

Minutes
W-1188 Technical Committee Annual Meeting
January 2-4, 2008 - Desert Research Institute DRI, Las Vegas, NV

The annual meeting of the Multi-State Regional Soil Physics Research Project W-1188 was called to order by Thomas Harter (Chair) at 10:30am on Wednesday, January 2, 2008. The participating project members and visitors are listed as follows:

Members:

Bradford, Scott	USDA-ARS, Salinity Lab, Riverside, CA
Dragila, Maria	Oregon State University, OR
Ghezzehei, Teamrat	Lawrence Berkeley Natl. Lab., CA
Harter, Thomas	Univ. of California, Davis, CA
Hopmans, Jan	Univ. of California, Davis, CA
Horton, Bob	Iowa State University, Ames, IA
Jacobsen, Jeff (Advisor W-1188)	Montana State University, Bozeman, MT
Jones, Scott	Utah State University, Logan, UT
Kelleners, Thijs	Univ. of Wyoming, Laramie, WY
Kluitenberg, Gerard	Kansas State University, Manhattan, KS
Knighton, Ray	CSREES-USDA, Washington, DC
McGlynn, Brian	Montana State University, Bozeman, MT
Nieber, John	Univ. of Minnesota, St. Paul, MN
Nielsen, Donald R.	Univ. of California, Davis
Ochsner, Tyson	USDA-ARS, St. Paul, MN
Schaap, Marcel	Univ. of Arizona, Tucson, AZ
Simunek, Jirka	Univ. of California, Riverside, CA
Tuli, Atac	Univ. of California, Davis, CA
Tuller, Marcus	Univ. of Arizona, Tucson, AZ
van Genuchten, Rien	USDA-ARS, Salinity Lab, Riverside, CA
Warrick, Art	Univ. of Arizona, Tucson, AZ
Wendroth, Ole	Univ. of Kentucky, Lexington, KY
Wraith, Jon	Montana State University, Bozeman, MT
Wu, Laosheng	Univ. of California, Riverside, CA
Young, Michael	Desert Research Institute DRI, Las Vegas, NV
Zhang, Fred	Batelle Pacific NW National Lab, Richland, WA
Zhu, Jianting	Desert Research Institute DRI, Las Vegas, NV

Guests:

Botros, Farag	Univ. of California, Davis, CA
Arye, Gilboa	Univ. of California, Riverside, CA
Ochiai, Naoyuki	Oregon State University, OR
Chief, Karletta	Desert Research Institute DRI, Las Vegas, NV
Hou, Zhenan	Univ. of California, Riverside, CA
Iassonov, Pavel	Univ. of Arizona, Tucson, AZ
Leising, J.F.	Southern Nevada Water Authority, NV
Segal, Eran	USDA-ARS, Salinity Lab, Riverside, CA

Siyal, Altaf Ali
Kamai, Tamir
Torkzaban, Saeed
Twarakavi, Navin
Yang, Changbing

USDA-ARS, Salinity Lab, Riverside, CA
Univ. of California, Davis, CA
Univ. of California, Riverside, CA
Univ. of California, Riverside, CA
Utah State University, Logan, UT

WEDNESDAY, JANUARY 2, 2008

10:40am - Chair Thomas Harter welcomes the group, announcement regarding the random sequence of speakers, determined through a lottery.

Introduction of participants

10:55am - Ray Knighton, USDA: The budget was signed by the President on Dec. 26, 2007. The CSREES budget fared pretty well. The Hatch budget stayed the same which means a net decrease of 0.65 % after an across-the-board recession. Approximately \$150 M in special grants were added to the budget after being deleted last year. NRI funding will be the same as last year, i.e., \$ 190 Mio. The NRI water program will again have \$4.5 M, the 406 Integrated water program will have about \$12.5 M, the soil program about \$4 M, and 5 Mio-\$ will be available in the Air Quality program (topics are related to: soil atmosphere exchange with gases). The Air Quality program had a success rate of 26 % in 2007. In order to obtain more focused and problem-specific proposals, there is a tendency in many programs to ask investigators to submit letters of intent prior to the main proposal application.

There is no Farm bill, yet. It is proposed that CSREES will undergo changes in the next farm bill. CSREES will probably be renamed to the National Institute of Food and Agriculture.

Agriculture is gaining more attention from EPA, with two new advisory committees, 1. reactive nitrogen; 2. general committee on agriculture. It is the first time in history that EPA will have such a directed focus on agriculture.

11:10am - Thomas Harter Chair, Year 2007 Business meeting: Jan Hopmans moves to approve the report for the year 2006 and the minutes of the meeting in 2007, Mike Young seconds, workgroup unanimously approves the annual report for the year 2006 and minutes for the meeting in 2007.

Committee nominates two candidates for becoming the next secretary: Marcus Tuller (8), Arizona, and Scott Jones (6), Utah. Markus was approved by the committee, and he accepts.

11:30am - Jeff Jacobsen, Montana State University, Administrative Report:

The current project phase will expire in 2009. Therefore, this will be a "writing year". In general, one or two year extensions of project would be possible
Plans ahead necessary with chore group. The objectives will need to be addressed in project presentations. For reviews of the projects, accomplishments and impacts need

to be specifically addressed. Besides publications, investigators should tell the differences, as a result of their research. Other funding than through this project should be identified and clearly mentioned in project reports. I will definitely reflect positively in the review process. Reports are evaluated by the regional review committee. Data that we submit to our Experiment Stations are looked at. Others have access and use the databases, now. In the future, more people will be looking for accountability. A long list of publications may not necessarily be satisfying. Impact statements may in some cases be valued rather than pure numbers of publications. Ray Knighton: An important criterion will be, how many new technologies were developed and adopted besides publications. Currently, Experiment Station Directors think of hiring staff that is able to write those impact statements.

Question: Where do you draw the line between research and extension?

This line becomes more blurred. In the past, NRI was straight research, without extension, but the Congress told that 20% of NRI budget should be used for combined research and extension type of work. This number now increased to 26% of funding.

However, there is still a huge need for basic research. 25 % of Hatch funds need to be used on regional projects. The regional and interregional projects and interaction with the line between research and extension being blurred imply that the outcome may not be dominated too much by agriculture.

Who is the community benefiting from our research, are those we ourselves or who? This depends on the RFA. For example, the heat probe sensor is meanwhile a widely used technique. It certainly meets the criterion of the objective to develop instrumentation.

11:45am - Donald R. Nielsen, University of California, Davis: Regional research projects started in the late 40's, this group exists since 1956. This was the first regional committee that came together to write a hard bound book. Another speciality is that many tasks within this group were accomplished as individuals, it was never a group with a common specific target such as an individual crop. "We always came together and tried to help each other and others."

Opportunities for soil physics research in the future: soil physical properties and conditions within soil profiles derived from surface soil water content distributions, correlation lengths in space and time relative to precipitation and evaporation events, covariance structure between soil hydraulic properties and water and heat fluxes at the land surface. Soil genesis and pedology: derive soil mapping units based on the spatial and temporal variance structure of physical, chemical and biological state variables, covariance structures of soil properties and their relation to mapping units and landform, soil and landscape processes across scales and their relation to soil taxonomy. Soil microbiology: microbial state variables in relation to land surface water content, microbial kinetics and metabolism in relation to soil water content and soil taxonomy. How can soil contribute to land-atmosphere exchange models at the regional scale and global scale models of climate change? We need to revisit basic concepts, need to experimentally validate soil water behavior simulations and their behavior across the landscape, and need to explore the unknown. Existing databases need to be extended with landform information for improving pedotransfer function concept. Rather than

justifying the discipline of soil science through pedology and soil mapping, the use of it for civilization and management needs to be shown. The meaning and quality of maps have to be critically evaluated. Homogeneity within mapping units and the criteria for establishing boundaries need to be questioned. The descriptions of horizontal extent, continuity and uncertainty of soil properties is still lacking in pedology. This lack can be closed by measuring auto- and crosscovariances across different scales, study aggregation and disaggregation behavior, develop alternatives to continual subdivision of soils into mapping units, and monitoring systems for deriving ecologically relevant processes, such as degradation, erosion, pollution etc.

Who steps forward? Soil physicists provide the equations, pedometricians the statistics, and pedologists the sampling locations based on scales of morphological characterization. This would elevate soil science, make the discipline useful for others to solve management and natural resources issues, and useful for social and political policy for sustainable soil management,

This is the best group in the world. For its continuous existence, a few people always worked hard to get the next project going. The group will not reach the goal with sampling, sampling, sampling, but with understanding covariances structures in space and time. The pedometricians and pedologists are ready for interaction.

Who would use this information?

Modelers, those who work in global regional models, and environmental management. This group never had to worry about its audience.

The group might go a slightly different direction towards pedologists, that is why Jan Hopmans invited a pedologist. We should not do soil physics for ourselves, but approach others and provide tools to use our concepts in models.

Look at soil science, we cannot scale up and down yet, but this is what we need to do.

The same mapping unit observed at different places shows that the covariance structures within each unit differ. Hence, we want to build on what we have done so far, but are unable to use mapping units in the right way to solve environmental problems.

12:10pm - Laosheng Wu, Univ. of California, Riverside, "Improved characterization and quantification of flow and transport processes in soils": Objective is to evaluate fate and transport of pharmaceutical products, especially DBPs and PCCPs in reclaimed water which is used for turfgrass irrigation. A lysimeter was established in the center of each of 12 plots. Water with 11 selected compounds was applied at two rates, approximately 1.15 and 1.55 ET_0 , irrigation with sprinklers, free drainage bottom boundary, leachate collected and analyzed (solid phase extraction) twice a week. Recovery of compounds in water samples between 75 and 122 %. Future work will be directed towards adsorption of PPCBs and DBPs in soil, and their interception by turfgrass.

12:25pm - Arye Gilboa, Univ. of California, Riverside, "Unsaturated water flow induced by naturally occurring dissolved organic matter": Humus is usually classified into humic and fulvic acids, but there is no model for functional characterization of organic matter. Naturally occurring dissolved organic matter (DOM) causes hydrophobic and

hydrophilic regions in soils, and affects the surface tension at the air-liquid interface, therefore unsaturated water flow is affected by naturally occurring DOM. Leaching experiments showed a change of surface tension of leachate with pore volume leached. Dynamics of surface tension with DOM displacement from soils. Capillary pressure - water saturation behavior could well be described in a model, and curves were scaled based on the contact angle. A series of further experiments showed the development of capillary pressure gradient induced by surface tension. Pronounced hysteretic behavior was shown in experiments, and the concentration-dependent surface tension may affect dispersion and adsorption coefficients.

12:50pm Lunch break

1:45pm - Tyson Ochsner, USDA-ARS Soil and Water Management Research Unit, St. Paul, MN, "In situ monitoring of soil thermal properties and heat flux during freezing and thawing": Soil heat flux so far has mainly been quantified under unfrozen soil conditions. This study should show whether heat flux sensing is also possible during freezing/thawing processes. This focus is relevant for many locations in the U.S., and its implications regard the surface energy balance, hydrologic processes, gas emissions, and land surface schemes on global climatic models. For frozen soils, the heat transfer can be described using a standard conduction-convection equation, with a "sink" term S , manifesting the rate of ice formation, which is balanced by the water flux gradient and the temporal change in liquid water content. This leads to the apparent heat capacity equation, and the apparent heat capacity C_a and apparent thermal conductivity κ_a , the latter including latent heat flux due to thermally-driven liquid water flow. The temperature gradient causes a matric potential gradient, and the result is thermally driven water flow. Knowing soil thermal properties, soil heat flux can be determined, but do heat pulse sensors support accurate measurements of apparent thermal properties and therefore quantification of heat flux under freezing/thawing conditions? During a winter in St. Paul, four heat pulse sensors were installed at 2.5 and 5 cm depth, and a measurement was obtained every 30 minutes, which was compared to the model developed by Fuchs et al. (1978) based on independently determined parameters. When the ambient temperature approaches the freezing point, the temperature increase will be lower because most of the heat goes into the phase change. The time t_m to the maximum temperature increase T_m is determined from heat pulse curves in frozen soils. The heat capacity C is inversely related to T_m , the thermal diffusivity α is inversely related to t_m , and the thermal conductivity is of course the product of C and α . The apparent thermal properties during a thaw process show a distinct upward peak for C and α at the freezing temperature, and a downward peak for κ , each of the thermal properties varying by more than two orders of magnitude. Measured and modeled thermal properties agreed reasonably, and so do measured and modeled heat flux. Over a seven-day period, the cumulative error was 6 %. Latent heat flux was 52 % of the total heat flux during snowmelt and soil thawing. Soil water retention parameter and monitoring snowmelt infiltration may be possible extensions.

2:10pm - New member nomination

Brian McGlynn, Montana State University Bozeman, fields of interest are terrain analysis, land-atmosphere gas exchange. The group votes unanimously for Brian becoming a new member.

Teamrat Ghezzehei, Lawrence Berkeley Natl. Lab., was also introduced and unanimously voted on as a new member.

2:15pm - Michael Young, Desert Research Institute, Division of Hydrologic Sciences, Las Vegas, NV, "Combining pedotransfer functions (PTF) and detailed geomorphic mapping to characterize runoff potential on an arid alluvial fan complex": The pedologic development of desert soils dominated by "pavement" and dust deposition causes a substantial temporal change of soil hydraulic conductivity K . Hydraulic conductivity in the surface soil decreases by about two orders of magnitude whereas in the subsurface it remains rather constant. As a consequence of decreasing surface layer K , the surface runoff potential increases. The questions underlying this project were whether we can use our knowledge of pedology and hydrology to better predict surface runoff potential on arid alluvial fans, and whether a site-specific characterization approach based on pedo-transfer functions would help predicting runoff from individual alluvial fans or groups of fans. A project was established in the Windmill watershed (Bunkerville, NV) where an example area was mapped and the DEM was established. Soil physical properties were measured at randomized locations. Mini-diskinfiltrometers were modified and automated for infiltration tests (Wooding equation), with 6-7 replicates taken per surface, yielding 47 tests in total. Moreover, rainfall events were executed at each site using a 0.6 by 0.6 m rainfall simulation experiment. These experiments should provide the time and height of water needed to cause surface runoff in order to derive the curve number (CN), as a non-physical property. The results should support a new map which should be compared to the classical NRCS map. For dry bulk density (BD) and saturated hydraulic conductivity K_s , four statistical groups were derived from the results: The young soils (Qf1/2) resulted in the largest BD and K_s -values. Dissected and eroded pavements (QTt) yielded the lowest BD but higher K_s -values. The lowest K_s -values were observed in the intact pavements (Qf4). The neural network based PTF was compared to a site-specific multiple linear regression (MLR) model, the latter being more precise as data directly measured in this study were used. Based on field-measured K_s , the CN was calculated with a standard estimation error of 3.7. Results of this study showed that simple experimental approaches were eligible for rapidly characterizing runoff potential, that the standard deviation could be reduced by considering landform in the analysis and site-specific measurements could improve the predictability of surface runoff in arid alluvial fans. In the future, other alluvial fans will undergo the same analysis, soil surface and geomorphic properties will be applied for water resource management, and regionally relevant PTFs will be developed. It was discussed how all these measurements can be combined to obtain one map.

2:45pm - John L. Nieber, University of Minnesota, St. Paul, "Regional hydrologic synthesis using a system model of watersheds: a new integrative tool to advance knowledge and predictability of hydrologic systems": Motivation for this work is the quantification of groundwater recharge at different spatial scales. The objective is to identify relations between main landscape characteristics and components of the water balance. A matrix of landscape characteristics and selected water balance components undergoes statistical analysis. Water balance components used are average annual stream runoff rate, average rate of minimal monthly stream runoff, ratio of minimal groundwater contribution to stream runoff. The geologic map of Minnesota is divided into various regions, representing a distinct combination of quaternary sediments and bedrock layers (hierarchical hydrogeological subdivision). The state-wide map is stepwise discretized into smaller and smaller more and more homogeneous areas for which the discharge can be well described. For each of these regions, the minimal monthly stream runoff and the minimum groundwater recharge are calculated. Landscape discharge is an integrated measure of groundwater recharge. With decreasing scale (finer resolution) the number of recharge mean classes increases from hydrogeologic region to hydrogeologic subregion to hydrogeologic district to hydrogeologic subdistrict. Since the number of gauging stations in the twin cities metro area was insufficient, results from the East Central Minnesota map were translated, and minimum groundwater recharges for districts and subdistricts were derived. Required principles for regionalization according to Pinneker, 1983): Comparability of data, territory must be subdivided into hydrologically similar subunits, and the hydrologic characteristic must be quantified conceptually valid and reliable. In the future, other hydro-climatic characteristics will be mapped, and other geosphere attributes will be included in the classification. Multiscale groundwater modeling: analytical methods (Worman et al., 2006) and numerical methods (Sonnenborg et al., 2003). The approach discussed here differs from others, inasmuch its beginning is mapping, and a model is developed on the mapped system. Other approaches begin with modeling and the model is applied to watersheds with similar characteristics. The model is regionalized by differencing some parameters and their variance across a territory.

3:15pm - Marcel G. Schaap, University of Arizona, Tucson, "Lattice Boltzmann methods for interfacial processes in porous media": The motivation of this study was to simulate fluid behavior in porous media at scales between 1 cm to 1 km. Usually, macroscopic transport characteristics such as the water retention curve, hydraulic conductivity function and diffusion-dispersion and partitioning coefficients are applied in the Darcy, Richards, and advection-dispersion equation. The main underlying questions were (referring to the Water Resources Research paper on simulating the soil water retention curve using Lattice Boltzmann model): How applicable is this concept at a larger scale? This problem was addressed in a study at the Hanford site, at which single-walled tanks are stored containing waste material with high pH values. The investigators were interested in possible pathways of chemicals in case the extremely corrosive waste causes leaks to the tanks. In some cases, nuclear waste left over from the Manhattan

project leaks already through corroded tanks and migrates towards the Columbia River. The experiment was performed at the "Sisson and Lu" infiltration site. A salt was injected and its migration studied. At a later time, another salt will be injected and its movement will be monitored while more soil physical measurements will be available. For the investigated soil volume, a 3-dimensional map of soil hydraulic properties was co-kriged based on 70 soil texture and bulk density samples and 1376 neutron probe soil water content (down to 20 m depth) readings. For the 70 soil property data sets, an artificial neural network (ANN) algorithm was applied to derive van Genuchten water retention parameters. How are macroscopic properties related to pore-scale physics. Using CT fluid behavior at the pore scale, the pressure-saturation relationship as well as the interfacial area, curvature, and contact angle should be observed. These interfacial processes should be described with the Lattice-Boltzmann method (LBM) which the distribution function of particles is discretized in space, time and velocity. Momentum perturbations are caused by cohesion (determine surface tension) and adhesion (determine contact angle) forces, as well as wetting and non-wetting components. The idea was to use surface tension and contact angle to affect either repelling or adhesion process, and to affect viscosity. Retention curves showed hysteretic behavior. The resulting Lattice units were scaled to physical units. The simulation results look very promising, especially for the pressure-saturation relationship, and the interfacial area. Curvature, contact angle and permeability are the next foci of the work. So far, conclusive results on measurements of the contact angle are expected.

3:45p Break

4:00pm - Naoyuki Ochiai, Department of Crop and Soil Science, Oregon State University, "Colloid behavior near grain-to-grain contacts: micromodel visualization": Most of the studies on transport of Phytophthora zoospores (somewhat larger than bacteria) through porous media being conducted in the 1950s and '60s were performed under water-saturated conditions. In this project transport of zoospores should be performed under real-world, i.e., unsaturated soil conditions. The 'ideal colloid' and zoospore transport behavior, and that of motile and immotile zoospores should be investigated in paired column and micromodel column experiments. In comparing studies with v between 6 and 70 m/d, colloids break through 0.1 pore volumes (PV) earlier than a bromide tracer. Particles may be limited to wide flow paths by size exclusion. Velocity truncation excludes them from the pore wall region. A glass-bead model and a paired-bead model were created to visualize the low-conductivity zones near grain-to-grain contacts. Colloids' trajectories were observed with curvatures similar to streamlines. How close to colloids come to bead-to-bead contacts? Only at above 140 μ m distance from the bead surface, colloids move and velocity increases with distance from the surface. Histograms show distance distributions of colloids to bead surfaces. Results are interpreted that those colloids exploring low-velocity zones become severely retarded and contribute to tailing, while those moving in high-velocity zones move at greater than average velocity and contribute to early breakthrough. Questions addressed by the investigators for the future regard whether 2D models would reflect 3D geometry adequately, whether these pore-scale processes could be upscaled to explain breakthrough behavior at the macro-scale, and what other

mechanisms may result in exclusion. It was suggested by the audience to continue the work under lower pore water velocities, in order to allow the colloids to diffuse into the here-called "exclusion zone". The exclusion zone may not appear as distinctively under smaller values of v . Furthermore, changing the chemical composition of the solute might provide better understanding of the exclusion processes.

4:30pm - Eran Segal, USDA-ARS Salinity Laboratory, Riverside, CA, "Bromide transport at field plot and undisturbed core: Scale, dimensionality, and decaying root channels study": In this study, the transport behavior of nitrate and pathogens at a dairy lagoon application site should be investigated as it is relevant for understanding contaminant and bacterial behavior in the environment. The objectives were to derive experimental site characteristics for being used as input for CDE- and MI-transport models. Solute transport parameters measured at the core scale should be validated at the field plot scale. The impact of channels created by decaying roots on transport parameters should be evaluated. In an undisturbed plot with four access rings (1 m diameter) in each corner, 48 tensiometers, 10 neutron access tubes, 48 solution and microbe samplers, and eight four-probe sensors (ECa) were installed. Soil is characterized as a sandy loam with an undulating sand layer underneath, followed by clay lenses. A two-dimensional field of K_s was generated based on soil textural information and the ROSETTA pedotransfer algorithm. Depth- and location-specific water retention curve and K_s parameters were derived from multistep outflow and constant head permeameter measurements. A steady state infiltration experiment was established at a rate of 6 cm day⁻¹, comparable to 0.1 K_s . A bromide pulse was applied for 47 hours. Bromide was monitored at 24-hr intervals, four locations and five depths. The 1D CDE model well reflected field breakthrough at different depths yielding a dispersivity of 2.4 m. Investigators gave insight in the huge variation among solute concentrations samples at different locations and the same depth. These spatial variations were addressed to non-uniform boundary conditions and soil heterogeneity. At the lab scale, a 65-cm-long soil column, equipped with tensiometers and TDR probes at four soil depths was exposed to a breakthrough experiment. Solutes were sampled using a fraction collector. Limited data may lead to wrong interpretations regarding CDE and MIM parameters. When results obtained at the core scale should be upscaled to the field scale, more than parameters than the dispersivity needed to be changed, i.e., the immobile water content and the α parameter. So far, as an effect of channels developed from decaying roots, the saturated water content as a fitting parameter had to be changed.

5:00pm - Markus Tuller, The University of Arizona, Tucson, "Impact of physico-chemical factors on initiation and evolution of desiccation cracks in Bentonite-sand mixtures": The motivation for this study is the physical-chemical environment and evolution of pore structure and the hydraulic behavior of clays. The relevance of this study is based on the fact that more than 217,000 contaminated sites in the U.S. exists in which clay liners are packed at the bottom to minimize leaching of contaminants to the groundwater and which need remediation. Moreover, preferential flow in agricultural soil with a high clay content can cause potential risks of groundwater contamination

with surface-applied chemicals. The objectives are to better understand the initiation and evolution of desiccation cracks as affected by solution chemistry, clay content, and temperature, and to establish a database for parameterization of physically-based models for hydraulic properties of clays and liner materials. Changes in the hydration status of swelling clays and soils cause a challenge with respect to derivation of transport properties due to a hierarchy of soil structure affecting water retention and soil pore space. Controlled experiments were performed with Na-bentonite-sand mixtures and Ca-montmorillonite mixtures saturated with 0.05 and 0.5M NaCl and CaCl₂ solution, respectively, to study the effect of monovalent and divalent solutions on crack development. Maximum water ratio and saturated permeability were measured prior to the dehydration experiments. Under controlled conditions, effects of drying rate, clay content and solution chemistry on initiation and development of surface cracks were investigated. High-resolution X-ray CT scanning and an algorithm to reconstruct pore space were used. Higher Na-bentonite content (40 %) caused the 0.5M NaCl to have a larger affect on macropore development during drying than lower content (20%). While the permeability decreased with increasing bentonite content (0 - 60 %), regardless of salt concentration in the solution, the water ratio increased at the same time, and to a stronger extent for the 0.05M solution than for the 0.5M solution. With divalent solutions (CaCl₂, Ca-Bentonite), the sample volume was apparently not large enough to observe a potential crack pattern. Further work will be directed towards image binarization, use of polyacrylamide (PAM) polymers, and polypropylene fibers, upscaling of cracking, and associated hydraulic behavior. So far, various algorithms have been used to convert grey-scale images into binarized images. These are further processed in the above-mentioned (Schaap) Lattice Boltzmann Model. A comparison between simulated and measured saturated hydraulic conductivity based on LBM and various binarization algorithms yielded promising results. Other opportunities of soil volume analysis reconstructed from CT measurements regard macroporosity, surface area, aperture distribution and crack depth and connectivity. In order to measure saturated hydraulic conductivity during volume changes of the materials investigated, a fully automated flexible wall permeameter is used, that allows real-time control of confining pressure and hydraulic gradient either under pressure or volume control.

Under real world conditions, the drying of clay liners might be caused by sources different from evaporation. The investigators are aware the in reality the drying is a long lasting process. Nevertheless, a basic understanding is well achieved.

THURSDAY, JANUARY 3, 2008

8:15am - Scott Bradford, USDA-ARS Salinity Laboratory, Riverside, CA, "Modeling the coupled effects of pore space geometry and velocity on colloid transport and retention": The advection-dispersion equation is considered with a first-order deposition and release which can be applied to filtration theory if the release coefficient is considered 0. By solving the flow field using the Navier Stokes equation, the colloid interaction with the solid surface is manifested by the κ -term in the equation which is a chemical interaction term. Alternatively, the DLVO theory describes the chemical

interaction between colloids and the solid surface where the magnitude of the energy barrier decreases with decreasing colloid size. Experimental observations are not always consistent with filtration theory predictions because attachment conditions can be unfavorable, the deposition profile may deviate from an exponential distribution and the relation between velocity and the size of the colloid is not accurately predicted. Filtration theory neglects the balance of applied and adhesive torques on colloids affecting deposition, and it neglects pore space geometry. The flow field around a single solid grain is considered here: Only a certain fraction of the solid surface will contribute to the retention of the colloid, resulting in a different flow field. The surface area available or favorable for attachment increases with the adhesive force and the resulting torque. Due to the flow field in pore space, a single sphere causes unfavorable conditions for colloid retention, and two spheres unfavorable or even highly unfavorable conditions. Micromodel experiments reveal that the current model does not adequately describe colloid retention. In the liquid film around two spheres, colloids move. The liquid film has to be divided conceptually into a mobile and a stagnant region, the latter causing static liquid holdup. Physical and chemical nonequilibrium, dual permeability, and the stochastic stream tube approach are examined. The rolling of colloids remains usually unconsidered in mobile-immobile models, but it is included here through an exchange coefficient Ω , related to D . The immobile fraction w is relatively small in this approach. Rolling of particles occurs but it has to get to the mobile region first. In the dual permeability model, a small advective component appears, and depending on soil type, different fractions of soil regions exist where flow processes occur relatively slowly. The stochastic stream tube model consists of an analytical solution with two stochastic parameters describing the joint probability density function, i.e., the pore water velocity, and the deposition coefficient. The PCNE, dual permeability, and stochastic stream tube models account for pore-scale hydrodynamics and are potential approaches for predicting colloid retention in porous media. Would a pore-scale model be sufficient? For fine to coarse textured soils, the Navier Stokes approach is computationally too intensive to be applied for more than a few grains.

8:45am - Scott Jones, Utah State University, Logan, "1. Microgravity soil physics - A sensor for snow melt dynamics" Over a temperature range between -10 and 30 °C, three TS1 sensors and soil moisture sensors were tested in a sand column and under constant water content conditions in time. These tensiometers are supposed to purge and refill themselves. The purging simply did not work. All 24 of these 1st generation sensors needed a variety of repairs and updates, and all those three that were tested here were repaired and updated. The sensor temperature readings failed at 2 °C, and at the same temperature, the sensors failed to purge water because the cups broke.

2. "Exploring soils and ecohydrological structure in small watersheds using electromagnetic induction": The main motivation behind this project was to tie an EC map of a 41-ha-watershed into the ecohydrology of that watershed and a vegetation map. A mosaic of trees, shrubs and grasses was digitized, and soil texture was sampled at 40 points. An EC map and 312 TDR soil surface water contents were obtained with a portable instrument within one day. The EC distribution was studied over regions with

different plant communities. The time of the year would have a significant impact on results through soil water content and its effect on electrical conductivity. The vegetation distribution to a large extent depends on the local moisture conditions and water content distributions, which again depends on soil texture. The coefficient of determination between EC and both clay and water content was 0.73. The question whether the clay and water content on EC could be sorted out, was answered with the suggestion to map EC at different times and water contents during the year.

3. Changbing Yang, "Two-dimensional water flux using a Penta-needle heat-pulse probe (PHPP): Numerical evaluation and laboratory experiment": The objective of this study was to evaluate a PHPP method for measuring 2D water flux synthetically and in lab experiments. Over a 10 by 10 cm domain, 30 simulations of a soil temperature field representing the geometry of the PHPP sensor were performed to estimate the water flux in the x- and y-dimension using the CORE2D V4 code. Water fluxes and the flow direction derived from temperature fields perfectly matched each other. A cylindrical 2D flow cell was used for water flux estimates from lab experiments. The results were matched the simulations well, and the conclusion was that the PHPP probe is eligible for estimating soil water flux in 2 dimensions.

9:15am - Ole Wendroth, University of Kentucky, Lexington, "1. How close to each other do soil samples need to be taken to monitor the spatial process of solute concentration and transport?": Impact of timing of salt or chemical application relative to subsequent rainfall and rainfall amount and intensity on solute leaching has not been studied intensively at the field scale. A pilot study was performed where a KBr tracer was applied to the soil surface in the field. Soil cores taken every 25 cm in horizontal distance were divided into 10-cm-depth increments and samples analyzed for soil water content and total anion concentration. The objective was to study spatial autocorrelation behavior, and spatial relations across different depths with crosscorrelation. The question was whether the local representativity of an individual solute concentration could be derived, and the temporal change in concentration during subsequent sampling could be obtained although the subsequent soil sample could not be taken at exactly the same spot. Through prior irrigation, initial soil water content differed systematically in the profile. Except for the uppermost compartment (0-10 cm depth) anion concentrations were spatially autocorrelated to a distance of 1 m down to 40 cm soil depth. Below, anion concentrations were very low, and bromide had probably not moved that deep. Anion concentrations were spatially crosscorrelated across 1 m for subsequent soil depths above 50 cm.

9:45am - Karletta Chief, Desert Research Institute, Division of Hydrologic Sciences, Las Vegas,: "Predicting saturated hydraulic conductivity from air permeability in desert soils": In the Sabino Canyon watershed, an aspen fire in 2003 caused huge damages. Consequences for soils were increased runoff, decreased permeability, increased dry bulk density, sealing of pores with ash, and soil disaggregation. This problem is especially important for coniferous soils after fire, where the combustion of organic matter caused the changes in soil properties. Consequently, in situ hydrophobicity

plays a major role in surface runoff. The objective of this study was to evaluate whether changes in saturated hydraulic conductivity K_{sat} induced by the impact of fire on soil properties could be derived from air permeability K_a as a quick measurement, and whether the relation between the two were valid for burned soils. In the literature (Loll et al., 1999; Iversen et al., 2001), K_{sat} and K_a follow a log-log-linear relationship. The latter can be measured much faster than K_{sat} if K_{sat} had to be measured using a single or double ring infiltrometer. For ten locations under different agricultural management, in situ and ex situ K_a were measured using a soil corer air permeameter (SCAP), based on the design described in Iversen et al. (2001). When applying the Jalbert and Dane (2003) shape factor, both methods agreed well. Prior research showed larger variability in the K_{sat} - K_a relation for structured soils and soils with limited drainage. Burned and unburned sites were investigated to identify whether K_{sat} could be estimated from K_a . Among these burned sites, different levels of burning severity were distinguished. Slope and location were evaluated as site-specific indicators for permeability. Results came close to the relations derived earlier by Loll et al. (1999) and Iversen et al. (2001). In situ K_a collected soon after a fire was helpful to predict immediate fire-induced changes on K_{sat} . As an indicator for changes of physical properties, air permeability might be sampled across the landscape together with soil water contents at different times without the additional effort of measuring K_{sat} .

10:05am - Break

10:15am - Fred Zhang, Pacific Northwest National Laboratory-Batelle, Portland, "Comparison of models of anisotropy in unsaturated hydraulic conductivity": The motivation for this study was the fact that the soil of the Hanford formation is spatially anisotropic (vertical/horizontal), and this anisotropy is water-saturation dependent. Isotropic soil field-scale hydraulic conductivity can be described using a geometric mean or an upscaled value. Layered soils may be described in the horizontal dimension by the arithmetic mean, and in the vertical dimension with the harmonic mean, whereas stratified soils can be represented in stochastic approaches. In this study, anisotropy should be described using a tensorial connectivity-tortuosity (TCT) concept. The vertical conductivity is user-defined, and the horizontal is the product of the vertical and a connectivity coefficient C . Depending on the degree of anisotropy, C varies. The TCT model describes the K vector as a function of C , effective saturation and the exponents and hydraulic conductivity coefficients, the latter two being isotropic. There exist different anisotropy-saturation relationships, i.e., exponential increase or decay with saturation. This concept was applied in an injection experiment in a 16 by 16 m experimental field with four transect crossing each other in the central point and having an angle of 45, 90 and 135 ° to each other. The change of the water content plume should be observed horizontally, in depth and time. Different simulation algorithms for averaging were compared to the layered TCT and the EHM TCT were compared with observations. TCT algorithms resulted in the smallest prediction error. The advantage of the TCT model is its applicability to different degrees of 3D-anisotropy, and it is based on common water retention curve and hydraulic conductivity functions. For future research, critical knowledge gaps would be upscaling methodologies of the

hydraulic conductivity function, and the directional measurement of the hydraulic conductivity function.

10:45am Saeed Torkzaban, University of California, Riverside, "Transport and fate of bacteria in porous media: Coupled effects of chemical conditions and pore space geometry": The problem considered in this study is related to transport of pathogenic bacteria in the subsurface, and riverbank filtration. The colloid filtration theory is based on above-mentioned work of Scott Bradford on colloid (or bacteria) retention (DLVO theory). With increasing distance from the solid surface, the interaction energy increases, however, in close proximity to the surface, unfavorable conditions for bacteria retention exist. Mechanisms for bacteria retention under unfavorable conditions should be investigated in column experiments and under different ionic strengths (1 ... 100 mM) of solution. Calculations based on the DLVO theory showed only minor impact of the solute concentration on the distance profile, however, the interaction energy indicating unfavorable conditions was largest under low ionic strength and decreased with increasing ionic strength. Breakthrough curves after a pulse input indicated the strongest retention under highest ionic strength. Deposition occurred in a secondary energy minimum, and retention depended on positively charge heterogeneities. After mixing, the latter effect of retention disappeared. Hence, if the secondary minima are eliminated, deposited bacteria will be released. However, mass balance calculations in elution experiments showed, that deposition in a secondary energy minimum is not the only mechanism. Resisting and driving torques were analyzed (see also Scott Bradford), and rolling was found to be the dominant mechanism for detachment under laminar flow conditions. Streamlines around the collectors were analyzed, and obviously, immobile regions were formed. For a single sphere model, conditions for bacterial retention may be unfavorable, but for two-sphere models, these may even be highly unfavorable, and can be improved only "unfavorable" by increasing the ionic strength. Bacteria retention in porous media strongly depends on solution chemistry, pore structure, and system hydrodynamics. How does the region change with velocity, does it go up with velocity or not? Under laminar flow conditions, the size of the region does not change. However, the assumption of laminar flow may not be valid. Moreover, attention to streaming potential might become necessary.

11:15am - Robert Horton, Iowa State University, Ames, "Measuring soil water evaporation": Soil water evaporation is one of the main water balance components, and can be estimated from the water balance if all other components are known. Alternatively, a soil core as a small-scale lysimeter can be used in the field through regular weighing and putting it back to the field soil. However, no energy information is obtained this way, i.e., the amount of heat that is taken away and the energy exchange between land and atmosphere is not captured. Remember, the three main transport processes carrying heat away from the soil surface are: energy entering the soil as soil heat flux, energy that is transported as warm air from the surface to the atmosphere as sensible heat, and the latent heat, which is the energy used to transport water vapor from the surface zone to the atmosphere. Under wet soil conditions, water

evaporates at the soil surface. The drier the soil becomes, the larger the soil depth to which evaporation extends. The objectives of this work were to develop a soil measurement-based approach for determining in situ soil water evaporation, and to observe the location of transient evaporation front within the soil. A heat pulse probe was developed. This three needle sensor with 40 mm long needles, a resistance heater and thermocouples is inserted in the soil. With this sensor, the influx and outflux of heat and the change of heat storage are measured. Hence, the latent heat for evaporation can be calculated. Heat pulse probes were installed at six different depths in the upper 6 cm of soil, thermal properties measured every three hours, and temperature every 30 minutes in a bare field soil. Vertical temperature gradients and thermal fluxes were derived for a period of six days. Overall, heat capacity and thermal conductivity decreased during this time period. Right after rainfall, the temperature gradient was the same at all depths. In the drying period afterwards, thermal gradients begin to increase with a delay in increase from shallow to deeper layers. Evaporation results obtained with the heat pulse method agree very well to those obtained from the minilysimeters. Hence, use of heat-pulse sensors and the heat-balance method well support the estimation of in situ soil evaporation. The next step will be to determine evaporation immediately after rainfall during stage 1 of evaporation. Further consideration might be given to water flow occurring at the same time, carrying energy.

11:45am - Jianting "Julian" Zhu, Desert Research Institute, Division of Hydrologic Sciences, Las Vegas, NV, "Equivalent unsaturated hydraulic conductivities for layered soils: Arithmetic mean or harmonic mean": Based on the previous year's findings, effective hydraulic parameters can be outside of arithmetic and harmonic mean. Here, the question of interest was, if the effective saturated hydraulic conductivity is assumed to be either arithmetic or harmonic mean, depending on the flow direction, will the arithmetic or harmonic mean still work for unsaturated flow? In the underlying theory for local scale considerations, constant capillary pressure head is assumed on top, and zero capillary pressure head at the bottom. Effective hydraulic properties and the joint log-normal distribution for K_s and α are given. The flux is based on equivalent hydraulic property conceptualization, and relative error of flux is obtained while the actual flux under horizontal heterogeneity case equals the one under vertical heterogeneity. For the vertical heterogeneity case, flux depends on the arrangement of α and K_s . For unsaturated flow under constant capillary pressure heads, the effective unsaturated hydraulic conductivity is between the arithmetic and the geometric mean for horizontal heterogeneity. For coarse textured and more heterogeneous landscapes, the effective hydraulic conductivity would move away from the geometric mean. In vertically heterogeneous soils, the effective hydraulic conductivity is between the geometric and the harmonic mean.

12:10pm - Jirka Šimůnek, University of California, Riverside, "The HYDRUS software - Recent applications and modifications": New features of the HYDRUS-1D software are coupled water, vapor, and energy transport, support for HP1 (HYDRUS and PHREEQC), nonequilibrium flow and transport including dual permeability, potential

evapotranspiration using Penman-Monteith and Hargreaves formula, water content dependence of degradation constants, and full compatibility with Vistas. The options of non-equilibrium solute transport models include uniform flow, mobile-immobile water flow, dual porosity, dual permeability, and dual permeability with mobile-immobile approach within the matrix domain. Chemical nonequilibrium transport includes the options of one-site kinetic model, two-site model (kinetic and instantaneous sorption), two-site kinetic model, dual porosity with one-site kinetic model, and dual permeability with two-site kinetic model. Furthermore, geochemical modeling will soon be possible with two HYDRUS-1D-based programs, i.e., UNSATCHEM, and PHREEQC (HP1). Currently, HYDRUS codes is coupled to PHREEQC, developed by USGS. This model allows to simulate a large list of reactions, some can be defined as equilibrium, and some as kinetic reactions. Since these models are programmed in different languages, it is a challenge to write a C++ interface as basic interpreter. Interestingly, Europeans come to America for a solution. But they found a European to find it. HP1 examples cover heavy metal transport, transport with mineral dissolution, kinetic biodegradation of NTA etc.. New features of Hydrus 2D/3D are: dual porosity systems with preferential flow in fractures and macropores while water being stored in the matrix, spatial root distribution functions, soil hydraulic property models include the Kosugi and the Durner approach, transport of bacteria with attachment and deattachment processes, hysteresis, and dynamic system-dependent boundary conditions. Further innovations are: "The unsaturated flow (HYDRUS) package for MODFLOW-2000", "Introduction to Soil Physics with HYDRUS modeling and application", and "Numerical evaluation of alternative heat pulse probe designs and analyses": Heater needle length, sensor location, HPP materials, and heat pulse intensity should be evaluated in their impact on coupled water, vapor and energy transport. Results obtained in HYDRUS 2D revealed that thermal properties of the HPP needed to be taken into account, as long as thermocouples are installed midway to the heater needle, measurements are less sensitive to experimental setups, and sensor needles can be shorter. For coupled water-vapor-energy transport, larger heat pulses can be used, and flux measurements are more sensitive, i.e., smaller fluxes can be measured.

12:40pm - Atac Tuli, University of California, Davis, "Heat Pulse Project": Some experimental aspects to the previously reported model simulations of heat pulse probe designs; the remaining problem is that slow fluxes are still complicated to measure. And the temperature resolution of small thermistors cannot reliably measure small temperature differences. Moreover, small heater diameters prevent applying high heat intensities. Therefore, a new heater, larger in diameter, and different in spatial arrangement of thermistor array was fabricated. Since Kluitenberg just came up with an analytical solution for a final cylindrical heat source, temperature data can now be analyzed, fitted to this analytical solution, and water flux values be optimized. Simulations showed that water flux "measurement" sensitivity increased with heat intensity. In the real experiments, a coiled heater was used for appropriate boundary conditions.

(Ongoing) Tamir Kamai, University of California, Davis: A percolation experiment was performed with fine control of influx and outflux into and out of a soil sample. Experiments showed the impact of heating duration and heat intensity on flux determination, given that the thermistors had a sensitivity of 0.01 °C. Compared to lower heating times and intensities, accuracy of water content measurements increased clearly even to fluxes below 6 and down to 1 cm d⁻¹. In order to minimize the effect of micro-scale vaporization of pore water, the heating pattern was changed to several short pulses. This way, the heater temperature could be reduced, while the response at the thermistor was almost identical. To further improve the design, shorter needles were examined, and resulted in good results as well. Finally, numerical simulations were performed using a concentric heat sensor. These results are a good basis for expecting a robust and highly capable probe for measuring soil water content and water flux.

1:05pm - LUNCH BREAK

1:45pm - Jan Hopmans, University of California, Davis, "Wireless network deployment in Sequoia National Park": A critical zone observatory should be established in the Sierra Nevada. One of the main objectives is to deploy wireless networks for soil moisture and energy balances. A number of wireless networks have been put out in Sequoia National Park. In this study, three networks were installed, i.e., the Isaacs link (Radio transmitter, receiver and repeater) with water mark resistance meters for soil water potential, the Decagon link with the ECH2O water content sensor and the Crossbow link combined with Isaacs Watermark sensors. The objective was to monitor soil temperature and soil water. For the Isaacs Watermarks, calibration in the lab is necessary prior to the field installation, and the temperature is a critical factor. The ECHOTE needs prior calibration as well and provides measurements of electrical conductivity, temperature and soil water content. Results should very good agreement between ECHO probe and independently determined soil water content for the Wolverton soil. In the Winter 2006/2007, the Isaacs network was put in use in Wolverton. A sensor transect was established. The Mote Crossbow System's configuration was presented, with a base station (Omni antennae) with various nodes distributed across the landscape. The different notes "interact" with each other to guarantee that the signals from the sensors arrive at the base station. The system is extremely energy efficient, and includes solar panels. First results show time series of continuous water potential and temperature data recorded over a time period of approximately two months.

2:05pm - Navin Kumar, Department of Environmental Sciences, University of California, Riverside, "Can texture-based classification of soils provide optimal grouping with respect to hydraulic parameters": Soils are usually grouped according to their particle size distributions, hydraulic characteristics, and morphological descriptions or any kind of lab testing. The most commonly used and accepted system is the USDA soil classification which divides soils into 12 groups, presented in the soils' textural triangle. Why are there straight lines between the classes, what is the justification for

using 12 classes? The objectives of this study were to evaluate whether the USDA soil classification system provides the optimal grouping with respect to soil hydraulic characteristics, and if not, what system would provide a better grouping, and what would be the optimum number of classes with respect to soil hydraulic properties. Moreover, what would be average parameter estimates for each of these hydraulic classes? For various soil types, hydraulic parameter sets were derived. Hydraulic classes were derived using a clustering algorithm, and the average hydraulic parameters were estimated for each class. For this clustering analysis, different soil samples should be distributed uniformly across the textural triangle. Since no data set like that exists, ROSETTA was used to generate 5151 hydraulic parameter sets (θ_s , θ_r , α , n , K_s) across the textural triangle. Clustering was performed using the k-means algorithm. Parameter sets were divided into sets of 2 to 30 clusters. The optimum number of clusters appeared to be 12 (9-14), which is interestingly the same as the number of textural classes. However, the soil hydraulic classes differ from the textural classes. The differences occur mainly where capillary pressures play a dominant role. In this numerical study, dry bulk density was not entered as an independent parameter to derive soil hydraulic properties, but it was incorporated being a function of sand, silt, and clay content. In the future, probably sand should be divided into more fractions.

2:45pm - Gerard Kluitenberg, Kansas State University, Manhattan, "Spatial variation in water-table fluctuations in vegetated riparian zones": Especially in Kansas but in many regions of the U.S., low streamflows are an increasing problem in the U.S., caused by consumption of ground water by phreatophytes among other reasons. An approach that is based on daily ground water table fluctuations seems to be applicable for quantifying ground water consumption. The objective of this study was to investigate major controls in phreatophyte-induced ground water table fluctuations, to use diurnal water table fluctuation measurements to quantify water consumption by phreatophytes, and ground water savings accomplished through control measures. Diurnal fluctuations in the riparian zone and adjacent pasture vary with respect to both amplitude and phase. Can the diurnal water table fluctuations be described using an analytical equation? The typical stream setting consists of a dry stream channel in the center, a vegetated riparian zone on both sides of the stream, and annual crops and pastures farther away from the stream. In the approach, the aquifer is assumed to be one-dimensional and homogeneous, and the consumptive water use changes with position. The flow is estimated by a linearized Boussinesq equation. The heavily vegetated riparian zone can be considered as a strip-sink with finite water use, whereas outside this strip, water use is zero. According to Townley (1955) the strip-sink is solved for, resulting in normalized amplitude of fluctuations, phase lag between ET_{Gp} and h_p , and head fluctuations and phase lags relative to the position and the period ($L^2S/(TP)$). In the following, the stream setting is divided into several parallel strip sinks with different ET_G rates according to vegetation types. Hydrograph signals would lead to underestimation of ET_G where amplitude reduction occurs, and overestimate ET_G where fluctuations are amplified. Using the solution presented here, would allow to identify the optimum location for measurements necessary for the procedure presented here. Unlike existing methods, ET_G estimation is effectively estimated by the well

hydrograph phase-lag information. Storativity and transmissivity will be estimated in the future. In addition, diurnal fluctuations of pressure head in the unsaturated zone will contribute to a better understanding of root water uptake causing diurnal water table fluctuations.

3:15pm - Thijs Kellenars, University of Wyoming, Laramie, "W1188: Soil Physics Research": Among other ongoing research projects, the Hydra probe impedance sensor was evaluated. This sensor provides five voltages. From voltages V_1 , V_2 , and V_3 , the real and imaginary permittivity parts can be calculated. However, the problem is that the voltage measurements themselves also take voltage. Voltage 4 refers to the temperature of the electronics, and voltage 5 reflects the soil temperature. The Hydra probe handles all this internally, and provides the real permittivity and the imaginary permittivity. Load impedance calculations result in the separation of the real and imaginary part. Four transmission line sections (circuit board, epoxy resin, metal bottom plate, and times) constitute the load of the circuit. Voltages V_1 , V_2 , and V_3 , need to be corrected for the voltage drop in the voltage measurement circuit. This correction is accomplished based on electric circuit theory by V_4 for calculating the electronics temperature. Measured voltages V_1 , V_2 , and V_3 are corrected by V_4 . These corrected voltages are then used to calculate the real and imaginary load impedance. Each load impedance is inverted to calculate the load impedance at the next level, and the load impedance Z_{in4} is then used to solve for the real and imaginary permittivity. Although the Hydra probe already converts voltages into real and imaginary permittivity automatically using standard parameter values, it was suggested that each sensor is independently calibrated by optimized parameters. Several sensors were calibrated after parameter optimization based on readings in air, ethanol, methanol, di-water and di-water with NaCl. The calibration results for the real and imaginary permittivity values look very promising, and the optimized parameters obviously differ from the standard values used by the manufacturer to divide into real and imaginary permittivity. However, the factory calibration works surprisingly well. Would the Hydra probe be sensitive to temperature fluctuations? It is constructed to compensate for temperature effects.

The 15 MHz operation frequency makes the use of this sensor difficult for different soils, but the advantage is that it splits up between real and imaginary part.

3:50pm - Excursion to the lysimeter station of the Desert Research Institute

Evening - Dinner

The chairman Thomas Harter thanked Mike Young in the name of the entire group for the excellent organization and infrastructure of this meeting as well as the interesting tour to DRI's research facility, the lysimeter station which is funded through NSF.

The group voted and decided that the next meeting location in January 2009 will be at the University of Arizona, Tucson. Organizers

FRIDAY, JANUARY 4, 2008,

8:30am - Brian McGlynn, Montana State University, Bozeman, "Landscape structure controls on watershed hydrology and biogeochemistry": The objective of this study is to link topography, geomorphic form, and landscape structure to water, energy, solute, and gas fluxes from the plot to watershed scale. A new DEM-driven flow direction algorithm was developed, because topography information steadily improves. Therefore, topographically-driven distribution of water should be evaluated. Area is chosen as a surrogate for water and flow accumulation. The type of algorithm, resolution of the DEM, and data quality cause a huge difference on the result. How does the shape of the watershed relate to discharge of the watershed? To develop a conceptual model of runoff generation depending on the watershed structure, the upland-riparian-stream connectivity over space and time was considered. The Tenderfoot Creek experimental watershed was intensively instrumented with hydrological measurement facilities (27 transects with wells and piezometers, flumes, 2 Eddy covariance H₂O/CO₂ towers, 600 m² plot with water content and snow temperature measurements, stream and groundwater sampling facilities) across nested catchments to focus on water and carbon research. The spatial water-table continuity and connectivity were derived, i.e., the connection of the area and its different compartments to the stream. How can many time series be integrated to condensed information? As a criterion for connectivity over time, the upslope accumulated area is considered and its behavior throughout the year. High upslope accumulated area refers to a larger connectivity, low upslope accumulated area to a low connectivity. This information is converted back into the landscape to answer the question: Given the existing stream network, where and when are streams connected? Flow duration curves and catchment connectivity curves are simultaneously interpreted with respect to the time equal or exceeded for a given flow condition (exceedance curve). The result is that topographically driven lateral distribution of water drives upland-stream connectivity, transient connectivity drives runoff generation, a high degree of heterogeneity remains in spite of adequate time integration of space-time behavior. Watershed carbon distribution and water flux should be studied across environmental gradients in order to determine associations between soil temperature, water content, substrate, and biological controls on CO₂ at the watershed scale. Results show that there is a relation between topography, topology and process patterns. Hydrological and biogeochemical processes reveal an organized heterogeneity.

9:00am - Altaf Ali Siyal, Sindh Agricultural University, Tandojam, Pakistan, currently visiting Professor at USDA-ARS Salinity Lab, Riverside, CA, "Desalination with partial ponding method using subsurface drains": Soil salinization is a severe problem in Pakistan. Over 6.8 Mio. ha (one third of the production area) are affected by salinization. How can soils affected by salinization reclaimed? Traditionally, the soil surface is flooded with good-quality water to leach salts out of the root zone through subsurface drains. However, leaching occurs at a faster rate above the tile drains than midway between the drains. Due to this spatial flow inhomogeneity, the desalination process may take long time and large quantities of good-quality water may be wasted. The question is whether ponding the whole area above drains or only partial ponding

would be more efficient to leach salt. Youngs & Leeds Harrison (2000) showed progressively increasing the ponding area between drains would result in only 16 % of water needed and only 75 % of the time of the conventional method. This system should be evaluated in this study using HYDRUS 2D/3D simulations. First, $\frac{1}{4}$ of the area above the drain was ponded. Then, $\frac{1}{2}$, $\frac{3}{4}$ and finally the entire area above the drain was ponded. According to these simulations, the step-wise increase of the ponding area obviously increased the leaching efficiency. Parameters to be considered in more detail would be soil texture, bulk density, hydraulic properties, soil layering, drain spacing, size and depth, the size of ponding area and time in ponding increments. Alternatively, sprinklers might be used instead of ponding, and the drains may be blocked until infiltration has stopped, and the drains may then be opened again. It is important to allow sufficient time for diffusion of salts out of the aggregates.

9:20am - Break

9:30am - Jon Wraith, Montana State University, Bozeman, "Linking mass and energy transport in soils to ecosystem-scale processes" (This work is closely related to the work of McGlynn, presented before): Water flow within and across soils affects catchment water storage and streamflow. Local soil physical properties are critical to greenhouse gas evolution and release, but are often not considered by those working at large scales. How do these local soil processes translate into emergent watershed processes? How can point measurements (flux tower measurements) integrate spatially and temporally variable soil processes to understand landscape-scale mass and energy exchange? This question was investigated in the USFS Tenderfoot Creek Experimental Forest. Seasonal thresholds, critical relationships and event-driven processes should be evaluated, and how they could be linked into large scale models. Soil pits were equipped with TDR probes, thermocouples, and gas diffusivity functions were measured on intact cores. The emerging issues considered here are watershed and carbon cycling processes in context of global change ecology and greenhouse gases. The critical knowledge gaps are: How do the critical drivers and relationships of water, carbon and gas processes vary across the landscape and how are they integrated in large-scale measurements? The role of W-1188 is integrated state-of-the-art knowledge in measurements and simulations and the evaluation of simplifications. In the context of objective 2, (develop and evaluate instrumentation ... at different scales), a hardware-software panel (waveform, permittivity, hardware, sample, software, travel time analysis) was developed. For example, temperature effects could be quantified, probes could be designed for specific conditions, e.g., high salinity, long cables, and waveform analysis was improved. Regarding objective 3, scale appropriate methodologies for the management of soil and water resources: "Performance of ash disposal pond vegetated cap system": Fly ash is generated by coal-fired power plants and is transported to disposal sites. Only some ponds have liners. Vegetative cover is intended to prevent leaching of heavy metals into groundwater. Selenium is detected in the groundwater near to older ponds close to a town. TDR probes were installed to continuously monitor soil water content and climatic sensors in selected locations. Obviously, precipitation water reaches the underlying ash layer, and in the future, better estimations of ETp will

be obtained and more realistic computer simulations (HYDRUS-1D) will contribute to improved management.

9:55am - Farag Botros, University of California, Davis, "Long-term nitrate leaching in a deep alluvial vadose zone: Flow and transport modeling": The objective of this study was to characterize the heterogeneity of a deep alluvial vadose zone, to model nitrate transport in the deep vadose zone, and to compare different modeling approaches to describe soil heterogeneity. The study site was an orchard with nitrogen fertilizer application varying between 0 and 365 kg N/(ha year). For the modeling, long-term fertilizer records were available, fruit yields were recorded, and in 1997, geologic stratification was obtained from 62 continuous soil cores drilled to the water table. From 120 small cores taken from these drilled cores, 96 hydraulic property data sets were obtained to be "good" data. The total N mass in the vadose zone was obtained from kriging interpolated water content and nitrate concentration was 48, 36, and 87 kg N ha⁻¹, while the mass balance suggests 218, 2161 and 478 kg N ha⁻¹ for the three subplots. Denitrification which was not supported by field measurements, and preferential flow might explain the discrepancy of the N storage. A seven-year-period was modeled based on three different conceptual approaches: Homogeneous model for layered soil (only large scale heterogeneity), a heterogeneous scaling factor approach, and a heterogeneous approach with all van Genuchten parameters being assumed as random fields and auto- and crosscorrelated. All three models gave similar results for the time for N being transferred through the vadose zone, total N stored in the deep vadose zone, and N breakthrough at the water table. None of the model approaches managed to explain the small amount of stored N in the deep vadose zone. Preferential flow allowed in the two heterogeneous models did not reflect the differences in the stored N mass sufficiently. Perhaps, the 100 cores being taken were not sufficient to characterize the small scale heterogeneity. Would 3-D modeling help? Perhaps, pruning of trees caused the discrepancy in the mass balance, nitrous gas emissions might have caused nitrogen losses, and perhaps cover crop (grass) between the trees might contribute to the diverging balance.

10:30am - Thomas Harter, University of California, Davis, "Scaling factor analysis in a hierarchical alluvial fan system": This work directly relates to the previously presented. How good is scaling as a simple representation of a hierarchical medium, how well does it represent actual variability of $K(h)$ and $\theta(h)$, and how well does it contribute to appropriate modeling of q , h , θ , c ? Miller scaling was applied in this study, based on an algorithm of Clausnitzer et al. (1992). Simultaneous scaling of h and $\ln K$ and of $\ln h$ and $\ln K$ was performed. Two different data quality levels were considered, i.e., "high only" for 70 samples in multi-step outflow experiments and inverse modeling, and "high plus regular" with 27 samples from water retention curve. Four hierarchical classifications for scaling were applied, i.e., no groups (all samples scaled simultaneously), grouping according to visual textural classification, grouping according to lab textural analysis, and grouping according to sediment facies. Criteria for the success of scaling were SS difference between scaled and mean function, and correlation between de-scaled and

original data. Transient multistep versus steady-state multistep had no significant influence on the quality. Simultaneous scaling of $\ln h$ and $\ln K$ yielded the best results. Ungrouped scaling caused results comparable to facies scaling, hence scaling across different geological layers does is ok.

10:50am - Break

11:00am Invited Presentation:

Ron Amundson, Pedologist, University of California, Berkeley

Introduction Jan Hopmans:

The suggestion was to broaden up the soil physics group, and to include Pedology. Several past discussions and Don Nielsen's presentation at the previous meeting Jan. 2007 had resulted in the strong demand, that our group should communicate with pedologists. On the other hand, some pedologists think in the same way that they needed to interact with other soil science disciplines so that the valuable pedologic description of soils compiled in soil data bases could be linked to processes occurring in soils. If both sides can get together, this would be very stimulating for the further progress of our group and the next proposal, led by Mike Young.

Ron Amundson:

"Soil Physics and Pedology"

Initially, Ron and other soil scientists (Jan Hopmans and others) had met on the UC Davis campus with a brainstorming on how the soil science programs in California could be better integrated.

An ignition for his presentation was Don Nielsen's presentation from last year, and the dilemma of soil science having no reliable quantitative measures of spatially distributed soil properties across the landscape.

Pedology and Soil Physics?

Many students in pedology have backgrounds in physics, mathematics, ecology, etc.. Why is there not a more visible interface so far? Why is pedology not integrated better? Pedology deals with soil properties, soil physics with processes resulting in soil properties vs. processes, Soil system vs. soil, and observational vs. experimental soil science. But in fact, here exist the real opportunities for process-based, integrated soil science.

Soil is a continuum, but mapping gives the impression of a boundary, a separation which does not exist in nature. Soil "system" was thought to break the soil continuum into meaningful segments.

The Hans Jenny book on "Soil Formation - A system of quantitative pedology" is increasingly criticized by some and appreciated by geologists and ecologists.

Since most soil properties are the result of advective and diffusive transport and reaction processes (Example: Cerling's CO_2 production and diffusion model equation for $^{13}\text{C}/^{12}\text{C}$: carbonate ratios, exponential process with depth, diffusion problem),

pedology concepts and courses should include basic transport models of gas, water, and heat. On the other hand, soil physics should not only deal mainly with water and irrigation but relate to microbiological and geochemical processes, and should also focus on field and observational problems.

How soil physics can play a role in pedology?

How can observational and experimental science be bridged? In situ geophysical processes and biology are at the cutting edge of earth sciences. Field observations can inspire new experimental approaches. Information in field trips and joint symposia, graduate education in field methods and soil physics.

Opportunities for process-based integrated soil science:

NSF programs (Low temperature geochemistry and geomicrobiology, critical zone observatories)

NASA planetary geology, and

Transformative efforts in SSSA

Example:

Is the hydrological model presented consistent with the observed geochemistry? No. There is clear need for interactions between soil physicists and pedologists.

11:30am The discussion following up Ron Amundson's presentation was directed towards a vision for future activities of the W1188 group. The discussion of the new project proposal and the next meeting in 2009 were very closely related.

Ron Amundson's presentation was received by the group as a great success and igniting contribution to the question what the role soil physics can play in related disciplines and vice versa, and how soil physicists, pedologists and others can start interacting with each other.

Knighton comment: There is a small group of soil pedologists who began looking at soil processes across landscapes.

Discussion of the Meeting next year:

Where shall it take place and what focus do we want it to have?

Nielsen comment: We need to meet at a different location, in order to meet, reach and exchange with new young scientists in related areas.

During the discussion following dinner the evening before, the group had decided to meet in January 2009 in Tucson, Arizona. Markus Tuller and Marcel Schaap will be the organizers.

What opportunities exist for soil physics and its relation to other soil disciplines and how can the meaning and the importance of soils be pointed out?

Different disciplines consider soils at different depths, e.g., critical zone or vadose zone: These terms often mean the same, but the term "soil" is not included. Our group should target at making "soils", their role and functions more known to a broader public.

The discussion resulted in the idea of having a different format of the meeting next year, i.e., to have the meeting divided and focus on different topics in different sessions.

Invited speakers from outside the group should give presentations, which could be the initiation of discussions of either the entire or smaller subgroups. These invited speakers should not come necessarily from soil physics but rather from related disciplines, especially those to we as soil physicists want to relate to. The organizing group from Tucson responded that there would be several potential speakers at University of Arizona, Tucson, who could be speakers during our meeting. Furthermore, it was discussed to have after oral presentations and discussions sessions time slots that would be filled with poster presentations. This would provide an opportunity for young career participants (probably mainly from the Tucson campus) to present their work.

Concluding discussion on next year's meeting:

The next meeting will be held over a 3-day period with beginning on Monday, January 5, 09 at noon time, and the end on Thursday noon, January 8, 09.

These 3 days will be divided into two days with presentations, and one day of brainstorming sessions including presentations of invited speakers. The format of sessions will probably be a "hybrid" type, including think tanks.

Sufficient discussion time needs to be provided for invited speakers to discuss and comment our proposal.

First suggestions on names for invited speakers were: Ron Amundson, Marc Parlange, Henry Lin, Jon Chorover ...(could not catch all names in the short time period and might have missed one or two. Please add any eventually missing ones).

11:45am The next steps in writing the new proposal for the time period 2009-2014:

The new proposal will have to be submitted to the Board of Western Directors in January 2009. The core committee will write a first draft of the proposal during the next 2 to 3 months, circulate it to the group, include comments from the group, and then have a first version of the proposal ready in summer of 2008. At this point it needs clarification whether this first version of the proposal needs further approval.

The group writing the proposal will be:

Mike Young (head), Scott Jones, John Neiber, Markus Tuller, Marcel Schaap, and Ole Wendroth

The vision documented in this new proposal will have strong impact on the focus and the format of the next meeting in January 2009.

The questions of the relevance of soil physics and whether or not to go for "esoteric" soil physics were discussed.

During the discussion, focus on either one or several objectives was debated with no strong opinion on particular objectives but with emphasis on broadening the focus of the group and opening it to related disciplines while not losing the identity of a "soil physics group". The link of soil physics to other disciplines will be a "driving force" for the coming meeting and project period.

Regarding format requirements for the new proposal, Jeff Jacobson will send guidelines to the Head of the writing group, Mike Young.

12:15pm Chairman adjourns the meeting.

Respectfully submitted,

Ole Wendroth
Secretary

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