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Some improvements in the GPS/Acoustic seafloor positioning

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GPS/Acoustic (GPS/A) seafloor positioning has become an indispensable geodetic observation for the monitoring of crustal activities near plate boundaries. There remain, however, substantial differences from GPS observation on land. Our group in Tohoku University has been working to cope with the problems under the programs for improved GPS/A observation system supported by the MEXT, Japan.

One of critical problems regarding the present GPS/A observation lies in the campaign style observation spending one or two days to measure the position of an array of acoustic transponders (PXPs) once or twice a year. It is similar to the triangulation observation on land before the age of the GPS. Chadwell et al. (2009, AGU Fall Meeting) made a step forward for this problem by carrying out a continuous GPS/A observation with a moored buoy. We are also developing a system using a moored small buoy.

Precision of seafloor positioning by GPS/A is another critical problems. Considering that plate motions are several centimeters per year in most cases, precision of a few centimeters by GPS/A is a big difference from a few millimeters by GPS on land. Estimating that lateral variations in the sound velocity in the ocean can be a key to improve the precision in the positioning and to reduce the required time for the measurement, we have partly succeeded in estimating the lateral variations in the acoustic velocity by using 4-5 PXPs (Kido et al., 2006; Kido et al., 2010).

Long-term attitude stability of the position of a PXP deployed on thick sediment has been a basic problem in the GPS/A observation. While a pillar of a GPS antenna for an observation point is set up firmly on the ground, a PXP is deployed on the seafloor after a free fall from the sea surface. It is a serious problem to detect coseismic crustal movements on the seafloor. M7-class earthquakes occurred in 2004 off Kii Peninsula, Central Japan, gave us an opportunity to study the problem. By using an ROV (remotely operated vehicle), we visually observed ten PXPs in 2006, seven of which had been used to detect coseismic seafloor crustal movements of 20 cm or more as was reported by Kido et al. (2006) and by Tadokoro et al. (2006). The diving survey confirmed that all of the seven PXPs stood stably on the flat sediment, no effects of the earthquakes being recognized. Even if slight tilts of the PXPs were caused by the earthquakes, the effect on the seafloor positioning by GPS/A was estimated to be 1 cm or less (Fujimoto et al., in press).

A PXP has been deployed for a permanent (actually several to 10 years) use. Therefore, it is not equipped with a recovery system as is used for an ocean bottom seismometers or pressure recorders. From our experience we have often wished to retrieve a PXP to revise its performance, to slightly change its position, or to reuse it after the battery is exhausted. We tried to use a long-life acoustic recovery system for three PXPs. We successfully recovered all of them 4.5 years after their deployment.