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Projection of land-use parameters for modelling hydrological change – concept and testing

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Investigations on the influence of future land-use change on the water balance mainly rest on model-based projections of land cover. This leads to restrictions for hydrological modelling since there are only a few parameters that may be related to land cover as the physical and biological surface of the earth. In fact, land use interrelates in numerous processes with the water balance depending on human activities and site-specific conditions. Therefore, these processes need a more detailed consideration. Up to now, there are only a few attempts to realise comprehensive projections of land-use parameters that are relevant for modelling hydrological change. Hence, a concept for a GIS-based parameter model has been developed to provide water-related land-use parameters in a consistent and dynamic way with a high validity and a high spatial resolution.

As basis a principal concept of the interrelation between land use and the water balance has been developed. Currently, it comprehends 15 hydrological processes such as evaporation, run off and leaching. For each process the relevant land-use parameters have been identified. For example, the process of evaporation is influenced by the NDVI, sealing and coverage canopy level. Overall, this leads to 46 land-use parameters, whereof 24 play a major role for settlements and 22 for the remaining landscape.

To analyse and project parameter values land-use types (LUT) are used. In a first step, they are derived as land cover from satellite images (GeoEye 2009, Landsat ETM+, SPOT) and from topographic maps, pre-processed with the spatial analysis tool SEMENTA® for further detailed information. Typology results in urban structure types (UST) for settlements and vegetation structure types (VST) for the remaining landscape. As second step, each LUT is determined regarding its water-related parameter values based on field surveys on test sites and subsequent statistical analyses (software R). Hereby, geo data on site-specific natural conditions such as soils, groundwater table, etc. are included. Parameter values with a high correlation to one LUT are concluded as specific to this type. All other parameter values are considered as independent and handled as geocoded in the subsequent work.

Particularly, the type-specific parameter values are seen as a mean for projecting land use using scenarios of regional change. The projections have two principal causes: (i) scenario- and model-based land-cover change and (ii) change of parameter values (e.g. increase of soil sealing in transition countries). They lead to new patterns of land use with revised parameter values considering the land-cover change, site-specific natural conditions and change of parameter values in a consistent way, at least, for the specific parameter values for LUT. To represent interrelations between parameter values and their spatial distribution the parameter model on water related features of land-use types (PWF-LU) is designed. Furthermore, it allows provision of parameter values in different units to address the requirements for a wide range of hydrological models (e.g. SWAT, WASIM-ETH).

The approach is currently tested in the upper part of the Western Bug River catchment (Ukraine) in a scenario analysis on mid and long-term climate change and land-use change impacts on the hydrological system with a coupled modelling approach (CCLM – PWF-LU – SWAT – RWQM1 and others). The paper presents initial results of the testing with a focus on the parameter model.