“Pesticide runoff modeling over urban landscape with HYDRUS2/3D models.”
Progress in 2014

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We are testing multiple approaches to simulate simultaneously the surface and subsurface water flow and solute transport. The **first approach** is based on describing subsurface water flow using the Richards equation:

$$\frac{\partial \theta}{\partial t} = \nabla\left[K(h)\nabla\left(h+z\right)\right]+q \qquad (1)$$

and surface flow using the kinematic equations (Köhne et al., 2011):

$$\frac{\partial h_s}{\partial t} = -\nabla\left[h_s U_s\right]+q_s \qquad (1)$$

Both surface and subsurface flow equations are solved independently, providing boundary conditions for each other. The **second approach** is to describe both subsurface and surface water flow using one general equation (Weill et al., 2009):

$$\sigma(h)\frac{\partial h}{\partial t} = \nabla\left[K(h)\nabla\left(h+z\right)\right]+q \qquad (1)$$

which takes the form of the Richards equation for subsurface flow and the diffusion wave equation for surface flow depending on the definition of the material properties $\sigma(h)$ and $K(h)$. For the Richards equations these two terms are as follows:

$$\sigma(h)=\begin{cases} C(h) & h<0 \\ S^* & h\geq 0 \end{cases}$$

$$K(h)=\begin{cases} K_{sat}k_r(h) & h<0 \\ K_{sat} & h\geq 0 \end{cases} \qquad (2)$$

while for the diffusion wave equation they are

$$K_{s,xx}(h_s)=K_{s,yy}(h_s)=\frac{h_s^{5/3}}{n_{man}e\sqrt{S}}$$

$$K_{s,zz}(h_s)=K_{zz} \qquad (3)$$

where K_{sat} is the saturated hydraulic conductivity [LT^{-1}], $K_r(h)$ is the relative hydraulic conductivity [-], S^* is the specific volumetric storage [L^{-1}], $C(h)$ is the soil capillary (hydraulic) capacity [L^{-1}], S is the mean local slope [-],e is the runoff layer thickness and n_{man} is the Manning's roughness coefficient [$L^{-1/3}T$]. In this approach both surface and subsurface flow are solved simultaneously in one continuous systems. It is expected that this approach may be more numerically stable.

During 2014 we started testing the modeling tools being developed to simulate surface runoff to evaluate collected laboratory experimental data involving high intensity rainfall (generating surface runoff) and application of various microorganisms (Bradford et al., 2015).

A new PhD student, Jing Liang, started working on this topic. She is working both with the HYDRUS model, as well as implementing the same modeling concept into the general partial-differential equations solver COMSOL, so that the newly developed model can be fully verified. She has presented her preliminary work on this topic during the Environmental Sciences Graduate Program Symposium (Liang, 2014) and at the W3188 meeting (Liang, 2015).

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Liang, J., Develop a fully coupled surface/subsurface dual-permeability model to describe overland flow and microbial transport, W3188 meeting, Las Vegas, NV, January 3-5, 2015.