Geodesy and broadband seismology from a mobile ocean bottom observation

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Our broadband ocean bottom seismometer (BBOBS) and its new generation (BBOBS-NX) have been in use to perform many practical observations for creating a new category of the ocean bottom broadband seismology since 1999. High mobility of the BBOBS and BBOBS-NX can be a breakthrough to realize the geodetic observation network on the seafloor too. Two this kind of attempts have been started since 2009. One is for vertical displacement measurement by using an absolute pressure gauge (APG) with the BBOBS, and another is for tilt measurement by using the mass position signal of the BB sensor. The former is already in several practical observations, but we still have problems in the long-term drift of the APG and also the short period noise of oceanic origin that is difficult to model in present. The later is at the evaluation stage by long term observations. From the test in 2010 at the land vault, the tilt resolution was comparable to that of the water tube tilt-meter, which is sub μrad. Result of an observation off Boso Pen. (KAP3 site) shows a clear peak signal in one tilt component at the same period of the slow slip event (SSE) occurred near the site between Dec. 2013 and Jan. 2014. Due to high noise level in another component that might be caused by the bottom current and/or topography of the site, it was difficult to perform more detail analysis. Another result at the Japan trench slope off Miyagi pref. between Sep. 2015 and April 2017 indicates large continuous tilt changes in both components. This amount of tilt can be explained by a similar SSE reported in Ito et al. (2013) that is difficult to detect at land observatories. But, we have no additional data nearby it to support existence of the SSE now. There is another unrecovered BBOBS-NX of two-years-long observation since 2015 at the KAP3 site, that has the important data for evaluation of this tilt observation system. From these test of the BBOBS-NX that has the BB sensor penetrated into the sediment, the effective resolution about a few μrad. We also made some tilt observations by the BBOBS that deployed on the seafloor. Compared with the tilt data of the BBOBS-NX, the effective resolution is larger as more than ten μrad, which is similar to the horizontal noise level difference between them. These resolution levels seem large compared with that of land observatories, but both instruments will be useful as they can be located above the source of such as SSEs. Recently, we have developed the autonomous type of the BBOBS-NX, which can be operated without submersibles. It will enable dense tilt observatories at the seafloor. The next target is the absolute or highly stable relative gravity measurement as the offline system. It may be realized by using a quantum interferometer technique that is already available as a laboratory instrument. This kind of observation will be useful to detect the vertical displacement, material migration below the seafloor and more.

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