Engineering Hydrology

Class 9

Infiltration: Horton Method

If you've not viewed it already, pause this webcast and open up the video under Lecture 8, a student-created video that illustrates a demonstration of infiltration. The student authors are Cui, Dearinger, Lyons and Martin.

Objectives

- Apply the Horton Method to estimate wetting front depth over time
- estimate aggregate amount of infiltration

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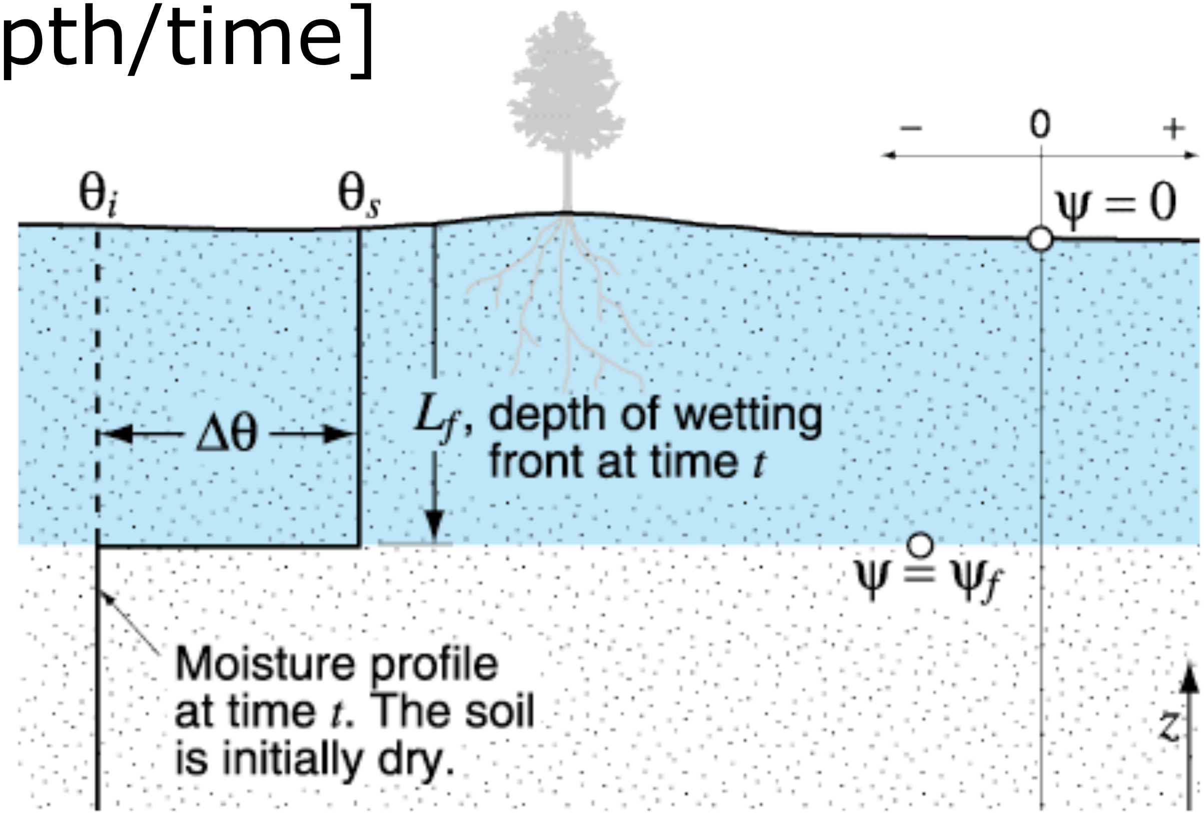
Conditions of infiltration

- P(t): precip event (rainfall and snow) [depth/time]



Note:

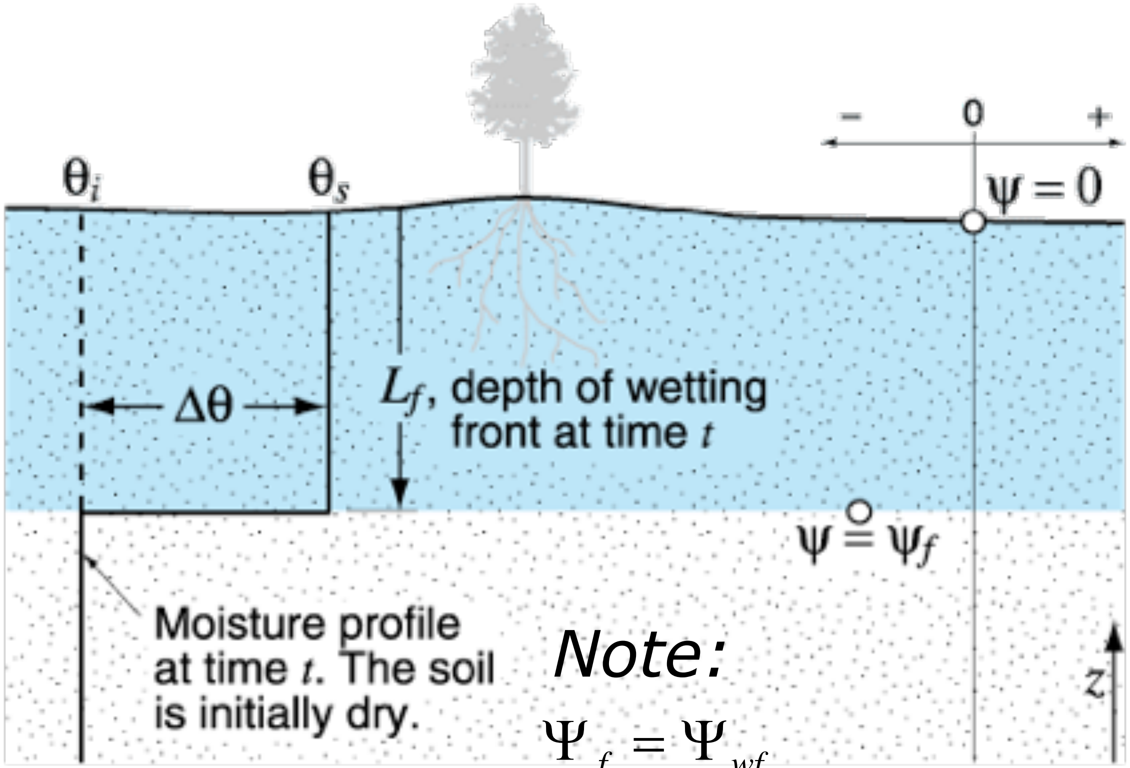
$$\Psi_f = \Psi_{wf}$$

and

$$L_f = L_{wf}$$

Conditions of infiltration

- P(t): precip event (rainfall and snow) [depth/time]
- f(t): infiltration rate [depth/time]
- H(t): the depth of ponding
- L(t): depth of wetting front
- Infiltration occurs under ponded or non-ponded conditions



Note:

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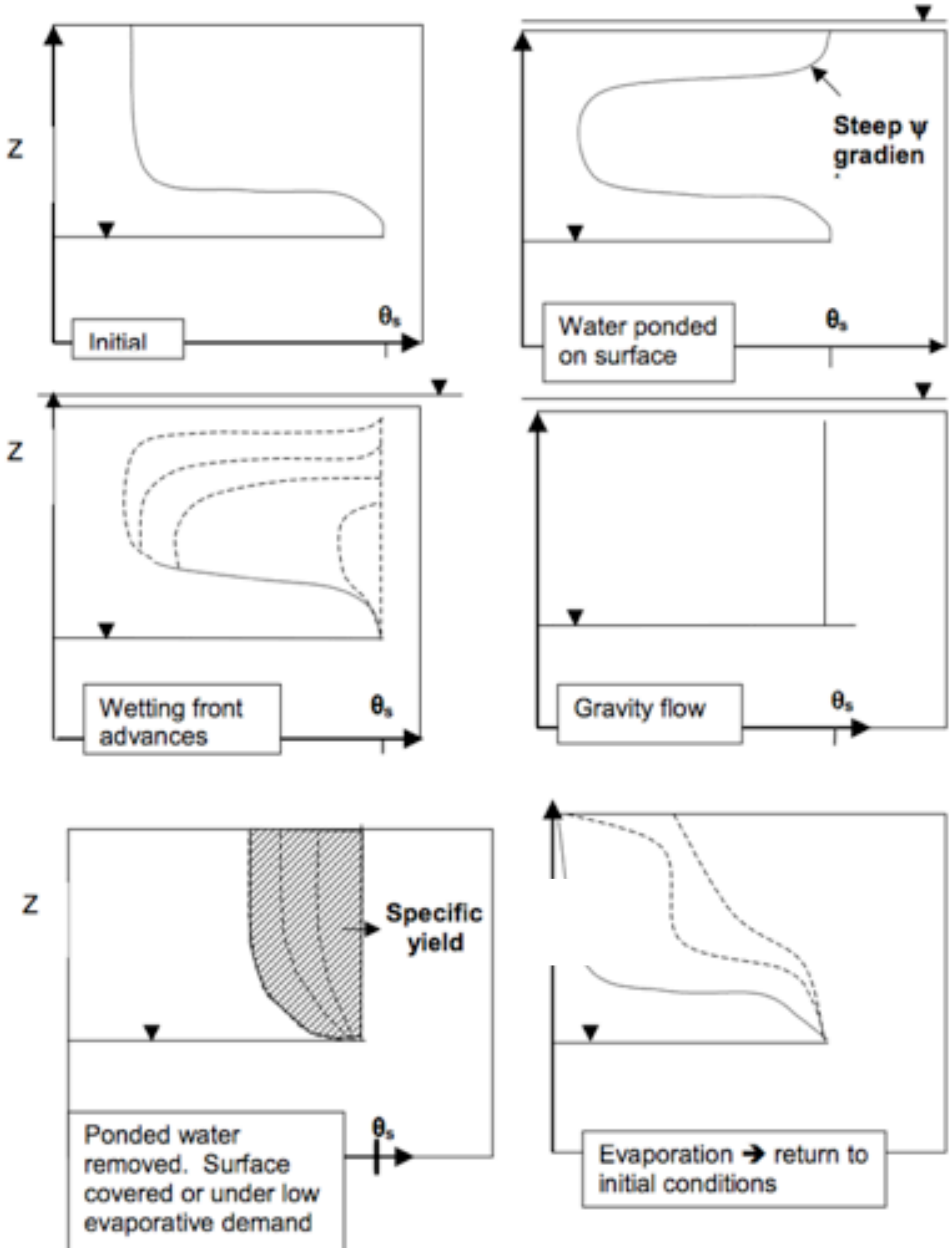
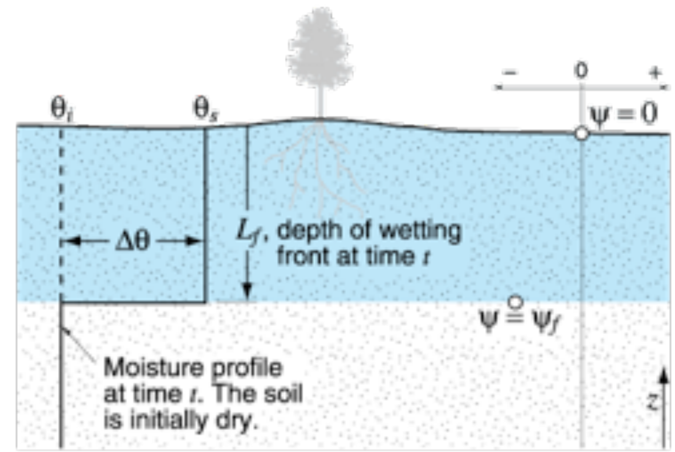
Process of Infiltration   [Note: Y axes = Z (depth); X axes = θ]





Conditions of infiltration

(1) No ponding (water has not accumulated on the soil surface)

$$H(\mathrm{t})=0, f(\mathrm{t})=P(\mathrm{t})$$

Infiltration rate is equal to precip rate

(2) Surface ponding

$$H(\mathrm{t})>0, f(\mathrm{t})=f_{\mathrm{max}}(\mathrm{t})<P(\mathrm{t})$$

(3) Surface ponding (Overland flow)

$$\mathrm{H}(\mathrm{t})>0, f(\mathrm{t})=0$$

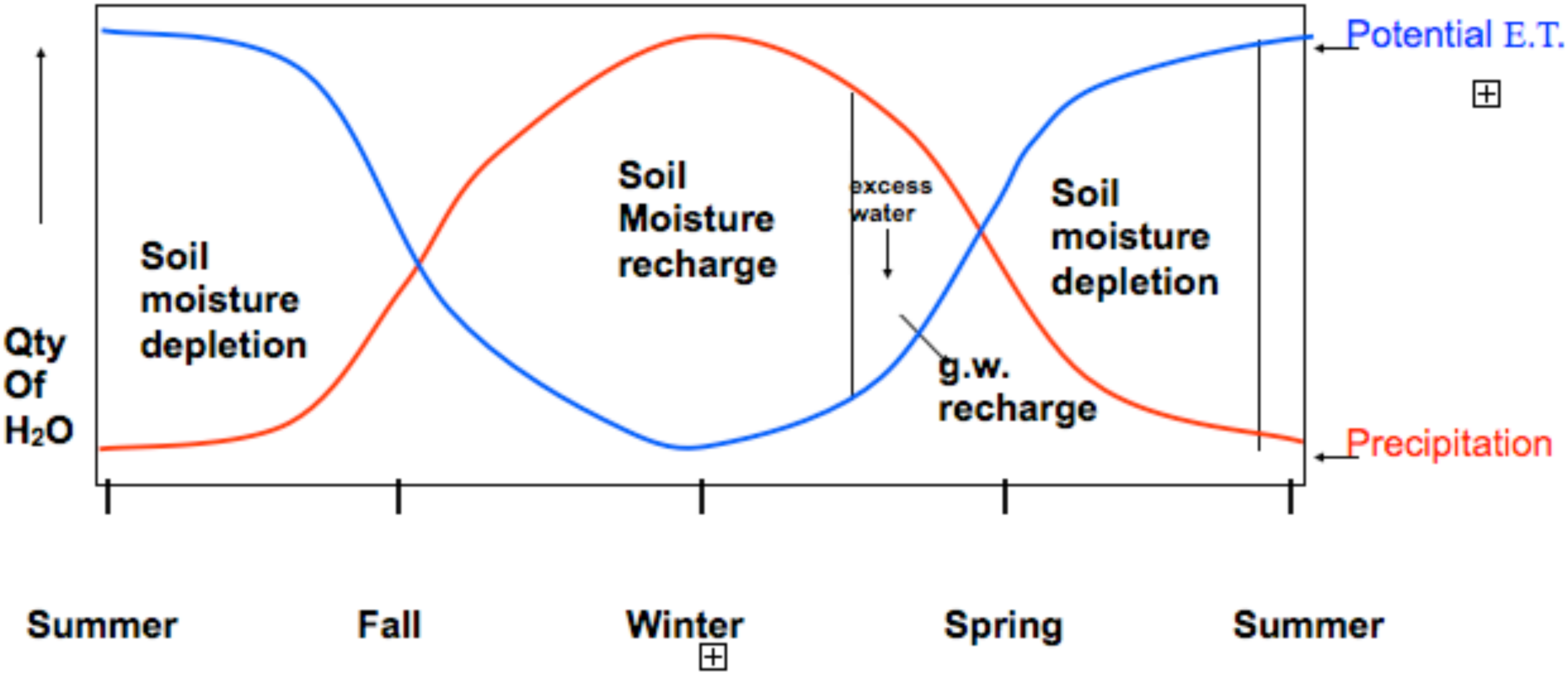
Infiltration Under Various Climatic Regimes

Humid climate:

- **precipitation in all seasons**
- **virtually all non-discharge areas are ground water recharge areas**
- **recharge occurs at all seasons**

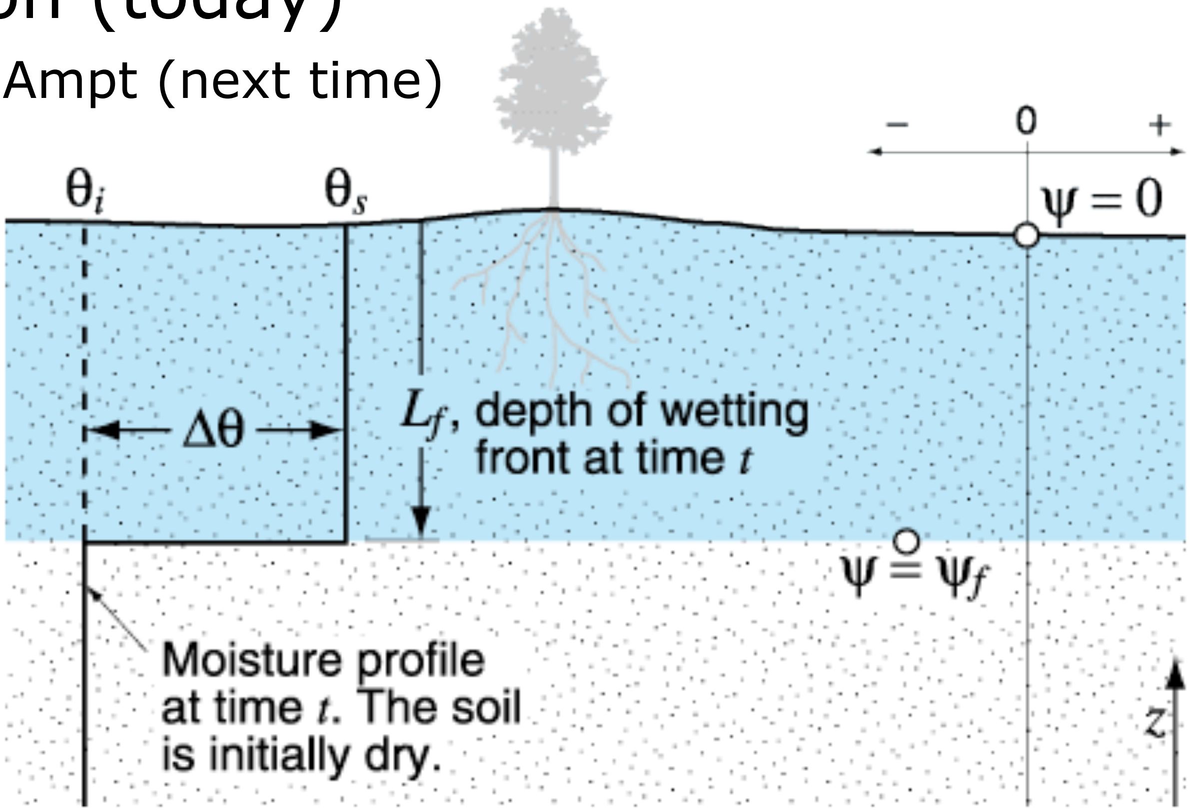
Humid to semi-humid climate – winter precipitation

Water balance of vadose zone



Methods we will examine:

- Horton (today)
- Green-Ampt (next time)



Note:

$\Psi_f = \Psi_{wf}$

and

$L_f = L_{wf}$

Another approach: Phi-index method

(reading material to be provided)

Horton method (1940)

- Maximum possible infiltration rates (f)
- Infiltration rate decreases with time after the onset of rainfall and ultimately reaches a constant rate (f_c)

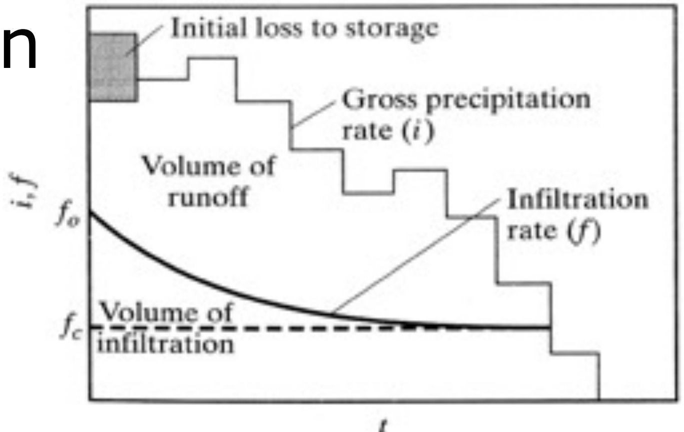


Figure 1-21

- If at any time the rate of rainfall exceeds the infiltration capacity, excess water will pond on the soil surface (then overland flow)

Horton method (1940)

$$f = f_c + \left(f_o - f_c\right)e^{-kt}$$

f : infiltration rate {length/time}

f_c: final infiltration rate

f_0: initial infiltration rate

k: decay parameter (a soil property)

f_c is equivalent to saturated hydraulic conductivity

Horton method (1940)

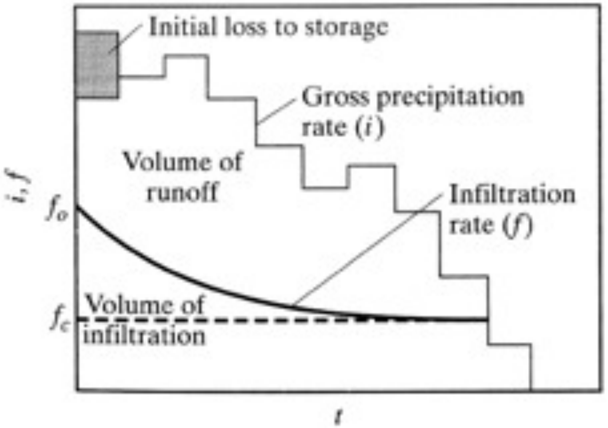
$$f = f_c + (f_o - f_c)e^{-kt}$$

Table 1–6. Typical Values of the Parameters of f_0, f_c, and k of the Horton Model

Soil Type	f_c (in./hr)	f_0 (in./hr)	k (hr^{-1})
Alphalpha loamy sand	1.40	19.00	38.29
Carnegie sandy loam	1.77	14.77	19.64
Dothan loamy sand	2.63	3.47	1.40
Fuquay pebbly loamy sand	2.42	6.24	4.70
Leefield loamy sand	1.73	11.34	7.70
Tooup sand	1.80	23.01	32.71

After Rawls et al., 1976.

Horton method (1940)



Infiltration rate

$$f = f_c + \left(f_o - f_c\right)e^{-kt}$$

Cumulative infiltration volume ($F(t)$)

$$F(t) = \int f(t)\,dt$$

(integrate above equation)

$$F(t) = f_c t + \left[\frac{f_0 - f_c}{k}\right]\left(1 - e^{-kt}\right)$$

Assumptions

- Assumes ponding conditions (P(t)>0)
- Infiltration rate decrease as a function of time
- After a certain period, infiltration rate becomes constant (at this condition, $f_c=K_{sat}$ - the value of conductivity for saturated flow)