SAHRA

ana NSF Science and Technology Center
at the University of Arizona

Welcome to SAHRA's

1st Annual Meeting

Tuesday, February 20, 2001 -

Friday, February 23, 2001

The DoubleTree Hotel - Tucson, Arizona

NSF Science and Technology Center for
SUSTAINABILITY OF SEMI-ARID HYDROLOGY AND RIPARIAN AREAS

SAHRA's First Annual Meeting
February 20-23, 2001

Doubletree Hotel - Reid Park - 445 S. Alvernon Way, Tucson, Arizona

AGENDA

Tuesday, 2/20 – Student Activity

1:00-6:00	San Pedro field trip (departs UA @ 1:00 and DoubleTree @ 1:20)
6:30	Student Dinner/Social, Gentle Bens Brewing Co. 865 E University Blvd.

Wednesday, 2/21 – Meeting of Scientists to Report on Research Task Progress

See Wednesday's expanded agenda for detailed schedule

8:30-12:00	Science Presentations by Researchers (faculty, staff, students, stakeholders)
12:00-1:30	Lunch/Posters
1:30 –5:00	Science Presentations -- *Continued*
6:00	Dinner (open to all) at Doubletree Inn

Thursday, 2/22 – Sustainability of Water Resources of the Semi-Arid Southwestern U.S.A.

All presentations are 30 minutes, followed by 10 minutes for questions

8:30-8:40	Welcome (*Sorooshian*, *Richard Powell* – VP for Research, *Bruce Umminger* - NSF)
8:40-9:10	Keynote Speaker – *John Bernal*
9:10-9:50	Managing Water Resources in the Southwest: Demand/Supply (*Valdes*/*Brookshire*)
9:50-10:20	Break/Posters
10:20-11:00	Modeling as a Tool for Decision Making (*Winter*/Stakeholder)
11:00-11:40	Advancing water management by sharing information and technology (*Woodard*/*Dave Harris*, Nature Conservancy)
11:40-12:00	CLIMAS Experience with stakeholders (*Hartmann*/*Pagano*)
12:00-1:30	Lunch/Posters
1:30-2:10	Understanding the Environmental Water Balance (*Bales*/*Dallas Reigle*, Salt River Project)
2:10-2:50	Understanding Basin-scale Solute and Water Balances (*Phillips*/*Rolf Schmidt-Peterson*, New Mexico Interstate Stream Commission)
2:50-3:30	Semi-arid Riparian Ecosystems - Understanding Corridors of Water and Biodiversity in the Desert (*Goodrich*/*Holly Richter*, Nature Conservancy)
3:30-3:50	Break/Posters
3:50-4:20	Your Role in Promoting Hydrologic Literacy (*Washburne*/*John Madden*, Desert View High School)
4:20-4:30	HyDIS – Collaborative Opportunities (*Imam*)
4:30-4:45	Planning for international outreach activities (*Liverman*)
5:00-6:00	Advisory Board Caucus
7:00-9:00	Working dinner: Meeting of Executive Committee, Advisory Board and NSF Reps

Friday, 2/23 – Planning On-Going and Future Activities

8:30-8:45	All convene: Discuss goals and procedures
8:45-10:30	Breakout sessions – Thrust Area planning
10:30-10:40	Break
10:40-11:30	All reconvene: TA leaders present summaries
11:30-1:00	Lunch

END OF FORMAL MEETING

Wednesday 2/21 Presentations for SAHRA 2001 Annual Meeting

	Oral Presentations	Poster Presentations
8:30	Session Introduction Soroosh Sorooshian, Doug James	
8:50	Overview & Poster Introductions (1 min. each), Roger Bales, Constance Brown Ginger Paige 1.1o. Geostatistical Interpolation of Point-Measured SWE in the Colorado River Basin, *Kevin Dressler, et al.* 1.2o. Dynamics of Energy Balance, Vegetation and Snowmelt: Implications for Alpine/Sub-Alpine Water Balance, *C. Brown and R. Bales* 1.3o. Toward High Resolution Precipitation Estimates from Multiple Sources of Information, *Shayesteh Mahani, et al.*	1.1p. Snow Distribution and Snow-Melt Modeling Studies in the Headwaters of the Rio Grande, *T. Bardsley, J. McConnell and D Boyle (DRI)* 1.2p. Rainfall Estimation Over the Southwest US Using the PERSIANN System, *X. Gao, K. Hsu, S. Mahani, and S. Sorooshian (UA)* 1.3p. Improved performance of PERSIANN System in High Resolution Precipitation Estimation, *K. Hsu, S. Mahani, Q. Fan, J. Li, X. Gao, and S. Sorooshian* 1.4p. A Two-dimensional Analysis of the Spatial Sensitivity of the Four-Electrode Electrical Resistivity Method, *Alex Furman, Ty Ferre, Art Warrick (UA)* 1.5p. Spatial Variability of Infiltration and Runoff Processes, *G. Paige, J. Stone and A. Warrick (ARS)* 1.6p. Temporal Stability of Soil Moisture: A promising technique for long-term water resources assessment in semiarid regions, *Binayak Mohanty and Todd Skaggs (UCR)* 1.7p. Rosetta: a Hierarchical Model for Estimating Soil Hydraulic Parameters, *M. G. Schaap, F. J. Leij and M. Th. van Genuchten (UCR)*
9:35	Overview & Poster Introductions (1 min. each), Fred Phillips, James Hogan 2.1o. Mountain-Front Recharge and the Dynamics of Ephemeral Streams in The Rio Grande Basin, Yizhong Qu and Christopher Duffy (PSU) 2.2o ^{32}Si – A new method for estimating semiarid vadose zone recharge, *Sharon Einloth and Brenda Ekwurzel (UA)* 2.3o. Shifting paradigms in semi-arid vadose – zone hydrodynamics: implications for water and solute balances at the basin-scale, *Michelle A. Walvoord and Fred M. Phillips (NMT)*	2.1p Modeling Actual Evapotranspiration of Riparian Vegetation, *Sung Ho Hong and Jan M.H. Hendrickx (NMT)* 2.2p. Surface Soil Moisture Variability at the Sevilleta LTER, J. Woolslayer; J.M.H. Hendrickx; J.B.J. Harrison, and L. Winters (NMT, LANL) 2.3p. Water flow through indurated calcic, Graciela Rodríguez-Marín, J. Bruce J. Harrison, and Jan M.H. Hendrickx (NMT) 2.4p. Investigating Relationships Between Vegetation and Moisture Fluxes in Deep Vadose-Zones: A study in the Rio Grande Basin, West Texas , *Michelle A. Walvoord and Fred M. Phillips (NMT)* 2.5p. Influence of rainfall variability on water and nitrogen cycling and productivity at a semiarid ecosystem transition, *Eric E. Small and William T. Pockman (NMT, UNM)* 2.6p. Controls on the Surface Energy and Water Budgets of Semiarid Environments, *Shirley Kurc and Eric Small (NMT)* 2.7p. Identification of Sources of Recharge in Avra Valley Alluvial Basin, *Dody A., Eastoe C., and Long A (UA-GEO)* 2.8p. Stable Sulfur Isotopic Composition of Dissolved Sulfate in Tucson Basin Aquifers, Arizona, and Its Use as a Tracer of Recharge Process and Ground Water Movement, *Gu, A.L., Eastoe, C.J., and Long, A. (UA-GEO)*

		2.9p. A New Map of ^{14}C Content in Groundwater in Tucson Basin, *C. J. Eastoe, A. Dody, A. Long (UA-GEO)* 2.10p. Singular Spectrum Analysis of Historical P, T, and Q in the San Pedro River Basin, Karsten Sedmera and C. Duffy (PSU) 2.11p. Chloride/Bromide ratios in the Rio Grande River, *Naomi Rosenau, Fred Phillips (NMT)*
10:20	Poster Break	
10:45	Overview & Poster Introductions (1 min. each) *Dave Goodrich, Russ Scott* 3.1o. Riparian vegetation water use and sources, *R. Scott, D. Williams, G. Lin, D. Goodrich* 3.2o. Hydrologic exchange and nutrient retention in the riparian zone of the San Pedro River, *Schade, J.D., D.B. Lewis, A. Kramer-Huth, M. Conklin, and N.B. Grimm* 3.3o. Using Temperature Sensors to Monitor Groundwater/Surfacewater Interactions in the San Pedro River, Arizona, *D. Lawler, S. Leake, J. Constantz, T. Ferre, and D. Goodrich*	3.1p. Characterizing stream nitrogen load as a result of geomorphological and hydrologic changes in the San Pedro River , *J.M. Hamblen, A. Kramer Huth, M.H. Conklin, J.D. Schade, D.B. Lewis, N.B. Grimm (UA, ASU)* 3.2p. Plant functional type variation and hydrologic processes in riparian ecosystems, *E. Gonzales, E., K. Hultine, and D.G. Williams (UA-RNR)* 3.3p. Recent applications of the Hydrus-2D software: Future plans "tentative", *J. Simunek and M. Th. van Genuchten (UCR)and M.P.L. Whitaker (UA)* 3.4p. Designing a Vadose Zone Monitoring System for the Measurement of Root Uptake Beneath a Riparian Area, *G. VonGlinski, T. Ferre (UA)*
11:30	Overview & Poster Introductions (1 min. each), Larry Winter 4.1o One Year Simulations of Precipitation Over the Upper Rio Grande Basin, *K. Costigan, J. Bossert, J. Stalker, and D. Langley (LANL)* 4.2o. The Modular Modeling System (MMS), *George Leavesley (USGS)* 4.3o. Development of a Coupled Model for the Rio Grande River Basin, *Everett Springer, L. Winter, K. Costigan, R. Murray and P-H. Tseng, (LANL)* 4.4o. Mass and Momentum Transfer at a Stream-Aquifer Boundary, *Regan Murray (LANL)*	4.1p. Development of Near-Real-time Land Surface Forecasts, *Y. Cui and J. Roads (UCSD/Scripps)* 4.2p. Modeling Efforts using Modular Modeling System in Southern Arizona, *Felipe Ip, Luis Bastidas, Hoshin Gupta (UA-HWR)*
12:15	Lunch and Poster Viewing	
1:45	Overview (3 min), Juan Valdes 5.1o. Analysis of Drought Condition in the Rio Conchos River Basin, *Tae-Woong Kim and Juan Valdes (UA-CE)* 5.2o. Culturally Diverse Views of Water Use and Management in the Salt/Gila and Upper San Pedro Basins, *Anne Browning , Robert Varady, Ann Moote, , Maria Gutierrez and Kevin Lansey (UA-Udall/CE)* 5.3o. Uncertainty, Benefit Transfers, and Physical Models: A Middle Rio Grande Valley Focus,	5.1p. Stakeholder Assessment in the Upper San Pedro River Basin, *Ann Moote and Maria Gutierrez (UA)* 5.2p. Water in Mexico, *D. Liverman, T. Cavazos, M. Wilder (UA), N. Pineda, J.L.Moreno (Colegio de Sonora),M. Kelly (Texas Center for Policy Studies)* 5.3p. Decision Support System for Sustainable Water Resources Management, *Antonella Sciortino, James McPhee, and William W-G. Yeh (UCLA-CEE)* 5.4a. Sustainability, Intergenerational Equity and Inter-temporal Efficiency: The Role of Discounting and Individual Choice, *David S. Brookshire, Stu Burness and Janie M. Chermak*

	David S. Brookshire, Janie Chermak, and Rick DeSimone (UNM) 5.4o. Urban Water Demand in the Southwest, *Janie Chermak, David S. Brookshir and, Stu Burness (UNM)* Poster Introductions (1 min. each)	*(UNM)* 5.5a. Water Use in a Mountain Front Recharge Aquifer with a Perennially Gaining Stream, *David S. Brookshire, Stu Burness, Janie Chermak and Rick DeSimone (UNM)* 5.6a. Preserve, Extend or Create It and They will Come: Migratory Birds and Riparian Habitat in the Southwest, *Kathy Smith (UNM)* 5.7a. Experimental Tests of Response to Changes in Water Prices, *David S. Brookshire, Janie M. Chermak, and Kate Krause (UNM)* 5.8a. The Farm Module, *Wolfgang Schmid (UA)*
2:45	Short Break	
3:00	Overview & Poster Introductions (1 min. each), Jim Washburne 6.1o. Improving the hydrologic literacy of K-12 teachers, *Julie Luft/John Madden (UA)* 6.2o. Water is Life - Water Education for Native Americans, *Mansel Nelson (NAU-EEOP)* 6.3o. Improving the hydrologic literacy of non-science undergraduates, J. *Washburne (UA)*	6.1p. Ask the Questions … Experience the Answers!, *Kerry Schwartz, AZ Project WET Education Program Coordinator(WRRC)* 6.2p. Tribal Watershed Training Program, *L. Lacher (WMA)* 6.3p. Everybody's doing it - Urban Water Conservation Programs, *Abby/Katherine* 6.4p. Proposed Biosphere2 Educational Collaboration, *Russell, Adams, Woods, Colodner (B2C)* 6.5p. Professional Development with Hopi Tribe, *A. Tecle (NAU)*
3:45	Overview & Poster Introductions (1 min. each), Gary Woodard 7.1o. Improving Interjurisdictional Water Management: Tribes, States and Feds, Bonnie Colby (UA-AgEcon) 7.2o. Water in Mexico, *Diane Liverman (UA-LASP)* 7.3o. SAHRA Promotional Activities, Web Site and Database Management, Kyle Carpenter	7.1p. SAHRA traveling display and kiosk 7.2p. Water Resource Challenges of MegaCities, *Gary Woodard (UA)*
4:30	Wrap-up Discussion	

Abstracts for SAHRA 2001 Annual Meeting
Wed. 02/21 Science Presentations

1.1o. Geostatistical Interpolation of Point-Measured SWE in the Colorado River Basin

K.A. Dressler[a], S.R. Fassnacht[b], R.C. Bales[ab], R.E. Davis[c], D. Lampkin[a], D.E. Myers[d]

[a] Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA), University of Arizona
[b] Southwest Regional Earth Sciences Applications Center (RESAC), University of Arizona
[c] Cold Regions Research Lab (CRREL), US Army Corps of Engineers (USACE)
[d] Department of Mathematics, University of Arizona

In this study we geostatistically interpolate spatial Snow Water Equivalent (SWE) for the entire Colorado River Basin of the Western US at a 1 km grid for the water years 1992-1993, 1997-1998 and 1998-1999, using multiple interpolation methods and multiple combinations of the snow telemetry (SNOTEL) and snow-course data. This study evaluated four techniques: Inverse Distance Weighting (IDW), Optimal Distance Averaging (ODA), hypsometric (regression with elevation) and step-wise linear multivariate regression (with 15 physiographic variables). We observed similar broad spatial patterns of SWE using the different techniques. However, within several sub-basins, small-scale differences in SWE distribution were observed, attributed to differences in the interpolation methods. Regression methods exhibit the best overall performance in relation to grid block error.

1.2o. Dynamics of Energy Balance, Vegetation and Snow Melt: Implications for Alpine/Sub-Alpine Water Balance

Constance Brown, Roger Bales
Department of Hydrology and Water Resources, UA

Snow accumulation, distribution and melt in higher elevations provide the basis for understanding and predicting runoff and recharge. In order to estimate and model snow distribution and melt above the mountain front, an intensive observation network (in space and time) is proposed for one local alpine area (Mt Bigelow in the Santa Catalina) to document the significant inputs and outputs to the sub-alpine water balance. This is especially critical during snow melt when there are rapid changes in both land-atmosphere exchange and hydrologic processes. Understanding dynamics such as melt patterns within vegetated canopy, turbulent and non-turbulent fluxes, surface temperature vs aerodynamic surface temperature, temporal and spatial forcing and mitigating parameters for snow melt and melt water supply, sublimation, co-evolution of snow melt, energy balance, soil moisture and evapotranspiration, is needed to varify and improve physically based energy balance snow melt models and evaluate approaches to aggregate snow melt estimates and predictions to larger scales.

1.3o. Toward High-Resolution Precipitation Estimates from Multiple Sources of Information

S. Mahani, X. Gao, K. Hsu, J. Li, Q. Fan, and S. Sorooshian
Department of Hydrology and Water Resources, UA

Under the support of the STC-SAHRA and NASA EOS-TRMM programs, our efforts have been focused on the high-resolution rainfall estimation and to extend our model estimates from rainfall to the snowfall depth during the winter seasons. With regard to the high-resolution rainfall estimation, our final goal is to provide hourly rainfall estimates at a 4 km x 4 km scale. Several efforts have been implemented in refining our developed rain algorithm (PERSIANN, Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks). In this presentation, practical applications of PERSIANN rainfall estimates over the Southwest United States and several recently developed rainfall and snow depth estimation algorithms are introduced.

1.1p. Snow Distribution and Snow-Melt Modeling Studies in the Headwaters of the Rio Grande

Tim Bardsley, Joe McConnell, Douglas P. Boyle
Desert Research Institute

The majority of runoff in many semi-arid regions begins as seasonal snow pack, so understanding the spatial and temporal distribution of snow and the processes that control snowmelt in these regions is critical. Initial SAHRA efforts at the Desert Research Institute are aimed at improving estimates of snow distribution in the headwaters of the Rio Grande in southwestern Colorado through a combination of hydrologic modeling and research snow surveys. Surface runoff and snow distribution will be estimated using a combination of USGS Modular Modeling System (MMS), GIS Weasel, Precipitation-Runoff Modeling System (PRMS), and "XYZ" snow distribution model. Subsequent, highly collaborative studies will be aimed at improving models of snowmelt processes by incorporating field measurements of snow distribution.

1.2p. Rainfall Estimation Over the Southwest United States Using the PERSIANN System

X. Gao, K. Hsu, S. Mahani, and S. Sorooshian
Department of Hydrology and Water Resources, UA

Precipitation is the main source of input to the surface hydrologic system. Better quantitative estimation of precipitation would enhance our prediction of flood and management of water resources. Under the support of the NASA EOS-TRMM and STC-SAHRA programs, a satellite-based precipitation system, PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) is developed. This system uses multiple sources of information from TRMM instant microwave rain rates (TRM 2A25) and ground-based radar rain rates in combination with visible and infrared imagery from multiple geosynchronous satellites to provide hourly rainfall estimates over the Southwest United States. In this presentation, evaluation of PERSIANN rainfall estimates during the monsoon season of 1999 over the Southwest United States is discussed. Further potential use of PERSIANN short-term rainfall estimation and diurnal, monthly, seasonal rainfall for hydrologic modeling and regional climate modeling will be addressed.

1.3p. Improve PERSIANN System in High-Resolution Precipitation Estimation

K. Hsu, S. Mahani, X. Gao, J. Li, Q. Fan, and S. Sorooshian
Department of Hydrology and Water Resources, UA

In this presentation, enhancement of the PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) system in high-resolution rainfall and snow estimation is demonstrated. In the development of rainfall algorithms, two approaches are tested. The first approach considers the relationships between various cloud types and their rainfall distributions. This approach includes a cloud classification scheme and a procedure for finding rainfall distributions with respect to each classified cloud type. The second approach addresses the improvement of rainfall estimates by providing effective system input features from mesoscale model (RAMS, the Regional Atmospheric Modeling System) parameters related to rainfall generation, such as precipitable water, column ice particle contents, lower wind flow vectors, and CAPE (Convective Available Potential Energy). On the snow depth estimation, a model is developed to estimate hourly snow depth by considering variables from various sources, including cloud-top temperatures of satellite infrared imageries, ground surface temperatures, and topographic information (elevations). Ground daily snow observations from 32 SNOWTEL sites were selected. Testing results show model estimates agree well with observations.

1.4p. A Two-dimensional Analysis of the Spatial Sensitivity of the Four-electrode Electrical Resistivity Method

Alex Furman, Ty Ferre, Art Warrick

Surface electrical resistance tomography (ERT) is a promising tool for nondestructive, noninvasive monitoring of water movement beneath ephemeral channels in arid environments. Characterization of the spatial sensitivity of the method as a function of electrode geometry is a necessary first step to improve survey design and to optimize the eventual inversion of ERT data to characterize subsurface hydraulic parameters.

We present a two-dimensional analysis of the response of a homogeneous system to small perturbations in the electrical conductivity. For each geometry considered, visualizations are presented that identify areas of greater and lesser sensitivity to subsurface electrical properties. Future work will extend these analyses to heterogeneous systems and into three dimensions. These results will be incorporated into the design of ephemeral stream monitoring networks to be implemented in Rillito Creek, the Walnut Gulch Watershed and along ephemeral reaches of the San Pedro River.

1.5p. Spatial Variability of Infiltration and Runoff Processes

Ginger Paige [1], Jeffry Stone[1], Art Warrick[2]

[1]USDA-ARS, Southwest Watershed Research Center, Tucson, AZ
[2]Department of Soil, Water, and Environmental Science, University of Arizona

Identifying source areas of runoff at a range of scales is essential to develop watershed scale evaluation models and methodologies to predict and assess impacts of upland management on watershed processes. Recently, a variable intensity rainfall simulator was used to measure and model the spatial variability of infiltration and runoff process on a small watershed within the Walnut Gulch Experimental Watershed. The results showed that runoff was significantly affected by rainfall intensity and the response varies with soil and vegetation characteristics. This study will be extended to a range of soil and vegetation sites within the San Pedro River Basin

1.6p. Temporal Stability of Soil Moisture: A Promising Technique for Long-term Water Resources Assessment in Semiarid Regions

Binayak P. Mohanty[1,2] and Todd H. Skaggs[2]
[1]University of California, Riverside and [2]George E. Brown Jr Salinity Laboratory

Time stability analysis of soil moisture is critical for determining the characteristic combinations of different factors such as soil, topography, vegetation, and climate that governs hydrologic processes at different scales. Related findings will help design the long-term water resources monitoring network at these scales. Using a data set from SGP97 Hydrology experiment, better time stable features were observed within a footprint containing sandy loam soil than within two pixels containing silty loam soil. Additionally, flat topography with split wheat/grass land cover produced the largest spatio-temporal variability and the least time stability in soil moisture patterns. Footprint-scale variability and associated nonlinear soil moisture dynamics may prove to be critical in the regional-scale hydro-climatic models.

1.7p. Rosetta: a Hierarchical Model for Estimating Soil Hydraulic Parameters

M. G. Schaap[illegible], F. J. Leij[illegible] and M. Th. van Genuchten[illegible]
[illegible]

Pedotransfer functions (PTFs) are increasingly being used to obtain soil hydraulic characteristics for local, regional and global scale hydrological problems. We present a set of PTFs that predict water retention, saturated and unsaturated hydraulic conductivity from texture bulk density and other soil data. We gave these PTFs a hierarchical character to make optimal use of limited or more extended sets of available predictors. The PTFs allow the prediction of water retention, saturated and unsaturated hydraulic conductivity and are implemented in the program Rosetta (available at www.ussl.ars.usda.gov/models/rosetta.htm) .

2.1o. Mountain-Front Recharge and the Dynamics of Ephemeral Streams in The Rio Grande Basin

Yizhong Qu and Christopher Duffy
Pennsylvania State University

Developing physically-based rainfall-runoff models for large river basins represents a major challenge in hydrology. In this research, historical observations, numerical experiments and signal processing tools will be applied to study the mechanisms and dynamics of recharge in the Rio Grande Basin. First, the river basin will be sub-divided based on physiography and singular spectrum analysis of historical weather and runoff records. Then numerical models (FEMWATER or WASH1/2/3D) will be applied and parameterized for each sub-region, and used to study the pattern of recharge in the Rio Grande. This, we hope, will be useful in studying mountain front systems in general.

2.2o ^{32}Si – A new method for estimating semiarid vadose zone recharge

Sharon Einloth and Brenda Ekwurzel
University of Arizona

Silicon-32 has gained significant interest as a tracer because of its strategic half-life of ~140yrs. Previously, though, the exchange of silica in water with that in soil sediments has precluded its use as a groundwater tracer. We suggest an alternate method to use silicon-32 as a tracer to indicate recharge patterns in semi-arid regions. This is done by taking advantage of the sediment exchange process and measuring the silicon-32 in the soil. A depth profile of 32-silicon deposition provides information on the depth penetration of infiltration for various time scale precipitation events.

2.3o. Shifting paradigms in semi-arid vadose –zone hydrodynamics: implications for water and solute balances at the basin-scale

Michelle A. Walvoord and Fred M. Phillips
New Mexico Tech

In the interest of groundwater resource management, we are concerned with accurately quantifying a component of the water and solute balances that is poorly understood: flux through deep semiarid vadose zones. Previous studies assume the deep flow regime to be dominated by a gravity-driven liquid flux. We offer a revised conceptual model of semiarid vadose-zone hydrodynamics that allows for upward fluxes, incorporates the geothermally-driven vapor flux and includes the critical role of desert vegetation in maintaining very negative pressures at the base of the root zone. Matric potential and chloride profiles, produced by numerically simulating the set of assumptions associated with each of the two conceptual models, strongly favor the revised paradigm. Our work suggests that values of recharge through semiarid vadose zones cited in previous studies may be significant overstimates.

2.1p Modeling Actual Evapotranspiration of Riparian Vegetation

Sung Ho Hong and Jan M.H. Hendrickx
New Mexico Tech

The US Salinity Laboratory Hydrus 1 D was used to model evapotranspiration in the arid riparian area, Bosque del Apache, NM. The field site consists of young (5 to 15 year old vegetation) open cottonwood-willow stands, and dense old-growth single-species cottonwood stands. Two micrometeorology towers in the saltcedar, and one in the cottonwood measure actual evapotranspiration rates at 90.4 cm/y in the cottonwood, and 132.5 cm/y in the saltcedar. Models were created to match conditions at the two-micrometeorology towers in order to calibrate the Hydrus 1 D models to the field site. Fifteen months of field and laboratory data were obtained from the site, and provided input data for the soil hydraulic parameters, soil profile data, root density, groundwater level data, and weather data. Evapotranspiration data contain a large amount of noise, and vary tremendously from day to day; therefore an averaged evapotranspiration rate was used to compare results. The resulting models in the Saltcedar area were found to match measured evapotranspiration when data are averaged to 10-day intervals. The cottonwood model underestimated soil evaporation, which is a result of soil cracks and vapor phase transport. These results show that the Hydrus 1 D model can be used successfully as a predictive tool to model evapotranspiration in field sites that have measured data.

2.2p. Surface Soil Moisture Variability at the Sevilleta LTER

J. Woolslayer; J.M.H. Hendrickx; J.B.J. Harrison, and L. WINTERS,
New Mexico Institute of Mining and Technology; Los Alamos National Labs

Study objective is to evaluate soil moisture variability on various spatial and temporal scales in central New Mexico. Volumetric soil water content samples were taken for the top 5cm of soil at 20 sites, 15 samples per site, on 8 sampling days from October 1999 through December 2000. Nineteen out of the 20 sites are dominantly medium grained sand which vary in volumetric water content from <1% to 8%. Comparisons of the soil water content among the 15 samples along the 150 meter transect at each site for each day shows that as the volumetric water content rises the variation also increases proportionally.

2.3p. Water flow through indurated calcic

Graciela Rodríguez-Marín, J. Bruce J. Harrison, Jan M.H. Hendrickx and Jirka Simunek
New Mexico Tech; U.S. Salinity Laboratory

Indurated calcic horizons are a common feature of desert soils in New Mexico. Literature reports proclaimed frequent dissolution pipes in these indurated calcic horizons. Our own field observations have confirmed this on the La Mesa Surface in southern New Mexico. Our laboratory measurements showed that the indurated calcic horizons have a low hydraulic conductivity while the soil materials filling the dissolution pipes have a relatively high hydraulic conductivity. This leads to the hypothesis that downward water fluxes inside and outside pipes differ considerably. The objective of this study is to test this hypothesis using laboratory analyses of soil samples taken within and outside pipes as well as computer simulations of unsaturated water flow. Laboratory analyses of chloride and carbonate contents showed that the soil profiles inside the pipes have much lower chloride and carbonate contents than the surrounding calcic horizons. Computer simulations of downward water fluxes over the period 1960-1990 confirm that water fluxes inside the pipes are much higher than those outside the pipes. Therefore, dissolution pipes in indurated calcic horizons may lead to higher ground water recharge rates than previously thought.

2.4p. Investigating Relationships Between Vegetation and Moisture Fluxes in Deep Vadose-Zones: A study in the Rio Grande Basin, West Texas

Michelle A. Walvoord and Fred M. Phillips
New Mexico Tech

The desire to better manage groundwater resources in arid and semiarid regions results in a need to better quantify all the components of the water and solute balance within a basin. The components of water and solute fluxes within thick vadose zones have been given little attention until recently. This ongoing project addresses the contribution of soil-water fluxes to the underlying aquifers by exploring the link between vegetation type and moisture fluxes. Soil cores from five locations under different vegetation types in the Rio Grande basin in West Texas were collected and analyzed for hydrologic physical parameters and natural solute tracers, including chloride, bromide and nitrate. Vegetation types included long-established Chihuahuan mixed desertscrub, recently-encroached creosotebush, plains grassland and juniper woodland. Matric potential and solute profiles indicated that xeric (desert) vegetation prevents all moisture from penetrating below the root zone and actually induces upward moisture fluxes below the root zone. In contrast, mesic vegetation appears to allow significant downward moisture and solute fluxes past the root zone. If vegetation type, a readily observable surface property, serves as a reasonable indicator of deep moisture fluxes, then the spatial distribution of recharge through desert floors might be characterized using vegetation maps. Such a method would be time-efficient and relatively inexpensive.

Application to the basin scale would require point measurements for ground-truthing, but field investigations would be much less extensive than conventional approaches since vegetation distribution patterns could be used to sample strategically.

2.5p. Influence of rainfall variability on water and nitrogen cycling and productivity at a semiarid ecosystem transition

Eric E. Small and William T. Pockman
Hydrology Program (NMT); Department of Biology (UNM)

Over the past century, extensive areas of grassland have been invaded by shrubland in the southwestern U.S. Grass and shrub systems are very different, so geographic shifts in the grass-shrub ecotone yield substantial changes in ecosystem structure and function. Our research objective is to evaluate how changes in precipitation amount influence the rate and mechanisms of the transition between semiarid grassland and shrubland ecosystems on seasonal to multi-year timescales. We are addressing three questions. (1) How do interactions between the water cycle and plants influence how soil moisture and surface water redistribution change in response to variations in rainfall? (2) How do interactions between nitrogen cycling and plants influence how the amount and time-space distribution of plant-available nitrogen changes in response to variations in rainfall? (3) How do the contrasting life history and physiological traits of grasses and shrubs produce different responses to changes in the availability of soil water and nitrogen?

We are addressing these questions by monitoring water and nitrogen cycling and plant productivity in rainfall manipulation plots. Plots are located at the grass-shrub biome transition, permitting a direct comparison of the responses of these functional types. We have constructed nine 10 m x 15 m plots: three receive rainfall addition, three are subjected to limitation in rainfall amount, and three are controls. Water addition and limitation are +/- 50% and maintained throughout the year, similar to the most intense droughts and wet periods observed during the 20th century. Our monitoring falls under three main categories: water cycling, nitrogen cycling, and plant productivity. Coupled monitoring of these different processes will help untangle the complex interactions between plants, nitrogen, and water in semiarid environments.

2.6p. Controls on the Surface Energy and Water Budgets of Semiarid Environments

Shirley Kurc and Eric Small
New Mexico Tech

Land-atmosphere interactions influence climate and hydrology in semiarid environments. Soil moisture state and vegetation type are believed to strongly control the nature of these interactions. We directly compare the influence of soil moisture and vegetation on the fluxes of water and energy between the land surface and atmosphere. This was accomplished by measuring the energy and water budgets at three sites spanning the shrub-grass ecotone boundary at the Sevilleta Wildlife Refuge, New Mexico. The Bowen Ratio-Energy Balance method was used at two of the sites and eddy correlation at the third.

We present the following results. First, changes in the evaporative fraction (EF) resulting from wet versus dry soil moisture conditions are dramatic. The EF is ~0.1 when the soil is dry and ~0.5 when the soil is wet following rainstorms. Second, changes in EF following rainfall events are short lived – persistence is on the order of days. Therefore, a soil-moisture rainfall feedback will only exist if the atmospheric conditions conducive for convective precipitation occur within several days after a rainfall event. Third, the evaporative fraction and net radiation response to rainfall and the persistence of anomalous conditions are nearly identical across the grass-shrub ecotone. This suggests that vegetation type yields a weak influence on land-atmosphere interactions in semiarid regions, compared to the effects associated with wet versus dry soil. It is therefore noted that, especially for the purpose of upscaling or downscaling information, vegetation does not control soil moisture-rainfall feedbacks in semiarid regions.

2.7p. Identification of Sources of Recharge in Avra Valley Alluvial Basin

Dody A[1]., Eastoe C[2]., and Long A.[1,2].

Hydrology and Water Resources Department; Geosciences Department; University of Arizona, Tucson, AZ

Avra Valley, an alluvial valley west of Tucson, supplies groundwater for agriculture and city uses. Recharge is from ephemeral streams and runoff from low mountains. Groundwater in most of Avra Valley has an $\delta^{18}O$ range of –8.3 to –7.0‰ consistent with an origin as low-altitude precipitation. Near the Santa Cruz River, $\delta^{18}O$ values as low as –9.8‰ indicate groundwater that originated as high-altitude precipitation. Tritium is undetectable (<1.5 TU) except for an area extending 2 km south of the Santa Cruz River. Rapid recharge of exploited aquifers occurs only in this area. High pMC values (>80) are also limited to this area. Lowest pMC values (20 - 30) are associated with warm groundwater of low $\delta^{18}O$ (–8 to –9‰) and undetermined origin.

2.8p. Stable Sulfur Isotopic Composition of Dissolved Sulfate in Tucson Basin Aquifers, Arizona, and Its Use as a Tracer of Recharge Process and Ground Water Movement

Gu, A.L., Eastoe, C.J., and Long, A.

Department of Geosciences, University of Arizona, Tucson, AZ 85721

Tucson basin groundwater has sulfate contents ranging from 4 to 960 mg/l, and d34S values ranging from -1.6 to +21 per mil. At least 3 end-member waters are present in basin sediments: 1. high sulfate with d34S near +13 per mil; 2. high sulfate with d34S of +4-6 per mil; and 3. low sulfate with d34S near +5 per mil. End-member #1 derives sulfate from Cienega Creek or Pantano Formation Gypsum; #2 from Santa Cruz River or Tinaja Beds gypsum; and #3 from mountain runoff. #1 contributes solute to a plume of water traceable from SE to NW across the basin. Other local end-members may be associated with fracture-flow in granitic gneiss (high sulfate, 8-10 per mil) and recent smelting (low sulfate, 0-3 per mil).

2.9p. A New Map of ^{14}C Content in Groundwater in Tucson Basin

C. J. Eastoe[1], A. Dody[2], A. Long[1,2]

Geosciences Department, University of Arizona; Hydrology and Water Resources Department

The ^{14}C content of groundwater in Tucson Basin ranges from 9 to 120 pMC (percent modern carbon) in a sample set gathered between 1984 and 2000. Surface water entering the basin at present appears to range from 80 to 107 pMC, indicating that interaction of rainwater with carbonate minerals in shallow sediment is rapid, and that values of pMC in the range 80 to100 can be consistent with recent recharge. Groundwater with pMC > 100 clearly recharged in the last 45 years, and is mainly found in areas south of the Rillito and Tanque Verde washes. Restricted areas of recent recharge from Rincon Creek and the Santa Cruz River near the airport are marked mainly by water with 80 to100 pMC and finite tritium. The western part of the Catalina foothills yields water with 80 to 100 pMC and undetectable tritium, probably tens to hundreds of years old. Water with <40 pMC occurs in the south-central part of the basin, remote from major drainages, in rock fractures transmitting water from high altitudes to the basin margins, and in a linear feature running northwest from Grant Rd. at First Ave.. This last feature is evidence for mountain-front recharge deep beneath the basin. Water with <40 pMC is probably thousands of years old.

2.10p. Singular Spectrum Analysis of Historical P, T, and Q in the San Pedro River Basin

Karsten Sedmera and Christopher Duffy, Pennsylvania State Univeristry

The goal of this poster is to show how singular spectrum analysis (SSA) can be used to identify long-term trends and patterns in the historical records of precipitation, temperature, and runoff from the San Pedro river basin in Arizona. SSA is a diagnostic signal processing tool used in our research to identify important changes in the climate and runoff within a regional watershed, such as the San Pedro river basin. The SSA results given will primarily highlight a few trends and interannual "cycles" in both climate and runoff of the San Pedro watershed. Thus the main theme of the poster will be a general discussion of how the climatic forcing of the San Pedro watershed relates to the regional runoff pattern.

2.11p. Chloride/Bromide ratios in the Rio Grande River

Naomi Rosenau, Fred Phillips, New Mexico Tech

Understanding the water and solute balances in the Rio Grande basin of New Mexico and Colorado is important because the water resources of this semiarid region are limited. We are addressing this question by trying to determine the source of the water in the river, whether from precipitation and more concentrated irrigation runoff or from deep basin discharge. We also looked at long term variability of discharge and salt concentration of the Rio Grande through distance and time by way of USGS water quality data. Records of precipitation are included as a baseline.

We have employed the ratio of chloride to bromide concentration to help constrain the sources of the water. Water samples, taken in both summer (irrigation and reservoir releases) and winter (background river discharge and solute loads), were taken at fairly regular distances from the headwaters of the Rio Grande in Colorado to the border at El Paso, Texas. Temperature, pH, conductivity, and total dissolved solids (TDS) were analyzed at each sampling point, and the concentrations of chloride and bromide were analyzed in the lab.

The concentrations of chloride, bromide, electrical conductivity, and TDS all increase with distance from the headwaters. Along several intervals the solute concentrations increase but there is no corresponding increase in the Cl/Br ratio. This indicates that the concentration of solutes is increasing due to evapotranspiration. Along other intervals the Cl/Br ratio increases along with the concentrations, indicating that other sources of water, such as deep basin discharge, may be entering the river. Future research will focus on better identifying these sources of salinity in the Rio Grande basin by measuring other tracers and gathering additional chloride/bromide data.

3.1o. Riparian vegetation water use and sources

Russell L. Scott1, David G. Williams2, Guanghui Lin3, David C. Goodrich1

1USDA-ARS Southwest Watershed Research Center, 2000 E. Allen Road, Tucson, AZ 85719
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Field and modeling studies are being conducted to determine the amount of evaporated water and whether that water is derived from groundwater or surface water sources for the riparian corridor of the San Pedro Riparian National Conservation Area in southeastern Arizona. Micrometeorological and stable isotope field studies are focusing heavily on the mesquite and cottonwood/willow forest ecosystems as they comprise the majority of the groundwater use. The modeling approach will ultimately provide a tool to help quantify current riparian water needs and predict how future management practices will alter the vegetation consumptive water use.

3.2o. Hydrologic exchange and nutrient retention in the riparian zone of the San Pedro River

Schade, J.D., D.B. Lewis, A. Kramer-Huth, M. Conklin, and N.B. Grimm

Department of Hydrology & Water Resources, University of Arizona
Arizona State University

Riparian zones are located in a unique position in the landscape to influence the exchange of materials between streams and their watersheds. Our goals are to identify flowpaths of hydrologic exchange between stream, riparian zone, and upland and to determine retention in the riparian zone of nutrients from water flowing through riparian soils. Other objectives are to determine mechanisms by which the riparian zone retains nutrients, and sources of nutrients for riparian vegetation. We are also interested in larger scale hydrologic interactions between stream, riparian and upland, and the potential for riparian zones to retain nutrient inputs from the uplands.

3.3o. Using Temperature Sensors to Monitor the Spatial and Temporal Distribution of Stream Flow in the San Pedro River, Arizona

David Lawler,[1,2] Stan Leake,[2] Jim Constantz,[3] Ty Ferre,[1] and Dave Goodrich[4]

[1]Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona.
[2]U.S. Geological Survey, Tucson, Arizona.
[3]U.S. Geological Survey, Menlo Park, California
[4]ARS, USDA, Tucson, Arizona

Current flow monitoring in ephemeral desert streams consists of one or more gauging stations, often spaced too far apart to provide detailed information on the distribution of stream flow. Streambed temperature is an easily measured parameter from which patterns of stream flow frequency and duration can be extrapolated. A network of temperature sensors was installed in the San Pedro River Basin to determine the effectiveness of this technique at ascertaining the spatial and temporal extent of stream flow in the river and tributaries. It was determined, based on diurnal temperature fluctuations, that it is possible to detect the presence of stream flow by monitoring streambed temperature.

3.1p. Characterizing stream nitrogen load as a result of geomorphological and hydrologic changes in the San Pedro River

J.M. Hamblen, A. Kramer Huth, M.H. Conklin, J.D. Schade, D.B. Lewis, N.B. Grimm
Dept. of Hydrology & Water Resources, UA; ASU

Our primary objective is to characterize the linkages between nitrogen cycling and winter and summer storm events in riparian systems, by examining contributions of precipitation, soil water, and groundwater to in-stream N concentrations, as well as changes due to sediment erosion and deposition. We hypothesize that storm events generate significant scouring of the stream channel, which may transport large nutrient loads and microbial biomass downstream. Scour chains will be used to estimate the depths of scour and fill produced during these storm events; these measurements will be correlated with process rate measurements for nitrification and water chemistry measurements through use of the Alpine Hydrochemical Model (AHM).

3.2p. Plant Functional Type Variation and Hydrologic Processes in Riparian Ecosystems

Yepez[1], E., K. Hultine[1], P. Ellsworth[1], G. Lin[2], and D.G. Williams[1].

[1]School of Renewable Natural Resources, University of Arizona.
[2]Columbia University's Biosphere2 Center.

Riparian ecosystems along arroyos and major rivers contribute significantly to basin-level fluxes of carbon, water, and mineral nutrients in desert regions. Sharp spatial and temporal gradients of water availability combine with frequent disturbances by floods and fire to establish very heterogeneous patterns of vegetation structure and composition along riparian corridors. The primary objective of our research group and contribution to SAHRA is to decompose riparian ecosystem fluxes of water and carbon into component fluxes arising from different riparian tree and understory species. We ask several basic questions about the role of these vegetation components in controlling patterns and rates of gas exchange at the ecosystem level. First, what is the proportional contribution of large woody species and understory herbaceous species to ecosystem gas exchange (photosynthesis, respiration, transpiration) and how do these component fluxes vary seasonally and interannually? Second, how much functional variation exists among the different woody species in terms of their impact on rates and patterns of riparian ecosystem transpiration? Third, how does tree size (age) determine rates and patterns of transpiration at the ecosystem level? Finally, how does depth to groundwater influence the active rooting depth and rate of transpiration from dominant woody species? We employ tree sap flow and stable isotope techniques to answer these questions. Our work is integrated with that of other investigators in Thrust Area 3 - Functioning of Riparian Ecosystems.

3.3p. Recent Applications of the HYDRUS-2D Software: Future Plans

Simunek, J., M. Th. van Genuchten and M.P.L. Whitaker
USDA-ARS Water Salinity Lab, Riverside CA; UA-HWR

HYDRUS-2D is a Windows-based computer software package for simulation water, heat and/or solute movement in two-dimensional variably-saturated media. The software was used in the past year in a large number of applications that include evaluations of a) virus transport at the field scale, b) several root water uptake models for a sprinkler-irrigated almond tree, c) water content and temperature profiles around land mines, d) a new method for slug-test analyses for large-diameter, hand-dug wells, e) the effects of nearshore recharge on groundwater interactions with a lake in mantled karst terrain, f) the sensitivity of protective capillary barrier performance to changes in rainfall rate, and many others. Recent applications of the HYDRUS-2D software within the STC include identification of a) hydrologic exchange between stream and riparian zones and b) the effects of small and large pipes observed in many indurated calcic horizons in New Mexico on ground water recharge. In th!
e upcoming two years we plan to include into the HYDRUS software many new processes including: a) coupled movement of water and energy (including vapor transport), b) an energy balance at the soil surface (using the Penman-Montheith method for calculating of potential ET), c) nonequilibrium flow and transport (dual-porosity, dual-permeability, and kinematic wave models), d) multicomponent solute transport (coupling with PHREEQC), e) overland flow, e) colloid, virus, and bacteria transport, and many others.

3.4p. Designing aVadose Zone Monitoring System for the Measurement of Root Uptake Beneath a Riparian Area

Gerd von Glinski and Ty Ferré
Dept. Hydrology and Water Resources, UA

As part of SAHRA's investigation of the sustainability of riparian areas in semi-arid environments, we will be conducting an integrated study of the effect of declining water table elevations on the transpiration of cottonwood trees. To date, no direct measures of root/soil interaction have been conducted to support in-tree (sap flow) and above-canopy (eddy correlation) measurements of transpiration. The challenge in obtaining such subsurface measurements of water exchange is the collection of water content measurements with high vertical spatial resolution to depths in excess of 50 feet. We propose to use a combination of time domain reflectometry (TDR) probes and cross-hole ground penetrating radar (GPR). TDR provides superior spatial resolution of the volumetric water content, but may face depth limitations due to signal loss in connecting cables. GPR can provide water content measurements to great depths, with reduced resolution of the water content profile. To limit the potential stresses imposed on the riparian habitat caused by repeated pumping, we are making every effort to optimize our monitoring system in the laboratory. The first phase of this optimization is the identification of the effects of increased cable length on the accuracy of TDR measured water contents. These results will identify the maximum depth of investigation possible with TDR, leaving the remainder of the profile to be monitored with cross-hole GP

4.1o. One Year Simulations of Precipitation Over the Upper Rio Grande Basin

Keeley R. Costigan, James E. Bossert, James R. Stalker, and David L. Langley
Los Alamos National Laboratory

We present results from the atmospheric component of a coupled modeling system that links a series of models to address water resources within a basin. The focus is on simulations of the 1992-1993 water year with the Regional Atmospheric Modeling System, RAMS, to determine the sensitivity of its precipitation predictions to grid resolution. Previous work has indicated that the simulation of precipitation, especially over elevated terrain, can be improved when grid spacing over the upper Rio Grande is increased from 20 km to 5 km. The current work examines whether this holds true in simulations of months to years, as required in regional climate simulations.

4.2o. The Next Generation of Models, Tools, and System Concepts in MMS

George H. Leavesley
USGS, Denver, CO

A modular approach to model design and construction provides a flexible framework in which to focus the multidisciplinary research and operational efforts needed to facilitate the development, selection, and application of the most robust distributed modeling methods and associated analytical tools. These concepts are not new or unique. However, the Open Source software system approach of the USGS Modular Modeling System (MMS), in which all members of the scientific community can participate and share in the design and development of the system framework, process modules, and analysis and support tools, separates MMS from most other modeling systems. Collaborative development of MMS with SAHRA and other educational, research, and operational organizations is rapidly expanding the capabilities and scope of MMS. Current research activities and ongoing system developments of interest to the SAHRA program are presented.

4.3o. Development of a Coupled Model for the Rio Grande River Basin

E. P. Springer, C. L. Winter, K. R. Costigan, R. E. Murray and P. Tseng
Los Alamos National Laboratory

As the demand for water resources in arid and semiarid regions grows, the effects of climate variability and land use are magnified. Models that couple the atmosphere, surface and subsurface components provide an approach where increased understanding is possible because feedback between components is incorporated into the analyses. To address these issues, Los Alamos National Laboratory is developing a coupled model of water resources in the Rio Grande Basin.

The coupled model is composed of the Regional Atmospheric Modeling System (RAMS), a surface water hydrology model, and subsurface flow model. RAMS provides the interface between global and regional climates and the meteorological variables to the Los Alamos Distributed Hydrologic System (LADHS). LADHS partitions precipitation into evaporation, transpiration, soil water storage, surface runoff, and subsurface recharge. The Finite Element Heat and Mass (FEHM) code will be linked to the land surface and channel flow components to simulate saturated and unsaturated flow and changes in the groundwater due to natural and anthropogenic effects.

Model structure, computational approach and data compiled to support model initialization are described. Simulation results will be presented.

4.4o. Mass and Momentum Transfer at a Stream-Aquifer Boundary

Regan Murray
Los Alamos National Laboratory

One challenge to integrated hydrological modeling is to ensure an accurate transfer of mass between various domains, for instance between layers of complex porous media, the atmosphere and the land surface, and streams and aquifers. I'll discuss the stream-aquifer interaction problem in which the physical dynamics, the geometry, and the characteristic space and time scales differ dramatically across the interface. Using the full Navier Stokes Equation in the interfacial region and a stochastic representation of the streambed geometry, I'll introduce the methods we are using to develop the appropriate boundary condition for mass and momentum transfer across the stream-aquifer interface.

4.1p. Development of Near Real-time, Long-range Hydrologic Forecasts with the ECPC RSM, VIC and Routing Models

Yifeng Cui and John Roads, UCSD

The sensitivity of numerical climate models to land surface hydrology is widely recognized. Current numerical prediction models simulate soil moisture continuously using analysis fields for the surface forcing rather than observed surface data, this results in significant errors in the analysis fields being accumulated in the soil moisture. ECPC is coupling a macroscale Variable Infiltration Capacity model VIC with Regional Spectral Model RSM to make long-range land surface and streamflow forecasts. Historical climatologies and climate model simulations are used as boundary conditions. The focus is on the Southwest region, which includes the Rio Grande and Colorado rivers. The real-time experimental daily and weekly land surface forecasts with VIC are available on the website now. In addition, offline run of VIC climatology is compared with RSM climatology for the period of 1950-1997. Preliminary results show an overall tendency for the ECPC-RSM simulations to underestimate the runoff in all seasons, to over predict evapotranspiration in winter and spring, and to produce much too low spatial but too high temporal variations of soil moisture. Overall, the precipitation bias and nudging of the reanalysis soil moisture are responsible for biases in many of the reanalysis surface fluxes.

4.2p. Modeling Efforts using Modular Modeling System in Southern Arizona

Felipe Ip, Luis Bastidas, Hoshin Gupta
University of Arizona - HWR

The objective of this research is to investigate the possibility of using MMS as a model integration tool for hydrologic processes in Southern Arizona. In particular, data from the 150 km^2 Walnut Gulch Experimental watershed were used to drive a distributed rainfall-runoff model, PRMS. The model was run in a distributed fashion using different numbers of Hydrologic Response Units (HRUs). Both daily and 15-minute time steps were used. The GIS driven “weasel” was used to derive the model parameters. The model performance was evaluated for five summer storms. In general, MMS is a good tool for a quick integration of different scale in-house models, and the GIS weasel is useful in deriving initial values of model parameters. In the future, the modeling efforts will be extended for the whole San Pedro and the Lower Colorado River basins. Hydrologic models suited for the semi-arid areas will be developed, tested, compared and integrated with different climatic models within the framework of a Modular System.

5.1o. Analysis of Drought Condition in the Rio Conchos River Basin

Tae-Woong Kim and Juan Valdes
Dept. of Civil Engineering and Engineering Mechanics, UA

To provide the foundation for water resources management, the characteristics of droughts in Rio Conchos basin (Mexico) are investigated. The drought analysis is based on the Palmer Drought Severity Index (PDSI). A frequency analysis of the PDSI is completed for all locations in the basin. Kriging is then used to obtain the spatial drought characteristics using the PDSIs. With this information, a drought severity-area frequency curve is proposed to estimate the area subjected to a drought of a given severity. Preliminary results suggest that the recent historical droughts occurred in 1990's have a return period of 10 and 20 years.

5.2o. Culturally Diverse Views of Water Use and Management in the Salt/Gila and Upper San Pedro Basins

Anne Browning-Aiken , Robert Varady, Ann Moote, , Maria Gutierrez and Kevin Lansey
Udall Center for Studies in Public Policy; Department of Civil Engineering, UA

Stakeholder perspectives on water management, policy and research needs are being assessed in the Upper San Pedro and the Salt/Gila River basins. Stakeholders have been identified in both basins in Arizona and Sonora, Mexico, and surveys either planned or completed in partnership with participating communities. Groundwater hydrology (supply) and water use (demand) in both basins, with the exception of the Mexican portion of the San Pedro, have been examined for the construction of models for hydrologic forecasting. The team will continue assessment of growth management options for the U.S. portion of the Upper San Pedro and to promote stakeholder collaboration to address water management and policy.

5.3o. Uncertainty, Benefit Transfers, and Physical Models: A Middle Rio Grande Valley Focus

David S. Brookshire, Janie Chermak, and Rick DeSimone
University of New Mexico

The effects of the relative uncertainty of information/benefit transfer methods, uncertainty of climate data and alternative population projections on policy decisions are explored. Motivation stems from the relative importance of more accurate data for policy analysis: the physical sciences, demography and economics. We seek to answer two questions: (1) is the accuracy of the benefit transfer and climate information of substantial levels to justify its use in policy decisions in reallocation issues?" And (2) "Where should research efforts be focused in order to improve analyses on which policy decisions are based. A hybrid economic-engineering model of water consumption in the Middle Rio Grande Valley is developed.

5.4o. Urban Water Demand in the Southwest

Janie M. Chermak, David S. Brookshire, Stu Burness
University of New Mexico

The accuracy of the demand model is of paramount importance in water allocation modeling. The empirical models in the literature may be inadequate and are at a high level of aggregation, which may mask important nuances of different demand groups. The price ranges over which most of the empiric al models are estimated may not be relevant for the current (or future) circumstances. Most municipal water utilities base the commodity charge on the cost of delivery. For example, Las Vegas NV's charges range from $0.74 to $1. per ccf. To the extent that these prices do not reflect the true cost of water, the empirical demand estimates based on such price ranges, may not adequate

5.1p. Stakeholder Assessment in the Upper San Pedro River Basin

Ann Moote and Maria Gutierrez

Udall Center for Studies in Public Policy, UA

To determine research interests and needs of residents, water managers, and policymakers in the Upper San Pedro River Basin, the Udall Center conducted interviews of water managers, policymakers, and scientists who work in the basin; surveyed residents of the Mexican portion of the basin; and reviewed recently completed public surveys and other input from U.S. residents of the basin. Mexican residents are particularly concerned about water supply for domestic use, while U.S. residents are more focused on water conservation to protect environmental benefits. Interviewees identified groundwater hydrology in the Mexican portion of the basin as a primary research need. Stakeholders also emphasized a need for improved communication among water users, water managers, and researchers.

5.2p. Water in Mexico

Diana Liverman, Tereza Cavazos, Margaret Wilder, (University of Arizona)
Nicolas Pineda, Jose Luis Moreno (Colegio de Sonora),
Mary Kelly (Texas Center for Policy Studies)

Several pilot and collaborative studies of water management in Mexico are summarized including work on the nature and causes of climate variability, the impacts of drought over the last 50 years, institutional issues in the Conchos river basin, and an overview of the process and implications of the restructuring of land and water management in Mexico.

5.3p. Decision Support System for Sustainable Water Resources Management

Antonella Sciortino, James McPhee, and William W-G. Yeh
Department of Civil & Environmental Engineering, UCLA

A decision support system (DDS) is proposed for the sustainable management of the San Pedro River National Conservation Area (SPRNCA). The San Pedro River Basin is characterized by competing water users, jurisdictional conflicts, international boundary, and environmental concerns. The SPRNCA is a riparian habitat for many species of animals and plants. Recent studies have shown that there are problems of decreasing base flow and deterioration of water quality. The proposed DDS is a multiobjective optimization model, in which the objective function incorporates the hydrologic and ecological variables. The optimization model is coupled with a groundwater flow and a contaminant transport model.

5.4a. Sustainability, Intergenerational Equity and Inter-temporal Efficiency: The Role of Discounting and Individual Choice

David S. Brookshire, Stu Burness and Janie Chermak
University of New Mexico

Many different definitions/interpretations of the appellative "sustainable" have been offered in the context of environmental/ecological frameworks. This paper explores the ramifications of the basic concept as it applies to economic decision-making. In particular, demonstrations of sustainability have focused on the attainability of sustainable allocations, however defined. We propose to go beyond these notions and inquire regarding the extent to which such concepts are operationally feasible within the context of behavioral models of resource allocation and economic policy implementation. The results are then applied to the case of private-habitat benefits maintenance in the context of the Upper San Pedro river basin.

5.5a. Water Use in a Mountain Front Recharge Aquifer with a Perennially Gaining Stream

David S. Brookshire, Stu Burness, Janie Chermak and Rick DeSimone
University of New Mexico

We explore the dynamic and conflicting interaction of incentives for private versus habitat water use in the context of a mountain front recharge system such as in the Upper San Pedro river basin. The basis of the hydrologic system is utilized within the context of competing demands for water. In particular a novel situation arises wherein private demands are consumptive use related while public, habitat demands, while clearly consumptive, are closely related to water stocks. Due to system lags, policy tools must be forward looking and anticipate future needs for and availability of water.

5.6a. Preserve, Extend or Create It and They will Come: Migratory Birds and Riparian Habitat in the Southwest

Kathy Smith
University of New Mexico

Non-market valuation of birding populations and relationship to water availability and the riparian areas requires a formal link between the physical sciences and behavioral sciences. This paper asks to what extent can bird populations be described in terms of diversity of populations, numbers in a given population, and spatial designation. This information coupled with the relationships to water availability and riparian elements is essential in a development of the non-market component of the value of water. This paper will serve as an input to the design of the non-market valuation study.

5.7a. Experimental Tests of Response to Changes in Water Prices

David S. Brookshire, Janie M. Chermak, and Kate Krause
University of New Mexico

Efficient management of water resources requires appropriate empirical estimates of water demand. Brookshire et al (2000) and Chermak and Krause (2000) indicate demand can be disaggregated across observable consumer groups. We extend the research over a wider range of prices and a larger number of participants. A series of experimental games that are specific to water consumption from a potentially exhaustible source are used. Using experiments we can alter the scenario being tested, which reduces the potential of hypothetical response since participants are rewarded based on the choices. Also, we have a sub-set of participants who have provided monthly water usage data for up to 36 months.

5.8a. The Farm Module

Wolfgang Schmid
HWR, University of Arizona

A critical part of any conjunctive management of surface and groundwater in an irrigation setting is the ability to determine the allocations of these waters to a farm unit. In the arid and semiarid Southwest, a surface water irrigation system will allocate water by priority to a farm. If there is insufficient surface water delivered to the farm, groundwater may be pumped to augment the surface water supply. Because irrigation systems are not 100% efficient in supplying the crop irrigation requirement, part of the applied water will infiltrate back to the groundwater system. When a groundwater model such as MODFLOW is used to aid in the conjunctive management of the irrigation system, it is necessary to have a farm module to help integrate the surface water diversions with the supplemental will pumping, and the recharge in excess irrigation waters. During the current year work has begun to develop a MOFLOW module that would simulate seasonal water applications from groundwater and surface water sources to a set of farms in an area.

The farm module will be tested in the Rincon-Mesilla Groundwater Model developed for the New Mexico-Texas Settlement Commission for the Lower Rio Grande of New Mexico. In addition, alternative conjunctive management schemes will be investigated that are constrained by the Ro Grande Compact. These alternatives will be in response to the State of New Mexico adjudication of the lower Rio Grande of New Mexico, and the need to quantify offer of water quantity to water users of the Rincon and Mesilla Valleys in New Mexico. These water quantities and their distribution in time are also pertinent to an operating agreement being negotiated between Texas and New Mexico parties for the Elephant Butte and Caballo Reservoirs.

6.1o. Cultivating Hydrologic Literacy in the Classroom through a Peer-centered Professional Development Program

Julie Luft and John Madden
University of Arizona, College of Education; Mountain View High School

This summer, participating science teachers will explore an issue that is regionally-based and linked to the major components of hydrologic literacy in a new, constructivist-based professional development workshop. Additional credit will be available to teachers who develop usable and pedagologically sound curriculum units that draw upon the major concepts in the workshop. To encourage implementation into the classroom, teachers will form collaborative partnerships (mentor, university educator, teachers) to reflect upon and refine their developed curriculum throughout the year. This program reinforces long-term professional development through peer-centered professional development and sound follow-up practices.

6.2o. Water is Life - Water Education for Native Americans

Mansel A. Nelson
Program Coordinator, ITEP-EEOP

The Environmental Education Outreach Program (EEOP) at Northern Arizona University (NAU) provides water educational outreach for Native American students. The water education is integrated into existing environmental education programs such as the Uranium and Radiation Outreach Education (UREO) program, Protective Circle (PC) program, and the Tribal Schools Ecological Monitoring Program (TSEMP). Understanding of water issues is vital for the sovereignty of tribes. Students, educators, and community members must understand issues related to management of water resources and water quality.

6.3o. Improving the Hydrologic Literacy of Undergraduate Students

Jim Washburne
Dept. of Hydrology and Water Resources, UA

Non-science general education classes represent a challenging yet important audience in SAHRA's campaign to promote and improve hydrologic literacy. Without question, these young adults need to be prepared to face tomorrows water issues with a sound understanding of today's experiences. Despite many successes, there is a significant difference between the student's desire to have local water issues described/explained to them and the instructor's desire to have the students define, interpret and understand these issues. This presentation will focus on program components that seem to be working during our first year of offering Arizona Water Issues (www.hwr.arizona.edu/hwr203/).

6.1 p. Ask the Questions …… Experience the Answers!

Kerry Schwartz
Education Program Coordinator, Water Resources Research Center, UA

Project WET (Water Education for Teachers) is an interactive, water education program for teachers and educators which promotes critical thinking and problem solving. Project WET workshops promote an understanding of each state's water resources through the use of creative activities and teaching tools to understand complex subjects. Using Project WET activities, participants observe how an aquifer works, how pollutants move, how landforms affect water flow.

There is no need to lecture about abstract water issues. The majority of people learn the most by seeing, doing and questioning. Project WET unveils the magic of water through a variety of teaching methods including whole-body activities, demonstrations, models, simulation, investigation, and role-play.

What is the desired final outcome? To promote awareness, appreciation, and knowledge about water resources and water issues. How do we do that? We get participants excited about water! Once they are excited about water, they will take an interest in learning about water. They will be conscientious about water use and potential water pollutants. They will become future advocates and stewards of our state's water resources.

6.2p. Tribal Watershed Training Program

Laurel Lacher
White Mountain Apache Tribal Hydrologist

As tribes increase their capacity and level of sophistication in natural resources management, they encourage their young people to pursue college educations and come back to serve their communities. Unfortunately, tribal members remain underrepresented in college as well as in tribal natural resource program management. The Tribal Watershed Training Program (TWTP) grows out of our experience in tribal management and seeks to close the circle of self-determination by grooming tribal members to lead natural resource management programs within tribal governments. TWTP also strives to cultivate synergetic links among tribes, academic institutions, and federal agencies.

6.3p. Everybody's doing it - Urban Water Conservation Programs

Abby Faust and Katherine McHugh, UA

A variety of water education posters will be distributed around the Poster hall which highlight the diverse range of perspectives and approaches taken to promote water conservation.

6.4p. Proposed Biosphere2 Educational Collaboration

Russell, Adams, Woods, Colodner
Columbia University's Biosphere 2 Center

A new collaborative effort between SAHRA and Biosphere 2 will involve enhancing the degree and distribution of hydrologic literacy efforts in both the middle school Passport to Learning Program and the undergraduate level Earth Semester program.

6.5p. Professional development with Hopi tribe

Aregi Tecle, NAU-Forestry

7.1o. Improving Interjurisdictional Water Management: Tribes, States and Feds

Bonnie Colby
UA-AgEcon

Large amounts of time and resources are expended addressing issues associated with Indian water rights in Arizona and other western states. Litigation and negotiations over tribal water rights are a primary concern among cities, rural communities, irrigators, tribes, environmental advocates, and public agencies. There have been a number of new developments in seeking to reconcile tribal claims and the needs of other water users over the past ten years. To inform policy makers, water users, public agency staff and the general public, the 1993 publication, Indian Water Rights: Negotiating the Future, is being updated and expanded this year. An executive training course is planned for the following year.

7.2o. Water in Mexico

Diana Liverman, Tereza Cavazos, Margaret Wilder, (University of Arizona)
Nicolas Pineda, Jose Luis Moreno (Colegio de Sonora),
Mary Kelly (Texas Center for Policy Studies)

Several pilot and collaborative studies of water management in Mexico are summarized including work on the nature and causes of climate variability, the impacts of drought over the last 50 years, institutional issues in the Conchos river basin, and an overview of the process and implications of the restructuring of land and water management in Mexico.

7.3o. SAHRA Promotional Activities, Web Site and Database Management

Kyle Carpenter
SAHRA

A new multi-disciplinary and decentralized science and education center like SAHRA faces both internal communications and coordination issues as well as challenges in identifying itself and conveying a consistent message to diverse stakeholders. A combination of public- and private-side Web sites, database management, and a slate of promotional materials is being implemented to further SAHRA’s science, policy and education missions.