orientation across all orientations of the true gradient. As an example, these results are applied to data collected from a monitoring network of 25 wells at the WIPP site during two different time periods. The simulation results are used to reduce the set of all possible combinations of three wells to those combinations with acceptable measurement errors relative to the amount of head drop across the estimator and base to height ratios between 0.5 and 5.0. These limitations reduce the set of all possible well combinations by 98 percent and show that size alone as defined by triangle area is not a valid discriminator of whether or not the estimator provides accurate estimates of the gradient magnitude and orientation. This research was funded by WIPP programs administered by the U.S Department of Energy. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

H11E-0899 0830h INVITED POSTER

Post-audits of Three Groundwater Models for Evaluating Plume Containment

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Groundwater extraction systems were designed using numerical models at three sites within a U.S. Army Ammunition Plant in Tennessee. Each site, and hence model, has unique qualities such as boundary conditions, extensiveness of the contaminant plume, and quantity and quality of hydrogeologic data. Performance of each of these extraction systems has been evaluated throughout their operation, providing an opportunity to perform post-audits on the accuracy of the groundwater models that were used in their design. Areas of comparison between the models and the observed response in the natural systems include hydraulic head, drawdown, horizontal and vertical gradients, and extent of capture zones. The results of the post-audits show the importance of using all available data in the construction and calibration of the models, the importance of having sufficient data, and the critical nature of an accurate conceptual model. The post-audits also show that although it may be possible to assess the accuracy of the model predictions, it is often not possible to explain the reasons for discrepancies between predicted and observed results. From a practical perspective, parameter uncertainty is important to account for in the development of the models and subsequent design of the extraction systems.

H11E-0900 0830h POSTER

Simulation Of Groundwater Flow And Reactive Transport In A Tidally Influenced Estuarine Aquifer

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Existing groundwater monitoring data from an estuarine sandy aquifer situated below an old industrial landfill (Scotland) showed that (1) leaching from sulphurous waste located in the landfill has generated an acidic plume; (2) associated with the low pH, metal contaminants within the acidic plume are slowly migrating towards the estuary; and (3) the groundwater fluctuations are influenced by the tidal oscillations of the estuary. In order to test the possible influence of rainfall/precipitation, tidal fluctuation and salt water intrusion on the groundwater flow and reactive chemical transport, a model for multi-component reactive transport with density dependent flow was developed and applied to the site. The groundwater flow and chemical transport in this coastal aquifer were simulated. Both the field observations and numerical simulations showed that the tidal influence on the groundwater table fluctuations was great even far inland. This influence could not be explained by standard analytical solutions. It is expected that the local morphology and hydro-geological conditions cause this behaviour. The simulation performed with a conservative tracer showed that it took much less time to reach the estuary than the acidic plume originating from the landfill, with the rate of movement influenced by recharge and tidal oscillations. Due to buffering reactions occurring in the geochemical system during the migration of the contaminants (ion exchange, mineral precipitation/dissolution and oxidation/reduction), the movement of the acidic plume and associated metals is strongly retarded. Sharp differences are apparent in chemical concentrations, pH and pe, between the plume location and unaffected areas.

H11E-0901 0830h POSTER

An Intermediate-Scale Groundwater Contamination Experiment

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Intermediate-scale experiments fill the gap between bench and field-scale experiments. They compensate for the missing subsurface heterogeneity in bench-scale experiments and the lack of environmental control and insuffcient sampling in field-scale experiments. A 4.22 by 2.74 by 2.13m intermediate-scale indoor facility that mimics a heterogeneous subsurface environment was constructed. To characterize the facility and to obtain a 3D subsurface contamination dataset, a 20-day point source continuous-injection experiment was conducted. Using 63 Time Domain Reflectometry(TDR) sensors, a salt concentration dataset was collected at a frequency of 20 minutes per measurement per sensor. The experiment data were compared with a finite element model - Princeton Transport Code(PTC) simulation. In the horizontal plain, which contains a point source, the PTC simulation were consistent with the TDR data. At other sampling locations, vertical to this plain, there were siginificant deviations between the PTC simulation and the TDR data.

H11F MCC: Level 2 Monday 0830h

Use of Artificial Intelligence Methods in Geosciences Posters *(joint with A, NG)*

Presiding: **M Morissey,** Oklahoma University**; S Postawko,** University of Oklahoma

H11F-0902 0830h POSTER

Comparison of Data-Driven Takagi–Sugeno Models of Rainfall-Discharge Dynamics

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Three different methods for constructing fuzzy rule-based models of the Takagi–Sugeno type relating rainfall to catchment discharge are tested on the Zwalm catchment in Belgium. They correspond to the grid partitioning (GP), subtractive clustering (SC), and Gustafson–Kessel clustering (GK) identification methods. The data set used to parametrize and validate the models consists of hourly precipitation and discharge records. The models are parametrized using a one-year identification data set and are then applied to a four-year data set. All models are found to have a low computation cost. Although the models show a similar performance, the best results are obtained for the GK method. A real-time flood forecasting algorithm is then developed, in which discharge measurements are assimilated into the model at either an hourly or a daily time step. The results suggest that the GK method can potentially be used as an operational flood forecasting tool.

H11F-0903 0830h POSTER

Precipitation Estimation from Remotely Sensed Information using ANN-Cloud Classification System

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Abstract Artificial Neural Network (ANN) models, which contain flexible architectures and are capable of discerning the underlying functional relationships from data, are recognized as very useful tools in geophysical applications. In this study, we demonstrate a hybrid ANN modeling system to estimate surface rainfall from satellite infrared imagery. The proposed network, Precipitation Estimation from Remotely Sensed Information using ANN-Cloud Classification System (PERSIANN-CCS), includes several components: (1) cloud image segmentation, (2) cloud patch feature selection, (3) patch feature classification using a self-organizing feature map network, and (4) patch-based rainfall estimates from a group of multiple nonlinear cloud top temperature and rainfall functions. The PERSIANN-CCS model was first calibrated using observations from Geostationary Operational Environmental Satellite (GOES) infrared imagery and the Next Generation Radar (NEXRAD) rainfall network. To further extend PERSIANN-CCS rainfall estimates over the remote regions, Tropical Rainfall Measurement Mission (TRMM) microwave rainfall estimates (TMI product 2A12) were used to adjust PERSIANN-CCS model parameters. The calibrated nonlinear cloud top temperature and rainfall (Tb-R) functions of classified cloud patches show highly variability, reflecting the complexity of dominant cloud-precipitation processes over various regions. Case studies show that PERSIANN-CCS captures the variability in rain rate at 12kmx12km grid and 3-hour resolutions, with a standard error of 3.0mm/hr and a correlation coefficient around 0.65. Additional insights into the cloud evolution and precipitation process from the classified PERSIANN-CCS cloud patch features and rainfall distributions are discussed.

H11F-0904 0830h POSTER

Use of artificial neural networks in prediction of subsurface hydrological processes

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Modeling of surface runoff for hydrological or agricultural purposes typically makes use of empirical or semi-empirical infiltration functions such as those by Horton or Kostiakov. The alternative of detailed numerical solution of the Richards equation is generally limited to research purposes because of greater complexity than the empirical forms and the need for a greater effort in order to obtain results. A major drawback of the use of empirical functions with regard to the subsurface is that boundary and initial conditions are not explicitly taken into consideration and the details of water distribution are not calculated. This limits the accuracy of the surface models to be site and event specific. In addition, it limits the applicability of surface models for studying recharge. We present here a new alternative to the detailed numerical solution of the Richards equation which is based on artificial neural networks (ANN). The methodology relies on extensive numerical solutions for various soil properties and geometries, building a large training set for the ANN. A dimensionless form of the numerical increases the efficiency of the database generation. At a second stage, the ANN in its recall mode can replace the numerical solution to obtain a dramatically faster solution, while retaining acceptable accuracy for both infiltration rates and water content distributions. The methodology is presented for several case studies with an emphasis on infiltration from trenches and furrows.

H11F-0905 0830h POSTER

Automated Parameterization of a Transpiration Model: A Comparative Study of Bayesian Analysis and a Procedure Based on Fuzzy Set Theory

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Bayesian inference using Markov chain simulation methods is a class of extremely useful techniques for drawing inference from uncertain data and parameterization of stochastic models. However, most simulation models in geosciences are deterministic and designed to capture the underlying mechanisms explicitly. Such models may not be easily formulated in stochastic terms. In addition, sometimes there is considerable uncertainty regarding the model structure and its components, and the errors may not be randomly distributed. Even when inputs are considered to have negligible uncertainty, due to the hierarchical nature and existence of feedbacks in many simulation models, it is difficult to set up an appropriate likelihood function for a Bayesian analysis of the model. Consequently, parameterization and uncertainty analysis of these models require considerable a priori knowledge about the joint distribution of parameters as well as the expected error distribution. These information may not always be available. In contrast, an alternative procedure developed using possibility theory in the context of fuzzy sets does not require the above a priori knowledge. The underlying assumption in this case is that the goodness of fit of the model output to a set of observed data can be interpreted as the membership grade function of a fuzzy set comprising of acceptable model-parameter combinations. In this study, the proposed method is compared extensively with Markov chain simulation procedure under various error models. The canopy conductance sub-model embedded within the Penman-Monteith equation for transpiration is used for this study. The analysis was conducted using synthetic data as well as measurements from Chequamegon Ecosystem Atmosphere Study (ChEAS) site in Wisconsin. Parameterization and uncertainty analysis using the fuzzy set based technique were found to be consistent with those obtained from the Bayesian analysis.

H11F-0906 0830h POSTER

Classification of Martian Terrain Using Automated Discovery of Structure Algorithm Applied to Digital Topography

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The morphology of Martian landscape is of great interest because it helps to identify physical processes responsible for the observable topography. Traditionally, the descriptive method, applied to imagery data, has been used to study and categorize different types of Martian landscapes. We are developing a complementary approach, wherein a landscape is classified by a computer algorithm on the basis of digital topography provided by the Mars Orbiter Laser Altimeter data. We have adopted the automatic discovery of structure (ADOS) methodology, an unsupervised learning technique that classifies the data by grouping together similar cases. We use probabilistic algorithm that groups cases into classes by modeling each class through probability density function. Each case has a probability of class membership and is assigned to the class with highest posterior probability. The optimal number of classes is determined by cross-validation. The ADOS algorithm is applied to group pixels in a digital elevation model (DEM) of Tisia Valles, a typical Noachian Martian surface located at 46.13E, 11.83S. This terrain is heavily cratered, and shows presence of channels. An auxiliary DEM of the same size is calculated to contain an elevation field modified to make the landscape drainable. The DEM has 163240 pixels, each pixel carries its local topographical information encapsulated in a list of six quantities ($h, \delta h, s1, s2, a1, a2$) which we call a topography descriptor. The components are: elevation, elevation difference between drainable and original DEMs, slopes in original and drainable DEMs, and contributing areas in original and drainable DEMs, respectively. Euclidean metric in space of topography descriptors is used to measure the "closeness" between pixels. The algorithm partitioned the pixels into 12 well-separated classes. Comparison of spatial distribution of these classes with visual rendering of digital topography reveals a geomorphic significance of obtained classification. Interiors of craters, ridges, inter-crater planes and channels are separated into different classes. Some subtle differences between otherwise similar terrain are picked up by our classification. Four classes represent crater interiors; they discriminate between different crater depths. Four classes represent inter-crater plains, they differ by actual elevation. Three classes represent ridges, they discriminate between different slopes. Finally, a single class represents channels. Using this classification we have constructed a thematic map of the Tisia Valles region that portrays spatial relations between various geomorphic features.

H11F-0907 0830h POSTER

Development of Discharge Ratings for Low-Slope Streams Under Tidal Effects Using Non-Parametric and Data-Driven Models

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Estimation of flow discharge in natural streams has been traditionally obtained using simple stage-discharge relations known as rating curves. However, in situations where streams are characterized by low gradients and are subject to tidal flow reversal effects, no simple stage-discharge relation can be developed. Instead, a more complex relation is required in which discharge is related to the stage and other relevant hydraulic variables. The present study investigates this issue using advanced data-driven computational techniques such as neural networks and non-parametric regression analysis. The proposed techniques will be applied to low-gradient streams in the Vermillion river basin in southwestern Louisiana. The results of the predicted discharge estimates are validated using actual discharge measurements in order to assess the performance of the proposed models and their prediction accuracy. The study also addresses issues such as selection of number of input variables, sample size requirements, computational efficiency, and uncertainty bounds of the developed models.

H11F-0908 0830h POSTER

Expectation-Maximization Algorithm Based System Identification of Multiscale Stochastic Models for Scale Recursive Estimation of Precipitation: Application to Model Validation and Multisensor Data Fusion

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Owing to the tremendous scale dependent variability of precipitation and discrepancies in scale or resolution among different types/sources of observations, comparing or merging observations at different scales, or validating Quantitative Precipitation Forecast (QPF) with observations is not trivial. Traditional methods of QPF (e.g., point to area) have been found deficient, and to alleviate some of the concerns, a new methodology called scale-recursive estimation (SRE) was introduced recently. This method, which has its root in Kalman filtering, can (i) handle disparate (in scale) measurement sources; (ii) account for observational uncertainty associated with each sensor; and (iii) incorporate a multiscale model (theoretical or empirical) which captures the observed scale-to-scale variability in precipitation. The result is an optimal (unbiased and minimum error variance) estimate at any desired scale along with its error statistics. Our preliminary studies have indicated that lognormal and bounded lognormal multiplicative cascades are the most successful candidates as state-propagation models for precipitation across a range of scales. However, the parameters of these models were found to be highly sensitive to the observed intermittency of precipitation fields. To address this problem, we have chosen to take a "system identification" approach instead of prescribing a priori the type of multiscale model. The first part of this work focuses on the use of Maximum Likelihood (ML) identification for estimating the parameters of a multiscale stochastic state space model directly from the given data. Expectation-Maximization (EM) algorithm is used to iteratively solve for ML estimates. The "expectation" step makes use of a Kalman smoother to estimate the state, while the "maximization" step re-estimates the parameters using these uncertain state estimates. Using high resolution forecast precipitation fields from ARPS (Advanced Regional Prediction System), concurrent rain gauge measurements and NEXRAD observations, the second part of this work presents the applicability and importance of the proposed approach towards QPF verification in an operational setting.

H11F-0909 0830h POSTER

Evolution of Neural Networks for the Prediction of Hydraulic Conductivity as a Function of Borehole Geophysical Logs: Shobasama Site, Japan

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In situ measurements of hydraulic conductivity in fractured rocks are expensive to acquire. Borehole geophysical measurements are relatively inexpensive to acquire but do not provide direct information on hydraulic conductivity. These geophysical measurements quantify properties of the rock that influence the hydraulic conductivity and it may be possible to employ a non-linear combination of these measurements to estimate hydraulic conductivity. Geophysical measurements collected in fractured granite at the Shobasama site in central Japan were used as the input to a feed-forward neural network. A simple genetic algorithm was used to simultaneously evolve the architecture and parameters of the neural network as well as determine an optimal subset of geophysical measurements for the prediction of hydraulic conductivity. The initial estimation procedure focused on predicting the class of the hydraulic conductivity, high, medium or low, from the geophysical measurements. This estimation was done while using the genetic algorithm to simultaneously determine the most important geophysical logs and optimize the architecture of the neural network. Results show that certain geophysical logs provide more information than others- most notably the short-normal resistivity, micro-resistivity, porosity and sonic logs provided the most information on hydraulic conductivity. The neural network produced excellent training results with accuracy of 90 percent or greater, but was unable to produce accurate predictions of the hydraulic conductivity class In the second phase of calculations, the selection of geophysical measurements is limited to only those that provide significant information. Additionally, this second phase predicts transmissivity instead of hydraulic conductivity in order to account for the differences in the length of the hydraulic test zones. Resulting predictions of transmissivity exhibit conditional bias with maximum prediction errors of three orders of magnitude occurring at the extreme measurement values. Results of these simulations indicate that the most informative geophysical measurements for the prediction of transmissivity are depth and sonic velocity. The long normal resistivity and self potential geophysical measurements are moderately informative. In addition, it was found that porosity and crack counts (clear, open, or hairline) do not inform predictions of transmissivity. This work was funded by the Japan Nuclear Cycle Development Institute. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94-AL-85000

H11F-0910 0830h INVITED POSTER

Nonlinear Multivariate and Time Series Analysis by Neural Network Methods, with Applications to ENSO

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Methods in multivariate statistical analysis are essential for working with large amounts of geophysical data— data from observational arrays, from satellites or from numerical model output. In classical multivariate statistical analysis, there is a hierarchy of methods, starting with linear regression (LR) at the base, followed by principal component analysis (PCA), and finally canonical correlation analysis (CCA). A multivariate time series method, the singular spectrum

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analysis (SSA), has been a fruitful extension of the PCA technique. The common drawback of these classical methods is that only linear structures can be correctly extracted from the data. Since the late 1980s, neural network methods have become popular for performing nonlinear regression (NLR) and classification. More recently, multi-layer perceptron neural network methods have been extended to perform nonlinear PCA (NLPCA), nonlinear CCA (NLCCA) and nonlinear SSA (NLSSA). This paper presents a unified view of the NLPCA, NLCCA and NLSSA techniques, and their applications to various datasets of the atmosphere and the ocean, especially in the nonlinear study of the El Niño-Southern Oscillation (ENSO) phenomenon.

H11F-0911 0830h POSTER

Prediction of Fluid Velocity in Highly Heterogeneous Conductivity Fields Using a Genetic Algorithm-Designed Artificial Neural Network

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A genetic algorithm (GA) is used to select the operational parameters of artificial neural networks (ANN) which are trained to predict fluid velocity. Populations of three-layer, feedforward backpropagation ANN's with varying numbers of hidden nodes, types and slopes of activation functions, alpha and beta learning rates and initial distributions of weights for both the input and hidden layers are created by the GA. The GA- defined ANN's are trained with inputs-output pairs of hydraulic conductivity neighborhoods and resulting fluid velocities at certain points in the simulation domain. The hydraulic conductivity fields are highly heterogeneous with an ensemble log conductivity variance of 1.0. Results of the GA are defined and selected ANN velocity predictions are presented.

H11F-0912 0830h POSTER

Detection of Visual Events in Underwater Video Using a Neuromorphic Saliency-based Attention System

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The Monterey Bay Aquarium Research Institute (MBARI) uses high-resolution video equipment on remotely operated vehicles (ROV) to obtain quantitative data on the distribution and abundance of oceanic animals. High-quality video data supplants the traditional approach of assessing the kinds and numbers of animals in the oceanic water column through towing collection nets behind ships. Tow nets are limited in spatial resolution, and often destroy abundant gelatinous animals resulting in species undersampling. Video camera-based quantitative video transects (QVT) are taken through the ocean midwater, from 50m to 4000m, and provide high-resolution data at the scale of the individual animals and their natural aggregation patterns. However, the current manual method of analyzing QVT video by trained scientists is labor intensive and poses a serious limitation to the amount of information that can be analyzed from ROV dives. Presented here is an automated system for detecting marine animals (events) visible in the videos. Automated detection is difficult due to the low contrast of many translucent animals and due to debris ("marine snow") cluttering the scene. Video frames are processed with an artificial intelligence attention selection algorithm that has proven a robust means of target detection in a variety of natural terrestrial scenes. The candidate locations identified by the attention selection module are tracked across video frames using linear Kalman filters. Typically, the occurrence of visible animals in the video footage is sparse in space and time. A notion of "boring" video frames is developed by detecting whether or not there is an interesting candidate object for an animal present in a particular sequence of underwater video – video frames that do not contain any "interesting" events. If objects can be tracked successfully over several frames, they are stored as potentially "interesting" events. Based on low-level properties, interesting events are identified and marked in the video frames. Presented here is performance data that compare the automated detection method with that of human annotators. The system enhances the productivity of human video annotators and/or cues a subsequent object classification module by omitting "boring" frames and marking candidate objects.

URL: http://www.mbari.org

H11F-0913 0830h POSTER

A Hybrid Global MISR Cloud Mask using Support Vector Machines and Active Learning

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The Multiangle Imaging SpectroRadiometer (MISR) onboard NASA's Terra EOS satellite provides unique sensing capabilities that promise potentially much better global cloud identification. A number of algorithms have been developed and implemented for detecting clouds in MISR data, some of which use MISR's unique multiangle sensing capability. All of these techniques are firmly grounded in the physics of remote sensing, but the accuracy of each method is highly dependent on different specific conditions. This presents a unique opportunity for soft computing methods. We are investigating techniques that use Support Vector Machines (SVMs) to combine the raw MISR data and the output of existing MISR cloud mask algorithms into a new and more robust global cloud mask. One of the main challenges in training a SVM (or any other supervised classifier) is that it is very expensive and time consuming to collect training data. To address this problem we have incorporated and are continuing to refine the relatively new technique known as active learning, in which the algorithm queries the human expert to supply training labels in regions that would be most beneficial for improving the model. We have developed an interactive application which utilizes SVMs and active learning to allow a scientist to quickly train a classifier for MISR data. In addition, we have performed a number of small-scale case studies and a global sampling study which compare the accuracy of the existing MISR cloud mask algorithms to our best SVM models.

H11F-0914 0830h POSTER

Using Decision Trees to Examine Relationships between Inter-Annual Vegetation Variability, Topographic Attributes, and Climate Signals

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The objective of this research is to develop KDD (knowledge discovery in databases) techniques for spatio-temporal geo-data, and use these techniques to examine inter-annual vegetation health signals. The underlying hypothesis of the research is that the signatures of inter-annual variability of climate on vegetation dynamics as represented by the statistical descriptors of vegetation index variations depend upon a variety of attributes related to the topography, hydrology, physiography, and climate. NDVI (normalized differential vegetation index) is enlisted to represent vegetation health and relationships between this index and topographic attributes such as elevation, slope, aspect, compound topographic index (CTI), and the proximity to a stream, are analyzed. Several scientific questions related to the identification and characterization of the inter-annual variability ensue as a consequence of our hypothesis. Investigations were performed using 13 years of 1-km resolution NDVI data from the AVHRR instrument on NOAA's POES (polar-orbiting operational environmental satellite) over the continental U.S. Various temporal change indices were used in order to identify anomalous inter-annual behavior in the NDVI index, including maximum absolute and relative deviations from the 13-year mean and positive and negative persistence indices (after Zhou et al., 2001). The KDD technique used in this research is the decision tree, which falls under the classification and prediction division of data mining techniques. The algorithm is similar to c4.5 and id3, but can handle continuous input and output values without binning and is optimized to determine the minimum error. Future work will incorporate clustering algorithms (both distance and density-based) and association rule algorithms (constraint-based) adapted for spatial-temporal data. Investigations will also be performed at smaller spatial scales, integrating higher resolution data. Throughout the growing season, elevation and slope are dominant factors associated with increased vegetation variability. From May to September slope prevails at high, rather than low elevations, although in the beginning and end of the growing season (April and October) this is not the case. This may possibly be due to the lack of vegetation at higher elevations at the fringes of the growing season. In general, the lower the slope, the greater the relative change in vegetation, thus linking zones of moisture convergence typically associated with low slopes to increased changes in vegetation over time. The relative change in vegetation is greater at mid-range elevations in April through June, high elevations in July through September, and low elevations in October. Zones of subsurface flow convergence, as captured by the CTI, play an important role in July through October; however, the influence alternates from low elevations in July to high elevations in August, reverting back to low elevations in September and October.

H11F-0915 0830h POSTER

A New Perspective on Modeling Groundwater-Driven Health Risk With Subjective Information

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Fuzzy rule-based systems provide an efficient environment for the modeling of expert information in the context of risk management for groundwater contamination problems. In general, their use in the form of conditional pieces of knowledge, has been either as a tool for synthesizing control laws from data (i.e., conjunction-based models), or in a knowledge representation and reasoning perspective in Artificial Intelligence (i.e., implication-based models), where only the latter may lead to coherence problems (e.g., input data that leads to logical inconsistency when added to the knowledge base). We implement a two-fold extension to an implication-based groundwater risk model (Ozbek and Pinder, 2002) including: 1) the implementation of sufficient conditions for a coherent knowledge base, and 2) the interpolation of expert statements to supplement gaps in knowledge. The original model assumes statements of public health professionals for the characterization of the exposed individual and the relation of dose and pattern of exposure to its carcinogenic effects. We demonstrate the utility of the extended model in that it: 1)identifies inconsistent statements and establishes coherence in the knowledge base, and 2) minimizes the burden of knowledge elicitation from the experts for utilizing existing knowledge in an optimal fashion.

H11G MCC: Level 2 Monday 0830h

Numerical Simulations of Flow and Transport in Heterogeneous Subsurface Systems Posters

Presiding: **Y Zhang,** University of Iowa

H11G-0916 0830h POSTER

Evaluation of the Effects of Potash Mining in the Region of the Waste Isolation Pilot Plant, Carlsbad, New Mexico

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The Waste Isolation Pilot Plant (WIPP) in southeast New Mexico has been developed for underground disposal of transuranic waste in halite beds of the Permian Salado Formation. Managed by the Department of Energy (DOE), the WIPP has been operational since March 1999. Regulatory requirements call for