Special Section: UZIG USGS
Vadose Zone Journal

UZIG USGS Research: Advances through Interdisciplinary Interaction

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Because vadose zone research relates to diverse disciplines, applications, and modes of research, collaboration across traditional operational and topical divisions is especially likely to yield major advances in understanding. The Unsaturated Zone Interest Group (UZIG) is an informal organization sponsored by the USGS to encourage and support interdisciplinary collaboration in vadose or unsaturated zone hydrologic research across organizational boundaries. It includes both USGS and non-USGS scientists. Formed in 1987, the UZIG operates to promote communication, especially through periodic meetings with presentations, discussions, and field trips. The 10th meeting of the UZIG at Los Alamos, NM, in August 2007 was jointly sponsored by the USGS and Los Alamos National Laboratory. Presentations at this meeting served as the initial basis for selecting papers for this special section of *Vadose Zone Journal*, the purpose of which is to present noteworthy cutting-edge unsaturated zone research promoted by, facilitated by, or presented in connection with the UZIG.

Abbreviations: UZIG, Unsaturated Zone Interest Group.

Research in the unsaturated zone (equivalent to the vadose zone) is by its nature highly multidisciplinary; researchers commonly have academic backgrounds in hydrology, agriculture, soil mechanics, fluid mechanics, civil engineering, or various other fields, often with additional expertise in biology, physics, chemistry, geology, or mathematics. The practical applications are in diverse areas such as environmental contamination, groundwater supply and quality, agriculture, mining, and ecosystem management. Modes of investigation are also diverse and include laboratory and field experiments, environmental monitoring, theoretical analysis, and numerical simulation. Consequently, for effective research and problem solving, both disciplinary and organizational boundaries have to be transcended.

The Unsaturated Zone Interest Group (UZIG) was initiated in 1987 as a topical interest group within the USGS, connecting people across institutional unit boundaries. At that time, some of those involved had unsaturated zone expertise, but often specialized toward soil science applications, while others had hydrologic expertise but were unfamiliar with the complexities of water and contaminant transport under unsaturated conditions. All had a need to solve problems that often were far removed from the agricultural settings typical of traditional soil science and soil physics—for example, thick unsaturated zones, watershed-scale hydrology, ecohydrologic applications, dry desert soils, and groundwater–surface water interaction. Other developments in unsaturated zone science have paralleled this course, such as the inauguration of *Vadose Zone Journal* in 2003 to fill a gap left by traditional divisions of subject matter. This interdisciplinary trend continues, affirming the direction that UZIG and *Vadose Zone Journal* have taken, for example, in the increasing prominence of such unifying concepts as hydropedology and the earth's critical zone (Kutílek and Nielsen, 2007; Lin, 2003).

The UZIG is an informal and spontaneous organization. In keeping with its purpose of serving as an alternative to formalized departments and institutional divisions, it is volunteer based and has no budget, dues, or official staff. The main unifying factor is an interdisciplinary approach to unsaturated zone problems. One consequence of informal structure is that meetings do not occur on a regular schedule but rather whenever a group of people within UZIG commits to organizing one. There have been 10 general meetings of the UZIG, most of them sponsored jointly by USGS and one or more other institutions, at intervals varying from one to four years. The scientific presentations, discussions,

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and field trips at these meetings have a more informal character than those of large scientific societies. Over 22 years, the UZIG has had increasing involvement of people outside the USGS, in keeping with its goal of bridging institutional and international boundaries. The original motivation and mode of operation are as valid as ever.

This special section of *Vadose Zone Journal* arose from the August 2007 meeting of the UZIG at Los Alamos, NM, jointly sponsored by the USGS and Los Alamos National Laboratory. Ten papers are included here. As expected, given the nature of the UZIG, they cover highly diverse subject matter, although they can be considered in two broad categories: (i) soil–water–plant–atmosphere interactions and (ii) unsaturated zone properties and processes. Some papers are topically on the border of these classifications, and some would fit well in either. We describe them briefly in the paragraphs below.

The first category, soil–water–plant–atmosphere interactions, includes papers on the dynamics of systems that include the unsaturated zone. In a study with agricultural and arid-region applications, Ochoa et al. (2009) investigated aquifer recharge from irrigation. They characterized water movement through the soil-surface–vadose zone–aquifer continuum in response to surface irrigation, contributing an improved understanding of the surface-water and shallow groundwater interactions in an irrigated valley of the Rio Grande in northern New Mexico. In another agricultural field and modeling study, Singh et al. (2009) evaluated cold-season hydrologic and erosion processes under different tillage systems in the U.S. Pacific Northwest. Field monitoring documented how tillage practices influence snow accumulation, soil freeze and thaw, surface runoff, and soil erosion. Their model, which included an energy budget–based winter routine, reasonably reproduced some of these processes, demonstrating potential for further development as a predictive tool for assessing land-management practices. Using an innovative multivariate analysis technique, Ritter et al. (2009) investigated the influence of hydrological fluxes on soil water dynamics in a humid subtropical forest. Dynamic-factor analysis identified net infiltration and potential evapotranspiration as important explanatory variables and showed fog-drip from the canopy had a negligible influence on the observed temporal changes in soil water status. Addressing a major contaminant-transport issue, Garcia et al. (2009) investigated the overall problem of tritium fluxes to the atmosphere adjacent to a low-level radioactive waste facility, with particular attention to the role of desert plants. By combining tritiated-water-vapor concentrations in plants and soil with evapotranspiration fluxes, they quantified the annual rate of tritium mass removal by this natural remediative process. Evapotranspiration was found to transfer substantial quantities of tritium from the subsurface to the atmosphere, although annually amounting to a small fraction of the total mass of tritium in the landfill.

The second category, unsaturated zone properties and processes, groups papers that emphasize the slower-changing characteristics of earth–air–water systems, such as conductivity, that mediate the response to outside influences in determining the faster-changing conditions, such as water content. In a fundamental study relevant to infiltration with diverse liquids, porous media, and conditions, Schulte et al. (2009) confirmed experimentally that a single value of intrinsic sorptivity can predict sorptivity values for a group of Miller-similar media over a range of conditions. For accurate infiltration and soil water predictions, Gowdish and Muñoz-Carpena (2009) derived a method based on a modified Green–Ampt method for quantifying a redistribution coefficient, based on saturated hydraulic conductivity and the order and duration of redistribution events. This simplified method maintains physical consistency between the descriptions of infiltration and redistribution and was found to have several advantages over solutions of Richards' equation, including faster execution, and applicability across a wide range of soil types. In an innovative field study, Nimmo et al. (2009) combined soil moisture–probe measurements with noninvasive electrical-resistivity imaging to assess the effects of pedogenic development on infiltration and redistribution in desert alluvium. They found that spatial heterogeneities in infiltration and redistribution generally increased with increased soil age, although with evidence that some early-stage developmental processes promote uniformity. Observed differences in the patterns of soil moisture distribution and retention also provided insight into potential ecohydrologic relations between soil age and the associated plant community. In a companion study, Mirus et al. (2009) combined inverse modeling with field data from Nimmo et al. (2009) to estimate effective soil-hydraulic properties for the different-aged soils. Simulations based on solution of Richards' equation successfully depicted the observed lateral and vertical water movement for the two younger soils; results for the oldest soil indicated a more complex conceptual model may be needed. Stauffer et al. (2009) obtained and analyzed breakthrough data of a tracer test in a deep and complex unsaturated zone at Busted Butte, NV. Parameter combinations that fit these data were found using the multiphase heat and mass transfer simulator FEHM in combination with the advanced optimization algorithms AMALGAM and SCEM-UA. Although both algorithms provided acceptable fits, the posterior distribution provided by SCEM-UA yielded far more information. The use of measured data to reduce the ranges of parameter values to be searched decreased the uncertainty of the results and yielded insight into parameter correlations. In a paper from the same meeting and published in a previous issue of *Vadose Zone Journal*, Reilly et al. (2009) evaluated the mineralogy of deep unsaturated-zone sediments and grain coatings with respect to the concentration of selected ions within them. They demonstrated that the mineralogy of grain coatings significantly affects the storage of nitrate and sulfate in the unsaturated zone. Figueras and Gribb (2009) have presented a fully automated laboratory apparatus for direct measurement of the soil moisture retention curve, which can also produce indirect estimations of unsaturated hydraulic conductivity as a function of water content. The user-friendly system was built from off-the-shelf hardware and software for rapid implementation by the scientific community.

Papers in this special section represent a small portion of the interdisciplinary unsaturated zone research promoted by the UZIG and the USGS. Their publication here exemplifies the constructive contributions to unsaturated zone science that are facilitated by active measures to span traditional disciplinary and institutional boundaries.

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