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Application of inclined sound velocity structure to the measurement of ocean bottom crustal deformation

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We are developing a geodetic method of monitoring crustal deformation under the ocean using kinematic GPS and acoustic ranging. The goal of our research is to achieve sub-centimeter accuracy in measuring oceanic crustal deformation by a very short-time measurement like 10 hours. In this study, we focused on lateral variation of acoustic velocity structure in seawater and applied an inclined acoustic velocity structure model to the data analysis.

We have a few measurement sites along Nankai trough. In each site, we deployed a trio of transponders on ocean floor (seafloor benchmark units) within distance comparable with the depth.

An ultrasonic signal is generated from a surface vessel drifting over the benchmark unit, which is received and replied by the benchmark unit. In this system, both acoustic velocity structure and the benchmark unit positions were determined simultaneously for the each measurement using a tomographic technique. This tomographic technique has been adopted on an assumption that the acoustic velocity structure is horizontally layered and changes only in time, not in space. Ikuta et al., (JPGU 2010) reported an approach to improve accuracy of benchmark positioning using a new additional assumption. The additional assumption was that the configuration of the transponders trio constituting one benchmark unit does not change. They determined the time evolution of weight center for the fixed transponder triangle between different measurements using all repetitively obtained data sets at once. This is contrasting to the previous method in which each data set for different measurement was solved independently. This assumption worked well in reducing number of unknown parameters. As a result, repeatability of benchmark positioning improved from 5 cm to 3 cm.

In the new model in this study, we arrowed the velocity structure to be changed horizontally also. The accuracy of the positioning improved to be much better than that by old approach. We adopted this new model and the approach to solve the real data sets. As a result, the repeatability of the benchmark positioning improved from 3.1 cm to 2.5 cm in horizontal component. Although the improvement is not significant, this is of great significance in strategy of analysis. We can adjust freedom of the model or adopt some constraint to make new model to be more robust.

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