Magnitude estimation by using ocean-bottom pressure gauge data

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Deployments of ocean-bottom stations such as DONET and S-net could enhance early signal detections and improvements of accuracy for hypocenter analyses of suboceanic earthquakes. However, at some accelerometer stations deployed in ocean-bottom areas, tilt and rotation motions of sensor and/or sensor hysteresis would have occurred during strong motions, which causes anomalous waveforms and analysis errors on seismic motions. At the 2016 moderate-sized suboceanic earthquake (Mjma 6.5) occurring off the Mie prefecture in southwest Japan, significant amplifications of observed amplitude to amplitude calculated from the empirical equation and their considerable spatial variations are found at the DONET stations (Nakamura et al., 2018), which would not be explained by the source radiation pattern and subsurface structures. These undesired amplifications and variations are considered to be caused by acceleration offsets that are associated with the tilt and rotation motions and/or sensor hysteresis and could contribute to the overestimation and instable estimation results of source analyses such as magnitude estimation and finite fault modeling. In this study, we attempt to estimate the amplitude magnitude by using pressure gauge (Paroscientific 8B7000-2) data at DONET stations instead of using accelerometer (Metrozet TSA-100S) data to suppress the undesired features and evaluate the stabilities. We analyzed the waveforms after integrating the observed pressure gauge data and applying a high-pass filter with a corner period of 6 s. In the case of ocean-bottom stations deployed in a water depth of more than 2,200 m, the amplitude of pressure waveforms in this period band is roughly consistent with the vertical amplitude of ocean-bottom velocity (e.g., Matsumoto et al., 2012). The period band of less than 6 s corresponds to that used for estimating the amplitude magnitude of the unified hypocenter catalogue and EEW by JMA. We constructed the empirical equation between the magnitude and the filtered amplitude data and estimated the magnitude for each event data.
Our results show that the magnitude estimated from using pressure gauge data correlates well with that in the JMA list. The deviation (two sigma) is 0.70, which is the same value as that estimated from using three component data of accelerometer. For the event data of the 2016 earthquake (Mjma 6.5), the estimated magnitudes by accelerometer data are 6.64–8.34, while those by pressure gauge data are 6.33–6.81, indicating that the magnitude estimation using the latter data provides less amplification and stable results. The pressure gauge installed at DONET stations may be relatively low sensor hysteresis and less effects of sensor rotation on short-period component of waveforms compared with those of accelerometer.

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