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What are the water sources for surface saturated areas in the riparian zones of a forested catchment?

Barbara Glaser (1,2), Daniel Partington (3), René Therrien (4), Marta Antonelli (5,1), Philip Brunner (6), Luisa Hopp (2), and Julian Klaus (1)

(1) Catchment- and Ecohydrology Research Group, Luxembourg Institute of Science and Technology, Esch/Alzette, Luxembourg, (2) Department of Hydrology, University of Bayreuth, Bayreuth, Germany, (3) School of the Environment and National Centre for Groundwater, Research and Training, Flinders University, Adelaide South Australia, Australia, (4) Department of Geology and Geological Engineering, Université Laval, Quebec, Quebec, Canada, (5) Hydrology and Quantitative Water Management Group, Wageningen University & Research, Wageningen, The Netherlands, (6) Centre of Hydrogeology and Geothermics, Université de Neuchâtel, Neuchâtel, Switzerland,

Riparian zones are a key landscape unit in catchments and function as a transmitting and buffering zone between the catchment and the stream. A typical feature of riparian zones are dynamically flooded areas. These surface saturated areas can influence runoff generation via overland flow and they can function as biogeochemical and ecological hotspots. Various studies have shown that the development of surface saturation is highly variable in space and time. Moreover, surface saturation can be generated by several processes, e.g. by infiltration excess, saturation excess or groundwater exfiltration. However, the variability of the spatio-temporal saturation patterns within riparian zones and how their formation is controlled by the different hydrological processes is seldom investigated. Depending on the dominant process (e.g. groundwater exfiltration or ponding precipitation), the impact of surface saturated areas on water quality, biogeochemical processes, ecology and runoff generation might differ in space and time.

In this study, we analysed the patterns of surface saturation in seven distinct riparian areas of the Weierbach catchment, a 42 ha forested catchment in western Luxembourg. We mapped the surface saturated areas with thermal infrared (TIR) imagery over a period of two years in weekly to biweekly intervals. The obtained TIR data set gave a detailed picture of the temporal and spatial variability of surface saturation in the riparian zone of the catchment. In addition, we could identify locations of discrete groundwater exfiltration into the riparian zone by relying on the temperature information obtained with the TIR imagery. However, the TIR observations did not provide any information on how much of the surface saturation was generated by groundwater exfiltration and how much originated from direct precipitation, overland flow or upstream water.

In order to investigate the interaction of different generation processes and water sources for the generation of surface saturation in more detail, we simulated the surface saturation with the 3D integrated surface subsurface hydrological model HydroGeoSphere. A validation of the simulated spatial and temporal variability of surface saturation with the TIR observations showed that the model could capture the locations and frequencies of surface saturation with high detail. This provided the necessary confidence in the model to use it for analysing the physical controls and processes underlying the variable surface saturation generation. We analysed the model output with regard to the contribution of groundwater to surface saturation in the riparian zone and eventually to the stream at different locations and during different hydrological conditions. This further improved our understanding of the processes controlling the variable surface saturated areas in riparian zones.