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Initial data evaluation of seismometer and tiltmeter installed in the C0002G borehole observatory in the Nankai Trough

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Cable connection between DONET (Dense Oceanfloor Network system for Earthquake and Tsunamis) and C0002G observatory was successfully completed on Jan. 24, 2013. The C0002G observatory has a sensor suite comprising a volumetric strainmeter, tiltmeter, seismometers, pressure gauge, and thermometer, which was installed during IODP Exp.332 on Dec. 2010. After the cable connection, it has become possible to obtain realtime observed borehole data through DONET seafloor cable. In this presentation, we report results of initial data processing especially for seismometers and tiltmeter for future advanced analysis.

We conducted initial data processing including: 1) Power spectral density analysis calculated from 1 hour continuous noise record and comparison results of each sensor. 2) Running spectrum analysis using continuous long-term data and comparison results of each sensor. 3) Estimation of sensor orientation. Details of each processing are described as follows.

1) Power spectral density analysis

We calculate Power spectral density (PSD) using background noise record with length of 1 hour. We obtain PSD plots calculated from each seismic sensor including a broadband seismometer (CMG3TBD, Guralp systems), geophone (GS-11D, Geospace), accelerometer (JA-5H200, JAE) and tiltmeter (LILY, Applied geomechanics). In the obtained PSD, microseisms peaks around 0.3 Hz are clearly visible for all sensors. We then compared obtained results of borehole sensors and DONET seafloor seismometer. Results show that the microseisms peaks of boreholes sensors are smaller than those of DONET seismometers. The difference is 10 dB for horizontal component, and is 3-5 dB for vertical component. For high frequency region, 1-50 Hz, noise-levels of borehole sensors are much smaller than those of DONET seafloor seismometer with the difference of around 20dB. These results imply borehole sensors can capture very small seismic events which cannot be captured by DONET seismometers. We also confirmed that obtained noise-levels are consistent with the results of land experiments which were conducted before installation. For geophone, we conducted the signal coil calibration method, and obtained response parameters which are not changed with those obtained during the land experiments. We then concluded that the borehole seismic sensors were not damaged during the installation.

2) Running spectrum analysis

We calculate running spectrum using long-term data acquired since Jan. 25 2013. We checked long-term stability of each borehole seismic sensor from the results. Results shows common characteristic as the results of 1 hour data. The daily changes of microseisms peaks are clearly visible in the results. Performance degradations of borehole sensors are not found in the results.

3) Estimation of sensor orientation

We applied a cross-correlation method based on Nakano et al. (2012) to teleseismic records to estimate orientation of borehole sensors. We calculate cross-correlation between rotated horizontal waveforms of borehole seismometer and reference horizontal waveforms of DONET seismometer. We calculated cross-correlations for each rotated angle from 0 to 360 degree with a rotation rate of 1 degree. We then obtained the orientation angle of 46 degree from North with clockwise rotation, which has a maximum amplitude of calculated cross-correlation.

The above mentioned results show that seismometer package and tiltmeter installed in C0002G observatory are functional with expected performance which was revealed by the land experiments. Now auto evaluation processes are running to monitor sensor functions on data server. We plan to carry out an advanced check for sensor response using earthquake records. We also plan to analyze very small seismic events which are captured only by the borehole observatory. Furthermore, we plan to perform seismic interferometry analysis applied to continuous noise records and earthquake records for structural monitoring.

Keywords: borehole observatory, seismometer, Nankai trough, data evaluation