Comparison of active seismic signals collected from DAS along seafloor cable and conventional OBS

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Distributed acoustic sensing (DAS), which can observe distributed strain by measuring Rayleigh scattering along optical fiber cable. DAS technology was first developed for Oil and gas exploration and reservoir monitoring. Recently, this technology is becoming new approach to observe seismic signal for earth science field (e. g. Lindsey et al., 2019). DAS technology has some advantages over conventional observation method. High spatial density is one of the most significant advantages. DAS technology allow us to measure seismic signal with spatial intervals of less than 10 m. Also, DAS technology can be easily applied to seismic monitoring / time-lapse survey by using existing optical fiber cables. However, to evaluate seismic records observed by DAS, quantitative analysis and discussion is still needed.

To evaluate seismic records observed by DAS, we conducted a field test with DAS acquisition using an existing seafloor cable, controlled seismic source and conventional seafloor seismometers. We used existing seafloor optical fiber cable installed in off-Muroto Cape, Japan. The cable is originally installed as a part of Long-Term Deep Sea Floor Observatory off Muroto Cape project in 1997 and now is not under operation. 2 conventional pup-up type ocean bottom seismometers (OBSs) were installed near the off Muroto cable and the arigun shooting line before the survey to observe airgun signal which could be used for comparison with DAS data directly. The distance between the cable and OBSs were less than 200 meters. We connected DAS acquisition system to the off Muroto cable for 6 days, from 30 Nov. to 5 Dec. 2019. In the same period and the same region, R/V Kaimei was firing airgun shooting with interval of 200m along a survey line near off Muroto cable. 50 km length of the cable from shore station was used for DAS acquisition, and seismic signals were observed every 10 m. Maximum water depth is around 1000 m.

We compared common receiver gathers of DAS and OBS of airgun shooting line, MROBS1, performed near the off Muroto cable for direct comparison DAS and OBS records. The maximum offset between receiver and shooting point of MROBS1 is 128 km and total number of shot points was 671 shots with shooting intervals of 200 m. Shot records of MROBS1 confirmed that the closest point of the cable to the OBS was around 21 km from the shore station. Seismic records observed by DAS along 21.2-21.4 km (21 receiver points) were stacked to generate DAS common receiver gather used for direct comparison with OBS common receiver gather. The direction of the off Muroto cable around 21 km is almost north-south direction. We rotated OBS horizontal record to the same direction of the cable direction. Initial results of the comparison DAS and OBS records are as follows: 1) Overall, OBS records have better S/N ratio than DAS records. In OBS records, seismic signal including refraction waves propagating deep boundaries are visible in long offset more than 120 km. In DAS records, the seismic signals are visible with shot-receiver offset of less than 70 km. 2) DAS records and horizontal component of OBS record are very similar with offset of less than 70 km. Results suggest that DAS observed down-going and refraction waves propagating along boundaries as P-wave and up-going as converted S-wave, which are also observed by horizontal component of OBS. S-wave refraction waves are not clearly visible in DAS records. 3) Time derivative waveform of DAS is in better agreement with OBS records better than raw waveform of DAS.

For further analysis and discussion, we have to perform quantitative analysis using DAS and OBS seismic records converted to physical values. However, initial results of comparison of DAS and OBS records suggest that DAS records include actual seismic signal including information of deep structure, and that DAS technology can be applied to seismic survey and monitoring in seismogenic subduction zone.

Keywords: Distributed acoustic sensing (DAS), Seafloor optical fiber cable, Ocean bottom seismometer (OBS), Airgun shooting, Seismic signal

