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Array observations of Love wave contribution to the ambient vibration H/V spectral ratio amplitude peak

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Measurements of the H/V spectral ratio of ambient vibrations are widely used for site characterization, for example to efficiently map variations in the fundamental resonance frequency within earthquake-prone towns or to derive shear wave velocity profiles of the shallow sub-surface that are important in the estimation of local ground-motion amplification. Part of the appeal of this method is due to the possibility of fairly quickly sampling an area with short duration (appr. 15 min) measurements for which only a single three-component station is needed. However, when interpreting the measurements it is often assumed that almost all of the ambient noise energy is carried by fundamental mode Rayleigh waves and that accordingly the H/V spectral ratio curve is a first order representation of the fundamental mode Rayleigh wave ellipticity. In this case, the amplitude peak of the H/V curve corresponds to a horizontal polarization of the fundamental mode Rayleigh wave and the frequency at which it occurs depends on the shallow subsurface structure (S-wave velocities in the sedimentary layers and depth to a large velocity contrast, i.e. the bedrock interface). Theoretical studies indicate that, depending on the location of sources and the site structure, other contributions to the wavefield, e.g. Love waves, higher modes, or body waves, can be important, too. While new methods are under development to more reliably extract the pure Rayleigh wave part of the ambient vibration wavefield from the typical single-station H/V recordings, we present evidence from array field measurements which documents the sometimes predominant contribution of Love waves to the observed H/V peaks.

Within the European research project NERIES JRA4 ("Developing and calibrating new techniques for geotechnical site characterization"), ambient vibration array measurements were performed at 19 selected European strong-motion sites in Greece, Italy and Turkey with varying site conditions (urban vs. rural, shallow vs. deep sediment-bedrock interface, essentially 1D vs. 2/3D subsurface structure, EC8 classes between A and E) to derive surface wave dispersion curves from the noise wavefield. Besides this immediate target, the array data also contain additional information on the wavefield, especially on the dominant propagation direction, that is useful when H/V ratios are derived and interpreted for individual array stations. Comparing main propagation and polarization directions within distinct frequency bands allows to distinguish between Rayleigh and Love waves as dominant components of the wavefield, and to investigate the composition of the wavefield specifically in the frequency band of the H/V peak. Array analysis with the three-component modified spatial autocorrelation (MSPAC) method moreover provides a direct indication of the frequency-dependent relative Rayleigh and Love wave contributions to the wavefield.

Focusing on those sites where a clear H/V peak is observed in the data within the frequency band that can well be analyzed with the larger arrays (diameter of several hundreds of meters), examples show that, while often both types of surface waves contribute to the H/V peak, Love waves dominate under certain conditions. Results from MSPAC and the frequency-dependent analysis of main propagation direction (using all three components of the recordings) vs. polarization of the wavefield show good agreement. These findings have important implications for the interpretation and especially inversion of measured H/V peaks for site characterization and point to an additional benefit of array recordings.