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Empirical evidence of Rayleigh waves in Norcia (central Italy) and their quantitative contribution to ground motion

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Spectral ratio techniques, such as the Horizontal-to-Vertical (HV) and Standard (SSR) may exhibit different trends in specific frequency bands when conducted in alluvial basins. A possible explanation of this discrepancy can be provided by the presence of Rayleigh oscillations, that are considered responsible of an amplification of the vertical component with respect to the horizontal. We propose a new methodology for the identification of Rayleigh waves arrivals, to test on small-size basins. With this procedure, candidate Rayleigh waves are localized in time-frequency domain on an instantaneous polarization plane which is constructed by defining the instantaneous maximum vertical and horizontal spectral amplitudes. Validation of the candidate Rayleigh arrivals is performed by evaluating the instantaneous ellipticity. This step yields to a quantitative measure of the polarization, providing an indicator of the Rayleigh contribution to ground motion. We tested this methodology in the Norcia basin (central Italy) using a 18 selected earthquakes ($2.0 < Ml < 5.0$) dataset which included seismic events recorded from the L'Aquila sequence (2009). We demonstrate the robustness of our methodology by localizing evidences of Rayleigh wave arrivals immediately from (1 s) up to 30 s after the first S-wave group, even for low-magnitude events ($M\text{l} < 3.0$). The generation of the detected Rayleigh waves analyzed in time-frequency range, appears to be magnitude-dependent and in function of the location in the basin. Our quantitative estimate of the Rayleigh polarization resulted to be comparable to the HV response value in specific frequency bands, for example in deamplification, demonstrating a plausible connection with Rayleigh oscillations. The authors encourage the usage or implementation of similar procedures conducted in basin studies, in order to determine quantitatively the Rayleigh contribution to ground motion, for a better characterization of the local seismic response.