the logged areas. Measured concentrations of nitrite-nitrate nitrogen showed changes only two years after the logging. This lag can result from slow initiation of felling waste decomposition and long residence of nitrates in mineral soils and wetland areas surrounding the stream. Sensitivity of modeled nitrate leaching to parameterization of decomposition and retention processes was assessed.

H31G-06 1150h

Modeling Investigation of Water Partitioning at a Semi-arid Hillslope and its Implication

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Recent generic modeling studies (Guan and Wilson, 2002, 2003) confirm conventional opinion that climate and bedrock (matrix and fracture) permeability are primary controls on the amount of water partitioning from the land surface into the underlying bedrock of semi-arid mountain blocks. Both steady and quasi-steady simulations show that the annual percolation rate across the soil-bedrock interface approaches saturated bedrock hydraulic conductivity when the mean net infiltration rate into the soil exceeds rock conductivity. When the mean infiltration rate is lower, the percolation rate approaches the mean infiltration rate. However, field observations of bedrock water content at a semi-arid hillslope (precipitation 450 700 mm/yr) with a highly permeable tuff (saturated hydraulic conductivity, Ks = 3*105 106 mm/yr) suggest only negligible percolation to the rock (Wilcox et al. 1997), while the sum of surface runoff and interflow through the soil was estimated to be 10 60 mm/year. The inconsistency of actual percolation and modeling prediction may have been due to the simplified generic modeling setting (no ET, macropore free soil cover, homogenous soil and bedrock), and the high permeability of the modeled soils in contrast to soils in the field situation. For example, low permeability soil layers (minimum Ks = 3 mm/year) in a multi-layer soil cover impede downward water movement; root dominated subhorizontal macropores enhance the downslope interflow through the soil; and roots extract the water from the soil which otherwise could percolate into the bedrock. We examine these mechanisms via rigorous 2D numerical modeling. The macropore is represented with a dual-permeability model. Evapotranspiration is simulated based on the atmospheric demand and the hydraulic conditions in the modeling domain. This work is aimed at improved understanding of water partitioning on hillslopes and distributed mountain block recharge in semi-arid areas.

H31G-07 1205h

The Role of Dry Soil Connectivity Barriers on Hillslope-Stream Connections

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Hydraulic connectivity on hillslopes can be an important control on runoff generation. In this study we investigate the relationships between annual soil moisture patterns, lateral hillslope flow, and streamflow in a semi-arid, snowmelt driven catchment. We identify five periods of soil moisture conditions: , 1) a summer dry period, 2) a transitional fall wetting period, 3) a winter wet, low flux period, 4) a spring wet, high flux period, 5) and a transitional late spring drying period. We then present a conceptual model of how streamflow is generated with respect to the moisture conditions, based on field studies and computer simulations. Transitions between the periods are driven by changes in the water balance between rain, snow, snowmelt and evapotranspiration. However, the transition from a dry moisture state to a wet moisture state is not necessarily synchronous with a switch from vertically dominated to laterally dominated flow. The climatic shift primes the catchment for lateral flow generation, but hydraulic connectivity within the hillslope is then dependent on the organization of that lateral flow, in this case along the soil/bedrock interface. The time lag between the dry-to-wet switch and the vertical-to-lateral switch occurs because the snowpack delays the delivery of water to the soil and the subsequent advance of the wetting to the base of deep soil zones. The resulting hydraulic disconnection at the soil-bedrock interface in the deep-soil regions of the catchment must be breached for significant lateral translation of water, pressure, and solutes occur.

H32A MCC: Level 1 Wednesday 1330h

Environmental Vadose Zone Hydrology Posters *(joint with B)*

Presiding: **M H Young,** Desert Research Institute**; T Harter,** University of California, Davis

H32A-0500 1330h POSTER

Tracing the Sources and History of Subsurface Contamination at the Hanford Site in Washington Using High-Precision Uranium Isotopic Measurements

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Groundwater contamination at the Hanford Site, Washington, resulted from decades of nuclear fuel production and processing. Understanding the fate and transport of contaminants has been complicated by the presence of multiple potential sources within relatively small areas. The contrasts in isotopic composition between natural and anthropogenic uranium promotes the measurement of uranium isotopic composition as a fingerprint and tracer of uranium contamination in the environment. In this study we focused on a uranium groundwater plume and two vadose zone U plumes associated with the B-BX-BY waste management area, used since the late 1940's for the storage of high-level radioactive waste. Groundwater U contamination was first detected in monitoring wells in the early 1990's. The groundwater plume (>30 ppb U) is currently approximately 250 m wide, at least 900 m long with U concentrations up to 525 ppb. The exact origin and history of this contamination is not well understood, since a number of tanks and incidents are potential sources. Using multiple collector ICPMS (Micromass IsoProbe) high precision uranium isotopic analyses were conducted of samples of vadose zone contamination and of groundwater. The measured isotopic compositions ($^{234}U/^{238}U$, $^{235}U/^{238}U$ and $^{236}U/^{238}U$) are used to distinguish contaminant sources, and are compared to a history of processed U fuel rod compositions. Based on the isotopic data, the groundwater plume appears to be related to a tank overflow event in 1951 that spilled high-level waste into the vadose zone. A second zone of identified vadose zone contamination does not seem to be an important contributor to the groundwater U plume. The variation in U isotopic composition of the groundwater samples is a result of mixing of contaminant U from the 1951 event and natural background U. The identified vadose zone contamination source is horizontally displaced from the initial locus of groundwater contamination, indicating that lateral migration within the vadose was at least 8 times greater than vertical migration. The time evolution of the groundwater plume suggests an average U migration rate of $\sim$0.7 m/day showing slight retardation relative to groundwater flow of $\sim$1 m/day.

H32A-0501 1330h POSTER

The effect of flow heterogeneity on the mobilization of colloids from metal-contaminated soils

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In vadose zone soils, colloid-facilitated transport has been shown to play a significant role in contaminant transport because colloids are abundant and the kinetics of contaminant desorption are likely to be slow relative to the time scale for colloid transport through the unsaturated zone. Understanding the rate of colloid generation and transport with respect to the surface area available for contaminant sorption and chemical composition of these colloids is critical for predicting colloid-facilitated transport. Soil cores (approximately 20 cm^3)obtained from the Arkansas River Valley in Leadville, Colorado, where there is significant metal contamination, were leached at three rainfall rates corresponding to 10-, 20-, and 100-year storm events. Effluent water samples were collected with a 2.5 cm spatial resolution at the base of the column. Samples were analyzed for colloid concentration, size and metal elements (Pb, Zn, Cu) in addition to Al, Si, and other metals. Despite significant variability in the spatial distribution of water flow, there was little to no variability in the rate of colloid generation, size of the colloids, or heavy metal generation within a time step. Generally, colloid size appeared to increase during the course of the experiments and greater concentrations of heavy metals were generated with increasing duration of each rainfall event.

H32A-0502 1330h POSTER

Tritium Phytoremediation at the Savannah River Site (SRS), USA: Water Management, Operations, and Research

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A sprinkler irrigation system is being utilized on a 22-acre upland forested area for the distribution of tritiated groundwater that is collected by a constructed pond before it can enter the Savannah River. Irrigation scheduling for the phytoremediation system is typically based on continuous soil water deficit calculations using observed rainfall data and estimated evapotranspiration. In situ measurements include soil water moisutre and water table depth. Vadose zone soil water samples are also collected for tritium analyses. Complex hydrological, biochemical, and ecological factors, as well as operations strategies, influence remediation system success. Factors that contribute to tritium remediation efficiencies, including relationships with irrigation volumes and frequency, as well as soil and vegetation types and characteristics within irrigation plots, are being evaluated. Related studies associated with the tritium phytoremediation project include vadose zone transport modeling and watershed scale water balance estimations. Data analyses from this project should aid in developing design criteria for future phytoremediation systems at SRS and other nuclear facilities.

H32A-0503 1330h POSTER

Low Permeability Layer Oxygen Barrier Method to remove nitrate from soil percolate: Effect of Temperature

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We are trying to develope a method to remove nitrate from soil percolate where high-concentration nitrate infiltrates into groundwater, for example, a site of land application olf wastewater. We construct a soil layer whose thickness is ranging from 1 cm to several inches and whose saturated hydraulic conductivity is approximately equal to the representative infiltration rate of the site. We call this a "Low permeability layer" because the permeability of this layer is usually much smaller than that of the original site. When water containing nitrate percolate into the soil, the low permeability layer becomes saturated and thus hinders the oxygen transport from the surface to the region below the low permeability layer. In a series of laboratory experiments, we found that this method can work, and that the obsereved nitrogen removal rate was much lower than that usually can be expected in fully anaerobic systems. In this report, we summarize the results of 2 years experiments and discuss the feasibility, limitation, and perspective of this method.

H32A-0504 1330h POSTER

Soil Leachates and Contaminant Mobilization

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In the past 30 years, the earth's northern climate has warmed appreciably. Mounting evidence suggests that climate warming is being amplified at the earth's polar regions. A warmer northern climate could lead to the gradual loss of circumpolar permafrost. Northern soils are estimated to contain 25-33% of the world's soil carbon, much of which is frozen in permafrost as poorly decomposed plant remains. Continued warming of the earth's climate would lead to the thawing of permafrost and the mobilization of organic matter. Dissolved organic matter in water can sorb contaminants, and may serve to mobilize them in surface and ground water. Understanding the origin of organic matter in water is important to our understanding of its chemistry and capacity to sorb and mobilize contaminants. Soil cores were collected from the Caribou Poker Creek Research Watershed (CPCRW) in July 2002. The soil cores were subjected to a laboratory leaching procedure. Soil leachates were analyzed by pyrolysis-gas chromatograph and mass spectrometry (py-GC/MS). This "molecular fingerprinting" analysis was used to help determine similarities and differences in organic matter leached from different areas in the watershed. As expected, preliminary results indicated that those cores with similar vegetation were more strongly correlated ($r > 0.95$) than those with dissimilar vegetation. Among the strongest correlated were the samples collected from areas containing spruce trees. However, the presence of aspen trees at a site caused the leachate to be statistically different, even if spruce trees were present. The results from this research will allow us to determine key differences in soil leachate composition. We seek to use this information to better understand the infiltration areas that produce organic matter with the greatest potential to mobilize contaminants.

H32A-0505 1330h POSTER

Carbon-14 Phase Partitioning and Transport in Unsaturated Sediments

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Wastes buried at the Radioactive Waste Management Complex (RWMC) of the Idaho National Engineering and Environmental Laboratory (INEEL) include activated metals that release radioactive ^{14}C as they corrode. To better understand ^{14}C phase partitioning and transport in the RWMC sediments, we conducted a series of transport experiments using ^{14}C (radiolabeled sodium carbonate) and non-reactive gas-phase (sulfur hexafluoride) and liquid-phase (bromide and tritiated water) tracers in a large (2.6-m high by 0.9-m diameter) sediment column. Steady-state unsaturated flow was established prior to injecting tracers into the column. Tracer migration was monitored in pore-water and pore-gas samples taken from co-located suction lysimeters and gas ports. One year after the ^{14}C injection, the column was cored and solid-phase ^{14}C activity was measured. ^{14}C measurements provide an average liquid-gas partition coefficient (Henry's law constant) of 4.0, an average liquid-solid partition coefficient (K_D) of 0.2 mL/g, and an activity mass balance of $\sim$94% (i.e., percent of injected ^{14}C). These determinations are consistent with values of the Henry's law constant (4 to 13) and K_D (0.4 mL/g) estimated prior to measurement of solid phase ^{14}C activity. The relatively good agreement between measured and estimated K_D values suggests the ability to estimate ^{14}C behavior, in the current system, based solely on liquid- and gas-phase activity measurements. The low partition coefficient values suggest that transport is effectively controlled by gas diffusion with minimal retardation by partitioning onto the solid phase, and little long-term retention. The implication for the RWMC is that ^{14}C released via corrosion of activated metals is primarily transported to underlying ground water and overlaying atmosphere in the gas-phase, rather than via downward liquid transport as was assumed by recent performance evaluation studies.

URL: http://www.inel.gov/esra/02portfolio/mesocarbon.shtml

H32A-0506 1330h POSTER

Sequestration of Metals by wet-dry Cycling of Soil and Soil Minerals at the Idaho Engineering and Environmental Laboratory (INEEL)

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The INEEL is the site of soil contamination by heavy metals and nuclides stemming from decades of nuclear waste processing, storage, and disposal. Much of the contamination is located within 1m of the surface, where contaminant movement can be influenced by the cyclic wetting and drying cycles that result from large amounts of infiltration in the spring followed by months of hot weather with little precipitation. We hypothesize that such wetting and drying cycles can retard contaminant migration by sequestering metals in less reactive phases. INEEL soil, quartz, goethite-coated quartz (Fe-quartz), andesine, Ca-montmorillonite, K-feldspar, calcite, smectite-illite, kaolinite and a no-matrix control were exposed to 200μM Cs, Sr, Cd, Cr, and U. After a two-week equilibration period, metals were analyzed using ICP-AES and ICP-MS. Samples were then evaporated to dryness and were subsequently re-wetted with air-equilibrated deionized water. This process was repeated four times; results were compared to continuously wet control samples. Preliminary results indicate that wet-dry cycling generally reduces metal availability, but the magnitude of the effect depends on the metal and the substrate with which it interacts. Control samples with no solid substrate showed no decrease in metal content throughout the experiment except for [U^{6+}-aq] and [Cd^{2+}-aq], which were oversaturated at the experiment's inception. The largest differences between wet-dry cycled samples versus their continuously wet counterparts occurred with U, Cd, and Cr. [U^{6+}-aq] was reduced by nearly 100% in cycled andesine samples compared to 25% in continuously wet control samples. [Cd^{2+}-aq] in cycled soil, Fe-quartz, quartz, and no matrix samples was up to 50% lower in concentration than that present in control samples. Results for [Cr^{6+}-aq] were similar, but with no difference in concentration for the no-matrix control. Differences in [Sr^{2+}-aq] and [Cs^{+}-aq] for cycled samples compared to control samples were largest for andesine and calcite. Concentrations of [Sr^{2+}-aq] and [Cs^{+}-aq] for cycled samples were 25-60% lower than that of control samples. Differences in wet-dry cycled clay samples compared to control samples for [Sr^{2+}-aq] and [Cs^{+}-aq] were present albeit smaller than that of andesine and calcite. Cycled samples were 1-5% lower in [Sr^{2+}-aq] and [Cs^{+}-aq] than was present in control samples. Microprobe analysis of soil and andesine suggests that Sr and Cs removal is controlled at least in part by ion-exchange with clays. X-ray diffraction evidence indicates that otavite and an unidentified U-bearing phase precipitate although the kinetics of precipitation are quite slow. Wet-dry cycling appears to enhance sorption processes; the impact of the process on transport and bioavailability will depend on reversibility and rates of reverse reactions.

H32A-0507 1330h POSTER

Efficacy of an Unsaturated Soil Flushing/Enhanced Bioremediation Technology

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Undesirably high concentrations of DDT and its daughter products DDE and DDD in some soils at Point Pelee National Park (PPNP) in Leamington, Ontario, Canada has resulted in restricted access to relatively large areas of the park. The contamination occurs primarily within the upper 20 cm thick Ah horizon, and has been linked to elevated levels within numerous local fauna. The common solution of "dig-and-dump" is not practical in this case since it would destroy the local protected ecosystem. Field trials conducted by McMaster University in partnership with Environment Canada, and Parks Canada have indicated that the application of solutions of cyclodextrin as a low-impact soil flushing/enhanced biodegradation remediation technology can remove a large proportion of DDT, DDE and DDD from the soil within a few months. Based upon previous studies at PPNP, the naturally occurring degradation processes would take decades to achieve the same mass loss. The cyclodextrin solutions exhibited a strong "tailing-effect" after approximately ten pore-volumes had passed through the Ah. There was an effect on soil hydraulic properties with decreased hydraulic conductivities and higher soil water retention, particularly where the higher concentration solutions were applied. The results indicate that soil flushing with cyclodextrin is highly effective to remediate pesticide contaminated soils. Additional work will quantify the relative amount of enhanced degradation versus mobilisation.

H32A-0508 1330h POSTER

Gas Push-Pull Test for In-Situ Quantification of Vadose Zone Microbial Activities

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Soils can act as a source or sink for greenhouse gases such as methane, carbon dioxide, and nitrous oxide. The dynamics of such gases in the subsurface is largely driven by microorganisms. To better understand greenhouse gas dynamics it is therefore necessary to quantify microbial activities and associated rates of gas transformation. Here we propose a novel field technique, the "Gas Push-Pull Test" (GPPT), for the in-situ quantification of vadose zone microbial activities. In a GPPT, a specified volume of a gas mixture containing one or more reactive gases (e.g., methane, carbon dioxide, oxygen) and non-reactive gas tracers (e.g., argon, neon, helium) is injected into the vadose zone at a desired location. Gas injection takes place through the perforated tip of a rod previously driven into the soil. Upon completion of the injection, flow is reversed and the gas mixture together with native soil gas is extracted from the same location. Rates of gas transformation are computed from the analysis of breakthrough curves obtained by measuring gas concentrations of tracers, reactants and/or metabolic products during extraction. In a first application, we present data on the quantification of vadose zone methanotrophic (i.e. methane-oxidizing) activity above the methanogenic zone of a petroleum-contaminated aquifer. In agreement with previously measured methane and oxygen profiles, first-order rate coefficients for methane oxidation during GPPTs ranged from 0.68 1/h at 110 cm below soil surface to 2.19 1/h near the groundwater table (290 cm below soil surface). Microbially-mediated methane oxidation was verified in an additional experiment in which acetylene was co-injected to inhibit methanotrophic activity, and by measuring shifts in stable carbon isotope ratios of methane (up to 40 per mill) during the

GPPTs. Gas push-pull tests should provide useful quantitative information on a range of different vadose zone microbial processes.

H32A-0509 1330h POSTER

Volatile Organic Compounds (VOCs) and Elevated Concentrations of Carbon Dioxide (CO2) in Unsaturated-Zone Vapors Near a Chemical and Low-Level Radioactivity Waste-Disposal Facility, Amargosa Desert Research Site, Nye County, Nevada

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As part of its Toxic Substances Hydrology Program, the U.S. Geological Survey is studying contaminant-transport processes in an arid environment at the Amargosa Desert Research Site (http://nevada.usgs.gov/adrs/). The site is near waste-disposal facilities 20 kilometers east of Death Valley National Park. Low-level radioactive waste was buried in unlined trenches of varying depth during 1962-92. Hazardous chemical waste was buried in unlined trenches at an adjacent facility during 1970-88. Mean annual precipitation at the site from 1981 to 2000 was 108 millimeters. The unsaturated zone is aerobic down to the water table, which is about 110 m (meters) deep. Sampling infrastructure south and west of the facility includes a grid of vapor probes 1.5 m deep, a 23.8-m-deep background borehole (JFDB), and two approximately 100-m-deep boreholes (UZB-2 and UZB-3), which are 160 m and 100 m from the nearest trench, respectively, and are instrumented for multilevel sampling. Analytes detected in unsaturated-zone-vapor samples include elevated concentrations of tritium and carbon-14; three chlorofluorocarbon (CFC) compounds, eight chlorinated solvent compounds, and toluene, all at concentrations exceeding 1,000 parts per billion (ppb) in UZB-3, and at lower concentrations in UZB-2 and in the shallow-vapor-probe grid; and CO2 in concentrations up to 2% in UZB-3, whereas maximum CO2 concentrations in JFDB are less than 0.2%. With the notable exception of toluene, VOCs that are known to be highly biodegradable are generally absent or occur at low concentrations (<100 ppb). The trends in the CO2 concentration profiles approximately parallel those of CFCs and radionuclides. The following preliminary conclusions have been drawn from the radionuclide, VOC, and CO2 data: 1. Biodegradation of organic substances is a reasonable explanation for the presence of CO2 in UZB-3 at concentrations greater those in JFDB (background), which are attributed to near-surface natural biological activity and abiotic geochemical processes near the water table. 2. Elevated CO2 concentrations and low concentrations (<1,000 ppb) of most biodegradable organic compounds in UZB-3 indicate that most of the degradation occurs near the waste trenches. 3. The VOCs that occur at high concentrations (>1,000 ppb) in UZB-3 are relatively recalcitrant to biodegradation in this environment. 4. The similarity among their vertical and radial concentration profiles indicates that the same vapor-transport phenomena are responsible for the observed elevated levels of CO2, hydrocarbons, and radionuclides. The CO2- and VOC-concentration data will be used to enhance ongoing efforts to develop process-based models of contaminant transport at the research site.

H32A-0510 1330h POSTER

Thermohydrologic Modeling of the Drift Scale Test in Partially Saturated Fractured Tuff at Yucca Mountain, Nevada

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Results of thermohydrologic modeling of the Drift Scale Test (DST) at Yucca Mountain show good agreement with field temperatures and liquid phase saturation during the heating as well as the cooling phases of the test. The DST is an ongoing large-scale thermal field test conducted by the US Department of Energy as part of the characterization of Yucca Mountain as a potential site of a geologic repository for high-level nuclear waste. The test location is 250 m below the ground surface, in fractured nonlithophysal Topopah Spring tuff, which is one of the host-rock units for the potential repository. The DST is one of a series of field-scale thermohydrologic tests designed to help investigators better understand the coupled thermohydrologic-mechanical-chemical processes that would occur in the host rock in response to the radioactive heat of decay from emplaced waste packages. The tests also provide data for the calibration and validation of numerical models used to analyze the thermohydrologic response of the near-field host rock and Engineered Barrier System (EBS). The rock was heated by nine floor heaters, placed along a 47.5-meter long heated drift, and arrays of wing heaters installed in horizontal boreholes on either side of the drift. A bulkhead separates the HD from the unheated section of the drift. Peak heater power during the heating phase was about 52 kW for the floor heaters and 135 kW for the wing heaters. The rock was heated for 4.1 years before all heaters were turned off on January 14, 2002. Monitoring of the cooldown phase is expected to last for at least four years. Using the NUFT code and the dual-permeability approach to representing fracture-matrix interaction, we utilize a half-symmetry model to simulate the thermohydrologic response of the rock to a heating and cooling cycle. The primary goals of the analysis were to study the heat-flow mechanisms and water redistribution patterns in the boiling and sub-boiling zones, and to compare model results with measured temperature and liquid-phase saturation data, and thereby evaluate rock property data sets available for modeling thermohydrologic behavior in the rock. We use a sensitivity analysis to examine the effect of data uncertainty on the results. We obtained a good match between model and observed temperatures, and found that the distinct dryout and condensation zones modeled above and below the heater level agreed fairly well with neutron measurements of liquid-phase saturation.

H32A-0511 1330h POSTER

A Practical Multifluid Flow Model Including Mobile, Residual, and Entrapped NAPL

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Flow of nonvolatile NAPL and aqueous phases that accounts for mobile, entrapped (water-occluded), and residual NAPL in variably saturated porous media is numerically modeled and compared against results from detailed laboratory-scale experiments. Residual saturation formation in the vadose zone is a process that is often ignored in multifluid flow simulators, which might cause an overestimation of the volume of NAPL that reaches the ground water. Mobile NAPL is defined as being continuous in the pore space and flows under a pressure gradient or gravitational body force. Entrapped NAPL is defined as being occluded by the aqueous phase, occurring as immobile ganglia surrounded by aqueous phase in the pore space and formed when NAPL is replaced by the aqueous phase. Residual NAPL is defined as immobile, non-water entrapped NAPL that does not drain from the pore spaces and is conceptualized as being either continuous or discontinuous. The numerical model is formulated on mass conservation equations for oil and water, transported via NAPL and aqueous phases through variably saturated porous media. To account for phase transitions, a primary variable switching scheme is implemented for the oil-mass conservation equation over three phase conditions: 1) aqueous or aqueous-gas with dissolved oil, 2) aqueous or aqueous-gas with entrapped NAPL, and 3) aqueous-free NAPL or aqueous-free NAPL-gas. Two laboratory-scale column experiments are modeled to verify the numerical model. Comparisons between the numerical simulations and experiments demonstrate the necessity to include the residual NAPL formation process in multifluid flow simulators. Pacific Northwest National Laboratory is operated by the Battelle Memorial Institute for the Department of Energy under Contract DE-AC06-76RLO 1830. This research is part of the Groundwater/Vadose Zone Integration Project funded through the U.S. Department of Energy's Richland Operations Office

H32A-0512 1330h POSTER

3D MRI Visualization of the Infiltration Outflow Experiment

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An automated experimental setup was built up to measure the flow of water through the soil sample located within the Magnetic Resonance (MR) scanner. A modified disc infiltrometer was used to adjust the boundary condition at the top of the sample. Free outflow was used as the bottom boundary condition. Pressure head was measured by tensiometer installed in the body of the sample. Values of hydraulic pressure head and cumulative flow data were recorded in time. Recurrent ponded infiltration-outflow and tension infiltration-outflow experiments were applied to two undisturbed samples (9 cm diameter, 8.5 cm height) of coarse sandy loam (Korkusova Hut, CZE). Water distribution within the samples during RPI was monitored using MR Imaging. Spin-echo protocol was used. The multiple slice horizontal 2D imaging was done during the steady state flow and during the equilibrium after drainage. The complete set of 2D images forms the 3D image of the soil core for each particular run. Also 3D matrices of MR parameters, namely signal intensity M and relaxation constant T1 were measured to evaluate the validity of MR signal of each voxel. Beside that, the internal structure of the soil cores was visualized by X-ray Computed Tomography. Preferential flow and a decrease of the steady-state infiltration rate between two successive infiltrations of RPI are typical for the soil studied. In this soil under near-saturation condition, significant preferential flow and initial-saturation dependent hydraulic properties have been regularly observed. It is hypothesized that the instable behaviour is mainly due to the air phase present within the sample. Data are used for evaluation of hydraulic characteristics for the dual permeability simulation model.

H32A-0513 1330h POSTER

Water Content Sensors For Use In Lab Columns

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Vadose zone hydrologic studies require accurate and reproducible estimates of the soil water content. When lab and field data need to be comparable, the use of the same sensor type in the field and lab would simplify the comparison process. We modified, built and calibrated 2 versions of electromagnetic sensors that are commonly used in the field, for use in 5 cm dia soil columns. The calibrations were found to depend on salinity levels and to benefit from the application of dielectric coating on the exposed electrodes. Both types of sensor were found to produce highly repeatable data typically +/- 0.0002 m^3/m^3.

H32A-0514 1330h POSTER

Comparisons of Bulk Dielectric Measurements of Tundra Moss Using 7 Different Technologies

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We seek correlations between measurements made by a variety of soil bulk-dielectric measurement devices in the two dominant moss types of Alaska's North Slope. In permafrost regions, the soil moisture content of the shallow subsurface exerts a critical control over the thermal properties regime of the deeper subsurface. The dynamics of land cover change are directly related to shifts in water balance and thus in moisture regimes in the shallow subsurface of the active layer. On Alaska's North Slope, soil moisture content data is being collected by a variety of research projects using numerous technologies, few of which are calibrated for soils high in organic content. We have carried out tests and calibrations for seven different soil moisture probes that measure moisture content using electromagnetic properties of the soil for Sphagnum and feather moss species. Two types of tundra cover the North Slope, Moist Acidic Tundra (MAT) and Moist Non-acidic Tundra (MNT), which differ in pH and in dominant bryophytic species. The dominant moss genus in the MAT and MNT are Sphagnum and feather moss species. All of the probes tested required a unique calibration equation for calculating water content from probe output, usually the bulk soil dielectric. The spatially weighted sensitivity of the sensor to the soil dielectric is one of the most important parameters influencing moisture measurement. We present calibration equations for each probe in the two moss types. The relationship between penetration depth and soil moisture levels is also considered with respect to optimum probe placement for ground-truthing of remotely sensed data. Ground-based and remotely sensed estimates of bulk dielectric are well-matched for comparison, as SAR remote-sensing also relies on the dielectric properties of the soil. The penetration depth of SAR microwaves has been found to be nonlinearly dependent on soil moisture, and small errors in field measurements can interfere with ground-truthing efforts. Thus one outcome of our research is to improve our ability to validate remote-sensing data, such that point measurements can more reliably interpolated to watershed-scales.

H32A-0515 1330h POSTER

Vadose Zone Sampling Methods for Detection of Preferential Pesticides Transport

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Leaching of agricultural applied chemicals through the vadose zone is a major cause for the occurrence of agrichemicals in groundwater. Accurate soil water sampling methods are needed to ensure meaningful monitoring results, especially for soils that have significant preferential flow paths. The purpose of this study was to assess the capability and the effectiveness of various soil water sampling methods in detecting preferential transport of pesticides in a strongly-structured silty clay loam (Hudson series) soil. Soil water sampling devices tested were wick pan and gravity pan lysimeters, tile lines, porous ceramic cups, and pipe lysimeters; all installed at 45 to105 cm depth below the ground surface. A reasonable worse-case scenario was tested by applying a simulated rain storm soon after pesticides were sprayed at agronomic rates. Herbicides atrazine (6-chloro-N^2-ethyl-N^4-isopropyl-1,3,5-triazine-2,4-diamine) and 2,4-D (2,4-dichloro-phenoxyacetic acid) were chosen as model compounds. Chloride (KCl) tracer was used to determine spatial and temporal distribution of nonreactive solute and water as well as a basis for determining the retardation in pesticides movement. Results show that observed pesticide mobility was much greater than would be predicted by uniform flow. Under relatively high soil moisture conditions, gravity and wick pan lysimeters had comparably good collection efficiencies, whereas the wick samplers had an advantage over gravity driven sampler when the soil moisture content was below field capacity. Pipe lysimeters had breakthrough patterns that were similar to pan samplers. At small plot scale, tile line samplers tended to underestimate solute concentration because of water dilution around the samplers. The use of porous cup samplers performed poorly because of their sensitivity to local profile characteristics: only by chance can they intercept and sample the preferential flow paths that are critical to transport. Wick sampler had the least variation, followed (in order) by pipe, tile, and cup samplers. This study has implications on determining best sampling method for monitoring agrichemicals where preferential flow paths are present.

H32A-0516 1330h POSTER

Water Flux Estimation by Multi Functional Heat Pulse Probe for Variably Saturated Sandy Soil

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A small multi-functional heat pulse probe (MFHPP) with 5 stainless tube that includes a heater, two vertically and two horizontally installed thermistors was developed for water flux density measurement. A heat pulse generated from heater tube was measured at thermistor tubes 6mm away from the heater. Vertically installed thermistor measurement was affected by water flow and the flux was estimated by analytical solution for heat conduction including convection. Volumetric heat capacity and thermal diffusivity were estimated at horizontally installed thermistor assuming effect of water flow was small. Parameter optimization was employed because parameters could be examined using many data points and are not affected by outliner or noise. Falling head hydraulic conductivity experiment and multi-step outflow experiment were conducted for saturated and unsaturated water flux estimation respectively. Results showed that volumetric water content calculated from volumetric heat capacity corresponded very well with gravitationally calculated water content for both static condition and transient flow ranging from 10-5 to 10-8 ms-1. Also thermal diffusivity corresponded well with the known thermal diffusivity. Saturated water flow was successfully estimated in the range from 6.5x10-7 to 1.7x10-4 ms-1. However, for unsaturated flow, estimation diverged systematically at lower than 10-6ms-1. This may be attribute to the resolution limit of thermistor measurement or uncertainty in thermal diffusivity measurement. As a whole, unlike traditional methods, this method does not require water potential and hydraulic conductivity measurements, but directly measures water flux at a single point. Moreover, water content and thermal diffusivity were substituted from horizontal measurement, thus required data were also obtained within the same volume. It is an advantage for field condition where water content or thermal properties are not always available.

H32A-0517 1330h POSTER

The Subsurface Flow and Transport Laboratory: A New Department of Energy User's Facility for Intermediate-Scale Experimentation

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Intermediate-scale experiments (ISEs) for flow and transport are a valuable tool for simulating subsurface features and conditions encountered in the field at government and private sites. ISEs offer the ability to study, under controlled laboratory conditions, complicated processes characteristic of mixed wastes and heterogeneous subsurface environments, in multiple dimensions and at different scales. ISEs may, therefore, result in major cost savings if employed prior to field studies. A distinct advantage of ISEs is that researchers can design physical and/or chemical heterogeneities in the porous media matrix that better approximate natural field conditions and therefore address research questions that contain the additional complexity of processes often encountered in the natural environment. A new Subsurface Flow and Transport Laboratory (SFTL) has been developed for ISE users in the Environmental Spectroscopy & Biogeochemistry Facility in the Environmental Molecular Sciences Laboratory (EMSL) at Pacific Northwest National Laboratory (PNNL). The SFTL offers a variety of columns and flow cells, a new state-of-the-art dual-energy gamma system, a fully automated saturation-pressure apparatus, and analytical equipment for sample processing. The new facility, including qualified staff, is available for scientists interested in collaboration on conducting high-quality flow and transport experiments, including contaminant remediation. Close linkages exist between the SFTL and numerical modelers to aid in experimental design and interpretation. This presentation will discuss the facility and outline the procedures required to submit a proposal to use this unique facility for research purposes. The W. R. Wiley Environmental Molecular Sciences Laboratory, a national scientific user facility, is sponsored by the U.S. Department of Energy's Office of Biological and Environmental Research and located at Pacific Northwest National Laboratory.

H32A-0518 1330h POSTER

Implementation of Automated Infiltration Soil Water Sampler: Application to Unsaturated Soil in Dune Fields

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Accurate measurement and sampling of infiltration water from root zone are necessary to understand soil and groundwater contamination processes. The traditional instruments for sampling water leaching below the root zone cause divergence or bypass of the water flow around the instrument itself. That results in undesired soil water profile and inaccurate sampling. A suction controlled lysimeter, which consists of porous plate connected to an automated vacuum system and tensiometers has developed. Soil matric pressure heads are measured just above the porous plate that installed horizontally and at the same depth in the natural soil profile. The vacuum system is automatically controlled so that the readings of the matric pressure heads match each other. This instrument does not disturb the water flow and the water sampling flux (qe) is almost similar to that of natural infiltration flux (qd). However, for sandy soils, porous plate would show some resistance to flow and soil water could easily accumulate above the porous plate. We improved the existing automated water sampler in order to measure the unsaturated zone in dune fields. High flow rate glass filters with different pore size; 0.02 to 0.03 mm (G3), 0.005 to 0.01 mm (G4), and 0.002 to 0.005 mm (G5) were studied in laboratory instead of the traditionally used porous plate. In the unsaturated steady-state water flow experiment, the value of vacuum pressure was set manually in reference to retention curve of dune sand. The water sampling flux measured by these samplers corresponded well with the irrigation flux (qi) when a suction of 60 cm H_2O was applied to G4 and G5 filters. Four different irrigation fluxes were studied. The average water collecting efficiency (WCE = qe divided by qi) was 118 percent for G4 and 147 percent for G5. We concluded that glass filter, especially, G4 filter was suitable as soil water sampler in dune fields. Finally, the improved sampler using G4 filter was buried into a lysimeter (120 cm high and 80 cm in diameter) to estimate WCE and compared qe with qd. Because most of the soil water in sandy soils is under the gravity force, relatively large suction brought over water sampling. Therefore, it is critical to reduce the over pumping. The quality of measurements and sampling will be determined by the design of the suction differences, release of excess suction and suction duration.

H32A-0519 1330h POSTER

Vadose-Zone Fluid and Solute Flux in Deep Arid Systems at the Nevada Test Site: Modeling the Effects of Climate Change, Plant-Soil Interactions, and Material Heterogeneity

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Understanding liquid and vapor fluxes in the vadose zone is necessary for assessments of both groundwater recharge and contaminant migration. However, direct measurement of such fluxes in arid vadose zones is virtually impossible. Therefore, they are estimated in this study using simulation techniques integrated with field and laboratory measurements of material properties, matric potentials, and environmental tracers. Compounding the problem, present-day fluxes are not in steady state. Rather, they represent ongoing responses to climate and vegetation changes that occurred tens of thousands of years ago, the exact timing of which is uncertain. Therefore, the simulations seek to reduce time-varying boundary condition uncertainty by coupling independent data sets highlighting different processes reflective of when the climate changed to the present warm, arid conditions at Frenchman Flat on the Nevada Test Site. As the climate changed to arid conditions, vegetation changes caused a major shift in the vadose-zone liquid flow patterns, as observed in matric potential and chloride profiles. As the climate changed to warmer conditions, stable isotopes of oxygen and hydrogen became enriched in the shallow soils due to increased evaporation. Thus, simulations seeking to match field observations address independent processes with the different data sets. Whereas chloride serves as a tracer for liquid-phase water only, the oxygen and hydrogen stable isotopes trace water movement in both liquid and gas phases. Flux estimates based upon chloride data are low and most sensitive to the timing of the climate change. Transport simulations for oxygen and hydrogen stable isotopes, which are dominated by vapor diffusion, indicate a shorter post-climate-change warm, dry period. Thus, if climate warming occurred concurrently with end of the pluvial period, the stable isotope simulation results support the lower present-day flux predictions. Most importantly for this study, the low estimated liquid and vapor fluxes suggest that diffusion of gas-phase contaminants is the more important process for contaminant migration assessment associated with shallow waste disposal.

H32A-0520 1330h POSTER

Field Observations of Fluid Transport in a Complex Heterogeneous Vadose Zone at the Idaho National Engineering and Environmental Laboratory (INEEL)

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Predicting fluid and contaminant transport in the vadose zone near the Idaho Nuclear Technology and Engineering Center (INTEC) at the INEEL has been problematic due to the complex geology underlying the site. In an attempt to better understand the controlling mechanism of subsurface fluid transport, a system of monitoring instruments were installed in boreholes around the perimeter of newly constructed percolation ponds, consisting of 2 cells each approximately 160,000 ft^2 in area. The instrumented region surrounding the ponds has been designated as the Vadose Zone Research Park (VZRP). Continuous discharge to the south cell began in October 2002 at an average flux rate of 1.5 million gallons per day and continued until July 2003 at which time the discharge was switched to the north cell. Hydraulic data were collected nearly continuously, monitoring hydraulic responses to discharge events to both cells. Discharge to the south cell resulted in rapid vertical percolation until reaching the surficial gravel/basalt interface (at about 60 ft below ground surface) at which time rapid lateral transport was observed in a southern direction. A near steady state of water levels was reached during this 10-month period. Switching discharge location only 100 feet to the north cell drastically altered hydrological conditions and flow paths within the subsurface. Recharge was observed in several new locations, while some locations ceased receiving water from the ponds entirely. Other locations temporarily drained, then received "new water" from alternate flow paths a few days later. Prior to switching discharge locations, 3 wells were installed in the north cell at depths of 7 ft, 12 ft, and 19 ft below ground surface. The wells were instrumented with electrical conductivity probes to monitor discharge from the INTEC facility, which receives a high conductivity spike every 12 hours from water softener regeneration. Field observations show that water reached the 7 ft well within a couple hours after the switch, while the other 2 wells remain dry even after one month. Based on these data, it appears that discharge to the north cell percolates vertically to a depth of approximately 10 ft before reaching a low permeability zone, which diverts flow laterally in a northern direction. Field observations of hydrological data indicate that initial water arrival times and locations appear to be controlled by low permeability zones and fast pathways. Arrival progression was neither vertically nor laterally sequential. Importantly, field observations indicate that minor transients in discharge flux and/or location resulted in extreme changes in fluid transport behavior. Based on these observations, it is apparent that our original steady-state conceptual model needs to be modified to incorporate not only lithologic complexities, but also temporal changes in discharge location and flux. Continued field monitoring combined with ongoing tracer testing at the VZRP is aimed at providing the information needed to improve predictive models designed specifically for complex heterogeneous subsurface environments.

H32A-0521 1330h POSTER

Transport Studies at the Vadose Zone Research Park, Idaho National Engineering and Environmental Laboratory: Results of Initial Tests

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The Vadose Zone Research Park (VZRP) provides a unique opportunity to investigate flow and transport in a thick, fractured and layered vadose zone. The VZRP includes two newly constructed percolation ponds each approximately 160000 square ft in area, which receive roughly 1.0 to 1.5 million gallons/day of uncontaminated process water. Monitoring wells and instrumented boreholes surround the percolation ponds. These are distributed in nested sets that allow continuous monitoring and sample collection along two important hydrologic contacts; one located at roughly 60' bls along a contact between alluvium and basalt and the other at 125' bls, along a sedimentary interbed in basalt. Both of these contacts support perched water zones. Hydraulic data have been collected nearly continuously since the first use of the percolation ponds in August 2002. Samples for geochemical studies were also collected during the first few weeks of discharge to the south pond to observe geochemical trends during initial wetting of the subsurface. During the summer of 2003, two tracer tests were performed. The first test consisted of injecting a conservative tracer (2,4,5-trifluorobenzoic acid) into the south pond, which had been receiving water for almost 10 months prior and for which hydraulic data indicated a steady state hydraulic system. The second tracer test was conducted in the north pond and consisted of simultaneous injection of two conservative tracers with different diffusion coefficients (2,4-difluorobenzoic acid, and Br- ion). Tracer injection coincided with the switching of water from the south to the north pond, which had been dry for 10 months prior. Thus, this test afforded us the opportunity to evaluate transport behavior in a relatively dry vadose zone, and to compare this to observed transport behavior under the earlier steady state, more saturated flow condition. Results from the first tracer test show tracer breakthrough in a shallow well, close to the south pond within approximately 30 hours with the peak at approximately 70 hours. In an adjacent, though deeper well located in a perched water zone at the 125' interbed, two tracer peaks were observed, one at approximately 50 hours and the other at approximately 200 hours, indicating multiple flow pathways and different travel times. Flow velocities calculated from this test are on the order of 100 m/day, in good agreement with velocities determined through hydraulic data. Initial results from the second tracer test show tracer recovery in at least four of the sampled wells. During this test, the discharge and four wells were also sampled for colloid concentration and particle size distribution. Colloid concentrations in the wells are roughly equivalent to, or larger than, those from the discharge and show sharp peaks up to an order of magnitude above background values. Comparison of colloid concentration data from the discharge, shallow wells located in the alluvium, and deeper wells in fractured basalt suggest that colloids are liberated in the alluvium and that advection through the fractured basalt does not affect the stability of the colloids. Preliminary tracer data show that tracer breakthrough in the monitoring wells occurred at similar times to colloid peaks. Further analytical work will yield breakthrough curves for the 2,4-tFBA that will be quantitatively compared with the colloid peaks.

H32A-0522 1330h POSTER

Effects of Surface Sealing, Soil Moisture Evolution, and Rainfall Intensity on Runoff From Hillslope Plots Burned by Wildfire

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The High Meadow Fire burned 43 square kilometers of mountainous semi-arid terrain southwest of Denver, CO during June of 2000. Burned areas like Hi Meadow are prone to extreme post-fire geomorphic responses including rill, sheet and channel erosion if the fire is followed by a significant rain event. As all of these processes are related to runoff development, it is important to develop accurate hillslope runoff models before developing erosion models. In this study, we examine the dynamics of near surface runoff-generation processes on burned hillslopes by integrating plot-scale measurements and physical models. In the summers (May-September) of 2002-2003, four 1 square meter plots were monitored for precipitation, soil moisture, sediment movement and runoff data. Sediment and runoff were collected on a daily basis, whereas soil moisture was collected every 15 minutes and the rainfall record was continuous. Measurements from the four plots were averaged to account for spatial variability. The largest rainfall event for which data were collected produced 0.026 m of runoff. The largest monitored events for which data were collected were of similar magnitude to those that have lead to catastrophic floods from burned areas in the past. Modeling of infiltration-excess processes using Richard's Equation were conducted to evaluate the effects of surface sealing from raindrop impact, soil moisture evolution and rainfall intensity. Soil particle size analyses, infiltration experiments, and soil moisture-suction curves were used to parameterize the models. The plot experiment results show the importance of antecedent soil moisture in runoff production. Modeling infiltration at this scale is the first step to predicting overland flow over entire hillslopes in burned regions.

H32A-0523 1330h POSTER

SPATIAL VARIABILITY OF FLOW IN COARSE, UNSATURATED MINING MATERIAL: RESULTS FROM FIELD-SCALE INFILTRATION EXPERIMENTS

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The spatial distribution of fluid flow during unsaturated conditions within an active gold mining heap-leach facility was studied. Flow and percolate chemistry data was recorded from free-drainage lysimeters. Highly variable flow was observed between lysimeters during steady-state infiltration conditions. The cause of the variability was determined to be more the result of highly spatially variable hydraulic properties than the variable distribution of applied flux to the surface. Using stochastically distributed hydraulic conductivity scaling factors, the variability of flow was reasonably reproduced with numerical simulations (HYDRUS-2D).

H32A-0524 1330h POSTER

Measured versus predicted recharge and bromide transport through a sandy soil in the San Joaquin Valley, California

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The unsaturated zone is a complex system of interacting processes that are often poorly characterized, making transport prediction inherently difficult. This study investigated the ability of Darcy-based models that included hysteresis, sedimentary heterogeneity, evapotranspiration (ET), and preferential flow to achieve accurate predictions of recharge and solute transport in a real-world setting. A natural-gradient bromide-tracer experiment was performed on a late-Pleistocene terrace deposit along the Tuolumne River in California. Bromide moved into the soil at the onset of the rainy season and then formed two peaks: one that continued moving downward into the profile, and one that reformed at the land surface. Sediment hydraulic properties were measured in the field and in the laboratory. Numerical models of water and solute movement allowed evaluation of various conceptualizations of the unsaturated flow system. Model outputs were compared to field measurements of matric pressure, moisture content, and bromide concentrations for the first eight months following application of tracer at the land surface. Prediction errors were large compared to measurement errors for all scenarios. The most consistent failures of the models were: (1) underestimation of the travel velocity of the downward-moving bromide peak, and (2) underestimation of matric pressures following passage of the wetting front. Realistic matches between model predictions and measured data could not be attained regardless of choice of retention-curve model or treatment of ET, hysteresis, or sedimentary heterogeneity. A composite-porosity preferential-flow model also failed to provide a match. Inclusion of hysteresis improved prediction of the surface bromide peak. Calibration of the hydraulic conductivity resulted in more marked improvements elsewhere, although the best match required conductivities roughly two orders of magnitude above measured values. None of the conceptual models captured all of the prominent features of the moisture, pressure, and concentration histories, illustrating the need for alternative models of unsaturated flow and transport.

H32A-0525 1330h POSTER

Field Measured Infiltration Fluxes at the Onset of Ephemeral Streamflow

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A variety of physical and chemical methods have been used to measure transmission losses and infiltration fluxes within large ephemeral streams in southern Arizona, USA. Often these methods are used to estimate a single infiltration flux for a streamflow event, typically measured during steady-state conditions. For long duration events this single estimate can be reasonable, but for short duration events (<24 hrs) typical of those in southern Arizona, infiltration fluxes at the onset of flow can differ substantially in magnitude from those throughout the duration of an event. Use of steady-state infiltration fluxes for short duration events can underestimate the true volume of infiltrated water if the magnitude of the fluxes at flow onset are larger than steady-state values and the duration of the initial transient period is long. For detailed water-budget analyses and hydrologic models dependent on accurate transmission-loss and infiltration-flux estimates, a more comprehensive event record that estimates these values throughout the duration of events is required. A two-dimensional array of water-content and temperature sensors was installed in Rillito Creek in Tucson, Arizona, for the purpose of measuring infiltration fluxes in situ during streamflow events. Infiltration fluxes measured at the onset of 25 streamflow events over a 3-year period ranged from 0.02 to 0.2 m/s in comparison to steady-state fluxes that ranged from $6x10^{-7}$ to $2x10^{-6}$ m/s. Fluctuations in antecedent soil-water content and fluid/sediment temperatures were examined as possible factors contributing to the observed range of onset fluxes. The average antecedent moisture content of the profiles for the 25 events varied from 0.16 to 0.33 m3/m3. Lower antecedent moisture contents were associated with higher onset infiltration fluxes. Average antecedent temperatures for the profiles ranged from 10^{o}C to 30^{o}C and were directly proportional to onset infiltration rates.

H32A-0526 1330h POSTER

Dynamic Measurement of Air Permeability as a Function of Water Content

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Determining the air permeability of a soil column as a function of water content is typically a tedious task because each measurement of permeability requires a constant water content over space and time. Between each individual measurement of permeability, the water content of the sample must be modified and allowed to equilibrate. A dynamic air permeability test is proposed that measures airflow rate, water content, and air pressure, while continually modifying the water content. Dry air is pumped into the inlet of an initially wet soil column, which slowly dries the soil within approximately 24-48 hours. A computer controlled gamma ray attenuation system measures and logs the water content along the length of the soil column over time. Hypodermic needles are inserted into the soil column and connected to pressure transducers, which measure the air pressure at multiple locations over time. An electronic flow meter logs the airflow rate over time. These measurements enable direct calculation of air permeability as a function of water content. Due to the large number of air pressure and water content measurements along the length of the soil column, the air permeability functions of individual layers can be distinguished from the remainder of the soil core. Because all measurements are computer controlled and logged, the system is completely autonomous.

H32A-0527 1330h POSTER

Influence of Air Discontinuity and Wall Effects on the Measurements of Hydraulic Parameters Under Dynamic Conditions

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Both dynamic (one-step) and semi-static (syringe pump) outflow experiments were carried out in the lab to test whether the resulting retention characteristics differed according to experiment type. Three sands of varying uniformity and coarseness were packed in a cylindrical sample holder. Compressed air was used to control the air phase pressure, while water was allowed to drain at atmospheric pressure from the outlet at the bottom of the sample. During the outflow experiments the capillary pressure was measured within the sample holder using a tensiometer connected to a pressure transducer. A medical CT-scanner was used to visualize and quantify the outflow patterns within the sand matrix during selected outflow experiments. Positive vertical shifts in capillary pressure during dynamic experiments were found in all three sand types at saturations close to porosity. The size and shape of the shifts corresponded with the dynamic effects found in previous work on the topic. Furthermore, the shifts were slightly greater in the coarsest and most uniform sand type. Numerical simulations of the one-step experiments using HYDRUS1D and T2VOC showed, however, that one of the basic assumptions when calculating the capillary pressure was most likely violated. The air phase could not be considered to be continuous at all times, and assuming this to be the case would result in positive shifts of the retention curves when running T2VOC. The results of using the CT-scanner showed the importance of achieving a homogeneous packing, since the investigated sand packing turned out to have an area at the edge of the sample holder with a higher porosity. This caused the edge to control the initial drainage. Therefore, the data collected at high saturations could not be expected to adequately describe the hydraulic properties of the inner sand. We also found that the time at which the inner sand commenced drainage coincided with a jump in capillary pressure for the resulting measured retention curve.

H32A-0528 1330h POSTER

Quantifying the Macroscopic Hysteresis Effect on Solute Transport in a Heterogeneous Sand Packing

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Under unsaturated conditions, water flow and solute transport in a soil material depend on the characteristic relationship between matric potential, water content and hydraulic conductivity. Due to pore size effects, these relationships can be hysteretic, i.e. dependent on preceding drainage and wetting processes. In porous media composed of different materials, an additional hysteresis phenomenon can be observed at the macroscale: it affects the permeability of the boundaries between the different materials and therefore the mass transfer through them. We performed solute transport experiments for different wetting and drainage conditions in a sand tank containing a heterogeneous structure composed by many layers of three sandy materials. Our purpose was to evaluate the effect of macroscopic hysteresis. For this reason we measured the water flow velocity, water content, spatial moments and the reactor ratio for several flow conditions. Being the total transport volume composed by unequal amounts of different sands, we also evaluated for each of them this amount. Some of the measured quantities showed a hysteretic behaviour and they can be indicators of the efficiency of the diffusion through textural boundaries.

H32A-0529 1330h POSTER

Generating Reproducible Heterogeneity for Laboratory Flow and Transport Experiments

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To understand the impact of heterogeneity on unsaturated flow and transport processes, many researchers have begun to conduct flow and transport experiments in laboratory analogues to heterogeneous geologic materials. Most of these experiments are conducted in macroheterogeneous media where homogeneous units are arranged to represent large-scale heterogeneity. However, most sedimentary media displays heterogeneity at a hierarchy of scales, the smallest of which is a stratum that is graded. Such stratification can lead to complicated wetted-phase structures that influence moisture retention, unsaturated hydraulic conductivity, access to surface area for reaction, and non-ideal transport. Because of the difficulty in reproducing “geologically realistic” microheterogeneity, the impact of small-scale stratification on flow and transport is difficult to evaluate using current laboratory constructed analogues. We have developed and evaluated a new approach for constructing reproducible, “geologically realistic” heterogeneity for laboratory flow and transport experiments. Using an apparatus with a computer-controlled arm, mixtures of sand are deposited in an experimental chamber through a tube. Mechanical grading processes within the tube and the chamber lead to stratification that mimics that produced by sedimentary processes. By varying the arm speed, stratum thickness and angle can be controlled. By using different sand mixtures, the grain size at the top and bottom of a stratum can be varied. Through the use of carefully designed computer programs, a variety of reproducible micro/macroheterogeneous structures can be produced.

H32A-0530 1330h POSTER

A Statistical Model for Predicting Unsaturated Hydraulic Properties of Deep Sediments at the Idaho National Engineering and Environmental Laboratory

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The development and application of property-transfer functions is an important approach for predicting unsaturated hydraulic properties from more easily measured bulk properties. At the Idaho National Engineering and Environmental Laboratory (INEEL), the unsaturated zone is comprised of thick basalt flow sequences interbedded with thinner sedimentary layers. Buried hazardous waste in the surficial soil is a possible source of contamination to the underlying Snake River Plain aquifer, which can be as deep as 200 m below land surface. Determining the unsaturated hydraulic properties of the sedimentary layers is one step in understanding water flow and solute transport processes through this complex unsaturated system. This study uses multiple linear regression analysis to construct simple property-transfer functions for estimating the water retention curve for deep sediments at the INEEL. The regression models were developed using laboratory measurements on 109 sediment core samples collected at depths of 9 m to 175 m at two facilities within the southwestern portion of the INEEL. These data included water retention measurements, the curve fit parameters for which are the dependent variables of the property-transfer functions, and bulk properties (such as bulk density and various representations of the particle-size distribution), which are the potential independent variables. The Rossi-Nimmo junction model was used to represent the water retention measurements. Three parameters define this retention curve model: 1) saturated water content (θ_{sat}), 2) a scaling parameter for matric pressure (ψ_o), and 3) a curve shape parameter (λ). The bulk property data and optimized hydraulic parameter values were used to develop a separate regression model for each parameter. The predicted parameters were then used to calculate the water retention curve from saturation to oven dryness. A selection process for the independent variables, referred to as "all possible subsets regression," was used to determine the best predictive model for each hydraulic parameter. Preliminary regression results show that textural class percentages were consistently better able to explain the hydraulic parameters than were other potential representations of the particle-size distribution. The adjusted coefficient of determination (adjusted R^2) for the best models, which consisted of some linear combination of textural class percentages and bulk density, ranged between 0.2 and 0.5 when all observations were included in the regression analyses. The residuals were close to normally distributed and were fairly homoscedastic when plotted versus the predicted dependent variable values. The low adjusted R^2 values may indicate that the bulk property data used in calibrating the models are not sufficient to completely predict the hydraulic parameters or may indicate significant measurement errors in the dependent or independent variables. Other bulk property data not available for calibrating the property-transfer functions, such as mineralogy, specific surface areas, or adsorption capacities, might correlate more strongly with the hydraulic parameters, and thus may be useful in future regression analyses. The property-transfer functions from this study provide a basis for development of a theoretical model that relies on physical relationships between the pore-size distribution and the bulk properties of the media and that should be more universal in its application throughout the INEEL and other geographic locations.

H32A-0531 1330h POSTER

Multi-Phase Flow at the Pore-Scale: Making Lattice Boltzmann Simulations fit Experimental Data

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In recent years significant progress has been made in the development of numerical models to describe flow and transport at the pore-scale. A promising modeling technique is the lattice Boltzmann method. However, the problem of how to identify appropriate lattice Boltzmann parameters and how to scale the simulations to comply with physical data is often not addressed. By looking at simple multi-phase flow systems we discuss the parametization and scaling issues. We make the link to real physical data by comparing simulations with observations of pore-scale two-phase flow. The experimental data consist of three-dimensional pore-scale images of oil-water drainage and imbibition experiments in a glass bead porous medium. The images were obtained at a resolution of 17 microns per voxel using the GSECARS microtomography beamline at the Advanced Photon Source, Argonne National Laboratory. From the images we compute fluid saturations and fluid-fluid interfacial areas enabling both a qualitative and quantitative comparison with lattice Boltzmann simulation results.

H32A-0532 1330h POSTER

Simulating Water Transfers at a Forest Field Site by Using Pedo-Transfer Functions

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Pedo-transfer functions (PTFs) are an essential building block for the modelling of water flow in soils. Many such functions have been developed for estimating the water retention curve and hydraulic conductivity from measured soil properties. Studies have previously been conducted to evaluate the performance of such functions against independent data sets obtained by laboratory measurements. Three PTFs, which have performed well in such studies, are here compared in the calibration and evaluation of a modified unsaturated flow model for forest soil water dynamics. This flow model is part of the multi-component reactive transport model MIN3P. The three functions perform similarly in reproducing the actual soil moisture data measured by TDR during about 3 years at different soil depths. All functions have difficulty simulating higher soil moisture contents. Improved results could be achieved by considering the presence of preferential flow paths. This has been simulated by implementing preferential flow schemes of varying complexity including an equilibrium flow scheme and a non-equilibrium flow formulation. The equilibrium approach, which involves a single permeability medium and a composite water retention curve, yields statistically the best results and is more flexible for calibration.

H32A-0533 1330h POSTER

Comparison of Aquifer Recharge Estimates Based on Measured and Estimated Hydraulic Properties

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Because unsaturated hydraulic properties, which are used to estimate recharge, are difficult and time consuming to measure accurately, models that estimate these properties indirectly are often used. Using data from six locations in southern New Jersey that appear to have steady-state flow conditions, five hydraulic property prediction and parameterization techniques were evaluated for recharge estimation. The unsaturated zone at this site, as in many coastal plain regions, is mainly sand to sandy loam in texture, which is considered a highly favorable case for soil hydraulic property estimation. Annual recharge has been estimated for several southern New Jersey watersheds by water budget methods and ranges from 33 to 49 cm/yr. Using these estimates as a gauge of reasonable values for steady flow, several indirect methods were compared to determine which are appropriate for recharge estimation in the coastal plain environment. The methods used in this study were: (1) simple power-law and hand-drawn curve fits to measured unsaturated hydraulic conductivity, (2) measured water retention and measured unsaturated hydraulic conductivity fit using the van Genuchten-Mualem model with fixed and optimized parameter values, (3) unsaturated hydraulic conductivity estimated from measured water retention with fixed and optimized parameter values, (4) estimation of water retention and hydraulic conductivity from bulk density and minimal textural information using the Rosetta pedotransfer function model, and (5) estimation of water retention and hydraulic conductivity using high resolution particle size distributions with the Arya-Paris and van Genuchten-Mualem models. Preliminary results show that while reasonable estimates can come from directly measured unsaturated hydraulic conductivity, the curve fitting method is critical because of the extreme non-linearity of the relationship between hydraulic conductivity and water content. Even a relatively good visual fit can lead to unreasonable recharge estimation values. A hand-drawn interpolation technique, and in some cases a simple power-law fit, yielded better results for these data than the van Genuchten-Mualem curve fit. In all cases, the Rosetta model lead to unreasonably high recharge estimates, primarily due to the over-prediction of saturated hydraulic conductivity. Water retention was predicted relatively well by the Rosetta Model. A combination of the Arya-Paris and van Genuchten-Mualem models also lead to over-prediction of recharge rates, and did not do as well as Rosetta in predicting water retention for this sandy material.

H32A-0534 1330h POSTER

Wave Propagation through Porous Media Containing two Immiscible Fluids

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Over the last three decades, an enormous amount of research has been dedicated to studying the physical mechanisms involved with elastic wave propagation and attenuation in fully saturated porous media. On the other hand, the modeling of elastic wave propagation and attenuation through unsaturated porous media has received little attention due to the complexity of developing an adequate theoretical representation. The current literature is lacking a mathematical model which simultaneously considers effects of inertial coupling and changes in capillary pressure in an Eulerian framework. The development of this kind of generalized theory can be undertaken in a systematic manner starting from momentum balance equations we have derived for immiscible two-phase fluid flows in deformable porous media. Based on our new model, a dispersion equation for the dilatational waves in unsaturated porous media was derived to describe how wave frequency depends on wavenumber. For a given wave frequency, we show analytically that there are three dilatational body waves existing in partially-saturated porous media. To gain insight into the fluid-dependent nature of three dilatational waves, a numerical simulation was performed to investigate the phase velocity and attenuation coefficient of three different modes of dilatational waves as functions of wave frequency and water saturation in Columbia fine sandy loam containing either water and air or water and oil.

H32A-0535 1330h POSTER

SPATIAL VARIABILITY OF SOIL HYDRAULIC PARAMATERS IN RELATION TO SEDIMENTARY FACIES

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The objective of this study is to evaluate the hypothesis that spatial heterogeneity of soil hydraulic properties can vary significantly with major stratigraphic units identified based on a visual texture determination of soil samples collected at the Kearney Research Site in Fresno, California. We used the concept of facies to characterize the heterogeneity of soil hydraulic properties that are defined in the form of van Genuchten model. Undisturbed and disturbed cores were collected from 60 boreholes drilled to a depth of 16 m in a nectarine orchard subject to a long-term nitrate

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experiment and were used to give a detailed subsurface sedimentologic description by color, texture, and moisture. Visual inspection was used to identify laterally continuous major stratigraphic units, referred to as facies. Undisturbed samples were originally grouped according to their core scale characterization of soil texture prior to conducting a multistep outflow experiment in conjunction with inverse modeling for laboratory determination of van Genuchten parameters. Correlations between the facies and van Genuchten parameters were tested by analysis of variance (ANOVA). Subsequently, Post Hoc Turkey HSD comparison technique was used to elucidate significant differences for the van Genuchten parameters between the facies and the correlations between facies for a given soil hydraulic parameter. Both ANOVA and pairwise comparisons suggested that facies bounding surfaces tend to separate regions with different soil hydraulic properties. In this application a facies-based approach provides a good basis to conceptualize subsurface heterogeneity.

H32A-0536 1330h POSTER

Hydraulic Property Determination of Vesiculated Soil Peds in Desert Pavement Environments

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Desert pavements are prominent features in arid and semi-arid environments, and can be found on a variety of landforms of significantly diverse ages ranging from Holocene to Tertiary. Desert pavements consist of a surface layer of closely packed gravel, typically one stone thick, that overlies a silt-rich vesicular A (Av) soil horizon. The vesicular horizon is composed of highly structured, prismatic soil peds, typically about 10 cm in diameter and less than 10 cm thick. Highly structured soils can greatly affect desert ecosystem development due to the impacts on local water balances. The concentration of silt and clay significantly reduces the infiltration rate and increases the water holding capacity, thereby reducing the penetration of wetting fronts. Field and laboratory studies were conducted to quantify the hydraulic properties of individual peds and pavement surfaces, and to ultimately use the information in a process-based evaluation of the soil moisture balance in arid environments. Field sites

H32A-0537 1330h POSTER

Mass Transfer Processes in Soils Containing Preferential Flow Networks : Experimental and Modeling Results

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Concurrent mass transfer processes through preferential flow pathways and other inter-aggregate voids contribute to non-ideal transport and complicate the prediction of water and solute fluxes in agricultural landscapes of the United States Midwest. To better understand these nonequilibrium transport processes in these soils, solute transport studies were conducted at the batch and column scales. In the batch study, bromide diffusion from several soil aggregates was monitored. Large diffusion rates measured in the batch study suggest that the inter-aggregate pores enhance solute diffusion to the interior soil matrix. This supposition was further supported by an estimated diffusion path length that closely matched the half-spacing of the soil peds. In the column-scale study, several miscible displacement experiments were performed at various levels of water saturation and input water flux using undisturbed soil cores from a corn/soybean field. Results show that the diffusive mass transfer at the column-scale is a non-hysteretic process. Estimated mass transfer rates, though still rapid, were slower than those estimated in batch diffusion experiments, most likely a result of more tortuous inter-aggregate pores and less continuity in the pore network. Based on numerical simulation of these experiments, it is concluded that these soils are dominantly comprised of two flow networks. The primary network of inter-aggregate pores and cracks enhance both diffusion and bypass flow at even modest levels of water unsaturation. When the soil approaches saturation, a secondary network of macropores formed from roots channels and earthworm holes overwhelms the preferential transport in the primary network to dominate the transport manifestation of water and solutes.

H32A-0538 1330h POSTER

Modeling Soil Moisture in Support of the Revegetation of Military Lands in Arid Regions.

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The National Training Center (NTC), the Army's primary mechanized maneuver training facility, covers approximately 2600 km^2 within the Mojave Desert in southern California, and is the subject of ongoing studies to support the sustainability of military lands in desert environments. Revegetation of these lands by the Integrated Training Areas Management (ITAM) Program requires the identification of optimum growing conditions to reestablish desert vegetation from seed and seedling, especially with regard to the timing and abundance of plant-available water. Water content, soil water potential, and soil temperature were continuously monitored and used to calibrate the Simultaneous Heat And Water (SHAW) model at 3 re-seeded sites. Modeled irrigation scenarios were used to further evaluate the most effective volume, frequency, and timing of irrigation required to maximize revegetation success and minimize water use. Surface treatments including straw mulch, gravel mulch, soil tackifier and plastic sheet

H32A-0539 1330h POSTER

Variations in Soil Salinity and Riparian Vegetation Coverage as Indicators of Stress in an Arid Watershed

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Soil salinity and riparian vegetation coverages of an arid area in northern Mexico through time were investigated. The study area comprises a 10 km segment of the lower Rio Conchos and surrounding undeveloped, non-irrigated land. The amount of area affected by salinity and the type of salinity were determined using EC (electrical conductivity) in conjunction with satellite images and corroborated by field analysis. The soil salinity derived from the remote sensing data was tied to precipitation, greenness of vegetation and water level of a nearby reservoir. The most appropriate method to assess soil salinity was found to be the selective principal component (SPCA) technique of Chavez and Kwarteng while the techniques utilized to discriminate vigorously-growing vegetation were tasseled cap transformation and the normalized difference vegetation index (NDVI). With this region undergoing a severe drought for the last ten years, the response of different parts of the ecosystem and changes in vegetation that so closely affect wildlife and other natural resources in this area can be better evaluated.

H32A-0540 1330h POSTER

Unsaturated Zone Tracer Test at the Bemidji, Minnesota Crude Oil Spill Site

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As a part of a study of the subsurface transport and natural attenuation of petroleum hydrocarbon contaminants at the Bemidji, Minnesota crude-oil spill research site, we used aqueous tracers to investigate solute transport from the soil surface through the crude oil-contaminated unsaturated zone to the water table. We applied tracer solution to the soil surface within a 5 by 12 meter tracer test plot that ran from a heavily oil-contaminated area to an oil-free zone. The depth to the water table was about 6 meters. The tracer test plot was instrumented with soil moisture probes, tensiometers, suction lysimeters, and drive-point sampling wells. Sixty liters of solution containing about 6.0E03 mg/l rhodamine WT and 1.0E04 mg/l bromide was uniformly sprayed on the soil surface in October 2001. We monitored subsequent tracer movement in response to precipitation by obtaining water samples weekly using the suction lysimeters in the unsaturated zone and the drive point wells in the saturated zone. Rhodamine concentrations were measured in the field using a fluorometer, and bromide concentrations were measured in the lab using ion chromatography. The time required for rhodamine tracer to reach the water table was 340 +/- 26 days. Travel times for bromide were about the same as for rhodamine, but the bromide data were less useful because the maximum bromide concentrations observed in the wells were close to background values. Rhodamine travel times through the oily unsaturated zone were not significantly different from the travel times through the oil-free unsaturated zone. However, the peak rhodamine concentrations found in ground-water samples obtained below the oil zone were an average of 3 times larger than the peak rhodamine values beneath the oil-free zone. We hypothesize that the rhodamine was adsorbed less in the oil-contaminated zone than in the oil-free zone because iron-containing minerals that absorb rhodamine have been largely removed from the oily sediments as a consequence of reducing conditions caused by the natural microbial degradation of the oil. It is also possible that the tracer solution flowed through the hydrophobic soil in the oil-contaminated area primarily in preferential pathways, bypassing much of the rhodamine-adsorbing sediment.

H32A-0541 1330h POSTER

Plume-Scale Testing of a Simplified Method for Detecting Tritium Contamination in Plants and Soil

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Research at the Amargosa Desert Research Site near Beatty, Nevada indicates that tritium movement from a closed low-level radioactive waste facility occurs primarily in the gas phase with preferential transport through coarse-textured sediment layers. However, models for movement of tritiated water vapor at the site fail to predict the extent of transport indicated by field measurements. In order to develop a better understanding of the spatial distribution of tritium contamination in the near-surface environment adjacent to the waste facility, a recently published tritium contamination-detection method was tested for collection and analysis of plume-scale data. The method entails solar distillation of plant water from foliage, followed by filtration and adsorption of scintillation-interfering constituents on a graphite-based solid-phase-extraction column prior to direct-scintillation counting. Samples were collected from 103 plants (creosote bush; *Larrea tridentata*) within a 72-ha area adjacent to the waste facility. Plant data showed elevated tritium concentrations up to 300 m from the waste facility. For a small ($\sim$ 8 ha) area where high-density soil-water vapor data were already available, plant-based and soil-based concentration contours compared favorably. Plant data for previously unmeasured areas identified "hot spots" that were later verified by direct soil measurements. Regression analysis of tritium concentrations from collocated plant- and soil-sampling sites showed that empirical relations could be developed to predict soil concentrations (y) from the more simply determined plant concentrations (x): e.g., the equation for root-zone soil concentrations (Bq/L) was $y = 1.156\ x + 55.17$ ($r^2 = 0.9521$; SEE = 250). Results of this work have improved knowledge of the extent of tritium contamination in the near-surface environment. The pattern of the tritium concentrations indicated that the observed contamination originates from two sources–the waste-burial trenches and surface spills inside the waste facility. A study is now underway to estimate the flux of tritium from the subsurface to the atmosphere. The approach includes a combination of (i) periodic measurement of tritium concentrations in soil, plants, and air at selected sites, (ii) mapped tritium distributions, and (iii) continuous measurement of evapotranspiration.

URL: http://nevada.usgs.gov/adrs/

H32A-0542 1330h POSTER

Simulating Remediation of CO_2 Leakage from Geological Storage Sites

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One strategy to reduce net greenhouse gas emissions is to inject carbon dioxide (CO_2) deep into subsurface formations where presumably it would be stored indefinitely. Although geologic storage formations will be carefully selected, CO_2 injected into a target formation may unexpectedly migrate upwards and ultimately seep out at the ground surface, creating a potential hazard to human beings and ecosystems. In this case, CO_2 that has leaked from the geologic storage site is considered a contaminant, and remediation strategies such as passive venting and active pumping are needed. The purpose of this study is to investigate remediation strategies for CO_2 leakage from geologic storage sites. We use the integral finite-difference code TOUGH2 to simulate the remediation of CO_2 in subsurface systems. We consider the components of water, CO_2 and air, and model flow and transport in aqueous and gas phases subject to a variety of initial and boundary conditions including passive venting and active pumping. We have investigated the time it takes for a gas plume of CO_2 to be removed from the vadose zone both by natural attenuation processes and by active extraction wells. The time for removal is parameterized in terms of a CO_2 plume half-life, defined as the time required for one-half of the CO_2 mass to be removed. Initial simulations show that barometric pressure fluctuations enhance the removal of CO_2 from the vadose zone, but that CO_2 trapped near the water table is difficult to remove by either passive or active remediation approaches. This work was supported by a Cooperative Research and Development Agreement (CRADA) between BP Corporation North America, as part of the CO_2 Capture Project (CCP), and the U.S. Department of Energy (DOE) through the National Energy Technologies Laboratory (NETL), and by the U.S. Department of Energy under contract DE-AC03-76SF00098.

H32A-0543 1330h POSTER

Modeling CO_2 and Carbon-Isotope Dynamics in a Deep Unsaturated Zone Near Beatty, Nevada

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Natural unsaturated-zone gas profiles at the Amargosa Desert Research Site near Beatty, Nevada show an increase in the partial pressure of CO_2 (PCO_2) from ~36 Pa at the land surface to ~900 Pa at the 110-m deep water table. The CO_2 profiles show generally increasing δ^{13}C values with depth, from a time-weighted-average $-18^o/_{oo}$ in the root zone to $-14^o/_{oo}$ at the water table, and strongly decreasing ^{14}C activities, from 120 percent modern carbon (PMC) in the root zone to 20 PMC at the water table. Field data suggest the presence of two CO_2 sources, one shallow and one deep. The shallow source results from seasonally variable respiration in the root zone. The deep source is located near the water table, and is presumed to represent steady production associated with calcite precipitation. We use a geochemical gas-diffusion model to better quantify CO_2 production and partitioning between shallow and deep sources. The model was developed by coupling the geochemical equilibrium model PHREEQC with a finite-difference gas-diffusion algorithm. The individual isotopic species of CO_2 are treated as separate chemical components that diffuse and react independently. Because shallow and deep sources are isotopically distinct, the measured δ^{13}C and ^{14}C profiles help constrain model solutions. Shallow CO_2 production reflects the isotopic influence of biological processes that include root respiration and metabolism of modern soil carbon. Deep CO_2 production reflects the isotopic composition of old groundwater (20 PMC). Model simulations run to steady state indicate that the shallow CO_2 source from root and microbial respiration comprises ~97% of the total CO_2 annual average production at this arid site. Despite the relatively small contribution from groundwater (~0.1 mol CO_2 m^{-2} yr^{-1}), upward diffusion from this source strongly influences the distribution of CO_2 and carbon isotopes in the deep unsaturated zone. Transient simulations for seasonally varying soil-respiration rates establish profile-perturbation depths as a function of time for PCO_2, δ^{13}C, and ^{14}C. The new model of carbon-isotopic profiles provides a quantitative understanding of isotopically distinct fluxes prerequisite for analyzing migration of $^{14}CO_2$ from radioactive waste in deep unsaturated zones.

H32A-0544 1330h POSTER

Simulating CO_2 Leakage and Seepage From Geologic Carbon Sequestration Sites: Implications for Near-Surface Monitoring

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The injection of CO_2 into deep geologic formations for the purpose of carbon sequestration entails risk that CO_2 will leak upward from the target formation and ultimately seep out of the ground surface. We have developed a coupled subsurface and atmospheric surface layer modeling capability based on TOUGH2 to simulate CO_2 leakage and seepage. Simulation results for representative subsurface and surface layer conditions are used to specify the requirements of potential near-surface monitoring strategies relevant to both health, safety, and environmental risk assessment as well as sequestration verification. The coupled model makes use of the standard multicomponent and multiphase framework of TOUGH2 and extends the model domain to include an atmospheric surface layer. In the atmospheric surface layer, we assume a logarithmic velocity profile for the time-averaged wind and make use of Pasquill-Gifford and Smagorinski dispersion coefficients to model surface layer dispersion. Results for the unsaturated zone and surface layer show that the vadose zone pore space can become filled with pure CO_2 even for small leakage fluxes, but that CO_2 concentrations above the ground surface are very low due to the strong effects of dispersion caused by surface winds. Ecological processes such as plant photosynthesis and root respiration, as well as biodegradation in soils, strongly affect near-surface CO_2 concentrations and fluxes. The challenge for geologic carbon sequestration verification is to discern the leakage and seepage signal from the ecological signal. Our simulations point to the importance of subsurface monitoring and the need for geochemical (e.g., isotopic) analyses to distinguish leaking injected fossil CO_2 from natural ecological CO_2. This work was supported by the Office of Science, U.S. Department of Energy under contract No. DE-AC03-76SF00098.

H32A-0545 1330h POSTER

Characterization of Soil Moisture Variability Along a Hillslope in a Semiarid Catchment, Dry Creek Watershed, Boise, Idaho

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The spatial and temporal distribution of soil moisture exerts significant control on hillslope hydrologic processes. Recent research has identified the need for soil moisture data collection at the point scale to assist calibration and validation of remote sensing data, to facilitate understanding of soil water fluxes, and for modeling of hillslope hydrologic processes. The objectives of this research were to describe the temporal and spatial distribution of soil moisture in a 0.02 square kilometer semiarid catchment in the headwaters of the Dry Creek basin near Boise, Idaho, and to collect soil water content data to assist the calibration and validation of a shallow soil hydrologic model for forecasting streamflow initiation and hillslope hydrologic processes along the Boise Front, Boise, Idaho. Additionally, the results of the study may be applied to the investigation of shrub encroachment in shrub-grass ecotones along the Boise Front relative to changes in soil moisture. Near-surface soil moisture data was collected using time domain reflectometry (TDR) along a 10 x 20 meter grid in a 0.02 square kilometer catchment (Upper Dry Creek study area) in the Boise Foothills. Results suggest that slope position and shape are the dominant topographic influences on soil moisture at the Upper Dry Creek site. Upper slopes were well drained, and middle to lower slopes represented a convergence of lateral subsurface flow. Soil moisture content on concave and convex slopes was greatest in the middle and lower elevations following snowmelt and in the upper and lower elevations during drydown. Results indicate that lateral unsaturated subsurface flow on steep concave and convex slopes (non-local control) is the mechanism for the distribution of soil moisture in the Upper Dry Creek study area during snowmelt.

H32B MCC: Level 1 Wednesday 1330h

Early Results From NASA's EOS Aqua Spacecraft Mission V Posters

(joint with A, OS)

Presiding: **S M Graham,** NASA Goddard Space Flight Center**; T S Pagano,** Jet Propulsion Laboratory, California Institute of Technology

H32B-0546 1330h POSTER

MODIS Albedo and Surface Reflectance Products From Combined Aqua and Terra Processing

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The combined Terra and Aqua MODIS BRDF/Albedo product (MCD43) has been operational and running in parallel with the standard Terra-only MODIS BRDF/Albedo product (MOD43) since June 2003. The same algorithm is being used to produce both sets of products (BRDF model parameters, white-sky and black-sky albedo, and Nadir BRDF-Adjusted Reflectance (NBAR)) although, in the case of the combined product (MCD43B4), two NBAR values are supplied at each location - one at the mean time of the Terra overpass and a second at the mean time of the Aqua overpass. Initial comparisons demonstrate how the addition of supplementary cloud-free surface observations from Aqua improve the sampling of the surface anisotropy and lead to a larger number of high quality full inversion retrievals across the globe. Presentation of comparisons between Terra-only and the Terra-plus-Aqua albedos and coincident field validation data from the SURFRAD/BSRN tower sites will also be made.

H32B-0547 1330h POSTER

AMSR-E Swath to Grid Toolkit

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The AMSR-E Swath to Grid Toolkit (AS2GT) is a suite of software tools to subset and grid Levels 1b and 2a AMSR-E swath data. Gridding options include control over the map projection, resolution, and dimensions of the output grid, selection of resampling method, choice of how to handle overlapping swaths, and subsetting by time or region. These tools make it easy to process data into custom grids with whatever time or spacial resolution you require. For example you could grid each individual overpass in your field study at full 5 or 10km resolution or you could create 3 day averages for the entire globe at 1/4 degree. AS2GT and its close relative, the MODIS Swath to Grid Toolkit (MS2GT), use the same configuration files to describe

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