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Combining experimentalist knowledge with modelling approaches to evaluate a controlled herbicide application experiment in an agricultural headwater catchment

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Although only a small fraction of the herbicide mass sprayed on agricultural fields reaches the stream in usual conditions, concentrations in streams may reach levels proven to affect organisms. Therefore, diffuse pollution of water bodies by herbicides in catchments dominated by agricultural land-use is a major concern.

The process of herbicide wash off has been studied through experiments at lab and field scales. Fewer studies are available at the scales of small catchments and larger watersheds, as the lack of spatial measurements at these scales hinders model parameterization and evaluation. Even fewer studies make explicit use of the combined knowledge of experimentalists and modellers. As a result, the dynamics and interactions of processes responsible for herbicide mobilization and transport at the catchment scale are insufficiently understood.

In this work, we integrate preexisting experimentalist knowledge aquired in a large controlled herbicide application experiment into the model development process. The experimental site was a small (1.2 km2) agricultural catchment with subdued topography (423 to 473 m a.s.l.), typical for the Swiss Plateau. The experiment consisted of an application of multiple herbicides, distributed in-stream concentration measurements at high temporal resolution as well as soil and ponding water samples. The measurements revealed considerable spatio-temporal variation in herbicide loss rates. The objective of our study is to better understand the processes that caused this variation.

In an iterative dialogue between modellers and experimentalists, we constructed a simple hydrological model structure with multiple reservoirs, considering degradation and sorption of herbicides. Spatial heterogeneity was accounted for through Hydrological Response Units (HRUs). Different model structures were used for dinstinct HRUs to account for spatial variability in the perceived dominant processes. Some parameters were linked between HRUs to constrain the parameter space and facilitate inference. The Superflex hydrological modelling framework provided the flexibility needed for the distributed iterative approach. The model was jointly calibrated to streamflow data and time series of herbicide concentrations.

Our preliminary results indicate that herbicide loss rates are generally higher for soils which are prone to saturation or when maximum rainfall intensity is high. While a very simple model is sufficient to characterize the hydrological response of the catchment, considerable extensions are needed to include the major conceptual herbicide transport paths in a physically reasonable way. With the current model we are able to reproduce streamflow dynamics, whereas identifying generalizable mechanisms that drive the wash off dynamics of different herbicides from different fields is challenging.