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Hydrological functioning of gullies and inter-rill areas during the initial stage of a developing ecosystem

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Gullies up to a few meters wide and up to one meter deep, as well as intermediate rather flat areas (so called inter-rill areas) are the two opposing characteristic surface features of the artificial research catchment 'Chicken Creek' in the vicinity of Cottbus (eastern Germany). They have emerged and intensified during the first five years of the ecosystem development. The present study aims at highlighting their hydrological functioning through a combination of in-situ and remote sensing of near-surface water content with numerical soil hydraulic modelling.
A time series of more than one year of near-surface soil water contents was obtained from approximately thirty spatially distributed Decagon sensors at a depth of 10 to 15 cm, as well as from an L-band radiometer positioned on a 10-m high tower facing a footprint area in the research catchment of approximately 100 m2. They were used to verify a one-dimensional soil water and heat transfer model (COUP, Jansson and Karlberg, 2002) simulating surface runoff, infiltration and groundwater recharge for typical gully and inter-rill areas. The model was fed with detailed information about soil hydraulic properties and driven with hourly meteorological data.
After calibration the numerical model correlated very well with the soil moisture measurements of the inter-rill areas (R2 = 0.68; root mean square error = 0.028 m3 m-3). This good agreement suggests that the chosen hydraulic properties of the uppermost soil layers are appropriate and that the simulated soil evaporation and snow dynamics are plausible. Also the much less dynamic soil water content in the gullies was reproduced well by the model.
The seemingly appropriate simulation of the near-surface water dynamics, suggesting most of the precipitation to infiltrate and percolate to the groundwater, contradicts visual observations that surface runoff is the dominant runoff mechanism during rain storms. This unsolved discrepancy shall be further investigated in the second project phase, a.o. with the analysis of isotope tracers.