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Hillslope characterization in terms of geophysical units based on the joint interpretation of electrical resistivity and seismic velocity data

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Hydrological conditions in a catchment depend on many factors such as climatic, geological, geomorphological, biological and human, which interact with each other and influence water balance in a catchment. This interaction leads to the subordination in the landscape structure, namely the weak elements subordinate to the powerful elements. Thereby, geological and geomorphological factors play an essential role in catchment development and organization. A hillslope consequently can be allocated to one class of the representative units because the important flow processes run at the hillslope. Moreover, a hillslope can be subdivided into stratigraphic subsurface units and significant hillslope areas based on the lithological change of contrasting interfaces. The knowledge of subsurface structures is necessary to understand and predicate complex hydrological processes in a catchment. Geophysical techniques provide a good opportunity to explore the subsurface.

A complete geophysical investigation of subsurface in a catchment with difficult environmental conditions never will be achieved because of large time effort in the field, equipment logistic, and ambiguity in the data interpretation. The case study demonstrates how a catchment can be investigated using geophysical methods in an effective manner in terms of characterization of representative units with respect to a functional role in the catchment. This case study aims to develop combined resistivity and seismic velocity hillslope subsurface models for the distinction of representative functional units.

In order to identify the contrasting interfaces of the hillslope, to localize significant hillslope areas, and to address the ambiguity in the geophysical data interpretation, the case study combined resistivity surveys (vertical electrical soundings and electrical resistivity tomography) with refraction seismic method, and conducted these measurements at one single profile along the hillslope transect and perpendicular to this transect. The measurements along the hillslope transect deliver the two-dimensional hillslope section of resistivity and seismic velocity distribution with contrasting stratigraphic interfaces, whereas the measurements perpendicular to the hillslope transect obtained from vertical electrical soundings survey localize significant hillslope areas indicating existence of two-dimensional features in the subsurface.

To demonstrate the suitability of the suggested approach, resistivity and refraction seismic measurements were carried out at the forested gently inclined hillslope in the Weierbach catchment, which belongs to the hydrological observatory Attert Basin locating in the mid-western part of the Grand-Duchy of Luxembourg. This hillslope is characterized by Pleistocene periglacial slope deposits, which plays an important role in the ecosystem functioning.

The obtained resistivity and seismic hillslope models of the Weierbech catchment complement well one another. The hillslope models identify three significant hillslope areas along the hillslope called as elementary functional units, and four electrical vertical stratigraphic units and two seismic vertical stratigraphic units that agree with lithological stratigraphy of this study site.

In conclusions, the suggested geophysical approach is suitable to characterise a hillslope as the representative unit only at a single transect in the efficient manner in contrast to the expensive 3D-measurements.