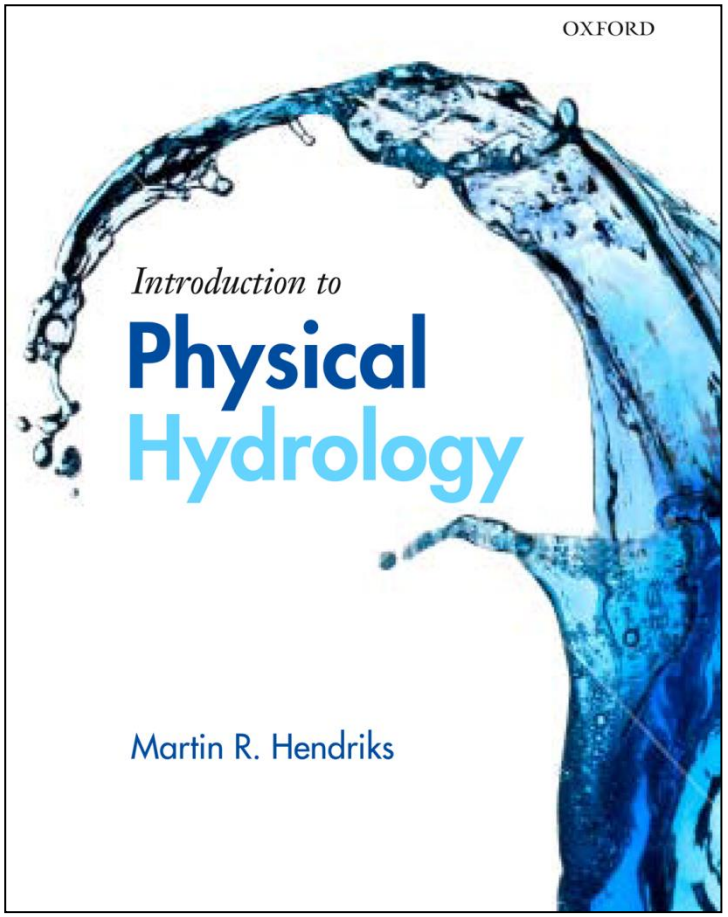
Soil water / Unsaturated Zone Hydrology



Paperback | 351 pages
Follow the book's didactic concept!

- Hydrological cycle
- Drainage basin
- Water balance

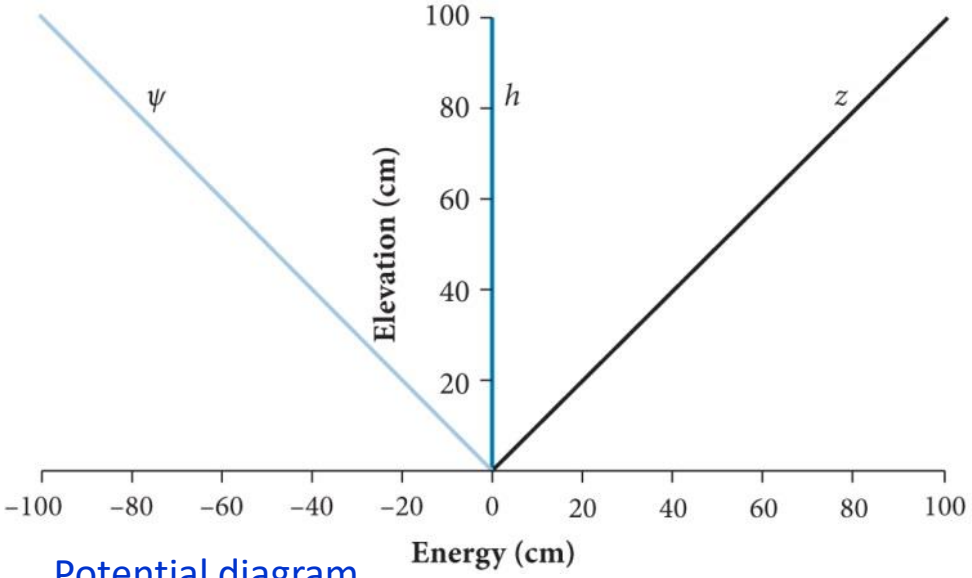
- Energy equation
- Flow equation
- Continuity equation

1. Introduction
2. Atmospheric water
3. Groundwater
4. **Soil water**
5. Surface water

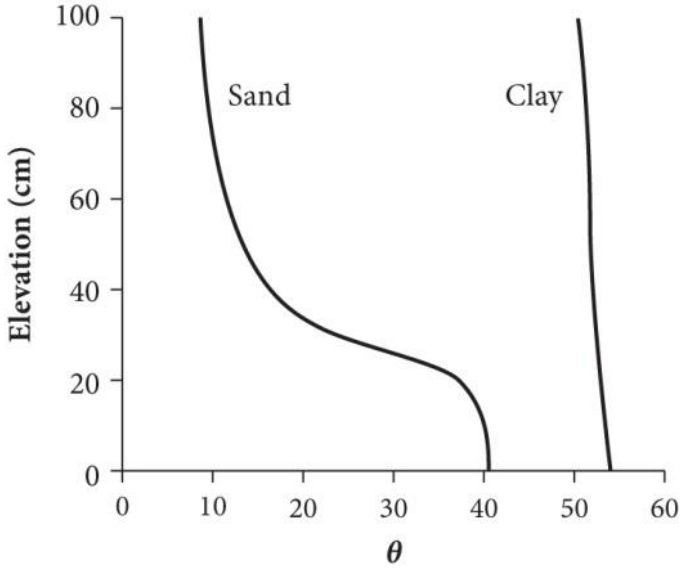
Exercises

Hydrostatics revisited

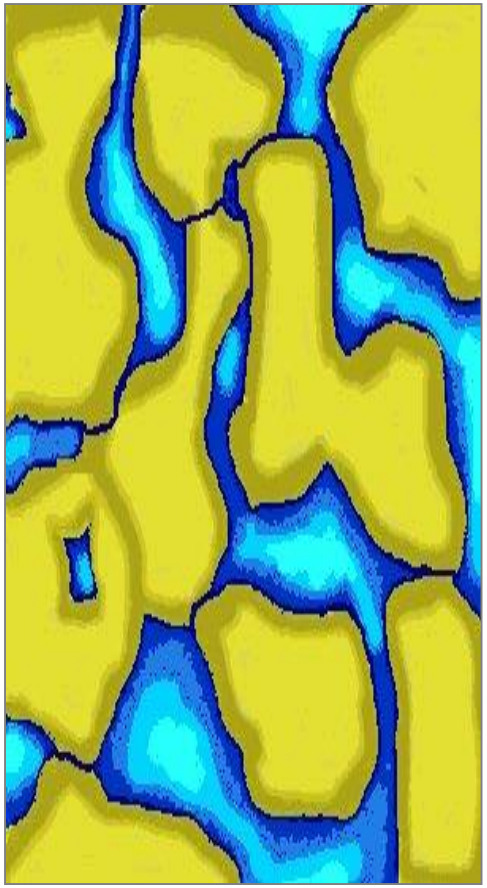
- Study of the forces in the soil-water system, when there is hydrostatic equilibrium
- All forces are in equilibrium: there is no water flow; the fluxes (*rates*) in the soil are zero; the moisture content (*state*) does not change
- The moisture content differs at different depths!



Potential diagram



Unsaturated water flow



The hydraulic conductivity is strongly dependent on moisture content.

The drier the soil, the smaller the conductivity, because:

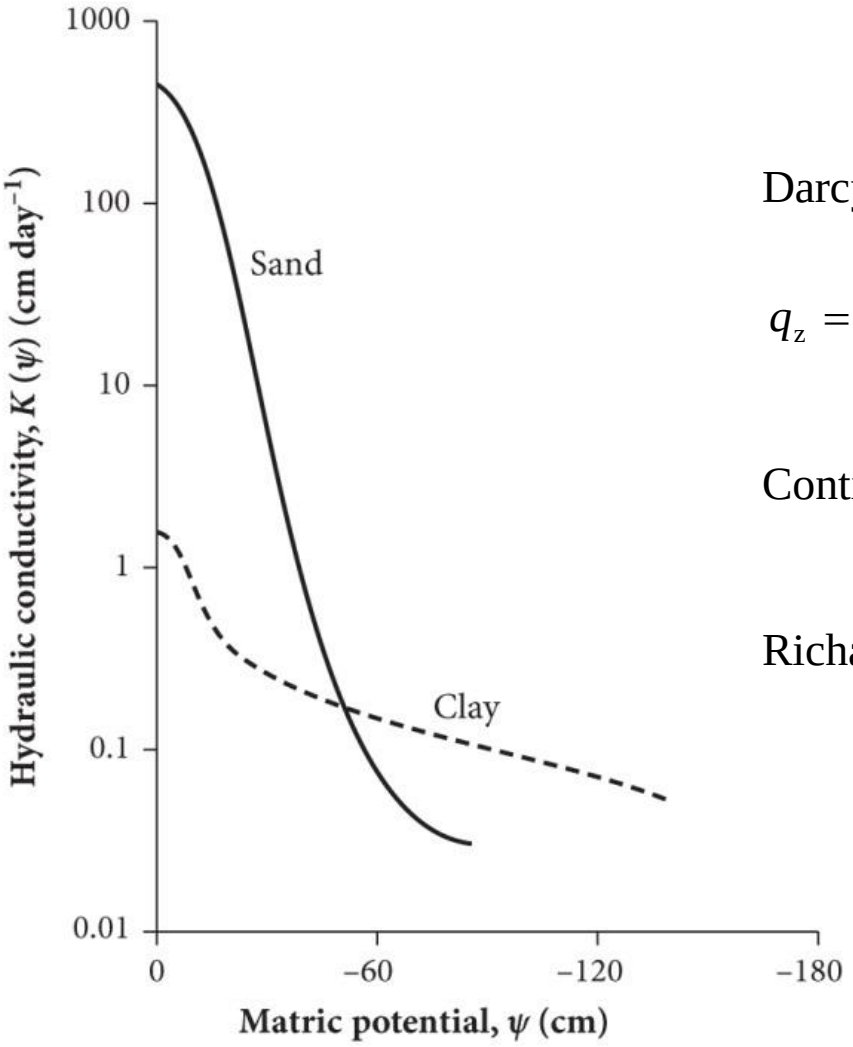
- water is bound stronger;
- water flow experiences more resistance;
- the water film along the soil particles is interrupted.

The hydraulic conductivity is highest at saturation.

With unsaturated flow, the hydraulic conductivity is a function of the matric potential or moisture content:

$$K(\psi) \text{ or } K(\theta)$$

Unsaturated hydraulic conductivity



Simplified from Bouma (1977)

Darcy-Buckingham equation:

$$q_z = -K(\psi)\frac{dh}{dz} = -K(\psi)\frac{d(z+\psi)}{dz}$$

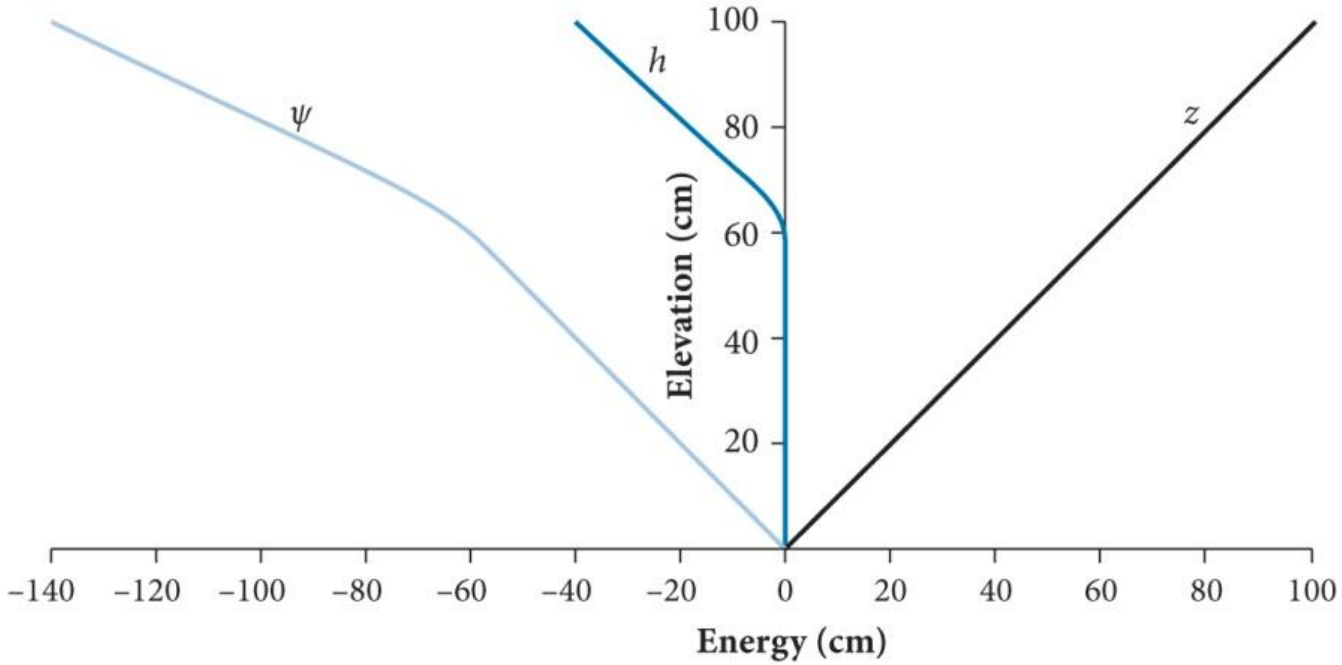
Continuity: $\frac{dq_z}{dz} = -\frac{d\theta}{dt}$ (Box M8)

Richards equation: $\frac{d}{dz}\left(K(\psi)\frac{dh}{dz}\right) = \frac{d\theta}{dt}$

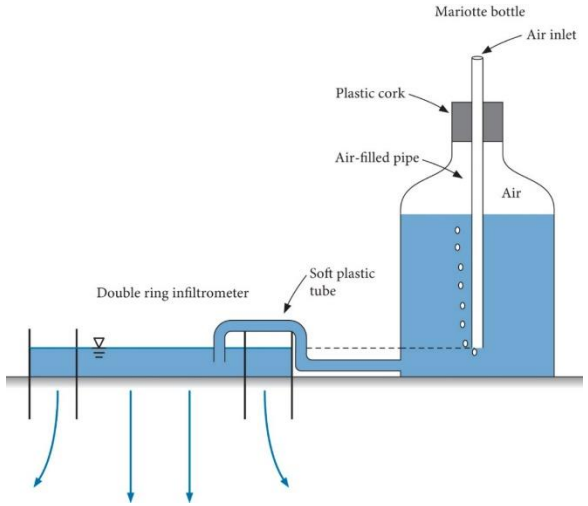
HYDRUS

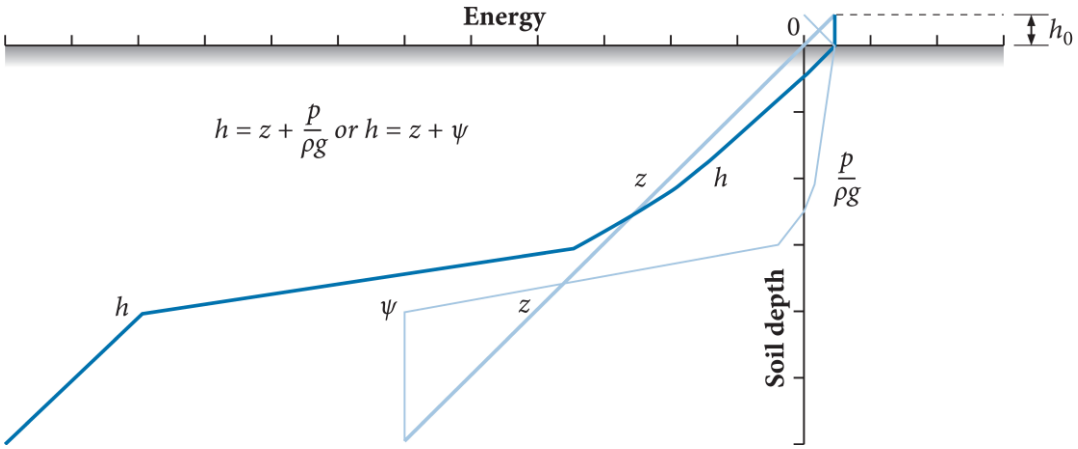
Evaporation

Potential diagram



Measuring ponded infiltration





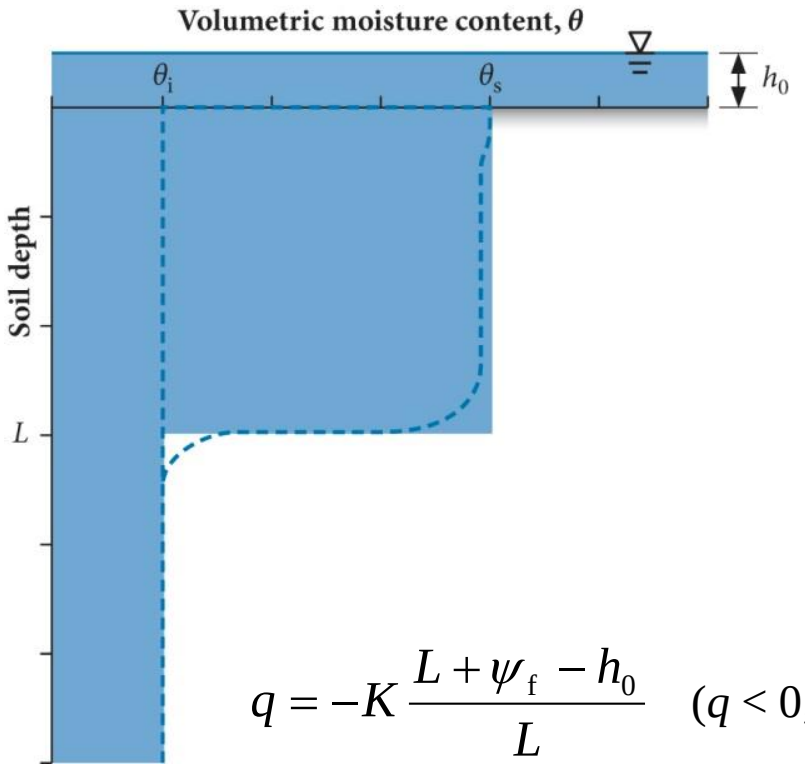
Measuring ponded infiltration

Green and Ampt equation

Ponded infiltration

$h = 0 + h_0$

$h = L + \psi_f$



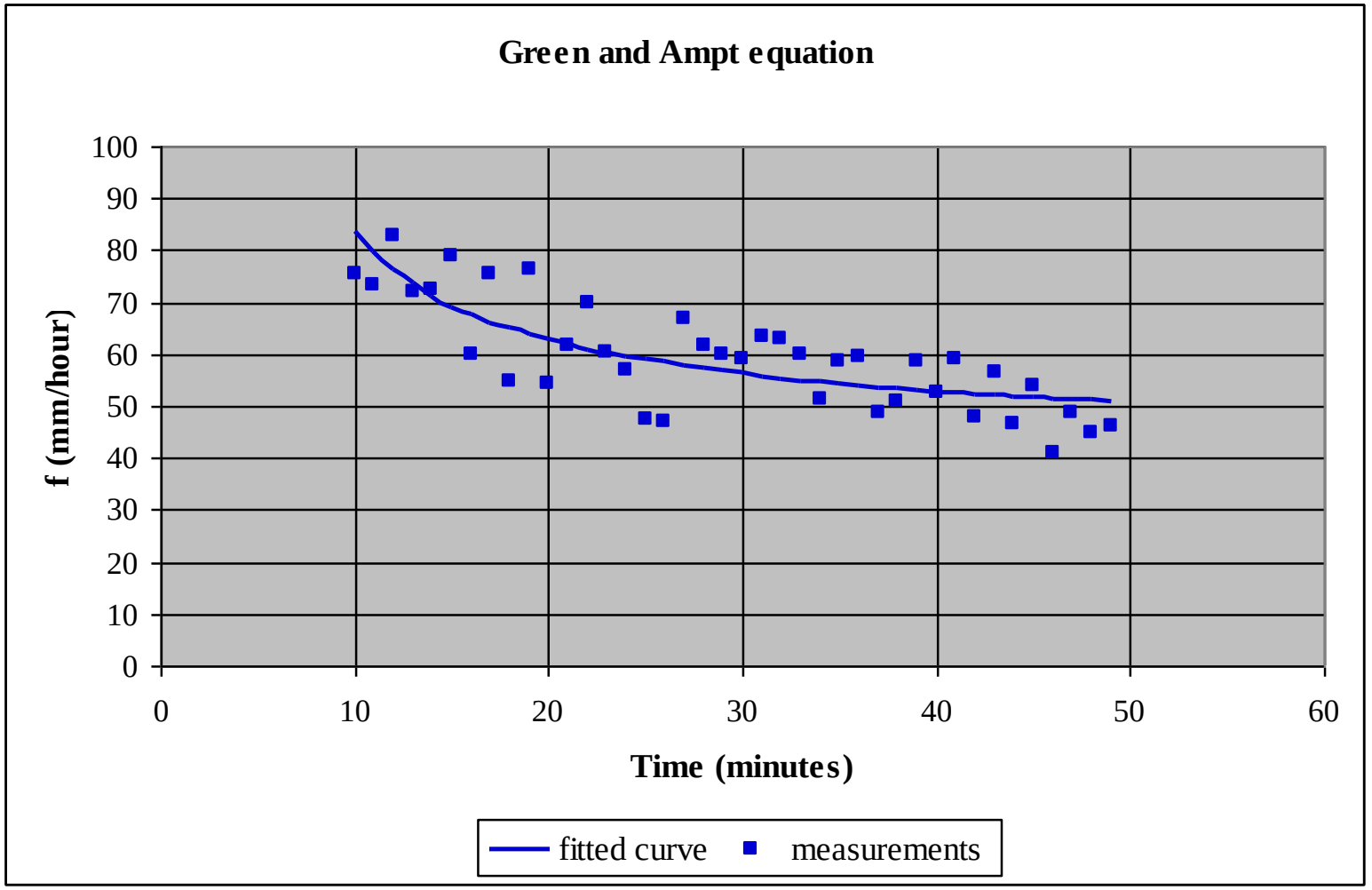
$$q = -K\frac{L + \psi_f - h_0}{L} \quad (q < 0;\ \psi_f < 0;\ L < 0;\ h_0 > 0)$$

$$f = K\frac{L + S_f + h_0}{L} \quad (f > 0;\ S_f > 0;\ L > 0;\ h_0 > 0)$$

$t \to \infty \Rightarrow f = K$, and $i = 1$ (gravity drainage)

Spreadsheet

Ponded infiltration



References

Bouma, J. (1977). Soil survey and the study of water in the unsaturated zone. Soil Survey Paper 13. Netherlands Soil Survey Institute, Wageningen, 106 pp.

Hendriks, M.R. (2010). Introduction to Physical Hydrology. Oxford University Press.