GPS/Acoustic seafloor positioning by using Japanese system off the coast of Miyagi

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1. Introduction

We developed an observation system for seafloor positioning combining kinematic GPS (KGPS) and precise acoustic ranging in sea water to investigate dynamics of plate boundary. We present a preliminary result of an experiment carried out off the coast of Miyagi Prefecture in August, 2003 (Ito et al. 2003).

2. Data Set

Data used for seafloor positioning consists of three elements: position of a sea-surface transducer, two way travel times between the transducer and precision acoustic transponders (PXP's) on ocean bottom, and the sound velocity structure. Using 3 GPS antennas and receivers on a buoy with a transducer at its bottom, we determine locations and attitudes of the buoy every second by KGPS analyses. The locations of transducer can, then, be calculated by measuring the relative position among the 3 GPS antennas and transducer.

Acoustic wave packets with a length of 18.6ms and a frequency of about 10kHz, are transmitted from the transducer toward PXP's on the seafloor. PXP's transmit the same signal as received to the buoy. We can calculate the two way travel time with resolving power of 0.002msec (1.5mm), by taking correlation between the transmitted and the received wave packets at the buoy.

During experiments, we deployed CTD to measure salinity, temperatures, and pressure, one hour before the buoy operation. We also performed XBT casts every 3 hours to measure temperature. Sound velocity structure is then estimated by using the empirical law by Del Grosso (1974) from these data.

3. Analysis Method

There are 2 steps to estimate the location of the center of PXP array. At first, we estimate the positions of each PXP using data collected while the buoy shifted around each PXP. We utilize a grid search to minimize RMS difference between the observed and calculated travel time. We firstly estimate horizontal locations of each PXP by fixing its depth, and then, estimate the depth of each PXP by using all data with fixed horizontal locations.

Next, we determine the coordinate of the PXP array using the data collected there.

4. Some Problems in the experiment

There were 3 problems in the experiment. Firstly, because of the short time we could collect data only for few hours in the center of PXP array. Secondly, there are some time windows when the results of KGPS analyses show large variance. Most of them are consistent with the period of high PDOP. Finally, we have insufficient CTD and XBT measurements and could not wake appropriate corrections for the variations in the sound velocity.