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Development of a new method for GPS/Acoustic seafloor observation using multi-buoy system

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We are developing a method for observation of seafloor crustal deformation using kinematic GPS and acoustic ranging system. The system measures seafloor crustal deformation by determining position of benchmarks on the seafloor using a vessel which link-up GPS and acoustic signals. Acoustic ranging is used to measure distance between the vessel and seafloor benchmarks. And kinematic GPS is used to locate the moving vessel every 0.2 seconds. Now we have deployed 4 seafloor benchmark units at Suruga Bay and 4 units at Kumano Basin. At each survey site, three seafloor transponders are settled to define a benchmark unit. In this system, each measurement takes about ten hours and both sound speed structure and the benchmark unit positions were determined simultaneously for the each measurement using a tomographic technique. This tomographic technique was adopted on assumption that the sound speed structure is horizontally layered and changes only in time, not in space. However, when sound speed structure has a heterogenity, the assumption of a horizontally layer causes error in the determination of seafloor benchmarks. So we are developing a new system using multi-buoy. In this system, multi-buoy plays role of vessel. Doing observation by the buoys, we can estimate spatial variation of sound speed structures every moment. In November 2012, first observation of seafloor crustal deformation using the buoys was held in Suruga Bay. In this study, we estimate a spatial variation of sound speed structures and, at the same time, defined some problems in this system. From checking of the waveform data, we found that there are differences in the yield of data. These differences are caused by the observation system itself. We estimate that when the difference of acoustic path is less than 413m, the buoys do not make a record of the waveform data. We estimated a spatial variation of sound speed structures by evaluating residuals of one-way travel-time between the buoys and the seafloor benchmarks. As a result, we found large scale (between the different buoys) spatial variation of sound speed structure. But small scale (between the same buoys) spatial variation was not detected. To estimate a small scale spatial variation, attitude of the buoys should be monitored by motion sensors like gyrocompass. From approximate calculation, it is predicted that traveltime errors of 0.16ms at maximum can be removed by introduction of a good motion sensor.

Keywords: seafloor crustal deformation, moored buoy, GPS/Acoustic, sound velocity, spatio-temporal variation