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Soil depth mapping using seismic surface waves: Evaluation on eroded loess covered hillslopes

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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 one is, in this study, particularly tested for characterising soil vulnerability to erosion.
The spectral analysis of surface waves (SASW) method is an in situ seismic technique used for evaluation of the stiffnesses (G) and associated depth in layered systems. A profile of Rayleigh wave velocity versus frequency, i.e., the dispersion curve, is calculated from each recorded seismogram before to be inverted to obtain the vertical profile of shear wave velocity Vs.
Then, the soil stiffness can easily be calculated from the shear velocity if the material density is estimated, and the soil stiffness as a function of depth can be obtained. This last information can be a good indicator to identify the soil bedrock limit.
SASW measurements adapted to soil characterisation is proposed in the DIGISOIL project, as it produces in an easy and quick way a 2D map of the soil. This system was tested for the digital mapping of the depth of loamy material in a catchment of the European loess belt.
The validation of this methodology has been performed with the realisation of several acquisitions along the seismic profiles:
- Several boreholes were drilled until the bedrock, permitting to get the geological features of the soil and the depth of the bedrock;
- Several laboratory measurements of various parameters were done on samples taken from the boreholes at various depths, such as dry density, solid density, and water content;
- Dynamic penetration tests were also conducted along the seismic profile, until the bedrock is attained.
Some empirical correlations between the parameters measured with laboratory tests, the qc obtained from the dynamic penetration tests and the Vs acquired from the SASW measurements permit to assess the accuracy of the procedure and to evaluate its limitations.
The depth to bedrock determined by this procedure can then be combined with the soil erosion susceptibility to produce a risk map. This methodology will help to target measures within areas that show a reduced soil depth associated with a high soil erosion susceptibility.