

## H23B CC: 220 C-E Tuesday 1330h

### Water Quality of Hydrologic Systems Posters

**Presiding:** S D Sebestyen, State University of New York - ESF; B Wemple, University of Vermont

#### H23B-01 1330h POSTER

##### Temporal and Spatial Variation of Ground Water Quality Using Stable Isotopes in Jeju Island

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The purpose of this study is to evaluate ground water quality and to identify the temporal and spatial variation of ground water contamination at Hanlim area, Jeju Island. Ground- and spring- water samples were collected in August and November, 2002, and April, 2003. And investigation for analysis of stable isotopes,  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ , was conducted in November, 2002, and April and August, 2003. Ground water is mainly (Na,Mg)- $\text{HCO}_3$  type. And Mg- $\text{HCO}_3$ +Cl type in ground water samples is also observed near altitude 20~40m, considering the effect of contamination. Spring water shows Na-Cl type, including the effect of seawater intrusion. Most of the ground water samples, however, had less values of S.M.I.(Seawater Mixing Index) than 1, implying the minimal effect of seawater intrusion in the study area. One ground water sample, showing (Ca,Mg)- $\text{HCO}_3$  type in August, 2002, is considered by the effect of shell materials in Seogupo formation. These various water types mean complicated reaction processes in the study area, such as 1) Reaction between ground water and geological materials, 2) Contamination due to agricultural activities and 3) Seawater intrusion. Nitrate contamination is significant and its concentrations increase sharply around altitude 100m. Contamination becomes more serious in the rainy season, August than in the dry season, November and April. The relationships between  $\delta^{15}\text{N}$ - $\text{NO}_3$  and  $\text{NO}_3$ -N concentrations show that the main origin of nitrate is chemical fertilizer. It agrees comparatively with the properties of land-use of study area. Constituents of fertilizer used in Jeju Island and nitrate also had positive correlation. Stable isotope ratios of  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  of precipitation in Jeju Island depend on air masses. Those of precipitation sampled in the study area reflect 'amount effect'. Isotopic composition is similar in all ground water samples, implying that seasonal variations in isotopes are attenuated during ground water movement through the subsurface flow paths. The isotopic values of each season are grouped separately. However, these isotope ratios are similar from the high area (altitude 300m) to the shore, meaning the fast ground water flow system from the recharge through infiltration of precipitation to the discharge at the shore.

#### H23B-02 1330h POSTER

##### Solute movement in the rhizosphere with the effect of soil moisture and plant uptake

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Nutrient loads from land to a water body effects the eutrophication processes. The assessment of leakage of dissolve inorganic nitrogen (DIN) solute from land provides useful information for nutrient management. Solute transport in the rhizosphere is a complicated process, which depends on solute property, water supply and movement, soil physiologic property, plant transpiration and uptake, etc. This presentation focuses on the effect of soil moisture and plant uptake on DIN leakage from soil. Plant nitrogen uptake is not

a monotonic function with soil moisture. When moisture is deficient, increasing moisture will increase water uptake and increase nitrogen uptake; when moisture is sufficient (e.g., at the field capacity), increasing it may dilute the solution, decrease nitrogen uptake, and increase nitrogen export. Under moisture over-sufficient conditions, anaerobiosis may harm plant and cause even lower nitrogen uptake. In nutrient management, it is important to know how flow affects nutrient leakage from the land. A proper mathematic function describing such processes is desirable to establish a correct mathematical model for nutrient management. A mechanistic computer model procedure for DIN uptake as a function of soil moisture is also presented.

#### H23B-03 1330h POSTER

##### Evaluating Nitrate Contributions From Different Land Use Types Across a Regional Watershed Using Flow and Transport Models

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Regional inputs of non-point source pollutants to groundwater, such as agriculturally-derived nitrate, have typically proven difficult to model due to sparse concentration data and complex system dynamics. We present an approach to evaluate the relative contribution of various land use types to groundwater nitrate across a regional Michigan watershed using groundwater flow and transport models. The models were parameterized based on land use data, and calibrated to a 20 year database of nitrate measured in drinking water wells. The database spans 1983-2003 and contains approximately 27,000 nitrate records for the five major counties encompassed by the watershed. The Grand Traverse Bay Watershed (GTBW), located in the northwest Lower Peninsula of Michigan, was chosen for this research. Groundwater flow and nitrate transport models were developed for the GTBW using MODFLOW2000 and RT3D, respectively. In a preliminary transport model, agricultural land uses were defined as the sole source of groundwater nitrate. Nitrate inputs were then refined to reflect variations in nitrogen loading rates for different agriculture types, including orchards, row crops, and pastureland. The calibration dataset was created by assigning spatial coordinates to each water well sample using address matching from a geographic information system (GIS). Preliminary results show that there is a significant link between agricultural sources and measured groundwater nitrate concentrations. In cases where observed concentrations remain significantly higher than simulated values, other sources of nitrate (e.g. septic tanks or abandoned agricultural fields) will be evaluated. This research will eventually incorporate temporal variations in fertilizer application rates and changing land use patterns to better represent fluid and solute fluxes at a regional scale.

#### H23B-04 1330h POSTER

##### Arsenic Speciation in Old Mine Waste Site in Korea - Preliminary Results

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The ulsan mine, which is known as an important producer of iron, tungsten and arsenic ores in south-eastern Korea, is located in Gyeongsangnam Province. This mine is of calcareous skarn deposit represented by ore pipe consisting mainly of magnetite with minor scheelite, sulphides, sulphosalts, arsenides and sulpharsenides (Choi et al. 1993). A total of 13 groundwater samples and a surface-water sample at an adjacent creek, Dalcheon, were collected in January 2004. Most samples showed neutral pH ranges and normal ORP and temperature conditions. But one sample showed basic

and extremely reducing condition, and another one was with relatively high temperature. Results of chemical analysis indicate that total arsenic concentrations of all samples are exceeding the WHO guideline for drinking water quality (10 ug/L), and 64% of those are over the Korean Drinking Water Guideline (KDWG) of 50 ug/L. Especially, arsenic concentrations in two samples exceed 1000 ug/L. Concentrations of some elements like Al, Fe, Mn,  $\text{SO}_4$  are over the KDWG in several samples, too. Consequence of arsenic speciation using IC-ICP-MS, arsenic exists as three species; arsenite, arsenate, and monomethylarsenate (MMA). Arsenite detected in three groundwater samples. Two of these were from wells in the tailing dam, and the other was the one with basic pH and extremely reducing condition. Arsenic in a surface-water sample mainly exists as MMA form that has lower toxicity than inorganic species. This indicates that microbial activity is the important factor to explain risks in the studied environment. Except for these samples, arsenic exists as arsenate form. Samples were prepared in two ways; 1) acidified water samples with phosphoric acid to the pH less than 2 and filtered through 0.45 um filter papers, and 2) filtered water samples first and then acidified. Comparison of the analysis from the two sample sets indicates that significant mass of arsenic appears to be with clay and the pH condition of the site environment is very important. From now on, proper sampling, preservation and treatment methods according to the site characteristics and arsenic species change will be studied.

#### H23B-05 1330h POSTER

##### Soil Surface Composition Effects on the Wettability of Aquifer Materials

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The wettability of subsurface porous media is critical for determining the distribution of non-aqueous phase liquids. Variations in the wettability of subsurface materials are generally attributed to sorption of hydrophobic contaminants. However, naturally occurring carbonaceous materials may influence the wettability as well. A series of seven soil materials were selected to determine the effect of organic carbon surfaces on soil wetting behavior. The materials represent organic carbon containing surfaces that may be found in soils from young humic matter to mature coal and shale kerogen. Measurements of organic liquid-water contact angle against cut rock faces reveal that surface composition alters the contact angle from the completely water wetted condition of quartz in the case of the mature carbon materials (Lachine Shale, Garfield Shale, Waynesburg Coal, and Plumbago Mineral Carbon). An examination of the soil elemental composition confirms that the bulk elemental composition of each material is separated on a plot of hydrogen to carbon versus oxygen to carbon ratios. The functional groups present at the surface of the soil materials were obtained with Fourier Transform Infrared Spectroscopy (FT-IR) analysis and indicate that the presence of oxygen containing surface functional groups is positively correlated with increased organic-liquid wetting. This study demonstrates that even in the absence of sorbing contaminants the subsurface is fractionally water-wet. This finding may help explain why subsurface distributions of non aqueous phase liquids can vary from those determined with laboratory sands.

#### H23B-06 1330h POSTER

##### The Impact of Geologic Heterogeneity on Stream Temperatures in the McKenzie River, Oregon: Implications for Climate Change and Land Use

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Stream temperature is recognized as an important component of water quality for aquatic life; less well understood is how the regional geologic setting controls stream temperature regimes. The McKenzie River watershed in western Oregon exhibits significant differences in geology and rock age between two contiguous volcanic provinces: the Plio-Pleistocene High Cascades and the Tertiary Western Cascades. Streamflow regimes from spring-fed streams originating in basins underlain by fractured and permeable High Cascade rocks have more gradual recession curves and higher baseflow unit discharges than surface-flow dominated Western Cascade streams. We examined corresponding differences in temperature between these two regions. Using spatial regime regressions, we analyzed stream temperature data from 56 sites within the McKenzie watershed. Streams with a majority contributing area composed of High Cascade rocks are colder and are less sensitive to air temperature fluctuations than Western Cascade streams during the July-September baseflow period. Based on site-specific air-stream temperature regressions, High Cascade spring-fed streams are less likely, given future air temperature increases, to exceed EPA stream temperature recommendations for chinook salmon and bull trout habitat. Finally, stream temperature for four surface-dominated and four spring-fed streams was modeled using a predictive heat budget model *SSTemp* to examine potential effects of a clearcut on stream temperatures. Model results show that spring-fed streams were less affected by this land use simulation than surface-dominated streams. However, slight perturbations to spring-fed streams may have cumulative effects on downstream reaches.

**H23B-07 1330h INVITED POSTER**

**A Hybrid Transfer Function/Chemical Mixing Model of Episodic Concentration-Discharge Dynamics**

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Interpretation of episodic concentration-discharge (c-Q) dynamics in streamflow requires that the investigator assume an underlying conceptual model of runoff-generating processes, against which observed patterns in streamflow chemistry may be compared. We explore the use of a simple 2-component transfer function flow model, combined with a chemical mixing model, to explain observed storm-to-storm differences in c-Q relationships for acid-neutralizing capacity (ANC) in three headwater catchments in Shenandoah National Park, Virginia. Observed rainfall, temperature, and streamflow time series are used to fit parsimonious flow models corresponding to a parallel combination of two linear reservoirs, one representing "fast" runoff pathways and one representing "slow" pathways. Outflow from these reservoirs is mixed in a small "near-stream" reservoir, representing the channel and surrounding saturated alluvium, to produce streamflow. Chemical mixing parameters, including throughfall ANC, slow reservoir dead storage, and near-stream reservoir volume, are varied in a Monte-Carlo framework. For a given storm, simulated realizations of streamflow ANC are categorized as "behavioral" or "non-behavioral" based on their ability to match observed ANC depression, post-storm ANC, and c-Q dynamics. Preliminary results indicate a degree of overlap in the behavioral parameter subspaces for different sets of storms. However, while the overall conceptual framework may be plausible, storm-specific behavior suggests that this relatively simple model will require embellishment in order to represent some aspects of the complex hydrochemical response of these catchments.

**H23B-08 1330h POSTER**

**Control of Antecedent Hydrologic Conditions on Temporal Patterns of Hydrochemical Export from a Temperate First-Order Agricultural Catchment**

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Nutrient (nitrate, soluble and total phosphorus) transport from agricultural catchments is difficult to quantify and predict because of the influence of variable hydrologic flowpaths and their interaction with nutrient pools. Nutrients are often transported from a combination of point and non-point sources that may vary temporally and spatially among catchments. However, our ability to quantify and predict discharge and nutrient transport patterns is confounded by the effects of antecedent hydrologic conditions (AHC) in upland areas. This research examines the role of AHC on discharge and NO<sub>3</sub><sup>-</sup> and P transport from a small (2.7 km<sup>2</sup>) first-order agricultural catchment in Southern Ontario. Runoff ratios (discharge/precipitation) range from 0 to 1 for 59 events occurring over a two-year study period. Runoff ratios increase throughout successive events as AHC become wetter although key indices of AHC such as water table position, pre-event streamflow and soil moisture do not yield predictive relationships. NO<sub>3</sub><sup>-</sup> and P transport from the catchment change under variable AHC, where NO<sub>3</sub><sup>-</sup> and P export may increase or decrease throughout suites of successive events. These patterns are linked to water table position and timing of fertilizer application. It is hypothesized that wetter AHC increase nutrient transport from the catchment by increasing macropore connectivity between surface soil horizons and tile drains.

**H23B-09 1330h POSTER**

**Using Major Elements to Determine Sources of Nitrate in Groundwater, Suffolk County, Long Island, NY**

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Suffolk County is the eastern most county on Long Island with an area of 2,500 square kilometers and a population of 1.4 million. Groundwater is the only source of potable water for Suffolk County. Nitrate levels have become a concern as a result of the continued eastward urbanization of Long Island since the mid 1900's. In 2003, 2% of 1000 public supply wells had greater than 10 ppm nitrogen as nitrate, 8% had 6 to 10 ppm nitrogen as nitrate and 62% of the wells were rated as susceptible to increased nitrate contamination based on land use, travel time and prevalence. Nitrogen as nitrate above 10 ppm is harmful to infants and is currently the drinking water standard of the Environmental Protection Agency. The major sources of the nitrate in the urbanized areas are most likely turf grass fertilizer and sewage from septic tank/cesspool systems and sewage treatment plants that provide only secondary treatment. Turf grass occupies about 28% of the land. Two-thirds of the houses have septic tank/cesspool systems and a majority of the sewage treatment plants discharge effluent to the groundwater. Previous investigators of the sources of nitrate in groundwater on Long Island have used 15N values of nitrate-nitrogen to identify nitrate contamination (Bleifuss et al., 2000; Flipse and Bonner, 1985; Flipse et al., 1984; Kreitler et al., 1978). However, due to overlapping source signatures, nitrogen isotopes alone were not sufficient to characterize the sources of nitrate. More recent studies have shown that major elements that accompany nitrate in the groundwater (Bleifuss et al., 2000; Elhatip et al., 2003; Trauth and Xanthopoulos, 1997) may distinguish sources of nitrate with less ambiguity. In this study samples of waste water from septic tank/cesspool systems and sewage treatment plants and samples of soil water collected below turf grass that is not fertilized, fertilized with organic fertilizer and fertilized with chemical fertilizer were analyzed for major elements. Major element data for groundwater from Suffolk County Water Authority municipal wells have been characterized as a function of capture zone land use (Source Water Assessment Project, CDM, 2003). The data for the groundwater and the waste water and the soil water were then compared. The elements Na, Mg, Cl, NO<sub>3</sub> and SO<sub>4</sub> proved most successful as nitrate tracers on element-element plots. There is a distinct relationship between land use and source of nitrate contamination such that ground waters sourced in: (1) low residential density areas (1 or less dwelling units per acre (DU/acre)) plot in turf grass cultivation fields (2) medium residential areas (2-10 DU/acre) and high residential areas (more than 10 DU/acre) plot as a mixture of turf grass cultivation and wastewater (3) agricultural

areas plot in the turf grass cultivation field and (4) vacant or open land use plot close to average rain water compositions.

**H23B-10 1330h POSTER**

**Concentrated Flow through a Riparian Buffer: A Case Study**

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Riparian buffers are often used for in-situ treatment of agricultural runoff. Although the benefits of riparian buffers are well recognized, concentration of flow can restrict the efficiency of contaminant removal. This study evaluates flow concentration at a agricultural site near Manhattan, Kansas. Manual and automated GIS analyses of a high-resolution digital elevation model were used to determine the fraction of runoff contributing to each buffer segment. Subsequent simulation of the system in WEPP (Water Erosion and Prediction Project) demonstrates the extend to which flow concentration affects buffer efficiency.

**H23B-11 1330h POSTER**

**Detachment of Bacteria From Porous Media in Laboratory Columns**

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Extended tailing, the continued elution of bacteria at low concentrations, has often been observed in breakthrough curves during both laboratory and field transport experiments. Tailing is caused by the slow detachment (also referred to as entrainment or desorption) of previously attached cells over time, with aqueous concentrations often orders of magnitude below the peak concentration. This transfer of bacteria from the solid phase to the aqueous phase results in the long-term release of bacteria back into drinking water supplies, posing potential human health risks. Unlike the factors controlling bacterial attachment to aquifer sediments, the processes controlling bacterial detachment from sediment surfaces are not well understood. We performed laboratory column experiments to investigate the transport and detachment of *Escherichia coli* (*E. coli*) at resting state through uncoated and Fe-coated quartz sand in KCl solution at low and high ionic strength (0.001-0.01 M). A one-half pore volume pulse of <sup>3</sup>H-labeled *E. coli* was injected into flow-through columns, and column effluent was sampled for approximately 18 pore volumes. To account for biological effects on detachment, experiments were also run using *E. coli* treated with 0.5% formaldehyde. To calculate bacterial detachment rates, we fit the one dimensional advection-dispersion equation modified to account for deposition ( $K_f$ ) and detachment ( $K_r$ ) to the breakthrough curves for each treatment combination. In general, higher ( $K_r$ ) values were observed under conditions less conducive to irreversible attachment, such as low ionic strength and uncoated sands. Tailing was not observed for experiments using Fe-coated sands, indicating that iron-coated sands irreversibly removed bacteria from the water column. There were no significant differences between fixed and live cells, indicating that bacterial cells at resting state behave like inorganic colloids, which suggests that under these conditions biological effects on attachment and detachment are minimal. Our results indicate that iron-coated sediments can permanently remove bacteria from groundwater under certain conditions. This knowledge is valuable for protecting groundwater supplies from contamination by pathogenic microorganisms.

**H23B-12 1330h POSTER**

**Transport of *Cryptosporidium*, *Giardia*, Source-specific Indicator Organisms, and Standard Water Quality Constituents During Storm Events**

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Microbial and water-quality measurements are collected during storm events under a variety of meteorological and land-use conditions in order to 1) identify risk of *Cryptosporidium* oocysts, *Giardia* cysts and other constituents, including microbial indicator organisms, entering surface waters from various land uses during periods of surface runoff; 2) optimize storm sampling procedures for these parameters; and 3) optimize strategies for accurate determination of constituent loads. The investigation is focused on four isolated land uses: forested with free ranging wildlife, beaver influenced forested with free ranging wildlife, residential/commercial, and dairy farm grazing/pastureland using an upstream and downstream sampling strategy. Traditional water-quality analyses include pH, temperature, turbidity, conductivity, total suspended solids, total phosphorus, total Kjeldahl-nitrogen, and ammonia nitrogen, *Giardia* cysts and *Cryptosporidium* oocysts. Total coliforms and fecal coliforms are measured as industry standard microbial analyses. *Sorbitol-fermenting Bifidobacteria*, *Rhodococcus coprophilus*, *Clostridium perfringens* spores, and Somatic and F-specific coliphages are measured at select sites as potential alternative source-specific indicator organisms. Upon completion of the project, the final database will consist of wet weather transport data for a set of parameters during twenty-four distinct storm-events in addition to monthly baseline data. A subset of the results to date will be presented, with focus placed on demonstrating the impact of beaver on constituent loadings over a variety of hydrologic and meteorological conditions.

## H23B-13 1330h POSTER

### Water Quality of a Tropical Montane Cloud Forest Watershed, Monteverde, Costa Rica

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The Rio Guacimal originates in the Monteverde Cloud Forest Preserve, located on the leeward side of the continental divide through Costa Rica. Agriculture and ecotourism has spurred growth adjacent to the preserve. Continued development coupled with changes in precipitation patterns could stress the quality and quantity of water. This study characterizes water chemistry and surface water hydrology of a 21 km<sup>2</sup> headwater catchment to evaluate effects of current and projected land use on water quality. Stream samples have been collected from up to 11 sites since March 2000. Two sites located on tributaries in remote, forested areas serve as references for sites located downstream of agricultural and residential areas. Waters were analyzed for specific conductance, pH, DO, acid neutralizing capacity (ANC), Ca, Mg, Na, NH<sub>4</sub>, SO<sub>4</sub>, NO<sub>3</sub>, Cl, PO<sub>4</sub> and dissolved silica. In the upland, forested streams, chemical loading is dominated by mineral weathering and cation exchange reactions. Silica, ANC and base cation concentrations all exceed sum of acid anions. During the dry season, concentrations of all dissolved constituents increase synchronously, but at different magnitudes (SO<sub>4</sub> and Cl by 15 µeq/L; silica by 250 µmol/L; sum of base cations and ANC by 120 µeq/L), suggesting that increased baseflow has a greater effect on temporal changes of chemical loads in high-elevation, forested streams than does evapotranspiration. Chemical loads of streams receiving runoff from populated areas are 2-5x more concentrated than the upland sites. Highest concentrations occur in Queb. Sucia (QS), which receives grey-water runoff from residential areas. Acidic runoff decreases the ANC of QS by 90-200 µeq/L; however high alkalinity (ANC=400-1000 µeq/L) prevents acidification. Acid anions in streams receiving grey-water runoff throughout the year are most concentrated during the dry season when dilution from precipitation is least. Conversely, a site that receives nonpoint source pollution from agricultural areas has its highest concentrations of acid anions during the wet season when surface runoff is the dominant flowpath.

## H23B-14 1330h POSTER

### The Effects of Atmospheric Deposition on High Alpine Lakes in Grand Teton National Park, Wyoming: Predicting Lake Sensitivity Using Basin Characteristics

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Atmospheric deposition is the primary cause of acidification in lakes and streams in the United States. Mountainous watersheds tend to have a low buffering capacity for nitrogen-based acidifying compounds because of their sparse vegetation, short growing season, poor soil development and the presence of extensive areas of exposed bedrock. Consequently, lakes and streams in mountainous areas are especially vulnerable to the effects of atmospheric deposition. Increased population growth in the western U.S., resulting in increased deposition of atmospheric pollutants, means that acidification of high elevation lakes and streams is a concern for resource managers, particularly in previously pristine wilderness areas. Basin physical characteristics such as topography, geology and vegetation are oftentimes vehicles for other variables that influence water chemistry more directly. Twelve high-alpine lakes in Grand Teton National Park (GRTE) were sampled to determine the responsiveness of aquatic systems to environmental input and to determine the controlling landscape parameters that regulate lake water chemistry. Limestone was the best predictor for alkalinity, conductivity and major cations. Granite also played a significant role in the prediction of alkalinity, conductivity and calcium. Median slope, metamorphic rock, and young debris served as the best predictors for nitrate concentrations. The amount of sedimentary rock (non-limestone) present in each basin had an influence on conductivity, calcium, magnesium and sulfate. Relations between measured and predicted concentrations were tested using data collected from surveys conducted in 1986 and 1996 in GRTE. The regression models for alkalinity, conductivity, Ca, Mg, and SO<sub>4</sub> reasonably predict values when compared to observed data. Over-prediction was consistent with the Ca/Na ratio model with most of the values being significantly greater than the observed values. Nitrate values were underestimated.

## H23B-15 1330h POSTER

### Using Streamwater Chemistry in Flowpath Analysis of Large-Scale Forested Watersheds Near Stowe, VT: Developed vs. Undeveloped Watersheds

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The analysis of flowpaths in small alpine watersheds has provided insight into the interrelationships between overall streamwater chemistry and the various flowpaths contributing to it. The purpose of this study is to determine whether the methods used in determining the flowpaths of small watersheds are applicable in a large-scale watershed. The two sites being studied are in the Mt. Mansfield region of Vermont. They are the Ranch Brook (9.6km<sup>2</sup>) and West Branch (11.7km<sup>2</sup>) watersheds. The techniques being implemented include the isotopic characterization of streamwater samples following a precipitation event, basic streamwater chemistry data and their relationship to stream discharge, and the determination of endmembers to the overall streamwater chemistry. Analysis of stream chemistry data suggests that up to three end members contribute to run-off production in both watersheds. A second aspect of this study is a comparison of the two watersheds. These watersheds are similar in all aspects except for the amount of development within each. Ranch Brook is undeveloped forestland while West Branch encompasses an alpine ski resort. Elevated chloride concentrations in the managed watershed suggest the possibility of contamination due to the application of road-salt. Initial oxygen isotope data suggests different flowpath patterns during snowmelt events, which may be the result of the impacts of ski trails and artificial snow on the West Branch site. These two sites provide the

unique opportunity to determine impacts of ski development on the streamwater chemistry of alpine watersheds. Future plans include sampling of potential end members such as soilwater, groundwater and snowpack and analysis of additional isotopic data in order to constrain our assessment of flowpaths contributing to the runoff in these basins.

## H23B-16 1330h POSTER

### Predicting Groundwater Nitrate Concentration from Land Use in Nantucket, Massachusetts

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Ground water nitrate concentrations on Nantucket Island, Massachusetts were analyzed to assess the effects of land use on ground water quality. Exploratory data analysis was applied to historic ground water nitrate concentrations to determine spatial and temporal trends. Maximum likelihood Tobit and logistic regression analyses of explanatory variables that characterize land use within a 1000-foot radius of each well were used to develop predictive equations for nitrate concentration at 69 wells. The results demonstrate that historic nitrate concentrations downgradient from agricultural land are significantly higher than nitrate concentrations elsewhere. Tobit regression results demonstrate that the number of septic tanks and the percentages of high-density residential, undeveloped and forestland within a 1000-foot radius of a well are reliable predictors of nitrate concentration in ground water. Similarly, logistic regression revealed that the percentages of forest, undeveloped and low-density residential land are good indicators of ground water nitrate concentration greater than 2 mg/L. The methodology and results outlined here provide a useful tool for land managers in communities with shallow water tables overlain with highly permeable materials to evaluate potential effects of development on ground water quality.



## H23B-17 1330h POSTER

### Rainfall Induced Chemical Transport from Soil to Runoff: Theory and Experiments

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Although both raindrop driven processes and diffusion play important roles in the transfer of chemicals from soil to surface runoff, current transport models either do not consider the two processes together, or use "effective" parameters with uncertain physical definitions. We developed a physically based, solute transport model that couples both mechanisms and tested it with laboratory experiments. One unique aspect of this study is that all the parameters were either directly measured or previously published, that is, there was no model "calibration" or "fitting." Our model assumes that chemicals near the surface of the soil are ejected into runoff by raindrop impact and chemicals deeper in the soil diffuse into a surface layer, or "exchange layer," via diffusion. The exchange layer depth and transfer processes are derived from the "shield" concept in the Rose soil erosion model (e.g., Rose, 1985). The model's governing equations were solved numerically and the results agreed well with experimental data (R<sup>2</sup> > 0.90). The model's sensitivity to various physical and chemical parameters illuminated the importance of both raindrop controlled processes and diffusion on chemical transport from soil to surface runoff.

## H23B-18 1330h POSTER

### Numerical Modeling of the Flow and Reaction of Methane-Rich Fluids in Tertiary Hydrocarbon Fields of the Santa Barbara Basin, Offshore California

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The Santa Barbara basin is a 100 km-long trough of Cretaceous to Holocene marine sediments within the transpressive tectonic setting of the California continental margin. Whereas the basin center is actively subsiding providing a prolific source of hydrocarbons, the northern margin of the basin has been faulted, folded and uplifted since Pliocene times. Basin-bounding faults such as the Refugio-Carneros fault acted locally as important conduits for the migration of hydrocarbons and basinal aqueous formation fluids that are of diagenetically modified Tertiary marine composition. Uplift of the basin flanks and the topographic relief of the Santa Ynez Mountains were also responsible for introducing meteoric groundwater that mixed with basin-derived methane-saturated formation water. The mixing may have resulted in extensive calcite mineralization that is locally observed along the Refugio-Carneros fault. The present study reflects an effort to characterize the flow, heat transport, and reactive geochemistry of groundwater during uplift of the basin margin using transient two-dimensional numerical modeling.

In the models, strong overpressuring in the Cretaceous Jalama Formation combined with steep topographic gradients in the Santa Ynez Mountains cause rapid venting of fluid along the Refugio-Carneros fault, and to a lesser extent along the Coast fault. Maximum groundwater velocities in the Refugio-Carneros fault are on the order of  $10^1$  m/yr, and temperatures are elevated at least  $75^\circ\text{C}$  above background levels, closely approximating homogenization temperatures of fluid inclusions in the calcite cements. Meteoric water infiltrating the basin from the Santa Ynez Mountains is channeled southward through the Vaqueros Sandstone until it reaches the Refugio-Carneros fault where it converges and mixes with northward-flowing methane-rich pore fluids derived from the Tertiary Monterey Formation, and deeper basinal fluids ascending the fault as a result of fluid overpressuring and buoyancy. The models demonstrate that the fresh meteoric water would have been effective in oxidizing aqueous methane, leading to the precipitation of calcite along the mixing interface within and near the fault plane, over time scales of 1000's of years.

## H23C CC: 220 C-E Tuesday 1330h

### Merging Soil Physics With Geophysics and Remote Sensing: Spatial and Temporal Variations in Shallow Soil Processes and Properties Posters

**Presiding:** R M Holt, University of Mississippi; C J Hickey, University of Mississippi; B Mohanty, Texas A&M University

## H23C-01 1330h POSTER

### Estimating Soil Loss Using ASTER and Diffuse Reflectance Spectrometry: a Case Study of the Village of Kambi ya Simba in Northern Tanzania's Rift Valley Highlands

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Since the inception of the Universal Soil Loss Equation, methods based primarily on factors of rainfall energy, slope, surface cover, and soil quality have been used to predict rates of soil erosion over small areas. It is widely recognized, however, that the USLE and similar equations (e.g., the Revised USLE and SLEMSA) fail to provide accurate predictions of soil loss for larger, more heterogeneous areas and thus, in such instances, they can only be used qualitatively. They also require expensive laboratory analysis of soils and detailed field measurements, putting them beyond the reach of many farmers; this is especially true in developing countries, where such assessments are most needed. Using a 40 sq-km Tanzanian village as a case study, this paper presents methods derived from soil loss equations for rapid, qualitative assessment of soil loss risk using ASTER images and digital elevation model (DEM), and diffuse reflectance spectrometry in the field. Two multispectral ASTER images (one before harvests - June 2002 - and one after - October 2002) were used to map the village's soil types and land use. A total of 100 topsoil samples were collected in the field, georeferenced, and scanned under a spectrometer (wavelengths 0.35 to 2.5 microns) from which a set of 10 samples was selected for laboratory analysis of grain size, org. C, N, and K. Laboratory results were successfully calibrated to the soils' hyper-spectral data using partial least squares regression (r-squared values ranged 0.84 to 0.98) and used to predict soil quality indicators for the entire set of samples. Averages for quality indicators (clay and org. C only) were then matched with their corresponding soil and land use types and paired with pixels containing ASTER DEM-generated slope values (30m x 30m resolution) and post-harvest, ASTER NDVI-derived cover estimates (15m x 15m resolution). Results show strong correspondence with field observations in terms of identifying areas where gully formation is likely to occur (and has occurred) and where crop yields significantly suffer from a lack of conservation measures (e.g., contour ridges). Also present is a significant, negative correlation ( $r = -0.21$ ,  $p < 0.0001$ ) between soil loss and pre-harvest vegetative health (NDVI).

## H23C-02 1330h POSTER

### Spatial Variability of Electrical Conductivity in North Mississippi Loamy Soils

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The use of non-contact electrical geophysical methods, such as electromagnetic induction (EM), to characterize and quantify spatial and temporal variations in soil properties is appealing due to low operational costs, rapid measurements, and device mobility. These methods are sensitive to soil electrical conductivity, which can vary with soil moisture, clay content, soil salinity, and the presence of electrically conductive minerals. We conducted a preliminary study to evaluate the controls on EM response in loamy soils present at the University of Mississippi (UM) Soil Moisture Observatory (SMO). The 5 acre SMO is located in a former agricultural field at the UM Biological Field Station, a 740 acre tract of land located 11 miles from the UM campus in Oxford, Mississippi. EM responses were surveyed along two intersecting transects using a Geonics EM38. The apparent electrical conductivity (EC) of the soil was determined in both a vertical and horizontal dipole position, which correspond to deep (1m) and shallow (0.5) measurements, respectively. Continuous soil samples were recovered from the transect points and analyzed for soil properties. Except for a weak negative correlation with moisture content, we found little direct correlation between EC and measured soil properties. EC variograms from surveys conducted on different dates consistently show a similar structure. Following a week of rain, three EM 38 surveys were conducted, each a week apart. During this survey period, a nearby meteorological station reported no significant precipitation, and the soils were drying. All EC variograms show similar spatial structures but decreasing amounts of variability consistent with drying and redistribution of soil moisture. These results suggest that soil physical properties, not soil moisture, control the spatial distribution of EC. Temporal variations in the variograms indicate a complex relationship between soil moisture and EC.

## H23C-03 1330h POSTER

### Spatial Variations in Soil Properties at the University of Mississippi Soil Moisture Observatory

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Geophysical and remote sensing technologies are being increasingly used to investigate the properties of shallow soils. Nearly all of the soil physical properties important to geophysical and remote sensing technologies, including electrical conductivity, electromagnetic properties, thermal properties, acoustic properties, and vapor phase transport processes, are controlled by soil mineralogy, soil structure, and the distribution of soil moisture. Spatial and temporal variations in these controls conspire to confound sensor observations and complicate data reduction and inversion by producing non-unique sensor signatures. To provide a facility for detailed study of soil - geophysical interactions, we are constructing a Soil Moisture Observatory (SMO) at the University of Mississippi (UM). The 5 acre SMO is located in a former agricultural field at the UM Biological Field Station, a 740 acre tract of land located 11 miles from the UM campus in Oxford, Mississippi. The soils present at the SMO consist of silty and sandy loam. Our preliminary activities at the site included collecting 60 continuous soil cores using a direct-push sampling probe and the installation of neutron access tubes along two intersecting transects. Continuous soil samples were taken to a depth of 1.5 m and analyzed for particle size distribution, porosity, bulk density, iron content, moisture content. Variograms of these data show that most soil properties have a horizontal correlation length of greater than 10 m. The horizontal correlation length for moisture content increases with depth from about 12 m near the soil surface to approximately 24 m at a depth of 1 m. Vertical variograms of soil moisture show evidence of a small-scale structure with a correlation length of 0.6 m.

## H23C-04 1330h POSTER

### Replicating Complex Soil Moisture Patterns with a Physically-Based, Distributed Model

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In this study, the Soil Moisture Routing Model (SMR) was tested against the spatially and temporally distributed soil moisture measurements made in the Tarrawarra catchment, Victoria, Australia. SMR is a spatially distributed, physically-based hydrologic model developed for watersheds with sloping terrain and shallow soils in which runoff is generated by saturation excess. SMR has been used to predict areas prone to saturation for several watersheds in the Northeastern United States and is currently being used to develop land management strategies to protect water quality. While the model has been successfully tested against observed streamflow hydrographs and against several soil moisture measurements that were made along hillslope transects, its ability to predict spatially complex soil moisture patterns has not been robustly tested. The dataset from the Tarrawarra catchment is unique in that it extends over a complete hydrologic year and provides soil moisture measurements at over 500 points in the 10.5 hectare watershed (Western and Grayson, 1998, Water Resour. Res. 24(10): 2765), thus, providing a unique dataset against which a spatially distributed model can be rigorously tested. Even with its simple description of hydrologic behavior, SMR was able to reproduce the spatially complex observed soil moisture patterns. All the input parameters were within the range of measured landscape and soil characteristics, which reinforces the claim that SMR is a legitimate, physically-based model. We found that model results can be further improved with minor calibration involving the spatial distribution of input parameters. Additionally, the sensitivity of the model to the primary input parameters was investigated with respect to this site.