Evaluation of accuracy in ship positioning from surrounding coastal reference stations

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To monitor seafloor crustal deformation is one of the most important roles of global strain measurement because about 70 % of the Earth's surface is covered with seawater. Additionally, most part of the plate boundaries and seismogenic zones of interplate earthquakes are located under the sea. To achieve the monitoring of seafloor crustal deformation, we have developed a system with kinematic GPS positioning and acoustic ranging.

We have repeatedly tested for the accuracy of our system at Suruga Bay, central Japan. Suruga Bay is an appropriate site to develop and test the seafloor observation system because an observation vessel can be well-surrounded by coastal GPS reference stations with short baselines. In addition, there is a plate boundary between the Philippine Sea and Eurasian plates beneath Suruga Bay where a large earthquake has been anticipated to occur in a seismic gap, and Suruga Bay is worthy of monitoring the crustal deformation.

In the Suruga Trough, we installed two sets of three ocean-bottom units at depths about 800 m on both sides of the trough on October 29-30 and November 19-21, 2002, respectively. We measured the slant ranges between the acoustic transducer on the observation vessel and the ocean-bottom units using our system. Combining ship positions measured by GPS, vessel's attitudes, and acoustic travel-time data, we determine the precise locations of ocean-bottom units. If we continue to measure their locations accurately, the observations enable us to estimate the strain accumulation at the plate boundary.

We used the software GIPSY/OASIS-II, developed by Jet Propulsion Laboratory, to determine the GPS antenna position every second by means of the kinematic positioning. The most characteristic feature in this study is to form a number of baselines from coastal reference stations to the vessel. The algorithm we have developed make it possible to calculate very accurate seafloor position with acoustic ranging data and the sound velocity estimated by the CTD profiler. We report how to evaluate vessel's trajectory and its systematic error. The present observation system will attain a centimeter-level resolution of sea-bottom position.