The effect of sound speed variation on GPS/Acoustic seafloor positioning

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We from three institutions jointly developed a precision, digital acoustic ranging system for deep seafloor. Scripps institution of Oceanography, University of California, started a GPS/Acoustic (GPS/A) experiment for monitoring crustal deformation on the southeastern slope of Hawaii Island by using the same acoustic system, and deployed 7 precision acoustic transponders(PXP). The area is on a long submarine slope, and ocean tide may bring about daily variations in sound speed structure. These features are similar to those of subduction zone. We therefore jointed the first cruise of the experiment in 2000 to examine the newly developed acoustic system and the effect of sound speed variations. We added one PXP and carried out GPS/A observation by using 3 PXPs deployed at the depth 2500 – 4500m. There was a GPS reference station at about 50 km away. Firstly we precisely located the position of each PXP. Assuming a constant sound speed, acoustic range residuals were 6-7 cm. The residuals suggest errors in the positioning of 30-40 cm.

Secondary GPS/A observation was carried out for 16 hours above the center of the PXP array. Temporal variation in the sound velocity was monitored with a continuous CTD observation. The results suggest that most of the sound speed variations are limited in the upper 500 m of the ocean. Difference between acoustic ranges to each PXP varies by +/- 60 cm due to daily variation of the sound speed. However, the variations in the sound speed were coherent among the travel times to the 3 PXPs, and most of the effects on the positioning of the PXP array were canceled. Residual of a single acoustic positioning compared with KGPS positioning was 8-10 cm RMS.

Finally we estimated the accuracy of array center on this experiment for 16 hours. The results may include oceanographic effects, KGPS and acoustic multi-path in short-term. Averaging the data over these 1-h blocks reduce the effect of short-term variations in the residual. Average position values for the array center for these 1-h blocks have been treated as individual measurements for purposes. Error in the average position of the array obtained from 16 hours measurements was estimated to be 2 cm RMS. And we discuss the accuracy of each part on GPS/A obsearvation.