Approximate Week
1. Getting organized.
   • Orientation to the class: lectures, quizzes, prep for class, lab kits, computational project
   • History of vadose zone understanding, relationship to saturated media.
   • Getting started with HYDRUS-1D

2. An Introduction to the Vadose Zone
   • Primer on soils
     - components of soils
     - soil classification
     - clay mineralogy

3. Introduction to Hydrus.

3. Physical and Hydraulic Properties of Variably Saturated Media
   • Basic definitions
   • Hydrostatics of unsaturated media
     Surface tension
     The characteristic curves
     Hysteresis and the independent domain approach

4. Hydrodynamics in porous media
   Motivation for Darcy's law and a few simple solutions
   Derivation of Richardson-Richards equation

5&6. Flow of Water in the Vadose Zone
   • The classic solutions
     - The Green and Ampt approximation
       The physical model
       Horizontal, vertical, ponded, and falling head infiltration
     - Solutions using Richardson-Richards equation.
       Bruce and Klute equation, the Boltzman transform, sorptivity
       Evaporation from a water table (Gardner, 1958) with
       application of exponential conductivity, diffusivity.
   • Preferential flow processes: capillary barriers, macropores, and fingered flow

7. Miller and Miller scaling and Characterization of soil hydraulic properties

8. Solute Transport in the Vadose Zone
   • Goal of quantitative approach: coupling mass-transfer and mass transport relations
   • Basic processes: Advection, adsorption, diffusion, transformation, degradation.
   • Transport of decaying solutes in uniformly saturated media: The diffusion equation
     (Linearity, superposition, erf and erfc solutions).
   • colloid transport

9. Three-phase flow
   • Surface tension, spreading pressure, layered menisci
   • Constitutive relations: Pressure-Saturation-Permeability
   • Funicular and residual saturation
   • Special problems with continuum assumptions: non-spreading oil.

10. Preferential flow – Macropore, fingers, and funnel flow processes

Note: Special 3-hour evening session to be held in the week of 9 to present simulation results