H61D-11 1120h

Drought Prediction Site Specific and Regional up to Three Years in Advance

Gregg Suhler[1] (1-573-815-0520; suhlergregg@earthlink.net)

Douglas P. O'Brien[1] (1-573-815-0520; obriend@dynapred.com)

[1]Dynamic Predictables, LLC, POB 1365, Columbia, MO 65205-1365, United States

Dynamic Predictables has developed proprietary software that analyzes and predicts future climatic behavior based on past data. The programs employ both a regional thermodynamic model together with a unique predictive algorithm to achieve a high degree of prediction accuracy up to 36 months. The thermodynamic model was developed initially to explain the results of a study on global circulation models done at SUNY-Stony Brook by S. Hameed, R.G. Currie, and H. LaGrone (Int. Jour. Climatology, 15, pp.852-871, 1995). The authors pointed out that on a time scale of 2-70 months the spectrum of sea level pressure is dominated by the harmonics and subharmonics of the seasonal cycle and their combination tones. These oscillations are fundamental to an understanding of climatic variations on a sub-regional to continental basis. The oscillatory nature of these variations allows them to be used as broad based climate predictors. In addition, they can be subtracted from the data to yield residuals. The residuals are then analyzed to determine components that are predictable. The program then combines both the thermodynamic model results (the primary predictive model) with those from the residual data (the secondary model) to yield an estimate of the future behavior of the climatic variable. Spatial resolution is site specific or aggregated regional based upon appropriate length (45 years or more monthly data) and reasonable quality weather observation records. Most climate analysis has been based on monthly time-step data, but time scales on the order of days can be used. Oregon Climate Division 1 (Coastal) precipitation provides an example relating DynaPreds method to natures observed elements in the early 2000s. The predictions leading dynamic factors are the strong seasonal in the primary model combined with high secondary model contributions from planet Earth's Chandler Wobble (near 15 months) and what has been called the Quasi-Triennial Oscillation (QTO, near 36 months) in equatorial regions. Examples of regional aggregate and site-specific predictions previously made blind forward and publicly available (AASC Annual Meetings 1998-2002) will be shown. Certain climate dynamics features relevant to extrema prediction and specifically drought prediction will then be discussed. Time steps presented will be monthly. Climate variables examined are mean temperature and accumulated precipitation. NINO3 SST, interior continental and marine/continental transition area examples will be shown. http://www.dynamicpredictables.com

URL: http://www.dynamicpredictables.com

H61D-12 1135h

Using Satellites to Monitor Surface Wetness

Alan N Basist[1] (828) 271-4099; Alan.Basist@noaa.gov)

Claude N Williams (828) 271-4711; Claude.N.Williams@noaa.gov)

[1]National Climatic Data Center, 151 Patton Ave. Rm. 120, Asheville, NC 28801, United States

A land surface wetness product is derived from the Special Sensor Microwave Imager (SSMI), which flies on a polar orbiting satellite with global coverage. The frequencies observed by the Special Sensor Microwave Imager are sensitive to liquid water near the earth's surface. The surface wetness can originate from multiple sources (i.e. precipitation, snow melt, irrigation). In conjunction with the Department of Agriculture we seek to establish the utility of the wetness product for real time monitoring of crop conditions around the world, and demonstrate the benefit of actual SSMI observations over modeled or interpolated analyses. We provide numerous examples showing how SSMI observations provide a more realistic spatial structure in areas where surface observations are limited. Moreover, due to the sparcity of in situ observations in many rural and poor areas of developing counties extreme events are frequently undetected. Consequently, by using the SSMI to observe the true spatial distribution of water near the surface in near real time, there can be timely action to mitigate the spread of water borne diseases and famine. In addition, we demonstrate that the surface wetness product has a strong correspondence with the upper level soil moisture at many locations. By analyzing the wetness values over an extended period, one can usually determine its association with deeper soil moisture (e.g., it was excessively wet two weeks ago; therefore, deep soil moisture is probably abundant, although it appears that the surface has dried out). This product is unique and the talk demonstrates the value of the SSMI observations to enhance monitoring activity, to validate global circulation model, and/or be assimilated into energy or water budget balances.

The relationship between brightness temperatures at different frequencies is used to dynamically derive the amount of liquid water in each SSM/I observation; i.e., there are no static apriori assumptions in the computation of the wetness values. They are derived at 1/3 degree resolution, and are calibrated and validated using independent high resolution in situ observations. A 15 year climatology (1988 to 2002) serves as the base period for monthly and weekly anomalies. The wetness product is based on a standardized cumulative probability gamma function with values from zero to one hundred percent. The standardization procedure accounts for variation in surface features around a region (i.e., forest, lakes, farm land, mountains), time of year (i.e., wet versus dry season), and soil type (i.e., clay versus sandy soil).

URL: http://www.ncdc.noaa.gov/ssmi.html

H61E MCC: 120 Saturday 0830h

Twenty-Two Years of Stochastic Groundwater Hydrology I

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

H61E-01 0835h

Solute Transport in Heterogeneous Formations of Bimodal Conductivity Distribution

Steven C. Lessoff (972-3-960-7232; slessoff@tx.technion.ac.il)

Technion, Faculty of Civil Engineering Environmental and Water Resources Engineering Technion City, Haifa 32000, Israel

Transport of a conservative solute takes place in a formation made up from a matrix of conductivity K_0 and porosity ϑ_0 and inclusions of properties K, ϑ. For given inclusions shape, the system is characterized by the two parameters $\kappa = K/K_0$ and the inclusions volume fraction n. In the past, approximate solutions of the flow and transport problems were obtained under the limit of low variability, i.e. $\kappa - 1 \ll 1$, and arbitrary n. The present study aims at solving the problem under the opposite limit of a dilute system, i.e. $n \ll 1$ and arbitrary κ. We are particularly interested in elongated inclusions (high length/thickness ratio) of high permeability contrast to the matrix. Such configurations are related to applications in which lenses or cracks are present in a medium of highly different conductivity. The basic procedure was developed by Eames, I., and J.W. Bush, [Longitudinal dispersion by bodies fixed in a potential flow, *Proc. R. Soc. Lond. A.*, 455, 3665-3686, 1999]. In the present study we extend the approach to inclusions of arbitrary porosity and elliptical shape, characterized by the parameter e, the ratio between the small and large axes, with emphasis on $e \ll 1$. We present the analytical solution of the flow problem and the procedure, requiring two quadratures, to calculate the macrodispersivity. Analytical solutions are obtained for two particular limits: $\kappa \ll 1$ and $\kappa \simeq 1$. The latter is compared with the limit $n \ll 1$ of small conductivity variance solutions.

The theoretical results are further applied to three types of media: horizontal lenses submerged in a homogeneous matrix, sparse cracks of random orientation in a matrix of contrasting permeability and channels of high permeability at the surface of a homogeneous medium. These discrete features are modeled as sparse elliptical inclusions of arbitrary conductivity. The longitudinal macrodispersivity is determined as function of the parameters characterizing the medium: the conductivity ratio κ, the anisotropy ratio of the ellipses e, the porosity ratio ϑ/ϑ_0 and the volume fraction $n \ll 1$ or the fracture number per unit volume. Unlike existing stochastic continuum solutions that are first-order in the logconductivity variance, the model developed here applies for an arbitrary permeability variance. This is of great advantage in media with high conductivity contrasts between the matrix and the inclusions. Simple results are obtained for inclusions of low conductivity, that lead to high macrodispersivity values that are underpredicted by the first-order continuum approach. In contrast, the presence of thin and highly conductive cracks leads to a finite longitudinal macrodispersivity that depends mainly on their length and the number density. An attempt is made to compare the present approach with the numerical simulations from the literature. This work includes material from [Dagan, G. and S. C. Lessoff, Solute transport in heterogeneous formations of bimodal conductivity distribution 1. Theory *Water Resour. Res.*, 37, 465-472, 2001] and [Lessoff, S. C. and G. Dagan Solute transport in heterogeneous formations of bimodal conductivity distribution 2. Applications, *Water Resour. Res.*, 37, 473-480, 2001]

H61E-02 0850h

Non-Unique Transmissivity Field Calibration and Predictive Transport Modeling

Sean A McKenna[1] (505 844 2450; samcken@sandia.gov)

John Doherty[2] (jdoherty@gil.com.au)

David Hart[3] (dbhart@cc.usu.edu)

[1] Sandia National Laboratories, PO Box 5800 MS 0731, Albuquerque, NM 87185-0735, United States

[2]Watermark Numerical Computing, 336 Cliveden Ave., Corinda, 4075, Australia

[3]Utah State University, Dept. of Electrical and Computer Engineering 4120 Old Main Hall, Logan, UT 84322, United States

Recent work with stochastic inverse modeling techniques has led to the development of efficient algorithms for the construction of transmissivity (T) fields conditioned to measurements of T and head. Small numbers of calibration targets and correlation between model parameters in these inverse solutions can lead to a relatively large region in parameter space that will produce a near optimal calibration of the T field to measured heads. Most applications of these inverse techniques have not considered the effects of non-unique calibration on subsequent predictions made with the T-fields. Use of these T fields in predictive contaminant transport modeling must take into account the non-uniqueness of the T field calibration. A recently developed "predictive estimation" technique is presented and employed to create T fields that are conditioned to observed heads and measured T values while maximizing the conservatism of the associated predictive contaminant transport model. Predictive estimation employs confidence and prediction intervals calculated simultaneously on the flow and transport models respectively. In an example problem, the distribution of advective transport results created with the predictive estimation technique is compared to the distribution of results created under traditional T field optimization where model non-uniqueness is not considered. The predictive estimation technique produces results with significantly shorter travel times relative to traditional techniques while maintaining near optimal calibration. Additionally, predictive estimation produces more accurate estimates of the fastest travel times.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company for the United States Department of Energy under contract DE-AC04-94-AL-85000

H61E-03 0905h INVITED

A Quarter Century of Uncertainty in the Aqueous Underground

Lynn W Gelhar (6172537121; gelhar@mit.edu)

Massachusetts Institute of Technology, Room 48-329, MIT, Cambridge, MA 02139, United States

During the past 25 years we have seen a dramatic change in the way researchers quantify the flow of underground water and the migration of associated contaminants in which the inherent ambiguity of predictions is characterized probabilistically . The vigor and intensity of this stochastic revolution is reflected in the thousands of research articles, dozens of scientific meetings, scores of computer codes, several books, and many millions of dollars of research grants that have focused on such issues. The need for stochastic approaches derives fundamentally from the complex natural spatial and temporal variability of subsurface hydrologic systems and the very limited nature of the observations available to characterize the properties and processes involved at pertinent application scales. From an applied perspective, realistic quantification of the uncertainty in model results is required if such predictions are to form a basis for sound decisions. There have been major advances in theoretical and computational methodology, but the impact of these new methods and results in practical applications has been limited. Some of the key accomplishments and remaining challenges in this area are summarized in the context of contaminant transport analysis applied to the issue of radioactive waste disposal. Here predictions over periods of thousands to millions of years and scales of tens of kilometers are sought and a probabilistic regulatory framework is imposed. The needs for more pragmatic research approaches that will address applied issues, and for candor regarding the limitations of quantitative uncertainty assessments of model predictions are emphasized.

H61E-04 0925h

Evaluation of Higher-Order Terms for Saturated Flow in Randomly Heterogeneous Media via Karhunen-Loève Decomposition

Zhiming Lu[1] (5056652126; zhiming@lanl.gov)

Dongxiao Zhang[1] (5056673541; donzhang@lanl.gov)

[1]Los Alamos National Laboratory, Hydrology, Geochemistry, and Geology Group, MS T003, Los Alamos, NM 87545, United States

In this study, we consider transient saturated flow in randomly heterogeneous porous media and try to obtain higher order solutions of mean head and mean flux, as well as their associated uncertainties based on the combination of Karhunen-Loève decomposition and perturbation methods. We first decompose the log hydraulic conductivity Y = lnKs as an infinite series on the basis of a set of orthogonal Gaussian standard random variables $\{\xi_i\}$. The coefficients of the series are related to eigenvalues and eigenfunctions of the covariance function of log hydraulic conductivity. We then write head as an infinite series whose terms $h^{(n)}$ represent head of n^{th} order in terms of σ_Y, the standard deviation of Y, and derive a set of recursive equations for $h^{(n)}$. We assume that $h^{(n)}$ can be expressed as infinite series in terms of products of n Gaussian random variables. The coefficients in these series are determined by substituting decompositions of Y and $h^{(n)}$ into those recursive equations. We solve the mean head (and mean flux) up to fourth order in σ_Y and the head (and flux) variances up to third order in σ_Y^2. We conduct Monte Carlo simulations (MC) and compare MC results against approximations of various orders from our moment-equation approach on the basis of Karhunen-Loève decomposition (KLME). We explore the validity of the KLME approach for different degrees of medium variability and different correlation scales. We also compare the results from the conventional moment-equation-based approaches (CME). It is evident that the KLME approach with higher-order corrections is superior to first-order approximations and is computationally more efficient than both Monte Carlo simulation and the conventional moment-equation-based approaches.

H61E-05 0940h INVITED

Stochastic Fusion of Information for Imaging the Vadose Zone–in memory of Professor Allan Gutjahr.

Tian-Chyi Jim Yeh (520-621-5943; yeh@hwr.arizona.edu)

The University of Arizona, Dept. of Hydrology and Water Resources, Building 11, Tucson, AZ 85721, United States

Geological media are inherently heterogeneous at many scales. To tackle the heterogeneity in the vadose zone, during the past two decades we have developed stochastic unconditional/conditional effective parameter approaches, being influenced by the work of Professor Gutjahr. Recent field infiltration experiments have shown that the unconditional approach with moisture-dependent anisotropy concept provides the best unbiased predictions with the minimal variance if the water diffusivity length is much greater than the vertical correlation scale of heterogeneity within a moisture plume. The water diffusivity length is defined as a(h)=K(h)/dK(h), which decreases with increasing capillary pressure. Conversely, when the water diffusivity length is much smaller than the correlation scale, the conditional approach is most appropriate. To gain the maximal effect of conditioning with minimal invasive sampling, a stochastic fusion technology is presented that assimilates geological, hydrological, geophysical, and geostatistical information. The approach is based on the recently developed sequential/successive linear estimator. Numerical examples will be shown that illustrate how the technology improves estimates of moisture content using an electrical resistivity tomography survey. Also to be shown are improvements in estimation of unsaturated hydraulic parameter fields by combining point measurements of the parameters and moisture content, and information from electrical resistivity tomography. It is evident form these and other advances that Professor Gutjahrs influences perpetuate throughout the fields of stochastic vadose zone hydrology and hydrogeophysics.

H61E-06 1020h

A Solution to the Computational Impasse of Stochastic Groundwater Modeling

Shu-Guang Li[1] (517-432-1929; lishug@egr.msu.edu)

Dennis McLaughlin[2] (617-253-7176; dennism@mit.edu)

[1]Department of Civil and Department of of Civil and Environmental Engineering, Michigan State University, East Lansing, MI 48824, United States

[2]Ralph M Parsons Laboratory, Massachussets Institute of Technology, Cambridge, MA 02139, United States

Stochastic theories of subsurface flow and transport have changed the way we think about heterogeneity but have not had much impact on practical groundwater modeling. Most numerical models still provide no information on prediction uncertainty. This gap between theory and practice is due largely to the excessive computational demands of available numerical methods for solving stochastic problems. The two primary alternatives, Monte Carlo and classical perturbation methods, both require large computational grids with grid spacings that are smaller than the log conductivity correlation length. This results in computational times that are many orders of magnitude greater than those required for conventional deterministic simulations. In addition, classical perturbation methods need much more real memory than comparable deterministic simulations. An alternative perturbation approach, the nonstationary spectral method, avoids these computational limitations by implicitly separating the problem into a slowly varying deterministic (nonstationary) part and more rapidly varying random (stationary) part. This separation is controlled by a transfer function that depends on both location and wave number. The spatial grid resolution required to derive the transfer function is comparable to that of a deterministic simulation. The wave number grid resolution does not depend on the domain size. General order of magnitude calculations and a simple groundwater flow example both demonstrate that the nonstationary spectral method is much more efficient than any of the alternatives. Although the method requires more computational effort than a traditional deterministic simulation the increase does not depend on problem size and is acceptabletolerable in most applications. The dramatic improvement in computational efficiency provided by the nonstationary spectral method finally makes it possible to include uncertainty analysis as a routine part of groundwater modeling.

URL: http://www.egr.msu.edu/~lishug

H61E-07 1035h INVITED

Synthetic Sediments and Stochastic Groundwater Hydrology

John L. Wilson (505-835-5308; jwilson@nmt.edu)

New Mexico Inst. of Mining and Technology, Department of Earth and Environmental Science, Socorro, NM 87111, United States

For over twenty years the groundwater community has pursued the somewhat elusive goal of describing the effects of aquifer heterogeneity on subsurface flow and chemical transport. While small perturbation stochastic moment methods have significantly advanced theoretical understanding, why is it that stochastic applications use instead simulations of flow and transport through multiple realizations of synthetic geology? Allan Gutjahr was a principle proponent of the Fast Fourier Transform method for the synthetic generation of aquifer properties and recently explored new, more geologically sound, synthetic methods based on multiscale Markov random fields. Focusing on sedimentary aquifers, how has the state-of-the-art of synthetic generation changed and what new developments can be expected, for example, to deal with issues like conceptual model uncertainty, the differences between measurement and modeling scales, and subgrid scale variability? What will it take to get stochastic methods, whether based on moments, multiple realizations, or some other approach, into widespread application?

H61E-08 1055h

Two-Dimensional Particle Tracking Under Radial Flow Conditions in Heterogeneous Media Conditioned on Wellbore Transmissivity

Carl L Axness[1] (+34 963879613; axness@dihma.upv.es)

J. Jaime Gomez-Hernandez (+34 963879614; jgomez@upv.es)

[1]Universidad Politecnica de Valencia, Dep. de Ingenieria Hidraulica, Esc. de Ing. de Caminos, Camino de Vera s/n, Valencia 46022, Spain

The tracer test is one of the few experimental tools that estimate transport parameters in-situ at local scale. Models used to interpret transport parameters from tracer tests usually assume spatial homogeneity in the aquifer. However, the moments of the solute plume in heterogeneous media are known to be primarily determined by the statistical nature of the hydraulic conductivity/transmissivity at the scale of the plume. We numerically simulate the effect of a 2D heterogeneous log-transmissivity on travel time moments of a non-reactive solute introduced into a steady injection well with prescribed head boundary conditions at the well and at an exterior radius. We compute the travel time distribution of particles introduced into the well to a prescribed (control) radius. In particular, we look at the effect of a high, low, or average local transmissivity at the wellbore (as compared to the effective mean transmissivity) on the travel time distribution and moments *of each realization* by conditioning on the log-transmissivity at the wellbore. A continuous velocity field generation and transport are developed in an annular geometry for accurate transport simulation around the well.

H61E-09 1110h

Radial flow to a well under transient conditions in an infinite randomly heterogeneous aquifer

Walter A Illman[1] (walter-illman@uiowa.edu)

Daniel M Tartakovsky[2] (dmt@lanl.gov)

Alberto Guadagnini[3] (alberto.guadagnini@polimi.it)

Shlomo P Neuman[4] (neuman@hwr.arizona.edu)

[1]University of Iowa, Department of Geoscience, 121 Trowbridge Hall, Iowa City, IA 52245, United States

[2]Los Alamos National Laboratory, Group T-7, MS B256, Los Alamos, NM 87545, United States

[3]Politecnico Di Milano, Piazza Leonardo da Vinci 32, Milano I-20133, Italy

[4]University of Arizona, Department of Hydrology and Water Resources, Harshbarger Bldg., Tucson, AZ 85721, United States

We present analytical expressions for leading statistical moments of vertically averaged hydraulic head and flux under transient flow to a well that pumps from an unbounded, randomly heterogeneous aquifer. Like in the widely used Theis equation, we prescribe a constant pumping rate deterministically at the well and at an infinite radial distance from the well, the drawdown is assumed to be zero. We model the natural logarithm Y = ln T of aquifer transmissivity T as a statistically homogeneous random field with a Gaussian spatial correlation function. Our solution is based on exact space-time nonlocal moment equations for multidimensional transient flow in an unbounded randomly heterogeneous porous media. Perturbation of these nonlocal equations leads to a system of local recursive moment equations that we solve analytically to second order in the standard deviation of Y. In contrast to most stochastic analyses of flow, which requires that the transmissivity be multivariate Gaussian, our solution is free of any distributional assumptions. It yields expected values of head and flux, and the variance-covariance of these quantities, as functions of distance from the well. The zeroth-order solution is the commonly used Theis solution in an infinite homogeneous aquifer. It also yields an apparent transmissivity Ta, defined as the negative ratio between expected flux and head gradient at any radial distance. Potential uses include the analysis of pumping and tracer tests conducted in such wells, the statistical delineation of their respective capture zones, and the analyses of contaminant transport toward fully penetrating wells.

H

H61E-10 1125h

Simulation of Free Surface Dynamics in Random Media via the Mapping of the Regular Domain on the Flow Domain.

Peter V Petrov[1] (pvpetrov@snezhinsk.ru)

Yuri N Lazarev[1] (yulaz@snezhinsk.ru)

Daniel M Tartakovsky[2] (dmt@lanl.gov)

[1]Institute of Technical Physics, Mathematical Division, P.O. 245, Snezhinsk 456770, Russian Federation

[2]Los Alamos National Laboratory, Theoretical Division, MS B284, Los Alamos, NM 87545, United States

We analyze the dynamics of the incompressible fluid interface in heterogeneous media by treating its hydraulic conductivity as a random field with known statistics. The use of a coordinate system tied to the moving fluid allows us to reduce the problem to a well-explored class of problems with fixed boundaries. Mean hydraulic head is represented as a series in powers of the effective conductivity fluctuations. The applied procedure is identical, up to the first order, to the standard perturbation expansion in the amplitude of the (log) hydraulic conductivity fluctuations. The conjugate gradient method with preconditioning is to solve for the relevant statistics. The problem matrix symmetry and its positive definiteness guarantee the robustness of the the method. RFLOW code has been modified to solve the resulting set of equations.

H61E-11 1140h

The influence of source size and sampling volume on the concentration pdf of conservative tracers released in heterogeneous formations

Daniele Tonina[1] (208-364-4090; dtonina@uidaho.edu)

Alberto Bellin[2] (+39 0461 882620; Alberto.Bellin@ing.unitn.it)

[1]Ecohydraulics Research Group, University of Idaho Boise Center, 800 Park Blvd., Suite 200, Boise, ID 83712, United States

[2]Dipartimento di Ingegneria Civile ed Ambientale, Università di Trento, via Mesiano, 77, Trento I-38050, Italy

We analyze the effect of sampling and releasing volumes on the concentration of a conservative tracer undergoing advection and local dispersion in a heterogeneous porous formation with variations of the hydraulic conductivity modeled as a Random Space Function. As customary we assume the logarithm of the hydraulic conductivity, $Y = \ln(K)$, as a normally distributed stationary random space function (RSF) with constant mean $< Y >$, variance σ_Y^2 and isotropic exponential covariance $C_Y(r) = \sigma_Y^2 \exp(-r/I_Y)$, where r is the two-point separation distance and I_Y is the log-conductivity integral scale. The porosity of the formation is assumed constant in space. Local dispersion, which represents the solute spreading caused by pore-scale velocity variations, and molecular diffusion, is modeled as a diffusive process with constant longitudinal and transverse dispersion coefficients D_{dL} and D_{dT}. The sampling volume acts as a smoothing mechanism reducing, together with dilution, the solute concentration. Assessing the effect of smoothing mechanisms is important for risk analysis, since it allows to evaluate the level of exposure of the biosphere to contaminants. The impact of the sampling volume on the first two moments of the solute concentration has been recently analyzed by Andricevic [1998], who concluded that while both local dispersion and sampling volume act as smoothing mechanisms reducing the peaks of concentration, their relative importance depend on the time from injection. We extend the analysis by Andricevic [1998] considering the combined effect of sampling and releasing volumes on the first two concentration moments and on the concentration pdf. New analytical first-order solutions are proposed for the moments and the concentration pdf, and validated through accurate numerical simulations. We conclude that at short times since injection, and as long as the source size is larger than the sampling volume, the main factor controlling the concentration distribution is the sampling volume, with pore-scale dispersion and the source size both playing a minor role. However, the source size should be considered when it is of the same order of magnitude of the sampling volume. The situation changes when considering large time limits, which may be relevant for old contaminations. In this case pore-scale dispersion introduces an appreciable additional smoothing in the concentration distribution, which effects are evident both in the long-term behavior of the coefficient of variation and of the concentration pdf.

H62A MCC: Hall C Saturday 1330h

Modeling and Observation of Precipitation Posters *(joint with A, GC)*

Presiding: **J McCollum,** University of Maryland**; A Bradley,** University of Iowa

H62A-0823 1330h POSTER

High Density Rain Gauge network for Validation of the AMSR-E Rainfall Estimation Algorithm

Jeff McCollum[1] (301-405-8033; Jeff.McCollum@noaa.gov); Witold F Krajewski[2] (wkrajew@engineering.uiowa.edu); Grzegorz J Ciach[2] (g-ciach@uiowa.edu); Anton Kruger[2] (anton-kruger@uiowa.edu); Zachary Taylor[2] (wtaylor@mail.iihr.uiowa.edu); Ralph R Ferraro[1] (Ralph.R.Ferraro@noaa.gov)

[1]CICS/ESSIC-NOAA, 4115 CSSB The University of Maryland, College Park, MD 20742, United States

[2]IIHR-Hydrosciences and Engineering, The University of Iowa, Iowa City, IA 52242, United States

As part of the Aqua AMSR-E (Advanced Microwave Scanning Radiometer-EOS) validation program, in the summer of 2002 we began deploying a 5 × 5 rain gauge network with 5 km spacing (covering an area of 25 km × 25 km) centered on the Iowa City, Iowa Municipal Airport. This spacing corresponds to the interval between adjacent 89 GHz AMSR-E footprints. The AMSR-E was launched on board the Aqua satellite on May 4, 2002, and we have been collecting AMSR-E data since June 1. We are going through many steps to insure good data quality, most importantly installing two gauges within one meter of each other at each location to alert us to possible problems if the rain rates do not correspond between the two. Together with the existing cluster of rain gauges in the Iowa City airport and its vicinity, the network consists of about 40 sites.

We will use these data to answer many questions, ranging from whether there is bias in the satellite rainfall estimates to what are the optimal temporal and spatial scales (including offsets) for comparison of satellite-based estimates with surface rainfall. We will determine the spatial and temporal statistics of instantaneous area-averaged rainfall over the 25 km grid necessary to assess the spatial and temporal sampling errors of our space and time averages, so that the bias can be assessed with statistical significance.

We will also determine the appropriate spatial and temporal scales for comparison of level 2 (instantaneous) satellite and ground reference (e.g., spatially averaged rain gauges or radar) estimates. The satellite observes a volume of vertical hydrometeors that contribute to the surface rainfall at a later period of time for a surface area assumed to correspond to the nominal satellite footprint area. Only with this high temporal and spatial resolution rain gauge network can we determine the area and times that should be compared with level 2 estimates so that the contribution from collocation errors to the satellite vs. ground reference difference is quantified and minimized. In the presentation we show preliminary results of the rainfall statistics and the satellite product evaluation.

H62A-0824 1330h POSTER

Stochastic Micro-structure of Rain and Scale Dependence of Spatial Correlations

Alex B Kostinski[1] (906 487-2580; kostinsk@mtu.edu)

Arthur R Jameson[2] (jameson@rjhsci.com)

Michael L Larsen[1] (mllarsen@mtu.edu)

[1]Michigan Tech, 1400 Townsend Drive, Physics Department, Michigan Technological University, Houghton, MI 49931, United States

[2]RJH Sci., Inc., 5625 N. 32nd St., Arlington, VA 22207, United States

This work focuses on the departures of real rain from the Poisson process. Importance of statistical stationarity and the essential distinction between Poisson distribution and Poisson process are emphasized. We then develop new tools for characterizing rain micro-structure. It is argued that the pair correlation function and the Ornstein-Zernike relation are ideally suited for scale dependent exploration of rain micro-structure. The importance and ubiquity of negative correlations at small spatial scales are discussed because all instruments are likely to yield negative pair correlation functions when pushed to their resolution limits. It is pointed out that observations of Poisson statistics on a given scale are, likely, a result of a cancellation of positive and negative correlations on possibly much shorter distances.

H62A-0825 1330h POSTER

How Much Rain Reaches the Surface? Analysis of High Resolution Rainfall Observations in the Goodwin Creek Watershed

Lisa C. Sieck[1] ((206) 543-0423; lsieck@u.washington.edu)

Matthias Steiner[2] ((609) 258-4614; msteiner@princeton.edu)

Stephen J. Burges[1] ((206) 543-7135; sburges@u.washington.edu)

James A. Smith[2] (jsmith@princeton.edu)

[1]University of Washington, 159 Wilcox Hall, Box 352700 Dept. of Civil and Environmental Engineering, Seattle, WA 98195, United States

[2]Princeton University, Dept. of Civil and Environmental Engineering, Princeton, NJ 08544, United States

A major storm passing over the 21.4-km^2 Goodwin Creek research watershed (Steiner et al. 1999) in northern Mississippi on 23-24 April 2001 is used as a case study to highlight some of the uncertainties of using hydrological and hydrometeorological data from various remote-sensing and point sources at greatly differing spatial and temporal resolution and coverage. Instrumentation at the site includes approximately 45 rain gauges of varying design (above ground and buried), a disdrometer, and three anemometers to observe the wind profile at the climate station in the center of the catchment. A local scale Doppler radar was also deployed at the site to record very-high resolution observations (50 m by 1 degree in space, tens of seconds in time) in both the vertical and horizontal directions. The difficulties obtaining accurate ground-truth rainfall measurements are discussed and aspects of the basin response to the storm are illustrated with soil moisture data and runoff measurements at the basin outlet.

H62A-0826 1330h POSTER

Adjustment of Daily Precipitation Data for two Alaskan Stations for 1995-2001

Jennifer L Benning[1] (907-474-5396; fnjlb2@uaf.edu)

Daqing Yang[1] (907-474-2468; ffdy@uaf.edu)

[1]Water and Environmental Research Center, University of Alaska Fairbanks, 441 Duckering Building PO Box 755860, Fairbanks, AK 99775-5860, United States

Systematic errors in precipitation measurements caused by wind-induced undercatch, wetting and evaporation losses are known to affect all types of precipitation gauges. These errors are more sensitive for solid precipitation than for rain. Thus, in Arctic regions, these systematic errors become significantly more pronounced than for other regions due to the relatively slow precipitation rates (exemplified by frequent occurrences of trace precipitation days), low temperatures, high winds, and low annual precipitation measurements that are characteristic of the Arctic climate. This study performed the daily adjustments of measured precipitation data for the National Weather Service (NWS) Stations at Barrow and Nome Alaska over a seven-year study period, encompassing from 1995 through 2001. Both NWS stations use the NWS standard 8-inch non-recording gauge to measure precipitation, however the gauge at Barrow was equipped with an Alter shield during the study period, while the gauge at Nome was unshielded, a condition which significantly increases the wind-induced gauge undercatch. The results of this study indicate that the bias adjustments increase the average monthly gauge-measured precipitation by 17-285%, or correction factors (equal to the adjusted precipitation divided by the measured precipitation) ranging from 1.2 to 3.8, for the Barrow station, and by 19-379%, or correction factors of 1.2 to 4.8, for the Nome station (with the larger percentages occurring in winter months). The increases to the average measured annual precipitation data are 66%, or a correction factor of 1.7, for Barrow and 128%, or a correction factor of 2.3, for Nome. It is expected that these increases will impact climate monitoring, the understanding of the Arctic freshwater balance, and the assessment of atmospheric model performance in the Arctic.

H62A-0827 1330h POSTER

Spatio-Temporal Rainfall Patterns in Northern Ghana, West Africa

Jan Friesen[1] (++49 228 73-4927; j.friesen@uni-bonn.de)

Nick van de Giesen[1] (++49 228 73-1720; nick@uni-bonn.de)

[1]Center for Development Research, Walter-Flex-Str 3, Bonn, NRW 53113, Germany

Rainfall reliability in West Africa has important societal consequences. However, our understanding of the rainfall generating processes in this region remains incomplete. This study aims at the detection of different rainfall producing processes and their characteristics during the later part of the rainy season in Northern Ghana. Rainfall in this region has three main origins: monsoonal advection, local convection, and squall lines. Different processes dominate during different parts of the rainy season, which runs from May through October.

Rainfall measurements were taken with tipping-bucket rain gages with high temporal resolution. A total of 16 rain gages were used, organized in two nested grids covering areas of 9x9 km and 3x3 km, respectively.

The recorded rainfall events were classified according to their origin primarily on the basis of intensity, duration, and spatial pattern and distribution. As local convective and squall line rainfall show similar characteristics, TRMM Precipitation Radar imagery was analyzed visually to help further distinguish between these two types. The main result is a procedure that allows to differentiate rainfall origins and a set of characteristic rainfall events.

Special attention is paid to squall line induced rainfall. Squall lines are crescent shaped atmospheric disturbances that move from East to West over the subcontinent and are associated with violent wind gusts and high rainfall intensities of up to 300 mm/h. These squall lines are mainly caused by interaction between