Q-Branch, which is related to CO2 abundance, and marine aerosol using the difference between the apparent surface temperature deduced from the 2616cm-1 window channel and the NCEP RTGSST product. Both sequences show unexpected global patterns and seasonal variability. The seasonal variability of the depth of the CO2 Q-Branch reveals patterns which may be related to fossil fuel burning, but still need to be confirmed by quantitative analysis.

H31A-03 0830h

Atmospheric Soundings from AIRS/AMSU/HSB

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AIRS was launched on EOS Aqua on May 5, 2002, together with AMSU A and HSB, to form a next generation polar orbiting infrared and microwave atmospheric sounding system. The primary products of AIRS/AMSU/HSB are twice daily global fields of atmospheric temperature-humidity profiles, ozone profiles, sea/land surface skin temperature, and cloud related parameters including OLR. The sounding goals of AIRS are to produce 1 km tropospheric layer mean temperatures with an RMS error of 1K, and 1 km layer precipitable water with an RMS error of 20 percent, in cases with up to 80 percent cloud cover. The AIRS data products are significant for studying climate variability and change, as well as for use in initialization of General Circulation Models with the objective of improving analysis fields and subsequent forecast skill. Data assimilation experiments to evaluate the impact of AIRS retrievals on analysis and forecast skill are being conducted. Sample fields of parameters retrieved from AIRS/AMSU/HSB data will be presented and validated as a function of fractional cloud cover. Select fields will also be compared to those contained in the ECMWF analysis, done without the benefit of AIRS data, on both an instantaneous and monthly mean basis, to demonstrate information that AIRS can add to that already contained in the ECMWF analysis.

H31A-04 0845h

Tropospheric O_3 Retrievals from the Baltimore Bomem Atmospheric Emitted Radiance Interferometer (BBAERI) during AIRS Validation

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We present the first results of an algorithm to retrieve tropospheric ozone abundances from the 1000 to 1100 cm^{-1} region of infrared spectra. This retrieval algorithm will be used to monitor tropospheric ozone levels and, in conjunction with meteorological observations, to determine the origins of the observed ozone. Our instrument, BBAERI, was built by ABB Bomem of Quebec, Canada and delivered to the University of Maryland, Baltimore County (UMBC) in March 2000. BBAERI's maximum optical path difference of 1 cm yields an apodized resolution of 1 cm^{-1}. Strong emission/absorption in the 10 μm region of the infrared (1000-1100 cm^{-1}) results from the ν_3 vibrational rotational transitions in the ozone molecule and gives rise to the spectral feature of interest. Spectral line spacing and pressure broadening do not allow an instrument of this resolution to resolve any of the lines, just the band shape. The retrieval consists of a statistical regression using eigenvector decomposition to constrain the solution. Regression coefficients are calculated from 2730 ozonesonde profiles varying in latitude from 25^oS to 65^oN. The regression is followed by a physical retrieval utilizing the K Compressed Atmospheric Radiative Transfer Algorithm (KCARTA) developed by Dr.L.Larrabee Strow and his group at UMBC. Validation results will be presented from field measurements taken in Huntsville Alabama November 2002 and the AIRS BBAERI Ocean Validation Experiment (ABOVE) at the Chesapeake Lighthouse June 2003. Ozonesondes used for validation were flown by Dr.Mike Newchurch, Mohammed Ayoub and Jing Song from The University of Alabama Huntsville. Additional ground ozone measurements were supplied by Dr.Eric Hintsa from Woods Hole Oceanographic Institution (WHOI).

H31A-05 0900h

Feasibility of Sensing Tropospheric Ozone with MODIS 9.6 μ Observations

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With the infrared observations made by the Moderate Resolution Imaging Spectrometer (MODIS) on board the EOS-Aqua satellite, which include the 9.73μ channel, a method is developed to deduce horizontal patterns of tropospheric ozone in cloud free conditions on a scale of about 100 km. It is assumed that on such small scale, at a given instant, horizontal changes in stratospheric ozone are small compared to that in the troposphere. From theoretical simulations it is found that uncertainties in the land surface emissivity and the vertical thermal stratification in the troposphere can lead to significant errors in the inferred tropospheric ozone. Because of this reason in order to derive horizontal patterns of tropospheric ozone in a given geographic area a tuning of this method is necessary with the help of a few dependent cases. After tuning, this method is applied to independent cases of MODIS data taken over Los Angeles basin in cloud free conditions to derive horizontal distribution of ozone in the troposphere. Preliminary results indicate that the derived patterns of ozone resemble crudely the patterns of surface ozone reported by EPA.

H31A-06 0915h

Characteristics of Water Vapor Under Partially Cloudy Conditions: Observations by the Atmospheric Infrared Sounder (AIRS)

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The variability and quality of tropical water vapor derived from the Atmospheric Infrared Sounder (AIRS) are characterized. Profiles of water vapor, temperature and surface characteristics (states) are derived from coincident Advance Microwave Sounding Unit (AMSU) and 3x3 sets of AIRS footprints. States are obtained under partially cloudy conditions by estimating the radiances emitted from the clear portions of the AIRS footprints. This procedure, referred to as cloud clearing, amplifies the measurement noise, and the amplification increases with cloud amount and uniformity. Cumulus and stratus cloud amount are related to the water vapor saturation, and noise amplification and water vapor amount may be partially correlated. The correlations between the uncertainty of retrieved water vapor, cloudiness and noise amplification are characterized. Retrieved water vapor is generally good when the amplification is less than three. Water vapor profiles are compared with correlative data, such as radiosondes and numerical weather center analyses and are in relatively good agreement in the lower troposphere

H31A-07 0930h

Measurements of Water Vapor and High Clouds Using Both the Aqua and Terra MODIS Instruments

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At present, the Moderate Resolution Imaging Spectrometer (MODIS) instruments on board both the Aqua and Terra Spacecraft platforms are collecting scientific data. MODIS has five channels located within and around the 0.94-micron water vapor band absorption region for remote sensing of water vapor. MODIS also has a narrow channel centered at 1.375 micron for remote sensing of high clouds. We have compared the near-IR water vapor products and cirrus cloud reflectance products derived from the Aqua and Terra MODIS data. The results will be presented. We have found that the Aqua MODIS cirrus cloud reflectances over certain geographical regions, such as the Tibetan Plateau and central Africa, are consistently greater than the Terra MODIS cirrus reflectances over the same regions.

H31A-08 0945h

Large-scale Transport of Carbon Monoxide as Observed by AIRS on Aqua

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We present the first observations of large-scale transport of tropospheric Carbon Monoxide (CO) as observed by the Atmospheric InfraRed Sounder (AIRS) onboard the Aqua satellite. Tropospheric CO abundances are retrieved from the 4.67 micron (2180 cm^{-1}) region of AIRS spectra in the 1-0 vibration-rotation band using the operational AIRS full retrieval algorithm running in research mode. In September 2002, locally enhanced CO amounts, correlated with MODIS fire counts in South America and Africa, are advected over the South Atlantic in qualitative agreement with previous airborne observations during TRACE-A. Back trajectory analysis confirms the general transport mechanisms while future investigation will focus on detailed chemical transport modeling. Additional transport off the southeast coast of Africa similar to the 2000 "river of smoke" episode also was observed during September 2002 in the AIRS CO retrievals.

H31B MCC: Level 1 Wednesday 0830h

Hydrogeophysics: Characterization and Monitoring of Subsurface Parameters and Processes III Posters

(joint with NG, MR)

Presiding: **A Binley,** Lancaster University**; T P Ferre,** University of Arizona

H31B-0445 0830h POSTER

Experimental Design Considerations for Estimating Flow Parameters with GPR and Hydrological Measurements

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Using a method recently developed in our group for estimating flow parameter distributions in the vadose zone with transient ground-penetrating radar (GPR) data (such as travel times or inferred values of water saturation) and hydrological data, we investigate various issues of experimental design for parameter estimation. Specifically, an extension of the pilot point

method was recently implemented in the iTOUGH2 software (Finsterle, 1999) so that GPR measurements collected during a transient flow event could be used to estimate distributions of flow parameters (Kowalsky et al., 2003). Using this approach, we examine the impact that ponding conditions, temporal sampling strategies, increasing degrees of soil heterogeneity, and varying soil characteristics have on parameter estimation uncertainty.

H31B-0446 0830h POSTER

Improving Estimates of Subsurface Water Content by Accounting for Saturation-Related Anisotropy

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Ground-penetrating radar tomographic methods are commonly used to obtain EM wave velocities in the subsurface, which are then transformed into estimates of soil water content using rock physics relationships. In most cases, velocity anisotropy is not accounted for in this process. That is, the earth is usually represented as a collection of isotropic, constant-velocity cells during the tomographic inversion of radar travel time data, and anisotropy information is not used when transforming velocities to water content. In cases where velocity anisotropy in the subsurface is significant, however, the inversion of travel time data under an isotropic assumption can result in serious artifacts; false heterogeneity can be produced because we attempt to fit an anisotropic medium with a series of isotropic cells. Further, not providing anisotropy information in the transformation from velocity to water content results in greater uncertainty in the water content values obtained. By accounting for velocity anisotropy in both the tomographic inversion and rock physics steps, we can improve estimates of subsurface water content obtained from radar tomographic data. A material consisting of thin isotropic layers is equivalent, in the long wavelength limit, to a homogeneous but anisotropic medium. Numerical modeling of 1-D coarse/fine layered systems under the assumptions of effective medium theory and capillary equilibrium indicates that, in the saturated zone, velocity anisotropy is likely unimportant because changes in velocity between layers result largely from porosity differences, which are minor. In the vadose zone, however, significant velocity anisotropy can result in layered systems due to the strong dependence of dielectric properties on saturation, and the pronounced saturation heterogeneity that can exist. As the overall saturation in the vadose zone decreases, fine-grained layers preferentially retain water while coarse-grained layers preferentially drain; this enhances the velocity contrast between the layers. Here, we investigate these results in the field through the anisotropic inversion of crosswell radar data collected near Abbotsford, British Columbia. We wish to examine under which circumstances it is important to account for velocity anisotropy in the tomographic determination of water content. Using an anisotropic, 1.5-D inversion code that incorporates ray tracing to determine ray paths from source to receiver, we compare velocity anisotropy in the vadose zone with that in the saturated zone.

H31B-0447 0830h POSTER

Estimating Saturation with Depth in the Vadose Zone of Volcanic Ash Deposits

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Surface geophysical measurements were conducted in a vast area of compacted ash deposits on the island of Dominica, West Indies. The seismic refraction data can be modeled as a power law velocity increasing with depth to the water table. Conversely, the electrical resistivity data fits a power law increasing in height from the water table. These two datasets/models are combined using basic rock physics models to predict the level of saturation from the surface to the water table. The geophysical predictions are compared to civil-engineering saturation profiles with depth.

H31B-0448 0830h POSTER

Push-Pull Test with Resting Phase as a Method to Estimate Hydraulic Parameters

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Groundwater velocity estimate from a drift pump back teset change depending on the length of drift time. Generally, smaller velocity estimates are obtained when the drift time increases. Push pull test is an injection and withdrawal test and the dispersivity estimates from the push pull test without drift time are usually smaller than those from the radially convergent-flow tracer test. In order to resolve these differences, we performed push pull tests for various resting phases. An analytical solution and moment value are obtained to analyze the push-pull test data with resting phases. Tracer tests with bromide ion as a tracer were performed under various resting conditions. The test results are compared with those obtained from natural-gradient and convergent-flow tracer experiments in bench and field scales.

H31B-0449 0830h POSTER

Azimuthal Resistivity Analysis Using a Capacitively-Coupled Resistivity Meter for the Determination of Hydrologic Parameters

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The contamination of groundwater has become a major concern during the last century. Methods are currently being developed to calculate hydrologic parameters for groundwater models. Azimuthal electrical resistivity (AER) has been used to calculate hydraulic transmissivity and effective porosity. Traditionally, a galvanically-coupled resistivity meter (GCRM) has been used to collect AER data. Using a GCRM for an AER survey requires large amounts of time to set the array. As an alternative for large study areas that require vast amounts of resistivity measurements, a capacitively-coupled resistivity meter (CCRM) may be used. Since the dipole cables connected to the transmitter and receiver are capacitively-coupled with the ground, there is no need for metal electrodes; thus the time needed to collect data is greatly reduced. The CCRM makes it feasible to collect a large amount of data in a relatively short period of time (e.g., 144 azimuthal readings per hour). The CCRM array is initially set with a 2.5 m distance between the transmitter and the receiver (x-distance); the spread of dipole cables on either sides of the transmitter and receiver (a-spacing) is 5 m. The x-distance and a-spacing remain constant while readings are taken at 10-degree increments until the array has been rotated 360-degrees. The x-distance in the array is then expanded by 2.5 m, and the above procedure is repeated. The maximum x-distance used is 20 m, which means that at any given azimuth 8 readings will have been taken with varying x-distances. Varying x-distances at each azimuth allow for the calculation of "true" resistivity through an inversion process. The array is then moved to a different location (station) at the same site and the aforementioned procedure is repeated. During this study AER surveys were completed at four sites in Western New York. Sites were chosen based on three criteria: 1) their proximity to outcrop containing fractures, 2) lack of elevation change, and 3) lack of obstructions (eg. trees, buildings, etc.). Readings were taken at three or four stations at each site. The inverted "true" resistivity values at each station were then normalized and averaged with all the other stations at the site. Therefore, variations in the hydraulic transmissivity by depth can be analyzed and any small-scale lateral heterogeneities removed from the final results. The theoretical basis for this approach and field data from these four sites will be presented.

URL: http://www.geophysics.buffalo.edu

H31B-0450 0830h POSTER

Geoelectric Soil Parameters Measurements During Ponded Infiltration Experiments in Field

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An attempt to measure simultaneously the water propagation, a result of a series of ponded infiltration experiments, and the TDR and multi electrode profiling and georadar characteristics was performed in the experimental area Na Lizu, a part of in the experimental watershed Sputka, Czech Republic. The experiment was done during a dry period in the middle of July 2002. The soil profile is formed by coarse sandy loam of the depth of approximately 1 m over weathered crystalline bedrock, the ground water level is not present. The soil is heterogeneous and therefore the significant preferential flow is expected. The 12 ponded infiltrations were done in a regular grid of a square area of 10 x 10 m. For geophysical measurements various geometry of measuring schemes were tested since it was a pioneering attempt to couple these types of measuring techniques. From TDR the detailed distribution of electric permitivity along the vertical axis was obtained in time during the infiltration experiment. The multi electrode profiling gives as a result the vertical stratification of resistivity, the parameter expected to reflect changes of water content. In tracing the amount of downwards moving water the TDR and multi electrode profiling supplied promising information, meanwhile the sensitivity of georadar was not sufficient to detect the soil moisture changes.

H31B-0451 0830h POSTER

Effects of bacterial sulfate reduction in saturated sediments on self-potential and magnetic measurements

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In situ bioremediation is a non-invasive groundwater remediation technique that stimulates microorganisms to catalyze desirable redox reactions. These redox reactions may be detectable using self-potential (SP) geophysical methods. If the contaminants are metals, chemical changes may also be detectable using magnetic methods. This project explores the suitability of SP and magnetic geophysical methods for monitoring bioremediation of metals contamination. These geophysical methods may be inexpensive, non-invasive alternatives to standard groundwater monitoring practices. The study is divided into a field component and a laboratory component. For the field study, geophysical data were collected at a metals-contaminated site undergoing in situ bioremediation. The data were collected before and after sulfate-reducing bacteria were stimulated by injection of bacterial nutrients into a monitoring well at the site. The collected data were examined for changes in groundwater geochemistry as determined by water sampling. For the laboratory experiment (in progress), a Plexiglas tank containing autoclaved quartz sand saturated with an iron-rich Desulfovibrio (a sulfate-reducing bacteria) media is used to simulate an aquifer. A species of bacteria will be introduced into the tank to remove iron (metal contamination) from the aqueous system. SP and magnetic geophysical data will be collected before and after the bacteria are introduced. The data collected from this part of the study will be compared with the field data to determine relations between microbial activity and geophysical measurements.

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H31B-0452 0830h POSTER

Hydrogeophysical Investigation at Luxor Archaeological Site, Southern Egypt

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Accelerated deterioration of the fabled monuments on the banks of the Luxor, southern Egypt, due to the elevated groundwater and increased salinity has caused global concern for preservation of these monuments. Groundwater delivering salts into the monuments' foundations evaporates leaving salts behind. Pressure developed during crystallization and hydration of residual salts within the foundations is suggested as the most likely cause for deterioration. The

viable and safe mitigation of the deterioration problem requires an understanding of the hydrostratigraphy of the Luxor area. An integrated geophysical and hydrological investigations including resistivity soundings, seismic refraction, ground penetrating radar (GPR), and chemical analysis of ground and surface water were conducted. The objective was to characterize the subsurface geologic/hydrologic units and identify sources responsible for rise in groundwater and increase in salinity. Integrated interpretations of the geophysical and hydrological data successfully characterized the shallow subsurface (<100m) into seven geoelectric (geologic /hydrologic) units. A thick silty clay unit (12-28m) underlies the area of the Karnak and Luxor Temples, which we interpret as a paleo-meander of the River Nile. Depth to the top of water-saturated zone was determined to be about 9m at the area of the temples. Based on the GPR results, the upper limit of capillary water at the Karnak Temples complex was determined to be 0.0- 2m, which indicates that the capillary rise within the silty clay can reach up to 9m. The groundwater flow direction was determined to be from the central cultivated areas towards the River Nile. The regional increase in groundwater salinity was towards the River Nile (or area of temples) in the same direction of the groundwater flow with maximum concentration beneath the temples. Based on these results, we suggest that, the salt accumulation on the monument's foundations is mainly due to salt transport by capillary water from the higher salinity groundwater or paleo-water in the thick silty clay unit.

H31B-0453 0830h POSTER

Preliminary results from coupled modeling of gravity and aeromagnetic data in the Waukesha Fault area of southeastern Wisconsin

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Increased concerns recently about the quantity and quality of groundwater resources in Wisconsin have brought about the need for better understanding of the subsurface geologic lithology and structure that controls groundwater flow. Concern centers on excessive drawdown in the deep sandstone aquifer system throughout southeastern Wisconsin and its relation to increasing levels of total dissolved solids and radium in some municipal supply wells. It is possible that preferential flow paths influence the circulation of groundwater to these wells and their vulnerability to contamination. The largest feature that could channel vertical and horizontal flow at the regional scale is the northeast trending Waukesha fault zone that intersects the main pumping center at Waukesha. The normal vertical displacement along the Waukesha Fault produces strong gravity and aeromagnetic anomalies coincident with the northeast trend of the fault. Previous gravity modeling studies associated with the fault are generally unconstrained yielding results with wide variation in fault geometry and vertical fault offset. Reasonable model fits were obtained with fault dip ranging from 10^o to 85^o with vertical offset ranging from 500 to 700 m. This study provides well-constrained results from coupled modeling of gravity and aeromagnetic (potential fields) data and incorporation of lithologic depths from the lithology database used to construct a regional numerical model for southeastern Wisconsin. We also utilized depth information from the only well (USGS Test Well, Zion, IL) that penetrates the entire Cambrian-Ordovician aquifer system to reach the Precambrian basement on the down-thrown (southeast) block of the fault. Preliminary modeling of gravity and aeromagnetic data along two profiles suggests vertical offset of Precambrian basement from 700 to 800 m along a normal fault with a 60^o southeast dip. Based on thickness of the Cambrian Mount Simon sandstone, preliminary results also suggest that most of the offset occurred during the Cambrian. The results of this study can be used to refine the representation of heterogeneity in the regional groundwater model and improve its value as a management tool.

H31B-0454 0830h POSTER

Determination of Solute Distributions in the Vadose Zone Using Downhole Electromagnetic Induction

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We used down-hole electromagnetic induction to determine the distribution of a salt pulse added to an unsaturated soil profile. Water was applied to the surface at a flux of 2.7 cm/d over a 3-m by 3-m area. After approximately 1100 days, a 6.9-g/L slug of NaCl was added to the infiltration water, increasing the irrigation water conductivity from 80 mS/m to 1300 mS/m. Electrical conductivity measurements were collected weekly with an EM39 probe (Geonics LTD., Mississauga, ON, Canada) in 13 12-m deep boreholes installed over a 16-m by 16-m area. Three-dimensional images based on these measurements showed salt distributions reflecting the site stratigraphy and the shape of the wetted bulb under the infiltrometer. The calculated mass of salt in the profile was compared to the known mass of salt infiltrated at the surface. Following models designed primarily for agricultural soils, the measured bulk soil conductivity (ECa) was converted to soil water conductivity (ECw) using estimates of the volumetric water content from monthly neutron probe measurements and the percent clay from lab analysis of continuous core samples. The calculations showed a close correspondence over time (r2 = 0.98) between the calculated total mass of salt in the soil water and the known mass of salt infiltrated at the surface. The low water content (<15% by volume) and low bulk soil conductivity (<100 mS/m) at the test site presented more resistive conditions than previous studies of this type and were sources of uncertainty in the calculated ECw values. Errors in the calculated mass of salt were particularly evident during the initial stages of the salt infiltration and following the salt pulse, when the average ECw was low. Sensitivity analyses showed that the calculated ECw was strongly dependent on the assumed cutoff between immobile and mobile water content. Calculations were relatively insensitive to soil temperature and percent clay. The results of this study indicate that downhole EM methods show much promise for characterizing water and solute distributions in the vadose zone.

H31B-0455 0830h POSTER

Assessing Redox Potential and Fluid Conductivity of a Contaminant Plume from Geoelectric Methods

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The redox potential and the fluid conductivity of a contaminant plume are two key-parameter to evaluate the plume development and to propose appropriate remediation technologies. we applied geo-electrical methods (self-potential, SP, and electrical resistivity tomography, ERT) to the Entressen landfill site (South-eastern France). From the knowledge of the piezometric head variation of the groundwater, the electrokinetic source is removed from the SP signals measured on the field. Then, a correlation (R=0.85) is obtained between the residual SP due to redox effect and the redox potential values measured in monitoring wells. The first-order linear relationship derived from this correlation is finally used to obtain a redox potential map of the overall contaminated site. A correlation (R=0.70) is observed between the electrical conductivities determined from the 3D ERT image and the conductivity of the groundwater measured in boreholes. From this correlation a map of the fluid conductivity is obtained. The maps of the redox potential and conductivity of the groundwater are both indicative of the presence of contaminants. The first one is more sensitive to the presence of organic matter and biodegradation. The second one gives information on the mineralization of the groundwater. Both maps can therefore be used to optimise the position of pumping wells for remediation.

H31B-0456 0830h POSTER

Identifying Monitoring Sites for Catchment-scale Soil Moisture Based on Hydrological Modeling

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Soil moisture plays an important role in partitioning rainfall into runoff and infiltration, and the incoming radiation into latent, sensible and ground heat fluxes, and is therefore an important variable in distributed hydrological models. Monitoring soil moisture at the catchment scale requires intensive field campaigns which are, from a logistic point of view, difficult to perform at a regular time interval. Remote sensing could provide an answer, however, its results should be validated against ground truth. Recently, Grayson and Western (1998) demonstrated the existence of Catchment-Average-Soil-Moisture-Monitoring (CASMM) sites which may provide relevant information with respect to the catchment average soil moisture behavior and allow to retrieve reliable estimates of areal soil moisture from a limited number of sample locations. However these sites do not provide information on the spatial variability in soil moisture and additional sites should be identified which allow to capture the spatial soil moisture pattern. In order to bypass intensive field campaigns necessary to identify these monitoring sites, a modeling approach is adopted which investigates soil moisture behavior. CASMM sites as well as other sites are identified and checked for their stability in time. The study is performed on a 2.26 km^2 subcatchment of the Zwalm basin (Belgium) where intensive field campaigns are currently conducted. Preliminary results are checked against modeling results to verify whether hydrological models can be used to localize relevant soil moisture monitoring sites. Grayson, R.B., Western, A.W., Towards areal estimation of soil water content from point measurements: time and space stability of mean response, Journal of Hydrology, 207(1-2), 68-82, 1998.

H31B-0457 0830h POSTER

Risk Assessment of Surface Faulting on Eastern Mexico City by Using Gephysical Methods.

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The accelerated urban growth in Mexico City, one of the world's largest metropolis has led to increasing environmental changes. Several low-income communities have settled on high-risk zones of the metropolitan area due to poor development regulations enforcement. Such conditions have contributed to increase the vulnerability of these areas where natural disasters such as flooding or landslides may occur. One of these areas is located in the eastern portion of Mexico City, within the Iztapalapa County. These urban settlements are located on top of non-consolidated lacustrine sediments. Ground conditions and an over exploitation of the local aquifer have caused fracturing, faulting and subsidence, affecting houses and public buildings in this area. In order to perform a risk assessment in this heavily urbanised area, a geophysical study was carried out to determine the location of shallow fractures. Several GPR and high-resolution gravity profiles were surveyed along selected roads. A shallow-surface faulting risk map was then constructed taking into account fault location and geometry, land use and other geological variables. This analysis allowed the study area to be divided into five vulnerability risk zones which can be used by local decision-making authorities for hazard prevention and planning of mitigation activities.

H31B-0458 0830h POSTER

Soil Moisture Content Estimation using GPR Reflection Travel Time

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Ground-penetrating radar (GPR) reflection travel time data were used to estimate changes in soil water content under a range of soil saturation conditions throughout the growing season at a California winery. Data were collected during four data acquisition campaigns over an 80 by 180 m area using 100 MHz surface GPR antennae. GPR reflections were associated with a thin, low permeability clay layer located between 0.8 to 1.3 m below the ground surface that was calibrated with borehole information and mapped across the study area. Field infiltration tests and neutron probe logs suggest that the thin clay layer inhibited vertical water flow, and was coincident with high volumetric water content (VWC) values. The GPR reflection two-way travel time and the depth of the reflector at borehole locations were used to calculate an average dielectric constant for soils above the reflector. A site-specific relationship between the dielectric constant and VWC was then used to estimate the depth-averaged VWC of the soils above the reflector. Compared to average VWC measurements from calibrated neutron probe logs over the same depth interval, the average VWC estimates obtained from GPR reflections had an RMS error of 2 percent. We also investigated the estimation of VWC using reflections associated with an advancing water front, and found that estimates of average VWC to the water front could be obtained with similar accuracy. These results suggested that the two-way travel time to a GPR reflection associated with a geological surface or wetting front can be used under natural conditions to obtain estimates of average water content when borehole control is available. The GPR reflection method therefore has potential for monitoring soil water content over large areas and under variable hydrological conditions.

H31B-0459 0830h POSTER

An inverse method for estimating the spatial variability of soil textures from observed soil moisture fields

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Soil texture (sand, clay, silt and rock contents) information is one of critical factors for understanding water cycle, since it affects almost all of water cycle processes, e.g., drainage, runoff, soil moisture, evaporation and evapotranspiration. To study water cycle regionally or globally, we must have a regional or global soil texture database. At the present stage, three soil geographic data bases are commonly used, i.e., the Soil Survey Geographic (SSURGO) database, the State Soil Geographic (STATSGO) database, and the National Soil Geographic (NATSGO) database. Those soil data are map-unit-based, which are associated with a great uncertainty. Ground soil survey is one way to reduce this uncertainty. However, ground survey is time consuming and labor intensive. In this study, a simple method for estimating mean and standard deviation of soil texture from observed soil moisture fields is proposed and applied to Throughfall Displacement Experiment (TDE) sites in Walker Branch Watershed (WBW) in eastern Tennessee. The results indicate that the suggested method is feasible and has potential for retrieving soil texture information globally from remotely sensed soil moisture data.

H31B-0460 0830h POSTER

Time Differential Electrical Resistivity for Water Resource Assessment: A Case Study in Curaçao, Netherlands Antilles

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A method of groundwater prospecting is presented that capitalizes on changes in electrical resistivity arising from annual variability in subsurface fluid flow. According to Archie's Law, effective resistivity is a function of pore fluid resistivity, saturation, and porosity. For competent Earth materials, short-term temporal changes in near-surface porosity are negligible because changes in effective pressure are small with respect to the bulk moduli of the materials. Therefore, annual variability in effective resistivity is dependent only on fluid flow via changes in saturation and, to a lesser extent, pore fluid resistivity. Aquifer detection is but the first step; thereafter, it is necessary to estimate permeability, capacity, and, importantly, sustainability. Time differential resistivity is well matched to the task because it detects prospective aquifers and also illuminates their natural hydrodynamics. Explicitly, this method captures an undeveloped aquifer's seasonal volumetric variability, which is important as engineers reconcile monthly demand with monthly supply. The best scenario would be to detect a capacious, intermediate-resistivity (high pore fluid resistivity and high porosity) zone that is invariant from season to season (clays and ore bodies excepted). Less desirable, but still manageable, is the case where a large, porous formation undergoes significant seasonal resistivity variation; it behaves as a subterranean river with little lag-time between meteoric water input and groundwater throughput; carefully timed extraction and storage would be required in this case. A suite of thirty-eight electrical resistivity soundings were collected from the wet and dry seasons at Plantages PortoMari, an ecotourist plantation on the semiarid island of Curaçao, N.A. The data were analyzed with special attention paid to wet-to-dry season resistivity ratios. The results suggest two possible courses of action. (1) A hypothetical limestone terrace was detected whose estimated minimum water volume fluctuates between approximately 1200m^3 and 2300m^3; this terrace may be tapped with several boreholes descending to an elevation of 25m ASL. (2) A shallow subsurface dam and extraction fence (10m BGS) might be installed where the watershed corridor converges onto a flat plain whose surficial lithology is comprised of poorly sorted alluvia atop an impermeable clayey unit. Both extraction scenarios require storage facilities, as neither hydrogeologic setting indicates a persistent aquifer.

H31B-0461 0830h POSTER

3D Inversion of Induced Polarization Data From Borehole Measurements to Map Subsurface Contaminations of Tetrachloroethylene and Trichloroethylene.

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The purpose of this study is to image contaminant plumes of tetrachloroethylene (PCE) and Trichloroethylene (TCE) in a subsurface environment. PCE and TCE have been used in the metals fabrication industry since the start of the second word war and subsequently millions of tons of these chemicals have been released in to the environment. Once in the water supply these contaminants are difficult to remove and can be toxic at the part per billion level. Remediation at the source of many of these contaminated sites, in the form of vapour extraction, can effectively remove alot of the chemicals but without techniques to delineate the size and shape of the contaminated zone, or to monitor the effectiveness of the remediation effort, it is difficult to quantify the remediation success. Using complex resistivity methods it is possible to determine the spatial extent and concentration of these chemicals due to their effect on the pore space chemistry. Even at parts per billion the contaminantas can significantly alter the IP signature enabling detection. Data were collected from a site in South Carolina where these chemcals are known to have been released in large quantities from the 1950's through to the 1980's. Induced Polarization data were measured in a multi-borehole environment to ensure good data coverage. Data is inverted using a 3D finite difference bi-conjugate gradient method and correlated to ground truth boreholes within the region of interest.

H31B-0462 0830h POSTER

3D Inversion of a Self-Potential Dataset for Contaminant Detection and Mapping

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Due to the complicated nature of subsurface contaminant migration, it is difficult to determine the spatial extent and severity of contamination, which can provide essential information for efficient remediation efforts. Self-potential (SP) geophysics is employed to provide a minimally invasive, fast, and inexpensive method for remote *in-situ* detection and three-dimensional mapping of subsurface DNAPL (Dense Non-Aqueous Phase Liquid) in conjunction with inverse methods. The self-potential method is commonly used to detect a variety of phenomena that are typically related to thermoelectric, electrochemical, or electrokinetic coupling processes. Surface self-potential surveys have been documented to show anomalies over areas known to be contaminated, but interpretation of these datasets is often mostly qualitative, and can be plagued with problems of non-uniqueness. In this study, oxidation-reduction (redox) reactions, one of the mechanisms associated with the attenuation of chemicals released into the environment, provide an electrochemical source for the SP signal. Electrochemical potentials associated with subsurface zones of redox activity are analogous to localized 'batteries' buried within native earth materials, and produce an electric field that is remotely detected using electrodes placed at the surface and in nearby boreholes. Three-dimensional inversion of the self-potential data incorporating resistivity information is the necessary step in characterizing the source parameters, which are directly related to the redox activity, and therefore to the contaminant itself. Surface and borehole SP data are collected in order to help constrain the solution in depth, and resistivity information is taken from an induced polarization survey performed over the same area during this field excursion. Inversion results are correlated with contaminant concentration data sampled from a series of ground-truth boreholes within the region of interest.

H31B-0463 0830h POSTER

Are there any relationships between the dry frame moduli and hydraulic properties of unconsolidated sediments?

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The petrophysical properties of unconsolidated sediments that affect their hydraulic properties also affect the dry frame bulk and shear moduli. These include the porosity, clay content and particle size distribution. We investigate the potential relations between these dependent and independent variables using data from laboratory measurements. The measurements were performed at varying confining pressures ranging from 5-40 MPa. Unconsolidated samples were characterized and their physical properties which include porosities, clay contents and particle size distributions were estimated. The relationships between these petrophysical variables and the dry frame were assessed to understand how they influence the dry frame moduli. Regression models were then developed to predict the dry frame moduli using these petrophysical properties and the applied effective pressure as the prediction variables. The prediction model is compared with existing models such as the Krief's Model. Such predictive models would serve as a useful tool in aquifer and reservoir characterization studies as well as time lapse seismic modeling.

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H31B-0464 0830h POSTER

Non-Linear, Bayesian Hydrogeophyiscal Inversion in the Vadose Zone

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A comprehensive approach for modeling the dynamics of soil moisture profiles in the vadose zone under conditions of parameter uncertainty, using an information-based Bayesian-stochastic framework, is proposed and applied to a field site in Napa Valley in California. The Bayesian framework is combined with the one-dimensional Richards' equation and van-Genuchten-Mualem soil models, with initial and boundary conditions provided by geophysical and meteorological measurements. To identify the model parameters such as the van-Genuchten-Mualem soil water retention parameters α and n, the porosity θ_S, and the saturated hydraulic conductivity K_S, soil texture analyses are performed and soil moisture content obtained from TDR, neutron probe and crosshole GPR are collected as a function of time. Soil texture information, combined with a hydrologic database – Rosetta, is used to derive prior information for the model parameters, which are considered as random variables. The prior probability density functions (pdfs) for the parameters are developed from minimum relative entropy considerations. Soil moisture content measurements using geophysical methods are then used to update the model parameters and to improve the prediction of the soil moisture profiles. Results show that as additional measurements are incorporated into the updating procedure, the uncertainty level associated with the model parameters is reduced. The approach also provides estimates of the statistical moments of the output soil moisture content. For both dry and wet seasons at the study site, the method predicts the soil moisture profiles very well.

H31B-0465 0830h POSTER

Monitoring Soil Water Dynamics in the Vadose Zone During Pumping With Ground Penetrating Radar

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Transient water movement within the vadose zone has profound effects on the response of unconfined aquifers to pumping. Much has been published regarding the interpretation of unconfined pumping tests. However, there remains a debate regarding the relative contribution of delayed drainage to the observed aquifer response. Some of the source of this ongoing debate is the lack of sufficiently convincing data to quantify the magnitude and extent of delayed drainage. We used borehole ground penetrating radar to provide exceptionally high spatial and temporal monitoring of soil water dynamics in the vadose zone during pumping. Results show the precise evolution of water content profiles. These profiles confirm the presence of significant delayed drainage. However, the resulting profiles are not well predicted by current numerical flow models. Does this point to another, poorly described mechanism that may control the response of unconfined aquifers?

H31B-0466 0830h POSTER

Geophysical Techniques Applied to a Stream-Aquifer System

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In north central Kansas the Republican River and its associated alluvial sediments are important regional surface and groundwater supplies. A test site, adjacent to the Republican River (near Clay Center, KS), has been established within the porous alluvial sediments to study stream-aquifer interaction and aquifer heterogeneity. This is potentially important research for understanding how to maintain a desired stream flow in the presence of withdrawals from the stream and the aquifer. The site was prepared with seven observation wells oriented along a line perpendicular to the river channel and centered about a productive irrigation well. Several geophysical techniques, including direct-push electrical conductivity (EC), ground penetrating radar (GPR), and shallow seismic methods, have been used at this site to characterize the aquifer. The EC geophysical method of subsurface investigation is typically used for gross lithologic definition. When numerous direct-push EC profiles are completed, a general impression of vertical and lateral variation of subsurface lithology can be inferred. Recently, this technique has been used to extract more information concerning subsurface characteristics; based on the three main parameters controlling the electrical properties of soils, i.e. gross lithology, water content, and water chemistry. In unconfined water table aquifers consisting of coarse alluvial deposits there is typically a sharp boundary between the saturated and unsaturated sediment, which can be seen on an EC profile as an abrupt change or shift in electrical conductivity as the probe is advanced through the sediments. Performing this EC profiling at a number of locations can define gross features of the local lithology and define the general shape of the water table and this has been done at the current research site. Additional EC profiles can be taken during pumping periods to document the lowering of the water table at selected locations and corroborate or compliment water level measurements taken from nearby observation wells. High-resolution shallow seismic reflection data sets were collected to image the top of the saturated zone during and after a pumping event at the test site. Two identical common mid-point seismic surveys were conducted; the first survey at maximum drawdown during the second day of continuous pumping; the second survey in the recovery phase of the aquifer 18 hours after pumping ceased. Differences as well as similarities in the times and amplitudes of P-wave reflections are evident in the two data sets. Seismic data will be correlated with GPR data, EC profiles, and monitoring well water-level data to evaluate the presence of lithologic and/or water table reflectors. GPR reflection data were also acquired to investigate the hydrostratigraphy of the test site. Radar data collected at undisturbed hydrologic conditions imaged near-surface lithologic changes, also identified in EC profiles. Variations in the attenuation of the GPR signal showed close agreement with EC profiles at well locations. The imaging of shallow reflectors in both seismic and GPR data sets warrants further investigation of the combined use of the two methods for hydrogeophysical investigations at this site.

H31B-0467 0830h POSTER

Focused subsurface flow in the Amargosa Desert characterized by direct-current resistivity profiling

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Environmental-tracer studies have shown that ground-water recharge in the thick alluvial fill of the Amargosa Desert is localized beneath ephemeral stream channels and anthropogenic sources of water, with little recharge beneath native vegetation on interfluvial areas under current climatic conditions. These borehole-based studies provided relatively robust but limited, one-dimensional (vertical) information that can be only tentatively regionalized using geomorphologic, pedologic, and vegetational mapping. The ability of direct-current (DC) resistivity profiling to complement and extend studies of the spatial distribution of subsurface flow was examined by making surface-based measurements ("soundings") along one transect normal to the depositional fabric in each of three geomorphologically distinct settings: a well-incised ephemeral channel system, a poorly incised (distributory) ephemeral channel system, and an interfluvial upland. Linear arrays of 32 to 80 electrodes were deployed with a uniform 2 to 5-m spacing between adjacent electrodes. A multiplexing 8-channel resistivity instrument made automated inverse-Schlumberger-array soundings along the deployed line, using up to 10 electrodes at a time. The line was shifted piecemeal until composite transects consisted of 168 to 232 electrode positions. This approach allowed rapid profiling of long transects at high resolution. Numerical inversions assumed horizontal constancy normal to the vertical slices being imaged, producing solution sets of optimized resistivity values for several thousand points within each modeled slice. Imaged slices were ~30 to 80 m deep and ~1 km wide. RMS errors between apparent resistivities in the model inversions and field-measured apparent resistivities were ~10%. On the basis of borehole studies, inverted resistivity (ρ) values denoted three categories of alluvium: (1) low-water-content coarse gravel and highly desiccated surface materials, with $\rho > \sim 200$ Ω-m, (2) vertical plumes of moist alluvium in areas of active recharge, with $\rho < \sim 20$ Ω-m, and (3) other low to low-medium water-content alluvium in areas without active recharge, with intermediate values of ρ. The upland profile revealed a laterally extensive gravel layer (category 1 alluvium) at a depth of ~25 m that intersects instrumented boreholes at the Amargosa Desert Research Site. This layer coincides with peak concentrations of radioactive gases and volatile organic compounds moving through the unsaturated zone from a nearby waste-disposal facility. DC-resistivity profiling appears useful for locating areas of active ground-water recharge as well as potential passageways for preferential gas transport in the Amargosa Desert and similar environments.

H31B-0468 0830h POSTER

Electrical Resistivity Imaging and Depression Focused Recharge

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Seasonal wetlands and small depressions play a fundamental role in recharging regional aquifers in the northern glaciated planes. Water from snowmelt collects in the depressions in the spring and infiltrates into the ground after the soil unfreezes. Infiltrating water leaches salts from the soil beneath depressions. The majority of the infiltrating water moves to the local uplands where it leaves the ground through ET leaving behind zones of evaporitically concentrated salts. A small percentage infiltrates down to the regional aquifer. Leaching and concentrating salts effect the electrical resistivity distribution of the subsurface. Three-dimensional electrical resistivity imaging (ERI) was combined with groundwater and soil measurements to generate a conceptual model of three dimensional fluid flow at San Denis, Saskatchewan. Water chemistry was used to generate a conceptual model of different geochemical zones which could be distinguished by the electrical conductivity of pore water. The Waxman-Smits equation was used to link groundwater electrical conductivity to in situ bulk resistivity. Electrical resisistivity from ERI was then used to map geochemical zones in the subsurface. ERI and chemistry show that infiltrating water reaches a regional aquifer at 20 meters depth. Seasonal wetlands have large zones of high resistivity that reach to the regional water table indicating that salts have been leached out of the tills to the depth of the regional aquifer. Small local depressions also have zones of leached soil beneath them indicating that they contribute to regional groundwater recharge. Since there are millions of small depressions, they may play a fundamental role in groundwater recharge and must be considered in land management. The images show a complex distribution of salts. Most of the salt is located in the upper weathered zone in the glacial tills and the horizontal distribution is controled by the locations of wetlands, steepness of slopes and the depth of the depressions. Adding ERI to the borehole and chemistry data generated a much more detailed and complex picture of water and solute cycling in the near surface.

H31B-0469 0830h POSTER

Electrical Monitoring of Fresh Water Displacement in a Brackish Aquifer During Aquifer Storage and Recovery: Forward and Inverse Modeling Results

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Aquifer storage and recovery (ASR) projects are now used to temporarily store water in the subsurface and to recover it when needed. When freshwater is injected into a brackish aquifer, a transition zone forms, due to mixing, diffusion and gravity. The front displacement and the width of the transition zone depend on the characteristics of the aquifer but, from repeated surveys conducted with an array of downhole

electrodes placed against the borehole wall, the changes in the front position/shape can be continuously monitored. Synthetic data were created for a targeted ASR situation through hydrodynamic and hydrodispersive modeling (performed with a finite difference scheme) that gave the salt concentration distribution in the aquifer, as a function of space and time, during ASR inject/store/pump cycles. Concentrations were converted first into water resistivity values R_w, and then into formation resistivity values R_t through Archie's law *(1)* calibrated on logging data:

$$R_t = \frac{a}{\phi^m} R_w \qquad (4)$$

where ϕ is the porosity, and a and m depend on the lithology. Based on this information, the response of downhole electrodes was computed by solving equation *(2)* (using a finite element modeling code) for electrical surveys conducted at repeated times during the planned ASR cycles, and in particular during the initial ASR testing phase:

$$\nabla . \sigma \nabla \Phi = 0 \qquad (5)$$

where σ is the electrical conductivity and Φ the potential. The sensitivity of the electrode monitoring technique to front displacement and shape changes was first demonstrated: with a 1 Amp injected current, $\frac{\Delta V}{\Delta r} \approx 1V/m$ and $\frac{\Delta V}{\Delta r} \approx 50mV/m$ for the short spacing electrodes, when the front is respectively 5 m and 35 m away from the wellbore. The inverse problem was then solved for the synthetic electrical survey data. The misfit functional *(3)* was minimized under two types of constraints: material balance (average front position being a function of the injected volume of water), and expected dispersion (relationship between transition zone width and front position). The *a priori* model at each time step was taken from the inversion results at the previous one.

$$J = \|d_p - d\|^2 + \alpha \|m - m_{apriori}\|^2 \qquad (6)$$

where d_p and m are the predicted data and the model parameters, d is the synthetic (or observed) data, and $m_{apriori}$ is the *a priori* model taken from the previous time step. This study showed the feasibility of using electrical monitoring for ASR projects, and notably for an early aquifer characterization, during the initial injection phase.

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H31B-0470 0830h POSTER

Field Comparison of Direct-Push Approaches for Determination of K-Profiles

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A large body of theoretical and experimental research has shown that spatial variations in hydraulic conductivity (K) are a significant factor in determining how groundwater and accompanying contaminants move in the subsurface. Therefore, a wide variety of direct and indirect techniques have been developed for the characterization of K variations at a site. Methods based on direct-push technology have much potential for use in shallow unconsolidated settings. However, the various direct-push methods differ in their expense, in terms of time, money, and effort, and the nature (qualitative vs. quantitative) of the information that they can provide. A field study was carried out at a test site near Nauen, Germany to evaluate and compare several direct-push methods for determination of spatial variations in K. The test site was established by the Department of Applied Geophysics of the Technical University of Berlin in collaboration with the German Federal Institute for Geosciences and Natural Resources. Extensive geophysical surface measurements (surface nuclear magnetic resonance, georadar, refraction seismic, and 2D dc geoelectrics), as well as data from a continuously cored borehole, are available. These data provide a controlled framework for the evaluation of different direct-push methods for the characterization of spatial variations in hydraulic conductivity. The following direct-push methods were investigated in this study: electrical conductivity (EC) and cone penetrometer (CPT) logging, slug tests, injection logging, and the direct-push permeameter (DPP). In addition, natural gamma (NG) logging was performed in pipe installed with direct-push technology. EC, CPT, and NG logging are very fast, but do not provide direct estimates of K. Their successful use for site characterization depends on the appropriateness of the applied empirical relationships. As shown by the results from Nauen, EC, CPT, and NG logging are often limited to the delineation of major units of relatively high or relatively low K. The other three methods, injection logging, slug tests, and the DPP, allow a direct assessment of the K distribution. Injection logging, which uses measurements of the flow rate and injection pressure to characterize K, is very fast (< 1 min per interval), but can only provide information about relative variations in hydraulic conductivity. Slug tests in direct-push equipment can provide more reliable K estimates, but require much more time per interval (60 mins). The direct-push permeameter is a tool for the performance of small-scale injection tests that can provide reliable K estimates in a relatively short time (10 mins per interval). The DPP appears to have the most potential for providing K estimates with an acceptable level of efficiency and accuracy. At the moment, however, the DPP is limited to relatively shallow depths at some sites because the downhole pressure transducers cannot be used with hammer-assisted forms of direct push. At those sites, a combination of injection logging and slug tests is recommended for assessing K variations at depth.

H31B-0471 0830h POSTER

Electrical Resistance Tomography to Monitor Mitigation of Metal-Toxic Acid-Leachates Ruby Gulch Waste Rock Repository Gilt Edge Mine Superfund Site, South Dakota USA

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At a cyanide heap-leach open-pit mine, 15-million cubic yards of acid-generating sulfides were dumped at the head of a steep-walled mountain valley, with 30 inches/year precipitation generating 60- gallons/minute ARD leachate. Remediation has reshaped the dump to a 70-acre, 3.5:1-sloped geometry, installed drainage benches and runoff diversions, and capped the repository and lined diversions with a polyethylene geomembrane and cover system. Monitoring was needed to evaluate (a) long-term geomembrane integrity, (b) diversion liner integrity and long-term effectiveness, (c) ARD geochemistry, kinetics and pore-gas dynamics within the repository mass, and (d) groundwater interactions. Observation wells were paired with a 600-electrode resistivity survey system. Using near-surface and down-hole electrodes and automated data collection and post-processing, periodic two- and three-dimensional resistivity images are developed to reflect current and changed-conditions in moisture, temperature, geochemical components, and flow-direction analysis. Examination of total resistivity values and time variances between images allows direct observation of liner and cap integrity with precise identification and location of leaks; likewise, if runoff migrates from degraded diversion ditches into the repository zone, there is an accompanying and noticeable change in resistivity values. Used in combination with monitoring wells containing borehole resistivity electrodes (calibrated with direct sampling of dump water/moisture, temperature and pore-gas composition), the resistivity arrays allow at-depth imaging of geochemical conditions within the repository mass. The information provides early indications of progress or deficiencies in de-watering and ARD- mitigation that is the remedy intent. If emerging technologies present opportunities for secondary treatment, deep resistivity images may assist in developing application methods and evaluating the effectiveness of any reagents introduced into the repository mass to further effect changes in oxidation/reduction reactions.

H31B-0472 0830h POSTER

INEEL Vadose Zone Research Park

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The Vadose Zone Research Park was developed to address mission critical issues related to operations, waste management, and environmental restoration at U. S. Department of Energy (DOE) sites that are located over thick vadose zones. The research park provides instrumentation and facilities for scientists to address vadose zone processes that are important in assessing operational activities, remedial measures, and long-term stewardship of DOE lands. The park, at the Idaho National Engineering and Environmental Laboratory (INEEL), is strategically located along the Big Lost River, an intermittent river, and around two new percolation ponds. This location provides the opportunity to study variable recharge from the river, continuous recharge from the ponds, and the interactions between the two sources. Drilling began in September 2000 and was completed in June 2001. Thirty one wells and instrumented boreholes have been installed at the park to monitor perched water, measure moisture movement, collect water and gas samples, and study intra-well geophysical properties. Nine of the boreholes, ranging in depth from 150 ft to 504 ft below land surface (bls), are instrumented to monitor moisture in the vadose zone. Instruments include: tensiometers, moisture content sensors, suction lysimeters, temperature sensors, gas ports and electrodes for electrical resistance tomography. Electrodes are evenly spaced throughout the borehole with hydrologic instruments concentrated in and near the sedimentary interbeds-discontinuous layers of silts and clays that occur between some basalt flows. Eighteen monitoring wells, ranging in depth from 60 ft to 250 ft bls, are completed with 4 or 6 inch PVC casing, and generally include an electrical resistivity electrode array attached to the casing. Three bore holes are constructed for testing cross-hole ground penetrating radar as well as for testing new nuclear logging tools being designed at the INEEL. The remaining borehole contains only an electrical resistivity electrode array. Moisture potential, temperature, and water level data are collected automatically by data loggers and transmitted by radio to a computer linked to the INEEL network. Researchers can view the data via the computer network. We are initiating studies of in-situ moisture content - matric potential curves, relative migration rates of sodium and chloride, development of preferred flow paths through the vadose zone, and imaging of background moisture movement using electrical resistivity tomography. Data collection, processing and imagery will all be automated. Imaging of all data types will be draped over the geology for correlation purposes.

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H31B-0473 0830h POSTER

Anomalous diffusion of electromagnetic fields in the near–surface

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Among the various geophysical technologies that have found a niche in shallow subsurface characterization and monitoring is the electromagnetic induction (EMI) method—a method that maps the spatial variability in ground conductivity arising from lithologic changes and the presence of pore fluids. Interestingly, a growing body of evidence suggests that the electrical structure of some geologic materials is inherently fractal, presumed to arise from the dynamical systems that generate and alter the formation and its overlying soil. These observations challenge the applicability of the standard modeling paradigm which rests squarely on the assumption of a spatially smooth (or at least piecewise smooth) distribution of physical parameters within the subsurface. As an alternative, and drawing upon near–surface EMI data recently collected from geologically distinct sites throughout New Mexico and Texas, we investigate the concepts of fractal signals and random walks through spatially-correlated heterogeneous media as a means to describe the observed variations in shallow subsurface EM response. This framework suggests that the diffusion process in geologic media may be described more completely by a

modified, fractional–order diffusion equation which is derived from a more generalized form of the standard Maxwell equations.

H31B-0474 0830h POSTER

Demonstration and Validation of a Passive Flux Meter under Controlled Field Conditions

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Subsurface contaminant mass flows and fluxes are increasingly being viewed as critical information needed to address issues pertinent to aquifer and groundwater remediation. Theses issues include; source prioritization, risk prediction, compliance monitoring, remediation endpoint evaluation, and contaminant attenuation assessment. Field experiments were conducted to demonstrate and validate a passive flux meter (PFM), which is a down-hole monitoring technology that provides for simultaneous, direct, in situ, point measurements of cumulative or time-averaged contaminant mass flux and water flux. The experiments were conducted in a subsurface flume located at the Base Borden Test facility in Ontario, Canada. The sheetpile enclosed flume was 15-m long and 2 m wide. Steady flow was established using four pumping wells located in the closed end of the flume. Flow rates and contaminant concentrations measured at the producing wells provided estimates of average groundwater and contaminant fluxes within the flume. Flux estimates were compared to direct measurements obtained from 6 flux meters and to calculated fluxes generated from multilevel samplers. Fuzzy analysis was used to characterize the uncertainty in MTBE mass flow and flux estimates generated from spatially integrating PFM measurements.

H31B-0475 0830h POSTER

Determination of specific storage of porous rocks from flow pump experiments: theoretical analysis and experimental evaluation

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Flow pump permeability experiments are one of the methods used to obtain both hydraulic conductivity and specific storage of rock samples. However, transient pore pressure changes during the experiments are affected by the storage capacity of the flow pump apparatus. In this study, we used two approaches to deal with this problem. One is a theoretical analysis using the concept of sensitivity and the other is a comparison of experimentally obtained specific storages from flow pump experiments and poroelastic measurements, to evaluate the effects of the storage capacity of the apparatus to calculate the specific storage of the samples. Both results show that it is necessary to reduce the ratio of the storage capacity of the flow pump apparatus to that of the sample as small as possible (less than 0.3 from theoretical analysis and less than 0.7 from experimental results) to accurately obtain the specific storage of the sample. Thus, to determine the best estimate of sample storage, we need to take into account the effect of the storage capacity of the apparatus. This allows proper design of the experimental apparatus for measuring the specific storage of rock.

H31C MCC: Level 1 Wednesday 0830h

Extreme Event Geomorphology I Posters *(joint with T, C, NG)*

Presiding: **K X Whipple,** Massachusetts Institute of Technology; **D R Montgomery,** University of Washington

H31C-0476 0830h POSTER

Hydraulic Response of a Mountain Stream to a Large Debris Flow Sediment Pulse

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Field and laboratory studies of landslide-induced sediment pulses have been used to develop numerical models of pulse dispersion and translation. Evolution of sediment pulses has been found to be dominated by dispersion when the grain-size distribution of the sediment wave is coarser than the ambient bed material and when the flood Froude number is high, whereas translation dominates the evolution of fine-grained sediment pulses in channels with low Froude numbers. A large debris flow, which delivered an estimated 750,000 m^3 of sediment and woody debris to Squire Creek in the North Cascades of Washington, provides a rare opportunity to examine the hydraulic response of a sediment pulse that includes clasts exceeding the flow competence of the receiving channel. The landslide initiated on a ridge approximately 670 m above Squire Creek during the morning of February 25, 2002 and filled a 400-m length of the valley floor to a depth of approximately 20 m. The pre-disturbance, step-pool channel had an estimated slope of 0.08 and drains an area of 25.7 km^2 at the study site. While the deposit has been incised to a depth of 5 to 10 m in the first 18 months following the event, considerable armoring of the bed surface appears to have stabilized a knickpoint at the toe of the deposit, a process hypothesized to reduce the dispersion rate of the sediment pulse. Because many of the clasts in the armor layer exceed the flood flow depth, rates of dispersion may be overestimated by the transport equations incorporated into numerical models. Relict boulders and steep reaches observed along Squire Creek and throughout similar mountain drainage basins in the Pacific Northwest suggest that channel-bed armoring and profile stabilization may be a more significant influence on the decay of large sediment pulses delivered by debris-flows than previously recognized. In particular, the persistence of such deposits has implications for large debris-flow dams as sediment capacitors in mountain channels that are confined by steep valley sideslopes prone to large infrequent landsliding. Monitoring of the Squire Creek profile over the next several years and comparison with ancient deposits identified elsewhere in the basin will investigate the mechanisms by which large landslide-induced sediment pulses disperse downstream and evolve into the boulder lag deposits that characterize many mountain streams.

H31C-0477 0830h POSTER

Effects of Alluvial and Debris Flow Fans on Channel Morphology in Idaho, Washington, and Oregon

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Formation of debris flow and alluvial fans at tributary confluences from episodic erosion associated with large storms and fires ("extreme events") are often viewed negatively over short time spans (years). However, when viewed over long periods of time (decades to centuries), fans that form at tributary junctions are often sources of morphological diversity in streams and rivers. To evaluate effects of tributary fans on the morphology of mainstem channels, we surveyed a total of 44 km of streams in the Sawtooth Mountains of Idaho (27 km), Olympic Mountains of Washington (10 km), and Central Coast Range of Oregon (7 km). Rejuvenated alluvial fans resulting from post-fire gully erosion in the Sawtooth Mountains created gradient nick points in 4th to 6th order mainstem channels (30 to 350 km^2 drainage area) that increased sediment storage upstream resulting in decreased channel gradients, widened flood plains, side channel construction, and the beginning of terrace formation. Downstream effects included increased channel gradients, often creating rapids. In 3rd and 4th order mainstem channels (< 10 km^2 drainage area) in the Olympic Mountains, there was statistically significant association between low-order confluences containing debris flow deposits and gravel abundance, wide channels, and numbers of logs and large pools. Moreover, heterogeneity of mainstem channel morphology increased in proximity to low-order confluences prone to debris flows in the Olympic study sites. In 3rd and 4th order channels in the Oregon Coast Range, density of large wood and boulders in mainstem channels (< 30 km^2 drainage area) increased with proximity to all debris flow fans at low-order confluences regardless of fan age, while channel gradients and sediment depth in mainstem channels increased with proximity to recent (< 60 yrs old) debris fans. Consequently, alluvial and debris flow fans can be significant agents of heterogeneity in riverine habitats, similar to other sources of major gradient nick points on mainstem channels (e.g. bedrock, rock falls, canyon constrictions, channel bends, etc.). However, not all channels are prone to tributary fan effects. Steep and confined mountain channels with high stream power may quickly transport deposits from debris flow and alluvial fans, leaving no morphological effects. Overall, these field studies provide a possible physical basis for recent observations of increased habitat use near tributary junctions (e.g. salmon spawning density, aquatic invertebrate density) and underpin emerging stream network theory on the organization of disturbance in creating and maintaining a variety of habitat in aquatic and riparian ecosystems.

URL: http://leebenda.siskiyou.net

H31C-0478 0830h POSTER

Erosion and its Effects on Geophysical Granular Avalanches

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Many types of extreme geophysical flows such as debris avalanches and pyroclastic flows can be classified as granular avalanches. While sedimentation from these flows and their resulting deposits have been the subject of intense study for the past half-century, the effects of erosion have been difficult to ascertain. Despite the known relationship between slope angle and thickness of a stable layer of loose debris on a slope, h_{stop}, which requires erosion during flow events, the positive change in volume of geophysical granular flows during transport has not been systematically studied. We present the results of experiments on the propagation of erosive granular flows. We use the experimental results to test a model that simulates granular avalanches in which erosion and deposition cause significant changes in mass and momentum during flow. Granular flow experiments were conducted under a variety of initial conditions to gain a quantitative understanding of erosion and its effects on propagation. Sand flows were released on a masonite plane to which 36 grit sandpaper had been glued. The masonite plane measured 95 cm times 60 cm. The plane was tilted at angles of 29.4 – 36.5 degrees. Particles of sand grains sieved to 2 and 2.5 phi were used. The 2 phi particles were dyed blue to aid in visualization. The angles of repose for the 2 and 2.5 phi particles were measured in two types of slumping experiments yielding angles of 34 degrees for the 2 phi particles and 35 degrees for the 2.5 phi particles. The 2.5 phi particles were poured onto the plane before each experiment to provide an erodible surface. The thickness of the erodible layer was h_{stop}. 425 $\pm$ 0.9 g of 2 phi particles were then released on this surface from a 10.5-cm diameter cylindrical container. The propagation of the sand was measured by videotaping while a horizontal grid was projected onto the plane to measure flow thickness. Because of geometrical distortions and the difficulty in ascertaining the edge of the flow during periods when the material was thinly spread, the error in the measurements of the flows positions is estimated to range from 1 – 2.5 cm. The sand was allowed to flow off the end of the inclined plane into a bin. We separated the two fractions by sieving. Using this technique, we were almost always able to ensure that < 1% of the