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Overland flow dynamics through visual observation using time-lapse photographs

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Overland flow process on agricultural land is important to be investigated as it affects the stream discharge and water quality assessment. During rainfall events the formation of overland flow may happen through different processes (i.e. Hortonian or saturation excess overland flow) based on the governing soil hydraulic parameters (i.e. soil infiltration rate, soil water capacity). The dynamics of the soil water state and the processes will affect the surface runoff response which can be analyzed visually by observing the saturation patterns with a camera. Although visual observation was proven useful in laboratory experiments, the technique is not yet assessed for natural rainfall events. The aim of this work is to explore the use of time-lapse photographs of naturally occurring-saturation patterns in understanding the threshold processes of overland flow generation. The image processing produces orthographic projection of the saturation patterns which will be used to assess the dynamics of overland flow formation in relation with soil moisture state and rainfall magnitude.

The camera observation was performed at Hydrological Open Air Laboratory (HOAL) catchment at Petzenkirchen, Lower Austria. The catchment covers an area of 66 ha dominated with agricultural land (87%). The mean annual precipitation and mean annual flow at catchment outlet are 750 mm and 4 l/s, respectively. The camera was set to observe the overland flow along a thalweg on an arable field which was drained in 1950s and has advantages of: (1) representing agricultural land as the dominant part of the catchment, (2) adjacent to the stream with clear visibility (no obstructing objects, such as trees), (3) drained area provides extra cases in understanding the response of tile drain outflow to overland flow formation and vice versa, and (4) in the vicinity of TDT soil moisture stations. The camera takes a picture with 1280 x 720 pixels resolution every minute and sends it directly in a PC via fiber-optic network. Exterior orientation is required to project the observed saturation patterns in the photographs onto orthographic map. This was done by georeferencing the on-field GPS points taken throughout the camera field of view to the orthographic map obtained from an airborne laser scanning (ALS) campaign.

Based on the projected saturation patterns, the patterns dynamics were analyzed in relation to soil moisture state and rainfall magnitude for events in autumn and winter 2014. From the observed events during saturated soil condition, tile drain flow reacted within one hour after the rain started, while no sign of saturation pattern evolving into overland flow was observed. Within two hours after the rain started, overland flow was fully formed along the thalweg which flowed to the erosion gully and created signal at the discharge station almost immediately. From the surface roughness aspect, field management is an important factor of overland flow development as surface runoff was formed faster along the tractor tracks. In overall, time-lapse photographs have potentials to qualitatively assess the saturation patterns dynamics during rainfall events with high time resolution and wide area coverage.