Comparison of strain and displacement-velocity seismograms: radiation pattern and reflection coefficients

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Distributed Acoustic Sensing (DAS) with optical fibers is the next generation recording system of seismic waves (Hartog, 2017). DAS has been already adopted in a variety of applications in exploration seismology, particularly now replacing conventional recording systems in vertical seismic profiling (e.g., Zhan, 2019). DAS records the strain-velocity component along a fibre while any conventional seismic instrument records displacement, velocity or acceleration of three components. Although the original strain velocity recorded by DAS could be transformed into those traditional seismograms (e.g., velocity) thanks to its continuous recording along the fibre, such approaches should be cumbersome for any future researches with the burst of data quantity because DAS yields continuous records in space along each fibre or 2-D data in comparison of 1-D ones (only in time) for conventional seismometers. The use of the original strain-velocity records should be therefore appropriate. In this study, we compare synthetic strain records with conventional seismograms such as displacement, which helps us to understand what kinds of characters of seismic waves will be detected well and what will be not sensitive with measurements with DAS. We shall take two fundamental examples for seismic researches: radiation pattern of a seismic source or double-couple point source, and reflection coefficients at the free surface with incident plane waves.

The radiation pattern of e_{rr} is exactly same as the that of P wave (i.e., four robes), those of other five components of strain tensors are quite different from that of S wave. If a single component is only observed, such as $e_{theta,theta}$, the strength and polarity should not be interpreted by previous results in seismology. The strain observed at the free surface with any incident plane wave behaves quite differently from conventional three components of displacement. For example, the vertical incident P wave yields the e_zz strain to be zero, due to the interference of the incident and reflected P waves with opposite polarity to each other while the displacement becomes doubled, as widely known.

Keywords: DAS, strain seismogram, reflection coefficeint, radiation pattern

