GPS/Acoustic seafloor positioning based on continuous temperature and pressure measurements in seawater

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1.Introduction

Observations of seafloor crustal deformation is very important to understand the dynamics of plate boundary that include the strain accumulation processes, great interplate earthquakes mechanisms, and submarine volcanoes activities. We have been developing an observation system with the GPS/Acoustic combination technique for monitoring of seafloor crustal deformation at the Suruga Bay [Tadokoro et al., 2003] and the Kumano basin [Tadokoro et al., 2004] from 2002 and 2003, respectively. Repeated measurements of seafloor transponder can reveal directly the seafloor crustal deformation in the focal area of the subduction zone. The primary purpose of our observation is to detect and monitor the crustal deformation caused by the subduction where huge earthquakes repeatedly occur.

2.Signification of GPS/Acoustic seafloor positioning

Suruga Trough is a stable tectonic area with convergence rate of 2-4 cm/year [Heki and Miyazaki, 2001]. Aside from this, we consider Suruga Bay as an appropriate site to evaluate the seafloor positioning because we can set the reference GPS station with short baseline (-20 km). The error of the horizontal component of kinematic GPS positioning given such distance is about 1-2 cm. For these reasons, we can evaluate the positioning analysis with high accuracy and the repeatability.

3.Purpose and Observation

In order to resolve a trade-off between the estimated structure of sound speed and positions of seafloor transponders, we need to estimate or measure the structure of sound speed precisely. In our observation, we adopted the precise measurement of spatio-temporal change of sound speed. We measure and model for the spatio-temporal change of sound speed based on repeated CTD (C: conductivity, T: temperature, D: depth) measurements [Sugimoto et al., 2005]. Since it takes about 30 minutes to deploy the CTD depth-profile, the model for spatio-temporal change of sound likewise has a 30-minute gap or delay on its record. Considering that most spatio-temporal change of sound speed is explained by the spatio-temporal change of temperature under the sea. We can measure and model the spatio-temporal change of temperature with a difference of less than 20cm/sec even with or without the measurement of salinity. Thus, we try to estimate the positions of seafloor transponders with the model for spatio-temporal change of sound speed based on continuous temperature and pressure measurements with 3 second sampling.

In our observation area, three acoustic transponders are installed as an array on the seafloor with the water depth of about 800 m. These transponders are located within a radius of about 300 m. Using the low-noise-engine vessel, we can control and keep the acoustic measurements distribution for each transponder. In parallel with the acoustic measurements, we also measure the sound speed profile of seawater using a CTD profiler three times per observation (about 5 hours). Moreover, the research vessel tows four TD-sensors with interval of 100 meters depth.

In this study, we will discuss the evaluation of the spatio-temporal change of sound speed that are measured and estimated simultaneously with spatio-temporal change of sound speed and position of seafloor transponders. And finaly, we will report the repeatability of positions of the seafloor transponders.