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Example of shear-wave velocity variations along a 2D seismic profile revealed by surface-wave analysis.

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Multiple-channel analysis of surface-wave (MASW) is implemented in 3 steps: recording surface waves in the field, determination of surface-wave dispersion curves and finally inversion of the obtained curves to derive a shear-wave velocity distribution with depth. If lateral heterogeneities are present, extracting accurate dispersion curves from MASW is challenging. To detect S-wave velocity variations along a 2D profile with good horizontal resolution short arrays should be used. However, using short arrays reduces the dispersion-curve accuracy and increases the chance of misidentifying dispersion curves from different modes.
To assess the possibility of determining dispersion curves from short geophone-arrays we carried out test measurements on a site where a borehole is present. A 190 m long seismic profile with a geophone spacing of 2 m was set up and 53 shot were fired every 4 m along the profile.
The borehole data indicate the presence of a 34 m thick layer of Quaternary heterogeneous alluvial sediments resting on Urgonian limestone. The interpretation of the seismic-refraction data shows variations of the P-wave velocity along the profile within the Quaternary sediments. Attempts to define surface-wave dispersion curves for each shot using a long array (of 16 up to 46 traces) were unsuccessful. The complex energy distribution in the velocity spectra which is due to coexisting fundamental and higher modes in small frequency bands as wells as velocity variations along the geophone array make it not possible to determine an accurate and reliable dispersion curve.
In a second step, we calculated dispersion curves using shorter geophone sub-arrays. This requires careful selection of the sub-array location and length. In this process, the location of velocity heterogeneities revealed by the seismic refraction interpretation were taken into account. In addition, we also took into account anomalies in surface-wave amplitude, the location of which were observed on maps that for a given frequency showed the measured amplitude in the shot-position – receiver-position domain.
We tested different techniques proposed in the literature for calculating dispersion curves using short sub-arrays. In our case, the procedure of Lin and Lin (2007) turned out to be efficient. For a given sub-array, a time-offset record is built by gathering seismograms acquired with different source-to-receiver offsets. When assembling the different data, a phase correction is applied in order to reduce the static-phase error induced by lateral velocity variations. To evaluate this correction, we calculated the cross-power spectral density of common-offset traces for two successive shots. We thus derived 22 multimodal dispersion curves along 10 m long geophone sub-arrays. We also took advantage of the borehole to acquire a S-wave vertical seismic profile. The S-wave velocity depth model derived from this profile was used as prior information in the inversion of the dispersion curves. Finally a laterally varying 2D velocity-model was established from the analysis of the 22 dispersion curves. It reveals a 3-layer structure in good agreement with the lithologies observed in the borehole. From the surface, a clay layer with a shear-wave velocity of 175 m/s overlies at 9 m depth a clayey-sandy till layer that is characterized by a 300 m/s S-wave velocity down to 14 m; below, down to 20 m, a gravel layer is observed that exhibits S-wave velocity variations along the profile from 400 to 600 m/s.

Lin C., and C. Lin, 2007, Effect of lateral heterogeneity on surface wave testing: Numerical simulations and a countermeasure. Soil Dynamics and Earthquake Engineering, 27, 541-552.