THE UNIVERSITY OF
ARIZONA®
TUCSON ARIZONA

Department of Hydrology and Water Resources

Presents

The 18th Annual

El Dia del Agua

March 6, 2008

Table of Contents

Student Research Presentations

8:00am ~ 8:45
Registration & Continental Breakfast

Master of Ceremony ~
Dr. James Washburne, Associate Director SAHRA/STC

9:00am ~ 10:00am ~ Oral Presentations
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 ~ Dr. Kenneth Schmidt
President of Kenneth Schmidt & Associates
"Trends in hydrogeology from 1964 to 2008"

1:30pm ~ 2:00pm ~ Poster Session
2:00pm ~ 3:00pm ~ Oral Presentations
3:00pm ~ 3:30pm ~ Poster Session

Master of Ceremony ~
Dr. Thomas Meixner, Associate Professor

3:30pm ~ 4:30pm
Guest Speaker ~ Dr. John Doherty
Director of Watermark Numerical Computing
"Model predictions – by no means right, but quantifiably wrong."

4:30pm ~ Award Presentations

Montgomery Prize ~ By Elizabeth León Mora
Best Oral Presentation ~ $1,000

Hargis Awards ~ By David Hargis
First Place Poster ~ $1,000 and Second Place Poster ~ $400

HWR Awards ~ By Jim Washburne
Best Speaker ~ $400 and Best Poster ~ $400

Agua-Man ~ By Caitlan Zlatos*, *HWRSA President

The Montgomery Prize

The Department of Hydrology and Water Resources would like to thank Errol L. Montgomery & Associates, Inc. for their support of the 17th 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:

- Groundwater exploration and development
- Contaminant assessment and remediation
- Artificial groundwater recharge
- Assured and Adequate Water Supply demonstrations
- 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 18th 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 research posters and two guest alumni 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!

Caitlan Zlatos
HWRSA President

Jessica Driscoll
HWRSA Vice-President

Rafael Rosolem
HWRSA Treasurer

Joe Gustafson & Will Veatch
HWRSA Social Chairs

Support your HWRSA by purchasing a T-shirt! On sale now! Website: http://www.hwr.arizona.edu/%7Ehwrsa/08tshirt.htmla/index.html

Special Thanks to Our Corporate Sponsors

Anteon Corporation
Arcadis
Balleau Groundwater, Inc.
Basin & Range Hydrogeologists, Inc.
Bill Allen Technical Services
Brown & Caldwell
Clear Creek Associates
Daniel B. Stephens & Associates, Inc.
Errol Montgomery & Associates
ECOMON
Geosystems Analysis, Inc.
Golder Associates
Groundwater Quality Consultants
Groundwater Resources Consultants, Inc.
Haley & Aldrich, Inc.
Hargis + Associates, Inc.
HydroSystems
Hydro Geophysics, Inc.
In-Situ, Inc.
Komex Environmental Engineering
Malcolm Pirnie & Associates, Inc.
Peter Mock Groundwater Consulting, Inc.
Salt River Project, SRP
Southwest Groundwater Consultants
Truchas Hydrologic Associates, Inc.
Turner Laboratories, Inc.
University of Arizona Water Resources Research Center
URS Corporation
Water Management Consultants
Westland Resources, Inc.
WESTWATER, LLC

Special Thanks to Our Friends

Michael W. Block
Michael Carpenter
Michael Geddis
Leslie Graser
Michael Osborne
Elaine Resnick
Agricultural Research Service
Arizona Hydrological Society, AHS
Community Water Company of Green Valley
Metro Water District
National Weather Service
U.S. Geological Survey

El Dia del Agua Organizing Committee

Thomas Maddock III, Department Head

James Washburne, El Dia del Agua Chair
Dennis Scheall, El Dia del Agua Co-Chair
Thomas Meixner, El Dia del Agua Co-Chair

James Broermann ~ Technical Support
Erma Santander ~ Administrative Coordinator

Evaluation Committee for Awards

Montgomery Prize
Elizabeth León Mora ~ Ralph Mora ~ Jim Washburne

Hargis Awards
David Hargis ~ Leo Leonhart ~ Dennis Scheall

HWR Oral Award
Mike Bradley ~ Martha Whitaker ~ Gary Woodard

HWR Poster Award
Don Young ~ Kristine Uhlman ~ John Villinski
Kyle Blasch ~ Fred Tillman ~ Jackie Moxley

HWRSA El Dia del Agua Committee
Caitlan Zlatos ~ President
Jessica Driscoll ~ Vice-President
Rafael Rosolem ~ Treasurer
Joe Gustafson & Will Veatch ~ Social Chair

Moderators
Kris Kuhlman ~ Caitlan Zlatos ~ Hoori Ajami

Sponsorship Committee
Candice Adkins
Kyle Brown
Navid Dejwakh
Erika Gallo
Joe Gustafson
Melissa Schlegel
William Veatch
Caitlan Zlatos

Event Coordinators
Brian Billy ~ Brittney Bates
Shane Clark ~ Eleonora Demaria
Navid Dejwakh ~ Erica DiFilippo
Jessica Driscoll ~ Kazungu Maitaria
Andy Neal ~ Stephen Osborn
Ari Posner ~ Seshardri Rajagopal
Rafael Rosolem ~ Melissa Schlegel
Liang Xue ~ Ann Youberg

Department Advisory Council (DAC)

Charles E. Ester III
Salt River Project ~ Phoenix, Arizona

David R. Hargis
Hargis + Associates ~ San Diego, California

Paul Hsieh
U.S. Geological Survey ~ Menlo Park, California

R. Bruce Johnson
City of Tucson Water ~ Tucson, Arizona

Leo S. Leonhart
Hargis + Associates ~ Tucson, Arizona

Peter Moch
Peter Moch Groundwater Consulting, Inc.
Paradise Alley, AZ

Errol L. Montgomery
Errol L. Montgomery & Associates ~ Tucson, Arizona

Michael M. Mooradian
PSI, Inc. ~ Long Beach, California

Thomas R. Schultz
Golden Associates ~ Tucson, Arizona

Daniel B. Stephens
Daniel B. Stephens & Associates ~ Albuquerque, New Mexico

Betsy Woodhouse
Southwest Hydrology, SAHRA ~ Tucson, Arizona

Don Young
WESTWATER, LLC ~ Phoenix, Arizona

EL Dia Del Agua ~ Lunch Guest Speaker
Dr. Kenneth Schmidt
President of Kenneth Schmidt & Associates
"Trends in hydrogeology from 1964 to 2008."

Ken Schmidt was born and raised in the San Joaquin Valley of California. He attended Fresno State College, and graduated with a B.S. in Geology with highest honors in 1964. After several years of working in Kern County, Ken entered graduate school in hydrology at the University of Arizona in 1967. He completed his M.S. degree in 1969 and a PhD 1971, with John Harshbarger. He worked for several years in southern Arizona for Harshbarger & Associates, then returned to Fresno to establish his own consulting firm in 1972. Ken maintained an office in Phoenix from 1978 to 2003, where his firm conducted extensive groundwater quality studies. He joined the American Water Resources Association in 1971, and became the National President in 1981.

Ken was a member of the original advisory committee for the Hydrology Department at the University upon its founding, and served as the chairman for several years. For years, he donated financially to the hydrology program. In 1995, Ken received the Distinguished Citizens Award from the University Alumni Association and the School of Engineering. As part of the observance of the 100-year anniversary of the founding of the Alumni Association in 1998, Ken Schmidt received a Centennial Achievement Award, presented to only about 100 outstanding alumni of the University.

EL Dia Del Agua ~ Guest Speaker
Dr. John Doherty
Director of Watermark Numerical Computing
"Model predictions—by no means right, but quantifiably wrong."

John Doherty is the director of Watermark Numerical Computing, based in Brisbane Australia. He is also the author of PEST, a package that is widely used for calibration and uncertainty analysis of models of all kinds.

John has been involved in the water industry for over 30 years, starting his career as a geophysicist, where he spent much of his time engaged in groundwater exploration in Australia's Northern Territory. After obtaining a PhD in Physics he then switched to environmental modelling and data analysis. This has been his principal area of work for the last 20 years while employed in the private, public and Tertiary sectors. He presently distributes his time between software development, professional education, and consulting. He also holds a part-time research position with the University of Queensland where he supervises a number of PhD students.

John's principle areas of consulting and research are in the use of regularised inversion for calibration and uncertainty analysis for highly parameterised, complex models of all kinds. He is also interested in the use of models as a basis for collective decision-making, with full account taken of the strengths and weaknesses of models as predictors of future system behaviour, and as mechanisms for identification of existing data gaps.

El Dia del Agua ~ Program Schedule

Time	*Scheduled Event*
8:00 - 8:45	**Registration & Check-In**
Master of Ceremony	**Dr. James Washburne, Associate Director SAHRA**
Moderator	*Kris Kuhlman*
9:00 - 9:20	**M. Akif Sarikaya***: Climate change from past to present on Mount Erciyes, Turkey (Pg. 15)*
9:20 - 9:40	**Julio Cañón Barriga:** *Downscaling precipitation from coupled climate models to assess the local impact of climate change scenarios (Pg. 16)*
9:40 - 10:00	**Guillermo F. Martinez-Baquero:** *Diagnostic Evaluation of the abcd Monthly Water Balance Model for the Conterminous United States (Pg. 17)*
10:00 - 11:00	**Poster Session**
Moderator	*Caitlan Zlatos*
11:00 - 11:20	**Navid Dejwakh:** *Using $\delta^{17}O$ to differentiate atmospheric from terrestrial sources of nitrate and estimate denitrification's influence on Tucson's groundwater (Pg. 18)*
11:20 - 11:40	**Rafael Rosolem:** *How Representative Is The Large-Scale Biosphere-Atmosphere Experiment In Amazonia (LBA) Results In Comparison To Long-Term Climatology? (Pg. 19)*
11:40 - 12:00	**Samantha Treese:** *The Effect of Effluent on Stream-Aquifer Interactions (Pg. 20)*

El Dia del Agua ~ Program Schedule Continued

Time	*Scheduled Event*
Master of Ceremony	**Dr. Thomas Maddock III, Department Head**
12:00 - 1:30	**Buffet Lunch and Speaker, Kenneth Schmidt**, *"Trends in hydrogeology from 1964 to 2008"*
1:30 - 2:00	**Poster Session**
Moderator	*Hoori Ajami*
2:00 - 2:20	**Stephen Osborn:** *Fluid and Gas Geochemistry of Upper Devonian Organic-Rich Shales, Northern Appalachian Basin (Pg. 21)*
2:20 - 2:40	**Matt Switanek:** *Seasonal Predictions of Climate Variability and Water Availability in the Colorado River Basin (Pg. 22)*
2:40 - 3:00	**Joseph R. Gustafson:** *Quantifying Variations of SWE, Chemistry, and Water Isotopes in a Montane Snowpack: Valles Caldera National Preserve, NM (Pg. 23)*
3:00 - 3:30	**Poster Session**
Master of Ceremony	**Dr. Thomas Meixner, Associate Professor**
3:30 - 4:30	**Guest Speaker Dr. John Doherty,** *"Model predictions - by no means right, but quantifiably wrong."*
4:30	**Award Presentations** *Montgomery Prize ~ By Elizabeth León Mora* *Hargis Awards ~ By David Hargis* *HWR Awards ~ By Thomas Meixner* *Aqua-Man presentation ~ By Caitlan Zlatos*

Oral Presentation Abstracts

Hydrology & Water Resources Students' Research Projects

Climate change from past to present on Mount Erciyes, Turkey

M. Akif Sarıkaya[1], M. Zreda[1], A. Çiner[2], C. Zweck[1]

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

Glacial activities in mountain settings provide valuable and direct information about climate; particularly local precipitation and temperature. Determination of extent and timing of past glacial activities can be used to predict past climate changes. For this purpose, we conducted a study on Mount Erciyes, historically known as Argaeus, (3917 m, a stratovolcano in central Turkey, 38.5 ^{o}N, 35.5 ^{o}E). We mapped the glacial extent and dated the moraines by using in-situ cosmogenic ^{36}Cl. During the Last Glacial Maximum (LGM) (21 ka ago; 1ka=1000 calendar years) glaciers in the mountain reached their maximum extents. They readvanced in the Early Holocene (between 10.9 ± 3.3 ka and 8.8 ± 1.4 ka). On that time, they were interrupted by volcanic activity on the flanks of the volcano. The last stage of glaciers readvanced during the Little Ice Age (1.2 ± 0.6 ka) and started to retreat again. Today, the mountain sustains a 250 m long glacier between the elevations of 3420 – 3600 m. This complete set of glacial activity reveals inclusive series of paleoclimatic data. Using the glacier modeling and paleoclimate proxies, we reconstructed the history of climate change in the region since LGM.

[2]Hacettepe University, Ankara, Turkey

Downscaling precipitation from coupled climate models to assess the local impact of climate change scenarios

Julio Cañón Barriga[1, 2], Francina Domínguez[1], Juan Valdés[3]

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

Climate change scenarios projected from coupled climate models must be downscaled to a degree that is useful for hydrologic applications of concern to water managers and stakeholders. A new statistical technique is developed by the authors to downscale temperature and precipitation projections from coupled climate models (at scales of 180x180 km approximately) to grids of 4x4 km for which a historic database is available, particularly for the Southwestern United States (defined as the states of Arizona, New Mexico, Utah and Colorado). Two coupled climate models, the MPI-ECHAM5 and UKMO-HADCM3, were chosen for the scenario analysis due to both their good performance in representing the climate of the Southwest and their ability to capture a realistic spatial and temporal signature of ENSO variability. The models were run for the period 2001-2100 using the SRES-A2 scenario (one of the most fossil fuel intensive, with increasing population and slow technologic advances). The proposed statistical downscaling incorporates the spatial and temporal variability associated with ENSO by using Multichannel Singular Spectrum Analysis (M-SSA). In addition, the method preserves the expected values and variances of the climate variables at the downscaled level. The time series are modeled on a cell-by-cell basis as stochastic processes consisting of a mean value, an ENSO-related quasi-periodic component and a random term associated with the residual variance of observed records. The downscaled values follow a realistic, dynamic spatial distribution, rather than a static, evenly distributed downscaling of mean values. The advantage of incorporating the variability associated with ENSO lays in the possibility to better represent the occurrence of extreme conditions related to EL Niño and La Niña years, at the regional and local scale, in the evaluation of future climate change scenarios.

[2]Universidad de Antioquia, Colombia
[3]Department of Civil Engineering and Engineering Mechanics, University of Arizona

Diagnostic Evaluation of the abcd Monthly Water Balance Model for the Conterminous United States

Guillermo F. Martinez-Baquero and Hoshin Gupta

Department of Hydrology and Water Resources,
The University of Arizona

Watershed classification systems should provide sufficient information to select proper conceptual and numerical formulations in the modeling of hydrological processes. This ideal situation is limited by our ability to sample the fluxes and characteristics of the watersheds, and the lack of theoretical frameworks that consider watershed heterogeneities across different locations and scales. This work uses several analytic tools to study relationships between watershed characteristics and dominant hydrologic processes at the monthly level by diagnosing the reasons for different levels of performance of the abcd Monthly Water Balance Model within the conterminous United States using data from the Hydro-Climatic Data Network dataset. To facilitate analysis of the data, cluster analysis and Artificial Neural Networks were used to identify groups of watersheds with similar input/output relationship and streamflow patterns. These watershed groups were used to examine the discriminatory power of different physical variables, indices and signatures of hydrologic behavior with regard to their dominant processes and the performance of the abcd Model and other benchmark models of reduced complexity. The diagnostic analysis resulted in a description of the problems encountered in modeling the water balance for each watershed group, and suggests a road map for future model and data improvements.

Using $\delta^{17}O$ to differentiate atmospheric from terrestrial sources of nitrate and estimate denitrification's influence on Tucson's groundwater

Navid Dejwakh[1], Greg Michalski[2], Thomas Meixner[1], Jennifer McIntosh[1]

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

The quality of groundwater is of major concern in the Southwest where water resources are scarce and we depend on groundwater for domestic use. Due to adverse health effects, waters with high nitrate concentrations (>45 mg/L) have been banned for domestic use by the EPA. Thus, it is important to consider the different sources and processes affecting nitrate concentration. Recent scientific advances allow us to employ the $\delta^{17}O$ of nitrates to distinguish atmospheric from terrestrial sources. Patterns of denitrification are also determined with higher certitude by coupling $\delta^{17}O$ with the $\delta^{18}O$-$\delta^{15}N$ system. In this study, we focus on the Tucson basin where agricultural activity is low, atmospheric deposition may be significant, and sewage treatment waters are an important aquifer recharge component. We analyzed groundwater samples collected along the Rillito River groundwater flow path and along two cross-sections beneath the sewage-fed Santa Cruz River. In addition, surface water samples were collected from ephemeral washes during rain events and from wastewater effluent. We apply this new technique to determine the proportion of atmospheric input and denitrification occurring in Tucson's groundwater. Results show that groundwaters contain up to 6% atmospheric nitrate and confirm that denitrification occurs along the Santa Cruz groundwater flow path.

[2]Department of Earth and Atmospheric Science, Purdue University

How Representative Is The Large-Scale Biosphere-Atmosphere Experiment In Amazonia (LBA) Results In Comparison To Long-Term Climatology?

Rafael Rosolem[1], William James Shuttleworth[1], Luis Gustavo Goncalves de Goncalves[2]

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

The Large-Scale Biosphere-Atmosphere Experiment in Amazonia has already contributed understanding significant components of the Amazon ecosystem. However, when considering LBA-derived information on whether the Amazon is a source or sink of carbon, or whether land-use changes in the Amazon are affecting the local/global climate, it is important to characterize the period during which the LBA has been carried out in terms of its climatological context. Such information is not only useful for future project planning but is crucial information for modeling purpose. This study investigated the extent to which the actual period of data collection at LBA sites is representative of the long-term climatology for the sites. The research uses long-term weather station data taken from the databases of Brazilian National Water Agency (ANA) and National Oceanic and Atmospheric Administration (NOAA) for stations located near the LBA sites, and compares these weather station data during the LBA data collection period with the entire dataset available for each weather station. Analysis of the precipitation records demonstrates that the precipitation climate during the LBA study period was not significantly different from the long-term climatology at all the LBA sites but that at a few sites the temperature climate during LBA was statistically different.

[2]Hydrological Sciences Branch (NASA Goddard Space Flight Center, Greenbelt, MD

The Effect of Effluent on Stream-Aquifer Interactions

Samantha Treese[1], Tom Meixner[1], James Hogan[1],
Amy McCoy[2]

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

Treated wastewater effluent from the Nogales International Waste Water Treatment Plant sustains perennial flow in the Upper Santa Cruz River, Arizona. Little is known about the effect of effluent on stream-aquifer interactions. Thus, a series of monthly field campaigns were undertaken to understand the impact of effluent on the streambed at 16 different sites along a thirty kilometer stretch of the river. The field campaigns had two focuses: physical transformations in the streambed and water source identification using chemical composition. Results indicate that the Santa Cruz River becomes disconnected from the aquifer adjacent to the point of effluent discharge. Furthermore, as the time between major flood events increases, the disconnection of the stream and aquifer extends further downstream. In total the results imply that water in the streambed is isolated from the groundwater, perhaps due to clogging and that barrier is only removed after especially large flood flows (10+ cms).

[2]Department of Arid Lands, University of Arizona

Fluid and Gas Geochemistry of Upper Devonian Organic-Rich Shales, Northern Appalachian Basin

Stephen Osborn and Jennifer McIntosh

Department of Hydrology and Water Resources,
The University of Arizona

Upper Devonian organic-rich fractured shales from the Northeast U.S. host economic accumulations of natural gas that are microbial in origin. Research in the Michigan and Illinois basins has shown that secondary microbial gas generation was enhanced by Pleistocene glacial meltwater recharge diluting formation water salinity. The Appalachian basin shares similar glacial history and lithostratigraphy. Yet, little is known about the brine geochemistry and recharge history at the basin margin where microbial gas may be generated. Brine and gas samples were collected from active Devonian oil and gas wells at the basin margin (W. NY and N.W. PA) to understand the source of fluids and assess the potential for microbial gas. Stable isotope (O, H, and C), alkalinity, and elemental analyses were conducted on water samples. Gas samples were analyzed for composition and compound specific isotopes (CH_4, CO_2, and C2). There is evidence for freshwater dilution of brines at the basin margin by modern precipitation and an increasing salinity trend toward the basin center. Low alkalinity and positive $\delta^{13}C_{DIC}$ values may indicate the early stages of methanogenesis and/or a relatively open hydrologic flow system. The relatively positive $\delta^{13}C_{CH4}$ values and high mole% of ethane and propane indicate thermogenic gas is dominant.

Seasonal Predictions of Climate Variability and Water Availability in the Colorado River Basin

Matt Switanek and Peter Troch

Department of Hydrology and Water Resources,
The University of Arizona

Regional climate patterns are driven in large part by ocean states and associated atmospheric circulations. Many regions that lie between semi-arid and semi-humid zones with seasonal rainfall, for instance, experience prolonged periods of wet and dry spells. Understanding the triggers that bring a river basin from one state (e.g. wet period of late 90s in the Colorado basin) abruptly to another state (multi-year drought initiated in 2001 to present) is what motivates the present study. Our research methodology investigates the predictive power of regional climate variability and its effect on hydrologic response. By correlating, using different monthly time lags, sea surface temperatures (SST) and sea level pressures (SLP) with basin averaged seasonal precipitation, surface temperature and discharge, we determine the most influential regions of the Pacific Ocean on climate variability for the Little Snake and Little Colorado basins. Using the most correlated data for each month, we use Gaussian Mixture Models to predict the basin's historic climate, given observed SSTs as our predictors. Finally, we compare quantitative predictions, using our methodology, to predictions obtained using the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) as our predictors.

Quantifying Variations of SWE, Chemistry, and Water Isotopes in a Montane Snowpack: Valles Caldera National Preserve, NM

Joseph R. Gustafson, P. D. Brooks, William C. Veatch, Patrick Broxton

Department of Hydrology and Water Resources, The University of Arizona

This study quantifies how vegetation, aspect, and storm track control spatial and temporal patterns in snow chemistry and water isotopes. This research is one of three simultaneous projects designed to identify how vegetation and topography control spatial and temporal patterns of snow water input to a characteristic southwestern U.S. mountain catchment.

We collected depth, density, stratigraphy, temperature, and snow chemistry samples from five snow pit locations on approximate monthly intervals between January and April 2007. Snow pit locations were established varying aspect and vegetation density independent of elevation. Snow samples were analyzed for major anions (Cl^-, NO_3^-, SO_4^{2-}), major cations (Ca^{2+}, Na^+, K^+), water isotopes, and biogeochemical nutrients (DOC, DN). Snow water equivalent (SWE) varied by 45% (187 - 340mm), SO_4 by 22% (10.6 - 13.5 meq/L) and $d^{18}O$ by 17% (-16.3 - -13.5‰), with SWE exhibiting an inverse correlation with both SO_4 (r^2 = 0.75) and $\delta^{18}O$ (r^2 = 0.96). The relationships between snowpack δD vs. $\delta^{18}O$ suggest these patterns resulted from snowpack sublimation rather than deposition. Using conservative tracer water balance equations, sublimation is estimated to range from -3.8% to 18.3% of the snowpack water budget. A precipitation lapse rate based on nearby meteorological stations suggests these estimates are low and may be convoluted by atmospheric water vapor interactions.

Poster Presentation Abstracts

Hydrology & Water Resources Students' Research Projects

El Dia del Agua ~ Poster Presentations
HWR STUDENTS RESEARCH PROJECTS

Investigating Ground-Water Movement Using Diverse Water Chemistries in the San Pedro Basin, Arizona

Candice B. Adkins[1,2], J. McIntosh[1], Chris Eastoe[3]

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

Ground-water in the San Pedro Basin in southeast Arizona is the main source of water for domestic, industrial, and agricultural use. As the population and demand on water resources increases, an improved understanding of the ground-water system is needed for effective water management. We are studying major ion chemistry and isotopes (O, ^{2}H, ^{3}H, S, ^{13}C, ^{14}C) in groundwater to investigate recharge areas, ground-water flow paths, and discharge of ground water in the San Pedro River. The San Pedro Basin is an alluvial basin-fill aquifer comprised of upper and lower units separated by a clay confining unit. The basin is bounded by crystalline and carbonate rocks of the Whetstone and Rincon Mountains on the west, and by crystalline rocks of the Rincon and Dragoon Mountains to the north and east. These mountain blocks contain distinctive mineral assemblages, which creates a chemical fingerprint in the ground-water allowing the identification of contributions of ground-water from the eastern and western sides of the basin to the San Pedro River. Initial results from 18 ion and isotope ground-water samples, combined with chemical data from ADEQ reports and the U.S. Geological Survey QW database show varying chemical compositions throughout the basin, as well as with depth between the upper and lower aquifers. Preliminary data suggests that ground-water chemistry varies spatially and with depth, reflecting interaction with the diverse geologies present in the basin.

---

[2]US Geological Survey, Tucson, Arizona

Application of GIS Based Tools for Groundwater Recharge and Evapotranspiration Estimation: Arc-Recharge and RIPGIS-NET

Hoori Ajami, James Hogan, Thomas Maddock III, Thomas Meixner

Department of Hydrology and Water Resources
University of Arizona

The impact of climate variability and change on groundwater resources is primarily determined by altering recharge and evapotranspiration (ET) rates. Typically, groundwater models employ temporally static recharge or ET rates with limited spatial variability across the basin. As a result most groundwater models cannot be used to assess the climate variability impacts on groundwater resources. A primary challenge to addressing this shortcoming is the need for spatially and temporally explicit recharge and ET model inputs. Geographic Information Systems (GIS) and spatially explicit data can be applied to develop these improved model inputs by quantifying and distributing recharge and ET across the model domain.

Two ArcGIS desktop applications were developed for ArcGIS 9.2 to enhance recharge and ET estimation- Arc-Recharge and RIP-GIS-NET. Arc-Recharge an ArcGIS 9.2 custom application is developed to quantify and distribute mountain front recharge along MODFLOW cells. RIPGIS-NET is an ArcGIS custom application that was developed to provide parameters for the RIP-ET package. RIP-ET is an improved MODFLOW evapotranspiration module that simulates ET using a set of eco-physiologically based ET curves. Arc-Recharge and RIPGIS-NET incorporate temporally and spatially explicit data for recharge and ET estimations. Using such tools, makes assessment of climate variability on groundwater resources more efficient.

Effects of groundwater recharge rates on metabolic pathways for coal bed methane generation in the Power River Basin

Brittney L Bates[1], Jennifer McIntosh [1], Romeo Flores[2]

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

The Powder River Basin (PRB) is a principle producer of coal bed methane world-wide. The basin contains an extensive well network which, combined with past studies, facilitates a unique opportunity to study the coupling of hydrology and microbial methane generation. Microbes generate methane via two metabolic pathways, acetate fermentation and CO_2 reduction. The relative importance of these pathways is dependent on the availability of organic substrates and other electron acceptors, groundwater velocity, salinity, and microbial community structure. A recent study by Flores et al. (in press) showed that methane was dominantly generated by acetate fermentation in areas of rapid recharge through clinker deposits. In contrast, methane in deeper coal beds was generated by CO_2 reduction over much longer timescales (<10 ka to >100 Ma). We propose to test this hypothesis by determining groundwater residence times along two transects across the basin and pairing the recharge rates to indicators of methanogenic pathways (e.g. carbon isotopes of CO_2, CH_4). Groundwater samples will be collected and analyzed for stable isotopes (O,H,C), carbon-14, tritium, noble gases, salinity, and nutrients. Constraining rates and modes of methane generation are necessary to evaluate the potential for stimulation of methanogenesis, and effects of CO_2 sequestration in coal beds.

[2]U.S. Geological Survey, Denver, CO

Designing Efficient Hydrologic Monitoring Networks Using Cost-Benefit Analysis

Joan B. Blainey and T.P.A. Ferré

Department of Hydrology and Water Resources,
The University of Arizona

Designing monitoring networks that can discriminate among competing conceptual models is a key challenge for hydrologists. We examined the impact of network design on the utility of measurements for constraining hydrologic prediction uncertainty. Based on limited initial data we objectively designed an effective monitoring network by comparing projected measurement costs with the expected benefits of improved hydrologic assessment. The measurement network design approach is applied to a hypothetical feasibility assessment for a proposed artificial recharge site. Specifically, predefined sets of candidate measurements (temporal gravity change) at a single location at a series of measurement times are considered. We use an ensemble approach to assess the likely impact of measurement error on prediction error and uncertainty for different combinations of candidate measurements (measurement sets). The ensemble of prediction errors is translated to a probability-weighted performance cost for each measurement set using a cost function. The total cost is calculated as the sum of the performance and measurement costs. We show that the optimal measurement set, defined as set with the lowest total cost, depends on the prediction of interest, the per measurement cost, the maximum risk-based cost associated with the hydrologic prediction, and the treatment of uncertainty in defining performance costs.

Ages, sources, and mixtures of agricultural irrigation waters and pristine groundwaters in the Saddle Mountains Basalt Aquifer, central Washington

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

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 groundwaters. In the case of oxic groundwater systems, such as the Basin and Range alluvial aquifers (SW), and the Columbia Plateau basalts (NW), 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)) and elemental chemistry to determine the sources, flowpaths, and residence times of groundwaters in the Saddle Mountains Basalt Aquifer in central Washington. 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), and high $d^{18}O$ values (-13.5‰ to-16.1‰); and 2) pristine groundwaters at depth with low NO_3^- (1-5 mg/l), no tritium, and low $\delta^{18}O$ values (-17.3‰ to-18.9‰). CFC ages of irrigation waters span the timescale since irrigation began in the region (~20 to 50 yrs b.p.). Nitrogen and oxygen isotopes of NO_3, in conjunction with high DO values, confirm that denitrification is not an important process in the organic-poor basalt aquifers. Irrigation recharge has reached ~100 m depth along predominately vertical flowpaths in less than 30 years.

[2]Department of Geosciences, University of the Pacific
[3]School of Natural Resources, The University of Arizona

The Relationship between Water Travel Times and Aspect: Toward a Greater Understanding of the Coupling between Hydrology and Solar Energy

Patrick D. Broxton, Peter A. Troch, Paul. D. Brooks,
Steve W. Lyon, Joseph R. Gustafson, William. C. Veatch

Department of Hydrology and Water Resources,
The University of Arizona

This study aims to use water travel times (the times that it takes for water to move through a hydrologic system) to gain useful information about the workings of small catchments. Specifically, we attempt to determine whether there are different travel times on different aspects (slope directions) of a given landscape. The travel times, themselves, depend on a variety of physical characteristics of catchments (e.g., storage size, conductivities, transpiration rates, etc) that are presumably functions of the amount of incoming solar energy; however, the relative importance of these factors is largely unknown. So far, we have found a general correlation between travel times and aspect for streams that drain different sides of Redondo Peak, a resurgent dome in the Valles Caldera, New Mexico. These travel times were determined using mixing relationships between the stable water isotopes (δ^2H and $\delta^{18}O$) content of rainfall and snowmelt inputs into the system. The goal, now, is to capture this behavior with catchment scale models, which accept different amounts of incoming solar energy. In the end, these relationships should help us to quantify differences between streams with different aspects in terms of how quickly water moves through and how they respond to varying inputs.

Determination of baseflow inputs in the San Miguel River Basin, a riparian area in the North American Monsoon region

Lissette De La Cruz[1], Thomas Meixner[1], James Hogan[2], Miguel Ranguel[3]

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

The North American Monsoon is an important climate phenomenon in Northwest Mexico and the Southwest United States. One of the best studied basins in this region is the San Pedro, in the United States. Using geochemical and isotopic mixing techniques the waters sources of the San Pedro have been shown to include a significant fraction of floodwater. In the current work we are extending this understanding to basins with different degrees of Monsoon influence. The more Monsoon dominated basin we are looking at is the Rio San Miguel, Sonora, Mex. Isotopic data gives a clear pattern of seasonal variability of recharge source composition. Chemical composition data allows differentiating between processes that occur along the river, in an approximately 80 km reach that we have sampled. The results indicate that it is possible to separate the basin into a lower and an upper reach. In the lower basin the data shows more evaporated water than in the upper basin. The isotopic data showing different precipitation processes with more depleted water at high altitude. Surface and groundwater average isotopic values are close to each other, with a slight enrichment in surface water indicating it is closer in composition to summer precipitation than groundwater.

[2]SAHRA, University of Arizona, Tucson, Arizona
[3]Geology Department, University of Sonora, Hermosillo, Son.

Evolution of Flowpaths in an Alpine Watershed of the Colorado Front Range, USA

Jessica Driscoll [1], Thomas Meixner[1], Mark Williams[2], Noah Molotch[3]

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

High elevation ecosystems are among the most sensitive to changes in climate and atmospheric deposition. Few studies have integrated the evolution of waters within these alpine systems with tracer and mixture model studies. The chemistry of stream water in these catchments is a result of the chemistry of the precipitation and changes in that chemistry due to chemical reactions along the flowpath of the meltwater to the stream. Chemical reactions between the rocks, soils, talus and rock glaciers and the meltwater lead to chemically distinct end members. The use of chemical tracers to perform end-member mixing analysis (EMMA) for the Green Lakes Valley (GLV) in the Colorado Front Range[4] does not spatially differentiate the physical flowpaths of waters, nor enable chemically distinct end-members to react. Chemical reactions are used to determine potential physical flowpaths in the alpine system by determining reactions between end members mineral weathering are calculated with PHREEQC using chemical data collected in 1996 and the mineral assemblage[5] of the GLV. Because EMMA solutions show variability in the contribution of end-members to the streamwater over snowmelt[4], PHREEQC was used to determine the differences in mineral weathering between end members for the three distinct phases of the snowmelt hydrograph.

[2] University of Colorado,
[3] University of California Los Angeles
[4] Liu et al., 2004
[5] Platts-Mills and Williams, Unpublished

Using geostatistial and artificial neural network methods to estimate 3-D distribution of soil and hydraulic properties across MAC site

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

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

We use geostatistical and neural network analyses to estimate the three-dimensional distributions of soil types and hydraulic properties in a relatively large volume of the vadose zone underlying the Maricopa Agriculture Center (MAC) near Phoenix, Arizona. Geostatistical analysis of soil texture and bulk density data from the site were 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 the pedotransfer neural network model ROSETTA to produce estimates of soil hydraulic parameter (saturated and residual water content, saturated hydraulic conductivity, van Genuchten parameters a and n) distributions across the site in three dimensions. The estimates compare favorably with laboratory-measured values of these same hydraulic parameters on soil samples extracted from a number of boreholes at the site.

[2]Department of Soil, Water and Environmental Sciences, The University of Arizona

Spatial and Temporal Patterns in Water Chemistry of Monsoonal Storm Runoff in the Tucson Basin

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

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

Scarce water resource management strategies in the Southwest include storm runoff recharge in ephemeral water ways and retention basins. Therefore, the fate and transport of non-point source urban contaminants during storm runoff is of major concern. This study addresses those concerns by identifying spatial and temporal patterns of monsoonal rainfall-runoff chemistry over an urban land use gradient. We analyzed the solute chemistry of storm runoff samples from Tucson Basin watersheds of distinct land uses: 1) commercial, 2) low density residential, 3) medium density residential and 4) mixed use. Most solutes appeared to be transported conservatively; however, nitrate-N was flushed from the mixed land use, produced in the low density residential and consumed in the commercial watershed. Temporal patterns indicate variability in chloride and dissolved organic carbon flushing as the monsoon progressed; suggesting that solute response to precipitation and runoff is watershed specific. Curiously, runoff chemistry and fecal indicator bacteria (*E. coli*) in the least and most urbanized sites (low density residential and commercial, respectively) behaved similarly, suggesting hydrologic rather than land use controls over solute chemistry. Our study indicates that land use coupled with hydrologic response to precipitation plays an important role in watershed solute sourcing, retention and transport.

[2]School of Natural Resources, the University of Arizona.

Effects of adaptive mesh refinement on estimation of hydraulic properties of aquifer

Phoolendra Kumar Mishra and T.C. Jim Yeh
Department of Hydrology and Water Resources,
The University of Arizona

The hydraulic tomography is emerging technique for subsurface characterization. In order to analyze the field scale subsurface problems, we need to discretize the domain in finite number of elements. For the case of uniform grid pattern over the whole domain the elements under high head gradient are numerically treated same as the elements with smaller head gradient. In this study we analyze the effects of mesh refinement on the estimations of properties. We developed the adaptive mesh refinement algorithm and applied to the part of domain where high gradient is expected for the forward model and also for the sensitivity calculations in inverse algorithm (SSLE). The hydraulic tomography added with adaptive mesh refinement is applied to a synthetic case and to a sequential aquifer test at actual well field and results are discussed.

Distributed Parameter Estimation Using a Regularization Approach

Prafulla Pokhrel[1], Dr. Hoshin Gupta[1], Dr. Thorsten Wagener[2]

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

The high dimensionality of the parameter search space can be solved by the introduction of additional information about the parameters. In this research the information contained in the apriori parameter estimates, derived using the soil data and the method developed by the National Weather Service, was used to identify regularization equations. These regularization equations were then used to constrain the parameter variability during the calibration process and reduce the dimension of the calibration problem. The study of spatial variability of apriori parameters with respect to the NRCS based curve numbers and the depth of soil showed some recognizable trends that could be exploited in the form of some simple regression equations. These equations, along with some inter parameter relations, were used as regularization equations. Calibration of the coefficients of the regularization equations instead of the Sacramento Soil Moisture Accounting Model parameters reduced the dimension of the problem from 858 to 33 unknowns and resulted in significant reduction in the objective function values.

[2]Civil and Environmental Engineering, Pennsylvania State University

A Dynamic Land Surface – Groundwater Interaction Parameterization for the NOAH Land Surface Model

Seshadri Rajagopal[1], Peter A Troch[1], Hoshin V Gupta[1], David Gochis[2], Steve W. Lyon[1]

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

Soil moisture of the land surface plays an important role in determining the coupling and partitioning of fluxes (latent and sensible heat) in land-atmosphere interactions. In general, most land surface models (LSM) represent the top 2-4 meter of the soil profile and adopt various techniques such as root zone controlled, Richard's equation based methods to calculate soil moisture. The role of groundwater in calculating soil moisture until recently was implicitly accounted for in several studies based on steady state kinematic subsurface flow. Recent published literature e.g. Niu et al., 2007, incorporate an explicit representation of the water table by implementing a simple groundwater model and show that this coupling of soil moisture with the deeper layers significantly modified the near surface soil moisture distribution. In the poster I propose to review some of these new techniques. Also, initial results from implementing a Darcy based capillary rise function and a sub-surface runoff with water storage and recharge based on the Boussinesq-Storage equation to the 1-D NOAH-LSM will be presented.

[2] National Center for Atmospheric Research, Boulder, Colorado

Investigating the source and timing of freshwater recharge into saline aquifers in the glaciated Illinois Basin

Melissa E. Schlegel[1], J. McIntosh[1], M.Person[2]

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

Economic reservoirs of microbial generated methane associated with organic rich geologic units are present in several interior basins in North America, including the New Albany Shale in the Illinois Basin. Deep subsurface (approximately 1500 to 2500 feet) methanogens in the New Albany Shale seem to be stimulated by a plume of low-salinity water that diluted and displaced saline brines. This dilute plume (DP) extends from basin margins toward the basin center in limestone aquifers and shales. The axis of the DP coincides with the axis of ice lobes that periodically covered portions of the basin during the last glacial period, indicating that the DP may originate from glacial melt water. $\delta^{18}O$ values of glacial recharge are significantly depleted (approximately -15 to -25‰) as compared to modern precipitation (approximately -8‰), however Illinois Basin $\delta^{18}O$ values in the DP are around -8‰. This study investigates three hypotheses concerning the enriched $\delta^{18}O$ values: 1) DP originates from modern recharge, 2) DP is a mixture of isotopically depleted Pleistocene aged recharge and formational brines, and 3) DP is from an isotopically enriched Pleistocene aged source. Data used in this study includes results from recent sampling of 17 New Albany Shale wells and peer-reviewed articles.

[2]Department of Geological Sciences, Indiana University, Bloomington, Indiana

Handling micrometeorological forcing in a changing climate
- Or the death of stationarity -

Aleix Serrat-Capdevila[1], Juan B. Valdes[2], Russell Scott[3]

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

While it has been assumed for a long time that natural processes occur within a stable envelope of variability, or following time-invariant probability density functions; this assumption may no longer hold (Milly et al. 2008). Small changes in annual averages might imply large changes in extreme events. Barnett et al. (2008) clearly identify some of the current impacts of anthropogenic climate change on the water resources of the American west. Due to strong non-linearities in natural systems, small changes in meteorological forcing can change hydrological processes in a significant way. The work here presented will analyze how changes in precipitation and temperature may affect hydrological processes in the San Pedro Basin. In particular we will focus on evapotranspiration (ET). We will analyze historical temperature trends in the basin as well as future projections and we will attempt to derive insights into its effects on hydrological processes in the basin: (1) how will riparian ET respond to an increase in mean temperatures and a longer growing season? (2) Can these changes be significant in the basin's water balance? (3) How may changes in temperature affect mountain runoff and recharge at the mountain-front? How are winter and summer rains expected to change in the current century? What are the implications of these projections? The presentation will attempt to give an insight to these questions.

[2]Department of Civil Engineering and Engineering Mechanics and SAHRA (Sustainability of Semi-Arid Regions and Riparian Hydrology), University of Arizona, Tucson, Arizona

[3]Agricultural Research Service, Southwest Watershed Research, Tucson, AZ

Determining water sources of the Lower Bill Williams River, Western Arizona

Scott Simpson[1], Thomas Meixner[1], James Hogan[,2]

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

Comparison of hydrographs from the Bill Williams River at the outflow from Alamo Dam (the origin of the river since 1968) and near it's confluence with the Colorado River near Parker, Az., indicate the importance of upstream high flows in sustaining downstream baseflow. This link is attributable to the large storage capacity of floodwater in the alluvial valleys between Alamo Dam and Parker, of which Planet Valley has both the greatest capacity and impact on the river. During baseflow, the river infiltrates completely at the upstream end of Planet Valley and reemerges at the downstream end where it enters the Bill Williams River National Wildlife Refuge. Preliminary results indicate that current inputs to Planet Valley are chemically and isotopically ($\delta^{18}O$, $\delta^{2}H$) distinct from streamflow and groundwater at the downstream end of Planet Valley. Streamflow and groundwater in the wildlife refuge are isotopically similar but differ chemically from streamflow leaving Planet Valley. This would indicate that one of more of the following is present below Planet Valley: (1) a solute source in the riparian aquifer, (2) subsurface addition of water from dry wash tributaries, and/or (3) storage of chemically distinct floodwater released from Alamo Dam prior to April 2007.

[2]SAHRA, University of Arizona, Tucson, Arizona

Spatial and Temporal Variability of Vertical Flux Between Surface and Ground Waters at the Upper San Pedro River, AZ

Carlos D. Soto-López and Thomas Meixner

Department of Hydrology and Water Resources,
The University of Arizona

Precipitation patterns in semi-arid river systems of the southwestern U.S. make stream-aquifer interactions an important source of water in perennial rivers. Nonetheless the spatial and temporal evolution of surface and ground water exchange across an annual cycle are not fully understood. Recent advancements in temperature sensor design have made small and self logging temperature sensors available and inexpensive. These sensors have enabled the use of temperature as an environmental tracer to identify direction of water exchange and quantify rates of exchange between surface and ground waters at point scales. This method utilizes the fact that groundwater temperature variability is negligible when compared to that of surface waters. Therefore, sediment temperatures in upwelling conditions behave differently than those under downwelling conditions. The objective of this research is to determine the spatial and temporal variations of the direction of exchange between surface and ground waters as time since flood increases. To do so we collected coupled surface and sediment water temperature at 4 different spatial scales using a nested hierarchy approach. Temperature values were recorded during 4 different campaigns representing different times since last flood (2.2, 6.3, 7.3, 8.4 months) at 15 minute intervals for 7 consecutive days. We then applied a coupled heat and water flow equation to the temperature time series to infer direction of exchange. The results of a preliminary analysis suggest that the direction of exchange does change spatially and temporally over the study period. The sampling period of May appears to have the most upwelling sites even though this period has the lowest flow. Also, exchange direction appears to change at distances of 1 m. This study highlights the relative heterogeneity of stream-aquifer interactions.

Quantifying the Effects of Forest Canopy Cover on Snow Accumulation and Ablation at a Continental, Mid-latitude Site, Valles Caldera National Preserve, NM

Will Veatch[1], P. D. Brooks[1], N. P. Molotch[2], J. R. Gustafson[1], and P. D. Broxton[1]

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

Basin scale estimates of water resource quantity and quality in snow-dominated systems are complicated by the interrelated forcings of topography and vegetation on snowpack accumulation and ablation. Although the effects of forest density on snowpack are relatively well characterized in northern systems, their interactions in the higher solar-radiation environments found at mid-latitude sites are not well understood. We measured snowpack properties in six snow pits and took a total of 1,350 measurements of snow depth through a continuum of forest canopy densities during the early season, peak accumulation, and melt season of spring 2007. By comparing depth data to canopy cover as measured in the field and by satellite, we quantify the interactions between snow and forest vegetation at the 30-m scale. Our results show significant correlations between snow depth and forest canopy density, as well as significant influences of forest edges on snow depth, indicating that vegetation influences snow processes beyond the canopy and canopy-fringe. We show how these findings can be used with nonlinear statistical methods and remote sensing products to improve basin-scale estimates of water-resource availability, better understand the possible effects of climate and vegetation change in southwestern forests, and inform integrated water and forest resource management.

[2]Department of Civil and Environmental Engineering, University of California, Los Angeles

Routing Water and Sediment in the Rillito River Using IALLUVIAL2: A Comparison Study

Mary A. Yaeger[1] and Jennifer G. Duan[2]

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

Predicting flood flows in rivers that flow through populated areas is of great importance, and computer models are useful tools in such an endeavor. This paper outlines a comparison study that examined the water surface and bed elevations of the 100-year flood event in the Rillito River at Tucson, Arizona. The results from IALLUVIAL2 were compared with those from HEC-RAS and GSTARS, as well as stage data from the USGS. Results showed that IALLUVIAL2, which cannot compute bridge effects, predicted a flood similar to that of the more commonly used HEC-RAS model, which does take into account bridges. Both models underestimated the flooding by about 2 to 4 feet, but accurately predicted the recession of each flood flow. This study also compared different equations within the IALLUVIAL2 model to find the most appropriate sediment transport and roughness equations for this particular river and found that Laursen and Manning's gave the best results. The results indicated the need of an appropriate model for predicting flood flows in ephemeral streams for water resource managers, engineers and urban planners.

[2]Department of Civil Engineering and Engineering Mechanics, University of Arizona, Tucson, Arizona

Groundwater Sources, Flow Paths, and Residence Times in the Middle Verde River Watershed

Caitlan M. Zlatos[1], James F. Hogan[1], Kyle W. Blasch[2], Donald J. Bills[3], and Thomas Meixner[1]

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

In the hydrogeologically complex Middle Verde River watershed, we aim to determine the hydrologic connection between aquifers underlying the Colorado Plateau and adjacent aquifers in the Verde River watershed and achieve an improved understanding of water sources and flow paths that contribute to and sustain the Verde River. Two seasonal surface water datasets collected from the Verde River and its tributaries (Oak Creek, Wet Beaver Creek, and West Clear Creek) and a groundwater dataset were analyzed for oxygen and hydrogen stable isotopes and major solute concentrations. Analyses based on solute relationships (i.e. sulfate-chloride and calcium-strontium) show evidence of distinct solute sources for the Verde River and its tributaries, as well as the geochemical distinctions between groundwater from the C, Redwall-Muav, and Verde Formation aquifers. Distinct Verde River trends, including overall increases in solute concentrations along two reaches (kilometers 13 to 32 and 60 to 68, as measured upstream from USGS gage 09506000), suggest dissolution of evaporite deposits within the Tertiary lakebed-derived Verde Formation. Notably, groundwater from Verde Formation wells in the Cornville/Lower Oak Creek region is geochemically similar to groundwater from the C and Redwall-Muav aquifers, suggesting hydrologic connection between the distinct aquifers.

[2]U.S. Geological Survey, Tucson AZ
[3]U.S. Geological Survey, Flagstaff AZ

~ Notes ~

~ Notes ~

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