Assimilation of images into a spatialized model of water and pesticide fluxes.

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General overview: pesticide transfer issues and challenges

Controlling and reducing surface water contamination by pesticides is a major issue for the protection of surface and groundwater resources and of aquatic flora, fauna, and biodiversity. To achieve the "good status" of rivers in Europe required by the Water Framework Directive, modeling tools are necessary to help in the management of pesticides applied in agricultural watersheds. Pesticide transfer can be accelerated or slowed down depending on landscape features, distribution of plots, and spatial and temporal distribution of pesticide applications. Since pesticides interact strongly and nonlinearly with the environment, it is essential to understand the flow paths in the surface and subsurface domains. Modeling should thus take into account all watershed characteristics, in particular soil properties, to help describe properly the risk of contamination of surface water.

Physically spatialized models that solve the surface and subsurface flow and transport equations make it possible to represent in fine detail water and pesticide fluxes at any point within the spatial discretization of the system. However, these distributed models depend on a large amount of spatialized parameters that render their practical application difficult. The different processes related to hydrology and pesticides interact in the surface and subsurface and are highly non-linear. Input parameter setting is a complex step and difficult at that scale, due to the high heterogeneity of the system (saturated hydraulic conductivity, humidity, rugosity, etc.) and the uncertainty on many parameters. For example, physico-chemical properties of molecules (adsorption, degradation, etc.) play a key role in their transfer pathways, but they are poorly known in the field and very difficult to measure. The process-based, hydrologic model of coupled surface-subsurface flow CATHY (CATchment HYdrology, [1]) was recently extended to reactive solute transport and evaluated in detail through a global sensitivity analysis [2].

Image data assimilation in the CATHY-pesticides model

To help parameterize this type of model, data assimilation methods that combine all of the available information (physical model, data, associated errors) to estimate the input parameters and correct the model can be used. Data assimilation techniques have only very recently been applied in detailed process-based hydrological modeling (e.g., [3] and [4] for the CATHY model) and even more rarely for pesticide transfer. In this study, we develop a Kalman ensemble data assimilation scheme [5] in order to estimate spatialized model parameters and to evaluate the impact that a more detailed parameterization has on pesticide transfer.

The data assimilation scheme will pay a special attention to the spatial properties of remote sensing images. Indeed, satellite imagery can potentially be very useful to help overcome the lack of spatial information for the model, due to the highly detailed spatio-temporal information they provide, but they are most often under-exploited by considering pixels as single data [6]. For example, classical DA approaches don't consider correlated noise on observations, defining the observation error covariance matrix as diagonal. This simplified representation makes the numerical resolution easier and can be valid for independent sensors, but images from a same satellite sensor are necessarily affected by spatially correlated errors. This study implements a solution to provide observation error covariance matrices adapted to spatially correlated errors, focusing on the observations operator description, and the definition of distances in the data assimilation scheme [7].

The methodological development for pesticide modeling will be tested on virtual data using twin experiments on a hillslope. The CATHY-Pesticide model setup will be based, however, on a real field experiment in the

Beaujolais vineyard region, including a vineyard plot and a vegetative filter strip, in order to stay close to well-known conditions (Figure 1).

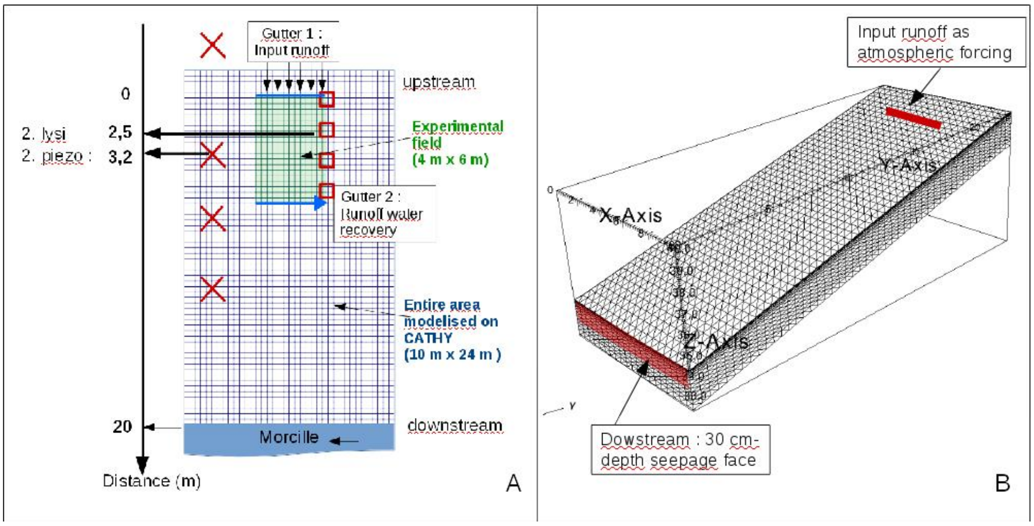

Figure 1: The experimental Morcille study site (left) and the modeling setup for CATHY (right).

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