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Department of Hydrology and Water Resources

Presents

The 19th Annual

El Dia del Agua

March 26, 2009

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10:00am ~ 11:00am ~ Poster Session
11:00am ~ 12:00 ~ Oral Presentations

Master of Ceremony ~
Dr. Thomas Maddock III, Department Head

12:00pm ~ 1:30pm Buffet Lunch ~ Registration Required
Luncheon Speaker ~ Chuck George Jr.
Chief Meteorologist KOLD News 13 & HWR Alumnus
"Science and the Media"

1:30pm ~ 2:00pm ~ Poster Session
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Master of Ceremony ~
Dr. Thomas Meixner, Associate Professor

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Guest Speaker ~ Dr. Eric Barron
Director, National Center for Atmospheric Research (NCAR)
"Beyond Climate Science"

4:30pm ~ Award Presentations

Montgomery Prize ~ By Elizabeth León Mora
Best Oral Presentation ~ $2,000

Hargis Awards ~ By Leo S. Leonhart
First Place Poster ~ $1,000 and Second Place Poster ~ $400

HWR Awards ~ By Thomas Meixner
Best Speaker ~ $400 and Best Poster ~ $400

Agua-Person Award ~ By Stephen G. Osborn, ***HWRSA President***
Teaching Excellence for Senior and Junior Faculty for HWR

The Montgomery Prize

The Department of Hydrology and Water Resources would like to thank Errol L. Montgomery & Associates, Inc. for their support of the 19th Annual El Dia Del Agua. For several years, Montgomery & Associates has sponsored a special cash award, *The Montgomery Prize*, for the best oral presentation at the annual student symposium. This prize is in addition to the two departmental awards (best oral and best poster presentations) and will be presented to the winner by Ms. Elizabeth León Mora with Montgomery & Associates. The award symbolizes the company's commitment to encouraging and rewarding excellence in oral presentation of hydrologic research. Montgomery & Associates offers similar awards during annual events at the University of Arizona and Northern Arizona University Geology Departments.

Errol L. Montgomery & Associates, Inc. is a hydrogeologic consulting group with more than 20 years of experience addressing groundwater availability, sustainability, and quality issues for municipal, industrial, mining, and governmental clients. Professional services include:

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- Hydrologic monitoring
- Satellite image analysis
- Groundwater flow and solute transport modeling

The firm's principal office is located in Tucson, Arizona, and branch offices are maintained in Scottsdale, Arizona and in Santiago de Chile.

The Hargis Awards

The Department of Hydrology and Water Resources would like to thank Hargis + Associates, Inc. for their continued support of the Annual El Dia del Agua. This year, Dr. David Hargis will present a first and second place cash award for the best poster presentations at the annual student symposium. Evaluation will be performed by a panel selected by Dr. Hargis. The Hargis Awards are made in recognition of the need for excellence in technical communications and serve as an incentive for participating students to demonstrate excellence in writing, visual presentation, and oral communication skills in support of their research projects.

Hargis + Associates, Inc. is a nationally recognized hydro- geology and engineering consulting firm founded in Tucson in 1979. The firm specializes in consultations in water resources, environmental assessment and remediation, litigation support, and mining. Headquartered in San Diego, California, the firm also has offices in Tucson and Phoenix, Arizona.

Message from the HWRSA President

Dear El Dia del Agua Participants,

On behalf of the Hydrology and Water Resources Student Association (HWRSA), we would like to welcome you to the 19th annual El Dia del Agua Student Research Symposium. El Dia del Agua (EDDA) is the perfect opportunity for students to present their current work at the Department of Hydrology and Water Resources (HWR) of the University of Arizona, which is known worldwide for its cutting-edge research in hydrology and related sciences.

This year we are glad to host a full-day event with nine oral presentations, twenty-two research posters and two guest speakers. This symposium is an event ***for the students*** and ***by the students*** in which we can receive first-hand responses from fellow hydrologists. Throughout the years, university faculty and professional hydrologists have supported and attended EDDA. This tradition serves to strengthen the hydrology community as well as to facilitate knowledge transfer between academia and the professional community. Furthermore, EDDA is a great place for prospective students to learn about the wide range of interesting research opportunities available to HWR students. The success of EDDA is possible thanks to the joint efforts of HWR faculty, administration, students, and sponsors. We are grateful to all of them for their time and generosity.

Thank you for taking the time to attend El Dia del Agua. After the awards session and closing ceremony please join us for SUDS at No Anchovies at 5 pm!

Stephen G. Osborn
HWRSA President

Kyle B. Brown
HWRSA Vice-President

Melissa Schlegel
HWRSA Treasurer

Candice Adkins &
Seshadri Rajagopal
HWRSA Social Chairs

Support your HWRSA by purchasing a handsome, insulated, stainless steel travel mugs, generously sponsored by Hargis and Associates, bear the HWR departmental logo on one side and the Hargis logo on the other, in addition to other items for purchase.

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Hargis + Associates, Inc.

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James Washburne, El Dia del Agua Chair
Thomas Meixner, El Dia del Agua Co-Chair
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Erma Santander, Program Coordinator

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Montgomery Prize
Elizabeth León Mora ~ Claire Zucker ~ Russ Scott

Hargis Awards
Bill Bull ~ Leo Leonhart ~ Dennis Scheall

HWR Oral Award
Gary Woodard ~ Lynn Orchard ~ Kathy Jacobs

HWR Poster Award
Kent Lang ~ Juan Valdés ~ Stan Leake
Francina Dominguez ~ John Parker ~ Harald Kling

Moderators
Kyle B. Brown ~ Erika Gallo ~ Stephen G. Osborn

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Kyle B. Brown ~ Vice-President
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Brittney Bates ~ Shane Clark ~ Andrew Neal
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EL Dia Del Agua ~ Lunch Guest Speaker
Charles George Jr.
KOLD News 13 Chief Meteorologist

"Science and the Media"

Chuck has a Rocky Mountain Emmy nomination, holds the Star Award from the American Women in Radio and Television, and has been named best television meteorologist of the year by Tucson Lifestyle Magazine and the Tucson Weekly. Chuck also has a Certified Broadcast Meteorologist Seal of Approval from the American Meteorological Society. Chuck has a Master of Engineering in Water Resources from the University of Arizona and has a Bachelor of Science in Meteorology from the University of Oklahoma.

Chuck and the First Alert team have an Edward R. Murrow award for the post-Monsoon special entitled "Monsoon Stories." Chuck is also a two-time Houston Press Club Television Meteorologist of the Year. He moved to Tucson for graduate school. Like so many other UA students, he fell in love with the Sonoran Desert and Tucson. A self proclaimed perpetual student, Chuck always wants to be the first to learn the most recent research in earth science, since the field is ever changing. Chuck loves taking the data and findings of the experts on the UA campus and incorporating it into his weathercasts. Chuck says he loves what he does because he is able to teach a mini science class on each of the evening shows.

Chuck George joined KOLD News 13 in February 2003 and forecasts the 5, 6, and 10 p.m. newscasts Monday through Friday. He also served as Chief Meteorologist at KOLD back in the mid-1990s before leaving for a few years for a job as morning meteorologist at the Post Newsweek station in Houston, TX: KPRC.

EL Dia Del Agua ~ Guest Speaker
Dr. Eric Barron
Director, National Center for Atmospheric Research (NCAR)

"Beyond Climate Science"

Eric J. Barron, director of the National Center for Atmospheric Research (NCAR), began a career in geology with an undergraduate degree from Florida State University (1973). After obtaining his master's degree in oceanography, marine geology and geophysics from the University of Miami (1976), his interest turned to climate studies with a Cray Supercomputing Fellowship at NCAR. Upon completing his Ph.D. in oceanography from the University of Miami (1980), he returned to NCAR as a postdoctoral research fellow and then continued as a research scientist in the global climate modeling group. In 1986 Barron went to Pennsylvania State University to direct the College of Earth and Mineral Sciences' newly formed Earth System Science Center (ESSC), and was promoted to professor of geosciences in 1989. Under Barron's leadership, the growth of ESSC resulted in the establishment of the College of Earth and Mineral Sciences' Environment Institute, encompassing the ESSC and a group of other research center. Barron became the director of this new institute in 1998 and earned the title of distinguished professor in 1999. In 2002 he was named dean of the College of Earth and Mineral Sciences at Penn State. Prior to coming to NCAR in July 2008, Barron served as dean of Jackson School of Geosciences at the University of Texas at Austin.

Barron's research interests are in the areas of climatology, numerical modeling, and Earth history. During his career, he has worked diligently to promote the intersection of the geological sciences with the atmospheric sciences and the field of earth system science. He served as chair of the Climate Research Committee of the National Research Council (NRC) from 1990 to 1996. In 1997, he was named co-chair of the Board on Atmospheric Sciences (BASC) of the NRC, and since 1999 he has chaired the BASC. Additional NRC panels on which Barron has served include the Committee on Global Change Research, the Assessment of NASA Post-2000 Plans, Climate Change Science, the Human Dimensions of Global Change, the Panel on Grand Environmental Challenges, and the Committee on Tools for Tracking Chemical, Biological, and Nuclear Releases in the Atmosphere: Implications for Homeland Security. In addition to serving on the National Research Council, Barron chaired the Science Executive Committee for NASA's Earth Observing System and NASA's Earth Science and Applications Advisory Committee (ESSAC). He has also served as chair of the USGCRP Forum on Climate Modeling, the Allocation Panel for the Interagency Climate Simulation Laboratory, the U.S. National Committee for PAGES and the NSF Earth System History Panel.

Barron is a fellow of the American Geophysical Union, the American Meteorological Society, and the American Association for the Advancement of Science. In 2002, he was named a fellow of the National Institute for Environmental Science at Cambridge University. In 2003, he received the NASA Distinguished Public Service Medal.

El Dia del Agua ~ Program Schedule

8:00-8:45	Registration, Check In & Continental Breakfast
8:45-9:00	Dr. James Washburne, Associate Director of SAHRA, Master of Ceremony
9:00-10:00	Oral Presentations, Kyle B. Brown, Moderator and 2008 El Dia del Agua Recipient of the HWR Award of Excellence for Poster Presentation
9:00-9:20	Candice B. Adkins ~ *"Use of Chemical and Isotopic Tracers for Estimating Ground-Water Recharge, Flow Paths, and Residence Times in the Middle San Pedro Basin, Southeast Arizona"*
9:20-9:40	Phoolendra Kumar Mishra ~ "*A new analytical solution for flow to a partially penetrating pumping well in a compressible unconfined aquifer"*
9:40-10:00	Seshadri Rajagopal ~ *"Improving Riparian Land Surface Flux Estimation Through Root Zone Groundwater Interaction in Semiarid Environments"*
10:00-11:00	Poster Session
11:00-12:00	Oral Presentations, Erika L. Gallo, Moderator and 2008 El Dia del Agua Recipient of the Hargis Award, Second Place Poster
11:00-11:20	Jessica M. Driscoll ~ *Use of a reaction path model to identify hydrologic flowpaths in an alpine catchment, Colorado Front Range, USA*
11:20-11:40	Andrew L. Neal ~ *Temporal Sensitivity of Satellite-Based Remote Sensing Products to Rainfall Pulse Events in Dryland Ecosystems*
11:40-12:00	Amy Rice ~ *Predicting Hydraulic Response: Comparison of Textural and Response Clustering Approaches to Soil Classification*

El Dia del Agua ~ Program Schedule
Continued

12:00	Dr. Thomas Maddock III, Department Head Master of Ceremony
12:00-1:30	Buffet Lunch and Speaker, Charles George Jr., Chief Meteorologist KOLD 13 News & HWR Alumnus, "Science and the Media"
1:30-2:00	Poster Session
2:00-3:00	Oral Presentations, Stephen Osborn, Moderator and 2008-2009 HWRSA President, ARSC Scholar
2:00-2:20	Brittney L. Bates ~ "*Effects of groundwater recharge rates and nutrient supply on metabolic pathways for coal bed methane generation in the Powder River Basin"*
2:20-2:40	Shawn J. Wheelock ~ *"GRS Evidence and the Possibility of Paleooceans on Mars"*
2:40-3:00	Ingo Heidbüchel: **"***Water Transit Time Controls"*
3:00-3:30	Poster Session
3:30	Dr. Thomas Meixner, Associate Professor HWR, Master of Ceremony
3:30-4:30	Guest Speaker, Dr. Eric Barron, Director, National Center for Atmospheric Research (NCAR), "Beyond Climate Science"
4:30-5:00	Award Presentations *Montgomery Prize ~ By Elizabeth León Mora* *Hargis Awards ~ By David Hargis* *HWR Awards ~ By Thomas Meixner* *Aqua-Person Award ~ By Stephen G. Osborn*

Oral Presentation Abstracts

Hydrology & Water Resources Students' Research Projects

Use of Chemical and Isotopic Tracers for Estimating Ground-Water Recharge, Flow Paths, and Residence Times in the Middle San Pedro Basin, Southeast Arizona

Candice B. Adkins[1,2], Jennifer McIntosh[1], Chris Eastoe[3] and Jesse E. Dickinson[2]

Department of Hydrology and Water Resources, The University of Arizona[1]

Major ion (Ca, Na, K, Mg, Sr, Fe, Zn, F, Cl, Br, NO_3, SO_4) and isotope (^{18}O, ^{2}H, ^{3}H, ^{34}S, ^{13}C, ^{14}C) chemistry of ground water, surface waters and precipitation with in conjunction with hydrogeologic data were analyzed to infer recharge areas, mixing of water sources, and residence times of ground water within the middle San Pedro watershed in southeastern Arizona.

Chemical variations include higher fluoride (up to 8 ppm) near the Dragoon Mountains, higher chloride (up to 54 ppm) near the Whetstone Mountains, and higher sulfate (up to 750 ppm) in both upper and lower sands and gravels owing to interaction with thick Permian or Neocene evaporites. Chloride is generally lower (less than 8 ppm) in the lower unit of the aquifer due to limited evaporation.

Oxygen isotope values ranging from -6.8‰ to -8.9‰ suggests recharge to the upper unit originates mostly from summer monsoon precipitation. Oxygen isotope values between -7.2‰ and -11.8‰ indicates recharge to lower units originates from a mixture of summer and winter precipitation and high elevation recharge. Low percent modern carbon values (8.0 to 37.8 PMC) within lower units indicate recharge within the past ~14,000 years. Detectable tritium (1.0-6.8 TU) near mountain blocks and shallow units indicate recharge within the past sixty years.

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[2]United States Geological Survey, Tucson, Arizona
[3]Department of Geological Sciences, The University of Arizona

A new analytical solution for flow to a partially penetrating pumping well in a compressible unconfined aquifer

Phoolendra Kumar Mishra and Shlomo P Neuman

Department of Hydrology and Water Resources,
The University of Arizona

Constant rate pumping tests are widely used to characterize the hydraulic properties of aquifers. A new solution is developed for flow to a partially penetrating well pumping at a constant rate from a compressible unconfined aquifer. The new solution generalizes that of Tartakovsky and Neuman (2007) by allowing the moisture retention and relative hydraulic conductivity curves in a finite unsaturated zone to be described by two different exponents and air entry values. Flow is taken to be three dimensional with axial symmetry in both the saturated and the unsaturated zones. We investigate the effects of unsaturated zone thickness and constitutive parameters on drawdown in both the saturated and the unsaturated zones as functions of position and time. We then use our new solution to analyze a pumping test conducted by Moench et.al [2001] in a glacial outwash deposit at Cape cod, Massachussets, and compare with results obtained for this aquifer by Tartakovsky and Neuman (2007).

Improving Riparian Land Surface Flux Estimation Through Root Zone Groundwater Interaction in Semiarid Environments

Seshadri Rajagopal[1], David J Gochis[2], Peter A Troch[1], Russell L Scott[3] and Hoshin V Gupta[1]

Department of Hydrology and Water Resources, The University of Arizona[1]

Accurate estimation and simulation of turbulent land surface fluxes in land surface models (LSM) is important for sustainability studies of riparian areas, e.g. how they react to changes in groundwater availability either through extended droughts or due to climate change. Because atmospheric evaporative demand is very high in semiarid environments, neglecting important sources of root water uptake can cause errors in the estimation of these fluxes. In this study we apply a simple parameterization of root-zone groundwater interaction to the Noah LSM and compare coupled (to groundwater) and uncoupled model runs to in situ observations of latent and sensible heat fluxes and soil moisture. Observations used in this study were collected at a riparian grassland site located near the San Pedro River, in Arizona, USA. Our results show that when the Noah model is run without the presence of a water table (uncoupled run) we get significant under (over) prediction of the latent (sensible) heat fluxes. By introducing a root-zone groundwater interaction (coupled run) we are able to better capture the observed turbulent flux dynamics. However, the coupled model still does not predict observed soil moisture dynamics accurately and in general overestimates soil moisture in the upper soil layers. Our findings suggest that a different root water uptake mechanism than currently implemented in Noah may be required to simultaneously reproduce both the latent and sensible heat fluxes and the vertical root zone water balance.

[2] National Center for Atmospheric Research, Boulder, CO
[3] Southwest Watershed Research Center, USDA, Tucson, AZ

Use of a reaction path model to identify hydrologic flowpaths in an alpine catchment, Colorado Front Range, USA

Jessica M. Driscoll [1], Thomas Meixner[1],
Mark W. Williams[2] and Noah P. Molotch[3]

Department of Hydrology and Water Resources
The University of Arizona[1]

End-member mixture analysis (EMMA) models have been used to discern the water sources in catchments over the last 20 years. Similarly, reaction path models (RPM) of chemical weathering have been used to understand the geochemical sources of constituents in catchments. Unifying these approaches offers the opportunity to connect the source of water to the hydrologic structure of the catchment. This approach was used in the Green Lake 4 catchment in Colorado during the 1996 snowmelt season. Unique combinations of flowpaths occur during discrete time intervals, which shows a dynamic hydrologic system. RPM results show notable non-flowpaths; soil water is not geochemically connected to any other end member. These changes reflect the catchment buffering capacity due to dilution effects and changes in weathering reactions in the catchment that are dependant on the duration and timing of snowmelt.

[2] INSTAAR, University of Colorado
[3]Department of Civil and Environmental Engineering, UCLA

Temporal Sensitivity of Satellite-Based Remote Sensing Products to Rainfall Pulse Events in Dryland Ecosystems

Andrew L. Neal[1], Shirley A. Kurc[1,2] and Paul D. Brooks[1]

Department of Hydrology and Water Resources
The University of Arizona[1]

Remote sensing data products provide spatially extensive data about physical hydrological and ecological processes. However, due to the timing of satellite flyovers, some remote sensing data may not fully observe a particular event. This is particularly true in semi-arid upland environments, which are known to respond to high-intensity, low-frequency rainfall pulses. Here we compare *in situ* measurements of ecological and hydrological fluxes and states (carbon and evaporative flux, soil moisture) to remote sensing data for a similar period for a (perennial) creosote upland in the Santa Rita Experimental Range. We intend to replicate this analysis across a variety of dryland ecosystems, including grasslands, annual shrublands, and montane forests. From this, we hope to gain a better understanding about the pulse dynamics in these systems and the ability of satellite-based sensors to detect those pulses.

[2]School of Natural Resources, The University of Arizona

Predicting Hydraulic Response: Comparison of Textural and Response Clustering Approaches to Soil Classification

Amy Rice, T.P.A. Ferré and M. Zreda

Department of Hydrology & Water Resources,
The University of Arizona

Soil classification in the United States focuses on texture, as determined by particle size distribution. It could be assumed that this classification should be useful for predicting hydraulic response because grain size is indicative of pore size, and pore size distribution has a primary response on water retention and permeability. However, although this assumption is made widely, we are not aware of its having been tested quantitatively. To test whether texture is a good predictor of hydraulic response, We conduct process-specific clustering, which groups soils, described by their particle size distribution, based on the similarities of their hydrologic responses.

Processes studied were flooding to saturation and precipitation followed by drainage. We show that traditional textural classification does not provide optimal prediction of hydraulic response. Rather, grouping using a clustering technique reduced the uncertainty of the predictions, especially if loamy soils are present. We discuss how response clustering can be applied to a wide range of hydrologic monitoring objectives. These include optimization of sensor network design, sensor placement, and groundtruthing efforts for sensors with relativey large footprints.

Effects of groundwater recharge rates and nutrient supply on metabolic pathways for coal bed methane generation in the Powder River Basin

Brittney L. Bates[1], Jennifer C. McIntosh [1] and Kathleen Lohse[2],

Department of Hydrology and Water Resources,
The University of Arizona[1]

Huge accumulations of natural gas in the Powder River Basin (PRB) are actively being generated by microorganisms. Microbes create methane via two metabolic pathways: acetate fermentation and carbon dioxide reduction. The relative importance of these pathways is primarily dependent on the bioavailability of organic matter, presence of nutrients, salinity, and microbial community structure. Previous studies by Flores et al. (2008) observed the dominance of acetoclastic methanogenesis in select areas near the basin margins and CO_2 reducing methanogenesis in the deeper central basin. We hypothesize that the spatial and depth distribution of CO_2 versus acetate–utilizing methanogens in the PRB is related to groundwater recharge rates, residence times, and nutrient supply. To test this hypothesis, we collected co-produced groundwaters and natural gas from 32 wells, along two transects across the basin that were parallel to regional hydrologic gradients. Variations in ion concentrations are coupled to age tracers to determine the effects of recharge rates and flowpaths on nutrient transport and cycling. Initial results show low sulfate concentrations and high sulfur isotope values of SO_4 indicative of sulfate reduction in shallow margin areas associated with acetate fermentation.

[2]School of Natural Resources, The University of Arizona

GRS Evidence and the Possibility of Paleooceans on Mars

Shawn J. Wheelock[4], James M Dohm[1,2], Victor, R. Baker[1,2], William V. Boynton[2], Alberto G. Fairén[3,4,] Justin C. Ferris[5], Michael Finch[2], Roberto Furfaro[6], Trent M. Hare[7], Daniel M. Janes[2], Jeffrey S. Kargel[1], Suniti Karunatillake[8], John Keller[9], Kris Kerry[2], Kyeong Kim[10], Goro Komatsu[11], William.C. Mahaney[12], Dirk Schulze-Makuch[13], Lucia Marinangeli[11], Gian G. Ori[11], Javier Ruiz[14]

Department of Hydrology and Water Resources,
The University of Arizona[1]

The Gamma Ray Spectrometer (Mars Odyssey spacecraft) has revealed elemental distributions of potassium (K), thorium (Th), and iron (Fe) on Mars that require fractionation of K (and possibly Th and Fe) consistent with aqueous activity. This includes weathering, evolution of soils, and transport, sorting, and deposition in the northern plains basins, as well as with the location of first-order geomorphological demarcations identified as possible paleoocean boundaries. The element abundances occur in patterns consistent with weathering *in situ* and possible presence of relict or exhumed paleosols, deposition of weathered materials (salts and clastic minerals), and weathering/transport under neutral to acidic brines. The abundances are explained by hydrogeology consistent with the possibly overlapping alternatives of ancient paleooceans and/or heterogeneous rock compositions from diverse provenances (e.g, differing igneous compositions).

[2]Lunar and Planetary Laboratory, University of Arizona. Tucson 85721, AZ. USA.3Centro de Biología Molecular, CSIC-Universidad Autónoma de Madrid. 28049 Cantoblanco, Madrid. Spain. 4Space Science and Astrobiology, Division, NASA Ames Research Center, Moffett Field, CA 94035, USA. 5 West Coast and Alaska Tsunami Warning Center, National Oceanic and Atmospheric Administration, Palmer, AK 99645, USA. 6Aerospace and Mechanical Engineering Department, University of Arizona, Tucson, AZ, 85721, USA.7United States Geological Survey, Flagstaff, AZ, 86001, USA.8Center for Radiophysics and Space Research, Cornell University Ithaca, NY 14853, USA.9Department of Physics, California Polytechnic University, San Luis Obispo, CA 9340, USA. 10Geological & Environmental Hazards Division, Korea Institute of Geosciences & Mineral Resources, Daejeon, South Korea. 11IRSPS, Università d'Annunzio, Pescara, Italy. 12Geomorphology and Pedology Laboratory, York University, Atkinson College, Ontario, M3J 1P3, Canada; Quaternary Surveys, Thornhill, Ontario L4J 1J4, Canada. 13School of Earth and Environmental Sciences, Washington State University, Pullman, WA 99164, USA.14Museo Nacional de Ciencias Naturales, CSIC, José Gutiérrez Abascal 2, 28006 Madrid, Spain

Water Transit Time Controls

Ingo Heidbüchel and P.A. Troch

Department of Hydrology and Water Resources,
The University of Arizona

Transit time distributions of two hillslopes, situated within the same small catchment in the Catalinas, were identified by using a transfer function - convolution approach with measurements of stable water isotopes in rain, soil and stream water. The resulting mean transit times of the two hillslopes differ considerably. Both have approximately the same area and mean gradient, but their underlying lithology is very distinct. The hillslope underlain with granite exhibits a five times shorter mean transit time compared to the hillslope underlain with schist. Soils on the granitic parent material are shallower and have a lower clay fraction and therefore a smaller storage capacity; hence they produce more quick surface runoff. In contrast, it takes longer for the water in the schist hillslope to reach the outlet – here the soils are deeper and more developed, so they retain the water longer. Within each of the hillslopes, there is also a distinct difference between divergent and convergent parts. Transit times of divergent parts are half as long as the transit times in their convergent counterparts. This can be attributed to differing flow processes. Vertical flow dominates in the divergent slopes whereas the convergent slopes also receive lateral inflow from uphill.

Poster Presentation Abstracts

Hydrology & Water Resources Students' Research Projects

El Dia del Agua ~ Poster Presentations
HWR STUDENTS RESEARCH PROJECTS

Quantifying Temporal and Spatial Variability of Mountain System Recharge in Semi-Arid Catchments

Hoori Ajami, Peter Troch, Thomas Maddock III,
Thomas Meixner and James Hogan

Department of Hydrology and Water Resources,
The University of Arizona

Groundwater recharge is likely to be altered as a result of climate change and variability impacting groundwater resources. In semi-arid Basin and Range systems where Mountain System Recharge (MSR) represents a significant component of recharge, this impact is likely to be more pronounced. Despite the importance of MSR in such basins' water budget, physical processes that control MSR have not been fully investigated. In most groundwater models, MSR is either derived from empirical relationships or estimated during the model calibration and water balance analysis. Therefore, these models are not capable of assessing the impact of climate variability and change on groundwater resources.

The objective of this research is to enhance our conceptual understanding of MSR, and quantify temporal and spatial variability of MSR in selected semi-arid catchments in the Basin and Range province of Arizona. Water budget analysis was performed using the coupled soil moisture-Hillslope Storage Boussinesq model in the Marshall Gulch catchment. streamflow and soil moisture data were used for the model calibration. Preliminary results show annual variability of MSR with pronounced differences in winter and summer seasons. Similar analysis should be performed in other catchments to develop regional recharge relationships.

Statistical Characterization of Ecologically Significant Streamflow Parameters in Southwestern basins

Michael Barnes and Tom Meixner

Department of Hydrology and Water Resources,
The University of Arizona

The hydrologic regimes of streams and rivers in the Southwest vary considerably across the region. These differing flow regimes influence dependent in-stream ecological processes. Characterizing this variability is important for establishing the link between river conditions and corresponding ecological processes. Saenz et al suggests the use of a set of parameters to create a robust manner in which to analyze flow regimes. This approach is useful for both inter and intra-basin comparisons and classification. Ultimately, a simple classification of seasons as hydrologically wet, dry, or average was sought to assist in efforts to establish the connection between ecological in-stream processes and flow. The USGS streamflow records for gauges on the San Pedro, Verde, Hassayampa, and Bill Williams rivers were analyzed and a suite of descriptive statistics was developed. A classification for wet, dry and average years was constructed using normal and log normally distributed daily average flow data. Further research will link this classification scheme and in-stream conditions.

A Multi-Tracer Approach to Determine the Impacts of Agricultural Irrigation Recharge on Groundwater Sustainability in the Saddle Mountains Basalt Aquifer, Central Washington, USA

Kyle Brown[1], Jennifer McIntosh[1], Laura Rademacher[2], Kathleen Lohse[3], Damian Gosch[1]

Department of Hydrology and Water Resources,
The University of Arizona[1]

Irrigation in semi-arid agricultural regions has profound effects on the recharge rates and water quality of shallow groundwater. In the case of oxic groundwater systems, such as the Flood Basalt aquifers of the western U.S., high nitrates from fertilizers persist for long time periods due to the absence of denitrification. Stable isotopes (^{2}H, ^{18}O) were used in conjunction with age-tracers (^{3}H, CFCs, ^{14}C), $^{87}Sr/^{86}Sr$, and elemental chemistry to determine the residence times, sources, and flowpaths of shallow groundwaters in the Saddle Mountains Basalt Aquifer. The results demonstrate the presence of two distinct groups of waters: 1) contaminated irrigation waters with high NO_3^- (11-116 mg/l), detectable tritium (2.8-13.4 TU), CFC ages between 20 to 50 yrs b.p., high $d^{18}O$ values (-13.5‰ to -16.1‰), and ~100 percent modern carbon (pmc); and 2) pristine groundwaters at depth with low NO_3^- (1-5 mg/l), no tritium, low $d^{18}O$ values (-17.3‰ to -18.9‰) and < 15 pmc. Nitrogen and oxygen isotopes of NO_3^-, in conjunction with high dissolved oxygen values, confirm that denitrification is not an important process in the organic-poor basalt aquifers resulting in the transport of high NO_3^- irrigation waters to depths greater than 40 m in less than 30 years.

[2]Department of Earth and Environmental Sciences, University of the Pacific
[3]School of Natural Resources, University of Arizona

Vegetation Responses to Precipitation in the Colorado River Basin

Julio Cañón[1,2], Francina Dominguez[1,2] and Juan Valdes[2,3]

Department of Hydrology and Water Resources,
The University of Arizona[1]

This presentation addresses the correlation between precipitation, temperature and vegetation activity in seven level-III ecological regions in the Colorado River Basin: the warm deserts of Sonora and Chihuahua, cold deserts of Arizona/New Mexico and Colorado plateaus, the temperate Sierras of Arizona and New Mexico, the Southern semiarid highlands, the Southern Rockies and the Western Cordillera. Time series of the bi-weekly Normalized Difference Vegetation Index (NDVI) and the Standardized Precipitation Index (SPI at 3 months of aggregation) from 1985 to 2007 were jointly evaluated for all the ecoregions using Multichannel Singular Spectrum Analysis (MSSA) to determine common oscillation patterns and significant lags in vegetation response to precipitation. Results show highly correlated responses (up to 70% of variance explained) between seasonally detrended NDVI and SPI-3 in each of the ecoregions, with distinctive delays in vegetation response ranging from one month in the Sonoran and Chihuahuan deserts to the south (which experience the fringe of the monsoon precipitation regime), to two months in the temperate Sierras and the semiarid highlands of mid latitudes, and three months in the Southern Rockies and the cold deserts of the Colorado and the Arizona/New Mexico Plateaus to the north, more affected by seasonal precipitation. From a hydrological viewpoint, the high correlation between the NDVI and the SPI-3 is useful to estimate evapotranspiration rates, runoff contributions and spatial distribution of precipitation in remote ungauged areas based on vegetation responses. From an ecological perspective the results are useful to predict vegetation responses to recorded precipitation in the ecoregions one to three months in advance.

[2]SAHRA Research Center
[3]Department of Civil Engineering and Engineering Mechanics

A New Approach for Estimating Alpine Snow Cover Using Fusion of Remotely Sensed Data and Artificial Neural Network Analysis

Elzbieta H. Czyzowska[1, 2] and Katherine K. Hirschboeck[1]

Laboratory of Tree Ring Research
The University of Arizona[1]

As multi-year drought persists, water managers in the mountainous western United States need reliable estimates of Snow Water Equivalent (SWE) in alpine regions for the accurate assessment of seasonal water shortages. One of the best ways to address this need is to improve daily snow cover area estimation of the seasonal snow cover through measurements of Fractional Snow Cover (FSC). This study generates estimates of FSC in a complex alpine-forested region of Colorado based on a blending of remotely sensed data at varying spatial and temporal resolutions. The approach is unique in that it fuses the data at the highest available temporal resolution (daily images; MODIS) and the highest available spatial resolution (1m; IKONOS), using moderate resolution data (30m; Landsat TM5/ETM+) as an intermediate step. An Artificial Neural Network (ANN) is used to estimate FSC from the remotely sensed data because it is a straightforward means of extracting fractional values contained in complex multi-spectral imagery. An example of the fusion and FSC estimation technique will be provided.

[2]Arid Lands Resource Sciences, University of Arizona

Strengths and Limitations of Long-term Streamflow Scenarios in the Southwestern United States

Jeannette G. Estes[1], Katie Hirschboeck[2] and Holly Hartmann[3]

Department of Hydrology and Water Resources
The University of Arizona[1]

Water managers in the southwest United States face the challenge of securing sustainable supplies of fresh water over the next century. In the Colorado River basin, climatic change raises the risk of increased stress on water supplies due to decreases in snowpack, increasing evapotranspiration demand, depletion of soil moisture, and streamflow reductions. Because climate plays an important role in water supply availability, there is an increasing need for practical methods that incorporate climatic variability into water management practices. This project compares the strengths and limitations of six methods of developing time series for use in hydroclimatic scenarios: (1) index sequential method, (2) Monte Carlo sampling, (3) quantile mapping, (4) quantity-linked quantile mapping, (5) meteorology-linked quantile mapping, and (6) GCM climate projection adjustments. The six methods for developing time series represent increasingly interconnected linkages of the past (tree-ring based streamflow reconstructions), the present (gauge-based streamflow and instrumental meteorological records) and the future (climate projections based on GCMs). The strengths and weaknesses of the six methods are evaluated using a set of criteria that includes flexibility, underlying assumptions, ease of use, the ability to address nonstationarity, and impacts on the resulting hydroclimatic scenarios. In addition, a library of MatLab software code for the six methods will be developed in support of a paleo-toolkit for "Treeflow," a website containing tree-ring reconstructions of streamflow for water management in the West: http://wwa.colorado.edu/treeflow/.

[2]Laboratory of Tree-Ring Research, University of Arizona
[3]Arid Lands Resources Sciences, University of Arizona

Using Geostatistics, Pedotransfer Functions to Generate 3D Soil and Hydraulic Property Distributions for Deep Vadose Zone Flow Simulations

Zhufeng Fang[1], S.P. Neuman[1], M.G. Schaap[2] and T-M. Yao[3]

Department of Hydrology and Water Resources,
The University of Arizona[1]

We used geostatistical and pedotrsnfer functions to estimate the three-dimensional distributions of soil types and hydraulic properties in a relatively large volume of vadose zone underlying the Maricopa Agriculture Center near Phoenix, Arizona. Soil texture and bulk density data from the site are analyzed geostatistically to reveal the underlying stratigraphy as well as finer features of their three-dimensional variability in space. Such fine features are revealed by cokriging soil texture (as primary variable) and water content measured prior to large-scale long-term infiltration experiments (as secondary variable). Resultant estimates of soil texture and bulk density data across the site are then used as input into a pedotransfer function to produce estimates of soil hydraulic parameter (saturated and residual water content, saturated hydraulic conductivity, van Genuchten parameters α and n) distributions across the site in three dimensions. We compare these estimates with laboratory-measured values of these same hydraulic parameters and find the estimated parameters match the measured well for θs, n and Ks but not well for θr nor α, while some measured extreme values are not captured. Finally the estimated soil hydraulic parameters are put into a numerical simulator to test the reliability and robustness of the models. Resultant simulated water contents do not agree well with those observed, indicating inverse calibration is required to improve the modeling performance.

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[2]Soil, Water and Environmental Sciences, University of Arizona
[3]GeoSystems Analysis Inc., Tucson, Arizona

Patterns and Controls on the Hydrochemistry of Monsoonal Storm Runoff Across an Urban Land Use Gradient in the Tucson Basin

Erika L. Gallo[1], P. D. Brooks[1] and K. A. Lohse[2]

Department of Hydrology and Water Resources,
The University of Arizona[1]

Urban storm runoff in arid regions is increasingly managed for local recharge. Therefore, the quality of this resource is an issue of regional importance. In this study we identified patterns and controls on the hydrochemical response from five catchments of distinct land uses: low, medium and high density residential, mixed and commercial land use. We used a biologically inert solute (chloride, Cl^-) and stable isotope values (δD and $\delta^{18}O$) of rainfall and runoff to infer physical and biogeochemical processes contributing to the solute chemistry observed. Solute response was similar in the commercial and low density watersheds, which had the highest mean seasonal concentrations of Cl^-, dissolved organic carbon (DOC), sodium, mercury and copper among others, suggesting a strong coupling of DOC and metal mobilization. The low density and commercial sites exhibited weakest and strongest seasonal chloride flushing responses. The Cl^-, δD and $\delta^{18}O$ data demonstrate flushing and evapoconcentration of solutes in the commercial site and solute retention in the low density site. Our study demonstrates that the urban storm runoff quality can not be predicted by land use alone and suggests transport controls on solutes at the most urbanized sites, and flow path and biogeochemical controls at least impervious sites.

[2]School of Natural Resources, University of Arizona

Source and Distribution of Isotopically-Depleted Groundwaters in the Columbia Plateau Basalt Aquifers, Washington

Damian Gosch[1], Kyle Brown[1], Jennifer McIntosh[1], Laura Rademacher[2], and Kathleen Lohse[3]

Department of Hydrology and Water Resources, The University of Arizona[1]

Naturally-occurring stable isotopes of water ($d^{18}O$, dH) and carbon-14 can provide information about the effects of past climate events on the hydrology of deep regional aquifer systems. During the Late Pleistocene, outburst flooding from Glacial Lake Missoula scoured out the landscape surface, leaving behind what is today known as the channel scablands in central Washington. We hypothesize that a significant portion of these floodwaters recharged underlying basalt aquifers and comprise an important drinking water resource today in this semi-arid region.

This study couples the use of stable isotopes of water with carbon-14 and geologic cross-sections to determine the age distribution and source of groundwater in the Columbia Plateau Basalt Aquifer System. Shallow groundwaters (< 100 m depth) in the basin have $\delta^{18}O$ values within the range of modern precipitation (-13.5‰ to -16.1‰), and ~ 100 percent modern carbon (pmc) representative of recent recharge. In contrast, deep groundwaters (100-700 m depth) have low $\delta^{18}O$ values (-18.9 to -17.3‰) and low radiocarbon values (< 15 pmc) corresponding to Late Pleistocene apparent ages. Given the dry climatic conditions in the Columbia Plateau region at the end of the Last Glacial Maximum, these Pleistocene groundwaters were likely sourced from paleoflood waters.

[2]Department of Earth and Environmental Sciences, University of the Pacific
[3]School of Natural Resources, University of Arizona

Modeling and Calibration of Groundwater Effecting Drain Flow in the Lower Rio Grande Basin

Andrew S. Hartz, T. Maddock III and T.P.A.Ferré

Department of Hydrology and Water Resources,
The University of Arizona

The states of Texas and New Mexico reached a historic agreement on water use from the Rio Grande River in 2008. To meet the demands of this compact, the state of New Mexico is updating their groundwater flow model for Administration and Management in for the Lower Rio Grande Basin. Part of this effort examines effects of the Canutillo well field on surface waters. The spatial effects on agricultural drain flows are highlighted in this poster. A model was built including the Canutillo wells. Then, the wells were removed from the original model and the effects on the drain return flows were quantified. Initial results show that one notable drain lost approximately 2% of the Rio Grande River's annual flow. Further, investigations are ongoing.

The calibrated model will be also be used as the basis of a novel application of geophysics to quantify groundwater storage changes. Specifically, the model predictions will be used to identify locations at which changes in the gravitational attraction at the ground surface will be measured through time. The goal is to combine less expensive, although less accurate, gravity measurements with highly accurate, but sparse groundwater levels to quantify changes in water storage through time.

Optimizing Sampling Design Based on Minimum Detectable Change in Trends Using the Seasonal Kendall Test

Melanie Lindsey and Thomas Meixner

Department of Hydrology and Water Resources,
The University of Arizona

The National Park Service Sonoran Desert Network is charged with preserving natural resources for current and future generations throughout southern Arizona and southwestern New Mexico. The quality of the Parks' water resources is imperative to this mission. The baseline water quality report from 2003found most of the springs in the Parks within the States' Aquatic and Wildlife standards. Some constituents that pose a problem are pH, trace metals, ammonia and E. coli. Water quality data from within the Parks are few, therefore sites near the Parks with years of samples collected monthly needed to be found. The first of these sites is Mogollon Creek in New Mexico, part of the Hydrologic Benchmark Network. Data collected from Mogollon Creek, Wet Bottom Creek and others are to be used to determine regional trends across the Sonoran Desert. The Seasonal Kendall test is used to determine significant trends in a dataset. These datasets will be evaluated for a Minimum Detectable Change (MDC) in surface water quality while minimizing the amount of false negatives (type 2 error) in trend detection. The MDC will help determine future sampling designs to optimize water quality monitoring within the Sonoran Desert Network.

Assimilation of Snow Cover Area information into land surface models to improve streamflow predictions in the Salt and Verde Rivers

Viviana López-Burgos, Seshadri Rajagopal, Guillermo Martínez and Hoshin Gupta

Department of Hydrology and Water Resources, The University of Arizona

Challenges related to growing population leading to increasing water demand and decreasing availability of water resources require a detailed quantification of hydrological processes and changes of climate patterns. The integration of detailed spatial information of water fluxes from remote sensing platforms and hydrological models is an important step towards this goal. The Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra satellite (launched in 1999) will be used to provide Snow Cover Area (SCA) data as input to the Variable Infiltration Capacity model (VIC). VIC will be used to assess climate change impacts on the local hydrology of two rivers managed by the Salt River Project, a water and energy supplier in central Arizona. This solution will help improve the management of reservoirs in the Salt and Verde River in Phoenix, Arizona (tributaries of the lower Colorado River basin), by incorporating physically based distributed models and remote sensing observations into their Decision Support Tools and planning tools. In addition, spatial-temporal analyses will be done to assess the condition of the watersheds' snow distribution throughout the years. This research seeks to increase the knowledge base used to manage reservoirs and groundwater resources in a region affected by a long term drought. It will be applicable and relevant for other water utility companies facing the challenges of climate change and decreasing water resources.

Investigation of Analytical Method for Pumping Test In Unconfined Aquifers

Deqiang Mao and Tian-Chyi Jim Yeh

Department of Hydrology and Water Resources
The University of Arizona

Existing analytical models for the analysis of pumping tests in unconfined aquifers rely on either a depth-averaged, two-dimensional groundwater flow equation with delayed yield source function, or a three-dimensional groundwater flow model incorporating the unsaturated zone with linearized assumption. Recent advances in computer technology and numerical analysis make it possible to investigate usefulness of the estimated hydraulic properties derived from these analytical models.

In this study, we first use a 3-D variably saturated flow model to simulate pumping tests in unconfined aquifers with both homogeneous and heterogeneous hydraulic properties. We then apply the new Tartakovsky and Neuman (2007) analytical model to the simulated drawdown-time data in the homogeneous aquifers to verify their abilities to obtain true hydraulic properties. Subsequently, the analytical model is applied to those simulated data in heterogeneous aquifers to obtain effective hydraulic properties. In addition, PEST combining VSAFT2 are used to estimate both saturated and unsaturated hydraulic properties. Moreover, sensitivity analysis is done for the unsaturated parameters. Our study shows that moisture retention characteristics and the unsaturated hydraulic conductivity characteristics have totally different impacts on the "delayed yield" phenomenon. Comparisons between numerical and analytical models show that analytical model may lead to unrealistic specific yield or unsaturated parameters.

Carbon and Water Fluxes for a Desert Turfgrass: Applications for Urban Settings

Andrew L. Neal and Shirley A. Kurc[1,2]

Department of Hydrology and Water Resources
The University of Arizona[1]

In urban areas, turfgrass is widely used for practical and aesthetic functions, from soil stabilization to parks and recreational sites. Most estimates of turfgrass carbon uptake depend on leaf-scale measurements or clipping data and water flux is generally determined using agriculturally-derived estimation tools. Eddy covariance (EC) provides a robust method to quantify fluxes of carbon and water and has been validated across a broad array of natural ecosystems—including semi-arid upland grasslands. However, its use in urban ecosystems is less prevalent. In this study, a small (~0.5ha) lawn in a complicated terrain setting is used as a proxy for an urban turfgrass application. We find that EC produces valid results despite the terrain complexity and provides an estimate for carbon uptake in similar settings. Our study demonstrates that EC can be used to estimate urban carbon budgets and evapotranspiration, with applications to a variety of management needs.

[2]School of Natural Resources, University of Arizona

^{129}I and Sr isotopes as tracers of large-scale fluid migration in the northern Appalachian Basin

Stephen G. Osborn and Jennifer C. McIntosh

Department of Hydrology and Water Resources,
The University of Arizona

Previous studies of ore deposits, fluid inclusions and clay mineral assemblages suggest that brines have migrated long distances across the Appalachian basin. This pilot study uses iodine and strontium isotopes as tracers of brine migration in the northern Appalachian basin (W. NY and N.W. PA). Samples were collected from producing oil and gas wells and analyzed for ^{129}I/I, ^{87}Sr/^{86}Sr, stable isotopes, and elemental composition. Measured ^{129}I/I values (28-1890X10^{-15}) are greater than expected cosmogenic values (10^{-19} to 10^{-21}), given the depositional age (>350 Ma) of the source organic matter. Fissiogenic ^{129}I/I values (50-100X10^{-15}), estimated from published ^{238}U (spontaneous fission to ^{129}I) data, cannot account for all of the high ^{129}I/I values. Large ^{238}U deposits in S.E. PA represent a regional fissiogenic iodine source in brines that may have been mobilized during the Alleghanian orogeny (~315 Ma). Strontium isotope results show a mixing trend between a radiogenic (0.7210) end-member (consistent with exchangeable ^{87}Sr/^{86}Sr on smectite-illite clay assemblages), with a low ^{87}Sr/^{86}Sr (0.7100) end-member (within the range of Paleozoic marine carbonates in the Appalachian basin). Relatively low K^+/Cl^- ratios have a weak correlation with radiogenic Sr values and may provide evidence for clay diagenesis by high temperature fluids expelled basinward during orogenic events.

Multiple-Criteria Calibration of a Distributed Watershed Model Using Spatial Regularization and Response Signatures

Prafulla Pokhrel, Koray Yilmaz and Hoshin Gupta

Department of Hydrology and Water Resources,
The University of Arizona

The study explores the use of a semi-automated multiple-criteria calibration approach for estimating the parameters of the spatially distributed HL-DHM model to the Blue River Basin, Oklahoma. The study was performed in the context of Phase 2 of the DMIP Project organized by the Hydrology Lab of the NWS. To deal with the problem of ill conditioning, we employ a regularization approach that exploits the information contained in *a priori* estimates of the spatially distributed parameter fields developed from soils and other geo-spatial datasets. The approach reduces the number of unknowns to be estimated using historical input-output data from 860 to 35. Two commonly used summary statistics of the model residuals, MSE and MSEL, are used to optimize fitting of the model to both the peaks and the recession periods of the time series data. A signature measure approach is used to select parameter sets that are close to Pareto optimal in terms of MSE and MSEL, but which provide more consistent representation of the hydrologic behavior of the watershed as summarized by measures derived from the flow duration curve.

Concentration changes of nutrients, trace metals, and labile organic matter due to Pleistocene recharge and dilution of Illinois Basin brines

Melissa E. Schlegel, J. McIntosh and T. Meixner

Department of Hydrology and Water Resources,
The University of Arizona

Economic accumulations of biogenic gas in the deep subsurface have recently been recognized as an unconventional semi-renewable energy source. Methane is generated as microbes reduce carbon dioxide and ferment organic acids (primarily acetate) sourced from organic-rich substrates, such as the Upper Devonian New Albany Shale (~1500m deep) and Pennsylvanian coalbeds (~100m deep) in the Illinois Basin. The occurrence of biogenic methane seems to be associated with a plume of anomalously low-salinity water that corresponds to the axis of the Michigan lobe of the Laurentide ice-sheet, suggesting that the dilute water is glacial in origin. We hypothesize that Pleistocene glaciation enhanced freshwater recharge into fractured shales and coalbeds, which significantly diluted formation water salinity to levels non-inhibitory for methanogenesis, and may have enhanced release of nutrients, trace metals, and labile organic matter, further stimulating biogenic methane production. To test our hypotheses we will use PHREEQC modeling to simulate initial basinal brine conditions followed by multiple percentages of fresh water mixing and subsequent microbial metabolism. Model results will be coupled with carbon-14, stable isotope, ion, trace metal, and acetate analyses to determine the groundwater age of the dilute plume and evaluate our understanding of interactions between the aquifer matrix, solute chemistry, and microbial processes in the subsurface.

Defining flood recharge processes and residence times: Bill Williams River

Scott C. Simpson[1], Thomas Meixner[1] and James Hogan[,2]

Department of Hydrology and Water Resources,
The University of Arizona[1]

The ultimate goal of this study is to provide the next step toward a detailed knowledge of the long-term, basin-scale impacts of flooding on surface and groundwaters. Here we investigate the Bill Williams River, which, during all but the largest floods, infiltrates entirely at the east end of Planet Valley and reemerges at the west end and enters a national wildlife refuge (NWR). To accomplish this goal, river and groundwater samples were collected from April 2007 through present. Isotopic ($\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S_{SO4}$, $\delta^{18}O_{SO4}$) and chemical differences in streamflow and groundwater below Alamo Dam indicate the dominance of unevaporated groundwater in NWR baseflow, suggesting minimal time, if any, in Alamo Lake. Isotopic analysis further shows that sulfate in NWR baseflow has undergone minimal reduction and that Planet Valley groundwater trends from more- to less-reduced sulfate with distance downstream. This trend indicates minimal time in Alamo Lake and offers the possibility that pre-dam water is the dominant NWR baseflow source. To quantify water ages, tritium (^{3}H) analysis is pending for all Planet Valley wells and three river samples. This approach will permit estimation of residence times in Planet Valley and quantification of NWR streamflow sources, thereby defining the impact of recharge-inducing floods.

[2]Center for Sustainability of Semi-Arid Hydrology and Riparian Areas (SAHRA), Tucson, Arizona

Use of KINEROS2 and the Continuous Slope-Area Method to Estimate Infiltration and Ground-Water Recharge from Ephemeral Stream Channels in Southeast AZ

Stewart, A. M.[1]; Callegary, J. B.[2]; Smith, C. F.[2]; Gupta, H. V.[1]; Leenhouts, J. M.[2], Goodrich, D. C.[3]

Department of Hydrology and Water Resources,
The University of Arizona[1]

KINEROS2, an event-based rainfall-runoff model, is being used to estimate changes between predevelopment and postdevelopment volumes of runoff and infiltration from ephemeral stream channel flows in southeastern Arizona. Modeling results will be used with a water balance to estimate associated changes to ground-water recharge. Runoff data, required for model calibration, were collected during 2007-08 using the continuous-slope-area method (CSA), currently under development at the USGS Arizona Water Science Center. CSA applies the slope-area computation algorithm (SAC) to continuous stage data collected in optimal-CSA reaches to calculate runoff time-series. CSA gages were installed at 11 ephemeral stream channel reaches. Gages consist of three equally-spaced cross-sections where pressure transducers are installed in the channel bed. For independent checks, one monitoring station was installed at a weir and 12 direct runoff measurements were made during summer 2008. Two gages in undeveloped areas were established to generate model parameters for the predevelopment scenario. To date, the highest stage measured was 1.2 meters, with an associated instantaneous SAC-calculated discharge of 22.5 cubic meters per second (preliminary). CSA data analysis is ongoing. The model has been parameterized and run with design storms. Measured rainfall data and CSA-calculated discharge still need to be incorporated into the model.

[2]U.S. Geological Survey Arizona Water Science Center, Tucson, Arizona
[3]U.S.D.A. Agricultural Research Service, Tucson, Arizona

Sources of groundwater in glacial till and bedrock aquifers in the Illinois Basin

Lisa Wade, Melissa Schlegel and Jennifer McIntosh

Department of Hydrology and Water Resources,
The University of Arizona

Freshwater aquifers in the Illinois Basin, located in Illinois and Indiana, support over 30 million acres of agriculture and 15 million people. The aquifers are composed of unconsolidated glacial till with a maximum depth of 150 meters overlying Pennsylvanian-Mississippian carbonates, fractured Upper Devonian shales and Silurian-Devonian carbonates. The Illinois Basin has less than 330 meters in elevation change, creating a low topographical gradient that likely constrains the circulation depth of modern recharge. However, 18,000 years ago, the region was inundated by kilometer-thick ice sheets that could have provided sufficient hydraulic head to drive subglacial recharge into deep basinal aquifers.

We hypothesize that shallow glacial till aquifers contain modern meteoric waters, while carbonate and shale bedrock aquifers contain Pleistocene glacial meltwaters. We also hypothesize that at present there is limited mixing between the shallow and deep aquifers. To determine the residence time and sources of recharge, we compiled new chemical and isotopic data collected this past summer with previously published datasets from the U.S. Geological Survey and others. Initial results show that groundwater in glacial till aquifers have short residence times (<50 years) and are susceptible to contamination, whereas Pleistocene groundwaters in bedrock aquifers were recharged prior to any anthropogenic activities.

Mean Flow and Turbulence Around Two Series of Experimental Dikes

Mary Yaeger[1] and Jennifer Duan[2]

Department of Hydrology and Water Resources,
The University of Arizona[1]

Scour around various structures obstructing flow in an open channel is a common problem. To better understand why this occurs, two questions must be answered: what are the mean flow and turbulence distributions around these structures and how do these mean flow and turbulence fields affect sediment transport? Which of these contributes more to sediment transport?

To answer this, a turbulence and shear stress study was conducted in a flat, fixed bed flume. A series of three dikes were placed on the left wall, partially obstructing the flow and a microADV was used to measure velocities near the bed in all three spatial directions. From these measurements turbulence intensities, Reynolds stresses, and bed shear stresses were calculated. Results showed that the largest magnitudes of all parameters of interest were concentrated around the second dike, with horizontal components of both Reynolds stresses and turbulence intensities having the highest magnitudes.

Better understanding of these processes will aid scientists and engineers in designing better embankments for prevention of bank erosion as well as preventing scour around bridge piers. This knowledge will also benefit river restoration projects, as areas around these embankments and dikes are often habitats for vegetation and fish.

VSAFT2: A Graphic User Interface for MMOC2

Chunshui Yu, Deqiang Mao and Jim Yeh

Department of Hydrology and Water Resources,
The University of Arizona

We are making available our powerful variably saturated two and three dimensional flow and transport models with user-friendly Graphical User Interfaces (GUIs). The GUI will allow a broader group of people to take advantage of the powerful forward and inverse modeling tools we have developed. This powerful software combines a proven finite element method for solving the steady-state or transient flow problem with the modified method of characteristics to solve the transport equations in variably saturated media. VSAFT2 then goes to the next step and also incorporates our powerful inversion method to facilitate the inversion of flow and transport models, as well as hydraulic tomography.

The GUI makes model pre-process a simpler, and error-free process, rather than a tedious job of editing text input files by hand. The program also interferes with the top of the line CFD software package Tecplot. New features include inverse modeling and hydraulic tomography, built-in geostatistical modeling features, random field generation, a triangular or rectangular finite element mesh and the ability to import a background image (map) for model setup.

Department of Hydrology and Water Resources
The University of Arizona
J.W. Harshbarger Building
P.O. Box 210011
Tucson, Arizona 85721-0011
http://www.hwr.arizona.edu