Course Outline - Fall 2021
BEE 542, "Vadose Zone Transport", or "Hydrology of Unsaturated Porous Media,"

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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