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Error analysis of seafloor precision acoustic transponder positions

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The Pacific plate is subducting at the Japan Trench at a fast rate of about 10 cm/y, and interplate earthquakes caused by the constant plate motions occur episodically at an interval of tens of years. The seismic coupling coefficient in this region has been estimated to be 20-40% from seismological analysis (Kawasaki et al., 2001). That is, large part of interplate stresses might be released with aseismic slips.

According to the analysis by Heki et al. (1997), co-seismic deformation on land was about 10 cm, whereas large deformation as large as 2 m was estimated on the seafloor. They have also shown that cumulative post-seismic deformation is comparable to the co-seismic slip. Although conventional space geodetic technique cannot be directly applied to the seafloor due to strong attenuation of electric waves in the seawater, precise seafloor positioning by using acoustic waves is crucial to give observational constraint on the studies of the interplate earthquakes. Asada and Yabuki (2000) deployed a few sets of GPS/Acoustic positioning system on the landward slope of the trench. We have also started an experiment both on the landward and seaward slope of the trench to give direct constraint on the seismic coupling at the subduction zone.

We developed a precision acoustic transponder (PXP) system for precise ranging of 10 km, enough to locate a position on the Pacific plate at about 6 km water depth, and confirmed precise acoustic ranging up to 14 km with the system (Fujimoto et al., 2001). We joined KT01-11 cruise of the R/V Tansei-maru, Ocean Research Institute (ORI), University of Tokyo, around the Japan Trench in late July 2001. We could allot 4 days to GPS/Acoustic experiments and deployed three precision acoustic transponders (PXP's) both on the Pacific plate (280 km from the coast, depth around 5450 m) and on the landward slope (110 km from the coast, depth around 1600 m). A surface buoy with 3 GPS antennas and a hydrophone was used for the GPS/Acoustic experiment.

We surveyed the positions of two out of three PXP's by towing a buoy in a about 4 km radius around each transponder. The position of the transducer on the buoy was determined relative to the three GPS antennas on the buoy by an optical survey on the deck of the ship. We also measured the pressure at each PXP. We will describe how the acoustic data between the buoy and each PXP is combined with the GPS-determined buoy positions, the pressure, and the oceanic density profile to produce an independent estimate of the global position of each PXP. For this purpose, proper treatment of error sources and error propagation deserve extensive discussion. In addition, we will quantify the effect of Doppler on acoustic measurements due to the buoy's motion.