Evaluation of the effects of seafloor station array size on the accuracy of GNSS-A observation using synthetic data

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The Hydrographic and Oceanographic Department of Japan Coast Guard has been performing seafloor geodetic observations since the early 2000s using the GNSS-Acoustic ranging (GNSS-A) observation technique. With the GNSS-A technique, we measure the acoustic wave travel times between the transducer equipped on the bottom of the survey vessel and the mirror transponders (seafloor stations) installed on the seafloor, while tracking the precise position of the survey vessel using GNSS. By combining and analyzing these data with the survey vessel attitude data and the acoustic velocity profile measurements, we can locate the position of a seafloor reference site in precision of centimeters.
One of the largest consequences of GNSS-A observation is the observation frequency, which is only up to several times per year per seafloor site due to the limited ship time and human resources. The current observation system lacks the temporal resolution to observe phenomena with time scales less than few months. To increase the temporal resolution of GNSS-A observation, it is necessary to improve the observation efficiency to maximize the observation frequency in a limited ship time.
One of the key factors that affects the observation efficiency is the size of the seafloor station array. Four seafloor stations are installed to form a square array, with the seafloor site in the centroid, so the horizontal location of the seafloor site can be well defined compared to when only one station is installed. The size of the seafloor station array has been defined empirically from the early GNSS-A observations; that is, the length of the diagonals of the seafloor station array should be approximately the same as the depth of the seafloor site (Spiess, 1985, GRS). Since the size of the survey line array, which the vessel sails along during the observation, is set to twice the size of the seafloor station array, it is inevitable that the deeper sites take longer observation times compared to the shallower sites. This is a large concern for the new seafloor sites installed in the fiscal year of 2019, which were placed near the Nankai trough axis and have depths of approximately 3000~4000 meters. To improve the observation efficiency, it is necessary to reduce the observation times at these deep seafloor sites, which can be done by reducing the seafloor station array and the survey line array sizes of these sites. However, the effects of reducing the array size on the accuracy of GNSS-A observation have not been evaluated and remain to be unknown.
To evaluate the effects of reducing the seafloor station array size, we conducted an experiment using the GNSS-A observation simulator (Yokota et al. 2015, JpGU) to generate synthetic GNSS-A datasets, inputting different array sizes for each run. Like the actual GNSS-A data, each synthetic dataset was analyzed with an algorithm that alternately estimates the acoustic velocity profile and the seafloor station positions using linearized inversion (Fujita et al. 2006, EPS). In our presentation, we will present the analysis results of the synthetic GNSS-A datasets and discuss the effects of seafloor station array size on the accuracy of GNSS-A observation.

Keywords: GNSS-A observation, GNSS-A simulator, seafloor station array