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Benefits from local geophysical measurements to model soil water movement in alpine hillslopes at the plot scale

K. Leroch, H.P. Nachtnebel, J. Fürst

Institute of Water Management, Hydrology and Hydraulic Engineering, BOKU - University of Natural Resources and Applied Life Sciences, Vienna

The objective of this paper is to demonstrate how geophysical measurements may assist in the improved modelling of soil water movement at the plot scale. The study was carried out as part of a project on runoff generation on alpine hillslopes after long-term precipitation, which consisted of intensive field experiments as well as modelling approaches at the plot and catchment scale. To improve the understanding of runoff generating processes at the plot scale, sprinkling experiments were carried out in 4 alpine catchments with different geological properties. In each of the selected catchments, 2 plots of 40 x 10 m (400 m2) were irrigated. The experiments simulated a rainfall intensity of 10mm/h over periods of more than 8 hours with simultaneous measurements of surface runoff, subsurface runoff, and soil water content (SWC). SWC was monitored by TDR measurements. In order to improve the monitoring of the spatio-temporal variability of SWC, geophysical in situ measurement techniques with different measurement principles as well as different spatial and temporal resolution were applied during the experiments: Ground Penetrating Radar (GPR) and Geoelectrical Resistivity (GR) imaging. These methods cover a range of spatial scales. With TDR probes, the soil water content of a sphere with a diameter of the length of the antennas is measured, i. e. a volume of appr. 1 dm3, while a single GPR measurement typically relates to the SWC of the top 10-20 cm of a soil column with a foot print of approximately 1m2, i.e. a volume of 100-200 dm3. This resolution is closely related to the representative elementary volume (REV) that is appropriate for numerical modelling of the flow processes at the plot scale. Processing of GR imaging is based on the assumption of a horizontally layered underground.The thickness of the layers (and electrical conductivities) can be resolved at 0.5 - 1 m near the surface, increasing to several meters for the deeper layers. From the TDR measurements at profiles with probes in depths from

10 to 75 cm, time series of SWC during the experiments could be acquired. The GPR technique resulted in cross and longitudinal sections through the plots, measuring the SWC of the top 10-20 cm of the soil several times before, during and after the irrigation. GR imaging profiles measured during the experiment can generally not detect SWC development in the top layer quantitatively, but rather serve as an indicator of eventual deep percolation. To study the sensitivity of runoff to different assumptions of soil parameters, inputs and boundary conditions, numerical modelling experiments were performed using HYDRUS-2D. A rigid calibration of the model was not feasible due to the large uncertainties in all variables, and especially of the heterogeneity of the soil properties. In some sites, with a very rugged terrain and a soil highly disturbed by large stones and tree stumps, HYDRUS-2D was not applicable at all. However, for (the few) sites with a rather homogeneous, fine grained underground and with grass vegetation, which adhere better to the continuum assumptions in HYDRUS-2D, the time series of SWC from the TDR profiles and the SWC longitudinal sections from the GPR measurements can be related to the respective SWC as computed by the model. The spatial variability of SWC in the GPR profiles can be used as an indicator of spatial heterogeneity of the soil.