EGU2020-6022
https://doi.org/10.5194/egusphere-egu2020-6022
EGU General Assembly 2020

What changes when we use ambient noise recorded by fiber optics?

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Ambient noise seismology has greatly reduced the cost of acquiring data for seismic monitoring and imaging by reducing the need for active sources. For applications requiring time-lapse imaging or continuous monitoring, we desire sensor arrays that require little effort, money, and power to maintain over long periods of time. Distributed Acoustic Sensing repurposes a standard fiber optic cable as a series of single-component strain rate sensors with spacing at the scale of meters over distances of kilometers. With a single location providing the power source and recording all data, along with the ability to use existing underground fiber optic networks, a small team is now able to easily establish a monitoring network and acquire massive amounts of strain rate data continuously.

This talk will explore two conceptual changes when using DAS data for ambient noise interferometry: greatly increased data volumes, and the difference between velocity and distributed strain-rate data. These two challenges will be illustrated in the context of experiments with applications in near-surface Vs imaging with applications in earthquake hazard analysis, permafrost thaw monitoring, and urban geohazard and hydrology monitoring.

On the issue of data volumes: Orders of magnitude more sensors and high sample rates (often in the kilohertz range) quickly result in data quantities that exceed the limits of computational infrastructure and algorithms available to many seismologists, potentially at the petabyte/year scale for modern acquisition instruments. New algorithms focused on reduced data movement are improving our ability to analyze more data with existing resources. This talk will include a brief overview of some recent algorithmic improvements for both ambient noise interferometry for imaging, and interferometry-based event detection.

On the issue of changing from velocity to distributed strain rate data: Because strain rate is a tensor quantity and velocities are a vector quantity, the sensitivity of DAS to seismic sources at different orientations is quite different from typical seismometers. This difference can be clear both in polarity and amplitude of the signal, and is particularly significant in shear and Love wave recordings. We will describe simple models to describe expected changes in how seismometers and DAS record the same noises, and the corresponding changes expected in noise correlation

functions. These sensitivity differences are more pronounced in ambient noise correlation functions than they are in raw signal recordings, effectively emphasizing a different distribution of ambient noise sources. Modeling these sensitivities helps determine which sensor orientations are reliable for use in ambient noise interferometry imaging.