

## Summary of UZIG activities at GSA

### Rocky Mountain Unsaturated Zones—Exploring Fire-Earth-Sky Connections (field trip)

This multisegment field trip, led by subject matter experts, will highlight four different multidisciplinary research efforts aimed at crucial problems involving unsaturated zones in the Rocky Mountain area. The first segment will investigate linkages of large hot fires to short-to-long term changes in the partitioning of rainfall and snowmelt into infiltration and runoff, with attendant flood generation and sediment transport. These linkages will be examined within the context of enhanced potential for extreme flooding and debris flows caused by hyperarid conditions following the September 2010 Fourmile Canyon fire—at the time the most costly in Colorado history. The second segment will investigate a site in the Boulder Creek member of the NSF-sponsored Critical Zone Observatory (CZO) network, where data-driven studies are exploring interactions among water, soil, and boundary-layer ecosystems across landscapes that include little-explored thick unsaturated zones on deeply sculpted erosional terrain. The third segment will investigate seasonal systematics of elemental exchanges across the land-atmosphere interface along transitions from undisturbed to urbanized land (comprising one investigational axis) and from prairie grassland to montane forests (comprising another). This portion will include a visit to an instrumented short-grass prairie site at the Rocky Flat National Wildlife Refuge, where land surface fluxes of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and water vapor are being correlated to soil-carbon dynamics. The final segment will investigate the legacy of nuclear weapons production, environmental contamination, and remediation at the Rocky Flats industrial site. The field trip will end with an optional dinner in an informal setting. Field Trip Leaders: Brian Ebel (CIRES Fellow, U. Colorado); Dean Anderson and Katherine Powell (USGS, Lakewood); Suzanne Prestrud Anderson (PI, Boulder Creek CZO); Bruce Honeyman (tentative; Colo. School Mines)

### Unsaturated Zone Geophysics

In this session we focus on the application of geophysical methods to provide quantitative estimates of unsaturated zone hydrologic properties and unique insights about vadose zone hydrologic processes. We welcome laboratory- to field-scales examples of new and novel methods to acquire, analyze and interpret vadose zone geophysics. Although examples of geophysical methods coupled with traditional hydrologic testing procedures are particularly encouraged, all approaches and aspects of surface, borehole, and cross-hole geophysical surveys, from data acquisition, through inversion, visualization and coupling of geophysical results to groundwater flow and transport models are of interest. Conveners: John W. Lane, USGS Office of Groundwater; Kamini Singha, Colorado School of Mines

## Vadose zone flow and transport in natural or engineer systems under extreme conditions

Engineered system such as a surface flow barrier or cover often creates an environment drier than the same soil under the natural condition. The surface flow barriers often contain a capillary break that is made of a fine (e.g., silt) layer over a coarse (e.g., gravel) layer. Sub-surface remediation using the desiccation technology immobilizes soil water with dissolved contaminants creates a very dry condition. Many other environment remediation technologies also create extreme flow conditions. Flow under these extreme conditions is generally not well understood. This session seeks theoretical or experimental study, measuring techniques, computer simulations, real-world problems, remediation technologies on flow and solute transport at low water content, in very coarse materials, low-permeability media, fractured systems, soilgravel mixtures, and across the texture interface. The flow type may be capillary flow, film flow, stable or unstable flow, preferential or funnel flow, Darcy or non-Darcy flow, temperature induced flow, and other flow types. Conveners: Z. Fred Zhang, Pacific Northwest National Laboratory; H. Liu, Lawrence Berkley National Laboratory; and J. Zhu, Desert Research Institute, Las Vegas, NV

## Anomalies, surprises, irregularities, and contradictions in variably-saturated subsurface flow

Detailed monitoring of subsurface hydrologic response dynamics and solute concentrations in complex, natural systems often reveals surprising observations, anomalous data, and apparent irregularities or contradictions between measured subsurface state variables and traditional flow theory. Critical evaluation of these deviations between observed and expected results can lead to important breakthroughs in our conceptual understanding of complex subsurface hydrological processes. This session welcomes submissions that present unexpected or surprising data that cannot be easily explained, analysis of unusual flow phenomena, and novel modeling approaches, with an overall aim of stimulating discussions and improving quantitative characterization of subsurface flow and transport processes. Conveners: Benjamin Mirus, USGS; Brian Ebel, University of Colorado at Boulder; John Nimmo, USGS

## Recent advances in the theory, characterization, and modeling of unsaturated zone processes

This session focuses on advances in understanding unsaturated zone processes that control gas and water transport using field and laboratory measurements, and theoretical and numerical models. Topics considering the groundwater-atmosphere continuum are of particular interest. Rationale: From arid to humid environments, unsaturated-zone processes control gas and water movement from the water

table to the atmosphere. Groundwater quality and availability predictions, landuse assessments, and climate change adaptations can all benefit from knowledge of unsaturated-zone dynamics. In particular, these processes include infiltration from the earth-surface through soils and fractured rock, fluid-soil and fluid-rock chemical interactions, and movement of water and energy. In combination, these processes often control partitioning and redistribution of natural and anthropogenically-derived liquid and gas-phase chemical constituents within the hydrogeologic system. Estimating fluxes of fluid, energy and chemical constituents through innovative sampling techniques, field and laboratory measurements, and modeling can help guide current and future decisions about land management. This session solicits contributions highlighting recent advancements in field and laboratory measurements, theoretical and numerical models, and other characterization techniques that improve the understanding of gas and water transport across the groundwater to atmosphere continuum. Conveners: C. Amanda Garcia, USGS Carson City; Michael H. Young, University of Texas at Austin; David A. Stonestrom, USGS Menlo Park

#### Impacts of Land-Use Change on Unsaturated-Zone Ecohydrology

Land-use change profoundly impacts unsaturatedzone biotic and hydrologic processes such as subsurface moisture dynamics, infiltration and runoff, sedimentary erosion and deposition, biodiversity, and ecological function. This session will explore recent work in assessing these process changes and related effects. Rationale: Land use directly affects biodiversity and hydrogeology. Human alteration of landscapes such as deforestation, introduction of invasive species, agriculture, and urban development have significantly altered landscapes all over the world. These disturbances typically result in habitat loss, degradation, fragmentation, and even extinction. There are fundamental interrelationships between biologic, hydrologic, and geologic processes and a change in one of these can cause functional or structural change in both of the other two. Specifically, there are changes in the unsaturated zone including alteration of soil hydraulic properties and processes, water quality and availability, rainfall/runoff partitioning, erosion, habitat suitability, biodiversity, and ecological health. This session aims to present an exciting and diverse range of studies focused on the unsaturated zone using a variety of field and modeling techniques to explore the environmental implications of land-use changes such as the introduction of native species, deforestation, urbanization, and agriculture. This will also include studies examining restoration effects on species reestablishment and diversity, restoration of soil function, and changes in hydrology. Conveners: Kim Perkins, USGS; David Bedford, USGS; and Darren Sandquist, CSU Fullerton

#### Bottoms Up! - Shallow Water Table Influences on Vadose Zone Biogeochemistry

Topics will focus on the influence of shallow water table conditions on hydrologic and biologic processes that control the unsaturated zone's biogeochemistry, contaminant fate and transport, and ecological community structure and composition. Rationale: Many hydrologic and biogeochemical processes in the vadose zone are influenced by variations in the water table near the surface. The importance of the vadose zone is often discounted in shallow water table environments because seasonal fluctuations in water tables result in periods of time where the vadose zone is significantly reduced or is absent completely. However, the dynamic nature of the shallow water table influences soil moisture conditions, oxidation reactions, biogeochemistry, and biogeochemical gradients, highlighting the importance of research in this area. The proposed session will help disseminate new research in the near-surface vadose zone, providing an opportunity for the broader GSA scientific community to learn about the role of vadose zone processes in terrestrial and wetland ecology, biogeochemistry, and emerging subdisciplines, such as ecohydrology. Conveners: Wesley R. Henson and David Kaplan, University of Florida