Seminar 4: Infiltration with DRUtES

Transport of contaminants in porous media
Applied Hydropedology

1 Background

Understanding **transient water flow** is important for many environmental and engineering application. Today, we are going to look at the infiltration of water into three different soil types

1. Sand
2. Silt
3. Clay

We use the Richard's equation, which for a one-dimensional problems states as

$$C\frac{\partial h}{\partial t} = \frac{\partial}{\partial z}\Big[K(\theta)\Big(\frac{\partial h}{\partial z} + 1\Big)\Big], \tag{1}$$

where C is the specific moisture capacity [L^{-1}], h is matric head representing the pressure head [L], and K is the hydraulic conductivity [$\mathrm{L.T}^{-1}$]. The '+1' originates from gravity head acting on the water in the soil.

2 Preparation

For this we will use

- Virtual Machine with Linux installation: Ubuntu mint
- Terminal and GitHub
- Texteditor Geany
- Open Source solver DRUtES

Pull the recent configuration files from DRUtES repository of the tutorial branch.

Open following files in Geany:

- global.conf
- water.conf/matrix.conf
- mesh/mesh.conf

3 Simulations

For all scenarios, we assume that the soil is in equilibrium. The water in the soil is in equilibrium when the gradient of the total head is 0. This means the value has to be the same across the profile. The bottom of our profile reaches the groundwater where we assume our reference line the geodetic head is therefore 0. We know that matrix pressure of saturated soil is also zero. The initial condition in total head across the profile is therefore 0.

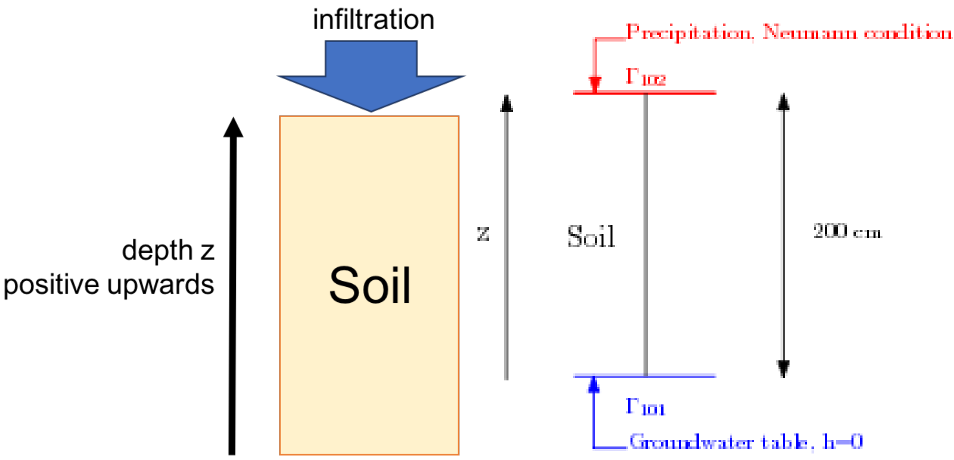


Figure 1: Domain set-up for 1D infiltration into soil.

We are using the well-known van Genuchten-Mualem parameterization to describe the soil hydraulic properties of our soils. The parameters describe clay, silt and sand (Tab. 1). We assume a constant flow of water infiltrating over the top boundary. We can also look at this as a constant rate of water and it therefore describes the temporal derivative. This type of boundary is called a **Neumann condition**. We assume that the groundwater table is at the bottom of our profile. We therefore assume a constant state of saturation at the bottom profile. In these scenarios we want to investigate the effect of spatial and temporal discretization.

We can assume a simple domain set-up as in Fig. 1. What is missing is the material properties defining the heat conduction. These can be found in Tab. 1 for two different materials: stone concrete and cotton.

Table 1: Material properties needed for scenarios.

Parameter	Description	Sand	Silt	Clay
α [cm^{-1}]	inverse of the air entry value	0.10	0.08	0.01
n [-]	shape parameter	2.2	1.8	1.5
m [-]	shape parameter	0.55	0.44	0.33
θ_s [-]	saturated vol. water content	0.4	0.45	0.5
θ_r [-]	residual vol. water content	0.0	0.05	0.1
Ss [cm^{-1}]	specific storage	1e-9	1e-9	1e-10
K_s [cm d^{-1}]	saturated hydraulic conductivity	400	40	4

Run simulations

To run the simulation with DRUtES, go back to the terminal window and write **bin/drutes** and hit enter

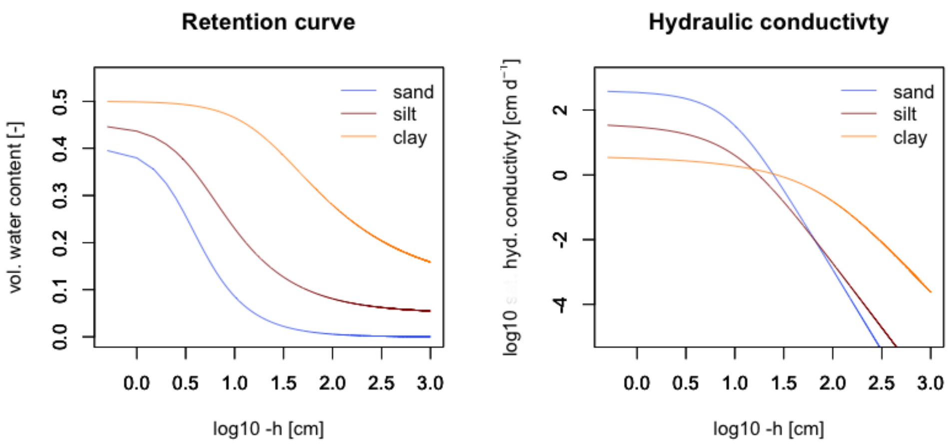
Visualizing results

We prepared an R script to visualize the simulation. Go to the terminal and execute:
`Rscript drutes.conf/makeplot -name writename`
`writename` should be meaningful such as 'sandstone' or 'cotton'

4 Tasks

Follow the **tutorial for 1D infiltration in soil** and answer following questions for all of the **3 materials**:

1. Look at the time setup. What is the simulation time?
2. What is the density of your mesh in cm? How many elements do you get?
3. What is the difference between sand/silt/clay in the parameterization?



4. Why are the initial results not smooth?