Limitations on ODE representation of drainage tiles in a hillslope runoff model

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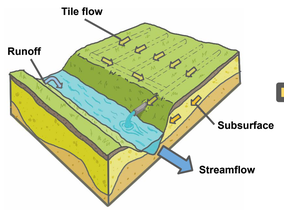
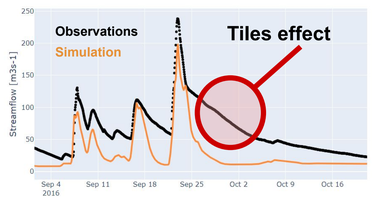
1. Introduction

Tile drainage at the hillslope scale



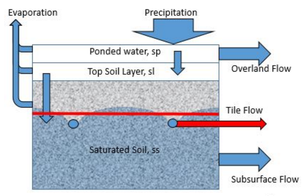
Slow recession at catchment scale



- Tile drainage induces changes in the **recession** curve increasing the **duration time of flooding conditions**.
- We use **Hydrus** simulations to find a relationship between **seepage** and **storage** at hillslope scale to incorporate into an **ODE model**.
- Finally, we couple the new ODEs to our HLM model for regional scale simulations.

2. Physical model

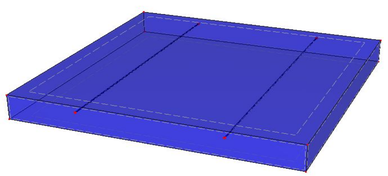
DRAINMOD Model



$$Q_{tile} = \frac{8k_e d_e \left(\frac{4(s-H)}{0.2\pi}\right) + 4k_e \left(\frac{4(s-H)}{0.2\pi}\right)^2}{L^2}$$

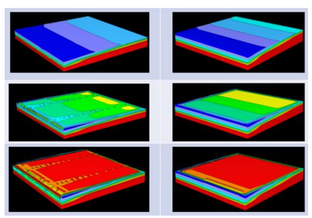
This three-compartment ODE model applies **subsurface flow** and **tile flow** (when valid) as functions of **subsurface storage** (Sloan et al (2016), Sloan et al (2017)). This representation is insufficient when including the effects of hillslope slope.

Hydrus-3D Model



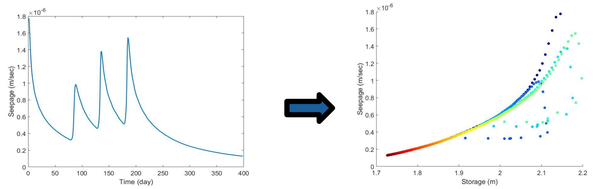
For this case, we setup a **tiled hillslope** in **Hydrus-3D.**

Tiled **No tiles**

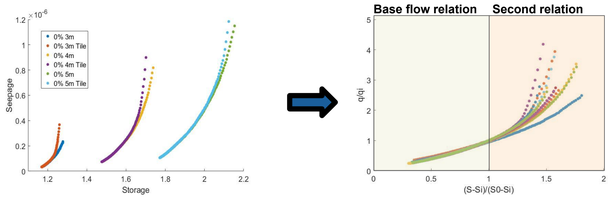


3. ODE representation

3D simulation results .

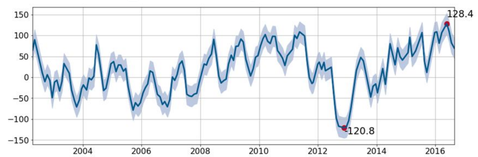


Storage / Seepage relationship obtained from Hydrus-3D model.



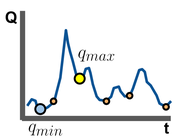
We identify a non-dimensional non-linear storage-seepage relationship that accounts for different hillslope slopes, subsurface depths, and tiling configurations

Inferring model parameters from data



Active water storage derived from GRACE

$$\Delta S = 0.248\,[\text{m}]$$



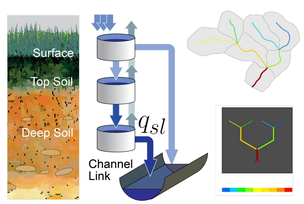
$$\Delta q = \max_t q_{min} - \min_t q_{min}$$

$$K_3 = \frac{\Delta q}{\Delta S \cdot A} \quad \Delta S = \frac{\Delta q}{K_3 \cdot A}$$

$$\min_t q_{min}$$

$$\max_t q_{min}$$

HLM model modification:



HLM - Linear reservoir:

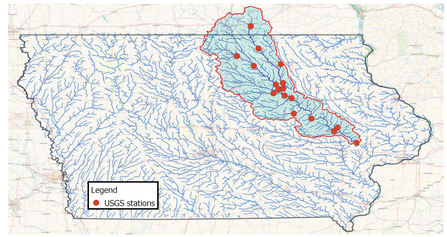
$$q_{sl} = S_s \cdot K_3$$

HLM - Tile:

$$q_{sl} = \begin{cases} S_3 \cdot k_3 & \text{if } S_s < S_i \\ \alpha e^{\beta S_s} & \text{if } S_s \geq S_i \end{cases}$$

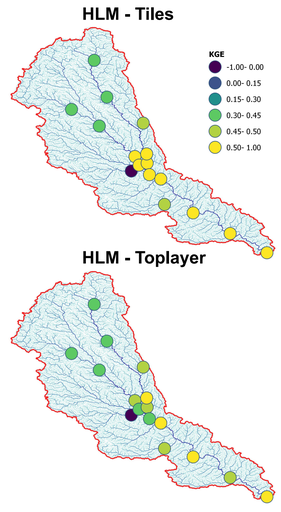
4. Results

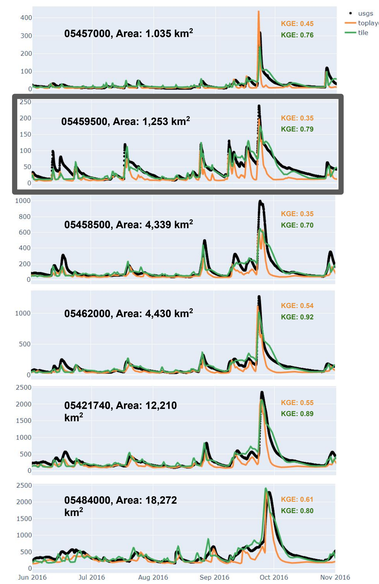
Watershed scale simulations



We validate model results at **19 USGS** stations.

HLM model results.





Contact and acknowledgments

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