Geophysical Research Abstracts
Vol. 16, EGU2014-11197, 2014
EGU General Assembly 2014

Seismic noise correlations to image changes in heterogeneous structures: applications to Piton de la Fournaise volcano and the 2008 Wenchuan earthquake

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In heterogeneous structures such as volcanoes or fault zones, direct waves are strongly attenuated and can hardly be used for classical imaging purposes. Still, the energy of the direct wave is not lost but converted to multiply scattered waves, also called coda waves. Due to their complex and random looking trajectories, these coda waves have long been considered as devoid of any useful information. But because of the longer time they spend in the medium, coda waves also show great sensitivity to small changes occurring in the structure. This feature has attracted increasing interest in the last decade to measure small velocity changes on volcanoes, fault zones, reservoirs ...

However, further processing is needed to assess the spatial positions/repartion of the changes. Interestingly, the variation of the coda waveform depends on the position of the change relative to the sensors as well as on the time in the coda. Theoretical expressions can be derived to relate the phase-shift and/or waveform decorrelation in coda waves to a local velocity change and/or structural change in the medium.

Going one step further, we used these expressions to formulate and solve an inverse problem that allows us to image minute changes taking place in heterogeneous structures. We here show the encouraging results obtained from volcano (2010 eruptions from Piton de la Fournaise) and fault zone monitoring (Mw7.9 Wenchuan earthquake). In particular, we show that this technique yields a great potential to forecast the location of volcanic eruptions.