Meeting Program

7th Unsaturated Zone Interest Group Workshop & Information Exchange

Land-Use Change, Climate Change, and Hydrologic Extremes: Unsaturated Zone Responses and Feedbacks

University of Florida, Gainesville April 4–6, 2017

Planning Committee Members:

Wesley Henson, USGS; Rafael Muñoz-Carpena, University of Florida

Jared Trost, USGS; Kim Perkins, USGS; John Nimmo, USGS; Ben Mirus, USGS

Amanda Garcia, USGS; Dave Stonestrom, USGS

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University of Florida Department of Agricultural and Biological Engineering

UZIG Welcome

7th UZIG Workshop & Information Exchange

It is our pleasure to welcome you all to the 7th Unsaturated Zone Interest Group Workshop. We have a great program that will provide ample opportunity to have small group conversations to facilitate interactions among well established and new unsaturated zone scientists.

This years' program includes a keynote address from Dr. Upmanu Lall, almost 2 days of oral and poster presentations, a short course on episodic recharge, as well as an all-day field trip examining unsaturated zone science in North Florida forests and a visit to one of Florida's Outstanding Waters, Ichetucknee Springs, where visitors will see a unique world-renowned aquifer system.

The philosophy of UZIG is to provide a forum in which ideas can be developed and exchanged at a more leisurely pace than is allowed in the typical national meeting venue. Additionally, the informal nature of the meetings allows for the presentation of new ideas that might not yet be adequately developed and investigated for presentation in a formal setting.

The Unsaturated Zone Interest Group (UZIG) is an organization whose members come from the USGS, national labs, academia and industry. The group was formed in 1987 to foster better communication among scientists working on, or interested in, unsaturated-zone hydrologic studies. Over 30 years, the UZIG has had increasing involvement of people outside the USGS, in keeping with its goal of bridging institutional and international boundaries. The UZIG encourages and supports inter-disciplinary collaboration and cooperative studies. To join our mailing list, get information about our bimonthly webinars, or join our community feel free to contact our chair Jared Trost (jtrost@usgs.gov) or visit our website https://mn.water.usgs.gov/uzig/index.html.

We look forward to an engaging and productive meeting!

The UZIG Workshop Planning Team

Keynote Speaker

7th UZIG Workshop & Information Exchange

From Paleo to Future climates: How could interannual to decadal to secular climate variations interact with vegetation, humans, soils and determine the phase space of the unsaturated zone

Dr. Upmanu Lall

Alan & Carol Silberstein Professor of Engineering & Director of Columbia Water Center, Columbia University, NY

His current research covers 3 major initiatives that are developed through the Columbia Water Center. The Global Water Sustainability Initiative is focused on an assessment of global water scarcity and risk. The Global Flood Initiative is motivated by the desire to predict and manage floods at a global scale recognizing their climate drivers, and supply chain impacts. Americas Water is driven by the goal of developing sustainable water management and infrastructure design paradigms for the 21st century recognizing the linkages between urban functioning, food, water, energy and climate. These programmatic initiatives are backed by research on systems level modeling of hydrology, climate, agronomy and economics. Dr. Lall has pioneered the application of techniques from (a) nonlinear dynamical systems, (b) nonparametric methods of function estimation and their application to spatio-temporal dynamical systems, (c) Hierarchical Bayesian models, (d) systems optimization and simulation and (e) the study of multi-scale climate variability and change as an integral component of hydrologic systems

Workshop Agenda

7th UZIG Workshop & Information Exchange

All Events at J. Wayne Reitz Union Rm. 3320 unless otherwise noted

Day 1 - April 3

7:00-8:30 PM	Informal Welcome Social - Paisano's Italian Restaurant Holiday Inn

Day 2 - April 4

8:00-8:45 AM	Registration and Speaker Preparation- Reitz Union 3rd Floor
9:00-9:20 AM	UZIG Welcome and Ice Breaker
9:30-10:30 AM	Dr. Upmanu Lall Keynote Address
10:30-10:50 AM	Coffee, Refreshments, and Poster Viewing
10:50-12:05 PM	Oral session 1 - *Chemistry, multiphase flow, and bioremediation processes in the unsaturated zone*
12:05-1:25 PM	Lunch (on your own)
1:25-2:40 PM	Oral session 2 - *Dynamics of flow through the unsaturated zone*
2:40-3:00 PM	Coffee, Refreshments, and Poster Viewing
3:00-4:15 PM	Oral session 3 - *Unsaturated zone influences on water storage and availability*
4:15-4:30 PM	Lightning talks and poster session
4:30-5:00 PM	Break
5:00-7:00 PM	UZIG Social and Poster Session Paisano's Italian Restaurant Holiday Inn

Day 3 - April 5

8:30-9:30 AM	Meet at Holiday Inn lobby and travel to first field site
9:30-11:30 AM	Austin Cary Forest Site Tour and Wildlife Viewing
11:30-12:30 PM	Travel to Ichetucknee Springs
12:30-1:30 PM	Lunch at Ichetucknee Head Spring (provided)
1:30-4:30 PM	Ichetucknee Springs Group Kayak/Canoe Tour*
4:30-5:30 PM	Travel back to Gainesville**

**River is slow and placid. No whitewater or drops. If desired, participants can elect to stay at head spring during kayak tour.*
*** May be opportunity to have dinner as a group on way home.*

Day 4 - April 6

8:30-9:45 AM	Oral session 4 - *Modeling unsaturated zone dynamics*
10:00-11:15 PM	The Future of Unsaturated Zone Research-UZIG Vision Publication Discussion
11:15-12:15 PM	Lunch (on your own)
12:15-2:45PM	Short Course: *Quantifying Episodic Aquifer Recharge: Relation to Total Recharge, Storm characteristics, and Climate Change*, presented by John Nimmo and Kim Perkins (USGS), Rogers Hall Room 122

Oral Speaker Schedule

Tuesday, April 4th		
Oral session 1 - Chemistry, multiphase flow, and bioremediation processes in the unsaturated zone		
Time	Speaker	Title
10:50 AM	Michael Plampin	Fundamental Investigation of Heterogeneity-Induced Multiphase CO_2 Attenuation in Shallow Aquifers using Intermediate-Scale Laboratory Experimentation and Numerical Modelling
11:05 AM	Gurpal Toor	Miracle in the Vadose Zone of Septic Systems: Understanding the Fate and Transport of Nutrients and Organic Contaminants
11:20 AM	Alexander Soroka	Irrigation Accelerates Nitrate Transport within the Growing Season
11:35 AM	Bin Gao	Effects of temperature on graphene oxide fate and transport in porous media
11:50 AM	Ofer Dahan	Real time improvement of remediation strategies in deep vadose zone: Implications from direct observations during bioremediation treatment
Oral session 2 - Dynamics of flow through the unsaturated zone		
1:25 PM	Andre Luiz Biscaia Ribeiro da Silva	Determination of water flux in sandy soils of Florida potato production
1:40 PM	David Sumner	Effects of capillarity and microtopography on wetland specific yield
1:55 PM	John R. Nimmo	Recognizing preferential flow in time-series measurements of soil water content
2:10 PM	Christophe Darnault	Flow Phenomena and Transport of Protozoan Pathogens and Radionuclides in the Vadose Zone: Effects of Soil Heterogeneity and Time-Variable Hydrologic Systems
2:25 PM	Bernardo Cardenas	Actual rain sensor dry-out times compared to estimated soil dry-out times
Oral session 3 - Unsaturated zone influences on water storage and availability		
3:00 PM	Kim Perkins	Estimating Episodic Recharge Based on Water Table Fluctuations
3:15 PM	David Kaplan	Continuous soil moisture monitoring to quantify the impacts of forest management on regional water yield
3:30 PM	Ying Ouyang	Estimate 120 years vadose zone water dynamic, crop irrigation demand, and groundwater conservation on an agricultural land in Mississippi
3:45 PM	Subodh Acharya, SA	Water use by pine forests of Florida: estimating interception loss from near-surface soil moisture data
4:00 PM	Meijing Zhang	Assessing the effects of canal operations and boundary conditions on groundwater flow and flooding risk in an agriculture area in South Florida
Thursday, April 6th		
Oral session 4 - Modeling unsaturated zone dynamics		
8:30 AM	Rao, Suresh C.	Modeling Landscape-scale Spatiotemporal Dynamics of Water Storage in the Critical Zone

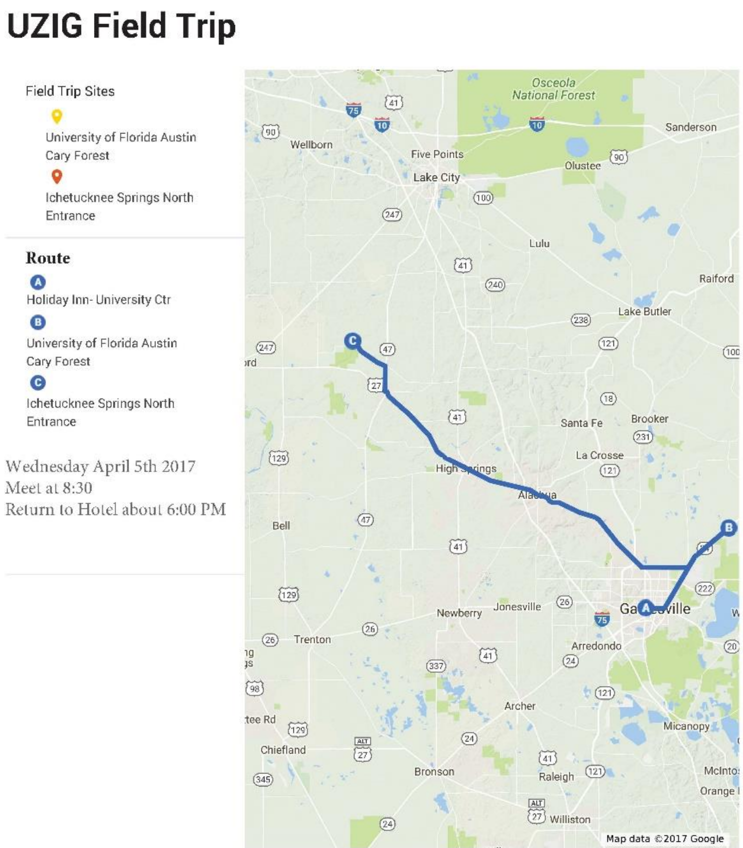
8:45 AM	Sanaz Borhani	Statistically based morphodynamic modeling of bedload transport
9:00 AM	Wesley Henson	Representing Rainfall-Runoff Response, Surface Soil Moisture Content, and Farm Soil Moisture Management in Basin to Regional Scale MODFLOW Models
9:15 AM	Jared Trost	Simulation of Potential Groundwater Recharge for the Glacial Aquifer System East of the Rocky Mountains, 1980-2011, using the Soil Water Balance Model
9:30 AM	Jesse Dickinson	Filtering of cyclical surface forcings in the vadose zone

Poster Session	
Presenter	**Title**
Michael D. Annable	Vadose Zone Gas Transport Measurement
Anupama John	Laboratory Assessment of Hydraulic Properties of Heterogeneous Organic Soils in the Everglades
Erin N. Kinsey (presented by Christophe Darnault)	Impact of Surfactant on the Fate and Transport of Toxoplasma gondii Oocysts in Soils
Jorge A. Leiva	Imidacloprid Fate and Transport in Unsaturated Citrus Root Zone in a SW Florida Flatwoods Spodosol
Biting Li (presented by Christophe Darnault)	Dynamics of Fluid Interfaces and Non-equilibrium and Preferential Flow in the Vadose Zone: Impact of Microbial Exudates
Rafael Muñoz-Carpena	Influence of Preferential Flow on Coupled Colloid, Nitrogen, And Phosphorus Transport Through Riparian Buffers
Ashley Pales (presented by Christophe Darnault)	Impact of Plant Exudates and Soil Constituents on Flow Processes in the Vadose Zone: Imaging and Measurements in a 2D System
Michael Plampin	Fundamental Investigation of Heterogeneity-Induced Multiphase CO2Attenuation in Shallow Aquifers using Intermediate-Scale Laboratory Experimentation and Numerical Modelling
Rajendra P Sishodia	Effects of future climate and groundwater withdrawals on water availability in semi-arid India
Jared Trost	A Direct-Push Sample-Freezing Drive Shoe for Collecting Sediment Cores with Intact Pore Fluid, Microbial, and Sediment Distributions
Maria Zamora Re, MZ	Relationship of salinity and nitrate concentrations measured by multisensor capacitance probes in the soil profile

Field Trip (April 5, 9:00-6:00PM)

Quantifying Effects of Forest Management on Unsaturated Zone Fluxes and Kayak Survey of Pristine Spring Ecosystem.

David Kaplan, Subodh Acharya, Wesley Henson



Short Course (April 6, 12:15-2:45PM)**

Quantifying Episodic Aquifer Recharge: Relation to Total Recharge, Storm Characteristics, and Climate Change

John Nimmo and Kim Perkins

Description:
At most locations, a substantial portion of aquifer recharge occurs during limited-duration episodes in response to individual input events such as storms or wet seasons. This course presents fundamentals of episodic recharge and demonstrates the Episodic Master Recession (EMR) method for quantification using time series data of water level and precipitation. It includes a session of hands-on experience setting up the EMR software for use with a particular data set. If time permits, participants can carry through to identify episodes and calculate recharge estimates. Participants should bring a laptop computer, ideally preloaded with RStudio and the EMR codes. Though example data will be provided, it's preferable for students to bring their own data sets of interest.

**limited seating available, contact kperkins@usgs.gov and jtrost@usgs.gov if interested)

UZIG MEETING WALKING MAP

Sights

- Bat Houses
- UF Gators Stadium
- Historic Downtown
- History and Art Museums
- Paines Prairie
- Historic Neighborhood

Directions from hotel to meeting rooms

A

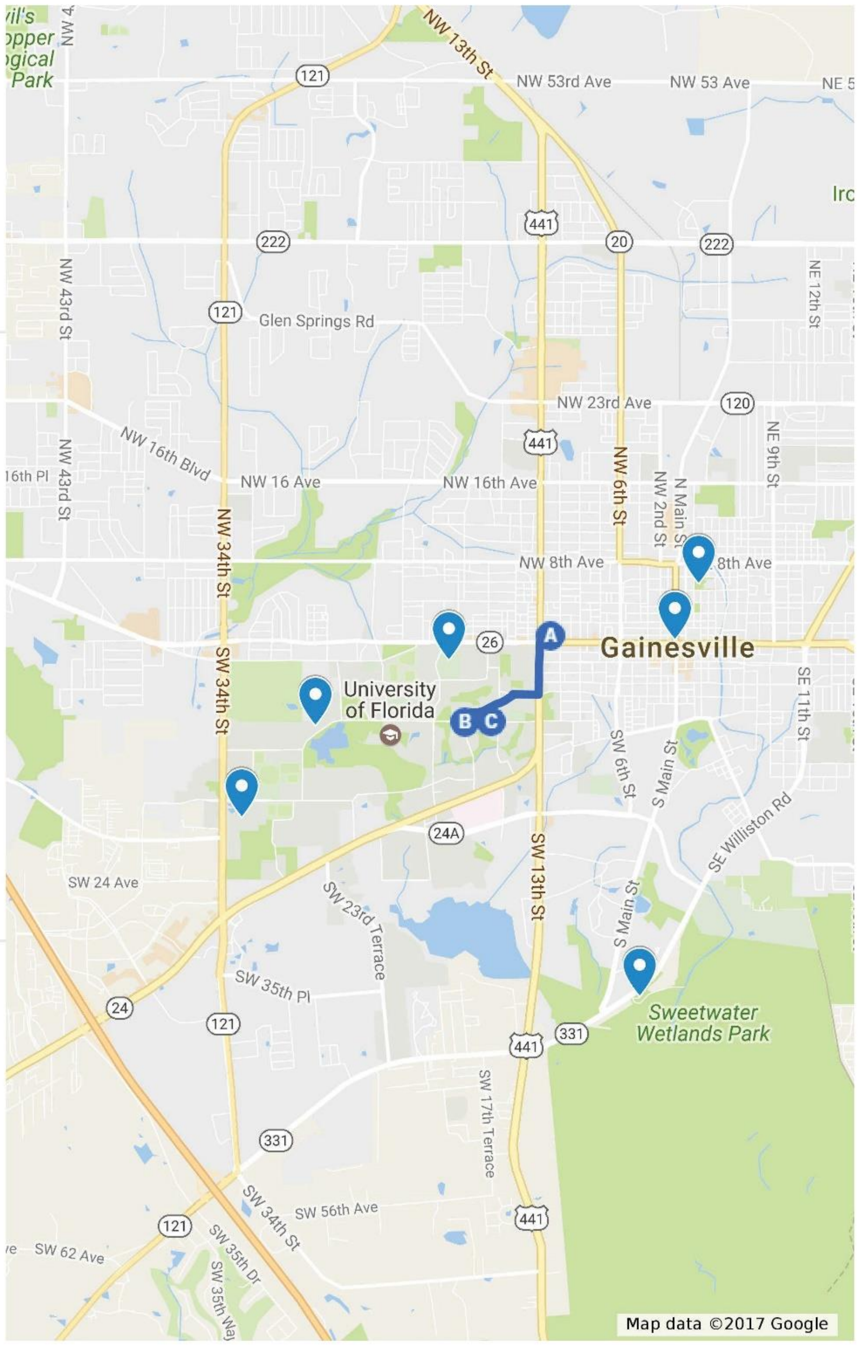
Holiday Inn University

B

Reitz Student Union Rm 3320

C

Rogers Hall Rm 122



Abstracts

2017 USGS UZIG Workshop & Information Exchange

Oral Session 1: Chemistry, multiphase flow, and bioremediation processes in the unsaturated zone

Fundamental Investigation of Heterogeneity-Induced Multiphase CO2 Attenuation in Shallow Aquifers using Intermediate-Scale Laboratory Experimentation and Numerical Modelling

Michael Plampin, National Research Program, Eastern Branch, U.S. Geological Survey

Coauthors: Rajesh Pawar (Earth and Environmental Sciences Division (EES-16), Los Alamos National Laboratory, Illangasekare, Tissa) and Mark Porter (Department of Civil & Environmental Engineering, Colorado School of Mines)

To assess the risks involved with leakage of stored carbon dioxide (CO2) from deep geologic formations into the shallow subsurface, it is crucial to understand how multiphase CO2 plumes are likely to evolve within shallow aquifers. Intermediate-scale laboratory experiments are ideal for investigating multiphase evolution processes, because they allow for the collection of higher-resolution data under better-controlled conditions than are possible in the field. For this study, a large, effectively two-dimensional, tank was constructed, densely instrumented, and filled with sand and water to mimic a shallow aquifer with multiple geologic facies. Lateral water flow was induced, water containing dissolved CO2 was injected, and the multiphase evolution of the CO2 plume was monitored through time via saturation, electrical conductivity, and temperature measurements from automated sensors, dissolved CO2 measurements from aqueous phase samples analysed with an ion chromatograph, as well as water and gas phase outflow measurements using computer-interfaced scales and flow meters, respectively. Two different sand combinations were used in separate experiments to assess the relative effects of different types of heterogeneities on the transport of CO2 through the system. Experimental results were then compared to simulations performed with the Finite Element Heat and Mass Transfer (FEHM) multiphase flow simulation code. After minimal adjustments to the important parameters, the model was able to accurately capture some, but not all, of the CO2 attenuation processes. This indicates that FEHM is potentially useful for predicting CO2 migration through shallow aquifers, but that the assumptions upon which it operates may limit its application.

Miracle in the Vadose Zone of Septic Systems: Understanding the Fate and Transport of Nutrients and Organic Contaminants

Gurpal Toor, University of Florida, Gulf Coast REC

Coauthors: Mriganka De, Sara Mechtensimer, and Yun-Ya Yang (University of Florida)

The knowledge of contaminants behavior in the vadose zone of septic systems is crucial to protect groundwater and surface water quality. Groundwater is a significant contributor of base flow in streams, rivers, and estuaries in areas with shallow groundwater such as Florida. The presence of porous sandy soils facilitates transport of water and chemical constituents present in septic tank effluent (STE). Our objective was to investigate the biophysical and hydrologic controls on transport of nitrogen (N), phosphorus (P), pharmaceuticals and hormones in the vadose of two conventional (drip dispersal, gravel trench) and an advanced system containing aerobic and anaerobic medias. These systems were constructed using two rows of drip pipe (37 emitters/mound) placed 0.3 m apart in the center of 6 m x 0.6 m drainfield. Each system received 120 L of STE (equivalent to maximum allowable rate 3 L/ft2/day) from office and graduate housing (daily employee load of ~50 people) of University of Florida's Gulf Coast Research and Education Center. During 20-month period (May 2012 to December 2013), soil-water samples were collected from the vadose zone using suction cup lysimeters installed at 0.30, 0.60, and 1.05 m depth and groundwater samples were collected from piezometers installed at 3 to 3.30 m depth below the drainfield. A complimentary one-year study using smaller drainfields (0.5 m long, 0.9 m wide, 0.9 m high) was conducted to obtain better insights and compute mass balance of water, N, P, and organic contaminants. A variety of instruments (including multi-probe sensors, suction cup lysimeters, piezometers, tensiometers) were installed in in-situ drainfields. Our results show that microbial-mediated N transformations such as nitrification and denitrification controlled N evolution in the vadose zone and subsequent movement of N to groundwater. While hydrologic controls (primarily rainfall during wet season: June to September) facilitated rapid transport of N in the soil profile and diluted different N species breakthrough in groundwater. Mean concentration of total P in STE was 12.7±5.6 mg/L, of which 77% of P was present as orthophosphate–P (PO4–P), with remainder as other P (particulate inorganic and organic forms). Most of the STE applied PO4–P was quickly attenuated in the drainfield due to fixation. For example, mean PO4–P concentrations at 1.05-m below drainfields of drip dispersal and gravel trench were <0.10 mg/L, which further reduced as STE percolated in the soil profile, resulting in <0.05 mg/L mean PO4–P in groundwater. Concentrations of four pharmaceuticals (sulfamethoxazole, carbamazepine, acetaminophen, and ibuprofen) and three hormones (estrone, 17β-estradiol, and ethinyl estradiol) below vadose zone were 7 to 14% of total applied acetaminophen, sulfamethoxale, and estrone. Our mass balance calculations show that all of caffeine, carbamazepine, and ibuprofen were either accumulated and/or bio-transformed in the vadose zone. We recovered 47% of applied water from STE and rainfall at 60-cm below drainfield, thus, implying that chemical constituents present in STE, if not attenuated in the vadose zone of septic systems, can potentially move to shallow groundwater and eventually end up in surface waters.

Irrigation Accelerates Nitrate Transport within the Growing Season

Alexander Soroka, U.S. Geological Survey

Coauthor: Judy Denver

Recent studies of nitrate transport in soil water beneath irrigated and non-irrigated cornfields indicate leaching losses are greater during the growing season than at other times of the year in the Delaware and Maryland Coastal Plain. Although in-season transport occurred under both fields, increased soil moisture from irrigation allowed for more frequent recharge events within the growing season due to periodic intense precipitation. Concentrations of nitrate below land surface reached 200 mg/L as N at 1 ft, and over 50 mg/L as N at 3 ft. Highest soil water nitrate concentrations were observed shortly after side dress fertilizer application in mid-June. Leaching of nitrate beyond the root zone occurred, while the estimated nitrogen use efficiency was greater than 50 percent (N uptake/N applied) in high-yielding corn (~250 bushels per acre). Leaching concentration and frequency was related to antecedent moisture conditions, which were affected by irrigation and soil properties at sampling locations. Results suggest that irrigation can increase N uptake efficiency in corn crops while simultaneously increasing nitrate transport past the root zone.

Effects of temperature on graphene oxide fate and transport in porous media

Bin Gao, University of Florida

Coauthor: Mei Wang (University of Florida)

Knowledge of the fate and transport of graphene oxide (GO) nanosheets in porous media is essential to understand their environmental risks. In this work, laboratory stability, batch sorption, and sand column experiments were conducted to examine the effects of temperature on the fate and transport of GO in porous media under various conditions. Temperature showed strong effects on GO stability in aqueous solutions under all tested conditions. Although results from batch sorption experiment showed that temperature affected the sorption of GO onto the sand grains at the low IS, the interactions between GO and the sand were relatively weak, which did make the temperature effect prominent. Under high IS conditions, temperature also showed notable effects on GO retention and transport in porous media. For all the combinations of experimental conditions, the higher the temperature was, the less mobile GO particles were. The effects of temperature on GO retention and transport in porous media were further verified though simulations from an advection–dispersion-reaction model.

Real time improvement of remediation strategies in deep vadose zone: Implications from direct observations during bioremediation treatment

Ofer Dahan, Ben Gurion University of the Negev

Coauthors: Idan Katz, Eyal Moshkowitz, Lior Avishai, Ilil Levakov and Zeev Ronen

An in situ bioremediation experiment of a deep vadose zone (~40 m) contaminated with a high concentration of perchlorate (>25,000 mg L-1) was conducted through a full-scale field operation. Favorable environmental conditions for microbiological reduction of perchlorate were sought by infiltrating an electron donor-enriched water solution using drip irrigation underlying an airtight sealing liner. A vadose-zone monitoring system (VMS) was used for real-time tracking of the percolation process, the penetration depth of dissolved organic carbon (DOC), and the variation in perchlorate concentration across the entire soil depth. The experimental conditions for each infiltration event were adjusted according to insight gained from data obtained by the VMS in previous stages. Continuous monitoring of the vadose zone indicated that in the top 13 m of the cross section, perchlorate concentration is dramatically reduced from thousands of milligrams per liter to near-detection limits with a concurrent increase in chloride concentration. Nevertheless, in the deeper parts of the vadose zone (<17 m), perchlorate concentration increased, suggesting its mobilization down through the cross section. Breakthrough of DOC and bromide at different depths across the unsaturated zone showed limited migration capacity of biologically consumable carbon and energy sources due to their enhanced biodegradation in the upper soil layers. Nevertheless, the increased DOC concentration with concurrent reduction in perchlorate and increase in the chloride-to-perchlorate ratio in the top 13 m indicate partial degradation of perchlorate in this zone. There was no evidence of improved degradation conditions in the deeper parts where the initial concentrations of perchlorate were significantly higher.

Determination of water flux in sandy soils of Florida potato production

Andre Luiz Biscaia Ribeiro da Silva, University of Florida

Coauthors: Heraldo Takao Hashiguti, Lincoln Zotarelli, Michael D. Dukes, Shinsuke Agehara, and Senthold Asseng

Shallow water table and low soil water holding capacity of northeast Florida sandy soils create challenges for growers to properly control the soil moisture at crop root zone. Recently, agricultural areas have been converted from seepage to tile drainage, subsurface drip or sprinkler irrigation to improve irrigation water conservation and ease management. The objective of this study was to evaluate soil water dynamics under seepage, tile drainage, subsurface drip and sprinkler irrigation and to optimize the soil water availability for potato crop. Potato was grown under different irrigation systems (IS) at the UF - Hastings Research and Extension Center during spring of 2015 and 2016. Hydrostatic soil conditions for each IS were identified and van Genuchten parameters determined to calculate the unsaturated water flux using Darcy's law for periods between rainfall events. Water table level and soil moisture at 15, 30, 45 and 60 cm depth were monitored every 15 min. Soil moisture and water flux were directly affected by the water table level. The average water table level were 52, 51, 56 and 55 cm below soil surface for tile, subsurface drip, seepage and sprinkler, respectively. When drained to equilibrium condition was establish for each IS, the water flux via capillarity to potato root zone had an average of 0.21, 0.27, 0.69 and 0.23 cm.hr-1 for tile, subsurface drip, seepage and sprinkler irrigation, respectively. Under the sprinkler irrigation, water application events supplied the water demand during the season, however, water flux through capillarity also contributed to soil water availability. Water table management IS had water flux as the main water source supplying the crop evapotranspiration, which average was 3.8 mm.d-1 during tuber bulking stage. Water table level rise similarly in response to rainfall in all IS. A rain accumulation of 23 mm increased the water table up to 35 cm, the tile drainage returned the water table to the original level within 24 h, which was three times faster than seepage, which had the slowest drainage. The alternative IS presented capacity to improve the soil water availability to meet potato evapotranspiration.

Effects of capillarity and microtopography on wetland specific yield

David M. Sumner, USGS Caribbean-Florida Water Science Center

Hydrologic models aid in describing water flows and levels in wetlands. Frequently, these models use a specific yield conceptualization to relate water flows to water level changes. Traditionally, a simple conceptualization of specific yield is used, composed of two constant values for above- and below-surface water levels and neglecting the effects of soil capillarity and land surface microtopography. The effects of capiltarity and microtopography on specific yield were evaluated at three wetland sites in the Florida Everglades. The effect of capillarity on specific yield was incorporated based on the fillable pore space within a soil moisture profile at hydrostatic equilibrium with the water table. The effect of microtopography was based on areal averaging of topographically varying values of specific yield. The results indicate that a more physically-based conceptualization of specific yield incorporating capillary and microtopographic considerations can be substantially different from the traditional two-part conceptualization, and from simpler conceptualizations incorporating only capillarity or only microtopography. For the sites considered, traditional estimates of specific yield could under- or overestimate the more physically based estimates by a factor of two or more. The results suggest that consideration of both capillarity and microtopography is important to the formulation of specific yield in physically based hydrologic models of wetlands.

Recognizing preferential flow in time-series measurements of soil water content

John R. Nimmo, USGS, Menlo Park, CA

Coauthors: Kim S. Perkins and Leia Gaten-Slahor

Preferential flow occurs episodically, occupies a small fraction of the unsaturated medium, and typically progresses faster than flow through the rest of the medium. It has great hydrologic importance, for example in controlling aquifer recharge and contaminant transport. Because of its confinement in space and time, preferential flow is difficult to detect. One method is to infer its occurrence from time series of soil water content, $\theta(t)$, a relatively easy measurement. A point sensor (not positioned in a preferential path) can detect such flow when water is absorbed out of the preferential path and into the soil matrix at the sensor's location. Carefully formulated criteria are necessary to recognize preferential flow in $\theta(t)$ data. One such criterion is nonsequential response of sensors at multiple depths, directly indicating a preferential bypass. This requirement is very restrictive, however, and underrepresents the incidence of preferential flow by missing its occurrence when it does not happen to bypass a sensor. Another indicator, potentially more inclusive, is travel at a speed impossibly fast by diffuse flow. There are few guidelines, however, for specifying the speed threshold that distinguishes diffuse from preferential flow. We have investigated this problem using $\theta(t)$ at three depths on a hillslope in Marin County, CA, along with fluctuation data from a shallow perched water table. Establishment of a velocity criterion, using experience from working with this data set, provides a means of recognizing preferential flow with less underreporting bias than other methods.

Flow Phenomena and Transport of Protozoan Pathogens and Radionuclides in the Vadose Zone: Effects of Soil Heterogeneity and Time-Variable Hydrologic Systems

Christophe Darnault, Department of Environmental Engineering and Earth Sciences, Clemson University

Understanding the behavior of contaminants in the vadose zone, the area between the soil surface and the groundwater table, is critical for the protection of the environment and public health, the mitigation of their impacts, and the development of effective remediation procedures. The prevalence of microbial pathogens due to wildlife and agricultural activities in rural and agricultural watersheds, and the discharge of radionuclide wastes during storage, handling, and disposal of nuclear materials in groundwater systems are inevitable. To study the fate and transport of these contaminants in the vadose zone, we have investigated their mobility under different hydrodynamic and biogeochemical conditions found in the natural environment. We have demonstrated the critical role that preferential flow (macropore flow and fingered flow), transient in water content and velocity, transient in solution chemistry, gas-water interfaces, solid interfaces, system heterogeneities, and their interactions and feedback have in the transport and retention of contaminants in the vadose zone. To elucidate the individual contribution of the mechanisms and environmental parameters affecting the transport and retention of these contaminants, as well as to quantify and visualize them, we have developed monitoring methods and tools using physical, chemical, microbiological, molecular, and non-intrusive technologies. The results of our research will contribute to the development and validation of fate and transport models of contaminants from pore scale to watershed scale for management and protection of groundwater resources, public health, ecosystem sustainability, risk assessment, and life-cycle analysis.

Actual rain sensor dry-out times compared to estimated soil dry-out times

Bernardo Cardenas, ABE Dept., University of Florida

Coauthors: Michael Dukes

Water scarcity is a global concern and is an intensifying problem in our own backyard, literally. An increasing number of municipalities throughout the country have mandates and/or cost-savings programs for the use of different devices that would help to irrigate landscapes more efficiently. One of the most popular devices for these effects are the so-called rain sensors (RSs), because they appear to be a useful tool for water conservation at a relatively low cost, easy installation, and low maintenance. Several types and models, which differ in method of operation, are commercially available. The most common RS models use hygroscopic disks that absorb water and expand proportionally to rainfall amount. As the moisture-laden disks expand, they activate a switch that interrupts the programmed irrigation cycle. The switch remains open as long as the disks are swollen. When the rain has passed, the disks begin to dry out and the switch closes again. A couple of studies have reported the dry-out time of some RS models provided with expanding disks. However, no actual RS dry-out times have been compared to soil dry-out times. Existing RS dry-out data from previous studies will be assembled along with hourly weather data to calculate hourly reference evapotranspiration (ETo). The ETo calculations will be used to estimate turfgrass evapotranspiration (ETc) using local turfgrass crop coefficients. Precipitation data will be used with ETc to simulate soil dry-out (using WAVE 3.0 software), based on three soil types: sand, loam, and clay loam. Finally, estimated soil dry-out times will be compared against actual RS dry-out data.

Estimating Episodic Recharge Based on Water Table Fluctuations

Kim S. Perkins, U.S. Geological Survey

Coauthors: John R. Nimmo (U.S. Geological Survey)

We present a method to identify and quantify episodic recharge by a consistent, systematic procedure. Our algorithm partitions a time series of water levels into discrete recharge episodes and intervals of no episodic recharge. It correlates each recharge episode with a specific interval of rainfall, so storm characteristics such as intensity and duration can be associated with the amount of recharge that results. Application to a particular site requires certain quantitative characteristics to be established using hydrologic judgment. These include the lag time between the start of rainfall and first water table rise, data noise tolerance, and water level recession characteristics. Because these values are determined once for a given site and are held constant through the whole data set, they do not contribute subjective influences affecting episode-to-episode comparisons. If applied to a period of data long enough to include recharge episodes with broadly diverse characteristics, the method has value for predicting how climatic alterations in the distribution of storm intensities and seasonal duration may affect recharge.

Continuous soil moisture monitoring to quantify the impacts of forest management on regional water yield

David Kaplan, University of Florida

Coauthors: Subodh Acharya (University of Florida), Daniel McLaughlin (Virginia Tech), and Matthew Cohen (University of Florida)

Managing forest lands for increased water yield is a potentially significant tool for regional water resource planning, but little is known about the impacts of forest management activities on long-term regional water yield. This project investigates water use at six sites across Florida that span gradients in geological setting, forest condition, and soils. At each site, six plots were developed to quantify water use (evapotranspiration, ET) between different forest management conditions, from clearcuts to mature intensive pine plantations and including sites typical of forest restoration activities. At each plot (n=36), water use and yield was estimated using a soil moisture water balance calculated from three banks of soil moisture sensors extending from the surface to >2 m (total of >600 sensors). Results from 2015 and 2016 show that leaf area index (LAI) predicts 52% of the variation in estimated ET relative to potential ET (PET). Residual variation was strongly predicted by groundcover. Taken together, these two metrics of vegetation structure explain 74% of the variation in estimated ET. Inclusion of other variables (density, height, basal area, species composition) may improve this association. These initial results support our working hypothesis, namely that forest management impacts water yield in predictable ways. While the impacts of stand management (including fire, thinning, fertilization, and herbicide application) have not yet been analyzed, these treatments have been occurring, and with ongoing data collection and analysis, we aim to resolve water yield variation between stands undergoing various forest and understory management.

Estimate 120 years vadose zone water dynamic, crop irrigation demand, and groundwater conservation on an agricultural land in Mississippi

Ying Ouyang, USDA Forest Service

Coauthors: Gary Feng

Mississippi is a major state for crop production in Southeast United States. Soybeans, corn and cotton are three major crop species, which have greater demand and higher commodity price and account for 65% of total crop lands in the state. The desire by farmers to enhance crop yields through irrigation has led to 92% increase in irrigated crop land from 1998 to 2008 and resulted in an overdraft of groundwater resources in many regions of Mississippi. Since 1970, groundwater level has declined more than 21ft in Mississippi Delta due to primarily agricultural pumping for crop irrigation. In this study, a STELLA (Structural Thinking, Experiential Learning Laboratory with Animation) based-model was applied to estimate vadose zone water dynamic, irrigation demand, and farm pond water availability in a crop land growing with soybeans, corn, and cotton from 1895 to 2014 in Mississippi. The irrigation decision was made by the model as the root zone water content was less than or equal to the management allowable depletion (MAD) root zone soil water content. Simulation results showed that there were 104 times for corn, 62 times for cotton, and 111 times for soybeans when the vadose zone water content was equal to or below MAD during the growing season over the entire 120-year simulation period. Rainwater had a decisive impact on crop irrigation demand and its availability for crops was normally mismatched with growing seasons. In general, corn used more soil water for growth than soybeans, whereas soybeans needed more irrigation water than corn. There were several times when no pond water was available for crop irrigation under dry climate over the 120-year simulation period. Overall, using on-farm storage pond for crop irrigation was a promised means for groundwater resources conservation in this region.

Water use by pine forests of Florida: estimating interception loss from near-surface soil moisture data

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Continuously monitored vadose-zone soil moisture data can be used to obtain reliable estimates of vegetation evapotranspiration from forests. However, a more detailed representation of the water budget that accounts for interception losses is required for understanding the water yield potentials. In this study, we use continuously monitored, near-surface soil moisture data to estimate rainfall interception by different pine forest of Florida. By estimating interception as the amount of rainfall required to induce a change in near-surface soil moisture above a threshold value, a functional relationship between rainfall and interception is developed. The relationship enables to obtain improved estimates of annual water yield from forests under different management systems.

Assessing the effects of canal operations and boundary conditions on groundwater flow and flooding risk in an agriculture area in South Florida

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Coauthors: W. Kati Migliaccio and Young Gu Her (Agricultural and Biological Engineering, University of Florida)

In south Florida, the C-111 project was originally constructed in the 1960s to provide flood protection and drainage for agricultural areas along the east side of Everglades National Park (ENP). However, modification of groundwater flows and storage has resulted in loss of ecosystem functions in the ENP. We investigated spatial differences in groundwater stage associated with varying rainfall, canal water stage and boundary conditions within the study area. We applied hydrologic models to improve our understanding of the drainage characteristics of the system and quantify the effects of canal management practices and different boundary conditions to predict groundwater storage and movement. MODFLOW-NWT was used to simulate the Biscayne aquifer flow system in the study area. Canals were simulated with the Surface Water Routing (SWR) package. Simulation results indicated that the developed model was able to reproduce measured groundwater levels in observation wells and flow rates in canals quite well. Scenarios were explored to investigate the effects of different rainfall patterns, canal stages and boundary conditions on water table response in agricultural area. Simulation results indicated that rainfall was predicted as the primary factor controlling the groundwater stages, while canal stages and boundary conditions were predicted to contribute to drainage processes of the Biscayne aquifer. This study highlighted the benefit of an integrated hydrological model to water resources management in South Florida, which is characterized by extensive canal systems.

Modeling Landscape-scale Spatiotemporal Dynamics of Water Storage in the Critical Zone:

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Landscape-scale spatial-temporal dynamics of water storage were explored using spatially explicit (4 X 4 km grids) numerical simulation model (NASA LIS) over the Midwest US region (~2 million km2). Hydro-climatic forcing (precipitation and potential evapotranspiration) was derived based on down-scaled, coarse-resolution reanalysis products (NARR, MERRA, NLDAS-2) and in-situ hydro-meteorological observations at ten locations across the study domain. Monitoring data for soil-water storage, based on long-term in situ observations (Ameriflux and SCAN networks) from ten locations within the study domain were also analyzed. LIS model outputs were generated for both stationary and nonstationary forcing over 2 to 3 decades. Over the past three decades across the Midwest US region, changes in total mean daily rainfall (P) are explained by changes in rainfall depths, but with stable rainfall frequency. These patterns and changes in PET, in turn, are manifested in time-series of soil-water storage across the region. In accord with previous smaller-scale studies, analyses of LIS simulations show that the Midwest US region is essentially hydrologically homogeneous, despite variations in soil taxonomy and land-use and land-cover. Thus, spatial-temporal variability in hydro-climatic forcing serves as the first-order control on soil-water storage dynamics. Vegetation, non-stationary hydro-climatic forcing (seasonality), and soil texture serve as second-order modifying factors to spatial and temporal patterns. Comparison of analytical and empirical pdfs [based on site specific monitoring data and LIS simulations] for soil-water storage revealed variable agreement, depending upon: (1) factors controlling modulation of the impacts of seasonal hydro-climatic forcing (e.g., root-zone depth); (2) differences in spatial scales (e.g., site-specific, point data vs grid-scale averages; and (3) differences in conceptual representations of key processes in the models (e.g., simplified vs complex representations, with number of parameters required as one indicator). Advantages and limitations data-model fusion approaches to forecasting impacts of climate change (e.g., droughts; crop yield loss; loss of ecosystem services; etc.) are briefly discussed.

Statistically based morphodynamic modeling of bedload transport

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It is necessary to understand the morphodynamic evolution of an erodible bed because of its application in a wide range of natural and environmental systems. There are two different approaches to this end: one is classical district approach which divides the bed deposit to two different layers the particles in the topmost layer which is called active layer have a finite probability for getting entrained in the bedload and all particles in the layer below active layer which is substrate has zero probability to get interact with sediment transport. There are some limitations in this approach. For example the particles in active layer are the only particles which are involved in sediment transport and the statistic nature of entrainment and deposition of particles has been neglected. To overcome these kinds of limitations the new probabilistic approach has been introduced that we are considering in this research which is based on this fact that all particles in a bed deposit are able to be entrained into bedlod. Our aim in this research is to develop a numerical model for probabilistic sediment mass conservation equations and validate our results with experimental data that are available from Wong and parker experiments in university of Minnesota. We have applied this model for a lower regime plane bed with quasi-normal approximation. For the model validation with experimental data for tracer dispersal we have implemented the elevation specific equation of conservation of tracer stones in uniform sediment.

Representing Rainfall-Runoff Response, Surface Soil Moisture Content, and Farm Soil Moisture Management in Basin to Regional Scale MODFLOW Models.

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The surface soil-zone moisture distribution controls the partitioning of precipitation into infiltration and runoff, influencing the spatiotemporal distribution of both groundwater recharge and groundwater evapotranspiration. In water budgets, both groundwater recharge and evapotranspiration components are highly uncertain. Better constrained estimates of these components are critical for evaluating groundwater sustainability and adaptation scenarios for climate variability. In addition, representing effects of land management behavior on surface soil moisture content can improve crop demand estimates in integrated hydrologic models. A new MODFLOW soil-zone package has been developed for the MODFLOW-2005 framework. This package simulates the partitioning of precipitation into runoff and infiltration, routes surface runoff using a cascading flow procedure, and estimates spatiotemporally distributed surface water content. This package uses an analytical approximation of Richards' equation that is numerically efficient and suitable for the large spatial discretization employed in basin to regional scale hydrologic decision models. The soil-zone package approximated the multi-storm infiltration and surface water content predicted by Richards' equation for several soil types and storm frequencies (<10% difference), and had good correspondence with other runoff models for the v-catchment problem. Current applications of the soil-zone package include a basin scale simulation and development of a new conceptual model for MODFLOW-OWHM. Future development efforts may include implementation in other models based upon the MODFLOW-2005 framework such as GSFLOW.

Simulation of Potential Groundwater Recharge for the Glacial Aquifer System East of the Rocky Mountains, 1980-2011, using the Soil Water Balance Model

Jared Trost, U.S. Geological Survey

Coauthors: Jason Roth and Stephen Westenbroek (U.S. Geological Survey)

The Soil Water Balance (SWB) model was used to estimate annual potential groundwater recharge values for calendar years 1980-2011 on a 1-km grid for the glacial aquifer system east of the continental divide. The SWB model computed potential groundwater recharge on a daily basis as precipitation in excess of interception, runoff, evapotranspiration, and soil water storage capacity. Model data inputs were publicly available and included: daily precipitation, minimum temperature, and maximum temperature (Daymet), land-cover classification (2001, 2006, and 2011 National Land Cover Database), and soil hydrology (derived from Natural Resources Conservation Service STATSGO database).

The SWB model uses parameters grouped by land cover class and/or soil type in a lookup table for calculating the various water balance components. Parameter values for interception, runoff curve numbers, maximum recharge rates, and root zone depths in the lookup table were calibrated through an automated process. The calibration targets were stream baseflows, calculated by the HYSEP local minimum method, in 39 watersheds throughout the model domain that exhibited hydrologic conditions appropriate for base-flow separation. The calibration basins were minimally disturbed 'reference' watersheds with high-quality, long-term continuous streamflow records selected from the GAGES II dataset. Thirty-four of the basins had at least 30 years of record and were included in the 2009 Hydroclimatic Data Network (HCDN). Three baseflow data aggregations for each basin were used in the calibration process: annual total baseflow for each year of complete flow data, annual total baseflow duration deciles, and mean of all annual total baseflows during the period 1980-2011. The model was validated against 40 basins that met the criteria for being a calibration basin, but were not used for calibration. The calibrated model reproduced the mean annual baseflow calibration targets well; the Nash-Sutcliffe efficiency coefficient (NSE) was 0.89 and the root mean squared error (RMSE) was 1.65 inches. The calibrated model also performed reasonably well for the mean annual baseflows in the validation basins (NSE of 0.82 and RMSE of 2.78 inches).

The 1988 to 1989 drought was the period of lowest potential recharge across the glacial aquifer system. Mean recharge across the system increased from about 4 inches per year in 2001 to about 8 inches per year in 2011. Approximately 45 percent of the recharge in the model domain occurred in forested areas, even though forests covered only about 25 percent of the model domain. About 30 percent of the recharge occurred in agricultural areas, which covered 48 percent of the model domain.

Filtering of cyclical surface forcings in the vadose zone

Jesse Dickinson, U.S. Geological Survey

Coauthors: Ty P.A. Ferré

Infiltration and downward percolation of water in the vadose zone are important processes that may limit availability of water resources in many areas around the world. However, estimates of these fluxes are often uncertain. Climate projections can include changes in both the timing and magnitude of rainfall, which increases the importance of understanding how the vadose zone filters these infiltration signals to better predict the impacts of climate change on groundwater resources. We use a combination of numerical and analytical modeling of unsaturated-zone flow to develop a simplified framework for understanding of how any climatic cycle can be filtered in groundwater systems. Our approach uses analytical solutions based on linear approximations of the Richards equation, and assumes that the effects of time-varying soil water properties are negligible. We evaluate the limit of the approximations by comparing results from the unsaturated flow numerical model HYDRUS-1D, which uses the full Richards equation. Using the analytical solution, we investigate the filtering properties of the vadose zone in Central Valley, California, and describe how variations in unsaturated flow from surface forcings are filtered prior to recharging the water table. Our approach to investigate the possible impact of climate forcings provides an alternative to computationally-expensive numerical models that solve the Richards equation to simulate vadose zone flow.

Poster 1: Vadose Zone Gas Transport Measurement

Michael D. Annable, Department on Environmental Engineering Sciences, Universtiy of Florida

Coauthors: Ryan Messer, Michael D. Annable, Jaehyun Cho

Movement of vapor in the vadose zone, and immediately above the capillary fringe, are needed to assess the transport and risk associated with subsurface contaminants. Movement and flux of carbon dioxide and methane are important metrics linking the importance of the vadose zone in greenhouse gas mass balances. The release of methane, both natural and due to unconventional oil and gas production, must be quantified to rigorously determine mass source and mass discharge relationships. These challenges point to the need for cost effective techniques for quantifying gaseous fluxes in the vadose zone. A technique developed for measuring groundwater flow and contaminant mass flux in porous media, the Passive Flux Meter (PFM), has potential to quantify vapor phase contaminant mass flux just above the capillary fringe and throughout the vadose zone. The modified method can be configured to assess both horizontal and vertical transport of gases and vapor phase contaminants. Laboratory bench scale experiments were conducted to assess the PFM method potential for quantifying vapor on constituent flux. A sorbent with a suite of volatile alcohol tracers was identified and eluted in column experiments characterize the vapor phase tracer loss rate. Field deployments suing the same tracer quite immediately above the capillary fringe at a DNAPL contaminated site indicated high contaminant mass flux suggesting and important exposure pathway for contaminant migration.

Poster 2: Laboratory Assessment of Hydraulic Properties of Heterogeneous Organic Soils in the Everglades

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Numerical simulations of soil processes use hydraulic parameters to define saturated and unsaturated flow distribution in a soil matrix. These parameters are better defined for mineral soils than for organic soils like peat. Furthermore, very little is known about the hydraulic properties of heterogeneous peat soils with organic matter at different degrees of decomposition and mixed soils of marl and peat commonly found in the Everglades. This research characterized the hydraulic properties of soils (primarily marl and peat soils) sampled from freshwater marshes and sloughs in the Everglades. Laboratory tests were used to determine the hydraulic parameters of soils, and quantify the influence of organic content (OC), and fiber content (FC) on saturated hydraulic conductivity and water retention curves. The results from this study showed that complex hydraulic behavior of heterogeneous organic soils could be predicted by fundamental soil physical properties like OC and FC. For peat soils, an increasing second-order polynomial relationship with OC explained 79% of variation in hydraulic conductivity. Marl soils had lower hydraulic conductivity than peat, however, mixed marl-peat soils had higher hydraulic conductivity than pure marl or pure peat soils, which may be explained by changes in pore-size distribution. For peat soils, an increasing linear relationship with FC explained 57% of variation in hydraulic conductivity. Additional sampling and testing are needed to further confirm the extent of the effect of degree of decomposition and degree of mixing marl and peat on the trends herein identified.

Poster 3: Impact of Surfactant on the Fate and Transport of Toxoplasma gondii Oocysts in Soils

Erin Kinsey (presented by Christophe Darnault), Department of Environmental Engineering and Earth Sciences, Clemson University

Coauthors: Erin N. Kinsey, Caroline Korte, Coralie L'Ollivier, Jitender P. Dubey, Aurélien Dumetre, Christophe J. G. Darnault

Toxoplasma gondii exists in nearly the entire world due to its numerous hosts and the prevalence of its definitive host, felids. It is one of the most prevalent parasites affecting warm-blooded animals. In humans, it may cause damage to the brain, eyes and other organs in fetuses and pose a threat to immunocompromised populations. T.gondii is transferred via the fecal-oral route or through the consumption of cysts in infected and undercooked meats. T. gondii has been detected in soil, open water and animal feed in agricultural settings and elsewhere, in addition to muscle tissue and feces of infected animals. Surfactants may be introduced to agricultural fields through the application of pesticides that include them, reused water or sludge and environmental remediation. Surfactants may influence soil hydrology properties and water flow thereby impacting pathogens conveyed in soil water. The goal of this study is to determine the impact of surfactants on the transport of T. gondii oocysts through natural soils. Because of the prevalence of both surfactant and T. gondii globally as well as the health risks presented by this pathogen, it is necessary to understand its fate and transport in the unstaturated zone. Vertical, gravity-driven flow of an artificial rain solution was allowed through soil columns that were packed in such a way to limit preferential flow. The rainfall solution used included KCl as a background electrolyte with Aerosol 22 surfactant in half of the column's rainfall. After flow through the columns reached steady state, a pulse containing about 2.5 million T. gondii oocycsts and KBr as a conservative tracer was added. Leachate samples were collected from the bottom of each column while artificial rain was applied. Following the cessation of the rainfall, the columns were sliced into 1 to 2 cm sections and samples were taken to characterize the retention of T. gondii within the columns. T. gondii in both the leachate samples and soil samples was quantified using qPCR.

Poster 4: Imidacloprid Fate and Transport in Unsaturated Citrus Root Zone in a SW Florida Flatwoods Spodosol

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Coauthors: Peter Nkedi-Kizza, Kelly T. Morgan, and Jawwad Qureshi

Imidacloprid (IM) is a neonicotinoid insecticide commonly soil-drenched in Florida to systemically control the Asian citrus psyllid (ACP). This study was established to monitor IM transport at surface and subsurface soil layers in Immokalee fine sand, which is a common Spodosol in SW Florida flatwoods. These soils formed in landscapes where the water table is shallow and prone to fertilizer and pesticide leaching under agricultural use. The experimental plots were located at the Southwest Florida Research and Education Center (Immokalee, Florida) and consisted of young citrus trees under micro-sprinkler

irrigation. IM was soil-drenched to study transport through surface and subsurface soil layers, and Br- was simultaneously applied as tracer for water movement. The study compared concentration profiles that included the citrus-root zone (CRZ) with soils of similar properties and no citrus roots (non-CRZ). Bucket augers were used to periodically sample five depths (0-15, 15-30, 30-45, 45-60, 60-75 cm) during four to eight weeks after IM soil-drench applications. Field experiments were replicated during four seasons (summer 2011 & 2012, spring 2012 & 2013).

The tracer showed mass recoveries >90% during the first few days of sampling, which was an evidence of little lateral dispersion at the scale of observation (<1 m). The tracer was lost to leaching one-to-two weeks after application. Overall, the mass recoveries for IM at the deeper sampling layers (45-75 cm) was higher in the non-CRZ than the CRZ, a difference that was attributed to plant uptake, and was confirmed by the decrease in ACP populations. In general, water (and IM) uptake was also evident by lower soil moisture content in the CRZ. IM lower mass recoveries in layers below the CRZ was an evidence of lower potential for leaching regardless of the initial IM application rates. The water and IMD uptake by the citrus roots in this worst-case scenario (sandy soils, low in soil organic matter content, and point-source applications) reduced leaching potential to shallow groundwater. Moreover, we concluded that water flow and solute leaching were considerably reduced because of the predominant unsaturated conditions that reduced soil hydraulic conductivity (K) and increased the IM retardation factor, when the soil volumetric moisture content (θv) was below or close to field capacity ($\theta v \approx 0.08$).

Poster 5: Dynamics of Fluid Interfaces and Non-equilibrium and Preferential Flow in the Vadose Zone: Impact of Microbial Exudates

Biting Li (presented by Christophe Darnault), Department of Environmental Engineering and Earth Sciences, Clemson University

Coauthors: Biting Li, Ashley Pales, Heather Clifford, Shyla Kupis, Wei-Zhen Liang, Sarah Henessey, Stephen Moysey, Brian Powell, Kevin T. Finneran, and Christophe J. G. Darnault

In the hydrological cycle, infiltration process plays a crucial role to distribute water into soil and provides numerous lives with possibility. As one of the major flow patterns, preferential or fingering flow is mostly formed and studied in heterogeneous media, which interacts with microbial and plant activity. Many papers have studied the relationship between plant root exudates and water transport in soil, however only a few cases of microbial exudates were studied. The main objectives of this poster were to investigate the influence of artificial microbial exudates -catechol and riboflavin - on preferential flow process, and to specifically show how concentration difference acting on them. The experiments were conducted in a two-dimensional initially dry tank that was filled with quartz sand. Contact angle and surface tension were measured to obtain the interfacial forces. The light transmission method (LTM) was used to capture light intensity, which was then converted into percentage of soil water saturation profiles both vertically and horizontally. The experimental results showed that the microbial exudate addition had an impact on infiltration process by deferring from the control NaCl solution, which was possibly due to a better water holding capacity. Moreover, a higher wettability and less capillarity was found in catechol solution when its concentration increased. Dissimilarly, the wettability of medium for riboflavin solution decreased as its concentration increased, but did not change much for other flow characteristics. The findings from analyzing water profiles and comparing interfacial parameters not only could fill the gap of study on microbial exudates interacting with preferential flow pattern, but also might reveal the importance of infiltration process on microbial activity.

Poster 6: Influence of Preferential Flow on Coupled Colloid, Nitrogen, And Phosphorus Transport Through Riparian Buffers

Rafael Muñoz-Carpena, University of Florida

Coauthors: Bin Gao (University of Florida) and Garey Fox (North Carolina State University)

The design of water quality conservation practices such as vegetative filter strips and riparian buffers typically focuses on surface runoff with subsurface nutrient transport usually assumed to be negligible. However, subsurface transport can become significant with preferential leaching and can negate the intended benefits of widely adopted control practices like riparian buffers. To limit degradation of ecosystem services and improve resource use efficiency, foundational research is needed on surface/subsurface transport mechanisms and techniques to simulate these pathways. Through both theoretical development and application-based research, we hypothesize that (i) if macropores are prevalent in riparian areas, then nutrients will rapidly leach through the surface to subsurface pathways, be rapidly transported to streams, and limit the effectiveness of conservation practices; and (ii) if mechanistic processes of preferential leaching and subsurface transport are incorporated into decision-support tools, then prediction of the performance of conservation practices such as riparian buffers will be improved. A new project is presented describing simultaneous injection experiments using tracers, colloids, nitrate, and phosphorus that will be performed in laboratory tests and at six field riparian sites to identify surface and subsurface transport mechanisms through state-of- the-art monitoring techniques. Experimental data will test and refine decision-support tools for riparian buffers through the use of an innovative model (VFSmod) and new theories (source- responsive model) on the effect of macropores and preferential pathways. This research will have wide reaching implications; the effectiveness of conservative practices will be better understood and more appropriately implemented, ensuring that funds utilized to prevent nutrient transport are successful in providing long-term agricultural sustainability.

Poster 7: Impact of Plant Exudates and Soil Constituents on Flow Processes in the Vadose Zone: Imaging and Measurements in a 2D System

Ashley Pales (presented by Christophe Darnault), Department of Environmental Engineering and Earth Sciences, Clemson University

Coauthors: Ashley Pales, B. Li, H. Clifford, N. Edayilam, D. Montgomery, T. DeVol, B. Erdmann, M. Dogan, N. Tharayil, N. Martinez, S. Moysey, B. Powell, and C.J.G. Darnault

The vadose zone is a highly interactive heterogeneous system where flow through the subsurface can be stable or unstable, depending on the system properties. This work looks into the effects of simulated plant root exudates on unsaturated flow in a homogenous porous media, as well as, the physical effects of the rhizosphere on vadose zone flow. A secondary objective of this work is to couple the use of light transmission method (LTM) with the capabilities of Matlab to quantify the saturation distribution within a 2D tank system with high spatial and temporal resolution. 2D transient tank studies dealing with simulated plant exudate solutions were conducted for three plant exudates, citrate, oxalate, and tannic acid, and a soil constituent, Suwannee River Natural Organic Matter. A 2D tank and rainfall simulator were used to induce an unstable flow regime, while a LED light and a camera captured the real-time images. The images were converted from red-green-blue into hue-saturation-intensity and analyzed in Matlab to obtain data about finger formation and saturation distribution. Fundamental measurements are used to characterize the solid-liquid and liquid-gas interfaces within the simulated solutions. The differences between the simulated plant exudates and the control solution (0.01M NaCl with hydroponic solution), are seen in the changes in idealistic finger formation and velocity of propagation illustrating that the plant exudates increased the wettability and mobility of the solutions during the infiltration process in unsaturated porous media.

Poster 8: Fundamental Investigation of Heterogeneity-Induced Multiphase CO2 Attenuation in Shallow Aquifers using Intermediate-Scale Laboratory Experimentation and Numerical Modelling

Michael Plampin, National Research Program, Eastern Branch, U.S. Geological Survey

Coauthors: Rajesh Pawar (Earth and Environmental Sciences Division (EES-16), Los Alamos National Laboratory, Illangasekare, Tissa) and Mark Porter (Department of Civil & Environmental Engineering, Colorado School of Mines)

To assess the risks involved with leakage of stored carbon dioxide (CO_2) from deep geologic formations into the shallow subsurface, it is crucial to understand how multiphase CO_2 plumes are likely to evolve within shallow aquifers. Intermediate-scale laboratory experiments are ideal for investigating multiphase evolution processes, because they allow for the collection of higher-resolution data under better-controlled conditions than are possible in the field. For this study, a large, effectively two-dimensional, tank was constructed, densely instrumented, and filled with sand and water to mimic a shallow aquifer with multiple geologic facies. Lateral water flow was induced, water containing dissolved CO_2 was injected, and the multiphase evolution of the CO_2 plume was monitored through time via saturation, electrical conductivity, and temperature measurements from automated sensors, dissolved CO_2 measurements from aqueous phase samples analysed with an ion chromatograph, as well as water and gas phase outflow measurements using computer-interfaced scales and flow meters, respectively. Two different sand combinations were used in separate experiments to assess the relative effects of different types of heterogeneities on the transport of CO_2 through the system. Experimental results were then compared to simulations performed with the Finite Element Heat and Mass Transfer (FEHM) multiphase flow simulation code. After minimal adjustments to the important parameters, the model was able to accurately capture some, but not all, of the CO_2 attenuation processes. This indicates that FEHM is potentially useful for predicting CO_2 migration through shallow aquifers, but that the assumptions upon which it operates may limit its application.

Poster 9: Effects of future climate and groundwater withdrawals on water availability in semi-arid India

Rajendra P Sishodia, Deaprtment of Agricultural and Biological Engineering, University of Florida

Coauthors: Sanjay Shukla

Combined effects of future climate and irrigation intensification on surface and groundwater systems are not well understood especially in data scare regions such as India. To improve the worsening water supply, efforts are needed to evaluate and quantify the performance of traditionally used and often recommended management strategies (e.g. dispersed water storage, drip irrigation and policy reforms) under growing societal water demands and changing climate. This study uses an integrated modeling approach (MIKE SHE/MIKE11) to evaluate the combined effects of future climate (2040-2069) and irrigation expansion on water levels and flows in an agricultural watershed in semi-arid south India. Increased future rainfall (7-43%, obtained from five Global Climate Models), combined with irrigation expansion was predicted to amplify groundwater recharge (15-67%), streamflow (9-155%), and hydrologic extremes such as well drying and floods; a 100-year flow event was predicted to occur every five years in the future. Projected future climate alone was shown to increase the water availability however, in combination with irrigation expansion and related increased withdrawals it resulted in earlier and more frequent well drying in the future. Storage of excess flows, reductions in pumping through power subsidy reforms, and conversion from flood to drip in 25% of the irrigated area can provide sufficient water for expanded irrigated areas in the future while also mitigating the human stress related to well drying as well as flooding. Reforms in agricultural subsidy policies involving reductions in power subsidy to fund economically desirable (high benefit-cost ratio) water storage and drip irrigation management may create a sustainable food-water-energy nexus in the semi-arid regions globally.

Poster 10: A Direct-Push Sample-Freezing Drive Shoe for Collecting Sediment Cores with Intact Pore Fluid, Microbial, and Sediment Distributions

Jared Trost, U.S. Geological Survey

Coauthors: Barbara Bekins (U.S. Geological Survey), Tom Christy (Geoprobe Systems)

Abiotic and biological reactions in shallow groundwater and bottom sediments are central to understanding groundwater contaminant attenuation and biogeochemical cycles. The laminar flow regime in unconsolidated surficial aquifers creates narrow reaction zones. Studying these reaction zones requires fine-scale sampling of water together with adjacent sediment in a manner that preserves in situ redox conditions. Collecting representative samples of these narrow zones with traditional subsurface sampling equipment is challenging. For example, use of a basket type core catcher for saturated, non-cohesive sediments results in loss of fluid and sediments during retrieval.

A sample-freezing drive shoe designed for a wire line piston core sampler allowed collection of cores with intact sediment, microbial, and pore fluid distributions and has been the basis for studies documenting centimeter-scale variations in aquifer microbial populations. However, this freezing drive shoe design is not compatible with modern-day direct push sampling rigs.

A re-designed sample-freezing drive shoe compatible with a direct-push dual-tube coring system was developed and field-tested. The freezing drive shoe retained sediments and fluid distributions in saturated sediment core samples by freezing a 10 centimeter plug below the core sample with liquid CO¬2. Core samples collected across the smear zone at a crude oil spill site near Bemidji, Minnesota,

were successfully extracted without loss of fluid or sediment. Multiple core sections in the aquifer were retrieved from a single hole. This new design makes an effective sampling technology available on modern-day direct push sampling equipment to inform myriad questions about subsurface biogeochemistry processes.

Poster 11: Relationship of salinity and nitrate concentrations measured by multisensor capacitance probes in the soil profile

Maria Zamora, Deaprtment of Agricultural and Biological Engineering, University of Florida

Coauthors: Michael Dukes (Agricultural and Biological Engineering, University of Florida)

Nitrogen (N) is a crucial element for crop production and it is highly used in agriculture lands. N applications that exceed crop absorption rates can result in potential losses through nitrate-N (NO3-N) leaching, causing health and environmental issues. Commercial multisensor capacitance probes measure volumetric water content, salinity and temperature of the soil profile at different depths. The objective of this research was to evaluate the relationship of volumetric ion content (VIC) recorded by the probes with NO3-N concentrations measured at different depths. Soil samplings were performed at four depths: 0-15 cm, 15-30 cm, 30-60 cm and 60-90 cm and were analyzed for NO3-N. These concentrations were compared with volumetric ion content (VIC) measurements recorded by the multisensory capacitance probes at nine depths from 5 cm to 85 cm. These sensors could become an important tool to track and reduce N leaching in agricultural systems, hence reduce potential issues associated with it.