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Although the spatial distribution of geochemical parameters is extremely important for many subsurface remediation approaches, traditional characterization of those parameters is invasive and laborious, and thus is rarely performed sufficiently to describe natural hydrogeological variability at the field-scale. This study is an effort to jointly use multiple sources of information, including noninvasive geophysical data, for geochemical characterization of the saturated and anaerobic portion of the DOE South Oyster Bacterial Transport Site in Virginia. Our data set includes hydrogeological and geochemical measurements from five boreholes and ground-penetrating radar (GPR) and seismic tomographic data along two profiles that traverse the boreholes. The primary geochemical parameters are the concentrations of extractable ferrous iron Fe(II) and ferric iron Fe(III). Since iron-reducing bacteria can reduce Fe(III) to Fe(II) under certain conditions, information about the spatial distributions of Fe(II) and Fe(III) may indicate both where microbial iron reduction has occurred and in which zone it is likely to occur in the future. In addition, as geochemical heterogeneity influences bacterial transport and activity, estimates of the geochemical parameters provide important input to numerical flow and contaminant transport models geared toward bioremediation.

Motivated by our previous research, which demonstrated that crosshole geophysical data could be very useful for estimating hydrogeological parameters, we hypothesize in this study that geochemical and geophysical parameters may be linked through their mutual dependence on hydrogeological parameters such as lithofacies. We attempt to estimate geochemical parameters using both hydrogeological and geophysical measurements in a Bayesian framework. Within the two-dimensional study domain (12m x 6m vertical cross section divided into 0.25m x 0.25m pixels), geochemical and hydrogeological parameters were considered as data if they were available from direct measurements or as variables otherwise. To estimate the geochemical parameters, we first assigned a prior model for each variable and a likelihood model for each type of data, which together define posterior probability distributions for each variable on the domain. Since the posterior probability distribution may involve hundreds of variables, we used a Markov Chain Monte Carlo (MCMC) method to explore each variable by generating and subsequently evaluating hundreds of realizations.

Results from this case study showed that although geophysical attributes are not necessarily directly related to geochemical parameters, geophysical data could be very useful for providing accurate and high-resolution information about geochemical parameter distribution through their joint and indirect connections with hydrogeological properties such as lithofacies. This case study also demonstrated that MCMC methods were particularly useful for geochemical parameter estimation using geophysical data because they allow incorporation into the procedure of spatial correlation information, measurement errors, and cross correlations among different types of parameters.

## H61A MCC: Hall C Saturday 0830h

### Advances in Information Fusion Technologies in Hydrological Sciences II Posters

**Presiding:** W Illman, University of Iowa; T Yeh, University of Arizona; D Tartakovsky, Los Alamos National Laboratory

## H61A-0743 0830h INVITED POSTER

### Application of Geophysical Methods and Numerical Models to Quantify Solute Transport Into a Fresh-Water Lake: Sea of Galilee, Israel

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The Sea of Galilee is the lowest freshwater lake on Earth, covering a pull-apart basin along the Dead Sea transform. Saline groundwater emerges through onshore and offshore springs and through flux from the lake's sediments. In this study, we combined geophysics, geology and numerical models to quantify

groundwater and chloride discharge rates into the Sea of Galilee. The results have practical implications for management of the lake and the surrounding aquifers. Multi-channel seismic reflection data define two distinct zones beneath the lake: a deep graben (aquitar) that underlies most of the lake, and shallow pre-rift units (aquifers) underlying the northwestern faulted part of the lake. Applying the novel surface marine modification of the TDEM (Time Domain Electromagnetic) method, the spatial distribution of brines in the sediments below the lake was delineated. Resistivities of 1.0 and 0.5 ohm-m were detected at depths of about 10 m below the lake bottom in most of the lake area, equivalent to approximately 11,000 and 22,000 mgCl/l, respectively. Relatively fresh groundwater was detected beneath most of the shoreline. It is hypothesized that the brine was leached from the sediments beneath the lake's margins due to forceful topography-driven flow systems, but still is trapped beneath the central part of the lake. The detection of shallow brine in the lake's sediment has led us to propose that in the late Pleistocene, during a short high-stand phase of former Lake Lisan, its saline water percolated into the subsurface. Since its recession and the instantaneous formation of the freshwater lake, the Sea of Galilee, the previously intruded brine has been flushed backwards towards the lake. Numerical simulations of fluid flow and of solute and heat transport show that a high-stand period of approximately 1,000 years in Lake Lisan was sufficient for saline water to percolate deep into the subsurface. Results of 1-D advective-dispersive chloride transport numerical simulations that take into account sedimentation and compaction at the lake bottom were compared with measured chloride concentration profiles in sediment cores. The calculated results validate the hypothesis that Lake Lisan solutes are currently discharged into the Sea of Galilee, and indicate that upward water velocity in the sediment ranges between 9 and 22 mm/year, implying that the total solute discharge into the lake induced by compaction is less than 5% of the total discharge.

## H61A-0744 0830h POSTER

### Stochastic Fusion of Information: An application to Monitoring Water Movement in STVZ Infiltration Field Site

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A stochastic information fusion technology that can assimilate different types of information (e.g., hydrologic, geologic, geophysical, geochemical, geostatistical information, etc.) to provide the best unbiased estimate and quantify its uncertainty is a promising tool to monitor and characterize the vadose zone. In this study, a stochastic fusion technology based on a combination of geostatistics, three-dimensional variably saturated flow model, and three-dimensional electric current flow model was developed. It was applied to the STVZ (Sandia-Tech Vadose Zone) field site at New Mexico to monitor the water movement in vadose zone during infiltration experiments. This fusion technology estimated water contents directly using data sets from surface and borehole dipole-dipole ERT surveys during different periods of the infiltration experiments. Water content measurements from neutron probe data of 13 boreholes were used to condition our estimates of water content. Spatial variability of the resistivity-moisture relation was also taken into account in our approach. To overcome difficulties associated with the large number of data sets, the fusion process was carried out sequentially by propagating conditional moments of variables. Results of our study illustrate the effectiveness of this fusion technology in real world problems.

## H61A-0745 0830h POSTER

### A Full-Bayesian Approach to the Estimation of Transmissivity Fields From Thermal Data

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Woodbury and Urych (WRR 36(8), 2000) proposed a Full-Bayesian approach to the estimation of transmissivity from hydraulic head and transmissivity measurements for two-dimensional steady state groundwater flow. Specifically, Bayesian updating (see Woodbury, 1989) was used to condition prior estimates of logarithm transmissivity [denoted as  $\ln(T)$ ] field with  $\ln(T)$  measurements. Then they incorporated hydraulic head measurements into the updating procedure by

adopting a linearized aquifer equation. Prior probability density functions (pdfs) of the  $\ln(T)$  field and any hyperparameters associated with its two central moments were determined from maximum entropy considerations. Any uncertainties in the basic geostatistical hyperparameters were removed by marginalization. Woodbury and Urych (2000) showed that the resolution of the  $\ln(T)$  field gradually improved through the updating procedure. In their work the problem was discretized very finely so that many more unknowns than data points are sought. In this way the heterogeneous nature of the porous media is more reasonably approximated. The Bayesian methodology reformulates this ill-posed inverse of deduction into a well-posed problem of inference. With this approach one can take advantage of data from different sources and any knowledge of the identified system can help constraint the inverse problem.

In this work the full-Bayesian approach is extended to estimate transmissivity field from thermal data. Linearized treatment to the advection-conduction heat transport leads to a linear formulation between temperature and  $\ln(T)$  perturbations. An updating procedure similar to that of Woodbury and Urych (2000) can be performed. This new algorithm is examined against a generic example. It is found that the use of temperature data is showed to improve the  $\ln(T)$  estimates, in comparison to the updated  $\ln(T)$  field conditioned on sparse  $\ln(T)$  and head data; also the addition of temperature data without head data to the update aids refinement of the  $\ln(T)$  field compared to simply interpolating the sparse  $\ln(T)$  data alone. These findings suggest that inexpensive temperature measurements are a promising data source for site characterization through the Full-Bayesian methodology, especially in the cases where limited and inaccurate hydraulic measurements are available.

#### ACKNOWLEDGMENTS

This work was performed at the University of Manitoba with support of Manitoba Hydro. This paper does not necessarily reflect the views of Manitoba Hydro.

## H61A-0746 0830h POSTER

### Numerical Simulation of Soil Water Content in the Unsaturated Zone Using Constraints Provided by Geophysical Measurements

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Soil moisture distribution and variation in the vadose zone is important for agricultural, engineering and contaminant studies. Conventional sampling techniques for estimating soil water moisture content are costly, time consuming, invasive, and typically recover information at a single point in space and time only. Geophysical techniques have the potential to provide dense and accurate information about subsurface soil moisture. However, these data still provide information about water content at the time of measurement only, and geophysical data acquisition is sometimes hindered by cultural or site conditions. For example, although both surface and crosshole GPR techniques have been successfully applied for providing soil moisture information over space and time, the penetration distance of the GPR signal is limited in soils having high electrical conductivity, sometimes inhibiting moisture profiling through the entire vadose zone.

In this study, we investigate the potential of coupling geophysical measurements with numerical modeling to provide information about soil moisture variations in space and over time. Such an approach was undertaken to permit estimation of soil moisture throughout the root zone even under difficult GPR data acquisition conditions, and also to yield insight into the dynamics of soil water distribution, including both state variables and fluxes. In this study, surface and crosshole geophysical measurements provide initial and boundary soil moisture conditions to a numerical simulator (TOUGH2-EOS9) based on Richards Equation. Simulations were run using information available from various geophysical techniques collected at a naturally heterogeneous agricultural field site, including surface GPR, crosshole GPR, neutron probe, and TDR measurements. Information about soil heterogeneity was obtained using borehole soil textural information, and meteorological water flux boundary conditions were obtained using rain gauges, sap flow meters and also from a nearby CIMIS weather station. Hydraulic conductivity, one of the most difficult field variables to measure, can be satisfactorily estimated using a stochastic inverse modeling approach. Comparison of soil moisture measurements (collected throughout a year at a field

site near Napa, CA) with the various simulations suggested that the approach was able to capture the natural evolution of the vadose zone soil moisture profile at several locations throughout the heterogeneous site. These results illustrate that improvement in the understanding of water cycling and its interaction with ecosystems can be obtained by coupling hydrological theory and measurements available from geophysical and meteorological techniques.

#### H61A-0747 0830h POSTER

##### Time-Series Analysis of Streambed Thermal Records to Model Surface Water - Groundwater Interaction Within a Coastal Watershed

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Heat has been used as a natural tracer in groundwater studies for decades to quantify surface water-groundwater (SW-GW) interactions. In this study we develop a new method that uses temperature records from multiple depths to estimate seepage rates independently. As daily temperature fluctuations propagate downward through streambed sediments, the natural temperature signal is attenuated and shifted in phase. These relationships are quantifiable using time-series methods, and are used to determine both the magnitude and direction of seepage (into or out of the streambed). Temperature vs. time (T vs. t) was measured at numerous depths beneath the Pajaro River and Corralitos Creek, California during Spring 2002, then modeled using the numerical model VS2DH (Healy and Ronan, 1996).

We generated a series of 1D and 2D simulations of streambed temperatures for each experimental site to derive quantitative relationships between phase lag, amplitude attenuation, and flow rate. We applied a mean stream temperature of  $15^{\circ}\text{C}$  and a sinusoidal (24-hour) oscillation of  $\pm 5^{\circ}\text{C}$ , and derived flow rates for the spacing of each sensor pair. T vs. t records were filtered using wavelet transforms and other time-series methods to isolate target frequencies for short term (diurnal) and long term (seasonal) variations. Our results show that phase shift is highly sensitive to seepage both into and out of the streambed, while the amplitude ratio is most sensitive to flow out of the streambed. Flow rates derived from model temperature records are similar to those estimated from differential discharge measurements during six months of preliminary sampling, equivalent to about 0.6 m/day. With these fundamental relationships defined, the heat or heat as a tracer method for estimating seepage rates can be widely applied to other SW-GW systems throughout the water year, including periods when extreme changes in water levels (i.e., during large precipitation and runoff events) preclude estimates based on differential-discharge or other methods.

#### H61A-0748 0830h POSTER

##### USING ENVIRONMENTAL ISOTOPES, GEOCHEMISTRY, AND AQUIFER TEMPERATURE TO ADDRESS FLOW REGIMES WITHIN THE EASTERN SNAKE RIVER PLAIN AQUIFER AT THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY.

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Beginning in 1997 a series of studies utilizing uranium and strontium isotopes were undertaken to characterize the Eastern Snake River Plain (ESRP) aquifer at the Idaho National Engineering and Environmental Laboratory (INEEL). These studies identified fast flow and slow flow zones within the ESRP aquifer at the INEEL. The work presented here is the result of continued study to characterize the physical properties of the aquifer. Especially the implications and origins of large-scale (10's of kilometers) slow flow zones located beneath the 2300 km<sup>2</sup> site. Coupling strontium and uranium isotope data from water samples with regional temperature, geophysical, and geologic data has proven to be a robust way to investigate large-scale flow characteristics in the aquifer. Depth-temperature profiles show that effective aquifer thickness varies dramatically across the INEEL from less than 100-m to over 350-m. Isotopic ratios support the conclusion that the thinner portions of the aquifer are "slow flow" zones in which the residence time of groundwater in the rock matrix is sufficient to allow significant water rock interactions to take place. The "slow flow" zones may be zones of increased diagenesis and pore filling mineralization caused by large volumes of upwelling geothermal waters penetrating into the upper, conductive portion of the aquifer. Our current compilation of the large database of isotope, chemical, temperature, hydrologic, and geophysical data in a GIS format enables us to use 50 years of data collected from observation wells and regional surveys to increase our understanding of a complex fractured-rock aquifer

#### H61A-0749 0830h POSTER

##### Steel Casing Resistivity Technology (SCRT): Innovative Applications of Electrical Methods for Buried Tank Leak Detection

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The need for non-invasive leak detection methods is extremely important for monitoring cleanup efforts of nuclear waste contained in underground storage tanks at the Hanford Nuclear Facility in Washington. Drilling is both very expensive and undesirable in the tank farms. Various geophysical imaging methods were evaluated over the past two years at two cold sites but within geologic conditions similar to the tank farms. The cold sites consisted of 1, a dense array of 32 steel casings, and 2, a mock tank in which various controlled leaks (injections) of a saturated aqueous solution of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>H<sub>2</sub>O were metered. Nearly all methods required invasive drilling for subsurface placement of sensors.

An innovative direct-current electrical method using existing infrastructure as grounding electrodes, such as steel casings and steel tanks, has shown very promising results and is undergoing further testing. The most useful results have been obtained by using multiple grounding points for spatial determinations and continuous time-series monitoring for temporal variations. Although the large size of tanks and lengths of casings make discrete volume estimations difficult, data acquired for test leaks to date have shown a surprising correlation between leak rates and the rate-of-change of specific electrical measurements. First order volume approximations can be made based on existing knowledge of the geologic environment and hydraulic parameters. Spatial data provide general leak location and gross flow characteristics, whereas temporal data indicate test leak commencement, cessation, and approximate leak rates. On-going testing is providing quantitative calibration information that is expected to transfer to the tank farm environments. Procedures are being developed that will simplify the installation and operation of the system in the tank-farm environments.

Implementation of the technology necessitated remote operation and monitoring of the electrical system. Additionally, two different groups required access to the system for performing independent experiments without interfering with each other. An internet-accessible system was established that allows real-time control and monitoring of the system.

#### H61A-0750 0830h POSTER

##### Inversion of Hydrogeological and Time-lapsed GPR Data for Flow Parameters

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Methods for estimating hydraulic properties are in great demand for modeling fluid flow and contaminant transport in the shallow subsurface. Estimates of flow parameters (such as permeability, porosity and parameters defining water retention curves) are typically obtained through the inversion of hydrogeological data (e.g., water saturation and capillary pressure measurements). However, ill-posedness and non-uniqueness often arise in such inverse problems making the solutions elusive. Incorporating additional types of data, such as from geophysical methods, is one way to improve the situation. Ground-penetrating radar (GPR) in particular has proven to be sensitive to subsurface fluid flow processes (e.g., changes in water saturation) though some uncertainty exists in interpreting GPR images. In the present work, an inverse technique is presented that uses time-lapsed GPR measurements along with transient hydrogeological data. Specifically, a maximum a posteriori (MAP) formulation, is chosen based on the Bayesian approach to parameter uncertainty, for its ability to incorporate prior information into the solution; this general framework can be simplified to other commonly used inverse problem formulations. Through a synthetic case study, numerical modeling of GPR and variably saturated flow allows for exploration of the benefits offered by inclusion of GPR data in estimation of flow parameters.

#### H61A-0751 0830h POSTER

##### Interactive Three-Dimensional Visualization for Digital Hydrogeologic Framework Models: GeoWall Presentation of the Grand Canyon

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Population and water use in northern Arizona are expected to double over the next fifty years. This trend, which takes in to consideration visitors to Grand Canyon National Park (over 4.4 million in 2001), makes water resource management one of the most important issues facing this high desert region. The complicated and politically charged question of how increased pumping will affect Grand Canyon springs has prompted managers to request the construction of predictive groundwater models for the large regional aquifer.

To effectively implement an acceptable management plan incorporating these ground water model predictions, many stakeholders must be involved in the discussion, and they all must have a realistic understanding of the complex, but data-poor hydrogeologic system surrounding the Grand Canyon. One way to facilitate such a discussion is through the use of a GeoWall, which combines new projection technology, fast graphics cards and Linux PCs into a low cost, three-dimensional computer projection system. An interactive hydrogeologic GeoWall visualization was developed for the eastern Grand Canyon region, allowing resource managers, park visitors, and employees the opportunity to view the geologic and hydrologic resources hidden behind the canyon walls. This visualization technique will help to facilitate public discussions about the groundwater resources of the Grand Canyon and the impact that development may have on them.

The most dramatic expressions of Grand Canyon ground water are the major springs issuing from dissolution-enhanced faults and fractures in the carbonate Redwall-Muav aquifer where it is exposed on the Canyon walls. Two of these springs are particularly important as both water supplies and cultural resources; Roaring Springs on the North Rim of the Grand Canyon is the sole water supply for the Park, and Havasu Springs on the South Rim is the water source for the Havasupai Indian Tribe. Municipalities and residents across northern Arizona also utilize this aquifer, but the cost and uncertainty associated with drilling into this aquifer have restricted the number of wells. There are currently only 10 wells on the Coconino Plateau south of the Colorado River and even fewer wells to the north. As development pressure increases, so does the need to realistically balance the

benefits of increased pumping with the costs of decreased spring flow.

#### H61A-0752 0830h POSTER

##### Evaluating Wetlands Sustainability Using a Hierarchical Systems Approach

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A hierarchical systems analysis approach, using Geographical Information Systems (GIS) software, is used to integrate and assess the different types of data necessary to characterize the surface and ground-water system as it pertains to the wetlands environment within the landscape context. This hierarchical approach was applied to the Cucumber Gulch wetlands complex, located near Breckenridge, Colorado.

The Cucumber Gulch watershed is currently being studied for proposed expansion and development of the existing Breckenridge ski area. The delineated wetland complex is a jurisdictional wetland and is protected under section 404 of the Clean Water Act. The proposed development has the potential to impact the wetlands complex.

The various data integrated through the hierarchical systems analysis include climate, topography, geomorphology, geology, vegetation, hydrology, and anthropogenic influences to the natural system. A three-dimensional solid computer model of the surface and sub-surface geology was constructed. Through analysis and integration of these various layers, the surface and ground-water hydrological framework and flow models were developed and calibrated. Throughout the process the ground-water modeling performed to assess the sustainability of the wetland was reconciled with the hydrological framework developed from the "soft" data layers, and with the hydrologic system conceptual model developed from the hierarchical systems analysis.

This hierarchical systems approach to modeling provided the Town of Breckenridge with means of assessing the validity of the computer models and potential impact to the wetland complex. Computer modeling was continually refined in response to this process.

#### H61A-0753 0830h POSTER

##### Evaluation of the Field Water-bearing Potential Using Geophysical Methods

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There are about 16 villages and the center of the district itself, Bilishti, in the Devolli field with a developed agricultural economy. The actual demand for drink and irrigation water has been considerably increased. As the existing irrigation system is damaged and outdated, it is necessary to have an evaluation of the water-bearing potential of the Quaternary formations of the Devolli Field. These formations are composed of various layers such as clay, sandy clay, sand, coarse-grained sand and gravels. Electrical soundings in a grid of 500 x 500 m and 250 x 250 m have been carried out in an area of 100 km<sup>2</sup> to evaluate the water-bearing-potential. Their location along with the geological map is shown in Fig.1. Their interpretation shows that the Quaternary formations thickness varies from some meters to 150 m at the center of the valley. It is shown in Fig.2. It has been made possible to distinguish different layers of various composition and non-homogeneous thickness composing the Quaternary formations, (Figs.3,4,5) but we have been mostly focused on the water-bearing coarse-grained sands and gravels, of higher thickness and consistency. This may help to plan an effective grid of holes to take out water. The history of the Devolli River beds formation during the Quaternary period is treated in this poster as well. This information has been obtained both from the traces of the river beds (which have often changed) and electrical soundings.(Fig.6) We can conclude that the results of the electrical soundings show that there are some waterbearing layers at different hypsometric levels. Two of them are the most important: (Figs.3,4) 1. The uppermost Upper Quaternary sand-gravel formations. 2. The deeper (but almost of the same composition) layer of the Q1 - Q2 formations.

The poster is composed of the explanatory text and six illustrating figures,

#### H61A-0754 0830h POSTER

##### Geostructural, Geomorfic and Hydrological Studies at Butrint Region

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During ten last years, there was observed a great interest for the ruins of ancient Butrint which is a world-known archaeological site. Inhabited since prehistoric times this region is now in the focus of our general opinion for its ecological, its heritages and tourist potential, water resources and fishing economy. From 1995 year of special interest are geophysical studies carried out in this area in the framework of integrated geological, archaeological and hydrogeological studies. Throughout its long history, Butrint had an interactive relationship with its hinterland and the even-changing coastline. The geology of Quaternary formation, from late to date, connected with neotectonic phenomena in that area developed intensively during Pleistocene, the Lake as a tectonic origin, delineation of the horizontal and vertical extend of the gravel reservoir and the estimation of water bearing reservoir are some goals of that study. The studies of Quaternary deposits evidenced both the sedimentologic evolutions during the Pleistocene time in which had been occurred sea, lacustrine and fluvial depositions. Histories of terrestrial erosion, near-shore sediment redistribution, times, magnitudes of sea level fluctuations, subsidence and compaction, land-sea interaction are obvious now. Up to now geophysical observation consist of vertical electric soundings (V.E.S.) with a grid 500x 250m and magnetic measurements inside a layout of 20 km<sup>2</sup> at Vrina plain. The soundings data, particularly resistivity variations are the base for sedimentologic studies due to the lack of boreholes. For a gravel deposition, in addition to the usual parameter maps as resistivity and thickness maps, combined multiparametric characterization maps have been plotted. These maps are more application on hydrogeologic domain than conventional parameter maps. Based on the sedimentologic and structural factors studied and geophysical maps and cross-sections, plenty of geomorphic problems are obvious now. The evaluations of the regional water bearing are estimated, separating salty waters area. Preliminary research suggests that in the Holocene the lake was a sea inlet which stretched 20 km to north of Butrint, as for as the city of Foinike, later Epiriot capital. Today the Lake is just 7.5 km long, being the result of the gradual silting up of this inlet with soils brought down by Bistrice and Pavlo rivers from the surrounding mountain ranges. Geomorphologic studies show the evidence to the advancement of the coastline is still occurring and the shoreline is still on the move. SEV data are used for compiling of the 100m shallower structure map in the Vurgu and Vrina fields, located in North and South of Butrint Lake. According to specific resistivity the depth interval of 0-100 m shows the great lateral and vertical diversity. Changes in bedding in the basin can be featured by the maps representing mean electric resistivity values weighted by the thickness of the respective beds. These series illustrates mean electric resistivity distribution of beds in three depth interval (10, 30, 80 m).

#### H61B MCC: Hall C Saturday 0830h

##### Observations and Modeling of Land Surface Hydrological Processes I Posters (joint with GC)

Presiding: V Lakshmi, University of South Carolina; T Cahill, Texas AM University

#### H61B-0755 0830h POSTER

##### Drought and Fire Effects on Evapotranspiration From Sawgrass in Florida

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Drought and fire are recurring natural processes in the extensive sawgrass (*Cladium jamaicensis*) marsh areas

of Florida. An understanding of the effects of these processes on evapotranspiration (ET) is critical for evaluation of the hydrologic flow system. ET fluxes were measured using eddy correlation techniques for a two-year period (2000-01) at a site within a sawgrass peat marsh in east-central Florida before, during, and after two droughts. During the second drought, wildfires consumed the sawgrass canopy at the field site. The impact of these droughts and the fire on ET are most easily described through the use of a value of ET normalized for the available radiant energy the evapotranspirative fraction (EF).

The impact of drought on the EF was dependent on the annual life cycle of sawgrass. During the growth stage (spring-summer), EF (averaging about 80 percent) apparently was independent of the water table depth and ET was unaffected by drought conditions. During senescence (fall-winter), EF dropped to as low as 40 percent as the water table declined. Apparently, during the growth stage, root growth allows sawgrass to seek soil moisture, thus preventing moisture limitation on ET during droughts, despite a declining water table. However, during senescence, the absence of vigorous root growth prevents sawgrass access to moisture deeper in the soil profile as the water table declines. In addition, the density of green, transpiring leaves decreases as partial browning of the canopy occurs. The non-expanding root distribution and reduction in green leaf density during senescence reduces the fraction of available energy consumed as ET and increases the fraction that generates sensible heat flux from the canopy.

A fire in the study area in February 2001, following three months of drought, removed the sawgrass canopy, but spared the roots. Sawgrass sprouts appeared within a few weeks and the canopy reached a height of two meters within six months of the fire. Despite a continuation of the drought for almost five months after the fire, EF increased from a pre-fire value of about 40 percent to a value of about 90 percent within three months after the fire. The increase in EF can be attributed to the burn-stimulated transition from senescence to growth stage and the associated development of a green canopy, largely free of non-transpiring, dead biomass.

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##### Development and Testing of a Model to Assess Subsurface Moisture Gradients From Diurnal Surface Temperatures and Soil Thermophysical Properties

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A one-dimensional, finite difference coupled heat and moisture transfer model for unsaturated zone porous media flow has been developed and tested. Inputs to the model include soil surface excursions, site topography, meteorological data, and detailed information about the soil thermophysical and hydraulic properties. Assuming homogeneity or knowledge of the stratification of the soil column and steady-state conditions (i.e. no recharge), the output is a profile of moisture gradients in the subsurface extending to the depth of diurnal fluctuations of moisture. This model primarily differs from existing one-dimensional heat and transport models in its incorporation of the 3-dimensional topography and diurnal shadowing of the study site and in its ability to provide information about relatively deep moisture profiles. These profiles are produced through the assumption of a moisture source (a water table or pseudo water table) at a given depth. The model was subject to sensitivity analyses and was calibrated in August 2002 in the Kau Desert, Hawaii, in an unvegetated area with layers of high moisture content in the subsurface. Field work consisted of 24 contiguous hours of monitoring soil surface temperature, meteorological data, and moisture content at several depths of the soil profile. Thermal conductivity of the soil was determined in situ, and field saturated hydraulic conductivity was determined with a Guelph permeameter. The other thermophysical and hydraulic soil properties of interest (specific heat, moisture retention curve, bulk density, porosity, grain axes, and van Genuchten parameters) were determined through laboratory experimentation. Results from the calibration exercise will be presented.

#### H61B-0757 0830h POSTER

##### Scaling Effect on Distributed Modeling

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