Identification of nonlinear response and estimation of S-wave amplifications at ocean bottom seismograph sites in Sagami Bay area, Japan

*Yadab Prasad Dhakal[1], Shin Aoi[1], Takashi Kunugi[1], Wataru Suzuki[1], Takeshi Kimura[1]

1. National Research Institute for Earth Science and Disaster Resilience

Deployments of large scale ocean bottom networks that comprise seismometers and pressure gauges (e.g., DONET in the Nankai Trough area, S-net in the Japan Trench area) are expected to contribute to earthquake and tsunami early warnings by prompt detection of earthquakes at subduction zones. The amplification effects of soft sediments at the ocean bottom seismograph (OBS) sites on the overestimation of the displacement-amplitude-based magnitudes have already been discussed (Hayashimoto and Hoshiba 2013; Nakamura et al. 2015). On the other hand, Hayashimoto et al. (2014) analyzed nonlinear site effects at three Off-Kushiro OBS sites which showed that recordings having PGA 100 cm/s^2 or greater display the nonlinear site response. Because the OBS sites are located on soft sediments, the sites may undergo large deformations during major earthquakes causing unpredictable site response. In this paper, we investigated nonlinear site effects and site amplifications at six K-NET OBS sites namely KNG201, KNG202, KNG203, KNG204, KNG205, and KNG206 located in Sagami Bay area of Japan. We employed the method of Wen et al. (2006) to identify the nonlinearity and the equation proposed by Noguchi and Sasatani (2011) to quantify the degree of nonlinearity. The methodologies use horizontal-to-vertical spectral ratios of S-wave recordings to identify and estimate the degree of nonlinearity (DNL). Our results showed that strong-motion recordings having horizontal vector PGA greater than 50 to 150 cm/s^2, depending on site, display clear signatures of nonlinear site response. For PGAs > 100 cm/s/s, peak frequencies of strong-motions are found to be shifted between about 20 % and 55% of the peak frequencies of weak-motions in the analyzed data ranges (PGA ˜ 450 cm/s/s). Similarly, the reduction of spectral ratios occurs by about 5 % to 70 % of the weak-motion peak spectral ratios. After identifying the thresholds for nonlinear response, we used the S-wave part of horizontal components having PGAs smaller than the thresholds to estimate amplifications at 0.2 Hz to 20 Hz by spectral inversion method. Our results showed amplification factors of about 10 to 50 at frequencies between 0.2 Hz and 10 Hz. In the case of strong shakings, the amplification factors may be substantially modified by nonlinear response and this effect should be investigated for real time application of the recorded motions. We describe in detail the data, methodology, and results of our study for identification of nonlinear site response at the OBS sites in (Dhakal et al., 2017).

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Keywords: Nonlinear site response, Ocean bottom seismograph, Site amplification

