content. Moderate correlations, with correlation coefficients ranging from -0.62 to -0.80, were found between soil moisture and both the red and infrared reflectance bands of the imagery. Strong correlations, with correlation coefficients of 0.88 and 0.90, were found between soil moisture and the imagery indices known as simple ratio and Normalized Difference Vegetation Index (NDVI). Spaceborne multispectral imagery (IKONOS) was used in more heavily vegetated sites to detect variations in moisture content using Tasseled Cap transformation and imagery classification algorithms. We use this algorithm to provide a map of relative moisture content across the levee surface. We demonstrate how detecting variations in soil moisture is useful in detecting shallow surficial slides using both airborne and spaceborne multispectral images along with image processing tools.

H14A-05 1630h

Predicting Soil Moisture Dynamics and Crop Yield Using Electrical Geophysical Methods

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Our research at the USDA's Agricultural Research Center (OPE3 field site) located in Beltsville, MD is motivated by the need to develop efficient and non-invasive methods for characterizing the soil properties that control soil moisture dynamics and crop yield. Soil moisture dynamics are controlled by hydraulic conductivity and soil water retention rate, which in turn are controlled by the soil texture (sand and clay content). In this study, we use time-domain reflectometery (TDR) and ground-penetrating radar (GPR) to measure the spatial and temporal variability in soil moisture on an experimental corn field. Electromagnetic induction (EM) and induced polarization (IP) measurements are observed to be highly correlated with soil texture, and can therefore be used to make high-resolution soil texture maps. We have found that the correlation of crop yield with the geophysically derived soil texture maps depends on the overall soil water availability. For example, the crop yield is positively correlated with clay content in 1999 (drought year), but is negatively correlated with clay content in 2000 (wet year). This ground based geophysical methodology provides a framework for the prediction of soil moisture dynamics and its effects on crop yield, and may allow for the optimization of fertilizer and pesticide applications so as to minimize non-point source pollution.

URL: http://hydrolab.arsusda.gov/ope3/

H14A-06 1645h

Surface Electrical Conductivity Prediction by Soil Moisture and Electromagnetic Mapping Techniques: Implication for Landmine Detection Technologies

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Electrical conductivity (EC) can be a source of significant signal interference in landmine detection, implying that there is a necessity for soil EC prediction in order to carry out safe demining operations in landmine affected countries in the world. A fundamental study on soil EC mechanisms and their relationship to moisture content has been carried out in order to increase the soil EC prediction accuracy when using data from various sensors, such as remote sensing, airborne and surficial electromagnetic (EM) methods. Results indicate that soil moisture consists of free water filling pore spaces and bound water which forms adsorbed water layers on the grain surfaces. The response of these two water phases to drying rates and EC are very different, to the extent that a moist clay poor soil may have low EC but a dry clay rich soil may have higher EC. This is a result of not only the bound water layers being a significant source of EC, but of the capillary component of the free water reacting differently to the different grain-sizes of the soil. The capillary water forms important electrical conductive bridges between the adsorbed water layers on the grains that constitute the soil. This implies that information on soil texture, mineralogy and their distribution are required for accurate EC prediction. Whereas information on these soil characteristics may be acquired by remote sensing and soil maps, soil moisture content is likely to vary from the time of data acquisition to that of demining operations, implying methods to predict these changes are required. In addition, soil type inhomogeneity, such as vertical and horizontal variation can also be a source of inaccuracies in moisture and EC predictions. However, these investigations also indicate that a wide band electrical frequency signal may have the possibility of providing information on, not only metallic mineral content, but on pore space, clay mineral type and water content. In addition, applications of airborne and surficial electromagnetic (EM) systems with varied frequency bands and coil configurations have the possibility of adding considerable information to the remote sensing data and overcoming many of their limitations. This paper reports the research progress being made in these areas. These results have also implications on the effect of geological factors on soil mechanical property predictions.

H21A CC: 220 C-E Tuesday 0830h

Isotope Tracing of Water and Carbon Cycling Processes in Large River Basins III Posters *(joint with B)*

Presiding: **K Telmer,** University of Victoria**; N L Miller,** Lawrence Berkley National Laboratory

H21A-01 0830h POSTER

A first synoptic water-isotope survey of the Yangtze River

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Variations in the oxygen- and hydrogen-isotope composition of water sampled along the main stem of the Yangtze River during a two-week campaign in January 2003 reveal systematic patterns that strongly reflect the over-riding influence of regional precipitation isotope fields. Secondary signals deriving from influx of evaporatively enriched waters from several major reservoirs along the system are also apparent. This first isotopic "snapshot" of the Yangtze River provides a key baseline for analysis of seasonal and interannual changes emerging from ongoing monitoring at selected stations, as well as affording a basis for isotope-mass balance analysis in combination with hydrometric and climatological data.

H21A-02 0830h POSTER

Assessing the Amazon Basin Circulation with Stable Water Isotopes

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The isotopic abundances of Oxygen-18 (δ^{18}O) and Deuterium (δD) over the Amazon are used to constrain simulations of the water cycle in this, the largest river basin in the world. Tracking the two stable but rare isotopes of water ($^1HD^{16}O$ and $^1H_2{}^{18}O$) makes it possible to trace Amazonian regional evaporative and condensation processes. This offers isotopic constraints on regional to global-scale atmospheric moisture budgets. Based on data in the Global Network on Isotopes in Precipitation (GNIP) database, we analyse the simulation of the land surface hydrology and water cycling. Temporal changes between 1965 and 2000 in stable water isotopic signatures in the Amazon have been used to evaluate global climate model (GCM) predictions revealing notable anomalies. For example, the differences in the wet season deuterium excess between Belem and Manaus are consistent with recent GCM simulations only if there has been a relative increase in evaporation from non-fractionating water sources over this period. Despite earlier predictions that land-use change signals would be found, late twentieth century data reveal no significant change in dry season isotopic characteristics. On the other hand, more recent isotopic data do show trends at stations in the Andes, where as much as 88% of the rainfall is thought to be derived from recycled moisture. At Izobamba the wet season depletions are enhanced (greater depletion) and the dry season ones decreased (less depletion). At Bogota only the wet months show statistically significant changes - also an enhancement. More depletion in the wet months is consistent with reductions in non-fractioning recycling such as through transpiration and in full re-evaporation of canopy-intercepted rainfall. These data might be linked to deforestation impacts. Results of GCM and simpler model simulations of the Amazon suggest that the recent stable isotope record is consistent with the predicted effects of forest removal, perhaps combined with greenhouse warming. At a minimum, large-scale simulations of South American climate ought to be tested against these isotopic data in any validation effort. Specific caveats our conclusions include: (i)monthly isotope data only are available in GNIP and hence analysed; (ii) the statistically significant seasonal changes reported might be related to, or even exaggerated by, El Niño-Southern Oscillation (ENSO) events or other climatic variations that modify the Walker circulation and Inter-Tropical Convergence Zone (ITCZ) position and hence affect the moisture climatology of the Amazon; (iii)no information on fluxes from simulated open water as a surface type in the Amazon GCM experiments has been considered; (iv)the selected models are failing to correctly simulate the relative components of transpiration and re-evaporated canopy interception in the Amazon dry season; and (v) no isotope tracking in the Amazon deforestation simulations was reviewed, because none is yet available. These shortcomings deserve further work.

H21A-03 0830h POSTER

Stable Isotope Hydrology of Walnut River Watershed, Kansas, The U.S.A.

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The isotope hydrology of a stream at any time primarily reflects the source components, which contribute to its discharge. Precipitation events influence the stream discharge during shorter times where as the ground and soil waters determine the long term effects. While the presence of surface water bodies affect the hydrological response of a stream, the extent of evapotranspirational process influences the stream hydrology by contributing to the atmospheric moisture and subsequent precipitation. Thus, to understand the regional hydrology it is important to investigate the relative contribution of various hydrologic components and processes through which water cycling occurs in that region. Such studies not only aid in regional hydrological studies but also compliment the efforts to identify global scale hydrological process. Such an effort is made - as a part of the Department of Energy's Water Cycle Pilot Study (WCPS) - to study the water cycling through various hydrologic compartments by using stable isotope variations in the Walnut River basin located in the southern Great Plains region of the United States. Apart from event-based precipitation, samples were collected quarterly from streams, ponds, ground water, soil and atmospheric vapor. The isotope values in precipitation and atmospheric vapor samples indicate a significant contribution of the locally evapotranspired moisture content to precipitation. A temperature dependent seasonal isotopic contrast in precipitation is reflected in the major tributaries of the Walnut river system where as the isotopic composition of smaller streams is governed by the recharge source and the extent of evaporation. The surface water bodies with their high rate of evaporation have a distinct isotopic composition from that of ground water and precipitation and were useful in estimating the relative contributions of these components during precipitation events. An isotopic mass-balance model to estimate relative contribution of various sources is presented together with a discussion on isotope climate relationship.

H21A-04 0830h POSTER

Development of the 1997 Red River Flood: New Insight from Water Isotope Data

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During the spring of 1997 near record winter snowfall on the Red River basin combined with frozen soils and a rapid spring melt resulted in extensive flooding in North Dakota and Manitoba. Floodwaters were sampled from the Red River at four locations around Winnipeg and analysed for major and minor ions, and organic contaminants. Here we present new oxygen and hydrogen data for floodwaters sampled in the vicinity of Winnipeg prior, during and after the main peak of the 1997 flood and review the geochemical data in light of the information the isotopic composition of the water can provide about the source and history of the water. The depleted delta values, and relatively high d-excess measured in Red River samples from the ascending arm of the 1997 seasonal hydrograph support the interpretation from the very dilute geochemistry that the waters at the beginning of the flood originated as winter precipitation. As the main peak of the flood reached Winnipeg the isotopic composition of floodwaters remained within the range of winter precipitation while concentrations of some organochlorine and pesticides reached maxima. After the main peak of the hydrograph the specific conductivity of the floodwaters increased, with minor increases in dissolved major ions typical of groundwater, decreases in nitrate and nitrite, and increased potassium concentrations. During the falling limb of the snowmelt hydrograph the geochemical and isotopic composition of the floodwaters both indicate a greater proportion of groundwater. Combining geochemical indicators of surface water history with isotopic indicators of water source and history allows for qualitative interpretation of the evolution of floodwaters in the Red River. In this area of extremely flat topography and low permeability sediments the isotopic composition of floodwaters generated after spring melt are consistent with meltwater inputs dominating through the rising limb and peak of the flood hydrograph.

H21A-05 0830h POSTER

Isotopic monitoring (2H, 18O) of the St. Lawrence and Ottawa rivers between 1997 and 2003- Links with interannual climatic variability and hydrological processes in their catchment basins

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This study based on a water isotope (18O and 2H) monitoring of the St. Lawrence and Ottawa rivers (Canada) is a contribution to the international IAEA project: Isotopes tracing of hydrologic processes in large river basins [Gibson et al., 2002. EOS 83: 613 et p.]. Sampling of the St. Lawrence and Ottawa river waters started in 1997, on a biweekly to weekly basis. Monitoring stations are located at Montreal (i.e., at the outlet of the Great Lakes), Quebec City (the estuary of the St. Lawrence) and at the Carillon hydroelectric dam, near the outlet of a major tributary, the Ottawa River into the St. Lawrence itself. The goal of the study was to examine the seasonal and interannual variability of isotopic signatures of the St. Lawrence and Ottawa rivers, in relation notably with interannual climatic variations, and seasonal hydrologic processes in the watershed (summer evaporation, snowmelt, transit time of precipitation signals into runoff). Waters sampled at the three stations depict distinct isotopic compositions. At Montreal, relatively stable isotopic composition are observed with a mean weighted annual value of -54 $^{o}/_{oo}$ for 2H and -7.1 $^{o}/_{oo}$ for 18O. The Ottawa River water at Carillon also displays stable isotopic compositions but much lighter values (weighted mean annual values: -80 $^{o}/_{oo}$ for 2H and -10.8 $^{o}/_{oo}$ for 18O). Finally, isotopic compositions at Quebec City are intermediate between those of Montreal and Carillon, but show a much larger variability. They reflect mixing between the heavy isotope enriched Great Lakes water, the lighter water from the Ottawa River, and highly variable inputs from smaller tributaries (from the Laurentides and Appalachian mountains). The mean weighted isotopic compositions at Quebec City are -65 $^{o}/_{oo}$ and -8.6 $^{o}/_{oo}$, respectively for 2H and 18O). Evaporative enrichment, in particular during low water level episodes, seem to be more important in the Ottawa River catchment than in the Great Lakes basin, based on a comparison of isotopic clusters at Montreal and Carillon (figure 1). Relatively strongly correlated relationships are observed between isotopic compositions at the estuary of the St. Lawrence River (Quebec) and hydrologic variables such as water discharge. The best fit follows the equation : 2HQUEBEC = -1.9E-03 * QQUEBEC - 41.9, R2= 0.59. Such a relationship leads us to conclude that some properties of the regional hydrology can be relatively well described by stable isotope systematics. In contradiction, air temperatures are not well correlated with isotopic signatures partly because of lag times between them in relation to transit time of precipitation signal into runoff. A comparison of isotopic values in precipitation to those of runoff gives an estimate of the mean transfer time of water from the catchment to the river estuary. For summer heavy isotope enriched, but scarcer precipitation, a transit time of approximately 3 months is observed, whereas in winter, it can be as long as 4 to 5 months due to the residence time of winter precipitation in the snowcover. The assessment of the interannual variability of the St. Lawrence River isotopic system will require a better estimate of the isotopic inprint from small tributaries (that drain isotopically buffered ground waters, particularly in winter). Data are presently at processing stage.

H21A-06 0830h POSTER

14C and 13C Contents of Dissolved Organic Matter in the St. Lawrence Estuary and in a Hydroelectric Reservoir From the Boreal Forest (Quebec)

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In this study we examine the 14C and 13C contents of Dissolved Organic Matter (DOM) in the St. Lawrence River, at its outlet near Quebec City, and in a large hydroelectric reservoir, from the Canadian Boreal forest (Robert-Bourassa reservoir) as a mean to document the origin and residence time of DOM in such large catchments. Samples of DOM were collected biweekly at the Quebec City station from November 2001 until November 2002, as part of a geochemical monitoring program of the river, carried out since 1997. At the Robert-Bourassa reservoir, sampling operations took place from July 15 to July 26, 2001. All samples were filtered and acidified on site, and preserved in brown glass bottles at 4°C. Prior to their isotopic analysis, DOM samples were freeze-dried. 13C analyses were made at GEOTOP whereas 14C measurements were performed at the Lawrence Livermore National Laboratory, for samples coming from the St. Lawrence River, and at the *Laboratoire d'Hydrologie et de géochimie isotopique* of University Paris XI for samples originating from the Robert-Bourassa reservoir. Results are expressed respectively in $^{o}/_{oo}$ vs. V-PDB and in % of modern carbon (% MC; i.e. 13.56 dpm/g C in 1950, for d13C=-25 $^{o}/_{oo}$). D13C values averaging -26.3 ± 0.2 $^{o}/_{oo}$ in the St. Lawrence, and -27.1 ± 0.2 $^{o}/_{oo}$ at the Robert-Bourassa reservoir, indicate that DOC originates from terrestrial production, although a slight influence of aquatic DOC is seen in the St. Lawrence river during low water level episodes. In the river, DOC-14C activities range from 97.7 to 106.7 ± 0.5 %, with a mean value of 103.9 ± 0.5 %, whereas samples from Robert-Bourassa reservoir show a range of values between 108.5 and 110.5 ± 0.9 %, with a mean of 109.5 ± 0.9 %. In comparison, measurements made during the late 80's, in a small brook of Ontario, yielded 14C-DOM activities ranging from 113 to 118 % MC (Schiff et al., 1990). Meanwhile, 14C-activity of atmospheric CO2 has decreased of approximately the same proportion. We conclude that soil-derived DOC represents the production of immediately preceding years, notably in the Boreal Forest reservoir, but that contribution of longer residence time DOC from the Great Lakes likely accounts for the slightly lower 14C-DOC values found in the St. Lawrence River. In conclusion, 14C and 13C contents indicate an overall short DOM residence time, thus that the primary production at its origin, and its degradation and transport in the drainage network are fast processes. Reference: Schiff, S. L., R. Aravena, S. E. Trumbore et P. J. Dillon. 1990. Dissolved organic carbon cycling in forested watersheds : a carbon isotope approach. Water Resources Research, 26, no 12, 2949-2957.

H21A-07 0830h POSTER

Assessing Sources and Ages of Organic Matter Supporting River and Estuarine Bacterial Production: A multiple Isotope (Δ^{14}C , δ^{13}C, and δ^{15}N) Approach

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We used radiocarbon (Δ^{14}C) and stable isotopic (δ^{13}C, δ^{15}N) signatures of bacterial nucleic acids to estimate the sources and ages of organic matter (OM) assimilated by bacteria in the Hudson River and York River estuary. Dual isotope plots of Δ^{14}C and δ^{13}C coupled with a three-source mixing model resolved the major OM sources supporting bacterial biomass production (BBP). However, overlap in the stable isotopic (δ^{13}C, δ^{15}N) values of some of the potential source end-members (i.e., terrestrial, freshwater phytoplankton, marsh-derived) prohibited unequivocal source assignments for certain samples. In freshwater regions of the York, terrigenous material of relatively recent origin (i.e., decadal in age) accounted for the majority of OM assimilated by bacteria (49-83%). Marsh and freshwater planktonic material comprised the other major source of OM, with 8-33% and 6-25% assimilated, respectively. In the mesohaline York, BBP was supported primarily by estuarine phytoplankton-derived OM in the spring and summer (53-87%) and by marsh-derived OM in the fall (as much as 83%). Isotopic signatures from higher salinity regions of the York suggested that BBP there was fueled predominantly by either estuarine phytoplankton-derived OM (July and November) or by material advected in from the Chesapeake Bay proper (October). In contrast to the York, BBP in the Hudson River estuary was subsidized by a greater portion (up to 25%) of old (24,000 BP) allochthonous OM, presumably derived from soils. These findings collectively suggest that bacterial metabolism and degradation in rivers and estuaries may profoundly alter the mean composition and age of OM during transport within these systems and prior to its export to the coastal ocean.

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H21B CC: 220 C-E Tuesday 0830h

Environmental Vadose Zone Hydrology Posters

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

H21B-01 0830h POSTER

Lattice Boltzmann Modeling of Gaseous Diffusion in Unsaturated Porous Media under Variable Gravity Conditions

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Liquid distribution in unsaturated porous media under different gravitational forces and resulting gaseous diffusion coefficients were investigated to enhance understanding of plant growth conditions in microgravity.