H61E-11 1140h

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

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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

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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

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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

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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

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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

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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 the monsoonal air layer and the African Easterly Jet. In Northern Ghana, line squalls produce most of the annual rainfall. At the end of the wet season, rain almost exclusively originates from squall lines. Because of their high intensities, squall lines and convective storms are hydrologically important for understanding runoff generation.

URL: http://www.glowa-volta.de

H62A-0828 1330h POSTER

A one-month comparison of modeled and measured precipitation over a small watershed the Southern Great Plains

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The processes that modulate the water cycle variability in small watersheds operate on horizontal scales that are small relative to the resolution of current operational weather forecast models, which is approximately 30-km. As a consequence, coupled models of the water cycle over these small watersheds must use mesoscale atmospheric models capable of resolving precipitation gradients across the watershed. There have been relatively few systematic attempts to evaluate the precipitation forecasts of mesoscale models on scales of only a few kilometers, or to evaluate the scale dependence of these forecasts. A principal goal of the Department of Energys (DOE) Water Cycle Pilot Study (WCPS) is to balance the water budget in a small watershed in the Southern Great Plains using observations of as many water cycle components as possible. Another goal is to evaluate various model components, both atmospheric and hydrologic, that could be joined to form an analysis and forecast system of the water cycle and its variability in this watershed.

As part of the WCPS, we are performing a systematic evaluation of the precipitation fields in two well-documented mesoscale models: MM5 and RAMS. The two models were run at different resolutions (48-km, 12-km, 4-km) for the month of March 2000 over a domain covering DOEs Atmospheric Radiation Measurement (ARM) Southern Great Plains Cloud and Radiation Testbed (CART) Site. The precipitation produced by the models at different resolutions is being compared to rain gauge-adjusted radar precipitation estimates over the entire domain. High-resolution precipitation forecasts over a small watershed are also being compared with high spatial resolution rain gauge and rain gauge-adjusted data over a small watershed within the larger domain.

The MM5 model appears to have excellent skill in forecasting precipitation occurrence and location, though some discrepancies are evident in the timing of specific events. We are currently examining the sensitivity of the results to the model resolution.

H62A-0829 1330h POSTER

Analysis of a Mesoscale Model for Depicting Rain-on-Snow Flooding Events in Mountainous Terrain

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Cold season rain-on-snow events are one of the major sources of flooding in the Pacific Northwest. Accurate modeling of the atmospheric fields forcing these events is leading to a better understanding of the atmospheric conditions behind these events and to better prediction of these floods. A mesoscale atmospheric model (RAMS) with nested grids is being used for high resolution simulations of winter precipitation and other climate variables in the Owyhee mountains of southwestern Idaho. The Reynolds Creek Experimental Watershed (RCEW) contains a dense array of meteorologic and hydrologic instrumentation with which to test the spatial and temporal hydrologic and atmospheric models. The large number of precipitation gauges in the RCEW cover a wide range of precipitation zones found in mountainous terrain. These gauges allow for a thorough assessment of the areal distribution and timing of modeled versus measured precipitation and temperature. A comparison of the modeled and measured data from two winter storms associated with rain-on-snow events shows close agreement in the spatial and temporal distributions of precipitation, temperature and other variables. The model correctly predicts the spatial distribution of precipitation and the temporal conversion from snow to rain-on-snow in the lower elevations of the watershed. The modeled precipitation is typically slightly lower than the measured values. Some of the high frequency (hourly) weather variability was not captured by the model, presumably due to lack of sufficient data in the initialization process. The longer term goal is to develop a tool for generating detailed weather information for winter time hydrologic studies including cold season flooding processes and to better understand the processes controlling winter flooding.

H62A-0830 1330h POSTER

Wind Profiler Observations of the Meiyu/Baiu Precipitation in the downstream of the Yangtze River

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Detailed observations of the Baiu/Meiyu frontal precipitation were acquired by several mobile platforms (three Doppler radars, a wind profiler system, three surface automatic weather stations) in the downstream of the Yangtze River for two campaigns of intensive observation (for about 50 days during June & July) period (IOP) in the years 2001 and 2001. For the first time, Frontier Observational Research System for Global Change (FORSGC) deployed a Lower Atmospheric Wind Profiler (LAWP) with Radio acoustic sounding System (RASS) at Dongshan (31°4′47” N; 120°26′3” E) in the Jiangsu province, about 120 km west of Shanghai, PR China. The two IOP data analysis suggested that the most of the time Meiyu/Baiu (heavy) precipitation tended to occur when the southwesterly low-level jet became strong under moist neutral stratification and strong gradient of equivalent potential temperature. During the heavy rainfall the LAWP can be used to provide clues for the forecasting of the maximum strength of winds and the arrival times of strong winds and gales. Observational results also indicate that the LAWP could help to improve the understanding of the atmospheric processes involved in severe weather during typhoon, clod front passage. The results suggest that convective boundary layer (CBL) height at Dongshan varies between 1 and 1.5 km and the CBL evolution depends on variety of factors and is not simply related to any local surface meteorological variables. The low boundary heights at Dongshan during July are probably related to low Bowen ratios (ratio of sensible to latent heat flux at the surface) and very high humidity. The CBL depth also indicates the prevailing synoptic situations during the Meiyu/Baiu season. We developed a simple algorithm to classify each profile into convective, transition (mixed convective-stratiform) and stratiform rain based on the wind profiler observations of the (Reflectivity, Doppler velocity & Spectral width) vertical structure of the precipitating clouds during Meiyu/baiu season. The highest percentage of occurrence appears in the evening and nighttime (18:00 to 20:00 BST). The peak of stratiform precipitating cloud has smaller value and comes later than the convective clouds. The time delay between the peak of the stratiform and convective precipitating cloud corresponds to the life cycle of the mesoscale convective system. In this presentation, we also discuss the similarities of the Meiyu/Baiu precipitating cloud systems observed during IOP 2001 and 2002 and also emphasize the characteristics difference of the frontal systems in the two IOP periods.

H62A-0831 1330h POSTER

An Automated Bright-band Height Detection Algorithm for Use with Vertically Pointing Doppler Radars

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Because knowledge of the snow level is critical to weather forecasters, river forecasters, and other users, the Weather and Climate Applications Division of the NOAA Environmental Technology Laboratory has developed an objective algorithm to detect the bright-band height from profiles of radar reflectivity and Doppler vertical velocity collected with a commercially available Doppler wind profiling radar. The algorithm uses vertical profiles to detect the bottom portion of the bright band, where vertical gradients of radar reflectivity and Doppler vertical velocity are negatively correlated. A search is then performed to find the peak radar reflectivity above this feature, and the bright-band height is assigned to the altitude of the peak. Reflectivity profiles from the off-vertical beams produced when the radar is in a Doppler beam swinging mode provide additional bright-band measurements. A consensus test is applied to sub-hourly values to produce a quality-controlled, hourly-averaged bright-band height. The bright-band height is a better estimate of the snow level than the melting level because of the time required for ice particles to melt as they descend. This paper discusses the development of the algorithm, testing and evaluation that were performed on the algorithm, and some specific applications of the algorithm to weather and hydrometeorological forecasting.

URL: http://www.etl.noaa.gov/programs/2002/pacjet/

H62A-0832 1330h POSTER

Dual Frequency Radar DSD Retrievals from CAMEX-4

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Preliminary retrievals of the rain-rate and a drop size distribution shape parameter in the form of the uncorrelated mass weighted mean drop diameter (D”), have been made with data from the JPL PR-2 dual frequency precipitation radar, which operated for the first time in the CAMEX-4 field project. Unfortunately, due to problems with the Ka-band TWT amplifier only two cases are available for investigation. The first a generally stratiform sample from tropical storm Gabrielle, is made up of light rain such that that both the Ku and Ka channels are able to see all the way to the surface. The second case from Hurricane Humberto features heavier precipiation and in a number of scans the Ka band is unable to penetrate to the surface before attenuation reduces the signal to the systems noise levels of approximatly 5dBZ.

Due to the various sources of uncertainity present in the retrival problem, instead of making conditional estimates of the rain-rate and D”, estimates of the maximum and minimum of these quatities due to the uncertainity are calcualted. As no in-situ measurements are avaliable for these cases for comparison to the estimates, foward reflectivities are calculated from the retrievals and compared to the measured reflectivities. This approach while not a valiation does highlight areas in which the DSD model used for the retrievals is both able and unable to explain the observed reflectivities and point the direction where further understanding of the precipation processes is required.

H62A-0833 1330h POSTER

An Experimental Study of Small-Scale Drop Size Distribution Variability: Comparison with Radar Observations

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The main goal of the X-Band Polarimetric Radar on Wheels (XPOW) study is aimed at exploring the advantages of dual-polarized X-band radar systems in radar rainfall estimation. However, the design of the experiment readily facilitates investigation of variability of reflectivity at small spatial scales, specifically at scales smaller than typical NEXRAD pixels. During this two-month field experiment in Iowa City, Iowa, high-resolution polarimetric radar data from the National Observatory of Athens mobile dual-polarization X-band radar were collected over a well-instrumented ground site. The site included four disdrometers, a vertically pointing X-band Doppler radar, and several dual-gauge tipping bucket rain gauge platforms in an area about 1.0 km by 1.5 km. These instruments were used to both augment and validate the data collected by the polarimetric radar, located approximately 8 km away. The disdrometers included a two-dimensional video disdrometer, an impact-type disdrometer, a bistatic radar-based disdrometer, and an optical disdrometer. The area in which these instruments were deployed corresponds to the size of one pixel from the Davenport NEXRAD, located 80 km east of Iowa City, allowing exploration of the variability of reflectivity at such scales. We present quantitative comparisons of reflectivity and rain rates retrieved from the XPOW radar, the Davenport NEXRAD and the disdrometers. We focus primarily on characterizing the variability of the XPOW and disdrometer observations via standard methods such as scatterplots and correlation analysis, in addition to considering gradients of reflectivity.

H62A-0834 1330h POSTER

Rainfall Intensity and Drop Size Measurements with Polarimetric X-band Radar

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Most studies for developing quantitative, scanning radar estimates of rainfall have been conducted using 3-GHz (S-band, 10-cm wavelength) weather surveillance radar systems, in order to avoid attenuation effects that significantly impair reflectivity (Z) measurements at shorter wavelengths. However, the recent extension of polarimetric differential phase methods to shorter-wave systems, including X-band (9 GHz, 3-cm), now allows these generally smaller radars to also be used for quantitative rain estimations. Differential phase offers rainfall estimates that are independent of reflectivity data, as well as a way to adjust for partial attenuation effects in X-band reflectivity data. Rainfall intensity and accumulation measurements based on specific differential phase (KDP) alone offer many advantages over traditional reflectivity-based rain estimates. In this study, rain observations obtained with a polarimetric X-band scanning radar are processed with algorithms that estimate rain rate using differential phase, reflectivity, and a combination of the radar's measurements of differential phase with attenuation-corrected reflectivity and differential reflectivity (ZDR). The attenuation-corrected ZDR measurements are also used to estimate mean raindrop diameter. Demonstration measurements were obtained at Wallops Island, Virginia, in 15 storms with rain rates ranging from very light to heavy. The radar estimates are compared with measurements by tipping bucket rain gauges and raindrop disdrometers located a few kilometers away. It was found that the combined Z-ZDR-KDP estimator provided the closest agreement with gauge measurements, having an overall 22 per cent relative standard deviation of differences. The attenuation-adjusted ZDR estimates of mean drop diameter also compared well with the disdrometer measurements.

H62A-0835 1330h POSTER

Development of Research Quality Radar-Rainfall Datasets for Hydrologic Studies

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Although there is plethora of radar-rainfall data readily available, there is lack of well-documented research quality data sets over land. Two well-known and extensively studied oceanic radar-rainfall data sets are the GATE and TOGA COARE. Both are well-documented and provide high space and time resolution data. These data sets and the efforts that went into the product development are described in scientific literature. Over land the most popular data sets are the operational products generated by NOAA from the network of WSR-88D radars. Some products combine data from radars and rain gauges but leave out little information for an independent evaluation of the quality of the product. Other long-term data sets, such as the Mississippi River Basin five-year long data sets created under the auspices of the GCIP program are the results of trade-offs between feasibility and accuracy. Data sets developed for TRMM validation are limited to the tropics.

Recognizing the need for high-resolution flexible radar data sets for use in hydrologic studies of flood generation mechanism, land-atmosphere-vegetation interactions, and scaling of rainfall processes, we are developing a system that will provide such data sets. The essential characteristics of the system are: (1) ability to effectively remove non-precipitation echo; (2) flexibility in specifying the algorithm that converts the observable (i.e. radar reflectivity) into the variable of interest, i.e. rainfall on the ground according to some specific criteria; and (3) ability to describe the main features of the product uncertainty. Our system, based on the WSR-88D level II reflectivity data will possess these characteristics. It is efficient enough to generate a large (one year or more) data set of rainfall products at the resolution limited only by the raw radar data. It incorporates the quality controlled rain gauge information via a calibration process. The calibration criteria allow trade-off between different error characteristics. We present examples of the products generated using the system from data from Kansas, Oklahoma, and Iowa.

H62A-0836 1330h POSTER

Hydrometeorological Analysis of Flash Floods in the Baltimore Metropolitan Region

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We examine flood response in the Baltimore metropolitan region using high-resolution radar rainfall estimates and a distributed hydrologic model. Analyses focus on organized convective systems during the warm season. These events become an increasingly important element of regional flood hydrology with urbanization. Radar rainfall estimates are based on volume scan radar reflectivity observations and have a spatial scale of 1 km and time scale of 5 minutes. Discharge observations are taken from 26 stream gaging stations in the Baltimore metropolitan area and have time increments of 5 - 15 minutes. Stream gaging stations represent basins with drainage areas ranging from less than 0.1 square kilometers to more than 100 square kilometers and land use ranging from highly urbanized to forested. Analyses illustrate the utility of high-resolution radar rainfall estimates for quantitative hydrologic analyses of flood response in an urbanizing region. In particular, hydrologic model analyses are used to illustrate the potential for enhanced integration of radar rainfall estimates into flash flood forecasting and information systems.

H62B MCC: Hall C Saturday 1330h

Numerical Simulations of Flow and Transport in Heterogeneous Subsurface Systems Posters

Presiding: **Y Zhang,** University of Iowa**; A Tompson,** Lawrence Livermore National Laboratory

H62B-0837 1330h POSTER

A numerical approach to simulating spatially variable anisotropy, with applications in two hydrogeologic settings

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We have implemented a new method (Lee et. al., 1999) for incorporating spatially variable anisotropy in a control volume finite element setting. Flux and pressure (or head) continuity is enforced at control volume interfaces while utilizing the full permeability tensor. We describe in detail the implementation of the method. The new method has performed very well in basin scale simulations.

We present preliminary results for model applications in northern New Mexico and at Yucca Mountain, Nevada.

An important aquifer unit in the Española Basin, Northern New Mexico, is a basin-fill sedimentary rock which is strongly anisotropic due to relatively fine-scale bedding structures. Both the dip and strike of the beds vary significantly spatially. We present simulations comparing predicted heads and discharge to rivers for three conceptual models of heterogeneity: isotropic, anisotropic (orthogonal to the grid), and anisotropic (oblique to the grid and variable in space).

At Yucca Mountain, fractures produce anisotropy which is not aligned with the principal axes of the numerical grid. The new method allows for accurate representation of these effects in those parts of the domain where the anisotropy is present and naturally reverts to a simpler differencing scheme elsewhere. Thus, the method is computationally efficient.

H62B-0838 1330h POSTER

Choices of scale and process complexity in hillslope models

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Water flow in the subsurface is a significant process participating in the response of watersheds to a variety of events, such as rainfall or irrigation. Accurately representing flow in a well-chosen fundamental geological unit of the watershed's subsurface environment is, therefore, a precondition for accurately representing the watershed response as a whole. In this work we focus on hillslopes as the fundamental geological units