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Modelling the contribution of groundwater flow to pesticide contamination of runoff water in a humid tropical catchment in the French West Indies

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Water contamination by pesticides from agricultural activities is a worldwide environmental problem. In volcanic tropical humid conditions, given the heavy rainfalls and soils with high infiltration capacities, the risk of contamination is high in case of cropping systems with intensive use of pesticides, like bananas.

However, previous studies on a cultivated catchment (17.8 ha) in the French West Indies showed that pesticide transfer can be complex: catchment runoff results from the interaction of overland and groundwater flows (Charlier et al, 2008, Hydrological Processes, 22, 22, p.4355-4370). Its contamination by a nematicide applied in banana cropping (Charlier et al, 2009, Journal of Environmental Quality, 38, 3, p.1031-1041) showed two successive phases, which were interpreted as stemming from two distinct contamination mechanisms: an event-dominated contamination phase when transport was linked to overland flow during precipitation shortly after pesticide application, and a stabilized contamination phase when transport originated mainly from the drainage of the shallow aquifer. Comparing the losses of the two phases during two monitoring campaigns showed that shallow groundwater, which is promoted in such permeable soils under abundant tropical rainfalls, seems to be the main contributor to runoff water contamination.

The aim of this work is to develop a modelling system of both overland and groundwater flows able to simulate the dynamic of water contamination by cadusafos observed in Charlier et al (2009, Journal of Environmental Quality, 38, 3, p.1031-1041) to confirm the contamination mechanisms that were hypothesized.

The modelling system is based on linking two models. First, a distributed surface model, MHYDAS (Moussa et al, 2002, Hydrological Processes, 16, 2, p393-412), is used to compute infiltration and Hortonian runoff at the field scale and its routing from the fields to the catchment outlet. Then, a three-dimensional finite-difference groundwater flow model, MODFLOW (McDonald and Harbaugh, 1988, USGS Book) and a modular three-dimensional transport model, MT3D (Zheng, 1990, USEPA Report), simulates water flow and cadusafos transport in the groundwater zone and their interaction with the hydrographic network. Results from the modelling system are compared with the observed data from the two monitoring campaigns mentioned previously which consisted in spreading cadusafos on a portion of the catchment and monitoring the concentrations in the soil and in runoff and groundwaters.

Preliminary results on parameter calibration and test of water flow hypothesis will be presented.