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Reliable spatial predictions despite uncertainty in distributed hydrologic models?

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Uncertainty is a crucial and critical aspect of hydrological modeling at every spatial and temporal scale. Accordingly, it has received much attention and many approaches have been developed to quantify effects of parameter and model uncertainty on model predictions. In this context, we ask the question whether hydrological modeling can be of real help for practical applications in land use management. For that purpose, hydrological models should help to delineate parts of a given catchment to be managed in a special way. Does the uncertainty inherent in most modeling efforts not preclude reliable predictions of e.g., contributing areas for diffuse losses of agrochemicals? The answer is "Not necessarily", based on model results in a small agricultural catchment of the Swiss Plateau.

We investigated the spatial distribution of contributing areas by means of a soil-type based rainfall-runoff model coupled to a modul simulating Phosphorus transfer to surface waters. Based on discharge data in different catchments of the study region and on field experiments, it was assumed in the model that saturation-induced runoff is the dominating process in this grassland dominated hilly area. Consequently, topography and soil types are the dominant factors controlling simulated discharge from the catchments. Despite large uncertainties with regard to predicted discharge volumes or P losses (in the order of 80% of the mean value during peak flow) caused by parameter uncertainty, the spatial location of contributing areas at any given moment showed little variability (about 10 to 20% variation). Therefore, if we are more interested in "Where" runoff is generated instead of "How much", ill-defined problems of parameter identification may be much less critical than for e.g., flood prediction.

Hence, in the context of land use management one has not to care so much about uncertainty of hydrologic modeling in general but has to investigate the uncertainty with regard to delineation of contributing areas. If the spatial pattern of runoff generation is dominated by temporally constant factors like soil type and topography, contributing areas may be predicted with sufficient reliability for practical purposes.

On the other hand, if land management has a direct influence on the hydrologic behaviour it may be difficult to model the catchment response adequately without detailed management data. We illustrate such a situation with the sealing effect of manure application, which may affect the runoff behaviour on grassland and with possible consequences for contributing areas. This may introduce substantial uncertainty into the model simulation due to ill-defined boundary conditions.