Imaging with ambient noise

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Since the turn of the century, developments in seismology, ultrasonics and underwater acoustics have caused a 180 degrees turn in the way we think about diffuse wave fields and noise. Contrary to their definition, diffuse wave fields appeared not to be fully disorganized and without any information. It has been shown theoretically and experimentally that the heterogeneities and boundaries of the medium in which a diffuse wave field propagates leave an imprint on the wave field that is characteristic for the medium. What is even more surprising is the fact that the inherited information about the medium can be retrieved in a very simple manner: if one determines the cross-correlation of noise registrations of a diffuse wave field at two arbitrary points in space, one obtains the impulse response of the medium (i.e., the Green's function) that would be measured if there were a source at one of the two points and a receiver at the other. In other words, by just passively listening to ambient noise and applying a very simple operation, one obtains the same information that would be obtained in a controlled experiment with manmade sources. It appears that this is true no matter how complex the medium is. This very simple principle has far-reaching consequences. To mention a few examples: in the field of ultrasonics, noise of thermal fluctuations in a specimen has been successfully turned into pulse-echo measurements of the specimen, in regional seismology recordings of ambient seismic noise have been used to reconstruct the crustal structure of southern California and other regions, and in exploration seismology recordings of background noise in a desert area have been turned into seismic reflection measurements of the area. In the presentation I will review the underlying principles in more detail, discuss new advances, and illustrate the method with several examples.