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Spatial and temporal explicit catchment modelling in aquatic risk assessment using the modular framework CMF

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The EFSA Guidance Document on Aquatic Risk Assessment indicates a key role for effect modelling in future aquatic risk characterisation in a tiered risk assessment framework. Such approaches require correspondingly adapted exposure tools and scenarios ranging from simple edge-of-field to spatiotemporally explicit landscape-scale catchment models. These approaches should be sufficiently flexible and transparent in order to design lower- and higher-tiers of consistent protection level. Current models like SWAT or MIKE-SHE come with a fixed model structure which makes adaption to tiers of different complexity difficult. Flexible and modular approaches are needed to provide a spatially and temporally explicit aquatic exposure pattern to investigate effects on organisms according to Specific Protection Goals.

A flexible and modular catchment model for water and pesticide transport has been developed which allows for stepwise adaption of model complexity to address tiered risk assessment problem formulations. The approach is based on the hydrological programming library CMF. Core functions of CMF are implemented in C++ and specific catchment setups are designed by Python scripting. The current approach focuses on the following abilities in order to investigate landscape-scale interactions: (a) a modular programming structure that enables replacement of process descriptions and (b) an incorporation of additional models; (c) an up-to-date connection between models at memory level in order to ensure high computing performance.

A landscape is represented by the following components:

i) Vertical water fluxes in fields are modelled with Richards equation, with the soil profile discretised into 24 soil layers. Each field holds a surface water, a groundwater and an optional drainage storage which are connected by a kinematic wave with the river bodies. ii) Plant growth (phenology, leaf and root growth, water uptake) is modelled with similar methods and parameters as in the model MACRO 5.2.

The setup was tested for a 350 ha catchment in Belgium under intensive arable use with detailed information on farming practice and observed discharge as well as herbicide loads at the catchment outlet for a time period of almost four years. The predicted environmental concentrations were used as input for an effect model in order to investigate the impact of the herbicide loads on the aquatic plant Lemna at population level.