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Electrical resistivity monitoring during rainfalls: instrumentation and results

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A 3D permanent electrical monitoring system was deployed on the Haute-Mentue catchment in Switzerland during 2004-2005 in order to follow the hydric behaviour of soil during rainfalls. Such surveys allow a precise characterization of vertical and lateral preferential flow during rainfalls. The collected information will permit to increase the understanding of the flood generating mechanism.

The study site is situated in the Swiss Plateau, 20 km north of Lausanne (Switzerland). It includes a square zone (8x8 m) in a spruce forest along the slope of the Ruzillon River (Haute-Mentue catchment). The Haute-Mentue hydrological behaviour was analysed during the last 20 years as this catchment is the experimental basin of the HYDRAM Laboratory of the Swiss Federal Institute of Technology in Lausanne. The permanent installation is coupled with equipment already installed on the Haute-Mentue catchment: a network of limnigraphic stations, a meteorological station, piezometers and TDR (Time Domain Reflectometry).

The monitoring system was set up at the Institute of Geophysics of the University of Lausanne. The permanent installation includes the system of current injection, three Squirrels dataloggers (Grant Instruments) and a system of 49 potential electrodes with inter-electrode interval of one meter and 8 current electrodes installed on the square ground 8x8 m. It is possible to calculate the apparent resistivities for two arrays (pole-pole and pole-dipole) at the same time. During one rain event about ninety measurements scan could be made with 20 minutes interval between the measurements. The first measurement scan is used as background. The 3D distribution of apparent resistivity for each scan is compared with the background as well as the 3D apparent resistivity decrements are calculated. For example, for a rainfall of 24 mm in 35

hours (07.04.2005-09.04.2005) one notices a general increase of the apparent resistivity variation with rainfall's duration. Three hours after the beginning of the event, the apparent resistivity variation is insignificant (2-4 %). As the rainfall and infiltration continue, the soil water percolated down and the apparent resistivity decreased with about 8-10 %, fourteen hours after the beginning of the rainfall, with the highest decrement concentrated in the bottom of the area. The apparent resistivity decrement did not uniformly distribute on the plane. Preferential infiltration is very clear.

Ruzillon subcatchment has gentles slopes that saturate quickly and generate return flow and saturation overland flow during the wet conditions and temporary perched lateral flow (interflow/funnelled flow) during intensive storm events in dry antecedent conditions. For this reason, one has to analyse the soils antecedent conditions in order to correctly interpret the monitoring results.

The proposed 3D noninvasive method of monitoring of spatial and temporal variations of resistivity during the rainfalls with different durations and intensities makes it possible to investigate the 3D rainfall infiltration process, the redistribution of the soil water during and after the rain, and other hydrological processes in the vadose zone.