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Revealing the two-dimensional response of a sediment-filled valley from ambient vibration records

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Numerical simulations have shown for long that 2-D resonance contributes significantly to the seismic response of deep sediment-filled valleys. Compared to 1-D response, such 2-D resonances may lead to higher amplification, extended signal duration and shifted peak frequencies. Since many urban areas are located along deep river valleys over soft surface deposits, there is a need for cheap ambient vibration methods to asses the resonance properties of such sites. This issue is addressed in the two projects SHAKE-VAL (SNF) and SISMOVALP (Interreg IIIB).

We introduce an approach to identify the 2-D resonance behaviour of a typical Alpine valley by analysis of ambient vibrations recorded simultaneously on dense arrays running perpendicular to the valley axis at different sites. The frequencies of fundamental modes of SV_0 and SH_{00} and some higher modes of SH resonance are identified by application of the site to reference spectral ratio method. Patterns of amplification and phase behaviour at the identified fundamental mode resonance frequencies of SV_0 and SH_{00} agree well with properties predicted by theory. Results of high-resolution frequency-wavenumber analysis applied to ambient noise recorded on circular arrays at the investigated sites suggest that the ambient vibration wavefield is dominated by standing waves at low frequencies (< 0.50 Hz), as expected in the case of 2-D resonance.

The observed 2-D resonance modes induce remarkable peaks in horizontal to vertical spectral ratios, which can not be reproduced with computations of Rayleigh wave ellipticity from a 1-D model of the sediment fill. We performed 2-D numerical simulations for realistic geophysical models of the sites using the 2-D direct boundary element method. The resulting site response explains the observed peaks at the fundamental mode SV_0 frequency very well, leading us to the conclusion that 1-D analysis

is insufficient for the selected sites.

These results suggest that ambient noise recorded simultaneously on dense arrays may be used to reveal the 2-D resonance behaviour of deep sediment-filled valleys.