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Simulating shifting vertical and lateral flow path conditions in periglacial cover beds of a small-scale low mountainous catchment

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Periglacial cover beds are widely spread in European low mountain regions. This concept is based on three main types of sedimentary layers differing in texture properties: The main layer containing silty material (aeolian loess sedimentation), the basal layer containing gravel and decayed bedrock material (frost weathering of bedrock) and sometimes the intermediate layer in between containing mixed material from main and basal layer. Each layer type is characterized by specific hydraulic properties related to the climatic conditions during sedimentation. Recent research shows a shifting effect on runoff generation depending on the water content of the periglacial layers. Under low water content the basal layer impedes vertical flow whereas at high water content it becomes a preferential flow path for interflow. Reproducing these shifting vertical and lateral flow path effects will increase the credibility of rainfall-runoff models.

The objective of this work was to implement these shifting effects in runoff modelling. We used the Catchment Modeling Framework (CMF) as modular toolkit. First we created a hillslope model to reproduce the effect of shifting flow path. Secondly, we built a semi-distributed catchment runoff model using Hydrological Response Units (HRU) defined by expert-knowledge based on topography, land use and groundwater information. The model was set up in a way that it provides the possibility to implement shifting vertical and lateral flow paths in later model runs.

We performed several field experiments in the small-scale agricultural Schwingbach observatory (1.28 km2 AEO, Hessen, Germany) to gain expert-knowledge. For instance, we identified the spatial distribution of periglacial cover beds, measured hydraulic soil properties and installed 13 piezometers. We further ran conductivity tests of the groundwater body in the piezometer using slug and bail tests. Climate data were used as forcing data and discharge data for calibration and validation of the model.

In doing so we reproduced the effect of shifting conductivity values in periglacial soil deposits based on saturation level in a hillslope model. We further provided a dynamic, expert knowledge based, semi-distributed model approach for future adaption of shifting flow path effects.

Keyword: flow path, expert knowledge, CMF, periglacial cover beds, runoff generation, subsurface flow