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Quantifying the impact of land-use changes at the event and seasonal time scale using a process-oriented catchment model

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Abstract. For optimal protection and integrated management of water resources, it is essential to quantify the impact of land-use change on hydrological regimes at various scales. Using the process-based catchment model TAC^D (tracer aided catchment model, distributed) two land-use scenarios were analysed for the rural and mountainous Dreisam basin (258 km^2): (i) an increase in urban area from 2.5% to 5%) and (2) a change in a natural land-use to a different kind of forest. The first scenario was executed using the land-use change modelling kit LUCK, which takes into account the topology of land-use patterns in their true positions. The TAC^D model simulated all hydrological processes both spatially and temporally (200 m x 200 m grid, hourly mode). For this study, physically-based modules for interception and evapotranspiration (Penman and Monteith approach) were introduced. The model was applied to the Dreisam basin with minimal calibration. Both an independent validation period and discharge in four nested sub-basins were modelled well without recalibration. Evapotranspiration patterns were simulated, successfully, both temporally and spatially. Increased urbanisation had an insignificant effect on the modelled single events and on the yearly water balance. Simulations of discharge from forest assuming natural land-use conditions indicated an increase in transpiration, a decrease in groundwater recharge and, consequently, in groundwater discharge (–15%), in surface water discharge (–4%), and in flood peaks (–22.7% and –7.3% for convective and advective floods, respectively). Land-use impact was also investigated by applying rainfall scenarios of different durations (12, 24, 48, and 72 hours), magnitudes (recurrence intervals of 1, 5, and 10 years) and distributions of rainfall intensity, i.e. maximum intensity at the beginning, middle or end of the event. Clearly, the intensity distribution has a greater influence on the simulated events than different land use scenarios. This indicated the importance of careful determination of the temporal intensity distribution for flood peak predictions. The use of the process-based model enabled analysis of the altered composition of internal runoff components. This demonstrated the potentially significant local effects of land-use change on flood runoff and water quality.

Keywords: land-use change, predictions, process-based catchment modelling, flood modelling, evapotranspiration modelling TAC^D model, LUCK

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