Accuracy of real-time GPS/Acoustic measurement using a slackly moored buoy

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Coseismic geodetic data near the source region of an offshore large earthquake is crucial for the real-time estimation of its magnitude and source mechanism. GNSS network enables us to obtain onshore geodetic data in real-time. In offshore area, seafloor pressure gauge network (e.g. DONET) provides offshore geodetic data in vertical component. However, offshore geodetic data in horizontal component cannot be obtained in real-time because a seafloor positioning by means of GPS/Acoustic (GPS/A) method is carried out only by a campaign style using a research vessel. For the real-time detection of seafloor crustal movement associated with a large earthquake in subduction zone, we have developed a real-time GPS/A seafloor positioning system using a moored buoy. The buoy is moored by a slack cable which is 1.5 times longer than the water depth against strong current. The seafloor positioning is performed at unpredictable position due to drifting of the buoy, which is generally apart from the array center. This is a unique drawback of buoy observation compared to ship observation because this results in significant systematic positioning error. Therefore, we assess the accuracy of the GPS/A positioning for this ill-conditioned survey.

We have tested the system over a year in Kumano-nada, Nankai Trough and obtained the data for seafloor positioning in real-time as follows. A single acoustic ranging, which consists of continuous 11 pings with 65 sec interval, was carried out once a week and optionally on-demand. This sequence totally amounts to 102 times of ranging during the trial. The buoy position during acoustic ranging was estimated using kinematic PPP technique. The data for seafloor positioning were transmitted to the land station via iridium Short Burst Data service. Due to the low bite rate of the satellite communication, the data were automatically pre-processed and compressed within the buoy. It takes about ten minutes to transmit the compressed data for seafloor positioning after acoustic ranging, while GPS raw data and acoustic waveform data were stored in the buoy logger for technical purpose.

Using the data transmitted in real-time, we can estimate the seafloor array position for each ping. We regard the two standard deviations of the estimated array positons as the accuracy of the GPS/A positioning, because actual movement during the trial is negligible compared to the error. The final accuracy is 0.9/0.7 m in EW/NS component, which is significantly larger than that using a vessel (~0.1 m). During the trial, the buoy is randomly located within a ~4 km radius around the array while a vessel can stay on the above the array center. Apart from the array center, the error propagation of the observation data (e.g. the buoy position, travel time) arises due to uncertainty of the array geometry. Then, we classified the accuracy into two types; the buoy is within or out of the array. The former is 0.3/0.3 m while the one of the latter is 1.0/0.8 m. The seafloor crustal deformation associated with offshore large earthquakes (~M8) on the above of source area is considered to amount to a few meters. For the detection of it, we should improve the accuracy when the buoy is out of the array. There is room for the improvement also by re-determining the array geometry more precisely.

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