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Digital mapping of soil thickness and stiffness using spectral analysis of multi-channel surface-wave data

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The purposes of the multidisciplinary DIGISOIL project are the integration and improvement of in situ and proximal technologies for the assessment of soil properties and soil degradation indicators. Foreseen developments concern sensor technologies, data processing and their integration to applications of (digital) soil mapping (DSM). Among available techniques, the seismic method is, in this study, particularly tested. The multi-channel analysis of surface wave-data (MASW) method is a relatively new in-situ seismic method for determining shear wave velocity profiles. Testing is performed on the ground surface, allowing for less costly measurements than with traditional borehole methods. The basis of the SASW method is the dispersive characteristic of Rayleigh waves when travelling through a layered medium. Rayleigh wave velocity is determined by the material properties (primarily shear wave velocity, but also compression wave velocity and material density) of the subsurface to a depth of approximately 5 meters. Longer wavelengths penetrate deeper and their velocity is affected by the material properties at greater depth and conversely for shorter wavelengths. MASW testing consists of measuring the surface wave dispersion curve, i. e, the variation of phase velocity with wavelengths, at the site and analysing it through an inversion processing to obtain the corresponding shear wave velocity profile. A dynamic source is used to generate surface waves of different wavelengths (or frequencies) which are monitored by a multi-channel cable at known offsets. A MASW device, adapted to soil characterisation, is proposed in the DIGISOIL project. The system was tested for the digital mapping of soil thickness and soil mechanical parameters for three targeted sites of the DIGISOIL project in Europe having their own pedological contexts (Northern France, Northern Italy and Luxembourg). Penetrometer soundings were also conducted for the purpose of verifying the accuracy of the procedure and evaluating its limitations. The obtained maps should be strong inputs for studies of soil compaction control, carbon stock calculation, pavement evaluation, soil thickness assessment and mapping of subsurface stratigraphy and should help to target conservation measures to the most threatened areas.