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Stream temperature as a tracer to document runoff generation at different moisture states

J. Lange (1), A. Hänsler (1)

(1) Institute of Hydrology, University of Freiburg, Germany
(jens.lange@hydrology.uni-freiburg.de)

The 1.3 km2 Engebächle catchment is located in the Black Forest Mountains, southwest Germany. The catchment is characterized by 1100 mm mean annual precipitation, steep slopes and crystalline rocks which are overlain by periglacial drift covers. During two different events in summer 2005 stream temperature measurements were used to illustrate runoff generation processes at different moisture states. Temperature sensors were placed immediately up-, downstream and within an extended saturated area at the upstream beginning of a 1.2 km channel reach. Down the reach these were followed by additional sensors and finally by a combined conductivity-temperature logger at the runoff gauge. The first event - a 25 min thunderstorm - occurred at dry preconditions and minimum baseflow, while the second 11h storm hit a wet catchment at the end of summer. Immediately before the first event stream temperature was generally high. During the event it dropped sharply by about 7°C reaching a minimum value inside the saturated area. Comparing this minimum with values in the stream channel immediately up- and downstream the saturated area, a maximum contribution of about 60% saturated area runoff was determined. During the second event temperature differences among the sensors were non significant suggesting a more uniform runoff generation. During both events drops in stream temperature were used for a two component hydrograph separation separating cold event rainfall from a relatively warm pre-event baseflow component. Rainfall temperature was approximated by air temperature and a cooling of the pre-event component by applying an energy balance model. Simultaneous hydrograph separation using conductivity served as plausibility control. Here baseflow of constantly high conductivity was assumed to be diluted by less mineralized rainfall. The separation results obtained by conductivity fell inside the uncertainty range of the temperature based calculation. At dry conditions (event

1) about two thirds of the quick flow (direct runoff) were found to be event water. The temperature based separation pointed to surficial runoff generation and flow paths. Overland flow from forest roads was considered as one probable runoff source, the other was saturated area runoff, which could directly be quantified at one location. At wet conditions (event 2) a similar rain amount produced only 36% of event water in quick flow. The much larger fraction of pre-event water originated from reservoirs only active at higher moisture states which was also apparent in a delayed flow recession.