On the broadband instrument response of fiber-optic DAS arrays

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Distributed Acoustic Sensing,DAS, is a novel tool in array seismology that measures the phase of backscattered laser pulses traveling in a fiber-optic cable, and relates this measurement to the axial strain induced on the cable by a propagating seismic wavefield. Combining DAS with telecommunications optical fiber networks has begun to address a range of earth science questions where cost and field logistics have historically hindered observations. Unlike classic inertial seismometers, DAS instrument response is presently unquantified. This topic includes a variable sensing element, the fiber, including packaging and installation, which changes between experiments. Ignoring this element, one DAS record should approximate a fixed-length strain gauge, which exactly measures Earth's motion down to quasi-static frequencies relevant to geodesy. In this paper, we test this hypothesis using seismological observations of teleseismic earthquakes and microseism noise spanning the 1 to 120 s period range. We use a commercial DAS interrogator unit connected to an optical fiber previously used for telecommunication and a colocated broadband seismometer to estimate the DAS transfer function. We find a direct correspondence with actual ground motion from 10-120 s. At shorter periods, 1-10 s, DAS amplitude response is enhanced by 3-11 dB. Phase response is flat over this range of periods. We interpret the recovered DAS response function in terms of hypothesized fiber coupling and photonic effects. We propose this calibration methodology for future DAS experiments where seismic amplitude information is desired.

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