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Modelling landscape-level pesticide concentrations with SWAT+ - an uncertainty assessment of application timing

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Modelling environmental concentrations of plant protection products at landscape-level is of growing interest for pesticide registration and product stewardship, including higher-tier studies in risk assessment, mitigation measures, monitoring support and decision making. However, landscape-level modelling is challenging due to uncertainties by modelling concepts and scaling as well as the extensive (geo)data demand for model parametrization and validation. This includes also limited information about application timing of pesticide products having strong impact on the model performance predicting pesticide concentrations in water bodies. Our work explores the impact of pesticide application timing using the eco-hydrological model SWAT+ (revised version of Soil and Water Assessment Tool) to explore uncertainty effects of application timing and the underlying mechanisms for the surface water exposure pattern in a small-scale catchment. Specific focus thereby was on method development to mimic realistic application timing considering plant stage, hydrology and weather conditions.

On this account, we setup a SWAT+ model of the Funne catchment (54.6 km²) in the North-West of Germany. The simulated daily streamflow was calibrated using publicly available gauge data (Selm-Ondrup) showing a very good hydrological performance of the model (NSE: 0.746). The impact of application timing was subsequently explored by different synthetic application scenarios for three pesticides with varying physio-chemical properties, in combination with static and rule-based timing options. First results taking runoff and drainage into account indicated that a simple forward oriented ruleset (i.e. using weather forecast) could significantly decrease pesticide loads at the catchment outlet on average by 16 to 46%. For individual years and substances, channel loads decreased by up to 92%, which could be attributed to the interaction of rainfall and wash-off timing as the main driver of concentration variation during runoff events. We will further explore the impact of drift entry and other processes (e.g. channel dissipation) as well as different application schemes.

These findings underpin the importance of realistic application timing in landscape-level simulations of pesticide concentration in surface water bodies. It is hence expected that landscape-level tools will play an important role in the future, e.g., for the development and operation of smart decision tools in agriculture.