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New approaches to advanced GPS/A geodetic observation on the seafloor

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(1) A plan for better positioning in shorter time

The 2011 Tohoku-oki earthquake was accompanied with exceptionally large coseismic slips near the trench axis, where land-based GPS has little resolution on the seismic coupling on the plate boundary. Then we have added 20 GPS/A observation sites along the Japan Trench for the Japanese geodetic group with a fund from the MEXT Japan. The Japan Coast Guard has also added 9 observation sites along the Nankai Trough. Although there still remains a big difference from the GPS networks on land, the extension of the GPS/A observation was a big progress. On the other hand, it requires more ship time. We have to solve this problem to fill the gaps such as the area near the Nankai Trough axis. Since we have spent half a day or a full day at a site for GPS/A observation, the first thing we should do is to reduce the time at a site.

We have estimated from our observation results that a breakthrough for the problem would be measurement of horizontal gradients of sound speed in the surface layer of the ocean. The group of Nagoya University had proposed to carry out acoustic positioning by using a few moored buoys. We have found that an important point in such positioning lies in nearly simultaneous acoustic ranging from two surface units apart at certain distance to four precision acoustic transponders (PXPs). Then we can roughly measure a sound speed gradient in the direction connecting the two surface units. The value in any direction can be obtained by changing the positions of the surface units. After some trials to get know-hows, we can reduce the observation time to get a repeatability of a few centimeters. If three surface units are available, a precise position can theoretically be obtained at each acoustic positioning. The Japan Trench area is one of the major fishery fields in the world, and many fishery nets longer than 10 km are extended there. We hope to carry out experiments at an appropriate site to validate this method consulting with fishermen.

(2) An approach to semireal-time continuous observation

Real-time continuous observation is the final goal of seafloor geodetic observation. A realistic target for the moment will be to get daily or weekly positions of the seafloor. There are two major problems in the way to semireal-time continuous GPS/A observation. Firstly GPS/A observation needs sea surface vehicles for the GPS positioning. A self-navigating buoy called Wave Glider can sail at about 1.5 knot with the power of surface waves of the ocean. It can survive in the rough seas associated with typhoons. We estimate that two sets of Wave Gliders or a pair of moored buoy and a Wave Glider can solve the first problem.

The second problem is precise GPS positioning. The kinematic GPS method we have used needs sending the GPS data from the sea surface unit to a land station. This requires satellite data transmission at least 4800 baud, for which we are studying a solution with a group of the JAXA. Recently we have found a tentative solution. Yamamoto et al. (this meeting) evaluated the stability of the kinematic solution of a station on land with the corrected signal by the StarFire system in October 2012. They confirmed that the standard deviation of the horizontal solutions is less than 1.5 cm. And also, the obtained time series is within 2 cm from the daily position by the GIPSY-OASIS II software version 6.1.2, which we use for the kinematic GPS positioning.

The battery capacity of the PXPs newly deployed in 2012 can respond about 20 times every day in a long-term observation. We expect that three surface units can get several centimeters of repeatability. Although the daily cost for the StarFire and the Iridium is much less than that for ship time, one week will be the minimum interval, if the observation continues for a year or longer. We need less expensive satellite data telemetry to get daily GPS/A positions for long time.

Keywords: seafloor geodetic observation, GPS/A, Tohoku-oki earthquake, seismic coupling, horizontal gradient of sound speed, daily position