H62E MCC: Hall C Saturday 1330h

Twenty-Two Years of Stochastic Groundwater Hydrology II Posters

Presiding: **V Tidwell,** Sandia National Laboratories**; R Holt,** University of Mississippi

H62E-0897 1330h POSTER

Testing a Gaussian assumption on the stochastic Buckley–Leverett equation

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We analyze a multivariate Gaussian assumption for transformations of saturation and flux using Monte Carlo simulations of the stochastic Buckley–Leverett equation. The Gaussian assumption is of interest both for closure of moment equations and for estimating the size of third- and higher-order moments, and is commonly invoked in stochastic subsurface models. Random permeability fields are generated from a multivariate log-Gaussian distribution using a Fast Fourier Transform method. Flux and saturation fields are numerically solved on a simplified 2-D domain. Using chi-square tests we find that a Gaussian approximation is inappropriate for transformations of saturation. We suggest a mixture model for distribution of saturation near a saturation front.

H62E-0898 1330h POSTER

Gaussian finite element closure of steady state unsaturated flow in randomly heterogeneous soils

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We present a new method for the solution of stochastic unsaturated flow problems in randomly heterogeneous soils, which avoids linearizing the governing flow equations or the soil constitutive relations, and places no theoretical limit on the variance of constitutive parameters. The method applies in principle to a broad class of soils with unsaturated properties that scale according to a linearly separable model, provided that pressure head has a near-Gaussian distribution. We apply the method to soils whose relative hydraulic conductivity varies exponentially with pressure head. The flow domain is a checkerboard of uniform subdomains within each of which the soil hydraulic properties are random constants. Across the flow domain, these properties are spatially auto- and cross-correlated. Flow is described by means of finite element equations with spatially-correlated random coefficients. Averaging the finite element equations in probability space, while treating dimensionless pressure head as a multivariate Gaussian function, yields a system of partially coupled nonlinear algebraic equations that can be solved numerically for the ensemble mean, variance and covariance of pressure head across the domain. We do so for two-dimensional flow in a bounded vertical domain under coupled mean uniform and convergent flows, and compare the results with those of standard Monte Carlo simulations.

H62E-0899 1330h POSTER

Inverse Modeling of Spatial Correlation of Permeability in Sediments with Hierarchical Organization

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The spatial covariance of ln(K) can be modeled with a hierarchical organization that corresponds to the organization of bedding within cross-bedded sediments. Such a model accounts for the spatial correlation of ln(K) within and across bedding units defined at one level. This is related to correlation of ln(K) at a higher level (larger scale) through the spatial correlation of indicator variables representing the proportions, geometry and juxtaposition patterns of the units at the lower level. In this paper the fitting of the components of the hierarchical model, written as nested functions, is considered in developing a hierarchical covariance model for use in estimation, simulation, or analytical derivation of macrodispersivity models. The components include the auto- and cross-correlation functions for both permeability and the indicator variables. The least square criteria, along with parameter prior information and other weighted constraints, are used as the objective functions of the inverse problem, which is solved by the Gauss-Newton-Levenverg-Marquart method. The method is tested on synthetic data and illustrated with real data from the Hamilton site, Ohio, with glaciofluvial sand and gravel deposits. The final global semivariogram and covariance obtained from model fitting produce good fits to the sample ones. The model results have also been used to examine alternative assumptions about correlation between facies, specifically the relative importance of auto- and cross-covariances. For the model semivariogram the variograms across facies are striking and cannot be ignored. For model covariance, the covariances across facies are indistinctive and the auto-covariances dominate over the cross-covariance.

H62E-0900 1330h POSTER

Effect of Construction Water on Chlorine-36 Studies at the Exploratory Studies Facility at Yucca Mountain, Nevada: Model Development and Uncertainty Analysis

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Chlorine-36 from nuclear tests in the 1950s and 1960s has been used to identify fast flow paths along fault and fracture zones at Yucca Mountain, the proposed U.S. repository for high-level nuclear waste. During the excavation for the Exploratory Studies Facility (ESF) at Yucca Mountain, construction water traced with lithium bromide was used as circulation fluid. After construction, rock samples taken along the wall were leached and found permeated to varying degrees by this circulation fluid. Fabryka-Martin et al. (1998) corrected bomb-pulse signal ^{36}Cl/Cl ratio through determinaion of the amount of chlorine contributed from the circulation fluid through a linear two-member mixing model of the Br/Cl ratio. However, this effort to quantify the presence of construction water is complicated by the presence of chemical heterogeneity in pore waters of rock samples, as well as by variability in Cl^- and Br^- concentration in the circulation fluid. Thus, the effect of this circulation fluid on samples is inherently associated with great uncertainty. In this work, we first develop a mixing model that accounts for the amounts of circulation fluid, Br^-, and Cl^- carried by the construction fluid. Then we quantify the chemical uncertainty of matrix pore water and circulation fluid and estimate the impact of this uncertainty on bomb-pulse signal ^{36}Cl/Cl.

H62E-0901 1330h POSTER

Eulerian Spatial Moments for Solute Transport in Three-dimensional Heterogeneous, Dual-permeability Media

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A Eulerian analytical method is developed for nonreactive solute transport in heterogeneous, dual-permeability media where the hydraulic conductivities in fracture and matrix domains are both assumed to be stochastic processes. The analytical solution for the mean concentration is given explicitly in Fourier and Laplace transforms. Instead of using the Fast Fourier Transform method to numerically invert the solution to real space, we apply the general relationship between spatial moments and concentration to obtain the analytical solutions for the spatial moments up to the second for a pulse input of the solute. Owing to its accuracy and efficiency, the analytical method can be used to check the semi-analytical and Monte Carlo numerical methods before they are applied to more complicated studies. The analytical method can be also used during screening studies to identify the most significant transport parameters for further analysis.

In this study, the analytical results have been compared with those obtained from the semi-analytical method and the comparison shows that the semi-analytical method is robust. It is clearly shown from the analytical solution that the three factors, local dispersion, conductivity variation in each domain and velocity convection flow difference in the two domains, play different roles on the solute plume spreading in longitudinal and transverse directions. The calculation results also indicate that when the log-conductivity variance in fractures is 10 times larger than its counterpart in matrix, it will hardly influence the solute transport, whether the conductivity field is matrix is treated as a homogeneous or random field.

H62F MCC: 103 Saturday 1330h

State-of-the-Art in Ecohydrology II

(joint with B, GC)

Presiding: **D Mackay,** University of Wisconsin**; C Luce,** USDA Forest Service

H62F-01 1330h INVITED

Darwinian Expression of Vegetation Form and Function

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The vertical fluxes of light and momentum in vegetation canopies are idealized to demonstrate that maximum absorption of solar energy occurs when the absorption coefficients of light and of horizontal momentum are equal. This reveals the structural conditions producing maximum nitrient flux in cylindrical crowns, and allows direct comparison of carbon demand by and atmospheric carbon supply to the canopy.

Stomatal response to light and to available water are idealized and a preferred state of zero leaf stress is assumed. Scaled to the full canopy these lead to the two dimensions of a feasible habitat space for a given C_3 plant species at the stable limit of which are the maximally-productive "climax" canopies.

Maximum net primary productivity is expressed as separate functions of both light-stimulated carbon demand and turbulence-diffused atmospheric carbon supply which are compared. Productivity is shown to have a broad global maximum containing those species that are not seriously water-limited or carbon-limited, thereby supporting the underlying assumption that nature selects for maximum productivity.

H62F-02 1425h INVITED

Hydrologic and Vegetation Changes in the Northwestern U.S. and Their Role in Shaping Past and Future Fire Regimes

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Fire is an important element of disturbance regimes that both responds to and shapes ecological and hydrological processes. The co-occurrence of high fuel accumulation, low fuel moisture, and fire-conducive weather patterns in recent years has given rise to large fires in the western U.S. The size and severity of these conflagrations have prompted a national debate over the causes and proper response to wildland fires. Examination of modern climate data during high-fire years reveals the importance of regional- and synoptic-scale climate anomalies that occur over months and seasons

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