Geophysical Research Abstracts
Vol. 13, EGU2011-4853, 2011
EGU General Assembly 2011

Soil Moisture Processes in the Shallow Subsurface Near Land/Atmospheric Interface- Challenges and New Research Approaches

Tissa Illangasekare (1), Kate Smits (1), Toshi Sakaki (1), and Abdullah Cihan (2)

(1) Colorado School of Mines, Center for Experimental Study of Subsurface Environmental Processes, Environmental Science and Engineering, Golden, United States (tissa@mines.edu, 1 303 273 3311), (2) Earth Science Division, Lawrence Berkeley National Laboratory, Berkeley, California, USA

Soil moisture processes in the subsurface near-land-surface, play a crucial role in the hydrologic cycle and global water budget. This zone is subject to both natural and human induced disturbances, resulting in continually changing soil structure and hydraulic and mechanical properties. Understanding of the dynamics of soil moisture distribution in this zone is of interest in various applications in hydrology such as land-atmospheric interaction, soil evaporation and evapotranspiration, as well as emerging problems in assessing the risk of leakage of sequestrated CO2 from deep geologic formations to the shallow subsurface that affects water quality and vegetation. It has been shown that the dynamic variation of shallow surface soil moisture defined by conditions at the land surface affects intrusion of toxic chemical vapor from waste sites into buildings. Soil moisture in the shallow subsurface will also play a critical role in the interpretation of remote sensing signals for the detection of buried land mines. Shallow subsurface soil moisture is highly influenced by diurnal temperature variations, evaporation/condensation, precipitation and liquid water and water vapor flow, all of which are strongly coupled. Modeling studies, have shown that soil moisture in this zone is highly sensitive to the heat and mass flux boundary conditions at the land surface. Hence, approximation of these boundary conditions without properly incorporating complex feedback between the land and the atmospheric boundary layer are expected to result in significant errors. In addition, natural soil heterogeneity as well as changes in the soil conditions due to natural and human induced disturbances contribute to spatial and temporal distribution of soil moisture. Even though, considerable knowledge exists on how soil moisture changes in response to the flux and energy boundary conditions, emerging problems involving land atmospheric interactions require the quantification of soil moisture variability both at high spatial and temporal resolutions than what is needed in traditional applications in soil physics and vadose zone hydrology. These factors lead to many modeling challenges, primarily of which is the issue of up-scaling. In general, measurements are taken at sparsely distributed spatial locations that need to be up-scaled and assimilated with remote sensing data. It is our contention that knowledge that will contribute to both improving our understanding of the fundamental processes and practical problem solution could not be obtained using only field data. Basic to this limitation is the inability to make field measurements at very fine scales at high temporal resolutions. Also, as the natural boundary conditions at the land/atmospheric interface are not controllable at the field even in pilot scale studies, the developed theories and models cannot be validated for diversity of conditions that could be expected in the field. As an alternative, we propose an innovative testing approach that couples a low velocity boundary layer climate wind tunnel to intermediate scale porous media tanks. Intermediate scale testing using soil tanks packed to represent different heterogeneous test configurations provides an attractive and cost effective alternative to investigate a class of problems involving the shallow unsaturated zone. In this talk, we will present examples of studies we have conducted in hierarchy of test systems including the intermediate scale. The advantages and limitations of testing at this scale are discussed using these examples. The features and capabilities of newly developed test systems are presented with the goal of exploring opportunities to use them to study some of the challenging multi-scale problems in the near surface unsaturated zone. It is our belief that filling the knowledge gaps in the understanding of this critical subsurface zone will help to advance hydrologic sciences to address many emerging and critical problems in water, climate and the environment.