SEISMIX 2020

# Assessing the coherence of fiber-optic strain data

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It was recently demonstrated that optical fibers, forming an integral part of modern telecommunications infrastructure worldwide, can be used to sense near-surface deformation in the form of distributed strain through light scattering. In contrast to the deployment of massive (large-N) receiver arrays, wavefields are essentially captured continuously along the fiber, which implies opportunities for the imaging of crustal features at an unprecedented spatial resolution. In contrast to nodal arrays, fiber-optic cables are ubiquitous in and between well-populated areas and their reach even extends under the oceans. As seismic signals are extracted using sparsely employed interrogator units, fiber-optic strain sensing is evolving into a cost-effective technique that promises to uniquely combine temporally extended (large-T) and large-N observations. As a result, fiber-optic strain sensing continues to raise increasing interest in controlled-source seismic exploration, earthquake studies, geothermal applications including hazard assessment, as well as various strands of ambient noise and environmental seismology, with the potential to unify efforts in different communities.

One of the reasons why a seamless integration of seismic imaging campaigns at different scales has rarely been successful so far arises from the fact that earthquake wavefields are often under-sampled in the upper crust, resulting in migration-type imaging to fail in these scenarios. Analogously, the significantly denser yet discrete source and receiver geometries encountered in exploration seismology are known to likewise crucially under-sample wavefields very close to the surface, thereby also resulting in an obscured region that prevents a more complete view of the Earth's crust. Typical spatial sampling intervals in the range of meters thus make fiber-optic sensing a prime candidate to fill these persistent gaps.

Originating from optics, coherence is a quantitative property of a wavefield, whose systematic treatment is directly linked to the principal capability of meeting imaging objectives. A signal only appears coherent and un-aliased, as long as spatial sampling criteria are met. In order to estimate the principal imaging potential of fiber-optic strain data, we quantify and assess the coherence of one of the most laterally extended (15 km) yet densest (4 m sampling interval) passive-seismic fiber-optic strain measurements to date, capturing natural and man-made seismicity on Reykjanes Peninsula, SW Iceland, in 2015. The estimated attribute fields as well as the data enhancement capabilities facilitated by this analysis are critically appraised. Highlighting one of the prevalent challenges of large-T fiber-optic strain sensing, a vast data volume of approximately 12 TB was accumulated in the limited recording period of only 9 days. To address this arising big-data challenge, in terms of storage and handling, we also investigate the general possibility of wavefield reconstruction and compression, as well as targeted phase separation with coherence arguments for the presented example event of the Iceland dataset.

Topic Area:
(1) New developments and advances in DAS applications