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Validating modelled variable surface saturation in the riparian zone with thermal infrared images

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Variable contributing areas and hydrological connectivity have become prominent new concepts for hydrologic process understanding in recent years. The dynamic connectivity within the hillslope-riparian-stream (HRS) system is known to have a first order control on discharge generation and especially the riparian zone functions as runoff buffering or producing zone. However, despite their importance, the highly dynamic processes of contraction and extension of saturation within the riparian zone and its impact on runoff generation still remain not fully understood.
In this study, we analysed the potential of a distributed, fully coupled and physically based model (HydroGeoSphere) to represent the spatial and temporal water flux dynamics of a forested headwater HRS system (6 ha) in western Luxembourg. The model was set up and parameterised under consideration of experimentally-derived knowledge of catchment structure and was run for a period of four years (October 2010 to August 2014). For model evaluation, we especially focused on the temporally varying spatial patterns of surface saturation. We used ground-based thermal infrared (TIR) imagery to map surface saturation with a high spatial and temporal resolution and collected 20 panoramic snapshots of the riparian zone (ca. 10 by 20 m) under different hydrologic conditions. These TIR panoramas were used in addition to several classical discharge and soil moisture time series for a spatially-distributed model validation.
In a manual calibration process we optimised model parameters (e.g. porosity, saturated hydraulic conductivity, evaporation depth) to achieve a better agreement between observed and modelled discharges and soil moistures. The subsequent validation of surface saturation patterns by a visual comparison of processed TIR panoramas and corresponding model output panoramas revealed an overall good accordance for all but one region that was always too dry in the model. However, quantitative comparisons of modelled and observed saturated pixel percentages and of their modelled and measured relationships to concurrent discharges revealed remarkable similarities.
During the calibration process we observed that surface saturation patterns were mostly affected by changing the soil properties of the topsoil in the riparian zone, but that the discharge behaviour did not change substantially at the same time. This effect of various spatial patterns occurring concomitant to a nearly unchanged integrated response demonstrates the importance of spatially distributed validation data. Our study clearly benefited from using different kinds of data – spatially integrated and distributed, temporally continuous and discrete – for the model evaluation procedure.