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Hydrological Land Classification Based on Landscape Units

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Landscape classification in meaningful hydrological units has important implications for hydrological modeling. Conceptual hydrological models, such as HBV- type models, are most commonly designed to represent catchments in a lumped or semi-distributed way at best, i.e. treating them as single entities or sometimes accounting for topographical and land cover variability by introducing some level of stratification. These oversimplifications can frequently lead to substantial misrepresentations of flow generating processes in the catchments in question, as feedback processes between topography, land cover and hydrology in different landscape units can arguably lead to distinct hydrological functions.

By making use of readily available topographic information contrasting landscape and hydrological units can be identified based on the concept of "Height above Nearest Drainage" (HAND; Renno et al., 2008; Nobre et al., 2011). These are characterized by different hydrological behavior and can be assigned different model structures, therefore allowing a more realistic representation of the catchment processes (Savenije, 2010).

We thus used hydrological and topographical data from the Wark Catchment with a surface area of 82 km2 in Luxembourg which clearly exhibits three distinct landscape units, namely plateaus, hillslope and wetlands. A smoothed 5x5 m2 DEM was used for analysis and identification of the three landscape units. Besides using the original HAND algorithm, several adapted versions, which allowed, amongst others, the inclusion of local slope and distance to the nearest drainage, in order to increase the accuracy of the results, were developed. These revised and extended versions of HAND not only allowed more accurate landscape unit identification based on more criteria than HAND, but also gave preliminary estimates of uncertainty in the landscape unit identification as they were implemented in a stochastic framework. As the transition thresholds between the landscape units are a priori unknown, they were calibrated against landscape units observed in the field using a single probability based objective function. Thus, as a result, each grid cell of the DEM was characterized by a certain probability of being a certain landscape unit, producing maps of dominant landscape and therefore hydrological units. As the preliminary result the percentage for wetland, hillslope and plateau are 15, 45 and 40 percents respectively for the Wark Catchment.

The maps of the most adequate HAND algorithm using HAND and slope in a probabilistic framework were then used to determine the proportion of the individual units in the catchment. Having assigned different model structures to the individual units, i.e. a deep percolation dominated one for the plateau, a rapid subsurface flow dominated one for hillslopes and a saturation overland flow one for the wetlands, the modeled runoffs were proportionally combined to give the total runoff of the catchment.

Including landscape classification into hydrological models seems to be a powerful tool which may also lead to other uses like the study of land use, soil type, sediment transport and in general more detailed information with relatively basic input data on how a catchment may work than a simple lumped model.