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Introducing seismic metamaterials and their potential geophysical applications.

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What if in the future the propagation of seismic surface waves in urban environments could be shaped at will? Until a few years ago, this question would have sounded rather provocative to the seismological community: Today, thanks to seismic metamaterials, this is no longer the case.

This talk reviews the recent developments that have brought metamaterials, introduced in the 90's to mould the flow of electromagnetic waves at micro- or nano-scales, to be promising in the control the propagation of seismic waves in the ground.

The idea behind a seismic metamaterial is tomodify the local properties of the ground through the insertion of inclusions of a different material at a sub-wavelength scale. The different types of inclusions, resonant or non-resonant, determine the property and the performance of the metamaterial. After a brief overview on some seminal acoustic experiments, we introduce three types of seismic metamaterials: The first is based on a cluster of closely spaced sub-wavelength resonators attached to the ground realising a metasurface that can stop the propagation of Rayleigh waves. A geophysical experiment has demonstrated that forest trees can act like this metamaterial for frequencyies between 30 and 100 Hz. The second type is derived from the previous, but now the subwavelength resonators realising the cluster are graded (i.e. of decreasing height) such that they allow Rayleigh waves to be converted into shear waves. Finally, in the last example, we present a metamaterial that uses soft soil inclusions in the ground to create a lens for rerouting seismic surface waves around an obstacle. Since most of the results shown here come from numerical simulations, this talk will be of interest also for numerical modelers concerned with scattering from deeply subwavelength (resonant) inclusions.