed that large co-seismic slip occurred along the Japan trench (Kido et al., 2011; Sato et al., 2011). For clarifying the mechanism of plate boundary earthquakes and forecasting Tsunami immediately, it is necessary to monitor seafloor crustal deformation and Tsunami in the source region. DONET and the GPS buoy system monitor Tsunamis in offshore. On the other hand, horizontal seafloor crustal deformation is measured by GPS/Acoustic surveys, which are mainly carried out by campaigns several times a year. Therefore, we cannot obtain information on co-seismic and post-seismic crustal deformations immediately. Considering the above, JAMSTEC, JAXA, Tohoku University have jointly developed a continuous observation system using a moored buoy and have started its sea-trial at Kumano-nada in 2013 and 2014 (Takahashi et al., 2014). In this study, we evaluate the accuracy of the estimate of horizontal seafloor crustal deformation using the data obtained by this system in the 2014 sea-trial. Moreover, we propose an analysis for improving positioning accuracy.

In general, GPS/A survey is carried out near the center of the transponder array, which cancel out the effect of the time?variation of layered sound speed structure. Due to violation in the assumption of layered structure, positioning accuracy of each shot is 20 ~30 cm. By repeating this in a campaign observation half a day, we realize to measure crustal deformation in a few cm order (Spiess et al., 1998). On the other hand, the buoy is moored by slack cable for observation at strong tide and the acoustic ranging is carried out at a point away from the array center. A set of acoustic ranging consists of 11 pings an interval 65 seconds. This cycle repeated once a week. Therefore, it is not possible to cancel the time variation of the speed sound. Based on the above and the fact that our target is detecting of the co-seismic slip associated with massive earthquake just above the source region, we aim that positioning accuracy is 1m order.

In the acoustic ranging, each travel time is obtained by picking up the maximum peak in correlogram between transmitted and received waves. In the current system, only 1ms of correlograms (8bit, sampling frequency: 100 kHz) are sent to land station to save bandwidth in the satellite communication. However, by investigating the raw data recovering after sea-trial, it is revealed that the travel time of multi-path at sea surface is often sent to land station through the process mentioned above. Imano et al. (2014) proposed the new method to pick up the earliest peak of peaks in a correlogram for a single acoustic signal. We estimate the array center based on Kido et al. (2006) using the travel time obtained by the conventional method and the travel time obtained by Imano et al. (2014). The standard deviation of the estimated array center using the travel time obtained by the conventional method is 3.7 m (East-West component) and 2.6 m (North-South component) in the data in a week, 5.2 m (E-W) and 3.9 m (N-S) in the data in the entire period. On the other hand, the standard deviation using the travel time obtained by Imano et al. (2014) is 0.45 m (East-West component) and 0.34 m (North-South component) in the data in a week, 3.6 m (E-W) and 2.2 m (N-S) in the entire period. The apparent fluctuation of the estimated array center of the latter is smaller than that of the former, in the same week data in particular. However, the fluctuation of the array center is a few meter order in the entire observation period. Therefore, we should take measures such as re-analyzing after determining the position of each transponder in the accuracy about 10 cm in order to aim that the accuracy of GPS/A measurement using the buoy system is 1 m order in the future. In this presentation, we demonstrate and discuss how much the accuracy is improved after the measure.

Keywords: Seafloor crustal deformation, Moored buoy