H12A-0965 1330h POSTER

Percolation- and Effective Medium-Based Models of Unsaturated Hydraulic Conductivity

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The unsaturated hydraulic conductivity function K(S) is of fundamental importance in understanding and predicting flow in the vadose zone. However, time and cost constraints typically require hydrologists to estimate K(S) rather than measuring it. Existing K(S) models are empirical; in this work we develop new theoretical models based upon percolation theory and effective medium theory. Percolation- and effective-medium-based theories have been recognized for over 25 years in the physics of transport in disordered systems as the premier means to "upscale" transport properties, i.e. to calculate system transport parameters from the variability at smaller scales. Percolation theory has recently been used to derive pressure-saturation curves, solute and gas diffusion, and the K(S) of probabilistic fractal porous media, and the results have given excellent agreement with experiment. An advantage of percolation theory vis-a-vis effective medium theory is the possibility to isolate effects of pore-sizes and the topology of the connections of pores on transport phenomena. The disadvantage of this procedure is that it can require treating different ranges of parameters, such as the moisture content, differently. The attractive aspect of effective-medium theory is its ability to handle all contributions to the physics simultaneously. We compare effective-medium and percolation theories using a model porous medium in which the pore radii are power-law distributed. In both theoretical treatments we observe a cross-over from critical pore-size dominated hydraulic conductivity at relatively large moisture contents to the dominance of the topological connections of the wetted pore space at moisture contents near the critical value for percolation.

H12A-0966 1330h POSTER

ENHANCED REMEDIATION OF TOLUENE IN THE VADOSE ZONE VIA A NITRATE-RICH NUTRIENT SOLUTION: FIELD STUDY

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The objective of this study was to test the effectiveness of nitrate-rich nutrient solutions and hydrogen peroxide (H202) to enhance in-situ microbial remediation of toluene. Three sand filled plots (2 m2 surface area and 1.5 meters deep) were tested in three phases (each phase lasting approximately 2 weeks). During each phase, toluene (21.6 mol as an emulsion in 50L of water) was applied uniformly via sprinkler irrigation. Passive remediation was allowed to occur during the first (control) phase. A nutrient solution (modified Hoagland), concentrated in 40L of water, was tested during the second phase. The final phase involved addition of 230 moles of H202 in 50L of water to increase the available oxygen needed for aerobic biodegradation. During the first phase, toluene concentrations in soil gas were reduced from 120 ppm to 25 ppm in 14 days. After the addition of nutrients during the second phase, concentrations were reduced from 90 ppm to about 8 ppm within 14 days, and for the third phase (H202), toluene concentrations were about 1 ppm after only five days. Initial results suggest that this method could be an effective means of remediating a contaminated site, directly after a BTEX spill, without the intrusiveness and high cost of other abatement technologies such as bioventing and soil vapor extraction. However, further tests need to be completed to determine the effect of each of the BTEX components.

URL: http://www.agu.org

H12B MCC: Level 2 Monday 1330h

Surface Water Hydrology and Water Resources Posters *(joint with NG)*

Presiding: **J M Jacobs,** University of New Hampshire**; C H Luce,** USDA Forest Service

H12B-0967 1330h POSTER

The Application of Censored Regression Models in Low Streamflow Analyses

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Estimation of low streamflow statistics at gauged and ungauged river sites is often a daunting task. This process is further confounded by the presence of intermittent streamflows, where streamflow is sometimes reported as zero, within a region. Streamflows recorded as zero may be zero, or may be less than the measurement detection limit. Such data is often referred to as censored data. Numerous methods have been developed to characterize intermittent streamflow series. Logit regression has been proposed to develop regional models of the probability annual lowflows series (such as 7-day lowflows) are zero. In addition, Tobit regression, a method of regression that allows for censored dependent variables, has been proposed for lowflow regional regression models in regions where the lowflow statistic of interest estimated as zero at some sites in the region. While these methods have been proposed, their use in practice has been limited. Here a delete-one jackknife simulation is presented to examine the performance of Logit and Tobit models of 7-day annual minimum flows in 6 USGS water resource regions in the United States. For the Logit model, an assessment is made of whether sites are correctly classified as having at least 10% of 7-day annual lowflows equal to zero. In such a situation, the 7-day, 10-year lowflow (Q710), a commonly employed low streamflow statistic, would be reported as zero. For the Tobit model, a comparison is made between results from the Tobit model, and from performing either ordinary least squares (OLS) or principal component regression (PCR) after the zero sites are dropped from the analysis. Initial results for the Logit model indicate this method to have a high probability of correctly classifying sites into groups with Q710s as zero and non-zero. Initial results also indicate the Tobit model produces better results than PCR and OLS when more than 5% of the sites in the region have Q710 values calculated as zero.

H12B-0968 1330h POSTER

Bivariate Drought Characterization Using Nonparametric Approaches

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Droughts cause significant damages both in natural environment and human society, especially, in a transboundary region, where sustainable water use and water right are one of main issues among countries and communities during droughts. Nonparametric approaches allow more flexibility in practice by better approximating the characteristics of the probability distribution of the records. This paper presents new development in nonparametric methods in which, using a kernel density estimator, a nonparametric random generation is proposed for synthetic generation of hydrologic time series. Based on the nonparametric probability density function estimator, comprehensive approaches for evaluation of drought characteristics at a site and over a region are presented. The nonparametric method using a kernel density estimator easily extends to the estimation of a drought probability density function in two dimensions. Based on the synthetically generated data from the nonparametric distribution, a methodology is introduced for estimating the bivariate characteristics of droughts. The proposed approach was applied to a catchment in the Lower Rio Bravo/Grande and the results compared satisfactory with several parametric approaches.

H12B-0969 1330h POSTER

Assessing Hydrologic Similarity of Watersheds by Analyzing Geometric Patterns in Streamflow Time Series

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The concept of hydrologic similarity has been used in the past in the field of watershed hydrology to identify points or units in watersheds to assess their similar responses for a specific rainfall event. The similarity idea has also helped in identifying hydrologic response units (HRU) and improved representation of hydrologic processes in distributed hydrologic models. In the present study hydrologic similarity at a watershed scale is evaluated by using observed hydrologic time series data. The process involves exploring patterns in data time series and is almost similar to pattern recognition task in which a specific structure is searched in data items or observations. The motivation for evaluating these patterns is derived from the fact that observed data carry information either about the process generating them or the phenomenon they represent. Therefore the main objective of this study is to explore the possibility of establishing similarity in the hydrologic response of the watersheds based on geometrical patterns identified from observed streamflow time series. If the distribution of geometric patterns is similar, then a hydrologic similarity can be assumed as the response of the watershed is reflected in the observed streamflow values. Once a hydrologic similarity between any two watersheds is established using the similarity in the geometric patterns, then one or more of the several watershed physical properties (landuse, soils or topography) can be used to confirm the hypothesized similarity. The concept of establishing hydrological similarity using streamflow time series is tested by analyzing historical streamflow data from several USGS gaging stations in the state of Kentucky. The streamflow data is processed using a data-sorting program developed specifically for analyzing geometric patterns. Digital Elevation Models (DEMs) are used to delineate watersheds using the location of the gaging stations as outlets of the watersheds. Similarity in Land use/Land cover information is used as one of tests to confirm the possible existence of hydrologic similarity. If hydrological similarity is established based on the patterns in streamflow time series, transferability of streamflow prediction approaches can be evaluated.

H12B-0970 1330h POSTER

Ensemble Streamflow Forecast Verification: Putting Research Into Practice

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The application of probabilistic forecast evaluation methods to synthetic hindcasts was demonstrated in a previous study. The goal of this initial research was to assess the potential for using specific verification methods for National Weather Service Ensemble Streamflow Predictions (NWS ESP). Results from this work indicated that the measures studied (ranked probability skill score, discrimination, and reliability) provided a comprehensive evaluation of forecast characteristics. However, it remained unclear whether the statistics could be put into practical application. The second phase and current phase of this study highlights the problems, issues, and obstacles that come to light

when trying to apply the developed statistical measures to operational forecasts. With respect to the NWS ESP forecasts, data archives presented a major obstacle to implementing the procedures on one type of forecast data set. Variations in forecast formats across the country present another challenge to be faced as formalized software development begins. Initial progress indicates that once implemented, this initial set of statistical measures will provide the NWS forecasters and users with consistent comprehensive forecast performance data.

H12B-0971 1330h POSTER

Seasonal Stream Flow Forecasting and Decision Support in Central Texas

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A decision support model based on stream flow ensemble forecasts has been developed for the Lower Colorado River Authority in Central Texas, and predictive skill is added to climatology-based forecasts by conditioning the ensembles on observable climate indicators. These indicators include stream flow (persistence), soil moisture, and large-scale recurrent patterns such as the El Nino-Southern Oscillation, Pacific Decadal Oscillation, and the North Atlantic Oscillation. In the absence of historical soil moisture measurements, the Variable Infiltration Capacity (VIC) Retrospective Land Surface Data Set is applied. Strong correlation between observed runoff volumes and runoff volumes simulated by the (uncalibrated) VIC model indicates the viability of this approach. Following correlation analysis to screen potential predictors, a Bayesian procedure for updating ensemble probabilities is outlined, and various skill scores are reviewed for evaluating forecast performance. Verification of the ensemble forecasts using a resampling procedure indicates a small but potentially significant improvement in forecast skill over climatology that could be exploited in seasonal water management decisions. Future work involves evaluation of seasonal soil moisture forecasts, further evaluation of annual flow forecasts, incorporation of climate forecasts in reservoir operating rules, and estimation of the value of the forecasts.

H12B-0972 1330h POSTER

Fractal structure of multivariate drought events recurrence analyses

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Droughts are events characterized by their prolonged persistence in time as a succession of low water availability indicator values. Derived properties such as duration, severity, or maximum intensity are used to analyze and characterize the events. However, the use of one or two of these properties is not always enough to fully perform a drought recurrence analysis over the period of record. Each event may have different characteristics that describe its exceptional aspect. In this work droughts are treated as multivariate events, using the direct sequence of recorded values in the analysis. Therefore all drought aspects are taken into account in the analysis. The mean frequency of recurrence (MFR) of such sequence is used to characterize each of the drought events. The MFR is computed by first estimating the mean frequency of recurrence considering event of a fixed duration w (MFRw). Second the result is generalized by considering the occurrence possibility of events of any duration by an embedding process. Analytical expressions of the MFRw were found in the form of an infinite series. To facilitate the computation this analytical expression was simplified by an approximate 3-parameters function. The parameters of this approximate function are related with the duration w by power law relationships. Furthermore, the relationship between MFR and MFRw follows also a power law, suggesting a fractal structure of the phenomenon. This allows explaining how recurrence properties of extreme events vary with the temporal scale used in the analysis. The droughts characterization based on this approach generates a drought index, the Drought Frequency Index (DFI). The index is compared with existing indexes in several case studies.

H12B-0973 1330h POSTER

A western U.S. seasonal to interannual hydrologic forecast system

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We describe a seasonal streamflow forecasting system for the western U.S. that incorporates the following elements. First, climate forecast ensembles (for 6-7 months, constrained by predicted sea surface temperatures) are taken either from the NOAA/NCEP or NASA/NSIPP global forecast models, or from Extended Streamflow Prediction (ESP) resampling of observed forecast period (12 to 14 month) precipitation and temperature (with compositing to reflect ENSO/PDO states). Second, the Variable Infiltration Capacity (VIC) macroscale hydrology model, implemented at 1/8 degree spatial resolution over the major river basins of the western U.S., is used to transform ensembles of land surface forcing variables (primarily precipitation and temperature) into corresponding streamflow ensembles for selected forecast points. Third, for the Columbia, Colorado and Sacramento - San Joaquin River systems, reservoir simulation models are used to produce corresponding ensembles of future reservoir storage, releases, and associated variables like hydropower production. We review previous experience with a pilot forecast domain consisting of the Pacific Northwest, with real-time testing beginning in January 2001. Forecasts for the entire domain beginning in September 2003 are also assessed. Among the forecast products, which are updated monthly, are monthly and seasonal streamflow distributions at bout 60 locations throughout the western US, spatial distributions of snow water equivalent, runoff and soil moisture for the entire domain, and reservoir system storages, operations and releases at selected locations in the three modeled systems.

URL: http://www.hydro.washington.edu/Lettenmaier/Projects/fcst/index.htm

H12B-0974 1330h POSTER

Identification of Pacific Ocean Sea Surface Temperature Teleconnections with Western United States Streamflow

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The western United States is currently experiencing a significant drought which is causing water shortages and low lake levels. This analysis will provide information on Pacific Ocean Sea Surface Temperatures (SSTs) as a predictor variable of Western United States streamflow. The Partial Least Squares (PLS) statistical technique will be utilized to determine the best predictor ranges. PLS, which is primarily used in chemical spectrometry analysis, is an extension of multiple linear regression. PLS is an exploratory tool used to select suitable predictor variables and to identify outliers. Streamflow data (water year total runoff volume in acre-feet) were obtained from the U.S. Geological Survey (USGS) NWISWeb Data retrieval (http://waterdata.usgs.gov/nwis/) for sixty four unimpaired streamflow stations in the Western United States from 1946 to 2001 (56 years of data). Principal Component Analysis was performed on the streamflow data to determine areas in which the streamflow stations behaved similarly. The time series for these components were then utilized as the predictand. SST data were obtained from the National Climatic Data Center website (http://lwf.ncdc.noaa.gov/oa/climate/research/). The SST data consists of average monthly values for a 2 degree by 2 degree grid cell and the range of data used for the analysis was Latitude 120 degrees West to Latitude 80 degrees East and Longitude 70 degrees South to Longitude 70 degrees North. This resulted in a grid with 81 cells in the x-direction and 71 cells in the y-direction (5,751 cells). The SST predictors cover a period from 1945 to 2000. The average monthly values of the SST predictors are averaged for each season: April-May-June (AMJ - spring season), July-August-September (JAS - summer season) and October-November-December (OND - fall season). The best long lead time (3 to 9 months) indicators for water supply forecasting will be identified.

H12B-0975 1330h POSTER

Elnino and the variability of Global Precipitation

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Until 1979, the evidence linking El Nino with changes in rainfall around the world came from rain gauges measuring precipitation over land and a handful of islands. Before the launch of the Tropical Rainfall Measuring Mission (TRMM) in November 1997, the remote sensing evidence gathered since 1979 was confined to ocean rainfall because of the very poor sensitivity of the instruments over land. In this paper we summarize the results of a principal component analysis of TRMM's 60-month (1/98-12/02) global land and ocean remote-sensing record of monthly rainfall accumulations. Contrary to the first principal component of the rainfall itself, the first three indices of the anomaly are most sensitive to precipitation over the ocean rather than over the land. With the help of archived surface station data, the first TRMM rain anomaly index is extended back several decades. Comparison of the extended index with the Southern Oscillation Index shows that the first principal component of the rainfall anomaly is strongly correlated with the El Nino / Southern Oscillation indices.

H12B-0976 1330h POSTER

Statistical Development of Flood Frequency and Magnitude Equations for the Cosumnes and Mokelumne River Drainage Basins, Sierra Nevada, California

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In-basin statistical relations allow for development of regional flood frequency and magnitude equations in the Cosumnes River and Mokelumne River drainage basins. Current equations were derived from data collected through 1975, and do not reflect newer data with some significant flooding. Physical basin characteristics (area, mean basin elevation, slope of longest reach, and mean annual precipitation) were correlated against predicted flood discharges for each of the 5, 10, 25, 50, 100, 200, and 500-year recurrence intervals in a multivariate analysis. Predicted maximum instantaneous flood discharges were determined using the PEAKFQ program with default settings, for 24 stream gages within the study area presumed not affected by flow management practices. For numerical comparisons, GIS-based methods using Spatial Analyst and the Arc Hydro Tools extension were applied to derive physical basin characteristics as predictor variables from a 30m digital elevation model (DEM) and a mean annual precipitation raster (PRISM). In a bivariate analysis, examination of Pearson correlation coefficients, F-statistic, and t & p thresholds show good correlation between area and flood discharges. Similar analyses show poor correlation for mean basin elevation, slope and precipitation, with flood discharge. Bivariate analysis suggests slope may not be an appropriate predictor term for use in the multivariate analysis. Precipitation and elevation correlate very well, demonstrating possible orographic effects. From the multivariate analysis, less than 6% of the variability in the correlation is not explained for flood recurrences up to 25 years. Longer term predictions up to 500 years accrue greater uncertainty with as much as 15% of the variability in the correlation left unexplained.

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H12B-0977 1330h POSTER

MOD_FreeSurf2D: a Surface Fluid Flow Simulation Model for Rivers, Streams, and Shallow Estuaries

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The MOD_FreeSurf2D, Modular Free Surface Flow in Two-Dimensions, computer model simulates free surface fluid flow in streams, rivers, and shallow estuaries under the assumptions of a well-mixed water column, a small water depth to width ratio, and a hydrostatic pressure distribution. The dependent variables in the model are free surface elevation, which provides total water depth, and fluid velocity. Primary advantages of MOD_FreeSurf2D relative to other two-dimensional models are a stable and computationally efficient numerical representation and a transparent representation of wetting and drying of the simulation domain. MOD_FreeSurf2D approximates the depth-averaged, shallow water equations with a finite volume, semi-implicit, semi-Lagrangian numerical representation similar to the TRIM method (Casulli, 1990; Casulli and Cheng, 1992; Casulli, 1999). The semi-implicit, semi-Lagrangian approach is computationally efficient because time steps can exceed the Courant-Friedrich-Lewy (CFL) stability criterion without significant accuracy degradation (Robert, 1982; Casulli, 1990). The rectangular, Arakawa C-grid, finite-volume layout allows flooding and drying in response to changing flow conditions without prior channel specification or closed boundary specification. Open boundary conditions available in MOD_FreeSurf2D are specified flux, specified total water depth, specified velocity, radiation free surface, and radiation velocity. MOD_FreeSurf2D requires initial topography, undisturbed water depth, and Manning's roughness coefficient. MOD_FreeSurf2D simulated results are shown to converge to the semi-empirical solution for a simple straight channel case. Two applications demonstrate the accuracy of MOD_FreeSurf2D. The first application is the evolution of water depth in the dambreak-style flume experiment of Bellos et al. (1992). In this case, MOD_FreeSurf2D accurately simulates the changing water depth in the flume during the experiment and models the wetting of the flume below the dam and the drying of the flume above the dam. The second application is simulation of a reach of the Kootenai River, ID studied by Lipscomb et al. (1998). Detailed 3D spatial measurements of water depth and velocity were numerically integrated and compared to the 2D values produced by MOD_FreeSurf2D. Results indicate that MOD_FreeSurf2D accurately simulates depth-averaged velocity and total water depth on the reach scale. Currently, MOD_FreeSurf2D is a fully vectorized set of custom Matlab functions. References: Bellos, C.V., Soulis, J.V., and Sakkas, J.G., 1992, Experimental Investigation of Two-dimensional Dam-break Induced Flows, Journal of Hydraulic Research, v. 20, p. 47-63. Casulli, V., 1999, A Semi-Implicit Finite Difference Method for Non-Hydrostatic, Free-Surface Flows, International Journal for Numerical Methods in Fluids, v. 30, p. 425-440. Casulli, V., 1990, Semi-implicit Finite Difference Methods for the Two-Dimensional Shallow Water Equations, Journal of Computational Physics, v. 86, p. 56-74. Casulli, V. and Cheng, R.T., 1992, Semi-implicit Finite Difference Methods for Three-Dimensional Shallow Water Flow, International Journal for Numerical Methods in Fluids, v. 15, p. 629-648. Lipscomb, S.W., Berenbrock, C., and Doyle, J.D., 1997, Spatial Distribution of Stream Velocities for the Kootenai River Near Bonners Ferry, ID, June 1997. U.S. Geological Survey Open File Report 97-830, 174 p. Robert, A., 1982, A Semi-Lagrangian and Semi-Implicit Numerical Integration Scheme for the Primitive Meteorological Equations, Journal of the Meteorological Society of Japan, v.60, n. 1. p. 319-325.

H12B-0978 1330h POSTER

Soils and Springs - Controls on the Isotope Hydrology of 3 Appalachian Landscapes

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Environmental isotopes, such as O-18 and D, have been used to study hydrological processes in a variety of settings. The seasonal variations of stream baseflow isotopic composition at a catchment outlet are often used to estimate the residence time of groundwater within a catchment. Residence time models can be improved with information related to the spatial variability of baseflow isotopic composition within a catchment. This study aimed to quantify the annual variations in O-18 composition of waters within several Appalachian watersheds representative of 3 common landscape types in central Pennsylvania: the Valley and Ridge-shale (Mahantango Creek); Valley and Ridge-carbonate (Buffalo Run); and Appalachian Plateau-sandstone (Benner Run). Bi-weekly precipitation, snowmelt, soil water, and baseflow isotopic composition data were collected for the 3 catchments over one year (May 1999-May 2000). Preliminary results suggest that soils at these sites can effectively damp seasonal precipitation O-18 signals by the time they reach depths of 1.62-2.85 meters in the subsurface. This suggests that seasonal isotopic composition variations in baseflow are due to waters that drain the shallower soils within these catchments. The presence of springs was found to exert an influence on baseflow isotopic composition within each of the catchments. Two watersheds contained diffuse-fed springs, which resulted in a damping of seasonal variability of baseflow isotopic composition downstream. The remaining watershed contained a conduit spring, draining carbonate bedrock. This spring discharge resulted in an increase in seasonal variability of baseflow isotopic composition downstream. The seasonal variability of baseflow isotopic composition observed at the catchment outlets was a result of the combination of several distinct water sources: slow-draining groundwater; fast-draining near-channel groundwater; and spring discharges. An improvement in modeling of residence times of these catchments may be achieved by quantifying the contributions of spring discharges.

H12B-0979 1330h POSTER

Ground Water Depth and Water use by Phreatophyte Communities During Drought

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Demand for limited water resources along the middle Rio Grande of New Mexico has been exacerbated by drought in recent years. Since the last wet year in 1999, river flows have been well below normal and ceased in some reaches. Alluvial ground water elevations have declined steadily. Riparian vegetation consists primarily of native cottonwoods and introduced saltcedar, phreatophytes which are commonly groundwater-dependent. We investigated how drought-induced lowering of local water tables affects riparian water use. Since 1999, we have quantified rates of evapotranspiration (ET) and water table (WT) depths at two sites with relatively deep WTs ($>$ 1.5 m) dominated by saltcedar, and since 2000 at two relatively shallow WT sites ($<$ 1.5 m) dominated by cottonwood. Our results indicate that drought conditions and lowered ground water levels do not influence water use in the shallow WT cottonwood forests but do appear to limit water use in deeper WT saltcedar stands, particularly where seasonal WT fluctuations are large. As facultative phreatophytes, saltcedars are more flexible in their use of water resources. It is unlikely cottonwoods could compete effectively with saltcedars in sites characterized by relatively deep groundwater and dynamic WT hydrographs. Restoration efforts along the middle Rio Grande, such as cottonwood planting, saltcedar thinning, and managed flooding must plan for drought. Restoration will likely be more successful in more stable, shallow WT environments, where cottonwood forests are able to sustain access to water resources during drought.

H12B-0980 1330h POSTER

Development of a Coupled 3-Dimensional Hydrological - Hydraulic Model Integrated With High Resolution Digital Elevation Model

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The lower Feale catchment is a low-lying peaty area of 200 km2 situated in southwest Ireland that is subject to annual flooding. Two of the 15 hydraulically independent polders making up the catchment have been instrumented as part of a pump experiment. The main purpose of this study is to monitor and evaluate the effectiveness of pumping for eventual implementation in a flood mitigation strategy in the remaining polders. The effectiveness of the system is monitored by a number of state-of-the-art, high frequency instruments including: an eddy covariance station for water vapour and carbon dioxide, radiometers, soil temperature and soil water probes, groundwater level gauges, water level gauges and rainfall gauges. A second, less extensive set of instruments is located in an adjacent non-pumped polder, which provides a control for the experiment. An electrical resistivity investigation and a ground-penetrating radar survey were carried out to collect subterranean data. A number of deep boreholes were drilled to calibrate these two surveys. A dynamic geographical database, built in ArcGIS (ESRI), is used to store the wide range of data collected and the results of the different surveys carried out. The data are fed into a 3-dimensional hydrological-hydraulic model of the two polders developed using Mike SHE coupled with a Mike11 model of the surface drainage network and hydraulic controls, and integrated with a high-resolution digital elevation model. The hydrologic-hydraulic model includes features of the hydraulic infrastructure such as pumps, sluiced culverts, backdrains and channel embankments. The paper will discuss in detail ongoing results.

H12B-0981 1330h POSTER

Comparison of Streamflow Response Among ARS Experimental Watersheds Using SWAT

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Long-term climatic and runoff data from experimental watersheds provide an essential foundation to calibrate and validate continuous watershed simulation models used for water resources or water quality applications. Proper calibration of a watershed simulation model is critical to ensure that hydrologic processes occurring on the watershed are well represented. Model validation is equally important to help provide a measure of confidence in the predictive capability of the model as scenarios that reflect changes in land management, land use, and climate variations are imposed on the watershed. With the rapidly increasing use of simulation models to assess the impacts of changes in land use, management practices, or climatic conditions on water resources and water quality at watershed scales, a need exists to determine model strengths and limitations for particular ecosystems and runoff regimes. In this study the Soil and Water Assessment Tool (SWAT) is used to predict hydrologic responses to long-term climatic conditions on USDA Agricultural Research Service (ARS) experimental watersheds throughout the United States. The objective of the study is to determine the suitability of the model to simulate streamflow under a wide range of ecosystems and runoff regimes. Portions of the available data sets are used to calibrate SWAT on the respective ARS watersheds, and other portions not used in calibration are then utilized to validate the performance of the model. Three quantitative and two qualitative evaluation criteria are used to assess streamflow simulated by SWAT: computation of 1) deviation of streamflow volume, 2) Nash Sutcliffe coefficient of efficiency, and

3) prediction efficiency and visual inspection of 4) hydrographs and 5) flow duration curves. A comparison of simulation results on watersheds within the ARS network provides a basis to test model robustness, evaluate model application to other watersheds within a given physiographic and climatic region, and determine areas of model development that are needed for improved simulation of hydrologic processes.

H12B-0982 1330h POSTER

Monitoring Sediment Transport, Stream Stage, and Salinity with Time Domain Reflectometry

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Preliminary results are presented from an ongoing investigation into the applicability of Time Domain Reflectometry (TDR) for remote, real-time monitoring of streambed dynamics, stream discharge, and water quality. A TDR based stream monitoring system involves propagation of a high frequency, low voltage electromagnetic pulse through waveguides installed riverbed sediments. Reflected signals (traces) from each sensor are analyzed to locate dielectric discontinuities resulting from air-water and water-sediment interfaces, as well as to evaluate the extent of signal attenuation due to the electrical conductivity of the media/water. Trace analysis is by way of a multi-section physical based model using the S11 scatter function and the Cole-Cole parameters for dielectric dispersion and loss (e.g., Feng et al., WRR 35(8), 1999). Application of this approach to data from laboratory experiments demonstrates that TDR can locate air-water and water-sediment interfaces to an accuracy of $\pm$1.9 mm at a precision of $\pm$0.4mm. Electrical conductivity of freestanding water above a sediment water interface is measured to $\pm$8 percent of the actual conductivity at a precision of $\pm$9 S/cm. Eight sensors have been installed in the Rio Grande at Albuquerque, New Mexico. Seven sensors capture riverbed dynamics while the eighth is installed adjacent to the riverbank to measure river stage. TDR measurements will be compared to independent measures of riverbed morphology, discharge, and water conductivity.

H12B-0983 1330h POSTER

Effects of Calibration Period and Trend Terms on Regression Model Based Streamwater Constituent Load Estimates

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An analysis was done to measure the effects of model calibration period length and model form on streamwater constituent load estimates. Selected regression models were applied to nitrate-plus-nitrite concentration data collected for the USGS National Stream-Quality Accounting Network Program at the Mississippi River at St. Francisville, La., from July 1967 through June 2003. Model calibration periods were varied from four to twelve years with each calibration period modeled at 1-year increments throughout the period of record, thereby producing multiple estimates of daily loads which were then compiled on an annual basis for each model. The regression model estimates the log of streamwater load as a function of the log of flow and flow-squared terms, sine and cosine seasonal terms, and long-term trend terms. Both linear and second order polynomial long-term trend model forms were used. A Minimum Variance Unbiased Estimator is used to correct for log back transformation bias correction. The root mean squared error (RMSE), expressed as a percentage of the annual load estimate, is used to assess the accuracy of the annual load estimates. Load estimates for a given year for models with the same calibration period length and model form are similar, except when the estimate is from the beginning or end of the calibration period. RMSEs are always lowest in the middle of the calibration period and highest at the beginning and end of the calibration period, with average increases in RMSE for each set of models with the same calibration period length and time-term combination ranging from 31% to 58% higher than the RMSE at the center of the calibration period. The r^2s of the polynomial trend models were higher than the linear trend term models, but only minimally. Despite improvement in r^2s, the RMSEs were higher for the polynomial time-term models, especially at the beginning and end of the calibration periods, indicating that the inclusion of the time-squared term may produce larger variance in load estimates. Longer calibration periods produced lower RMSEs for both linear and polynomial long-term trend models. It is suggested that as the calibration period increases, the long-term time terms will not accurately model temporal changes in the relation between concentration and discharge. However, the RMSE appears to be more sensitive to the increase in the number of samples in the calibration set in that RMSE decreases as calibration period increases. The results of this analysis alludes to the importance of residual analysis, in addition to model r^2s and RMSEs, to ensure that model form is appropriate for the data because calculations of RMSE assume that the error is due to sampling and not due to the lack of model fit.

H12B-0984 1330h POSTER

Modeling Episodic Surface Runoff in an Arid Environment

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Methods were developed for estimating episodic surface runoff in arid eastern Washington, USA. Small (1–10 km^2) catchments in this region with mean annual precipitation around 180 mm produce runoff in about half the years, and such events usually occur during winter when a widespread cold snap and possible snow accumulation is followed by warmer temperatures and rainfall. Existence of frozen soil appears to be a key factor, and a moving average of air temperature is an effective predictor of soil temperature. The watershed model DHSVM simulates snow accumulation and ablation reasonably well at a monitoring location, but the same model applied in distributed mode across a 850 km^2 basin overpredicts runoff. Inadequate definition of local meteorology appears to limit the accuracy of runoff predictions. However, runoff estimates of sufficient quality to support modeling of long-term groundwater recharge and sediment transport may be found in focusing on recurrence intervals and volumes rather than hydrographs. Usefulness of upland watershed modeling to environmental management of the Hanford Site and an adjacent military reservation will likely improve through sensitivity analysis of basic assumptions about upland water balance.

H12B-0985 1330h POSTER

Spatial and Temporal Variability of Near-Shore Clarity in an Alpine Lake

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Spatial and temporal variability in localized nearshore locations of Lake Tahoe, CA/NV was investigated using turbidity and light attenuation measurements. Between 2001 and 2003, several areas were identified as turbidity hotspots and chosen for further study. The effects of storms, high winds, snowmelt runoff, and calm conditions on clarity were monitored at these areas. Data was continuously collected at a depth of one meter and displayed in real time. A comparison of the spatially plotted results shows an increase in turbidity after storms and during runoff events concentrated around the Upper Truckee River, Bijou Creek, and Edgewood Creek. Turbidity values ranged from 0.17 ntu in unaffected areas to up to 20 ntu in the most concentrated sections of the plume. In addition to the turbidity measurements, particle analysis was undertaken on water from three areas adjacent streams and from a distance of two kilometers off the mouth of the Upper Truckee River. Particles collected on a 0.1 micron filter

H12B-0986 1330h POSTER

Composition of Rainwater and its Impact on Regional Hydrologic Processes in the Midwestern United States

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This study was conducted in the Midwestern United States to determine the impact of rain composition on the regional hydrologic processes. It was hypothesized that a considerable amount of atmospheric aerosols in the region are derived from agricultural soil. These suspended soil particles include farm chemicals that contain nitrogen, phosphorus and sulfur compounds, which can dissolve in raindrops during condensation and change the rain composition leading to increased levels of acidity and nutrients to the surface water. In order to conduct this study, the predominant source of atmospheric moisture was determined by analyzing the isotope (oxygen and deuterium) composition of rainwater and surface water in the area. The observed ranges of Oxygen and Deuterium isotope values (in parts per thousands) are for Ames, delta-O: -30.1 to +1.3, delta-D: -233.0 to +10.1; for Cedar Falls, delta-O: -31.8 to -0.5, delta-D: -245 to -4.0; and for Iowa City, delta-O: -17.5 to -0.6, delta-D: -132.0 to +2.0. It was observed in this study that the isotopic relationships between delta-O and delta-D are generally well correlated with the Meteoric Water Line (MWL) suggested by Craig (1964) in all three sampling locations of the study area. On the contrary, approximately 50% of the samples in Ames, 61% in Cedar Falls, and 44% in Iowa City have d-excess values that are higher than +10 parts per thousand. Although the d-excess averages suggest a predominantly oceanic source of moisture (d-excess = +10 ppt), many condensation events were impacted by recycled (subjected to evaporation, transpiration, etc.) water from terrestrial sources. The results of chemical analysis of rainwater shows that the particulate materials from land sources, especially the agricultural chemicals considerably impacted the general composition of atmospheric moisture. The concentrations of chloride, nitrate, and sulfate, respectively are 3.0, 4.9, and 5.2 mg/L in Cedar Falls, and 4.0, 6.9, and 5.3 mg/L in Ames. This study indicates that the chemical as well as the isotopic composition of atmospheric vapor can be influenced by its interaction with the regional biospheric processes. Additionally, it is concluded that rainwater can transport land-derived aerosol particles to the area lakes and streams and thereby influence the general productivity in the aquatic ecosystem. More data are needed to quantify such productivity.

H12B-0987 1330h POSTER

Salinization Sources Along the Lower Jordan River Under Draught Conditions

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The Lower Jordan River, once a flowing freshwater river, is suffering from an ongoing reduction of discharge and water quality. The river flows between the Sea of Galilee and the Dead Sea, an aerial distance of about 105 Km. The severe reduction is caused by an excessive exploitation of its sources and diversion of sewage and agricultural drainage into the river. The extreme low flows and low water quality threaten the natural existence of the river and its potential use for agriculture. In spite of its importance, little research has been done in the river. The objectives of the study were to measure the discharge and water composition along the river and to evaluate the main sources that control its flow and chemical characteristics. The hypothesis of the study was that interaction with subsurface flows significantly affects the river flow and chemical composition. The research is based on a detailed field study, which included flow rate measurements in the river and its tributaries, water sampling and analysis and mass balance calculations of water and solutes. A portable Acoustic Doppler Velocimeter (ADV) was used to measure velocities and bathymetry at different locations across the river sections. Due to accessibility constraints, a floating traverse construction, which enables the ADV's deployment from one bank of the river, was developed. It was found that flow rate ranges between 500-1,100 L/s in northern (upstream) sections and 300-1,650 L/s in the south. This low discharge represents a significant reduction from historical values and is lower than recent published estimations. This research represents base flows only, as the measurements were done during a period of two consecutive draught years. Calculated mass balance of water flows in the

northern sections shows that the subsurface source contributes to the river around 200-670 L/s (30-80% of the river flow). Calculations of solute balance show that the subsurface flows add 20-50% of the mass of solutes (e.g. Sulfate) that flows in the river. The assumption of a hydraulic gradient that points at inflows from subsurface flows is encouraged by high water levels measured in nearby piezometers. Possible natural subsurface sources include shallow groundwater or rising of water from deep formations. The existence of adjacent thermal wells strengthens the reasonability of such water rise. Possible anthropogenic sources include return flows and effluents. The results are consistent and agree with the geochemical and isotopic analyses. It is concluded that the impact of the subsurface component on the Jordan River is significant and must be taken into consideration, for future water management schemes and implementation of the Peace Treaty between Israel and Jordan.

H12B-0988 1330h POSTER

Physical and Chemical Implications of Mid-Winter Pumping of Tundra Lakes

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Northern Alaskan oil exploration has relied on limited freshwater resources to create ice road and ice pad infrastructure since the 1970s. The result is an ice infrastructure (ice roads, airport runways, and drilling pads) that increases access to remote areas while decreasing maintenance costs and environmental impacts related to gravel roads and pads. However, some questions have been raised regarding the environmental pumping effects on these freshwater lakes. Potential issues include altering the existing water balance, impact to aquatic life including fish and invertebrates, and influencing water chemistry. As some lakes are pumped year after year, cumulative effects may also occur. Additionally, pumping may influence over-wintering fish habitat in nearby rivers if there is a hydraulic connection. The intent of this research is to understand and model the physical and chemical effects of water withdrawal on the lakes of the North Slope of Alaska. First year results indicate full recharge of index lakes during spring melt and minimal chemical differences detected between pumped and non-pumped lakes.

H12B-0989 1330h POSTER

Discriminant Flash-Flood Forecasting in an Urban Environment

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This study demonstrates the application of high-resolution weather radar data, quantitative precipitation nowcasting, combined with simple hydrologic modeling to forecast flood potential for multiple, discriminate urban watersheds. The approach defines metadata models based on the Extensive Markup Language (XML) to disseminate severe storm attributes (their size, orientation, history, and forecast position) and 5-minute, 2-hour rainfall accumulations for the watersheds to an Automated Location Evaluation in Real Time (ALERT) urban flood warning system- the Urban Drainage and Flood Control District (UDFCD), in Denver Colorado, USA. In addition, a simple graphical display system based on the World Wide Web Consortium's (W3C) Scalable Vector Graphics (SVG) format, requires only the simple exchange of small XML data files from the Nowcasting server to the UDFCD client for monitoring storm position and streamflow by the UDFCD in realtime. Example of severe storms that produce local flooding in the UDFCD domain will be shown.

H12B-0990 1330h POSTER

Modeling hydrologic processes at the residential scale

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In California, urbanization has led to polluted runoff, flooding during winter, and water shortages during summer. There is growing interest in application of microscale hydrologic solutions that eliminate storm runoff and conserve water at the source. In this study, a physically-based numerical model was developed to better understand hydrologic processes at the residential scale and the interaction of these processes among different Best Management Practices (BMPs). This model calculates all in-flow and out-flow using an hourly interval over a full year or for specific storm events. Water enters the system via precipitation and irrigation and leaves the system via evapotranspiration, surface and subsurface runoff, and from percolation to groundwater. The model was applied to two single-family residential parcels in Los Angeles. Two years of data collected from the control and treatment sites were used to calibrate and validate the model. More than 97% of storm runoff to the street was eliminated with installation of low-cost BMPs (i.e., rain gutters that direct roof runoff to a lawn retention basin and a driveway interceptor that directs runoff to a dry-well in the lawn retention basin). Evaluated individually, the driveway interceptor was the most effective BMP for storm runoff reduction (65%), followed by the rain gutter installation (28%), and lawn converted to retention basin (12%). Installation of an 11 m3 cistern did not substantially reduce runoff, but did provide storage for 9% of annual irrigation demand. Simulated landscape irrigation demand was reduced 53% by increasing efficiency through use of a drip irrigation system for shrubs, and adjusting monthly application rates based on evapotranspirational water demand. The model showed that infiltration and surface runoff processes were particularly sensitive to the soil's physical properties and its effective depth. If the existing loam soil were replaced by clay soil annual runoff discharge to the street would be increased by 63% when climate and landscape features remained unchanged.

URL: http://cufr.ucdavis.edu

H12B-0991 1330h POSTER

A Decision Support System for Demand Management of the Rio Conchos Basin, Mexico

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There is a need for integrated models of transboundary watersheds such as that of the Rio Grande/Rio Bravo (RGRB) along the US/Mexico border. We present the first stage an interdisciplinary effort to develop a semi-distributed regional dynamic simulation model (DSM) for examining water issues in the Lower RGRB basin. The RGRB serves as the border between the U.S. and Mexico. We focus first on the Conchos River basin, which contributes approximately 70-80% of the surface flow in the lower RGRB basin. Irrigated agriculture has historically been the major user of water and irrigated acreage continues to expand, but it faces increasing competition from industrial development, maquiladoras, and increasing residential water demand. International agreements such as the Treaty of 1944 between the US and Mexico stipulate that the flows in the RGRB are equally split. Yet uncertainties remain due to vagaries in the legislation. For example, Mexico is required to provide an average of 350,000 AF/yr over a five-year cycle, unless "extraordinary drought" occurs, although the Treaty does not define extraordinary. The characterization of droughts poses a significant problem for hydrometeorologists and water resource engineers. Our simulation model incorporates drought indices developed to characterize droughts in semi-arid and arid regions and statistical approaches to examine the spatial influence of droughts. To examine the effects of various structural and institutional changes to water use in the basin to meet the requirements of the Treaty and simulate climactic issues, we model agricultural, municipal, and industrial water demands that are directly linked to sectors of the regional economy using input output (IO) models. IO models can be used to examine how changes in water deliveries to the agricultural or manufacturing sectors affect the level of output, employment, and wages in the regional economy. All model outputs will be incorporated into a decision support system that will provide a tool to simulate hydrological profiles, ecosystem variability, changes in irrigation technology, and changes in management regimes within the basin and will serve to inform decision-makers of the water demand and supply changes necessary to meet the needs of international obligations and growing populations in the short and long term. The initial set of available management options include water banking and water trading within each country as well as irrigation standards, application efficiency, and water banking across borders.

H12B-0992 1330h POSTER

Effect of Rainfall Aggregation on Hydrologic Predictions

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Remotely sensed soil moisture data are becoming increasingly available, however the variability within the remotely sensed footprint is spatially averaged. The representation of spatial heterogeneity of soil moisture is essential for modeling processes that are nonlinearly related to soil moisture, such as the partitioning of sensible and latent heat fluxes. A number of studies have suggested that the spatial variability of soil moisture varies with wetness. At different locations, scales, and wetting and drying conditions, soil moisture patterns have been linked to topography, soil characteristics such as porosity and wilting point, and rainfall distribution. The objective of the proposed study is to examine the effects of rainfall temporal and spatial aggregation on spatial variability of soil moisture and runoff predictions on a 1000-km2 watershed. High-resolution radar-estimated rainfall from the IHOP2002 experiment will be used. These rain fields are aggregated in space and time. The hydrologic response of a distributed hydrologic model to the aggregated rain fields will be statistically compared with the response of the model to the original rainfall fields to quantify the impact of the spatial and temporal aggregation on hydrologic predictions. The proposed procedure will combine information from these simulations to determine what adjustments need to be made to the predicted fluxes.

H12B-0993 1330h POSTER

Examining Runoff Production Using Radar-Rainfall and Physiographic Databases

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The lack of rain gages is problematic for studies of runoff production in many basins, as localized phenomena can seriously affect runoff production. Without taking into account the small scale space-time variability of rainfall, it is impossible to examine with certainty the partitioning of rainfall into runoff. In this study, we make use of a new WSR-88D derived hourly rainfall database, covering the entire Mississippi basin, which was produced for the GCIP program. In this preliminary study we examine the roles of space-time rainfall patterns and basin structure in explaining the quantity and timing of runoff from 11 basins throughout Illinois with drainage areas ranging from 62 to 932 sq. km from Water Years 1996-2000. The study will later be expanded to basins throughout the upper Midwest. Factors being considered include the effects of river network structure, both in plan (i.e., the width

function) and in elevation (basin hypsometry) on routing; the effects of land-use, land-cover and soils, including the presence of drainage tiles on infiltration and interflow; the effect of geology on baseflow; and the effects of land-use, land-cover, and vegetation on evapotranspiration and pre-storm soil moisture. Statistics used to characterize the hydrographs, which are derived from hourly USGS streamflow data, include peaks, dispersion and skewness, volume, and relationships between flow and rainfall quantities such as runoff ratio. This new radar-rainfall data set combined with physiographic data using GIS facilitates the study of rainfall-runoff relationships in unprecedented detail over a large number of basins, distributed over a wide geographic area, using a consistent methodology.

H12B-0994 1330h POSTER

Incorporating Field Intelligence Into Conceptual Rainfall-runoff Models

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A major challenge in the hydrological sciences is to incorporate observed physical processes into general hydrological models with minimal data requirements and limited model complexity. One approach is to move away from discharge-based calibration schemes, which often assume model structures to be correct, and allow field observations to inform and test new model structures. The use of this knowledge will contribute to (1) the development of an expanded set of variables to verify hydrological model performance and reflect the overall watershed function and (2) provide useful information regarding the development of model structures and landscape discretizations. We identify a set of three variables that focus on the composition of stream water, using artificial hydrograph separations to provide estimates of the time source (e.g., event vs. pre-event) and the geographic source (e.g., hillslope vs. riparian) of streamflow, and explicitly accounting for mass transfer to provide estimates of residence time. In addition to these variables, we present a set of methods and data designed to incorporate experimental understanding directly into the model structure and catchment discretization. These ideas are illustrated through application at the H.J. Andrews Experimental Forest's Lookout Creek watershed in the western Cascades of Oregon.

H12B-0995 1330h POSTER

Florida Pre-Drainage Everglades Rainfall-Stage Statistical Model as a Step for Rainfall Driven Operation

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The Comprehensive Everglades Restoration Plan, CERP, is designed to capture, store and redistribute fresh water previously lost to tide and to regulate the quality, quantity, timing and spatial distribution of water flows in South Florida. One of the major CERP components is to improve water deliveries to the Everglades. To improve delivery quantity and timing, the existing calendar based regulation schedules are to be replaced with a "Rainfall Driven Operation" (RDO) procedure applied at a short time scale (e.g. weekly). An important step towards a successful RDO is to estimate the pre-drainage (or "natural") stage (water level) response at multiple control locations to recent and/or projected weekly rainfall. Physical modeling of this process in real time is considered difficult. Extensive data analysis shows that this system is non-linear. An Artificial Neural Network, ANN, model is developed to estimate the relationship between multiple stage and rainfall locations for natural conditions considering eight locations throughout the Everglades, and using the historical (1965 -1995) output of the Natural System Model (NSM) developed by the South Florida Water Management District. The ANN uses a combination of stage and rainfall at different time steps as predictors and stage at the next time step as predictant. Stage thresholds at which the stage-rainfall response changes are identified. The ANN regression procedure captures the multiple thresholds and the multi-stage response in a relatively parsimonious manner. Model performance during both dry and wet spells is tested. A strategy for how the estimated natural system conditions can be used in real-time operation of the system is also discussed.

H12B-0996 1330h POSTER

Variability of Pan-based and Penman-based Evapotranspiration Estimates in California

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Daily data from 29 meteorological stations from the California Irrigation Management Information System (CIMIS) covering the period from 1990 to 2002, and from 7 pan-evaporation stations from the National Climatic Data Center (NCDC), were used to characterize variability and trends in reference evapotranspiration (ETo) in California. ETo daily anomalies in California exhibited higher variance during the spring compared to other seasons. The higher variance is associated with larger ETo seasonal values -due to the higher spring irradiance- compared to winter and autumn, combined with large ETo reductions associated with relatively common cloudy days. Although the irradiance is also high during the summer, ETo estimates during this season are very close to the seasonal -clear sky- medians and therefore have low variance, due to the much lower frequency of occurrence of cloudy days. The combination of high seasonal values and relatively frequent cloudy days is only observed during the spring, the most variable season in terms of ETo. Atmospheric circulations at 700 mbar pressure levels (Z700) over a region off the West Coast of North America, approximately between 30 and 45 latitude, are most closely associated with the historical ETo variations. ETo is significantly positively correlated (r=+0.7) with Z700 in this region at daily, monthly and seasonal time scales, especially during the spring, through atmospheric circulation influences on the variability of radiation, relative humidity and cloudiness. This correlation pattern was identified using the CIMIS data (1990 to 2002) and its robustness was verified using the pan data (1965 to 2000). This pattern is consistent with other studies that have showed connections between atmospheric circulation in the eastern Pacific and precipitation and streamflow variations in California. Estimates of spring actual evapotranspiration from 1984 to 2002 computed based on the CIMIS data showed moderate, but significant increasing trends in most of the Central Valley, generally associated with increasing trends in minimum temperature. Future work will verify these trends using the NCDC data.

URL: http://tenaya.ucsd.edu/~hhidalgo/home.htm

H12B-0997 1330h POSTER

Investigation of influence of ETc estimation methods to simulate water balance using MIKE SHE

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Potential evapotranspiration, ETc plays an important role in simulating soil water content, drainage and water table elevation. Among many different methods to estimate ETc, crop coefficient approach (ETc = ET0*Kc), the effect of the various weather conditions are incorporated into reference evapotranspiration, ET0 and the crop characteristics into the crop coefficient Kc, has been adopted in this study. However, Kc can be obtained from either single or dual crop coefficient methods according to FAO guidelines. In single crop coefficient approach, the effect of both crop transpiration and soil evaporation are integrated into a single crop coefficient to obtain crop ETc. On the other hand, crop coefficient can be improved for estimating the effects of daily evaporation from wet soil on Kc and by splitting the coefficient into evaporation and transpiration has been demonstrated in many studies. This study investigates how ETc obtained from these two methods influences the simulation of water content using MIKESHE, a physically based hydrologic model, keeping all other parameter and dynamic variables constant. The results indicate that little improvement in terms of RMSE can be achieved using the dual crop coefficient method.

H12B-0998 1330h POSTER

Runge Kutta Algorithm applied to a Hydrology Problem

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In this paper, the author utilizes a fourth order Runge Kutta Algorithm technique to solve a design problem in Hydrology and Fluid Mechanics. Principles of Fuzzy Logic Design methodologies were utilized to analyze the problem and arrive at an appropriate solution. The problem posed was to examine the depletion of water from a reservoir. A suitable model was to be created to represent different parameters that contributed to the depletion, such as evaporation, drainage and seepage, irrigation channels, city water supply pipes, etc. The reservoir was being fed via natural resources such as rain, streams, rivers, etc. A model of a catchment area and a reservoir lake is simulated as a tank and exit discharge is represented as fluid output via a long pipe. The Input to the reservoir is assumed to be continuous-time and time varying. In other words, the flow rate of fluid input is presumed to change with time. The required objective is to maintain a predetermined level of water in the reservoir, regardless of input conditions. This is accomplished by adjusting the depletion rate. This means that some of the Irrigation channels may have to be closed or some of the city water supply lines need to be shut off. The differential equation governing the system can be easily derived using Bernoulli's' equation. If hd is the desired height of water in the reservoir and h(t) represents the height of water in the reservoir at any given time, K represents a positive constant. (dh/dt) + K [h(t) - hd] = 0 The closed loop system is simulated by using fourth-order Runge-Kutta algorithm. The controller output u(t) can be calculated using the above equation. The Runge-Kutta algorithm is a very popular method, which is widely used for obtaining a numerical solution to a given differential equation. The Runge-Kutta algorithm is considered to be quite accurate for a broad range of scientific and engineering applications, and as such, the method is heavily used by many scholars and researchers. In summary, Runge-Kutta is a common method of solving ordinary differential equations using numerical integration techniques. The principle is to use a trial step at the midpoint of an interval to cancel out lower-order error terms. Suppose that hn is the value of the variable at time tn. The Runge-Kutta formula takes hn and tn and calculates an approximation for hn+1 at a brief time later, tn+ä. It uses a weighted average of approximated values of f(t, h) at several times within the interval (tn, tn+ä). hn+1 = hn + (1/6) [k1 + 2k2 + 2k3 + k4] k1 , k2 , k3 & k4 are four gradient terms. Fuzzy logic FLC rule base can be developed based on the above derivations and equations. Further, a graphical representation of water level over a time step period can be obtained.

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H12B-0999 1330h POSTER

A Physically Based Distributed Hydrologic Model with a no-conventional terrain analysis

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A physically based distributed hydrological model is presented. Starting from a contour-based terrain analysis, the model makes a no-conventional discretization of the terrain. From the maximum slope lines, obtained using the principles of minimum distance and orthogonality, the models obtains a stream tubes structure. The implemented model automatically can find the terrain morphological characteristics, e.g. peaks and saddles, and deal with them respecting the stream flow. Using this type of discretization, the model divides the elements in which the water flows in two classes; the cells, that are mixtilinear polygons where the overland flow is modelled as a sheet flow and channels, obtained by the interception of two or more stream tubes and whenever surface runoff occurs, the surface runoff is channelised. The permanent drainage paths can are calculated using one of the most common methods: threshold area, variable threshold area or curvature. The subsurface flow is modelled using the Simplified Bucket Model. The model considers three type of overland flow, depending on how it is produced:infiltration excess;saturation of superficial layer of the soil and exfiltration of sub-surface flow from upstream. The surface flow and the subsurface flow across a element are routed according with the mono-dimensional equation of the kinematic wave. The also model considers the spatial variability of the channels geometry with the flow. The channels have a rectangular section with length of the base decreasing with the distance from the outlet and depending on a power of the flow. The model was tested on the Rio Gallina and Missiaga catchments and the results showed model good performances.

H12B-1000 1330h POSTER

Two-Component Hydrograph Separation and Mean Residence Time at Small Forested Catchments in Japan

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Two-component hydrograph separation was conducted, and mean residence time (MRT) was calculated for small forested catchments in Japan to understand runoff processes. The study site is located on the east coast of Japan . Annual precipitation averages 1426.9 mm over the past 20 yrs (1981-2001). Soils are derived from volcanic ash (Inceptisols). Surficial geology is primarily schist and amphibolite. Streamflow was continuously monitored using a V-notch weir at the outlets of the entire basin (HX, 75.28 ha) as well as subbasins including HO (15.68 ha), HB (2.48 ha), HA (0.84 ha), and HV (0.82 ha). HA is nested in the upper portion of HB, which is covered with a mature (80 yr old) forest of Japanese cedar and cypress. HB is nested in the lower portion of HO, which is covered with a young (12 yr old) stand of the same species except for HB. Streamwater was collected at these gauging stations approximately every 10 days from 1998 through 2001. Bulk samples of rainwater were collected at an opening of the meteorological station at the same intervals, together with bulk samples of throughfall under the canopy in HA. Streamwater during runoff were also sampled at HA and HB. Sequential throughfall was sampled in HA. Water samples were analyzed for oxygen-18 and deuterium. The variation of d value (d=D-818O) in throughfall ranged from approximately 5 to 25 permils, while that in streamwater was approximately 11.5 to13.5 permils. The seasonal variations of throughfall and streamwater were approximated by sinusoidal functions. The MRT was calculated using the damping of the amplitude, and its relationship with basin size was examined. In addition, two-component hydrograph separation was conducted at HA and HB based on variable source areas. It was found that generally more than half of pre-event water discharged into the stream. In this study, MRT was calculated for HA and HB considering the large amount of pre-event water discharging into the stream during the storm runoff period.

H12B-1001 1330h POSTER

Wavelet analysis of the hydrologic effects of Glen Canyon Dam on the Colorado River at Lees Ferry, Arizona

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Continuous wavelet transformation is a powerful analytical tool with which to analyze the hydrologic effects of dam construction and operation on river systems, an issue of great managerial, political, and social interest in the western United States. Using continuous records of instantaneous discharge from the Lees Ferry gaging station and records of daily mean discharge from upstream tributaries, we conducted a continuous wavelet transformation (CWT) analysis of the pre- and post-dam hydrologic structure of the Colorado River in Grand Canyon, downstream from Glen Canyon Dam. CWT of mean daily discharge provided a highly compressed and integrative picture of the near-total elimination of pronounced annual and subannual wavelet features after dam construction. Events such as droughts, managed floods, and uncontrollable snowmelt-driven discharge were also visible. The continuous record, interpolated to consistent hourly intervals, revealed a much finer scale image of river conditions. Prior to dam construction, the CWT showed the influence of warm season peak discharge periods, discharge driven by the monsoon and dissipating tropical storms, and annual droughts. In the post-dam period, strong wavelet signals related to diurnal power generation, weekly shutdowns in power generation, shifts in daily discharge management, and the 1996 experimental flood were dominant. The CWT approach appears to represent well-known features of dam operation without generation of spurious results. Thus, CWT, with quantitative statistical significance tests, should be a promising tool for assessing (1) dam operation in less well-studied regions and (2) real-time success or failure of management attempts to reconstruct desired flow characteristics.

H12B-1002 1330h POSTER

A Time-Integrated Geospatial Database of 20th Century Modifications of the Mississippi River System

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As part of a multi-year NSF-funded grant looking at changing flow conditions on the Mississippi River System, we are building a time-integrated geospatial database of engineering activities along the Mississippi and the Lower Missouri Rivers. This paper is intended to present the goals of the database, report on its current status, and present some preliminary results and illustrations. The spatial scope of the database includes the entire navigable length of the Mississippi and the Lower Missouri Rivers, and the temporal scope of the database extends back to the middle of the 19th century. The research project in which we are developing the database is designed to establish the empirical links between river engineering structures and activities and changes in flood probabilities and flood levels that may result. The project involves four principle steps: (1) compilation of historic hydrologic data, (2) specific-gage analysis, (3) construction of GIS-based geospatial database of engineering data, and (4) geo-statistical analysis to determine which independent variables, to what degree, and in what combination, control the observed shifts in flood response. We have assembled historic hydrologic data sets of daily stage and discharge at each long-term rated gage on the Mississippi and Lower Missouri Rivers in digital format. Specific-gage analysis of the hydrologic data has now been completed in order to identify changes in flood behavior at each gaging station over time. The most significant result from the SGA was that at most gages on the Lower and Middle Mississippi and on the Lower Missouri River the stages associated with large-discharge flows rose systematically over the durations of record. To implement the third step, spatial data is being collected in order to construct a geographical information system (GIS) database of the spatial and temporal distribution and nature of engineering structures in the study area. GIS layers include location of levees, with their year of emplacement and elevations coded, wing dams (a.k.a. dikes, groins, or jetties), including year of emplacement and extension, revetments, bridges, meander cutoffs, diversions, dams, and where available channel bathymetry.

H12B-1003 1330h POSTER

High Resolution River Routing in the CCSM2 Climate System Model

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The delivery of freshwater to the ocean from continental runoff is a critical factor in the global climate system. The current version of the NCAR climate model CCSM2 (Community Climate System Model, version 2) uses river routing at half degree resolution. While this is acceptable in the current model, high power computer architectures now available such as the IBM Power 4 and Cray X1 are allowing development of higher resolution climate component models and parameterizations. Subgrid orography parameterizations will allow for the production of more accurate runoff within a grid cell. Higher resolution routing is necessary to take advantage of this improvement. Other new parameterizations are adding chemical species to the terrestrial biosphere that will need to be transported via rivers to the oceans. A five-minute resolution river routing scheme has been developed in support of these improvements. We present the results of this new river routing scheme.

H12B-1004 1330h POSTER

How do summer precipitation variability correlate with pre-summer soil moisture variations in U.S.?

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The relative importance of the land and ocean impacts on U.S. precipitation changes with seasons and the influence of the land surface is the strongest during the warm season. As a major memory mechanism of the land surface, soil moisture has typical decay time of 2-3 months over U.S. continent, suggesting that the impact of such persistence of soil moisture on precipitation could be on seasonal timescales. The variability of U.S. summer average precipitation displays strong geographical dependence with large variability in the southeastern United States. The covariance of the U.S. summer mean precipitation with pre-summer soil moisture conditions is examined in this study using the singular value decomposition (SVD) method. The 40-year historic monthly data of precipitation and soil moisture generated by a multi-layer soil model coupled with a climate model are used to perform the SVD analysis. The well correlated expansion coefficients of SVD dominant modes indicate a significant association between summer precipitation pattern and pre-summer soil moisture variation.

H12B-1005 1330h POSTER

Computational Modeling of Self-Preserving Turbulent Wall Jets and Associated Scour

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Turbulent wall jets frequently occur in the natural environment (e.g. avalanches, turbidity currents) and have therefore been the focus of many theoretical and experimental studies aimed at understanding their behavior and impact on bed scour. From a computational perspective, wall jets are relatively straightforward to compute, but difficult to predict accurately using eddy-viscosity turbulence models. Essentially, the wall jet can be viewed as a combination of two separate layers: a wall boundary layer and a free mixing layer; the interactions between the two being responsible for many of this flows interesting features. Simulations of turbulent wall jets presented here involve solving the Reynolds-averaged Navier-Stokes equations and providing an appropriate model for the Reynolds stresses, the terms which contain the shear stresses associated with turbulence problems. We report on the use of two distinct classes of turbulence models: (1) a second-order closure model of turbulence based on the solution of modeled transport equations for all non-zero components of the Reynolds-stress tensor and, (2) a two-equation, eddy-viscosity model of the type frequently used in environmental applications. The models are tested for their ability to predict the hydrodynamic behavior of turbulent jets developing over plane smooth surfaces with emphasis on the behavior of the wall shear stress. The predicted wall shear stress can later be used to assess

scour. Emphasis is placed on the special class of self-similar flows which, for wall jets, requires the ratio of the maximum-to-free stream velocities to be constant with streamwise distance. In this study, we consider values of this ratio from 0 to 0.8: the zero case corresponding to the challenging case of a wall jet developing in stagnant surroundings, a common occurrence in natural systems. The primary interest is the accurate prediction of the rate at which the jet expands into the surrounding environment, and the wall shear stresses that are the cause of severe scour associated with turbulent wall jets. We present comparisons with experimental data and with empirical correlations. These show that the second-order closure model succeeds in capturing many of the important features of this complex flow, including the separation of the points where the turbulent shear stress and the mean velocity gradients are zero. The wall shear stresses are also well predicted with this model but less so with the two-equation model. The implications of these results on the prediction of bed-load sediment transport will be discussed.

H12C MCC: Level 2 Monday 1330h

Coordinated Enhanced Observing Period (CEOP) I Posters *(joint with A, OS, GC)*

Presiding: **J O Roads,** Scripps Institution of Oceanography**; R Lawford,** NOAA

H12C-1006 1330h POSTER

A Simplified Land Data Assimilation Scheme (LDAS) for Assimilation of AMSR-E Data and Its Application to CEOP Reference Site: Mongolia

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Soil moisture controls the portioning of land surface heat fluxes into the atmosphere and influences the global and/or regional water cycle. However, improvement in the forecast skill of quantitative/qualitative soil moisture forecasts has been slow. This could be attributed to uncertainties in model physics, parameterization, and initial conditions. With the rapid increase of satellite data, the skill of quantitative/qualitative soil moisture forecasts is expected to be improved by using these data. This paper investigates the method of retrieving spatial distributions and temporal variations of key land surface variables such as soil moisture and soil and canopy temperatures from passive microwave radiance measurements by using the novel application of data assimilation. The Land Surface Scheme (LSS), which forms the heart of the data assimilation algorithm, is a bio-physically based Model (Simplified Biosphere Model2: SiB2) of soil, vegetation, and atmosphere interaction. Our Land Data Assimilation Scheme (LDAS) takes into account both model and observation uncertainties and provides dynamically consistent data product of land surface parameters. The satellite sensor Aqua/AMSR-E measurements, gathered over one of the CEOP reference site: Mongolia, are assimilated into the LSS using our LDAS. However, satellite observations of brightness temperatures are likely be available only over relatively larger spatial scales. In order to integrate spatial heterogeneity effects and pursue the optimal usage of large spatial scale satellite observations, we have introduced a simplified downscaling approach inside the LDAS. An assessment of the experiment results and the impacts of AMSR-E data and the data assimilation concepts in the modelling of land surface processes will be discussed.

H12C-1007 1330h POSTER

Model-Based Analysis on the Mountain-Valley Circulation in the CEOP Reference Site

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The mountain-valley circulation system in the Tibetan Plateau, one of the Coordinated Enhanced Observing Period (CEOP) reference sites, has been investigated. We set the target area around Naqu, which is located between the two mountain ranges running east to west in the north and the south. GEWEX Asian Monsoon Experiment-Tibet Intensive Observation Period of 1998 (GAME-Tibet IOP) data showed the diurnal variation of the convective activities and mountain-valley circulations. Wind from mountain to valley, accompanied by convection over the mountain range was observed during the afternoon while the wind direction changed at night with the mountain convection disappearing. At the same time, the convective precipitation areas moving from mountain to valley were observed by Doppler radar. Sometimes this convective precipitation system induced the vorticity. By using the atmosphere-land coupled regional model to investigate this phenomenon, we successfully clarified the mechanism of diurnal circulation going through the following steps. The convective clouds develop over the mountains encouraged by latent energy release. It leads to deep convective clouds with a high cloud bottom, while it also makes a huge amount of precipitation because of the relatively small saturation pressure. At the same time, these convections can bring down the westerly momentum in the upper troposphere with their downward stream. Then, this precipitation cools the surrounding air mass (by 2 to 4 K) by strong evaporation due to the relatively dry surrounding atmosphere. This significant amount of cold air mass under the cloud bottom induces a pressure gradient (meso-high) in the direction of the valley. As the wind blows from mountain to valley, lined convections are formed with cold air mass, with pushing up comparatively warm air mass in the valley. On the other hand, the contrast in the strength of westerly between inside and outside of the meso-high makes vorticity. For this validation, we made a comparison between the observation data and the simulation data. And these simulation data indicated pretty good correspondence with the observation data.

H12C-1008 1330h POSTER

US CONTRIBUTIONS TO THE COORDINATED ENHANCED OBSERVING PERIOD (CEOP) AND THEIR BENEFITS TO US WATER CYCLE RESEARCH

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The USA is a major contributor to the World Climate Research Programme's Coordinated Enhanced Observing Period (CEOP). Many US scientists are engaged in the project because they are convinced of the project's value for longer-term climate studies. The facilities of DOE, NASA and NOAA feature in US contributions to CEOP data set development. Through support from NOAA and NASA, UCAR is playing a major role in data processing and data set development. In return for these contributions, US scientists now have access to large international data sets that did not previously exist or were difficult to access. The use of these data sets for Water and Energy Simulations and Predictions and Monsoon system studies are already underway. These efforts will contribute to the Climate Change Science Program's (CCSP) Water Cycle theme, GEWEX Americas Prediction Project and NOAA's emerging Intraseasonal to Interannual Prediction (ISIP) program. The systems being developed through this process will advance some of the goals of the Water Cycle theme within the Integrated Global Observing Strategy (IGOS) Partnership. However, there will be many more opportunities for creative use of these data sets. The purpose of this presentation is to increase awareness of the US contributions to CEOP; to provide interested scientists with information on how to access these data sets and to obtain feedback on additional uses of these unique global data sets.

H12D MCC: Level 2 Monday 1330h

Hydrologic Predictions in Ungauged Basins: PUB I Posters *(joint with NG)*

Presiding: **T Wagener,** University of Arizona**; D Schertzer,** Laboratoire de Modélisation en Mécanique, Université Pierre et Marie Curie

H12D-1009 1330h POSTER

Regional Flood Frequency Equations: What Level of Complexity is Rational?

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The "single-return-period" prediction equation of the log-log multivariate regression form in which a peak discharge of a specific return period is related to one or more watershed and meteorologic characteristics is the most frequently used regional flood frequency procedure in the US for ungaged, uregulated rural streams. Equations are developed for a region that is identified as homogeneous based on underlying hydrologic/meteorologic and geologic/soil properties. The number and type of explanatory variables used in regression equations vary. For example, most regional regression equations developed by the US Geological Survey and compiled into "The National Flood Frequency Program," are based on watershed characteristics such as: drainage area, mean basin elevation, and channel slope. Other explanatory watershed variables used include parameters such as: storage area of lakes/ponds, forest cover, channel length, basin shape, high elevation index. Climatic characteristics present in some of the equations consist of mean annual rainfall, rainfall amount for a specified duration, mean annual snowfall and/or minimum mean January temperature. The development of GIS based models, such as ArcHydro or Watershed Modeling System, has created an opportunity to easily produce extensive sets of hydrologic parameters that could be investigated as possible predictors of T-year discharges. As a result, prediction equations tend to be even more complex than they used to be. However, based on our results, it appears that such equations may actually generate less accurate flood estimates than very simple equations that include only one or two predictors. Equations are highly sensitive to uncertainties (errors) in explanatory variables, both in calibration and in prediction mode. Based on our study for several watersheds in Utah we'll try to answer the question on how much complexity in prediction equations is really rational.

H12D-1010 1330h POSTER

A new GIS-based routing scheme for hydrological models

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The development and application of a new GIS-based routing scheme for hydrological models are presented in this paper. The new approach differs from previous methods in four aspects: (1) it computes the flow direction continuously from 0° to 360° and allows runoff to leave each grid from any angle between 0° to 360° rather than from only one of the eight directions (i.e., 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315°) which allows the new GIS-based routing scheme to be able to represent efficiently effects of different spatial and temporal resolutions of the digital elevation model (DEM) data on river network routing; 2) it considers impacts of land cover/use change on overland and river routing dynamically; (3) it advances the early routing methods by fully coupling it with a hydrological distributed model to consider runoff re-infiltration; and (4) it corrects the flow directions at the boundary grids of a watershed by taking the advantage of DEM data at a finer spatial resolution. The new routing scheme