Seminar

HYDRUS 2D - introduction, setting up the domain, results visualization

Theory repetition

Richards equation

$$\frac{\partial}{\partial x}\left(K_x(\theta)\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_y(\theta)\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_z(\theta)\frac{\partial h}{\partial z}\right)+\frac{\partial K_z}{\partial z}=\frac{\partial \theta}{\partial t}$$ ***… in 3D***

$$\frac{\partial}{\partial z}\left(K(h)\frac{\partial h}{\partial z}+K(h)\right)-S=\frac{\partial \theta}{\partial t}$$

van Genuchten

$$\theta_e(h)=\begin{cases}\dfrac{1}{\left(1+(-\alpha h)^n\right)^m} & h<0\\ 1 & h\geq 0\end{cases}$$

Mualem

$$K_r(\theta_e)=\theta_e^{1/2}[1-(1-\theta_e^{1/m})^m]^2$$

Theory repetition

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

Advection dispersion eq. as implemented in HYDRUS

Sink (flow)

Reactions (decay)

$$\frac{\partial\theta c}{\partial t} + \frac{\partial\rho s}{\partial t} = \frac{\partial}{\partial z}\left(\theta D\frac{\partial c}{\partial z}\right) - \frac{\partial qc}{\partial z} - Sc_r - \mu_w\theta c - \mu_s\rho s + \gamma_w\theta + \gamma_s\rho$$

c – solute concentration in liquid phase
s – solute concentration on solid phase

Molecular diffusion coef.

Long. dispersivity (*input*)

Dispersion coefficient

$$D = D_w\tau + \lambda|v|$$

Tortuosity factor

Mean pore velocity

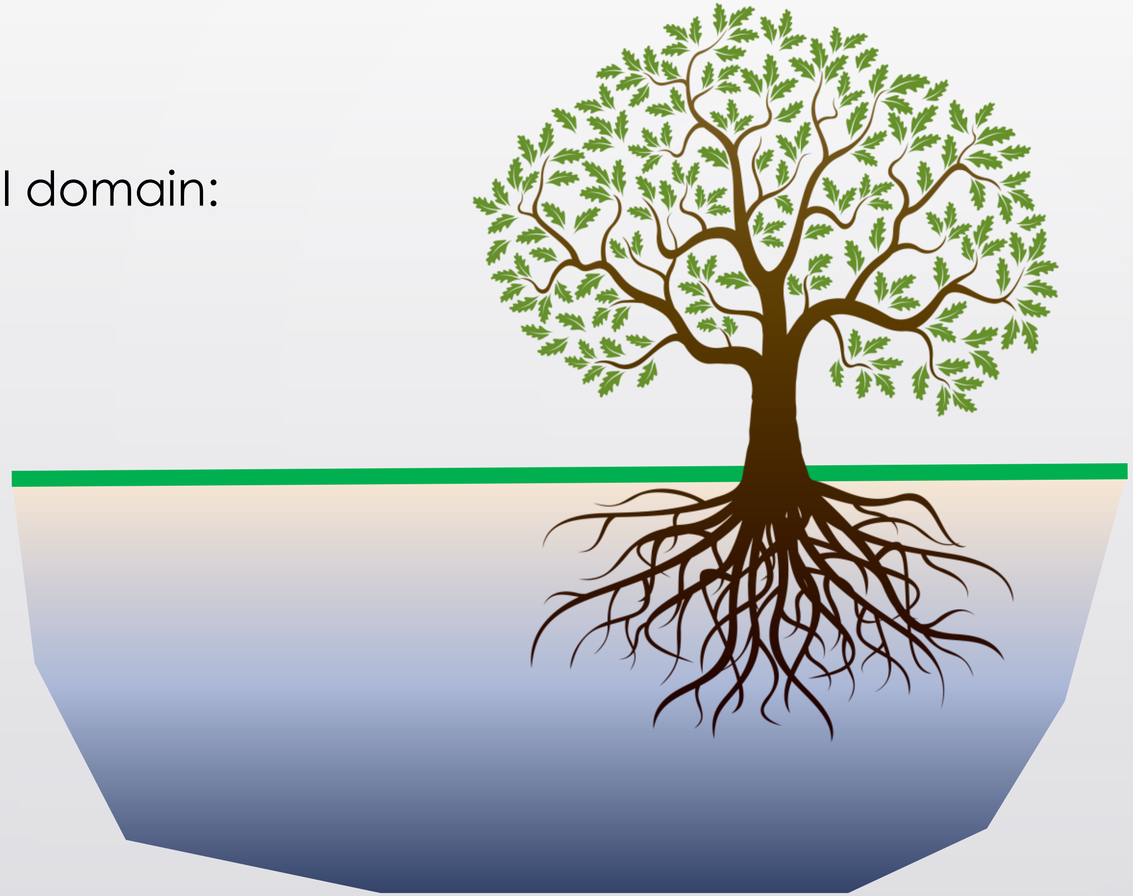
Equilibrium adsorption:

$$s = k_d c^\beta/(1+\eta c^\beta)$$

Distribution coeff.

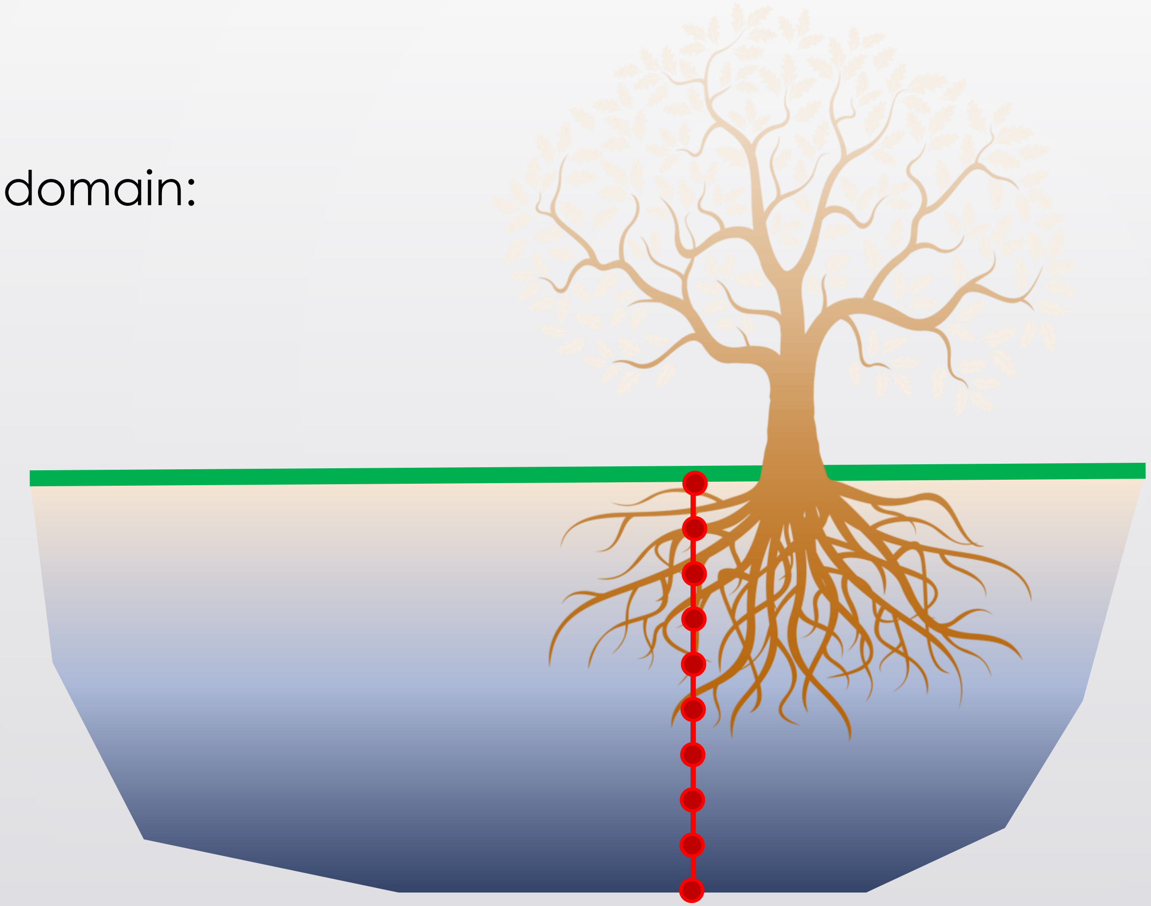
Discretization in 1D

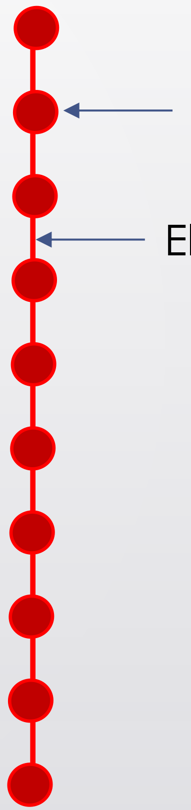
Real domain:



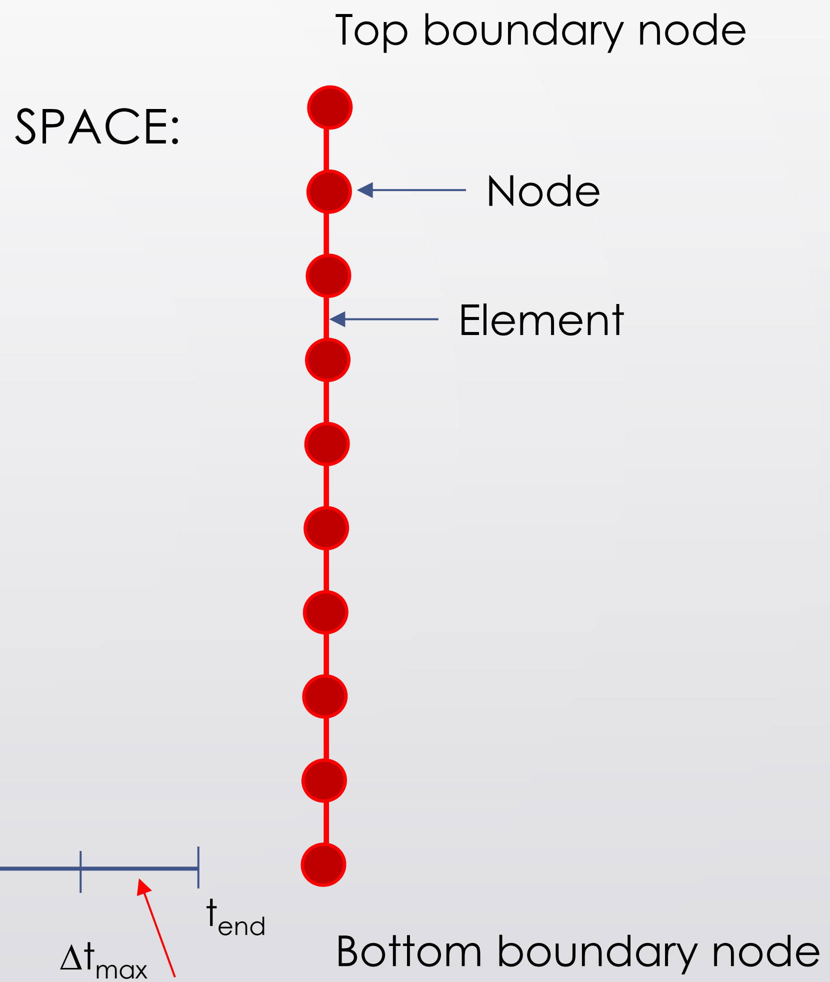
Discretization in 1D

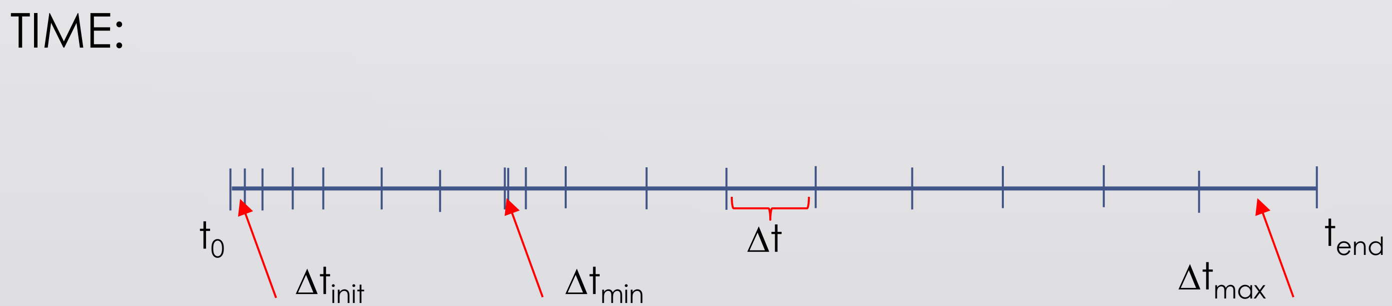
1D domain:



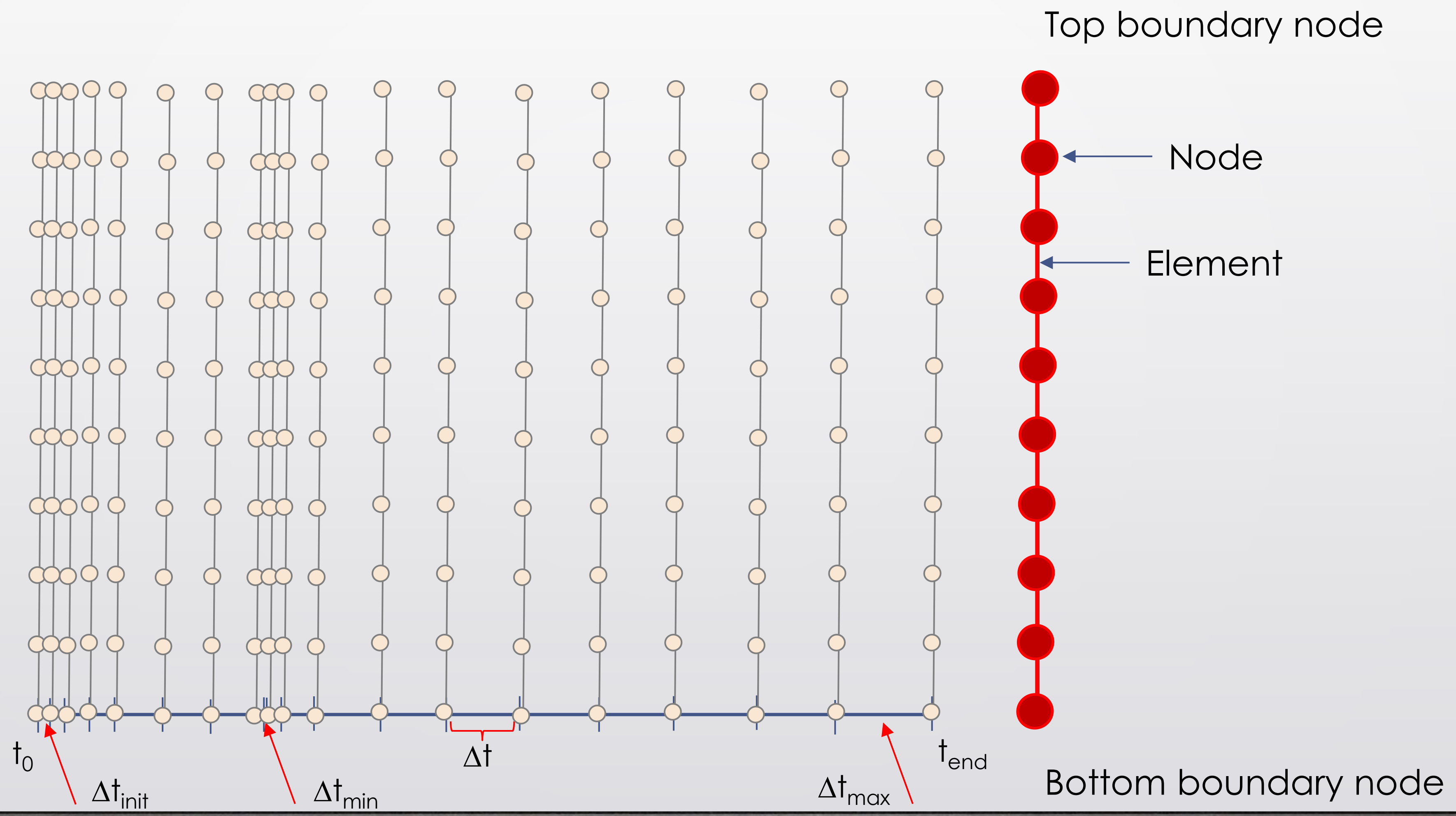


Discretization in 1D





Discretization in 1D - calculation matrix



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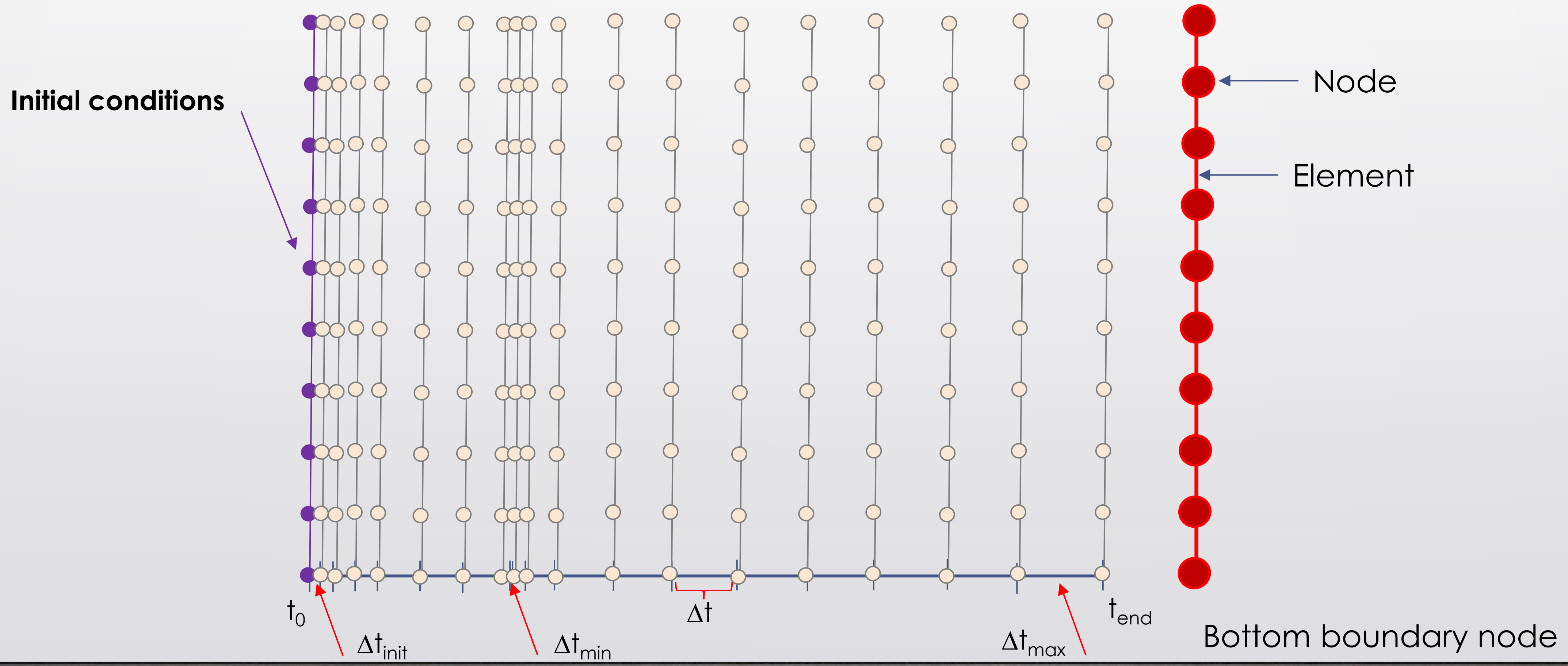

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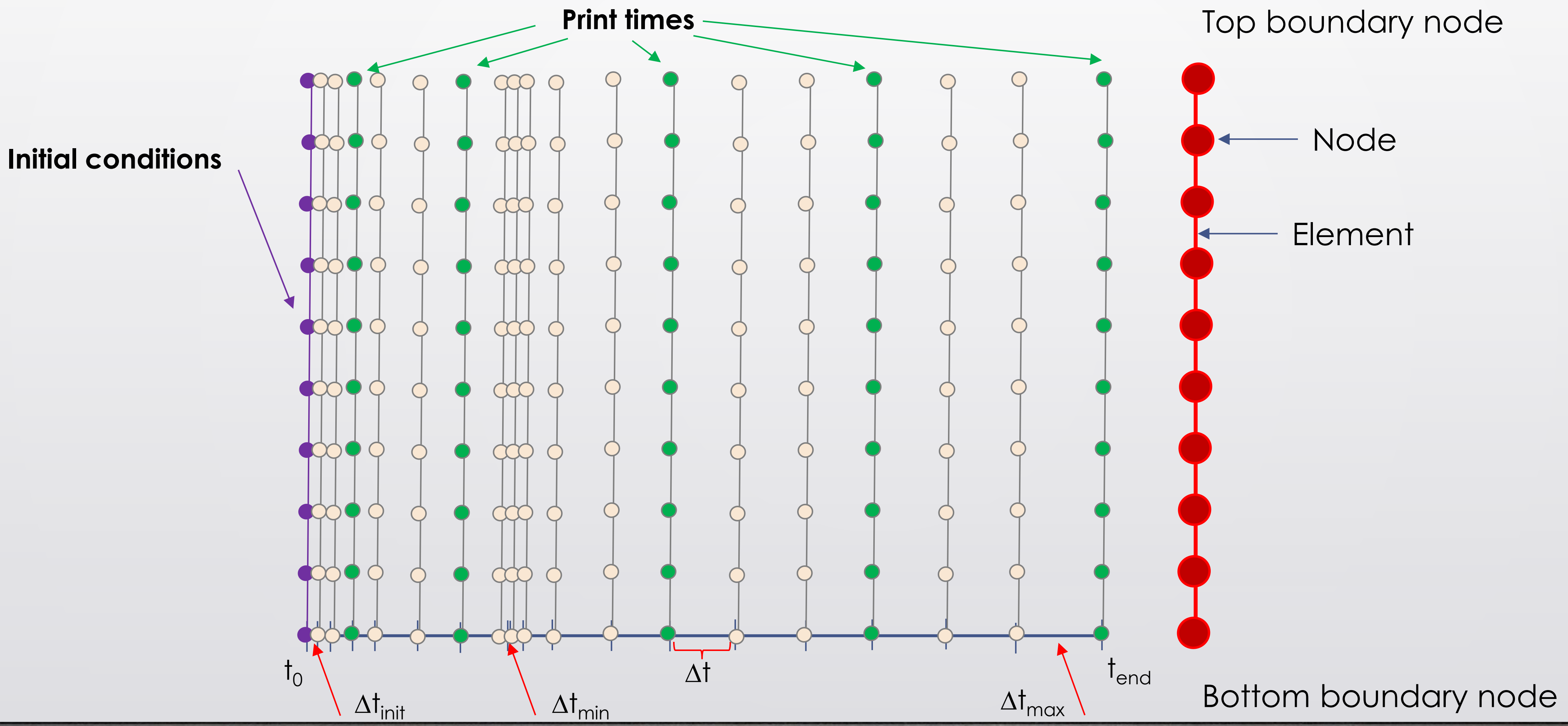

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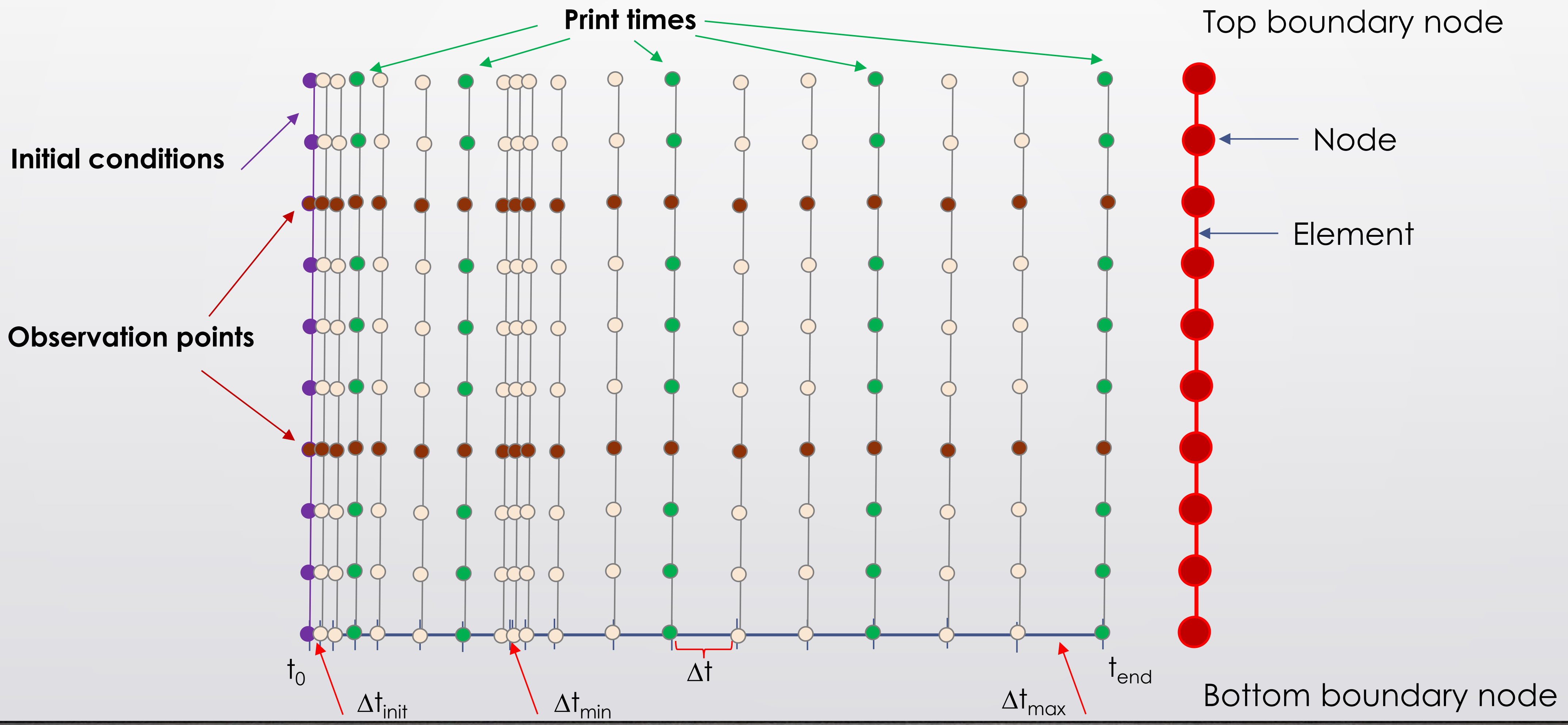
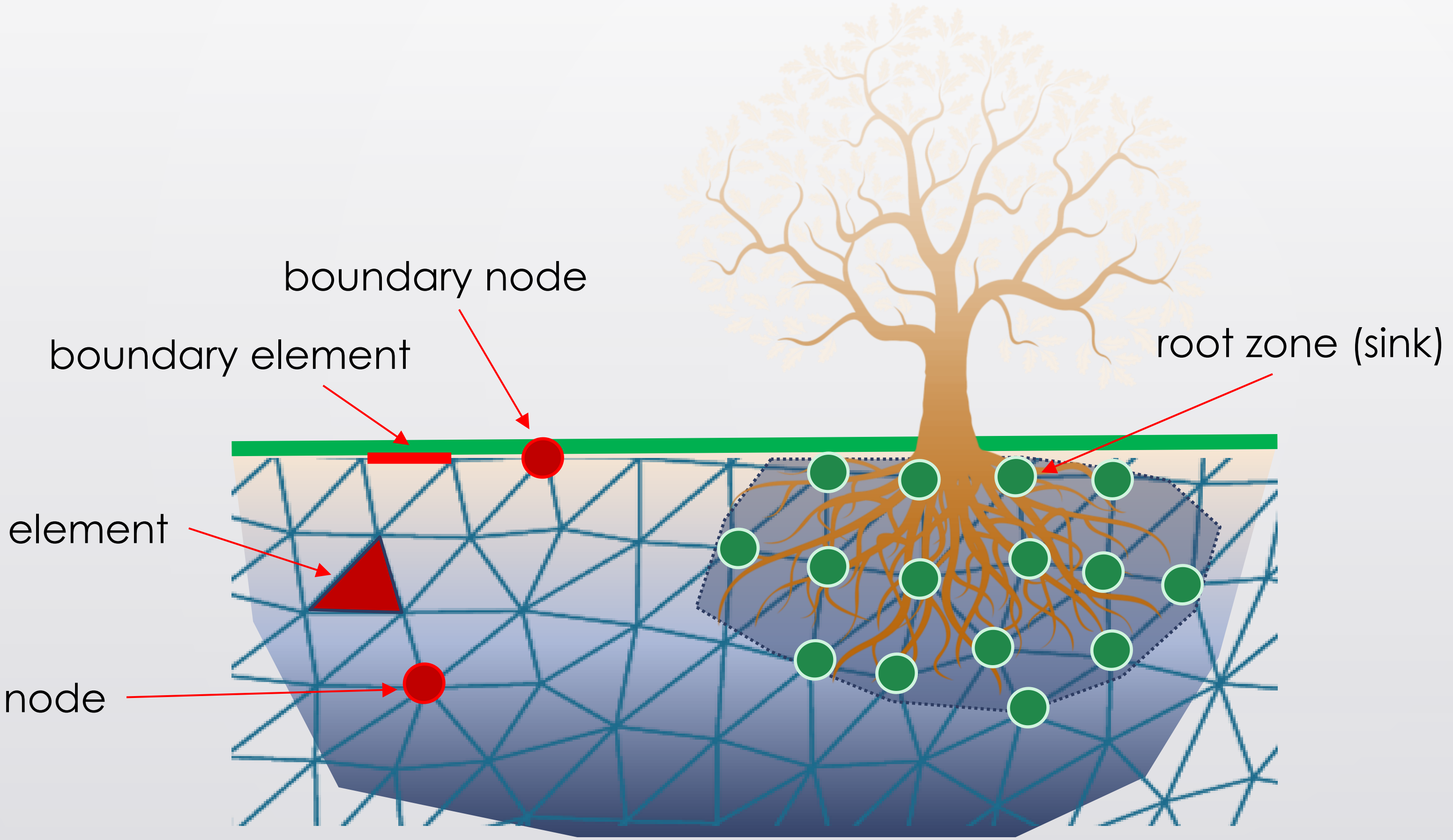
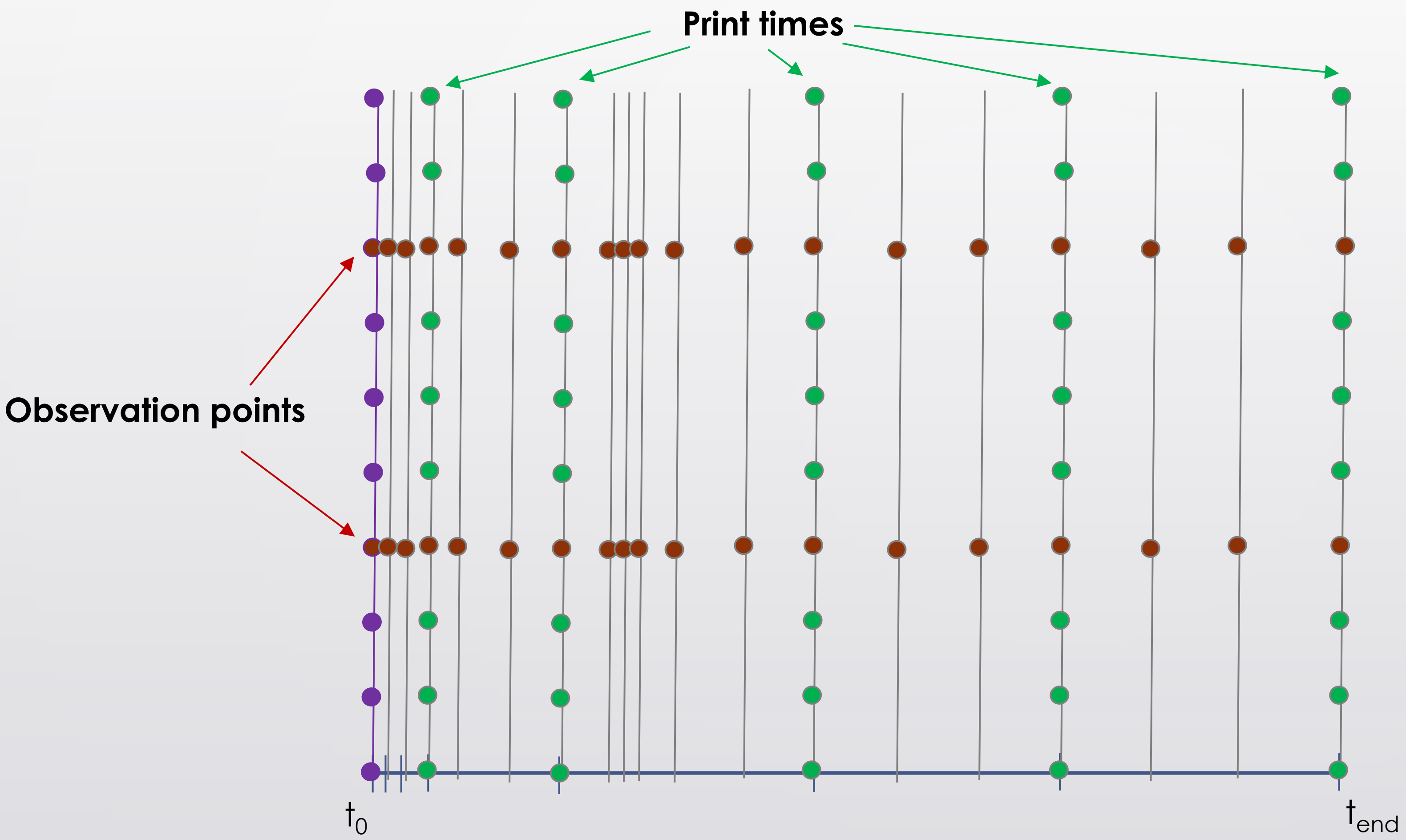


Discretization in 2D

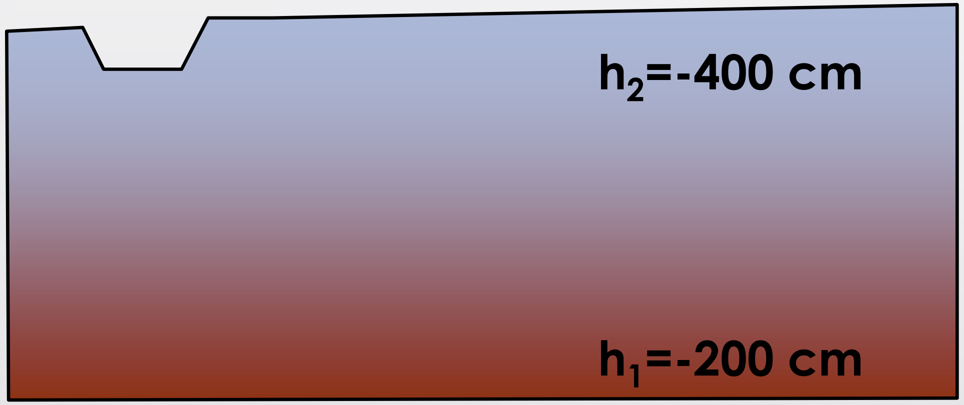


Discretization in 1D - results

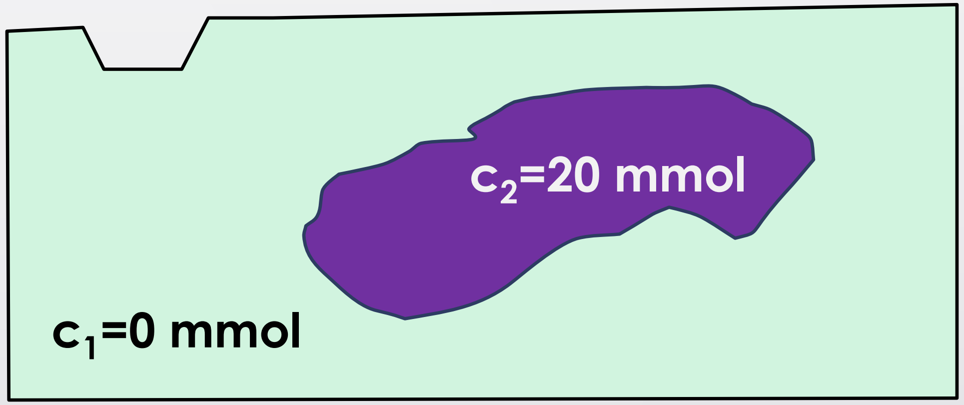


Initial conditions

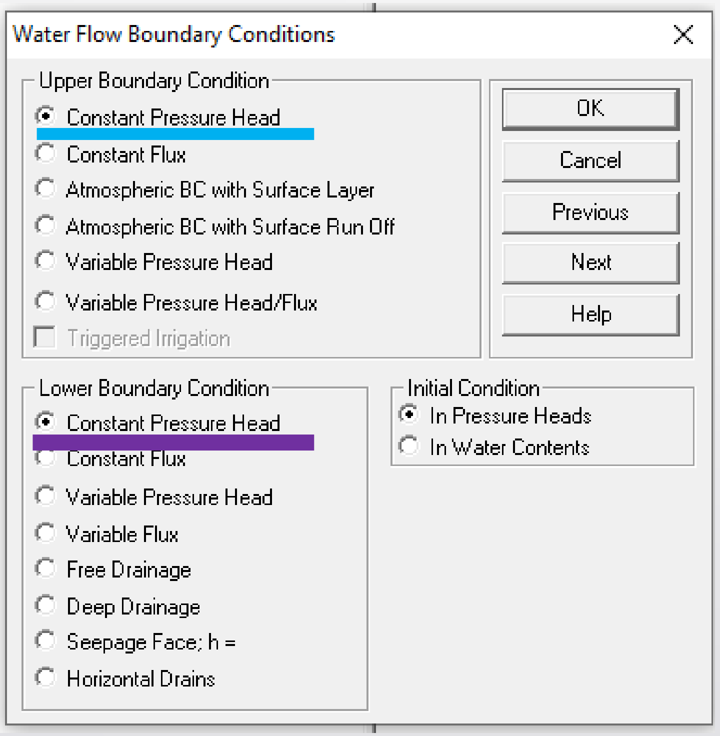
Richards eq.:
Matric potential / water content distribution

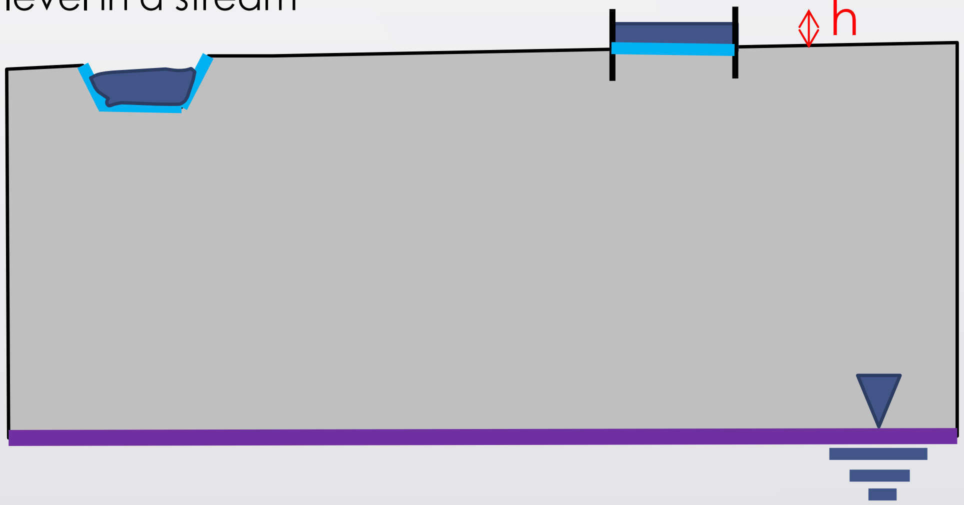


ADE:
Initial solute concentration distribution

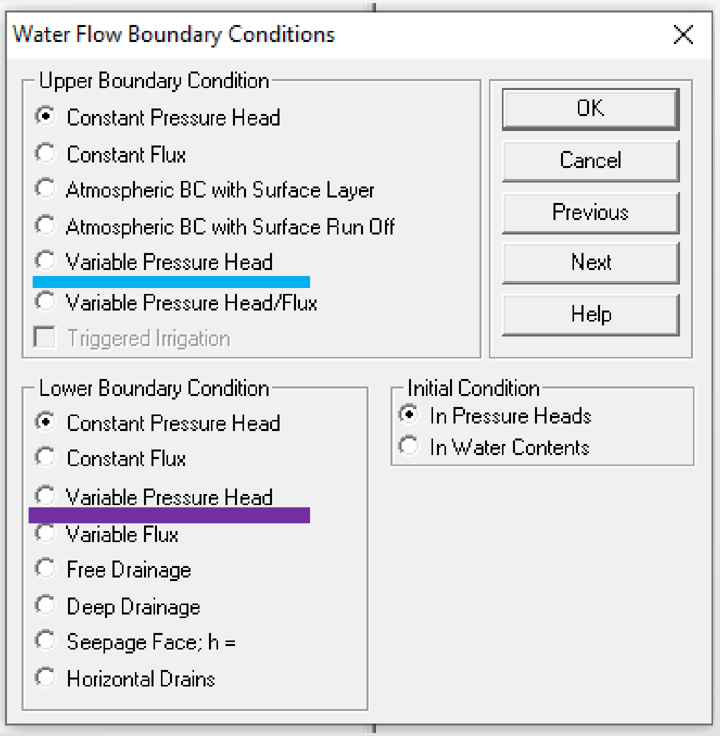


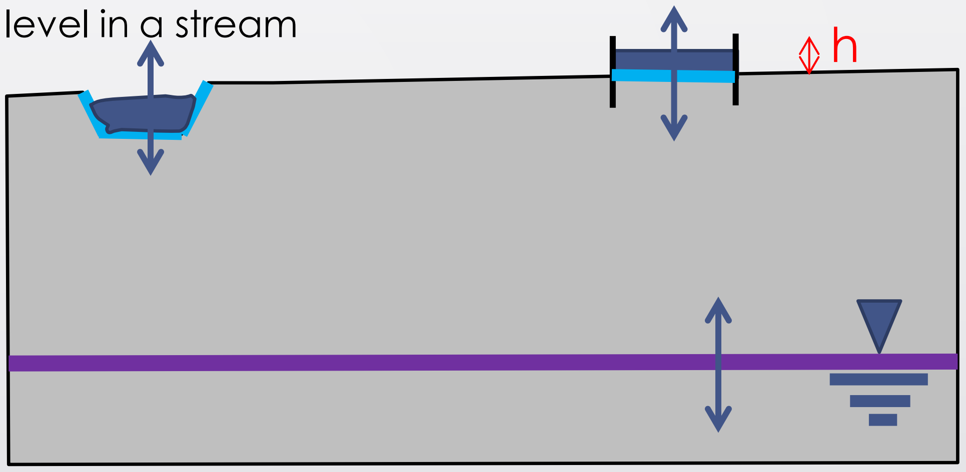
Boundary conditions - Repetition





Boundary conditions





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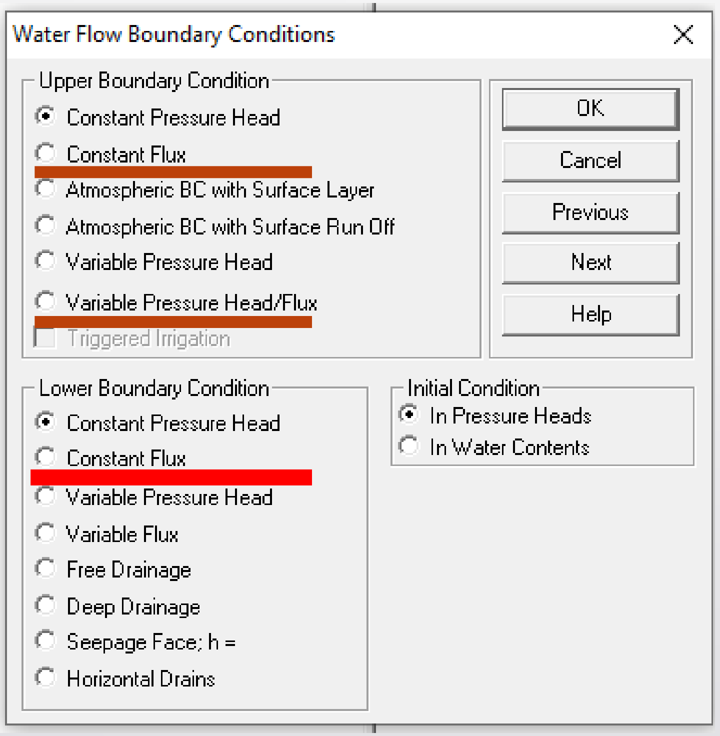
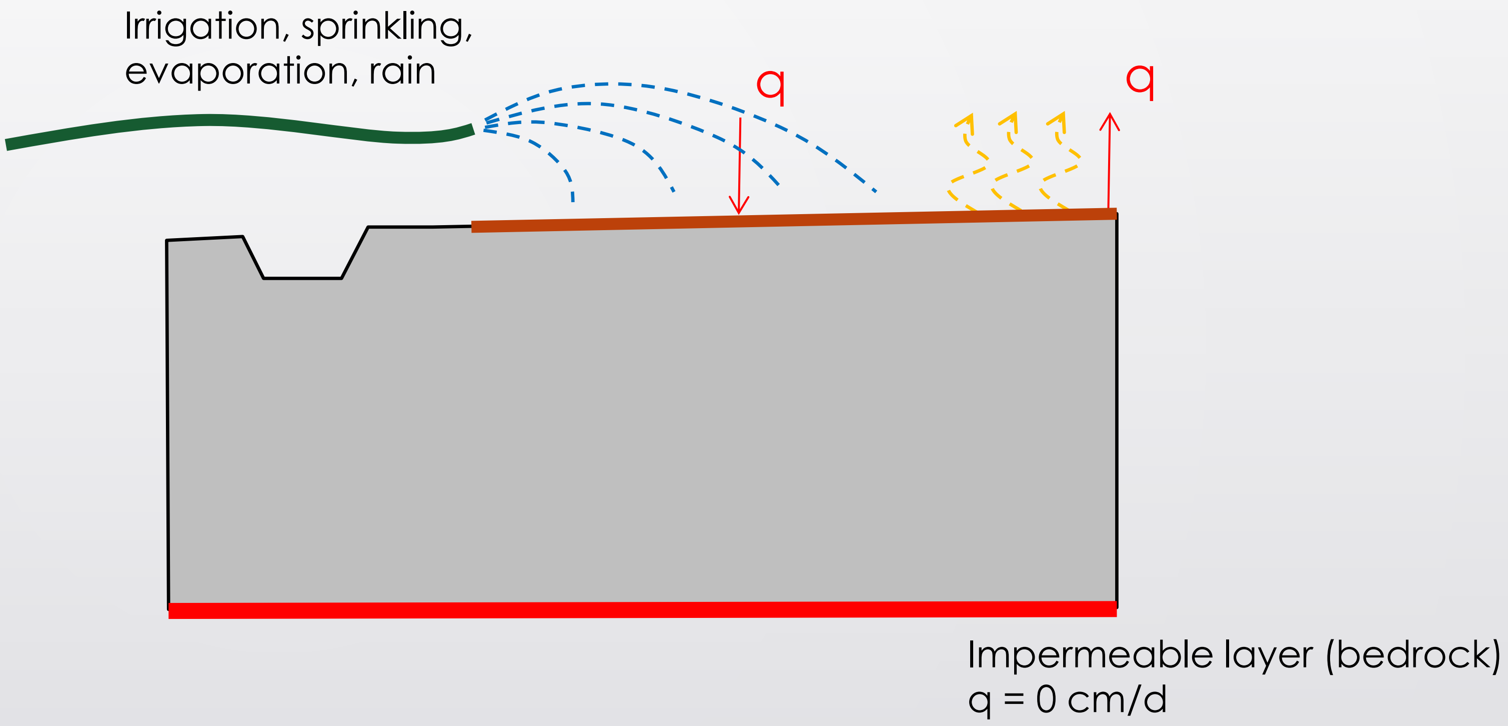
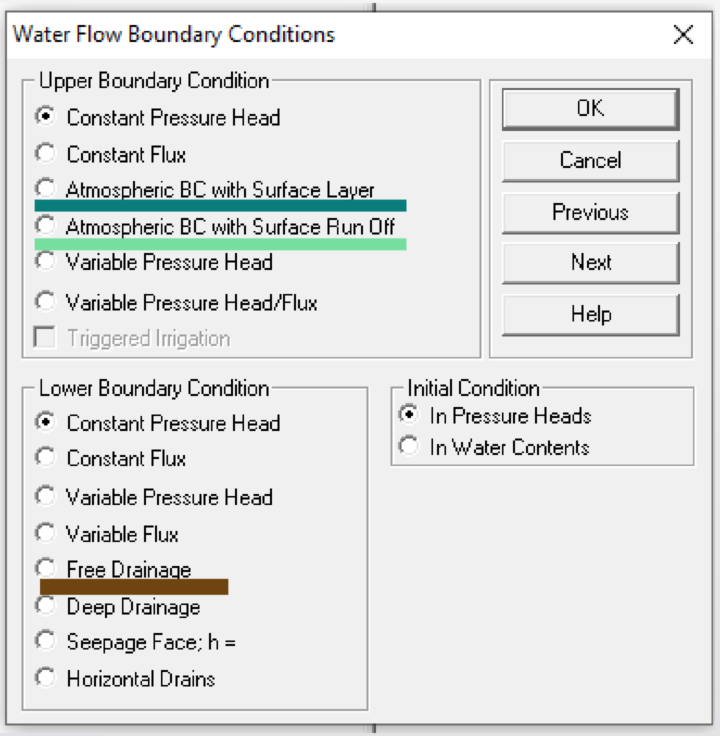
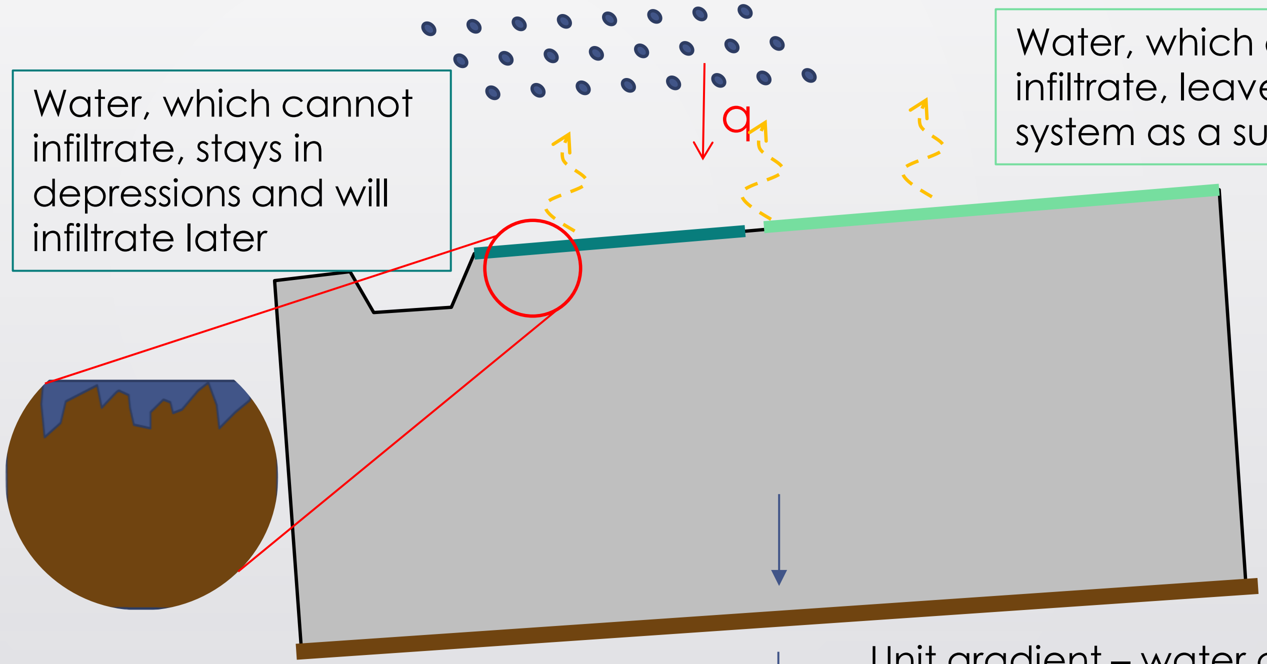




Boundary conditions



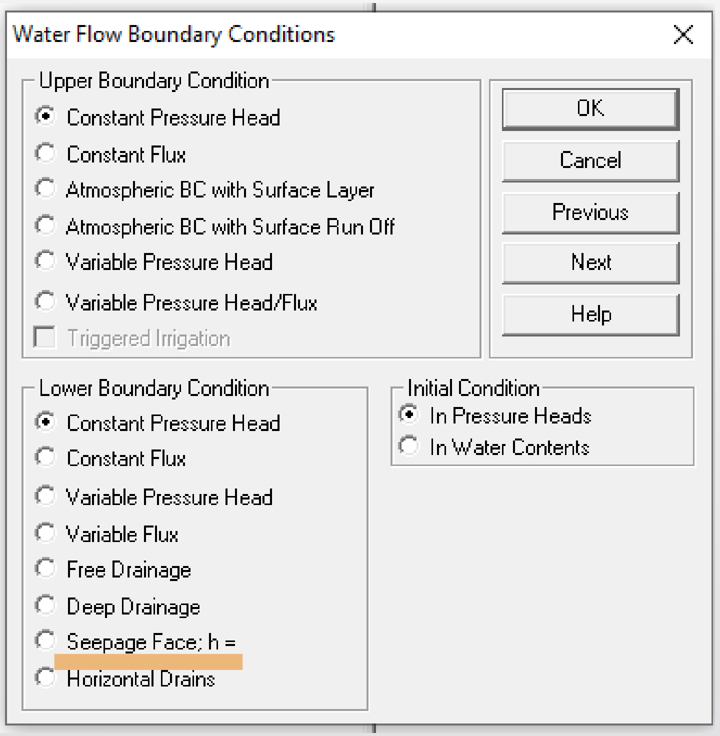
Rainfall + evaporation (with variable intensity)



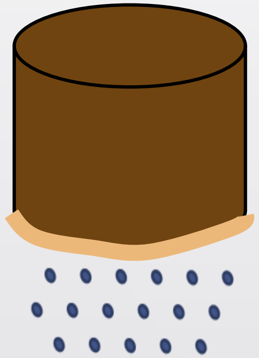
Water, which cannot infiltrate, leaves the system as a surface runoff

Unit gradient – water continuous to flow into “an infinite” soil profile below

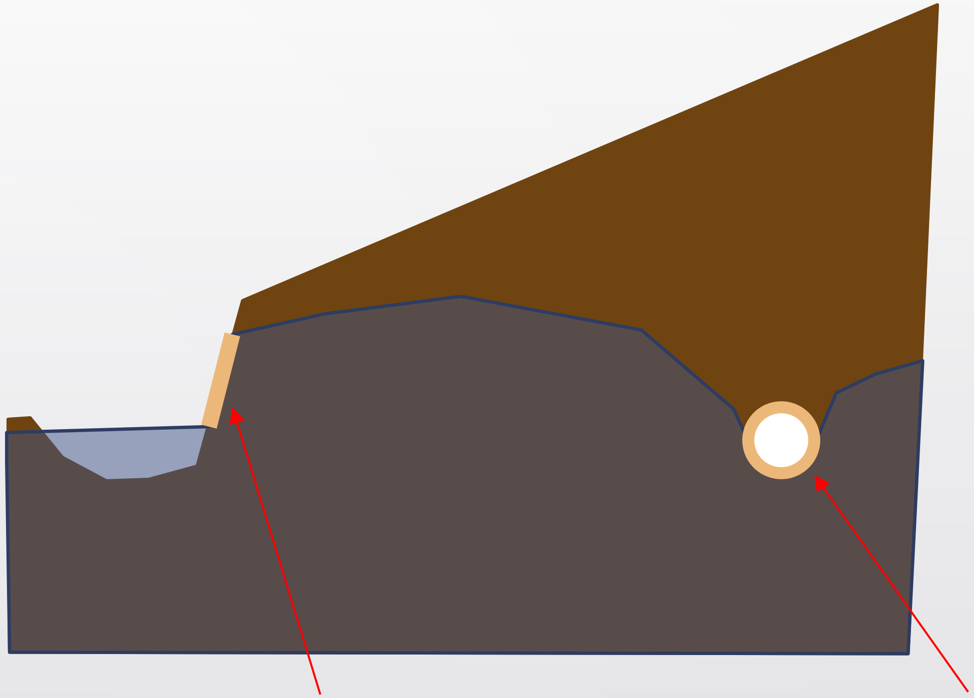
Boundary conditions



Interface between soil and atmosphere



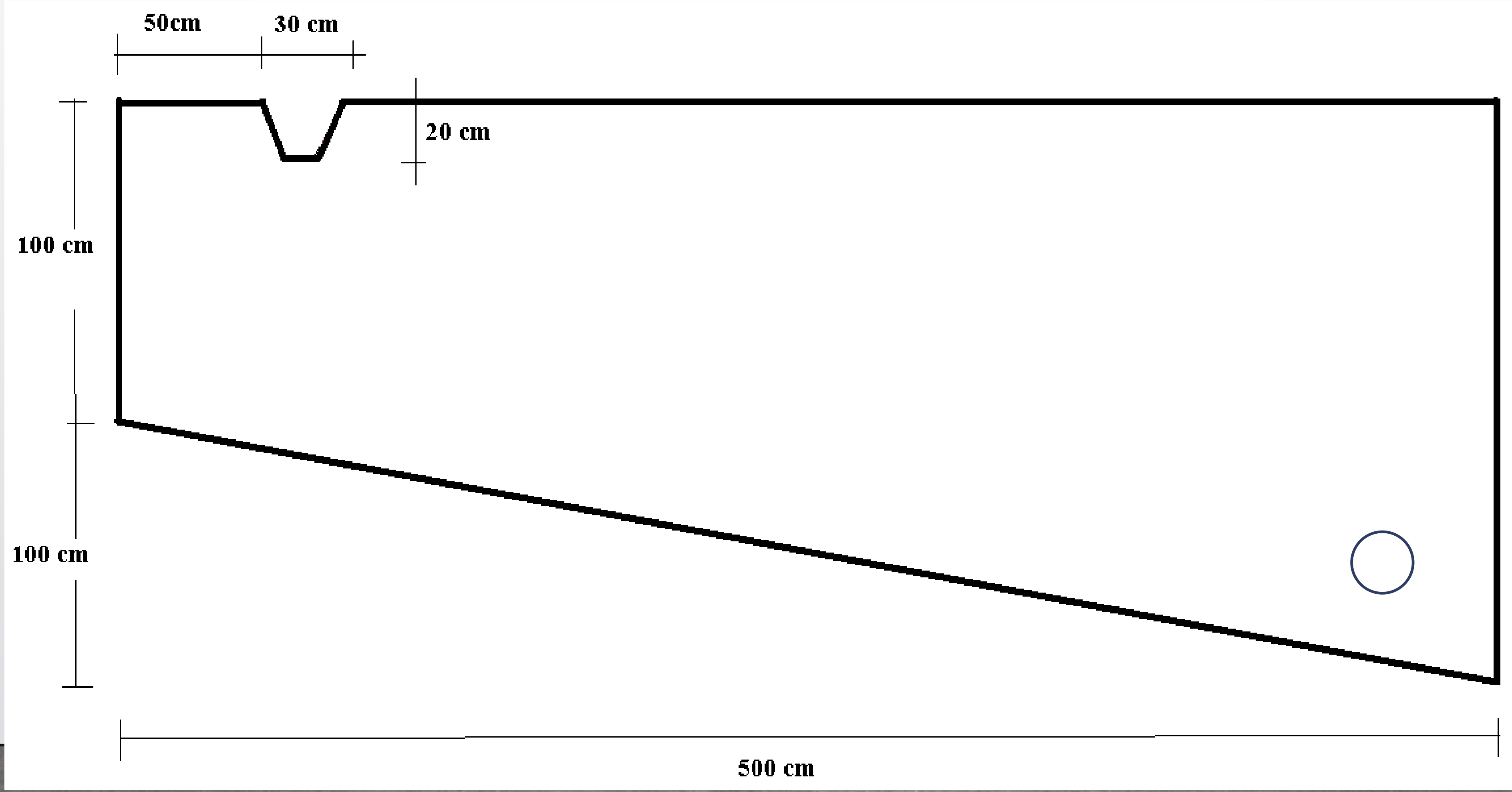
Lab soil sample



Groundwater seepage

Tile drain

Ditch infiltration with impermeable bottom boundary

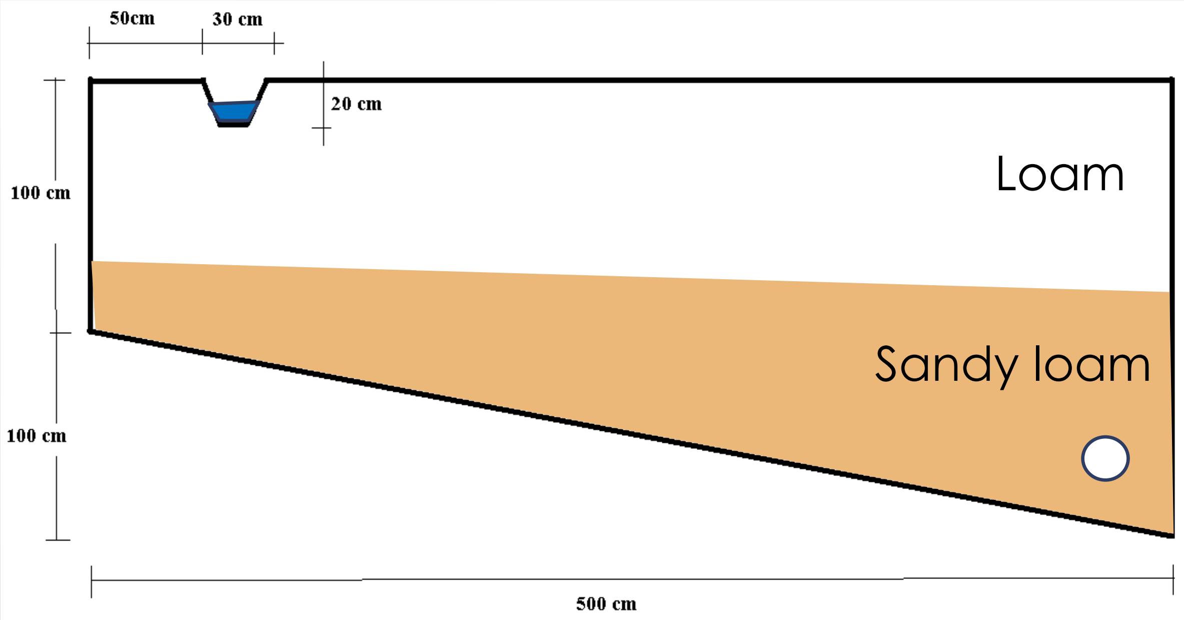


Ditch infiltration with impermeable bottom boundary

The ditch was filled with 8 cm of water.
Initial conditions: pressure 0 cm at the lowest point of the domain, the rest in equilibrium
Boundary conditions: no flux – everywhere except the ditch and the tile drain

Duration: 50 days

Soils: upper horizon *loam*, bottom layer *sandy loam* (use catalogue soil hydraulic properties)



Ditch infiltration with impermeable bottom boundary

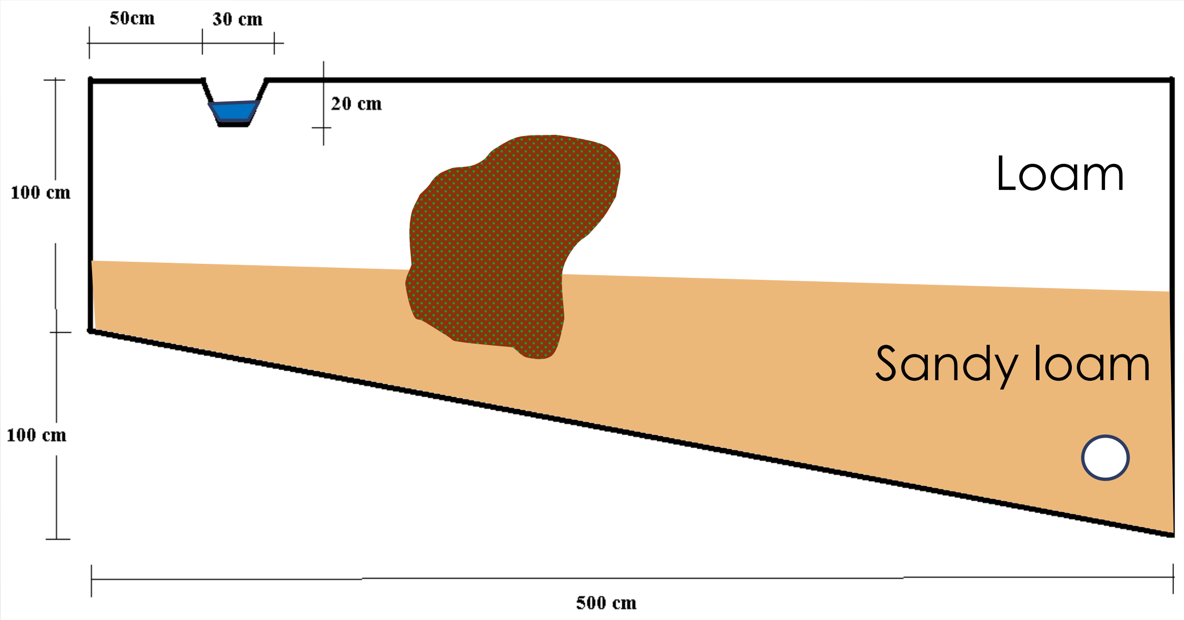
Transport:

1. Simulate a conservative tracer, dissolved in infiltrating water for a duration of 1 day, conc. 5 mg/cm^2.
2. Consider solute B already located in the simulated domain (pick a location between the ditch and drainage). k_d = 1.1, conc. 10 mg/cm^2.

Dispersivity in both directions: 40 cm
Topsoil bulk density: 1.28 g/cm^3, bottom 1.40 g/cm^3

Print information: select 200 print times with time step of 6 hours

Flowing particles: Insert 5 – 15 flowing particles (few close to the ditch, rest as you wish)



Ditch infiltration with impermeable bottom boundary

a/ Observe, how is the domain being filled with water and how do the solutes propagate.

b/ Identify locations with the highest velocities.

c/ How much water/solutes were infiltrated and recovered via the drainage after 10 and 50 days?

d/ How much solutes remain in the domain after 50 days?