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The Community Land Model (CLM) can be used to examine the physical, chemical, and biological processes through which terrestrial ecosystems affect and are affected by climate. CLM simulates the hydrological cycle and surface energy budgets using water and energy balance approaches. CLM's outputs include soil moisture, latent and sensible heat fluxes, and surface temperature. The Soil Moisture Experiment 2003 (SMEX03) was conducted to provide validation data satellite and aircraft based microwave remote sensing instruments. As part of the SMEX03 experiment, soil moisture, surface temperature, and vegetation data were collected in the Little River watershed, GA. Eddy flux stations measured energy fluxes at three sites with distinct vegetation characteristics. This study compares the CLM's biogeophysical and hydrological outputs to measured soil moisture and energy flux data.

H22B-0933 1330h POSTER

The effect of land-cover misclassification on predicted impervious surface

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If land-cover data are available for a study area, a coefficient-based impervious surface modeling approach is relatively straightforward and quick to implement. Impervious-surface estimates developed by using this approach, however, may be biased or imprecise for several reasons, including land-cover misclassification. Data collected as part of a U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program study in New England were used to assess whether impervious-surface model predictions were improved by explicit adjustment of National Land Cover Data (NLCD) land-cover values to account for misclassification. Adjustments were based on a user probability matrix derived from published accuracy-assessment information. NLCD and field-measured impervious-surface values at 55 New England study sites were used to assess models for predicting impervious surface. Four models were distinguished by land-cover resolution (Level I and Level II) and whether land-cover data were adjusted. The relatively poor classification accuracy of the NLCD developed-land class (74% for Level I developed land and 40-61% for Level II developed categories) generally results in adjustments that decrease the amount of developed land. These downward adjustments begin when relatively low amounts of developed land are present in a study site. Because developed-land impervious-surface coefficients have a high value, decreases in the amount of developed land will lower predicted impervious-surface values relative to those in models using unadjusted NLCD data. The results of the investigation are mixed as to whether impervious-surface models that account for land classification error rates result in meaningful improvements in impervious-surface predictions over models that do not make these modifications. The model-verification results suggest that NLCD Level I land-cover data, adjusted for land-cover misclassification, is preferable to other land-cover options for use in models predicting impervious surface. There was no significant difference between paired observations of observed and predicted impervious-surface values when the adjusted Level I data were used. Significant differences between paired observed and predicted impervious-surface values occurred in the other three models. Overall, the sensitivity of the models to land-cover classification errors and adjustments for these errors was small; the difference between predicted impervious surface from a model using unadjusted land-cover and simulated values from an adjusted model ranged from 1-2%.

H22B-0934 1330h POSTER

Global Soil Moisture Estimates from a Long-Term Hydrometeorological Forcing Data Set

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Offline land surface modeling simulations require meteorological forcing with consistent spatial and temporal resolutions. Although reanalysis products present an attractive data source for these types of applications bias to many of the reanalysis fields limits their use for hydrological modeling. In this study we develop a global 0.5 degree forcing data set for the time period 1979-1993 on a 6-hourly time step through application of a bias correction scheme to reanalysis products. We then use this forcing data to drive a land surface model for global estimation of soil moisture and other hydrological states and fluxes. The simulated soil moisture estimates are compared to in-situ, satellite observations and to the modeled estimates of Nijssen et al. [2001]. In general, there is good agreement between anomalies in modeled and observed root zone soil moisture (top one meter). Similarly for the surface soil wetness state, modeled estimates and satellite observations are also in general statistical agreement, however, correlations decline with increasing sub-grid variability and vegetation amount. Comparisons to the data set of Nijssen et al., [2001] also demonstrates that both simulations present complimentary estimates of wet and dry root zone soil moisture anomalies, despite being derived from different land surface models, using different data sources for meteorological forcing, and with different specifications of the land surfaces properties. Results of this study demonstrate that reanalysis products corrected to observations can be used within a land surface model to produce soil moisture estimates in general agreement with surface and root zone observations.

H22B-0935 1330h POSTER

The Greening of the McGill Paleoclimate Model. Part I: Improved Land Surface Scheme With Vegetation Dynamics

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The formulation of a new land surface scheme with vegetation dynamics for coupling to the McGill Paleoclimate Model (MPM) is presented. The new land surface component incorporates significant improvements over the old version used in the MPM, which can be summarized as follows: (i) Parameterization of deciduous and evergreen forests by using the model's climatology and the output of the dynamic global vegetation model: VECODE, developed by Brovkin et al.; (ii) Parameterization of leaf budburst and drop by using the model's climatology and plant function type dependent threshold values for these quantities; (iii) Parameterization of the seasonality of leaf area index by using time-dependent growth; (iv) Calculation of land surface albedo by using vegetation-related parameters, snow depth and the model's climatology. The results show considerable improvement of the model's simulation of the present-day climate. In particular, the strong seasonality of terrestrial vegetation and the associated land surface albedo variation are in good agreement with several satellite observational datasets. The first application of this new version of the MPM to Holocene millennial-scale climate variability is described in a companion paper, Part II.

H22B-0936 1330h POSTER

Comparison of Seasonal and Spatial Variations of LAI/FPAR From MODIS and Common Land Model

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This paper compares by land cover type seasonal and spatial variations of MODIS leaf area index (LAI) and fraction of photosynthetically active radiation (0.4 - 0.7 μm) absorbed by vegetation (FPAR) from two and half years with those from the Common Land Model (CLM) and investigates possible reasons for notable differences. The FPAR value is mainly determined by LAI in MODIS and both LAI and stem area index (SAI) in CLM. On average, the model underestimates FPAR in the Southern Hemisphere and overestimates FPAR over most areas in the Northern Hemisphere compared to MODIS observations during all seasons except northern middle latitude summer. Such overestimation is most significant in winter over northern high latitudes. The MODIS LAI is generally consistent with the model during the snow-free periods but may be underestimated in the presence of snow, especially for evergreen trees. The positive FPAR bias is mainly attributed to CLM SAI of deciduous canopy and higher LAI than MODIS for evergreen canopy as well. The negative FPAR bias results from several factors including differences in LAI and soil albedo between CLM and MODIS or limitations of the geometric optics scheme used in the model. Therefore, the MODIS algorithm needs to better represent the winter LAI retrievals while the model needs to better quantify LAI and SAI. Since stems will not have the same single scattering albedo as green leaves, it may be inappropriate for the model to treat LAI and SAI the same in the FPAR and albedo parameterizations. If so, the role of SAI in these parameterizations needs reformulation.

H22C MCC: Level 2 Tuesday 1330h

Hydrogeophysics: Characterization and Monitoring of Soil Properties and Processes in the Laboratory III Posters *(joint with NG, MR)*

Presiding: **D Lesmes,** George Washington University**; S Vega,** Stanford University

H22C-0937 1330h POSTER

Experimental Rock-on-Rock Abrasive Wear Under Aqueous Conditions: its Role in Subglacial Abrasion

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We have determined experimentally the rate of abrasive wear of rock on rock for a range of rock types as a function of normal stress and shear displacement. Unlike abrasive wear in fault zones, where wear products accumulate as a thickening gouge zone, in our experiments wear particles were removed by flowing water. The experiments are thus directly pertinent to one of the most important processes in subglacial erosion, and to some extent in river incision. Wear was produced between rotating discs machined from rock samples and measured from the progressive approach of the disc axes towards each other under various levels of normal load. Shear displacements of several km were produced. Optical and scanning electron microscopy

were used to study the worn rock surfaces, and particle size distributions in wear products were characterized using a laser particle size analyzer. Rock types studied were sandstones of various porosities and cement characteristics, schists and a granite. In all cases abrasion rate decreased logarithmically with displacement by up to 2 orders of magnitude until a steady state was approached, but only after at least 1 km displacement. The more porous, less-well cemented rocks wore fastest. Amount of abrasion could be characterized quantitatively using an exponentially decaying plus a steady-state term. Wear rate increased non-linearly with normal contact stress, apparently to an asymptote defined by the unconfined compressive strength. Microstructural study showed that the well-cemented and/or lowest porosity rocks wore by progressive abrasion of grains without plucking, whereas whole grains were plucked out of weakly-cemented and/or more porous rocks. This difference in behavior was reflected in wear-product particle size distributions. Where whole-grain plucking was possible, wear products were dominated by particles of the original grain size rather than finer rock flour. Comparison of our results to glacier basal abrasive wear estimated from suspended sediment load (Findeln Glacier, Switzerland) showed the steady-state experimental data seriously to underestimate the natural wear rate. This suggests continuous resetting of the subglacial surface occurs, so that wear is continuously in the 'running-in' stage.

H22C-0938 1330h POSTER

Electrical and Hydraulic Properties of Humified Bog Peat as a Function of Pore-fluid Conductivity

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The electrical properties of organic sediments and their relationship to physical properties are poorly understood. A simple approach to relate electrical properties to physical properties commonly applied to inorganic sediments is to model the electrolytic conductivity and the surface conductivity as parallel conduction paths. Low-frequency electrical measurements were made in conjunction with hydraulic conductivity measurements on peat samples from an 11 m section collected in a large freshwater peatland. The electrical and hydraulic measurements were made as a function of NaCl concentration and depth of burial. In all cases, the electrical conductivity of the peat was not well modeled by the parallel conduction path model, with the model yielding formation factor values close to one. Sample measurements along the section suggest a slight increase in the formation factor and surface conductivity values with depth. Hydraulic conductivity measured by constant head method shows a marked increase with increasing NaCl concentration, which we believe results from expansion of macropore porosity by chemical dilation as proposed by others. Attempts to return the samples to their original conditions by decreasing the salinity only partially restored the hydraulic conductivity values, indicating a permanent disruption of the hydraulic properties of the peat. The increase of surface electrical conductivity and hydraulic conductivity with depth may indicate a close correlation with the high cation exchange capacity of organic matter and its tendency for chemical dilation as decomposition of organic matter increases with depth. We propose that the electrical conductivity of peat cannot be modeled by an electrolytic and a surface conduction path in parallel. The increase in the electrolytic conduction causes ionic accumulation and dispersion processes, expanding the macropore porosity and hence inducing a decrease in the formation factor values. A proper electrical model for organic materials such as peat needs to include this pore dilation effect caused by the increase in electrolytic conduction.

H22C-0939 1330h INVITED POSTER

Hydrological and Petrophysical Properties of Unconsolidated sediments from Spectral Electrical Response Measurements.

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Predicting the hydraulic properties of soils (hydraulic conductivity, porosity, and degree of saturation) from non-invasive geophysical measurements is appealing to geoscientists involved in the hydrological characterization and contamination assessment of the earth's subsurface. There is the need to understand the quantitative relationship between measurable geophysical attributes and hydraulic parameters of sediments or soils.. Variety of models (parametric and equivalent circuit) have developed for modeling spectral electrical response (SER) of soils, as a heterogeneous multi-phase system. The validity and usefulness of these models in predicting the hydraulic parameter were assessed using laboratory measurements of the spectral electrical response(0.01Hz to 10 kHz) of over 30 soil samples with wide variability in physical properties. The soils are fully characterized: hydraulic conductivity, porosity, grain size distribution and moisture content of each soil sample were measured. The SER measurements are utilized to estimate the hydraulic parameters characterizing the soils. The intrinsic parameters, which describe the response of the model are retrieved by inversion schemes and are used in empirical regression models to predict the soil properties. Such relationships between parameters characterizing the spectral electrical response of soils and their hydraulic properties may provide versatile non-invasive methodology of obtaining hydraulic conductivity and porosity of soils using geophysical measurements

H22C-0940 1330h POSTER

Study of DNAPL Pool Morphology Using X-ray Attenuation to Evaluate Limitations of Partitioning Tracer Method in Complex Entrapment Architecture

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Characterization of sites contaminated with organic waste chemicals that are in the form of DNAPLs (dense non-aqueous phase liquids) still remains a major challenge in the implementation of remediation schemes. The Partition Interwell Tracer Technique (PITT) has been proposed and used as a non-intrusive method for the estimation of total mass of DNAPL in source zones. PITT uses a suite of chemical tracers that are injected into the source zone and the tracer breakthrough curves that are retarded by the tracer partitioning into the entrapped DNAPL are analyzed to determine the average saturation. In existing methods, PITT data are analyzed assuming local equilibrium exists between phases. This assumption may not be applicable at heterogeneous sites that produce complex entrapment architecture that contains high saturation pools. The groundwater flows around pools due to the reduced aqueous relative permeability caused by entrapment. Bypassing water may reduce the contact between the tracer solution and the NAPL and saturation will be underestimated. However, discernable partitioning of tracer may occur in the transition zone of the pool where the saturation of DNAPL varies from full to residual. The purpose of this research is to study the morphology of DNAPL pools and evaluate under what conditions the PITT limits the mass estimate within a pool. As rate limited behavior is expected within the transition zone, PITT under of rate limited partitioning was evaluated. X-ray attenuation provides an effective way to non-destructively measure the saturation distribution of DNAPLs in the laboratory. The high accuracy and the resolution of this technique allows for the measurement of the spatila distribution of saturation within DNAPL pools. Based on experiments that involved the creation of pools with known volumes of DNAPL in a test cell, errors were evaluated by comparing estimates obtained from PITT and the x-ray measurements. The experimental data in conjunction with model analysis were used to make a determination of limitations of PITT technique for characterization of DNAPL source zones where a significant fraction may be entrapped in the form of high-saturation pools.

URL: http://cesep.mines.edu

H22C-0941 1330h POSTER

USE OF TRANSIENT ELECTROMAGNETIC SOUNDINGS (TEM) TO LOCATE URBAN SOLID WASTES DISPOSAL SITES, IN COATZACOALCOS, VERACRUZ, MEXICO.

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Anthropogenic activities and their impact cause complex alterations in the natural quality of superficial and groundwater. Urban solid waste disposal represented an important source of contamination of groundwater. One of the main problems of the Coatzacoalcos, Veracruz area is the urgent necessity to close some dumps, actually in operation. At present, the municipal government has the project of selecting an urban waste disposal site that fulfills the official ecological norms, with appropriate geologic conditions and a useful life of 15 years. Study area, El Rebozo 1, is covered for sandy - clays from Filisola Formation. Also has outcrops of shales belonging to the Nanchital Formation. This Formation presents low porosity and permeability. It could serve as container in the construction of the landfill. We carried out 6 transient electromagnetic soundings (TEM), to determine the thickness and distribution of this formation in depth and to establish the existence of aquifers. The geophysical studies were carried out along a line of 680 m, with variable separation among stations between 150 m to 250 m, crossing the study area in SW direction. Results of TEM survey, geological, hydrological information and drilling survey confirmed the wide distribution in the studied area of the shale layer from the Nanchital Formation. The average thickness of the shale layer is 70 m and it presents low possibilities of storing an important aquifer. It could be considered as an impermeable layer that can be used as base for the construction of the landfill. Underlying the shale layer there are sandy-clays that could reduce the possible lixiviation from the landfill. Use of TEM provides larger advantages than the conventional electric methods (SEVs) and also more detailed information on the geologic and hydro-geologic conditions from the underground. The integration of geophysical methods with other disciplines allows more integrated systematic research in hydrogeology and contamination processes.

H22C-0942 1330h POSTER

Seismic and Tilt Data Processing for Monitoring Groundwater Contamination

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We are conducting a feasibility study to see if we can detect changes in the state of saturation in groundwater by seismic means. This field study is based on laboratory experiments that show large changes in seismic attenuation when contaminants change the wettability of porous rocks. Three tiltmeters and three seismometers were installed at different distances from a controlled irrigation site near Maricopa, AZ. The research site has a facility to controllably irrigate a 50 m by 50 m area with water and chemical surfactants. The instruments are used to record naturally-occurring, low frequency strain and seismic signals before, during and after irrigations. The purpose of the data analysis is to develop techniques for looking for the differences in station response due to local differences, such as contamination in the vadose zone and groundwater. Ours is not a conventional way of data processing for our non-traditional use of the data, since the variations in instrument response caused by the trace amount of contaminants are very small. We are looking for small changes in the relative response between the instruments. For the seismic data, not only do we examine large events, such as Earthquakes, but also microseisms. We use microseisms as our source and the related processing is an attempt to measure the tiny changes in instrument response caused by differences in irrigation and contamination at the three different locations. In tilt data processing, the large events caused by regional water pumping, oil productions, and Earthquakes, etc. need to be removed, since we wish to use the Earth solid tide as our strain source. The key issue during the process of removing the large events is to make sure that the tide signals are not also removed or greatly distorted. A method and corresponding codes were developed for automatically removing data at the three stations induced by large events. After completing this processing, the signal left is the local Earth tide data. Through comparing these observed data with the theoretical tide amplitudes specific to our field location we can find the relative responses of the three instruments and influences induced by the contaminations.

H22C-0943 1330h POSTER

Experimental/Laboratory Study of Zeta and Streaming Potentials at In Situ Conditions

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Streaming Potentials and zeta potentials were measured at equilibrium conditions, while at elevated temperatures of 23-200 degrees C and pressures of 20 MPa, on intact rock samples of Fontainebleau Sandstone, Berea Sandstone, and Westerly Granite. The techniques for achieving and measuring streaming potentials at equilibrium conditions, while at elevated temperatures and pressures is presented. The streaming potential coupling coefficient for Fontainebleau sandstone decreased in magnitude from 195 nV/Pa at 23 degrees C to 33 nV/Pa at 160 degrees C before rising to 41 nV/Pa at 200 degrees C. The Berea Sandstone coupling coefficient decreased in magnitude from 100 nV/Pa at 23 degrees C to 23 nV/Pa at 160 degrees C and then increased in magnitude to 100 nV/Pa at 200 degrees C. The Westerly Granite coupling coefficient increased in magnitude from 23 nV/Pa at 40 degrees C to 68 nV/Pa at 120 degrees C, then decreased in magnitude to 43 nV/Pa at 160 degrees C and then increased in magnitude to 50 nV/Pa at 200 degrees C. The Fontainebleau Sandstone zeta potential changes in magnitude by approximately 0.036 mV/C degrees between 23C degrees and 120 degrees C. At 120C degrees the slope changes in magnitude to 0.15 mV/degree C and stays at that average slope until 200 degrees C is reached. The Berea Sandstone zeta potentials increased in magnitude in the region between 23-160 degrees C with a change in magnitude of 0.044 mV/degrees C, the region hotter then 160 degrees C changes in magnitude by 3.8 mV/degrees C. The Westerly Granite zeta potential changes in magnitude by 0.095 mv/degree C which then changes to 0.25 mv/degree C at 110 degrees C.

H22C-0944 1330h POSTER

Non Equilibrium Infiltration in Unsaturated Laboratory Soil Columns

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During infiltration of water into initially dry soil columns non-equilibrium conditions were observed in the soil water potential and water content histories. These effects were manifested by: non-unique water potential - water content relationships as a function of time under steady infiltration; delayed equilibration of water content relative to that of water potential; overshoot of a steady-state water content and water potential following step increases or decreases in infiltration rate; and equilibrium scanning curves appearing to be infiltration-rate dependant. Observation of these effects in the laboratory requires accurate measurement of flow rate, water content and water potential. Results of these experiments suggest that rapid step increases in flow rate will not allow the dynamic effect to dissipate or true equilibrium to be achieved. Further, it is not clear that single-valued constitutive relationships can exist under simulated laboratory scale transient infiltration events which has profound implications on field scale prediction of water and contaminant monitoring and prediction.

H22C-0945 1330h POSTER

Size Exclusion Effects of Colloid Transport in Saturated Porous Media

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We present physical evidence of colloid exclusion from certain pore spaces due to size exclusion, and the connection between our pore scale observations and column scale experiments of colloid transport in saturated porous media. At the pore scale, we observed the influence of the ratio between pore throats and colloids (T/C ratio) at different flow velocities on the size exclusion effect. Preferential paths, a result of size exclusion, become more distinct for larger colloids and for greater pressure gradients, with an important effect on dispersion of the colloids. The measured colloid velocities are 4 to 5.5 times greater than the estimated pore water velocity. In the saturated sand column, early breakthrough of colloids increases with colloid size and water velocity, compared to a conservative solute tracer. For the column experiments, the observed colloid velocities are 1.1 to 1.2 times greater than the tracer velocities. Dispersion of colloids is significantly less relative to the tracer. The dispersion coefficient can be about one order of magnitude smaller, for example comparing 3 mm colloids and the tracer. In contrast with solute transport, dispersivity is not just a function of the medium characteristics, but is also a function of colloid size due to the size exclusion effect, particularly at low Peclet numbers.

H22C-0946 1330h POSTER

Pressure and Chemical Potential: Effects Hydrophilic Soils Have on Adsorption and Transport

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Using the assumption that thermodynamic properties of fluid is affected by its proximity to the solid phase, a theoretical model has been developed based on upscaling and fundamental thermodynamic principles (termed Hybrid Mixture Theory). The theory indicates that Darcy's law and the Darcy-scale chemical potential (which determines the rate of adsorption and diffusion) need to be modified in order to apply to soils containing hydrophilic soils. In this talk we examine the Darcy-scale definition of pressure and chemical potential, especially as it applies to hydrophilic soils. To arrive at our model, we used hybrid mixture theory - first pioneered by Hassanizadeh and Gray in 1979. The technique involves averaging the field equations (i.e. conservation of mass, momentum balance, energy balance, etc.) to obtain macroscopic field equations, where each field variable is defined precisely in terms of its microscale counterpart. To close the system consistently with classical thermodynamics, the entropy inequality is exploited in the sense of Coleman and Noll. With the exceptions that the macroscale field variables are defined precisely in terms of their microscale counterparts and that microscopic interfacial equations can also be treated in a similar manner, the resulting system of equations is consistent with those derived using classical mixture theory. Hence the terminology, Hybrid Mixture Theory.

H22C-0947 1330h POSTER

Autoregressive Extrapolation for Seismic Tomography problems with Applications to Soil and Rock Physics

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Seismic tomographic experiments in soil and rock are strongly affected by limited and non-uniform ray coverage. We propose a new method to extrapolate data used for seismic tomography to full coverage. The proposed two-stage autoregressive extrapolation technique can be used to extend the available data and provide better tomographic images. The algorithm is based on the principle that the extrapolated data adds minimal information to the existing data. A two-stage autoregressive (AR) extrapolation scheme is then applied to the seismic tomography problem. The first stage of the extrapolation is to find the optimal prediction-error filter (PE filter). For the second stage, we use the PE filter to find the values for the missing data so that the power out of the PE filter is minimized. At the second stage, we are able to estimate missing data values with the same spectrum as the known data. This is similar to maximizing an entropy criterion. Synthetic tomographic experiments have been conducted and demonstrate that the two-stage AR extrapolation technique is a powerful tool for data extrapolation and can improve the quality of tomographic inversions of experimental and field data. Moreover, the two-stage AR extrapolation technique is tolerant to noise in the data and can still extrapolate the data to obtain overall patterns, which is very important for real data applications. In this study, we have applied AR extrapolation to a series of datasets from laboratory tomographic experiments on synthetic sediments with known structure. In these tomographic experiments, glass beads saturated with de-ionized water were used as the synthetic water-saturated background sediments. The synthetic sediments were packed in plastic cylindrical containers with a diameter of 220 mm. Tomographic experiments were then set up to measure transmitted acoustic waves through the sediment samples from multiple directions. We recorded data for sources and receivers with varying angular coverage and used the data to tomographically reconstruct the internal sediment structures. The new tomographic inversion strategies using AR extrapolation should enable better delineation of structures in soil and rock which is important for characterizing the near-surface. Acknowledgments: LJPN acknowledges Purdue University Faculty Scholar program at Purdue University.

H22C-0948 1330h POSTER

Comparison of Laboratory Data and Theoretical Predications of P-wave Transmission Through NAPL/Water Mixtures in Unconsolidated Porous Media

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Laboratory measurements have shown that the presence of NAPL contaminants in unconsolidated porous media cause a reduction in P-wave velocity (Vp) and increased attenuation compared to water-saturated conditions. These results motivated our current project to test the ability of high-frequency seismic crosswell tomography to monitor remediation-induced changes in DNAPL distribution. As part of this project, we evaluate several constitutive models relating media properties and NAPL saturation to P-wave transmission characteristics. An appropriate relationship is useful for both estimating NAPL detectability limits and quantitatively interpreting seismic tomography results from the field. Gassmans fluid substitution relationships under-predict the magnitude of Vp changes measured in synthetic sand packs and aquifer core samples having variable NAPL saturations. The specific conditions of the shallow subsurface such as low effective stress, high porosity (30-40%), and irregular grain shapes may contribute to the discrepancy. Intrinsic fluid phenomena such as adhesion tension or pore-scale fluid distribution may also play a role. We present new measurements of Vp and seismic attenuation in partially NAPL saturated glass-bead packs. These results provide a controlled model for comparison to our previous work on natural aquifer samples and grain geometry closer to that assumed by traditional contact models. We also consider the applicability of the Biot, Biot-squirt, and scattering models to P-wave velocity and attenuation prediction for the NAPL saturated samples.

H22C-0949 1330h POSTER

Experimental and Theoretical Memory Diffusion of Water in Sand

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The basic equations used to study the fluid diffusion in porous media have been set by Fick and Darcy in the mid of the XIXth century but some data on the flow of fluids in rocks exhibit properties which may not be interpreted with the classical theory of propagation of pressure and fluids in porous media. Concerning the fluids and the flow, some fluids carry solid particles which may obstruct some of the pores diminishing their size or even closing them, some others may chemically and physically react with the medium enlarging the pores; so permeability changes during time and the flow occurs as if the medium had a memory, intending that at any instant the process of diffusion is also affected by the previous local value of pressure and flow of the fluid. This phenomenon should be taken into account when writing equations for diffusion of fluids in porous media. The scope of our work is to show, with experimental data, that during the diffusion the permeability of sand layers may decrease due to reassessment of the grains and consequent compaction. We also provide a memory model for diffusion of fluids in porous media, obtained by introducing a derivative of fractional order n in the classical equations, which fits well the flux rate observed in our laboratory experiments of diffusion of water in sand. The classic theory, in the case of constant diffusivity, with constant boundary and initial conditions, would give a constant flux contrary to the results of our laboratory experiments and so one would have to introduce in the equations a time variable diffusivity which is a priory unknown

and would have to be determined monitoring the permeability changes caused by the flux in the sand. We have also seen that, with the boundary and initial conditions used, the relaxation time of the flux, that is the time to reach stability, is about 10 hours which in turn implies that the compaction of the sand in the sample has the same relaxation time. However in terms of the memory model the flux and the associated relaxation time are now defined by two parameters, and not only one as in the classic theory; the parameters are the order of fractional derivative n and the pseudodiffusivity. Finally we show that the flux rate variations observed during the experiments are compatible with the compaction of sand, due to the amount of fluid which went through the grains locally, and therefore with the reduction of porosity, in fact in all experiments we observed that flux decreases in time to about 70 percent of initial value and that the volume of sand reduces of about 3 percent; moreover, using empirical Fair and Hatch law for permeability, the sand volume and flux reductions seem compatible; which proves that mechanical compaction occurring during diffusion is caused by the permeability changes which in turn cause the flux variations.

H22D MCC: Level 2 Tuesday 1330h

Remote Sensing of the Land Surface III Posters *(joint with A, B)*

Presiding: **E Wood,** Princeton University

H22D-0950 1330h POSTER

Soil Moisture Mapping During SMEX03 Using Airborne NOAA C- and X-band Polarimetric Scaning Radiometer (PSR)

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Remote sensing of soil moisture can be accomplished using L-band (1.4 GHz) microwave radiometry, and such data provides reasonable penetration of crop vegetation canopy as well as measurements of soil moisture at soil depths of up to 10 cm. Radiometry using higher microwave frequencies provides progressively less penetration of vegetation and soil probing depth, but is more amenable to implementation using airborne or spaceborne antennas of practical size. The Japanese AMSR-E imaging radiometer on board the NASA EOS Aqua satellite is one such sensor capable of retrieving soil moisture using a microwave channel at 6.9 GHz with 75 km spatial resolution. Aqua was launched in May 2002, and will provide a global soil moisture product based on AMSR-E data The Soil Moisture Experiments in 2002 and 2003 (SMEX02/03) campaign were designed to provide early post-launch validation for Aqua via an airborne imaging study that simulates AMSR-E low-frequency microwave imagery. The airborne sensor used for the simulation is the NOAA Polarimetric Scanning Radiometer (PSR) operated on the NASA Wallops Flight Facility's P-3B aircraft. The PSR is the only operational airborne radiometer system to provide multiband polarimetric brightness imagery. It was developed at the Georgia Institute of Technology and the NOAA Environmental Technology Laboratory starting in 1995 in response to a general national need for high-resolution multiband polarimetric imagery for satellite algorithm development and calibration/validation studies. Objectives of the PSR flights during SMEX03 included: (1) providing high-resolution AMSR-E (55^{o} incidence) underflight data at vertical and horizontal polarization, (2) developing algorithms using combined C- and X-band data for soil moisture retrieval in the presence of several types of vegetation canopies, (3) studying the detailed spatial and temporal signatures associated with soil moisture variations on a sectional (1-km) spatial scale, (4) developing algorithms relating C- and X-band soil moisture imagery with coincident L-band imagery for future L-band satellite development purposes, (5) developing hardware and algorithms for mitigating anthropogenic radio frequency interference in soil moisture radiometry, and (6) providing soil moisture data at field scale for land surface hydrology studies. We will present composited quick-look PSR/CX images of eight high-altitude flights conducted over two regional areas in Oklahoma during the July 2–14, 2003 period. Images show general drying in both regions interspaced with short periods of increased soil moisture following brief rainfall events.

URL: http://www.etl.noaa.gov/data/psr/smex03/

H22D-0951 1330h POSTER

Estimating broadband emissivity of North Africa using satellite thermal infrared multispectral radiometers

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Surface broadband (8-13.5 micrometer) emissivity in the thermal infrared region is an important parameter for the studies of energy budget and surface energy balance. This paper focuses on estimating broadband emissivity using two sensors on NASA's Earth Observing System (EOS) Terra satellite, Advanced Spaceborne Thermal Emission and reflection Radiometer (ASTER) and MODerate resolution Imaging Spectrometer (MODIS). We developed a method to estimate broadband emissivity using two regressions. The first regression is to relate the broadband emissivity to the emissivities for the five ASTER channels using libraries of spectral emissivity. This regression is used for mapping the broadband emissivity, which is necessary for the calibration of the second regression. The second regression is to extend the map to continental scales using the relationship between (a) the ASTER broadband emissivity map and (b) spectral emissivity and spectral reflectance data from MODIS data. The broadband emissivity values calculated from first regression were used to calibrate the second regression. We applied this regression to MODIS data and generated a broadband emissivity map over the Sahara Desert. The range of the broadband emissivity was found to be between 0.86 and 0.96 for the desert area. The expected RMS error of the map is about 0.02. Such emissivity map could be used as an input of climate model and could contribute to improve the surface and air temperature up to 1 degree C.

H22D-0952 1330h POSTER

Remote Sensing Spatial Resolution Analysis Using a Two-Source Energy Balance Model for SMEX02/SMACEX

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As part of the Soil Moisture Atmosphere Coupling Experiment (SMACEX) conducted during the Soil Moisture Experiment 2002 (SMEX02) in June and July, the potential impact of spatial resolution of input data derived by remote sensing on flux estimation was analyzed. Land surface temperature and the Normalized Difference Water Index (NDWI) derived from remotely sensed data along with meteorological data were used as provide inputs for a two-source canopy model. This model evaluates soil and vegetation contributions to the energy fluxes and radiometric surface temperature. The primary source of remotely sensed data was the Landsat satellites. The model and the Landsat data were used to estimate land surface fluxes over the watershed area. These high resolution estimates clearly showed spatial and temporal variations due to the different crop covers (primarily corn and soybean) and management practices. In particular, surface temperature showed very significant spatial variation at the Landsat pixel resolution. These spatial variations are difficult to observe in a coarse resolution image, such as MODIS or AVHRR and it is clear that a great deal of spatial information that is useful at the field scale is lost when AVHRR or MODIS is used. As validation, the fluxes estimated from the two-source model were compared with those derived from aircraft based flux data. Although there are differences the simple two-source model provides a useful technique to use with remotely sensed thermal and NIR/SWIR data. Spatial variations in the fluxes at different spatial scales were also analyzed to investigate the impact of resolution on radiative properties and resulting impact on energy and water flux estimation.

H22D-0953 1330h POSTER

Determining the Snow Depth Distribution on a Mountain Slope Using an Airborne Laser Scanner

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In heavy snow districts in Japan, snow cover makes slopes more unstable. For example, the snow load affects the normal stress and the snow glide affects the shear stress of the slope. Furthermore, snow thaws in spring and changes into meltwater, which increases the pore water pressure in the ground. To understand quantitatively the effect of snow cover on slope stability, the distribution of snow depth must be obtained. However, it has conventionally been estimated by multi-point measurement only by a probe pole with low plane resolution. In this study, we used an airborne laser scanner both during the snow period and non-snow period to measure both surface elevations. We determined the snow depth distribution by calculating the difference in each value with high accuracy and high resolution. The scanned area is located near the west coast of Japan. The scanning slope has an area of 18 ha and elevation of 500 m to 700 m above sea level. In midwinter, this area is normally covered with snow up tp 3 - 4 m depth. The scanning was conducted in February 2003 for the snow period and in May 2003 for the non-snow period. The calculated snow depth was 2.3 m on average. However, snow depths of more than 4 m or less than 1 m sometimes appeared, showing that the snow cover was not uniformly distributed on the mountain slope. Furthermore, our research revealed the following characteristics of the distribution. 1) The snow depth on a north-facing slope is larger than that on a south-facing slope, which we consider to be the result of the difference in solar radiation between the slopes. 2) The snow depth is less on a steep slope near the mountaintop and ridge, and is larger between the contour line where the slope gradient changes from steep to gentle. This is thought to be because snow is blown off by the wind or that snow drifts are formed.

H22D-0954 1330h POSTER

The Hydrosphere State Mission (HYDROS) Soil Moisture and Freeze/Thaw Exploratory Mission

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The Hydrosphere State Mission (HYDROS) is a pathfinder mission in the NASA's Earth System Pathfinder Program (ESSP). The objective of the mission is to provide exploratory measurements that constitute the first global scale measurement of Earth's soil moisture and land surface freeze/thaw conditions. The mission builds on the heritage of ground-based and airborne passive and active low-frequency microwave measurements that have demonstrated and validated the effectiveness of the measurements and associated algorithms for estimating the amount and phase (frozen or thawed) of surface soil moisture. The mission data will enable advances weather and climate prediction and in mapping processes that link the water, energy and carbon cycles. The proposed HYDROS instrument is a combined radar and radiometer system operating at 1.26 GHz (with VV, HH, and HV polarizations) and 1.41 GHz (with H, V, and U polarizations). The radar and the radiometer share the aperture of a 6-meter antenna pointing at 35^{o} with respect to nadir. The lightweight deployable mesh antenna is rotated at 14.6 rpm to provide a constant look-angel scan swath of 1000 km. The large swath provides a global coverage of the