Development of observation system for seafloor crustal deformation: Measurement errors with acoustic positioning (2)

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The observation system for the seafloor crustal deformation have been being developed since 1996. The rates of the plate motions around Japan range from a couple of cm to about 10 cm per year. Thus, it is necessary that the errors of this system should be less than a few cm to detect the seafloor crustal deformation. Therefore, the primary factors that cause the measurement errors must be investigated.

In this study, simulations were carried out taking into account the velocity structure obtained by CTD observation which was carried out in Suruga Bay in January, 2001. The simulation in this study enable us to investigate the cause of vertical errors on the seafloor reference position. Furthermore, we have determined a way to minimize the vertical errors remarkably.

Observation of seafloor crustal deformation is very important to determine the nucleation processes and mechanisms of large earthquakes as well as the activities of submarine volcanoes.

The observation system for the seafloor crustal deformation have been being developed since 1996. This system consists of two main components; (1) kinematic GPS positioning of research vessel and (2) accurate acoustic measurements of distances between transducers attached on the side of the vessel (vessel unit) and the ocean bottom (seafloor references).

The travel times of the ultrasonic waves from the vessel unit to seafloor references and back into the unit are observed. The vessel unit sends 3.41-ms-long ultrasonic chirp waves with a gradual change in frequency (12 to 8 kHz). Seafloor references send new chirp waves whose frequencies change from 8 to 12 kHz after receiving signals from the vessel unit. The vessel unit detects signals by calculating the coefficients of cross correlation between the ideal signal without various noises and received signals. We are able to obtain the time it takes from the vessel unit and seafloor references and back into the vessel unit.

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Yamada et al. (2000, SSJ Fall Meeting), using numerical simulations to estimate measurement errors with acoustic positioning, reported that the chirp waves are usually noise-proof and their arrival times are detected precisely. Moreover, they showed that (1) the positions of seafloor references can be determined precisely if there are observation lines on both sides of the references, (2) the seasonal changes of sonic-wave velocity structure may have little effect on determining positions of seafloor references, and (3) the daily changes of them could cause serious measurement errors. They also reported that the vertical position of the seafloor reference could usually be determined about 10 cm off from their real position even though the position was determined in 95% accuracy. This error in position may be due to the velocity structure used in their analysis.

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