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Abstract

Saturation area connectivity in the Hydrological Open Air Laboratory

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Introduction and context

Figure 1a – Downstream view of september 2024 event

Figure 1b – Upstream view of september 2024 event

- Traditional ways of estimating surface runoff utilize rainfall event characteristics, soil characteristics, topography of the surface, as well as other hydraulic or empirical relations to predict catchment response to a rainfall event.
- Increased accessibility to better cameras has opened up the possibility of studying surface runoff phenomena by visual observation.
- This work presents a novel way of estimating runoff amounts and timings, using overland flow **connectivity metrics.**

Study area

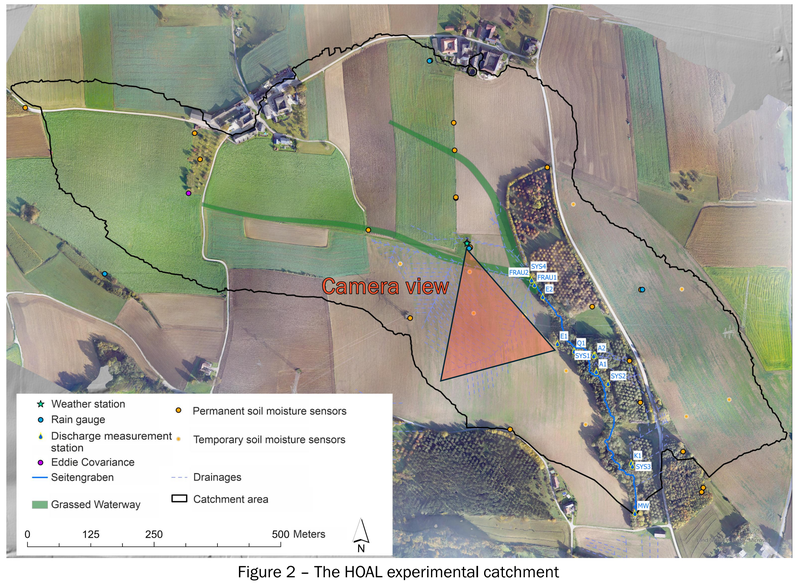

Figure 2 – The HOAL experimental catchment

- This methodology is applied in Hydrological Open Air Laboratory. Which is a small (66 ha), densely instrumented experimental catchment located in Lower Austria.
- The primary instruments utilized for the study are the network camera (Sanyo 2 Megapixels VCC-HD5600 located at the weather station from 2015 – 2020), the tile drains, soil moisture sensors, discharge stations located at the inflows along the stream, as well as the main catchment outlet discharge station.
- The study period is from 2015-2020, for which there is a continuous dataset.

Hypothesis

Rainfall events with a higher degree of saturated area connectivity result in a faster and larger runoff response.

Methodology - Event selection

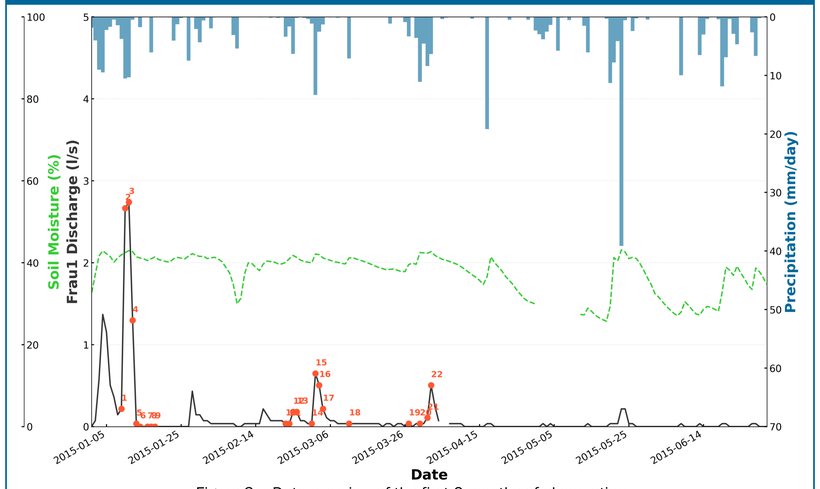

Figure 3 – Data overview of the first 6 months of observation

Due to the angle and elevation of the camera, the selection of the events requires an unobstructed view from the camera to the observed part of the hillslope, as well as precipitation, soil moisture, and discharge measurements.

Methodology – Connectivity scale calculation

Pre-processing of camera images:

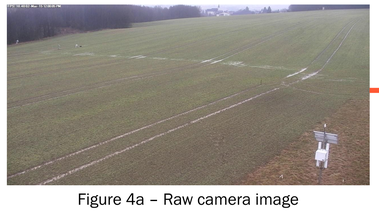

Figure 4a – Raw camera image

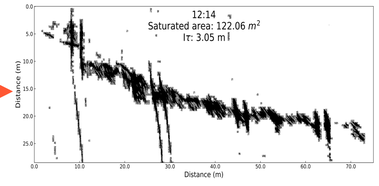

Figure 4b – Pre-processing results

The pre-processing of images is based on the work of Silasari et. al (2017); DOI: 10.1002/hyp.11272

Connectivity calculation:

The used spatial connectivity scale metric comes from Western et al. (2001), it is defined as following from the lag-dependent connectivity function $\tau(h)$:

$$\tau(h) = P(x \leftrightarrow x+h | x \in A, x+h \in G)$$

Where: x is the pixel in question, h is the distance from the pixel, A is a connected patch, and G is a connected patch distinct from A.

From which the connectivity scale is defined as the integral of the connectivity function – or in short **integral scale**:

$$I\tau = \int_0^h \tau(h)dh$$

Due to computational requirements, a FORTRAN module has been developed that calculates the connectivity scale.

Results

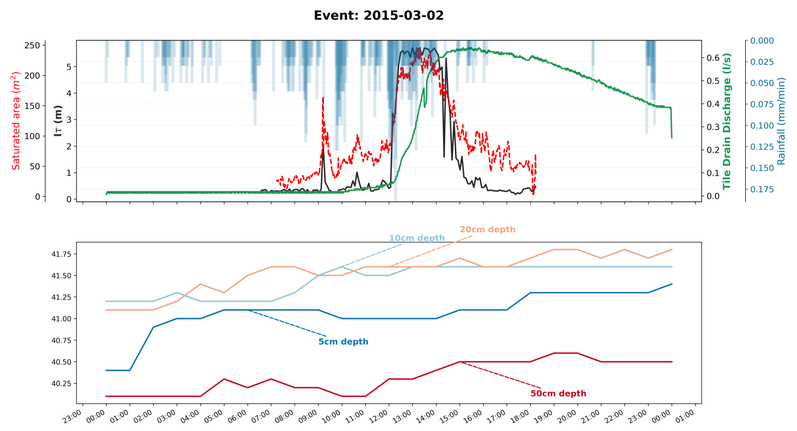

Figure 5 – Response of the observed area to a rainfall episode

- The figure above shows the response of the observed area to a rainfall event.
- The response of the proposed metric – the integral connectivity scale – is analogous to the response of the catchment to soil saturation and ponding on the surface.

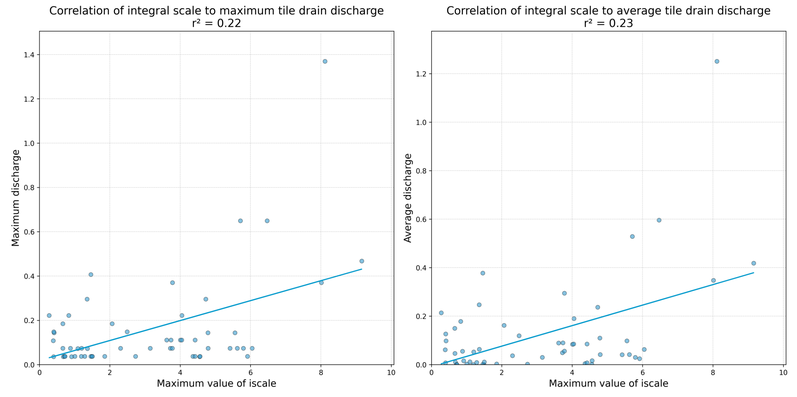

Figure 6 – Relating the integral scale to actual discharge

- As the integral connectivity scale is “faster” than the response of the tile drain discharge, it is useful to compare the two.
- The integral connectivity scale explains some 22-23% of the tile drain response in the 2 hours following the maximum detected value of the integral connectivity scale in a day.

Acknowledgments

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