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Detection of post-seismic movement after Tohoku-oki Earthquake using GPS/Acoustic technique

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Using GPS/Acoustic seafloor geodetic observation (GPS/A observation), we can directly measure seafloor movements, which cannot be obtained from on-land geodetic observation. For example, Kido et al. (2011) and Sato et al. (2011) detected huge co-seismic displacements associated with 2011 off Pacific coast of Tohoku Earthquake near the Japan Trench, 150km distant from the coast.

After the occurrence of the Tohoku-oki Earthquake, we deployed new seafloor benchmarks at 20 sites along the Japan Trench from Ibaraki-oki to Sanriku-oki. Including three sites installed before 2011, we totally have 23 sites to monitor the post-seismic movement for the Tohoku-oki Earthquake. We have conducted four GPS/Acoustic surveys at present (09/2012, 11/2012, 07/2013, 10/2013) at these sites.

The surveys consists of two types of observations; they are moving survey to locate the position of individual seafloor transponders that make up each geodetic site and point survey to determine the precise location of the center of the transponder array. The displacement at each site is estimated from the temporal change of the array center position. However, we identified two dominant factors that influence the precision of the array center positioning in our observation.

The first factor is the instability in the waveforms of acoustic signals. In GPS/A analysis, we calculate cross-correlation waveform between received and transmitted signals, and determine the timing of maximum peak as round trip travel time. However, multiple peaks separated by 0.3-0.5ms each other are found in a cross correlation waveform, whose relative amplitudes are influenced by the relative position between the hydrophone on the research ship and the seafloor transponder. We have developed an algorithm that can automatically picks up the first peak from the multiples and reduces the error in determining round trip travel time. The detail of this problem and the algorithm will be reported by Azuma et al. (2014, JpGU).

The second factor is uncertainty in the position of the hydrophone equipped on the research ship with respect to three GPS antennas at the top of the ship for attitude determination. In our observations, it is difficult to directly measure the relative position of the three GPS antennas and the hydrophone attached at the end of the pole mounted on the ship's side; the provisional position based on the drawing has about 1m offset. The horizontal component of the offset causes systematic deviation in the apparent position of the transponders depend on ship's heading. Taking this behavior into account, we can correct for the horizontal offset with about 5cm in accuracy. The vertical offset is thought to have less influence on the estimation of the array center position because the sound speed correction intrinsically includes the vertical offset. However, accuracy of offset estimation is still insufficient, hence the estimation technique must be refined further.

After these correction, we have succeeded to obtain preliminary movements at 10 sites using the data in two of the four surveys (09/2012 and 07/2013) at present. These preliminary results generally indicate eastward seafloor movements at the northern Sanriku-oki sites and westward movements at off-Miyagi sites. In this talk, we introduce outline of the analysis and up-to-date results of evaluation of the post-seismic movement incorporating the data in 11/2012 and 10/2013.

Keywords: seafloor geodesy, Tohoku-oki Earthquake, Japan Trench, post-seismic movement