Geophysical Research Abstracts
Vol. 21, EGU2019-14606, 2019
EGU General Assembly 2019

Estimating seismic velocity changes and relative source locations simultaneously from coda wave interferometry

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Coda Wave Interferometry (CWI) is a method for observing and quantifying changes in a medium, which uses the diffuse, multiply-scattered waves, found in the tail of the seismogram. These later arriving waves are very sensitive to small changes in a medium. CWI is a potential source of new information on simultaneous changes in seismic velocity and the relative locations of earthquakes induced by subsurface engineering projects, regional stress changes, or by the earthquakes themselves. When compared against conventional methods, CWI provides significant improvements in the accuracy and precision of estimates of both changes in velocity and relative source locations. When simultaneous perturbations of velocity and source locations occur, CWI estimates remain accurate. As CWI provides an estimate for the separation between two sources, we use CWI on a cluster of sources to estimate their relative locations, all using a single seismic receiver.

CWI estimates for velocity change represent an average between changes in P and S wave velocities (VP and VS). We present a method to unravel the changes in VP and VS individually, using CWI estimates made at multiple time windows in the coda and prior knowledge of the medium. We demonstrate the method and results in rock physics data from a laboratory experiment.

These results are significant as they represent a major improvement in characterizing the evolution of subsurface properties and microseismicity for a variety of applications including a range of problems in subsurface engineering and time lapse-monitoring.