Studying volcanoes and faults based on correlations of ambient seismic noise

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Traditional observational methods in seismology are based on earthquake records. It results in two main shortcomings. First, most techniques are based on waves emitted by earthquakes that occurred only in geologically active areas, mainly plate boundaries. This results in a limited resolution in all other areas where earthquakes are not present. Second, the repetition of earthquakes is rare, preventing the study continuous changes within active structures such as volcanoes or faults.

Nowadays, the seismic networks are producing continuous recordings of the ground motion. These huge amounts of data consist mostly of so called seismic noise, a permanent vibration of the Earth due to natural or industrial sources. As described in many studies where noise has been used to obtain the Green's function between receivers, coherent waves are extracted from noise signals even if, at first sight, this coherent signal appears deeply buried in the local incoherent seismic noise. Recent studies on passive seismic processing have focused on two applications, the noise-extracted Green's functions associated to surface waves leads to subsurface imaging on scales ranging from thousands of kilometres to very short distances; on the other hand, even when the Green's function is not satisfactorily reconstructed from seismic ambient noise, it has been shown that seismic monitoring is feasible using the scattered waves of the noise-correlation function.

One of the advantages of using continuous noise records to characterize the earth materials is that a measurement can easily be repeated. This led recently to the idea of a continuous monitoring of the crust based on the measurements of wave speed variations. The principle is to apply a differential measurement to correlation functions, considered as virtual seismograms. The technique developed for repeated earthquakes (doublets), proposed by Poupinet et al., 1984, can be used with correlation functions. In a seismogram, or a correlation function, the delay accumulates linearly with the lapse time when the medium undergoes a homogeneous wave speed change and a slight change can be detected more easily when considering late arrivals. It was therefore reasonable, and often necessary, to use coda waves for the measurements of temporal changes. Noise based monitoring relies on the autocorrelation or cross-correlation of seismic noise records (Sens-Schönfelder and Wegler, 2006, Brenguier et al., 2008a,b). When data from a network is available, using cross-correlation take advantage of the number of pairs with respect to the number of stations.