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Ambient vibration analysis as a proxy for the detection of buried geological structures

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In this work we tested the capability of single station ambient noise spectral ratios (HVNSR) technique to be used as a proxy for detecting sharp variations in the subsoil characteristics in sedimentary basins.
In sites characterized by 1D response HVNSR is able to detect the resonance frequency of sediments (f0) to be related with their thickness and velocity. In quasi-1D geological situation, a smooth variation in the resonance frequency suggests some variation in the thickness of the soft sedimentary layers or in their velocity.
In the case of sharp lateral variation of the subsoil, as in presence of morphological steps or buried faults in the bedrock, the noise wave-field becomes more complex and spectral ratios show some directional effect strictly related to the presence of the lateral heterogeneity (Matsushima et al. 2014).
In this work we focus our attention on the detection of a buried shallow tectonic element known in bibliography (Galadini, Galli 1999) as the Luco dei Marsi fault, located in the western margin of the Fucino basin (central Appenines, Italy).
We performed simultaneous ambient noise measurements using MarsLite digitizers equipped with Lennarts 3d-5s velocimeters along a transect, with inter-station distance between 30 and 50 meters, which crosses perpendicularly the surface projection of fault line. The collected data, analyzed with classical HVNSR technique, show some complexities in the f0 distribution compatible with the presence of the buried fault.
In detail, our results highlight a 1D response with a clear resonance peak for the stations located away from the fault. Moving closer to the fault line, where the 1D condition is not verified, the resonance peak becomes broader. Directional analysis of spectral ratios suggests the dependence of the noise wave-field to the presence of the fault line. Close to the geological feature, results of directional analysis show a doubling in the resonance frequency with relative amplitudes changing for fault-parallel and fault-normal direction of polarization. To support with an independent approach our observations, an electrical resistivity tomography was performed along the transect whose results show the presence of a clear step in a high resistivity shallow layer that can be assumed as the bedrock. After this analysis we decided to extend the ambient noise transect towards the centre of the basin where no fault line is mapped and where we expected a smooth lowering of f0 values due to the deepening of the bedrock. This feature was really observed for a while but at a distance between 400 and 500 meters from the Luco fault we detected again some anomaly in HVNSR data with a doubling of resonance frequency and relative amplitudes depending from the direction of polarization. This observation suggests the presence of deeper tectonic element parallel to the Luco fault. As a conclusion of our work we believe that HVNSR and polarization analysis can represent a quick and fast method to hypothesize the presence of buried discontinuity in the subsoil and can be usefully used to guide the positioning of more sophisticated geophysical analysis aimed at mapping their geometries.