

EGU2020-7343

<https://doi.org/10.5194/egusphere-egu2020-7343>

EGU General Assembly 2020

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Distributed Acoustic Sensing from mHz to kHz: Empirical Investigations of DAS Instrument Response

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With the upside of high spatial and temporal sampling even in remote or urban areas using existing fiber-optic infrastructure, Distributed Acoustic Sensing (DAS) is in the process of revolutionising the way we look at seismological data acquisition. However, recent publications show variations of the quality of DAS measurements along a single cable. In addition to site- and orientation effects, data quality is strongly affected by the transfer function between the deforming medium and the fiber, which in turn depends on the fiber-ground coupling and the cable properties. Analyses of the DAS instrument response functions in a limited part of the seismological frequency band are typically based on comparisons with well-coupled conventional seismometers for which the instrument response is sufficiently well known to be removed from the signal.

In this study, we extend the common narrow-band analyses to DAS response analyses covering a frequency range of five orders of magnitude ranging from ~ 4000 s period to frequencies up to ~ 100 Hz. This is based on a series of experiments in Switzerland, including (1) active controlled-source experiments with co-located seismometers and geophones, (2) low-frequency strain induced by hydraulic injection in a borehole with co-located Fiber-Bragg-Grating (FBG) strainmeters, and (3) local to teleseismic ice- and earthquake recordings with co-located broadband stations.

Initial results show a site-unspecific, approximately flat instrument response for all experiments.

The initial results suggest that the amplitude and phase information of DAS recordings are sufficient for conventional geophysical methods such as event localisation, full-waveform inversion, ambient noise tomography and even event magnitude estimation. Despite the promising initial results, further engagement by the DAS community is required to evaluate the DAS performance and repeatability among different interrogation units and study sites.