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Shallow 3D Geophysical Structure from Joint Inversion of Group Slowness Dispersion and HVSR Curves using a Small-Scale Ambient Noise Array in Urban Environment: The Case of Thessaloniki City (Northern Greece)

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Shear wave velocity (Vs) is a key parameter to determine the shallow geophysical subsurface structure geometry in a study area. Numerous geotechnical and geophysical (active and passive) methods are widely used to retrieve information about the shear wave velocity distribution with depth and to evaluate reliable geophysical ground models. The main problem arising is the application of these methods in urban environments where the limitations increasing significantly for several reasons (e.g. dense conurbation, sensitivity to human activities). Thus, the exploitation of passive geophysical methods is developed throughout the recent decades for reliable geophysical subsurface structure investigation in such environments. For this reason, we implemented passive geophysical methods based on the analysis of ambient noise recordings at a small-scale array of sensors in the urban area of Thessaloniki city (Northern Greece), in order to investigate the 3D geophysical structure properties and geometry. Specifically, ambient noise data were processed using the ambient noise array tomography and the Horizontal to Vertical Spectral Ratio (HVSR) method.

Ambient noise array tomography method is able to provide the 3D Vs distribution in three main processing steps. Rayleigh wave travel times are extracted from the cross-correlation traces of ambient noise recordings of the vertical components for specific frequencies. These travel times are inverted using a tomographic approach incorporating approximate Fresnel volumes and inter-frequency smoothing constrains to produce group velocity maps for the same frequency values. Finally, local group slowness dispersion curves are reconstructed at every node of a predefined tomographic grid of nodes in the study area. The 1D inversion of the local group slowness dispersion curves using a node based neighborhood algorithm (Wathelet, 2008) derives the Vs distribution with depth and lead us to the evaluation of a 3D geophysical subsurface model for the study area. In order to provide additional information to the 1D inversion procedure, hence reducing the non-uniqueness of the problem, we also used Horizontal to Vertical Spectral Ratio (HVSR) curves derived from every recording station of the array and interpolated them to all tomographic grid node. The joint inversion of group slowness dispersion and HVSR curves, assuming that the latter correspond to ellipticity, provided a smoother spatial distribution of the subsurface layers' interfaces of the 3D geophysical model for the study area. This model is compatible with the local geological setting, as well as with previous larger scale studies in the same area.