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Continuous measurements of ocean bottom crustal movements based on GPS-acoustic system using GPS buoy

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We report the results of experiments of continuous measurements of ocean bottom crustal movements using GPS buoy and acoustic system.

We have developed a GPS buoy system for the early detection of tsunami. The system uses a buoy that is freely floating on the sea, tied to the sea bottom using an anchor, equipped with a GPS sensor at the top of the buoy. The system enables us to estimate the position of the buoy in a few centimeter accuracy.

On the other hand, Spiess (1985) and other researchers have developed the GPS-acoustic system for estimating the ocean bottom position in sub-decimeter accuracy. However, these systems have used owned or chartered vessels to measure the position of ocean surface, so that the measurements have been only intermittent. After the 2011 Tohoku-oki earthquake of Mw9.0, it has been recognized that continuous monitoring of ocean bottom crustal deformation is very important. Thus, we got an idea in that the GPS buoy could be used for the continuous monitoring of the ocean bottom crustal movements, if an acoustic system is equipped at the GPS buoy.

Based on this idea, we started experiments using our GPS buoy, which is located off Muroto Peninsula, western Japan, in the year of 2013. After a preliminary experiment in March 2013, we made an experimental observation from August to October of 2013. Three transponders were placed around the buoy and the equipment of sound sender/receiver at the side surface of the buoy. The water depth of the site is about 700meter and the ocean bottom transponders are placed so that the distances among these are in the same scale. We will report the results including noise characteristics of data, daily repeatability of estimated ocean bottom position, effects of swinging buoy, etc.

Currently, 15 GPS buoys have been established around the Japanese coasts. Augmentations of the acoustic system in these GPS buoy network will provide a powerful tool of monitoring ocean bottom crustal movements as well as tsunamis. Further requirements to GPS buoys are to be placed farther offshore, say, more than 100km from the coast. Recent developments of the GPS buoy system, including a newly developed algorithm, PPP-AR (precise point positioning with ambiguity resolution), clarified this requirements. However, still another problem of how data at the buoy placed far offshore is transmitted to land in real-time manner is still to be solved. For such problem of a newly designed high capacity data transmission system using a dedicated satellite system will be necessary. Our current experiment will provide an important data for designing a specification of such satellite system.

Spiess, IEEE Trans. Geosci. Remote Sens., 23, 502-510, 1985