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Multiply scattered seismic waves as a tool for volcano monitoring: An application to Fogo Volcano, Sao Miguel, Azores

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Multiply scattered waves are a new tool for monitoring changes in the Earth's subsurface. In many applications, detecting the change in a medium is more interesting than creating an image of the medium. An example of this is volcano monitoring. For those living close to a volcano it is more important to know whether a volcano is changing rather than knowing its precise internal structure.

We are using a coda wave interferometry technique (Snieder 2002) to monitor changes in acoustic or elastic media. The technique is able to detect minute changes in seismic velocity in the medium; detect perturbations in the location of the source of the elastic waves; and detect random changes in the locations of the wave scatterers between the source and the station. In synthetic seismic data, we can accurately measure a change in the seismic velocity as small as 0.1%, and/or a shift in the point of excitation of the elastic waves over a distance as small as a few metres.

In field data waveforms recorded at the same station over time sometimes are reproducible and are very similar. We can assume that those events, called *multiplets*, are created at the same source positions with approximately the same source mechanisms and have the same source-receiver path. The first arriving waves are almost identical, yet the later arriving waves (coda) show distinct changes. The coda are created by multiply scattered waves which have "sampled" the medium more than the ballistic

arrival, detecting small changes in the medium not captured by the early arrivals. The method accurately measures the change in the seismic velocity or in the location of the source using the changes in these late-arriving waves.

In this study, we apply the technique to a dataset collected at Sao Miguel, Azores, from April to September 2003. While we analyse the data to identify source movement (comparing our results with ones obtained by more classical source location techniques), we also try to relate our results to temporal fluctuations in gas emissions recorded at the two ground based CO_2 monitoring stations on the island.