HWRS 505: Vadose Zone Hydrology

Lecture 16

10/17/2024

Today: HYDRUS-1D exercises

Review of Lecture 15

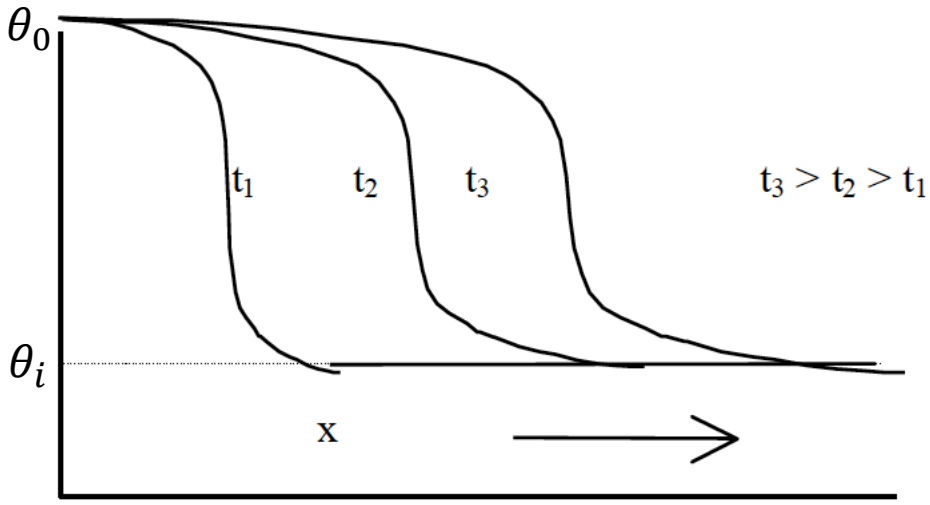
Numerical solution for transient Richards equation

- What is the difference (physically and numerically) between the three forms of the Richards equation?
- How did Celia et al (1990) solve the issue of mass balance error in the time derivative term of the Richards equation?

Examples

❑ Example 1

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial x}\left(D(\theta)\frac{\partial \theta}{\partial x}\right).$$



Boundary conditions: $\theta = \theta_0$ for $x = 0, t > 0$; $\theta = \theta_i$ for $x = L, t > 0$

Initial conditions: $\theta = \theta_i$ for $0 \le x \le L, t = 0$

Sample Parameters

Soil type: Loam (use the default soil properties in HYDRUS)

$L = 100$ cm

$\Delta x = 1$ cm

$\theta_i = 0.15$

$\theta_0 = 0.4$

Total simulation time: 10 days. Print the results every 1 day.

Questions to think about

1. Does the wetting front location $x_f \sim \sqrt{t}$?
2. Save the water pressure profile figure to a PowerPoint slide. Then, change θ_0 to 0.3. Compare the two simulated water pressure profiles. Which propagates faster? Why?

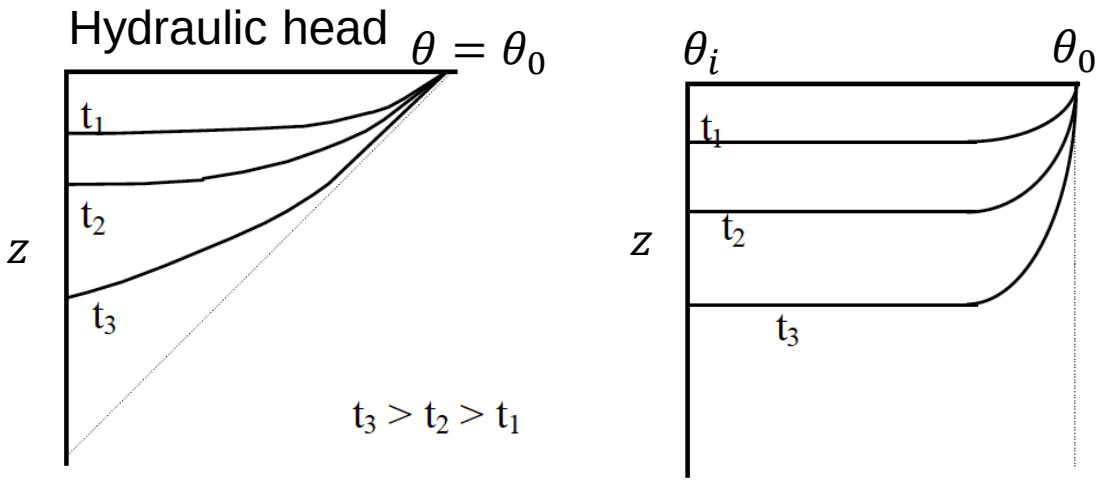
Examples

❑ Example 2

Boundary conditions for infinitesimally small ponding height:

Top: $\theta = \theta_0$ for $t > 0$ Bottom: $\theta = \theta_i$ for $z = -L$

Initial conditions: $\theta = \theta_i, -L \leq z \leq 0$



Sample Parameters

Soil type: Loam (use the default soil properties in HYDRUS)

$L = 200$ cm

$\Delta x = 1$ cm

$\theta_i = 0.15$

$\theta_0 = 0.4$

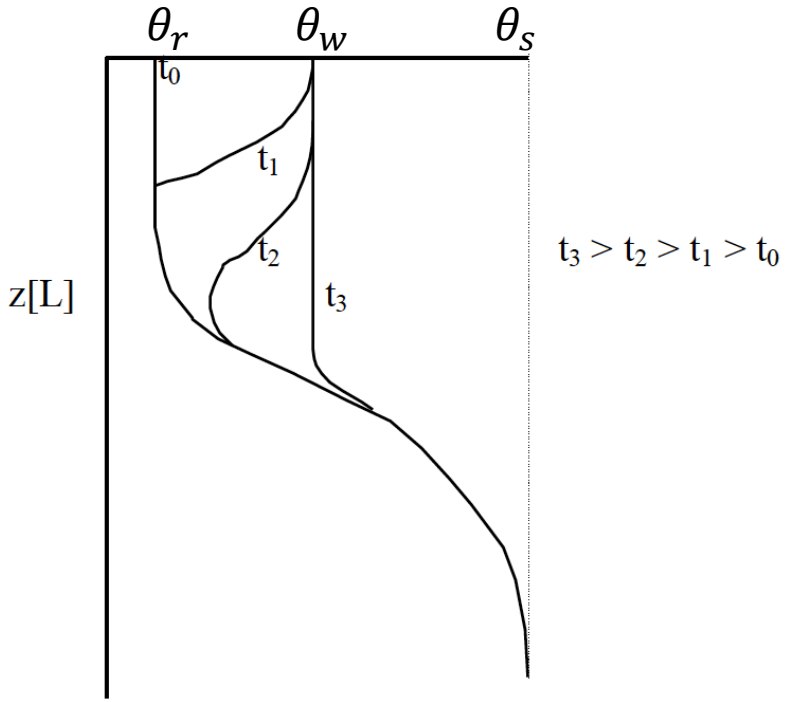
Total simulation time: 10 days. Print the results every 1 day.

Questions to think about

1. Does the wetting front location $x_f \sim \sqrt{t}$ or $x_f \sim t$?
2. Given the soil properties, can you estimate the infiltration rate at $t = 10$ days?

Examples

❑ Example 3



Note:
(1) The unit in HYDRUS for constant surface flux is cm/day
(2) Positive denotes upward in a vertical column and denotes right to left for a horizontal column.

Initial conditions: $h = -(L + z)$, $-L \leq z \leq 0$, $t = 0$

Boundary conditions: Constant infiltration ($q = -1$ cm/day) at top and $h = 0$ at the bottom.

Sample Parameters

Soil type: Loam (use the default soil properties in HYDRUS)

$L = 200$ cm

$\Delta x = 1$ cm

Total simulation time: 10 days. Print the results every 1 day.

Questions to think about

1. Given the soil properties, can you estimate θ_w?
2. Can you sketch the steady-state solution?