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Shear-Velocity Imaging of the Alpine Lithosphere from Ambient Noise: Validation Against Earthquake Data

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Seismic ambient noise, i.e. seismic signals generated by the coupling of atmosphere and oceans with the solid Earth, have been used extensively over the last decade to derive velocity models of the subsurface. The so-called ambient- noise method benefits from the increasing number of available seismic stations; central Europe, for instance, is now covered by a set of extremely dense seismic networks. We assemble a new database of ambient-noise-based surface-wave dispersion, and validate it by comparison with the more established two-station method, based on earthquake measurements. In ambient-noise theory, the averaging of cross-correlated signals from a specific station couple over a long time period gives an estimate of the empiric Green's function between the two stations where destructive interference will cancel all uncorrelated source signals. However, the Green's function is reproduced correctly only when the distribution of noise sources is truly random, which is clearly not the case in reality.

On the other hand, the two-station method uses surface waves generated by earthquakes whose epicenters are aligned with the station couple of interest. The phase spectra of the cross correlation can then be translated into phase velocities. We compare both methods, in order to confirm the validity of the ambient-noise approach both for Rayleigh and Love waves. The results are generally in good agreement and justify the simplifications made in the theoretical derivations. We invert the observed phase velocities to determine a high-resolution image of the Alpine subsurface; the frequency range of noise signals allows us to constrain the shear-velocity structure of the crust down to mid-lithospheric depth. This study is an extension of earlier efforts by Molinari, Verbeke, Boschi and co-workers. These efforts are the first steps toward the identification of a new, reference model of the European crust, taking advantage of a broad variety of data (e.g., joint inversion of earthquake and noise data) to constrain seismic velocities to larger depths and with higher resolution.