IMAGING THE EARTH'S INTERIORS BASED ON CORRELATIONS OF SEISMIC NOISE

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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. Passive seismic imaging and monitoring are based on the extraction of the coherent contribution to the seismic field from the cross-correlation of seismic noise between station pairs.

The main idea is to consider seismic noise as a wave field produced by randomly and homogeneously distributed sources when averaged over long time series. In this particular case, cross-correlation between two stations yields the Green's function between these two points. Since the first application of this idea in seismology appeared in 2004, the passive seismic imaging became a widely used method with application at very different scales going from global tomography to 100m-scale imaging of shallow subsurface.

The feasibility of noise-based seismic imaging in every particular case depends on spatio-temporal properties of the available noise wavefield. Therefore, a logical initial step for most of noise-based studies is to characterize the distribution of noise sources that strongly depends on the spectral range under consideration. At high frequencies (> 1Hz) the noise is strongly dominated by local sources that may have very different origins and are often anthropogenic. At these scales, the properties of the noise wavefield should be studied separately for every particular case and no reasonable generalization can be done. At longer periods, noise is dominated by natural sources. In particular, it is well established that two main picks in the seismic noise spectra in so-called microseismic band (1-20 s) are related to forcing from oceanic gravity waves. At longer periods, the oceanic infragravity waves play a major role in the seismic noise excitation.

To date, numerous studies has demonstrated that, when considered over sufficiently long times, the noise sources become sufficiently well distributed over the Earth's surface and that dispersion curves of fundamental mode surface waves can be reliably measured from correlations of seismic noise. This led to fast development during recent years of the ambient noise surface wave tomography. It consists of computing cross-correlations between vertical and horizontal components for all available station pairs followed by measuring group and phase velocity dispersion curves of Rayleigh and Love waves that are then regionalized and inverted to obtain three-dimensional distribution of shear velocities in the crust and the uppermost mantle.

Most recent studies have demonstrated that body waves propagating between pairs of stations can also be retrieved from correlations of seismic noise in favorable conditions. This opens a possibility to develop noise-based imaging of deep parts of the Earth.