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Department of Hydrology and Water Resources

Presents

The 20th Annual

El Dia del Agua

March 31, 2010

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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 20th 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 eight oral presentations, twenty-two research posters and two guest speakers. This symposium is an event ***for the students, by the students*** which facilitates direct feedback 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.

Ingo Heidbüechel
HWRSA President

Matthew Switanek
HWRSA Vice-President

Phoolendra Mishra
HWRSA Treasurer

Viviana López~Burgos
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.

El Dia del Agua ~ Program Schedule

8:00-8:45	Registration, Check In & Continental Breakfast
8:45	Welcome Dr. Thomas Maddock III, Department Head Ingo Heidbüechel, 2009-2010 HWRSA President
8:50-9:30	**Oral Presentations ~ Moderator Damien Gosch,** 2009 El Dia del Agua Recipient of the Donald R. Davis Undergraduate with Distinction Award, and the 2010 Tucson Chapter President of Arizona Hydrologic Society **8:50-9:10,** Seshadri Rajagopal ~ *"Assessing impacts of climate change in a semi arid watershed using downscaled IPCC climate output"* **9:10-9:30,** Ari J. Posner ~ *"Numerical Modeling of River Meander Evolution"*
9:30-10:30	Poster Session
10:30-11:30	**Oral Presentations ~ Moderator Ingo Heidbüechel,** 2009-2010 HWRSA President, and the 2009 El Dia del Agua Recipient of the Montgomery Prize for Best Oral Presentation **10:30-10:50,** Stephen G. Osborn ~ *"Microbial Fractionation of Iodine Isotopes: Evidence from Appalachian Basin Brines"* **10:50-11:10,** Erika L. Gallo ~ *"Controls on Monsoonal Storm Runoff Magnitude and Quality of Urban Catchments in the Tucson Basin"* **11:10-11:30,** Andrew J. Somor ~ *"Beetles & Streamflow: Hydrologic Implications of the Mountain Pine Beetle Epidemic in Western Forests"*
11:30-12:00	Buffet Lunch

El Dia del Agua ~ Program Schedule
Continued

12:00	Dr. Karl Flessa, Department Head for Geosciences, Director of the School of Earth and Environmental Sciences (SEES)
12:00-1:30	Plenary Lecture Dr. Randy Olsen, Prairie Starfish Productions, University of Southern California, *"Don't be Such a Scientist: Talking Substance in an Age of Style"*
1:30-2:00	Poster Session
2:00-3:00	**Oral Presentations ~ Moderator Erika Gallo,** 2009 El Dia del Agua Recipient of the Hargis Award Second Place Poster **2:00-2:20,** Phoolendra Kumar Mishra ~ "*Radial Flow to a Partially Penetrating Well with Storage in a Confined Aquifer"* **2:20-2:40,** Scott Simpson ~ *"Influence of Regional Gradients on Flood-Driven Recharge in Semi-Arid Rivers"* **2:40-3:00,** Matthew Narter ~ *"Measurement and Estimation of Organic-Liquid/Water Interfacial Areas for Several Natural Porous Media"*
3:00-3:30	Poster Session
3:30	Dr. Thomas Meixner, Associate Professor HWR
3:30-4:30	Keynote Speaker, Dr. David Kraemer, Dept. of Geosciences, University of Nevada, Las Vegas, *"Hydrophilanthropy—The International Challenge for Universities"*
4:30-6:30	Award Presentations ~ Refreshments & Appetizers *Montgomery Prize ~ By Elizabeth León Mora* *Hargis Awards ~ By David Hargis* *HWR Awards ~ By Thomas Meixner* *Donald R. Davis Award ~ By Martha Whitaker* *Aqua-Person Award ~ By Ingo Heidbüechel*
7:00	Tucson Screening of the movie Sizzle: A global Warming Comedy, with writer-director Randy Olsen, at The Loft Cinema, located at 3233 E. Speedway

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El Dia del Agua Awards Evaluation Committee

Montgomery Prize
Elizabeth León Mora ~ Ralph Morra ~ James Washburne

Hargis Awards
David Hargis ~ Leo Leonhart
Dennis Scheall ~ Rob Wilhelm

Hydrology & Water Resources
Award of Excellence for Oral Presentation
Ann Kramer Huth~ Mohammed Mahoud

Hydrology & Water Resources
Award of Excellence for Poster Presentation
Deirdre Brosnihan ~ George Kalli
Jeff Kennedy ~ Aleix Serrat
Katie van Werkhoven ~ Larry Winter

Donald R. Davis
Undergraduate with Distinction Award
Martha Whitaker

Oral Presentation Moderators
Damian Gosh ~ Ingo Heidbüechel ~ Erika Gallo

HWR Student Association Officers
Ingo Heidbüechel ~ President
Matthew Switanek ~ Vice-President
Phoolendra Mishra ~ Treasurer
Viviana Lopez-Burgos ~ Social Chair

The Montgomery Prize

The Department of Hydrology and Water Resources would like to thank Errol L. Montgomery & Associates, Inc. for their support of the 20th 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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- 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.

Donald R. Davis
Undergraduate with Distinction Award

Donald Davis joined the UA Department of Hydrology and Water Resources in 1972, so he was one of the most senior members of the faculty. His primary research focus was decision making under hydrologic and other uncertainties, and his basic approach utilized Bayesian decision theory in a general system setting.

Even though his halcyon days of funded research were behind him, up until shortly before his death on January 25, 2009 Dr. Davis was still actively engaged in independent statistical studies with individuals both inside and outside the university, and he continued to serve on MS and PHD exams. He was still advising master's and especially doctoral students who were majoring and minoring in Hydrology with the statistical aspects of their research projects. He was an active faculty examiner for the Doctoral Qualifying Exams in surface hydrology and water resources.

Don served as the Undergraduate Coordinator and was the primary advisor to undergraduates with a major or minor in Hydrology and Water Resources. He taught the year-long Senior Capstone and Senior Honors Thesis courses and was a rotating instructor for the College of Engineering's freshman course, Engineering 102. Along with Gary Woodard, he designed and oversaw the Master of Engineering degree program in Water Resources Engineering and helped that fledgling program get off the ground.

Dr. Davis left an endowment to the Department of Hydrology and Water Resources specifically for undergraduates, whom he nurtured. The evaluation will be made by the Undergraduate Advisor. The Donald R. Davis Undergraduate with Distinction Award will recognize an outstanding undergraduate student who demonstrates proficiency of excellence in writing, speaking and visual poster or oral presentation.

Dr. Donald R. Davis will be remembered not only for his academic and advising contributions, but for his love of the undergraduate program he so nurtured.

Up and Coming Hydrologist

The Department of Hydrology & Water Resources would like to showcase two outstanding students who focus their award winning science fair projects on some aspect of applied hydrologic science. Both students received a special category award from the Department of Hydrology & Water Resources.

Josh Oetter
Oetter Academy, Tucson, Arizona
"Stopping the Soil"

Stopping the Soil investigates if certain plants prevent erosion better than others. The plants used were the Latana, Sierra Gold, and Gazania. To determine which plant kept the dirt back the best, the equation Weight Lost divided by Weight Before equals Percentage Lost was used. (SciEnTeK-12 Foundation. 2nd Place—6th Grade)

Kelsey Waite
Tucson High Magnet School, Tucson, Arizona
"Determining the location and spreading of the salt water—fresh water interface in wells using simple resistance measurements"

Many coastal areas are home to large concentrations of people, creating a huge demand for fresh water resources. The over exploitation of fresh groundwater is one of the leading causes of salt water intrusion, which is becoming an increasing threat to coastal cities' fresh water supply. Careful management is important to knowing where the interface (mixing zone) between the salt water and fresh water is, and how much spreading there is at the interface to ensure safety of the wells. In previous research, the most common way of finding this interface in the field is by using Electrical Conductivity (EC) measurements.

For this experiment, a column was built containing thermocouples and electrodes. Fresh water was added to fill the column half way before slowly introducing salt water through the bottom. As time increased, the EC of the area between the middle two electrodes (where the interface was located) increased. This means that the interface is spreading, causing salt water to move upward into the freshwater. The experiment has many applications in the field where a probe could be designed to determine where the interface between the salt water and fresh water is located. *(SciEnTeK-12 Foundation (SARSEF) 2nd Place ● Invitation to Stockholm Water Environment Fair ● Arizona Hydrological Society 1st Place (Region, State) ● UA Water Sustainability 1st Place ● Wallace Foundation Scholarship ● 3rd place In Environmental Science ~ Arizona Science & Engineering Fair)*

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EL Dia Del Agua ~ Plenary Lecture

Dr. Randy Olson
Prairie Starfish Productions and
University of Southern California

"Don't be Such a Scientist: Talking Substance in an Age of Style"

Randy Olson (born October 3, 1955) is a scientist-turned-filmmaker who earned his Ph.D. in Biology from Harvard University (1984) and became a tenured professor of marine biology at the University of New Hampshire (1994) before changing careers by moving to Hollywood and entering film school at the University of Southern California. He has written and directed a number of short films and feature documentaries which have premiered at film festivals such as Tribeca Film Festival and Telluride Film Festival. Most of his films draw on his science background, involve humor, and address major science issues such as the decline of the world's oceans, the controversy around the teaching of evolution versus intelligent design, and the attacks on global warming science. His company, Prairie Starfish Productions, is based at Raleigh Studios in Hollywood, California. He is currently the Director of the Shifting Baselines Ocean Media Project. His work includes Flock of Dodos and Sizzle: A Global Warming Comeday.

EL Dia Del Agua ~ Keynote Speaker

Dr. David Kreamer

Department of Geosciences
University of Nevada, Las Vegas

"Hydrophilanthropy - The International Challenge for Universities"

Dr. David Kreamer is a Professor of Geoscience, Graduate Faculty in Civil and Environmental Engineering, and past Director of the interdisciplinary Water Resources Management Graduate Program at the University of Nevada, Las Vegas. He also serves on the faculty of the University of Nevada, Reno, Hydrologic Sciences Program. His Ph.D. is in hydrology from the University of Arizona, with undergraduate work in microbiology and chemistry. Before coming to the University of Nevada in 1990, he served as an Assistant Professor in Civil Engineering at Arizona State University. Dr. Kreamer serves as Director of the National Groundwater Association's Division of Scientists and Engineers, is an Executive Board Member of the U.S. National Chapter of the International Association of Hydrogeologists, serves as Editor of the USNC International Association of Hydrogeologists Newsletter, and will co-convene the 2010 Annual Ground Water Summit, April 11-14 in Denver, CO, which is a Joint Meeting of the National Ground Water Association and the Groundwater Protection Council. He is currently Editor of a theme issue of the Universities Council on Water Resources publication, *Journal of Contemporary Water Research and Education*, on the subject of "Hydrophilanthropy", to be published later this year. Dr. Kreamer's research includes subsurface fluid flow, environmental contamination, spring vulnerability and sustainability, and water and energy supply, particularly in the Developing World. He has authored over 45 professional publications and has given over 150 invited lectures, seminars and workshops in recent years for U.S. Environmental Protection Agency, U.S. Bureau of Land Management, the National Ground Water Association, and the Superfund University Training Institute, presented short courses for over half the States or Commonwealths in the United States, and lectured for other groups such as City of Phoenix, University of California Extension, and Hanford Nuclear Site. He also has given presentations at over 40 Universities, and has been an invited speaker in Europe, Asia, the Caribbean, Pacific island nations, South America, Africa and the Middle East. Among other activities, in the last year David has testified before the U.S. Congress on the effect of uranium mining on the springs of the Grand Canyon, and given a short course on water quality to the Iraqi Ministry of the Environment in Bagdad.

2010 El Dia del Agua
Student Volunteer Committee

Gustavo Carrillo-Soto
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Erika Gallo
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Matt Switanek
Clare Stielstra
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Rachel Lambeth-Beagles

Oral Presentation Abstracts

Assessing impacts of climate change in a semi arid watershed using downscaled IPCC climate output

Seshadri Rajagopal, Francina Dominguez, Hoshin V Gupta, Peter A Troch, and Matej Durcik

Department of Hydrology and Water Resources
The University of Arizona

This presentation discusses our research aimed at helping water managers at the Salt River Project (SRP), Phoenix, assess long term climate change impacts for the Salt and Verde River basins, and make informed policy decisions. Our goal is to assess the future 100 year water balance by development, application and testing of a physically based distributed hydrologic model forced by downscaled IPCC climate information. The variable infiltration capacity (VIC) model is set up to simulate historical observed streamflow at the outlet of Salt and Verde River basins using gridded observed precipitation and temperature data. The model is calibrated using the Shuffled Complex Evolution (SCE-UA) method incorporating observed climate elasticities of the Salt and Verde River basins. The most appropriate models and emission scenarios from the Global Climate Model's (GCM's) participating in the IPCC fourth assessment were then chosen and statistically downscaled to incorporate ENSO variability. The forcing dataset created using the downscaled data was used to analyze the basin scale responses to climate change. In this presentation, the scenarios based on future climate forcing data will be presented.

Numerical Modeling of River Meander Evolution

Ari J. Posner and Jennifer Duan

Department of Hydrology and Water Resources
The University of Arizona

River meander migration is one of the most perplexing and intriguing problems in open channel hydraulics. Traditional methods correlate meander geometry with hydraulic parameters based on regression analysis. With advances in computing technology, analytical and computational models are now applied to predict evolution of meander planforms. To sustain instream infrastructure, improve ecologic functions, and protect water quality, understandings of meandering processes are of scientific and societal values. Challenges in simulating meandering processes include the roles of bends on streamwise and transverse velocity, sediment transport, and bank erosion. This study adopted first and second order analytical solutions for the flow field. Several bank erosion models were implemented to predict the rate of bank erosion and consequently the evolution of meandering planforms. The modeling results were analyzed and compared to observed data. Meander migration consists of downstream translation, lateral expansion, and downstream or upstream rotations. Several measures are formulated to determine which resulting planforms are closest to the experimental data. Preliminary results suggested models highly depend on the selected bank erosion model. Parameters (e.g. bank erosion coefficient) need to be defined accurately from field measurements. Future work will analyze the uncertainty of modeling results and determine confidence interval bounds for channel thalweg solutions.

Microbial Fractionation of Iodine Isotopes: Evidence from Appalachian Basin Brines

Stephen G. Osborn and Jennifer C. McIntosh

Department of Hydrology and Water Resources
The University of Arizona

Iodine isotope ratios (^{129}I/I) have been employed as a tracer of organic matter diagenesis and fluid flow in regional scale hydrologic flow systems and for assessing the global circulation of radionuclides. Many geochemical studies generally do not consider fractionation of ^{129}I/I values as significant, likely due to iodine's high molecular weight. Recent studies on other high molecular weight elements (up to mercury) show that microbially-mediated fractionation is significant and measureable, citing advances in analytical techniques, stepped oxidation-reduction reactions involving elements with multiple valence states, and assimilation of lighter isotopes as a controlling factor. Several brine samples collected from the northern Appalachian Basin have ^{129}I/I exceeding background levels of fissiogenic iodine (>270x10^{-15}). These samples have increasingly negative δ^{13}C-DIC values (<-22‰) and decreasing sulfate concentration with depth, consistent with microbial sulfate reduction. In addition, they have low chloride levels (<2,000 mM), within tolerance limits for microbial metabolism. ***Given that iodine has multiple oxidation states and that microbes mediate its transformations, we hypothesize that fractionation of iodine isotopes by microbes may explain anomalously high measured ^{129}I/I ratios in Appalachian Basin brines.*** This result may have important implications for an improved understanding of iodine biogeochemistry and its use as a natural tracer in hydrologic studies.

Controls on Monsoonal Storm Runoff Magnitude and Quality of Urban Catchments in the Tucson Basin

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

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

The importance of recharged storm runoff as a renewable water resource continues to increase in the semi-arid southwest, thus raising questions regarding urban storm runoff magnitude and quality. While conceptual frameworks from humid regions suggest that land use controls storm runoff magnitude and quality, here we ask: what controls monsoonal storm runoff magnitude and quality in semi-arid urban catchments? We collected stage data and stormwater samples from five urban Tucson Basin catchments during the 2007 and 2008 summer monsoons. Our data show that monsoonal runoff magnitude is mainly controlled by rainfall magnitude and catchment imperviousness. Surprisingly, antecedent conditions did not impact runoff magnitude, and runoff quality did not correlate with imperviousness or land use. Concentrations of some solutes including the hydrologic tracer chloride decreased with discharge; while concentrations of other solutes including calcium and nitrate-N, varied independently of discharge. Chemograph hysteresis and clustering analysis suggests that runoff quality is controlled by: 1) solute flushing and dilution, and 2) constant solute sourcing due to large solute reservoirs. This study shows that in semi-arid urban catchments, rainfall magnitude, solute sourcing and hydrologic transport largely control runoff magnitude and quality; and challenges land use as the primary control of runoff responses.

[2]School of Natural Resources and the Environment, The University of Arizona

Beetles & Streamflow: Hydrologic Implications of the Mountain Pine Beetle Epidemic in Western Forests

Andrew J. Somor, P.D. Brooks, P.A. Troch, and A.A. Harpold

Department of Hydrology and Water Resources
The University of Arizona

Over the last decade, millions of acres of western US forests have been reduced to areas of standing dead trees following eruptions in mountain pine beetle (MPB) populations. Numerous studies have identified climate change and forest management practices as key contributors to the recent MPB outbreak. Additional research has shed light on the biological processes leading to tree death and characteristics of infested trees, which include bright red foliage within one year of infestation (red-attack) and loss of needles in the years following (gray-attack). Less attention has been given to understanding the effect of MPB induced tree die-off on hydrological processes which regulate stream and river flows. Here, we test two hypotheses related to hydrologic partitioning following MPB infestation: 1) reduced transpiration losses following red-attack results in increased stream baseflow, and 2) reduced canopy interception following gray-attack results in increased surface runoff. We test these hypotheses using hydro-climatic data from sites distributed throughout the western US experiencing a range of MPB impacts. A comprehensive knowledge of effects of the MPB epidemic on streamflow can aid water resource managers and water supply projections, as these effects may differ from those of other forest disturbance types.

Radial Flow to a Partially Penetrating Well with Storage in a Confined Aquifer

Phoolendra Kumar Mishra and Shlomo P Neuman

Department of Hydrology and Water Resources
The University of Arizona

Drawdowns generated by extracting water from a large diameter (e.g. water supply) well are affected by wellbore storage. An analytical solution in Laplace transformed space for drawdown in a uniform anisotropic confined aquifer caused by withdrawing water at a constant rate from a partially penetrating well with storage is presented. When the pumping well is fully penetrating our solution reduces to that of *Papadopulos and Cooper* [1967]; *Hantush* [1964] when the pumping well has no wellbore storage; *Theis* [1935] when both conditions are fulfilled; and *Yang et.al. [2006]* when the pumping well is partially penetrating, has finite radius but lacks storage. We use our solution to explore graphically the effects of partial penetration, wellbore storage and anisotropy on time evolutions of drawdown in the pumping well and in observation wells. We end by analyzing synthetic pumping test data using our new analytical solution.

Influence of Regional Gradients on Flood-Driven Recharge in Semi-Arid Rivers

Scott Simpson and Thomas Meixner

Department of Hydrology and Water Resources
The University of Arizona

The rise in stream stage during high flow events can convert gaining streams to losing streams. Aquifer response to these events impacts the geochemical composition of both near-stream groundwater and post-event streamflow. Our study focuses on the following questions. (1) How do point-scale processes vary with localized differences in stream-aquifer connectivity? (2) What significance do these processes have on post-flood water quality? Shallow subsurface samples (< 1.6 m) were collected along two gaining and two losing reaches of the Upper San Pedro River to better understand vertical flood recharge through the streambed. Anion data from these samples indicate that subsurface floodwater residence times are greatly influenced by the stream-aquifer gradient's direction and magnitude. Strongly gaining reaches show minimal floodwater retention shortly after large events, whereas weakly gaining and seasonally variable (i.e. gaining in winter, losing in summer) reaches retain floodwater from smaller events for longer periods. Overall, the results indicate that reach-scale differences in stream-aquifer connectivity of gaining-losing rivers controls the amount of floodwater recharged locally during events and the time-scale of it's subsurface retention.

Measurement and Estimation of Organic-Liquid/Water Interfacial Areas for Several Natural Porous Media

Matthew Narter[1] and M.L. Brusseau[1,2]

[1]Department of Soil, Water, and Environmental Science
The University of Arizona

The transport and fate of organic contaminants is mediated by pore-scale processes such as multi-phase flow (immiscible displacement) and mass transfer (evaporation, dissolution), which in turn are controlled by the organic-liquid/water interface. The objective of this study was to quantitatively characterize the interfacial area between immiscible organic liquid and water in natural porous media. Synchrotron X-ray microtomography was used to obtain high-resolution, three-dimensional images of solid and liquid phases in packed columns. Images were processed to generate quantitative measurements of organic-liquid/water interfacial area. Ten porous media, comprising a range of median grain sizes, grain-size distributions, and geochemical properties, were used to evaluate the impact of porous-medium texture on interfacial area. The results show that total specific organic-liquid/water interfacial area is a linear function of fluid saturation. Furthermore, fluid-normalized specific interfacial area was shown to correlate very well to median grain diameter. These two functionalities allow the development of a simple method for estimating specific organic-liquid/water interfacial area as a function of fluid saturation for a given porous medium.

[2]Department of Hydrology & Water Resources, The University of Arizona

Oral Presentation Notes

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Poster Presentation Abstracts

Pilot Tests of Enhanced Denitrification Using Ethanol

Andrew K. Borden[1], Justin Berkompas[1], Ziheng Miao[1], Kenneth C. Carroll[2], W. Jody Waugh[3], Edward P. Glenn[1], and Mark L. Brusseau[2]

[1]Department of Soil, Water and Environmental Science
The University of Arizona

Uranium mining and processing near Monument Valley, AZ has resulted in the formation of a large nitrate plume in a shallow alluvial aquifer. The results of prior field and bench-scale characterization studies indicate that the nitrate plume is undergoing a slow rate of attenuation via denitrification, and that denitrification rates can potentially be increased by an order of magnitude with the addition of ethanol as a carbon substrate. The objective of the present study was to investigate the potential of using ethanol to enhance the natural denitrification occurring in the alluvial aquifer. Pilot tests were conducted using the single well, push-pull method. Compound-specific stable isotope analysis (^{15}N and ^{18}O) was conducted to characterize nitrate transformation. Geochemical data (e.g., NO_3, NO_2, and N_2O) were collected to help characterize reaction rates and nitrogen mass balance. The results show that the concentration of nitrate decreased, while the concentration of nitrous oxide increased. Continued monitoring after completion of the pilot test shows that nitrate concentrations surrounding the injection well have decreased by four orders of magnitude, indicating that the impact of the pilot test has been sustained for several months. The results of the study will be used in the evaluation and design of a full-scale remedial action.

[2]Department of Hydrology & Water Resources, The University of Arizona
[3]S.M. Stroller Corporation, Grand Junction, CO

Using Existing Agricultural Infrastructure for Restoration Practices: Factors Influencing Successful Establishment of Cottonwood over Tamarisk

Daniel P. Bunting[1], Shirley A. (Kurc) Papuga[1,2], Matthew R. Grabau[3], Michael A. Milczarek[3], Gregg Garnett[4], Martin Karpiscak[1], David Quanrud[1]

[1]School of Natural Resources and the Environment
The University of Arizona

Following Lower Colorado River Multi-Species Conservation Program objectives, the Bureau of Reclamation is converting agricultural fields to restoration areas using existing irrigation infrastructure to support native mesic species. Irrigation practices aim to favor native over non-native species growth as numerous studies have shown that cottonwood (*Populus* spp.) out-compete tamarisk (*Tamarix* spp.) under irrigation that mimics natural flooding. In May 2007, small-scale restoration plots at Cibola National Wildlife Refuge were seeded with native riparian vegetation. Willow established poorly and cottonwood established abundantly, but tamarisk also established abundantly as a volunteer species. As a result, a monitoring program was initiated in 2008 to assess native versus non-native species competition. Two irrigation regimes were implemented during 2008 to provide two treatments (i.e., small versus large estimated depletion of plant-available water). Optimal irrigation depth and frequency would produce draw-down rates promoting root elongation toward groundwater with a goal to eventually cease irrigation. Vegetation characteristics were monitored at the beginning and end of the growing season to document changes in crown, canopy, and density and to obtain growth rates and mortality. Current results at our study site indicate that cottonwood can outcompete tamarisk with respect to growth rate, cover percentage, survival, and density over time.

[2]Department of Hydrology and Water Resources, The University of Arizona
[3]GeoSystems Analysis, Inc.,Tucson, AZ, USA
[4]US Bureau of Reclamation, Boulder City, NV, USA

Constraining the hydrogeology of the Willcox Basin in SE Arizona using natural tracers

Philip Calabrese and Jennifer McIntosh

Department of Hydrology and Water Resources
The University of Arizona

The Willcox Basin, located in SE Arizona, is a broad semi-arid closed basin. Residents in the basin depend completely on groundwater for domestic and agricultural water supplies. Despite this, very little is known about groundwater recharge areas, residence times, flowpaths and water quality in the basin. A pilot study was conducted in August 2009 to begin to address these knowledge gaps. Oxygen and hydrogen isotopes of groundwater samples, collected along a transect from the Dos Cabezas Mountains towards the Willcox Playa, were compared to published precipitation data to determine the elevation and seasonality of recharge. Recharge to basin groundwater occurs primarily at mid to low elevations during summer monsoons. These results differ from the adjacent (more narrow) San Pedro Basin, where recharge to basin groundwater primarily occurs at high elevations from winter precipitation. Groundwater samples contained no detectable tritium, indicating recharge occurred prior to the 1950s. A spatial analysis of the major components of groundwater quality gave insight into areas of higher concentration and possible sources of contamination. High levels of arsenic and fluoride (up to 29 ppb and 8 ppm, respectively) in groundwater are of water quality concern in the basin.

Understanding Hydrologic Catchment Similarities through Detailed Hydrologic Modeling

Gustavo A. Carrillo-Soto[1], Peter A. Troch[1],
Murugesu Sivapalan[2], Thorsten Wagener[3],
and Keith A. Sawicz[3]

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To what extent do landscape structure and climate control the watershed hydrologic response? Addressing this question requires improvement of our understanding about how catchments work. We assert that such improvement will come from the reconciliation of data and theory. In this study a low-dimensional semi-distributed model is developed (SM-hsB) in which the geomorphic, pedologic and ecologic structures of the watersheds are used to investigate, using a bottom-up modeling framework, how landscape characteristics and climate control the hydrologic behavior. The model allows developing a parsimonious relationship between physical processes and watershed characteristics leading to a dimensional analysis that can be used to establish a catchment classification system. Six catchments from the MOPEX database are used to apply and test the model. Initial results show good agreement between observed and modeled hydrological signatures. We then investigate what geophysical and climatic characteristics of the catchments control the hydrologic signatures by applying different climates to each catchment. Inter-annual variability pattern in the runoff coefficient is mainly controlled by climate signal. Relative magnitudes of the runoff coefficient are mainly control by storage and release characteristics. Future work will include snow-dominated catchments and extend the analysis to pedologic and ecologic structures.

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Natural Fire Cycling Effects on Tree Stand Characteristics:

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Twentieth century forest fire management practices within protected areas of the United States have had an impact upon natural forest cycles. Fire intensity and frequency have detrimental or beneficial consequences on growth cycles and stand densities. Burn periodicity and severities are recorded in the ring series of tree growth. The Sierra Madre is a mountain range in western Mexico that is part of the larger American Cordillera that traverses up into the United States through Canada and into Alaska. Slab samples from Mexican pine trees *Pinus patula* were sampled from a site within the Sierra Madre Occidental in Mexico. Using standard dendrochronological method, samples were age dated and a fire history was reconstructed. Since Mexican land management officials do not actively suppress their forest fires this particular study was done to understand how natural occurrences of fire affect tree stand characteristics. Research needs to be done on the fire histories of unregulated and regulated forests to understand the effect fires have on these characteristics. This particular research was done as an effective comparison to help understand how to effectively manage forest systems.

Transport of Titanium Oxide Nanoparticles in Sand

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Nanoparticle contaminants are becoming more prevalent as their use by industry increases. These emerging contaminants are defined as particles with a diameter of 1 - 100nm, and come from a variety of sources, both commercial and industrial. Concern about nanoparticles has grown as early studies have indicated that, aside from their own toxicity, nanoparticles also have the ability to increase the mobility of other contaminants in the environment. Nanoparticles enter the environment through various waste streams, including land-applied biosolids. A series of miscible-displacement experiments was performed to examine the retention and transport of titanium dioxide in natural porous media. The experiments were conducted in a manner to characterize longer-term behavior. In addition, the impacts of residence time (e.g., mean pore-water velocity) and water chemistry (e.g., pH and ionic strength) on transport were assessed.

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Using an Inverse Geochemical Reaction Path Model to Analyze the Effects of Climate Change on Mineral Weathering Reactions in Alpine Ecosystems

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Changes in climate alter the timing and pattern of snowmelt, which drives geochemical reactions in alpine catchments. This study aims to assess the impact of these changes on mineral weathering reactions through the use of a reaction path model (RPM). The inverse geochemical RPM approach within PHREEQC was used to find estimates of geochemical weathering fluxes and infer the hydrologic structure of the Green Lake 4 catchment in the Colorado Front Range. Source water samples from two (wet and dry) snowmelt seasons were averaged for each source water location for two (early and late) time periods. These data were used in the RPM to determine geochemical connectivity of source waters and to infer physical connectivity. Initial results indicate this connectivity varied between wet and dry years, as well as from early and late time periods. Preliminary analyses show weathering reactions are independent of wet, dry, early or late groupings. The magnitude of flux of the mineral appears to be directly related to the flux of snowmelt in the catchment for the time period. These results show the dependence on geology and snowmelt input to the geochemical reactions in the system. RPM analysis of geochemical connectivity and transit times is planned in the Valles Caldera.

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Determining Dissolution of Fired and Unfired propellants during transport within the vadose zone

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The expenditure of munitions at firing ranges indicates a small percentage of propellants are not being consumed and are being deposited onto the ground soil. Soluble propellant constituents are being released into the environment from particulate residues. The goal of this project is to compare the dissolution and transport of liquid and solid unfired and fired propellants. Investigations include liquid nitroguanidine (NQ) and solid and liquid nitroglycerine (NG) constituents. Saturated flow column experiments were conducted to determine how constituents interact with soils. Results of this work provides critical information regarding both release potential and fate in the soils for propellant constituents to support environmental management decisions in areas subjected to high munitions expenditure.

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Water Transit Time Controls
Part II: Topography and Soils

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To enhance prediction of the hydrologic response of ungaged basins, it is necessary to relate water transit times to easily measurable catchment properties. Transit times were modeled for 10 sub-catchments within two north-facing hillslopes in the Catalina Mountains. Both hillslopes are similar with respect to drainage area, mean slope and climate. The modeled water transit time distributions, obtained from hydrometric and isotopic data analysis, were compared to a number of topographic properties such as mean slope, area, mean flowpath length, curvature. None of those could explain much of the variation of the transit times. In a second step, modeled soil depth distributions were used to relate average soil depth to mean transit time. The modeled soil depth data was generated using only basic climate data, digital elevation model data and geologic data. These modeled soil depths were averaged over the sub-catchments. It was found that they are able to explain 80 percent of the variation of the transit times. This means that in these catchments mean soil depth is the predominant transit time control. With this knowledge it is possible to predict transit times (and therefore catchment response) by modeling soil depths, even in catchments where hydrologic information is sparse.

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Two oceans' influence on lower Colorado River water supply

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In 2007 the seven U.S. states that share territory in the Colorado River basin came to an agreement on how water allocations would be handled during shortage conditions within the basin's reservoir storage system. This agreement heightened interest in how water supplies might be affected on mid- to long-term scales. A growing body of research has investigated how climatic processes such as the Pacific Decadal Oscillation (PDO), Atlantic Multidecadal Oscillation (AMO), and the El Nino/ Southern Oscillation (ENSO) influence weather patterns, drought occurrence, and to some extent streamflow variability. This research focuses on drivers of water supply variability in the lower Colorado River basin. Using observed streamflow data from the lower basin and the Upper Gila River, path models point to a significant direct effect of AMO on streamflow, while PDO and ENSO's impacts are primarily through their effect on precipitation. Could AMO be a driver of storage release of groundwater into streamflow? To examine this question, tree-ring reconstructions and the VIC-model are employed to see if relationships in the observed record hold.

Reducing cloud obscuration on MODIS Snow Cover Area products by applying spatio-temporal techniques combined with topographic effects

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Rapid population growth in Arizona is leading to increasing demand and decreasing availability of water, requiring a detailed quantification of hydrological processes. The integration of detailed spatial water fluxes information from remote sensing platforms, and hydrological models is one of the steps towards this goal. This project is exploring the use of MODIS Snow Cover Area (SCA) information to update the snow component of a land surface model (LSM). Because cloud cover obscures the images, a rule-based method is used to remove the clouds. The rules include: combination of SCA maps from two satellites; time interpolation method; spatial interpolation method; and the probability of snow occurrence in a pixel based on topographic variables. The application in sequence of the first three rules resulted in a reduction of cloud obscuration by 62% and its accuracy will be tested using a synthetic approach. The results of this research will be used on a LSM to improve the management of reservoirs on the Salt River. This research seeks to improve SCA data for further use in a LSM to increase the knowledge base used to manage water resources. It will be relevant for regions where snow is the primary source of water supply.

Building a seasonal groundwater model for the upper San Pedro Basin

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Climate change and groundwater withdrawals as well as natural conditions can induce conditions where streams and aquifers are disconnected. The loss of a flowing stream and decreases in groundwater levels can have an adverse impact on riparian vegetation. One approach to understanding how stream-aquifer interactions can change due to human and climatic impacts is through the use of a groundwater model. A ground water model is a scale model of an aquifer that simulates the spatial and temporal properties of the system of interest. The current study focuses on the upper San Pedro River basin and interaction of this river with its surrounding aquifers. The construction of the model is especially designed to incorporate the effects of seasonal flood conditions which have a significant impact on the quantity and quality of water in the aquifer and the San Pedro River itself. Given the seasonal nature of flooding the model will be constructed around three seasons: a monsoon season, a winter rainy season and a dry season. Model development will focus on linking the constructed MODFLOW model to the surface water system. It is expected this linkage will present conceptual and technical challenges to model construction and our conception of basin and range aquifer systems.

Impacts of Housing Density on the Microclimate of Urban Ephemeral Streams

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Over the last two decades, the southwestern United States has grown faster than any other region in the country. Expanding urban boundaries and new developments are becoming a major feature of the growing southwest. The US Census Bureau predicts this trend will continue in Nevada and Arizona for at least the next twenty years. Ephemeral streams dot the landscape of the southwest, and unfortunately their charismatic natural state attracts development. We anticipate that this development will have negative consequences on the microclimate within these ephemeral streams, thereby impacting their natural state. Here we report on the findings from two years of micrometeorological observations made within ephemeral streams neighbored by developments of different housing densities in Marana, Arizona.

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Pumping Test Inference of Saturated – Unsaturated Aquifer Properties

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Analytical solutions for aquifer response to pumping are commonly used to infer the hydraulic properties of aquifers. A new analytical solution for the analysis of pumping test data from an unconfined aquifer is presented. Our analytical solution for flow to a partially penetrating well in a compressible unconfined aquifer allows inferring its saturated and unsaturated hydraulic properties from drawdowns recorded in the saturated and/or the unsaturated zone. We investigate the effects of unsaturated zone constitutive parameters and thickness on drawdowns in the saturated and unsaturated zones as functions of position and time; validate our solution against numerical simulations of drawdown in a synthetic aquifer having unsaturated properties described by the van Genuchten - Mualem constitutive model; use our solution to analyze drawdown data from a pumping test conducted by the US Geological Survey at Cape Cod, Massachusetts; and compare our estimates of van Genuchten - Mualem parameters with laboratory values obtained for similar materials in the area.

Potential for Water Salvage by Release of the Biocontrol Beetle, *Diorhabda elongata*, on Tamarisk (*Tamarix ramosissima*) Dominated Western U.S. Rivers

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The biocontrol beetle, *Diorhabda elongata*, has been widely released in the upper basin of the Colorado River to control Tamarisk in the western U.S. A primary motivation for beetle release is to salvage water that would otherwise be lost to transpiration by Tamarisk. We used the Enhanced Vegetation Index (EVI) from the MODIS sensors on the Terra satellite to evaluate the prospects for water salvage at 15 riparian release sites in Utah, Colorado, Nevada and Wyoming. EVI was combined with meteorological data to estimate evapotranspiration (ET) at the release sites and in adjacent sites to which the beetle might have spread. ET was estimated at 16-day intervals from 2000 to 2008, encompassing pre-release and post-release periods at each site. Baseline ET rates tended to be low, from 2-6 mm d^{-1} in summer (less than half of potential ET). Ground observations confirmed that beetles were active at all sites following release, defoliating stands of Tamarisk over areas as large as 200 ha. At four of the sites, ET rates estimated by MODIS EVI decreased markedly one to two years after release. At other sites, however, no decrease in ET was detected, and ET tended to recover to pre-release levels at affected sites. Ground data collected at four sites on the Dolores River include vegetation structure, composition and phenology as well as bird monitoring and productivity. Beetles are still spreading and the eventual fate of Tamarisk stands remains to be determined.

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A Simple Conceptual Framework for Analyzing Daily Measurements of Ecohydrological Fluxes

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Moisture availability plays a critical role in regulating evapotranspiration and carbon dioxide fluxes at the landscape scale, especially in dryland ecosystems. The sensitivity of drylands makes them well-suited to ecosystem-level analysis based on the vertical distribution and temporal dynamics of soil moisture. Previous studies of ecosystem response to moisture have not applied consistent soil moisture measurement techniques, which complicates synthesis of the results. Here, we present a simple conceptual approach which joins ecological and hydrological information. This framework partitions soil moisture into two zones by depth and enables simple, testable hypotheses about moisture pathways (evaporation versus transpiration), carbon processes (assimilation versus respiration) and secondary controls on fluxes (e.g. temperature effects and nutrient availability). We demonstrate that this method successfully identifies periods of net ecosystem uptake and net release of carbon for several eddy covariance sites in the semi-arid southwestern United States. We also assess the seasonality of soil moisture control on water and carbon fluxes.

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Using Time-Lapse Digital Photography to Monitor Changes in the Critical Zone

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The Critical Zone (CZ) includes the land surface, vegetation, surface water bodies, pedosphere, vadose zone, and groundwater aquifers. Within the CZ important interconnected physical, chemical, and biological processes influence the mass and energy exchange that governs everything from biomass production to water storage. However, many of these processes operate on different temporal and spatial scales, and little is known about how these processes interact. We have begun to link these processes by analyzing time-lapse digital images. These images have the potential to link processes across different disciplines, such as snow hydrology and ecology, quantitatively. In December, 2009, we co-located time-lapse enabled digital cameras with an operational 30 m eddy covariance tower on Mt. Bigelow within the Santa Catalina Mountains at the University of Arizona CZ Observatory. We mounted a single overstory camera at the top of the eddy covariance tower and three understory cameras at heights of 1 m within the footprint of the tower. All four cameras record images hourly. Here we describe our methodology for processing these hourly images and show preliminary results from our image analysis, including snow level and phenological monitoring.

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Measuring and Modelling in Hydrodynamics in Crushed Basalt in Support of Constructed Hillslopes in Biosphere2

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The University of Arizona has recently acquired Biosphere2 (B2) [http://www.b2science.org], an environmental research facility for a Critical Zone Science. As part of a ten year management plan three hillslopes (12x30x1m) will be constructed within the B2 greenhouses. The general objective is to carry out ground-breaking integrated hydro-geo-ecological research that cannot be carried out anywhere else. The intended soil for the hillslopes is required to have a loamy sand texture and consist of crushed basalt to ensure both reasonable hydraulic properties and weatherability within the expected lifetime of the project (10 years).
The original basalt material did not meet the particle size and hydro-chemical requirements of the B2 science committee. The purpose of the current investigation is therefore to quantify the changes in the hydraulic properties of the material after grinding the basalt, as well as predicting the variation of hydrodynamic water content and pressure in the basalt profile before and after saturation. For this purpose, four grindings times of the same initial material are being compared to determine optimum soil hydraulic as well as soil chemical properties.

Experimental Investigation of Long-Term Removal of Trichloroethene from Various Porous Media

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Immiscible liquids have proven to be a lasting source of subsurface contamination at many hazardous waste sites. Understanding the transport and fate behavior of these contaminants will allow for better site characterization and determination of applicable remediation technologies. In many cases, contamination will persist after remediation due to several factors, such as residual saturation in inaccessible pore spaces, contaminant in low permeability zones, or contaminant sorbed to the porous media. Experiments were conducted at the column scale to investigate long-term removal of chlorinated solvents from various porous media. Desorption behavior of TCE was examined for 'aged' media as well as freshly contaminated media. Experiments were also conducted to elucidate dissolution behavior of organic immiscible liquids at residual saturation in various porous media. Elution behavior was characterized through monitoring of effluent concentrations over 6 or 7 orders of magnitude. Additionally, synchrotron X-ray microtomography was conducted to characterize the pore-scale morphology of the immiscible liquid as a function of dissolution.

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Scratching Beneath the Surface: Probability Analysis of Soil Moisture with Depth in a Semiarid Ecosystem

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Recognized as playing a key role in partitioning water, carbon, and energy fluxes, soil moisture is measured in a generally inconsistent and inadequate manner both in depth and sampling frequency. In sparsely vegetated semiarid ecosystems, this is especially problematic: regardless of storm size surface soil moisture is depleted, mainly through evaporation, in less than three days. Yet, large storms do wet the deeper soil layers, triggering and sustaining biological activity. Because moisture in these different soil zones play unique roles in the partitioning of water, carbon, and energy fluxes, we must gain a more quantitative understanding of the magnitude, variability, and persistence of moisture in these zones. Here, we present an analysis of two years of half-hourly soil moisture data from a creosotebush-dominated ecosystem at the Santa Rita Experimental Range from 7 depths (2.5, 12.5, 22.5, 37.5, 52.5, 67.5 and 82.5 cm), under 6 profiles (3 bare and 3 canopy). We characterize soil moisture at each depth using a simple statistical analysis and present a frequency analysis comparing the probability distribution of soil moisture at each depth. We argue that results from this study can be used to inform future modeling efforts and soil moisture measurement campaigns.

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Methanogen variations related to hydrogeochemical conditions in organic-rich shales and coals in the Illinois Basin, U.S.A.

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Deep subsurface methanogens produce approximately 20% of the world's methane from organic-rich coals and shales, yet little is known about their metabolic and environmental requirements. Parameters influencing microbial methane generation include type of organic matter, and salinity and sulfate concentrations. In the Illinois Basin, two organic-rich units, Pennsylvanian coalbeds (~300m deep) and the New Albany Shale (~750m deep), support methanogenesis across a steep salinity gradient with variable sulfate concentrations. We hypothesize that 1) similar to other deep subsurface environments, the types of methanogens in the Illinois Basin are limited, and 2) methanogen variations reflect changes in hydrogeologic conditions. Using groundwater sampling results for solute chemistry, stable isotopes, cell counts, and terminal restrictive fragment length polymorphism, we find that methanogenic species numbers are low, and largely restricted to two groups for the coal and shale. Yet, substrate type has a significant correlation coefficient (>0.3) with species variation, indicating that type of organic matter influences methanogens. Also, chloride and stable isotope values of water have significant correlation coefficients (>0.3) with species variation. These conservative tracers are affected by meteoric water <50,000 years old, indicating that deep recharge influences methanogenic diversity, and may have transported methanogens into the paleopasteurized subsurface.

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Measurement Based Uncertainties in Temperature Based Estimates of Stream-Aquifer Flux

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The use of temperature to quantify stream-aquifer interactions has become a common scientific measurement technique. Many researchers have developed methods to analyze time series of temperature beneath the streambed to estimate the direction and/or magnitude of water fluxes between surface and ground waters. While there has been considerable use and examination of these methods, there is a lack of scientific focus on how uncertainties in temperature measurements propagate and affect the estimates of water fluxes. We use a numerical model (HYDRUS-1D) to develop "true" temperature time series in a stream and streambed. Uncertainty is added as normally distributed noise with a mean of zero. This synthetic data is analyzed using a commonly applied analytical solution to infer the water flux. Inferred fluxes are compared to the "known" flux to calculate the error and uncertainty is determined by multiple error realizations and true fluxes. Results show that instrument placement and accuracy strongly influence the uncertainty of flux estimates. The worst conditions are associated with large upward fluxes (> 0.4 m/d) with deep measurements (>0.3 m), which can lead to biases and uncertainties of 0.45 m/d and 1 m/d, respectively. However, downward flow conditions generally do not lead to appreciable errors.

Decadal Hydroclimatic Predictions in the Colorado River Basin Using Instrumental and Reconstructed Records

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In a water-stressed region, such as the Colorado River basin, it is essential to improve current hydroclimatic predictions. The Atlantic Multidecadal Oscillation (AMO) and the Pacific Decadal Oscillation (PDO) are two climate indices that have long been recognized for influencing the hydroclimates in regions across the United States. In this study, a meteorological index defined as precipitation minus potential evaporation (P-PE) is used to represent the hydroclimatology in each of the 22 subbasins of the Colorado River basin (CRB). The instrumental AMO and PDO time series are then used to retrospectively forecast, a decade in advance, the most recent 40 ten-year running means of instrumental (P-PE) for each subbasin. Positive skill is observed in all subbasins along the eastern border of the CRB, where the Colorado Headwaters subbasin sees the highest skill. Tree ring derived reconstructions of AMO, PDO, precipitation, and temperature data are also used to make retrospective forecasts of the meteorological index for 200 ten-year running means ending in the year 1961. The forecast skill of (P-PE) is dramatically reduced when the reconstructed records are used.

Multimodel Bayesian and Information Theoretic Frameworks for Optimum Groundwater Characterization and Monitoring Design

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To better use or protect our groundwater resources, it is necessary to understand the aquifer response to our groundwater exploitation and pollution remediation scheme. Such understanding entails collecting suitable data. However, only a few measurements of aquifer parameters and state variables can be collected so that we cannot be certain with the groundwater problems. In addition, since the current method of collecting data is costly, it is necessary to design the data collection in a cost effective way. Building a framework to analyze the value of the information (VOIA) is a way to design the data collection scheme. Although the value of information or data-worth analysis was incorporated into the framework of modern statistical theory, a major limitation of the previous work is VOIA relies only on a single model. Hydrologic environments are open and complex, rendering them prone to multiple interpretations and mathematical descriptions. A multimodel approach to optimum data worth analyses is developed, which relies on modern concepts of model averaging within Maximum likelihood Bayesian and information theoretic framework. Both model and parameter uncertainties have impact on the predicted worth of new data, and MLBMA provides a systematic way to predict worth of alternative data collection schemes under these uncertainties.

Poster Presentation Notes

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