THE UNIVERSITY OF ARIZONA

Department of Hydrology and Water Resources

Presents

The 23rd Annual

El Dia del Agua

April 10, 2013

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Message from HWRSA

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 23rd Annual El Dia del Agua Student Research Symposium. El Dia del Agua 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 please to host a full-day event with nine oral presentations, eighteen 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 El Dia del Agua. This tradition serves to strengthen the hydrology community, as well as to facilitate knowledge transfer between academia and the professional community. Furthermore, El Dia del Agua is a great place for prospective students to learn about the wide range of interesting research opportunities available to HWR students. The success of El Dia del Agua is possible thanks to the support of HWR faculty, students, sponsors, the School of Earth and Environmental Sciences, and the UA College of Science.

Thank you for taking the time to attend El Dia del Agua.

HWRSA Officers

HYDROLOGY & WATER RESOURCES STUDENT ASSOCIATION OFFICERS

From Left to Right

Timothy Bayley, Vice President
Colin Kikuchi, President
Bobby Chrisman, Social Chair
Jenna Shelton, Treasurer

~

Not Photographed ~ Thomas Meixner, Faculty Advisor

El Dia del Agua ~ Program Schedule

8:00-8:55 Registration, Check In & Continental Breakfast (*North Ballroom*)

8:55-9:00 Welcome by Dr. Larry Winter, Professor and Department Head, Hydrology and Water Resources, and Colin Kikuchi, 2012-2013 President, Hydrology and Water Resources Student Association

9:00-9:45 **Oral Presentations ~ Moderator Daniel Ritter, Ph.D. Candidate**

9:00-9:15, Biederman, Joel A. ~ *Compensatory processes dampen impacts of insect-induced forest die-off on catchment water balance and biogeochemical fluxes*

9:15-9:30, Kikuchi, Colin ~ *Discrimination-Inference to Reduce Expected Cost Technique (DIRECT): Application to groundwater-surface water investigations*

9:30-9:45, Yu, Chunshui ~ *A Unified Surface Flow Routing Algorithm for Hydrologic and Hydraulic Applications*

9:45-11:00 Poster Session

11:00-11:45 **Oral Presentations ~ Moderator Katherine Condon, 2012 El Dia del Agua Recipient of the Hydrology and Water Resources Award for Excellence, Poster Presentation**

11:00-11:15, Sánchez-Mejía, Zulia ~ *Deep Soil Moisture Control on Land Surface-Atmosphere Interactions in Semiarid Ecosystems*

11:15-11:30, Shelton, Jenna ~ *Fate(s) of injected CO2 in a coal bearing formation, Gulf Coast Basin: chemical and isotopic tracers of microbial-brine-rock-CO2 interactions*

11:30-11:45, Merino, Manuel ~ *Evaluation of the Performance of Satellite Precipitation Products over Africa*

11:45-12:00 Proceed to the South Ballroom for Luncheon and Presentations

12:00-1:30 Buffet Luncheon located in the South Ballroom - Dr. Thomas Meixner, Associate Department Head, Professor Hydrology and Water Resources, and El Dia del Agua Chair ~ Introduction to Lunch Speaker, Maria Baier, CEO Sonoran Institute, UA Alum ~ *Hydrologists: Arizona's Real Rainmakers*

1:30-2:00 Poster Session

2:00-2:45 **Oral Presentations ~ Moderator Kirstin Neff, Ph.D. Candidate**

2:00-2:15, Witte, Becky ~ *Impacts of Climate Change and Population Growth on Water Stress in the Tucson Active Management Area*

2:15-2:30, Condon, Katherine ~ *The importance of episodic fluvial particulate carbon and nitrogen export following fire, relative to long-term fluxes*

2:30-2:45, Zapata-Rios, Xavier ~ *Hydrological Response of Semi-Arid Upland Catchments to Changes in Winter Precipitation*

2:45-3:30 Poster Session

3:30-4:30 Dr. Larry Winter, Department Head, Hydrology and Water Resources ~ Introduction to Keynote Speaker, Dr. Abe Springer, Professor of Hydrogeology, School of Earth Sciences and Environmental Sustainability at Northern Arizona University ~ *Watershed Investment Programs: Friend or Foe of Watershed Management and Science?*

4:30-5:30 Award Presentations ~ Refreshments & Appetizers
Montgomery Prize ~ By Timothy Bayley
Hargis Awards ~ By Leo Leonhart
HWR Awards ~ By Larry Winter
Donald R. Davis Award ~ By Thomas Meixner
Eugene S. Simpson Award - By Thomas Meixner
Aqua-Person Award ~ By Colin Kikuchi

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Kirsten Neff

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El Dia del Agua ~ Awards Evaluation Committee

Montgomery Prize
Best Oral Presentation
Certificate and Award of $2,000
Timothy Bayley ~ Deqiang Mao ~ Martha Whitaker

Hargis Awards
First Place Poster ~ $1,000, Second Place Poster ~ $400
Leo Leonhart ~ Dennis Scheall ~ Rob Wilhelm

Hydrology & Water Resources
Award of Excellence for Oral Presentation
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Kim Beisner ~ Thomas Maddock III
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Hydrology & Water Resources
Award of Excellence for Poster Presentation
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Aleix Serreat-Capdevila ~Mark Thomasson

Donald R. Davis
Undergraduate with Distinction
Certificate and Award of $400
Colin Kikuchi, Joel Biederman, Jenna Shelton

Eugene S. Simpson
Undergraduate Poster Award
Certificate and Award of $400
Colin Kikuchi, Joel Biederman, Jenna Shelton

The Montgomery Prize

The Department of Hydrology and Water Resources would like to thank Errol L. Montgomery & Associates, Inc. for their support of the 23rd Annual El Dia Del Agua. For many 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 made in addition to the two departmental awards (best oral and best poster presentations) and will be presented to the winner by 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 water resource consulting group with more than 25 years of experience addressing groundwater availability, sustainability, and quality issues for municipal, industrial, mining, and governmental clients. Professional services include:

- Groundwater exploration and development
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The firm's principal office is located in Tucson, Arizona, and branch offices are maintained in Scottsdale, Arizona, Lima, Perú, 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 EI Dia del Agua. Dr. Leo Leonhart, Principal Hydrogeologist and Chief Technical Director, Hargis+Associates, Inc., of Tucson, will present first and second place cash awards for the best poster presentations. 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 an environmental consulting firm specializing in hydrogeology and engineering. Established in 1979, they are headquartered in San Diego, California and have offices in Mesa and Tucson, Arizona. Practice areas include all aspects of hydrogeology and environmental engineering focused in the following markets: industrial, aerospace, mining, water resources, government and legal.

As a client service organization, Hargis + Associates, Inc. takes pride in being attentive and efficient in meeting their client's needs and solving their problems. In addition to technical expertise, communication and responsive coordination are hallmarks of their reputation.

Eugene S. Simpson Undergraduate Poster Award

Professor Eugene Simpson began his professional career with the U.S. Geological Survey in 1946 where he was involved with problems of migration and dispersion of radioactive wastes that might accidentally or operationally be discharged into groundwater.

In 1963, he was hired by Dr. John W. Harshbarger as a member of HWR's inaugural faculty, and he continued his research interests in aquifer mechanics, the migration of pollutants in groundwater, and the application of environmental tracers to problems of groundwater circulation. Simpson served as Department Head from 1974-75 and 1979-81.

After his retirement in 1985, he remained active in the profession, serving the U.S. Chapter of the International Association of Hydrogeologists as Secretary-Treasurer from 1984-89 and as President from 1989-92. During his tenure as President, he became the Founding Editor and first Editor-in-Chief of the IAH journal, *Applied Hydrogeology*, which later became *Hydrogeology Journal* (Springer), the official journal of the IAH.

The Geological Society of America Hydrogeology Division honored him with the Distinguished Service Award in 1992, and the International Association of Hydrogeologists elected him an Honorary Member in 1993.

Following retirement, he resided in Tucson until his death at the age of 78 in December 1995. At that time, the Eugene S. Simpson Endowment was established to provide financial support for undergraduate and graduate students, especially those studying hydrogeology and subsurface hydrology.

The Department of Hydrology and Water Resources would like to thank the family, friends, and former students of Eugene S. Simpson for their continued support and contributions. In March 2012, the inaugural Eugene S. Simpson Undergraduate Poster award will be made for the best undergraduate poster with priority given to hydrogeology or subsurface hydrology content, Simpson's areas of expertise. The evaluation will be made by the undergraduate coordinator and undergraduate faculty instructors, especially those representing hydrogeology and subsurface hydrology.

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 a committee appointed by the department. 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 also for his love of the undergraduate program he so nurtured.

El Dia Del Agua ~ Luncheon Speaker

Maria Baier, CEO
The Sonoran Institute

Maria Baier began her work as Chief Executive Officer for the Institute as CEO in December 2012. Prior to joining the Institute, Maria was the Commissioner of the Arizona State Land Department (ASLD), a position she held since 2009. At ASLD, Baier has been responsible for managing millions of acres of Arizona state trust lands. Proceeds from land sales and leasing primarily benefit schools and education in Arizona.

Baier has also served as a Phoenix City Councilwoman, and has held several executive positions, including president of MBC, Inc., a sustainability consulting firm; president and CEO of Valley Partnership, a trade organization, and director of the Trust for Public Land, Arizona Field Office. She spent 10 years on the Executive Staff of the Office of the Governor, serving two administrations.

Baier is a member of the Arizona State Bar and received her Bachelor of Arts Degree from Arizona State University and her Juris Doctor from the James E. Rogers College of Law at the University of Arizona in Tucson.

"Abstract for Discussion with Hydrologists"

There is often an artificial distinction between values to the natural world and values to the economy. Nowhere is this artificial distinction more easily exposed than with water. Without much effort, it can be observed that what impacts one part of nature first will eventually impact nature more broadly, and those broader impacts force choices. Since economies are based on human behaviors, it is only a matter of time until the natural condition influences human behaviors to the point that economies are modified. We see evidence of such modifications in places like Prescott, where the determination by ADEQ under the Groundwater Management Act led to a declaration of "not in safe yield" for the Prescott AMA a decade ago. That region continues to be challenged by its water constraints in terms of building a sustainable economy. Many other examples also will be cited. In these circumstances, many of the key figures for developing paths forward are hydrologists. They are the primary source for determining the consequences of activities on the natural world and set the stage for the rest of us to determine how and when each of us might be affected and what measures we must undertake to avoid problems.

El Dia Del Agua ~ Keynote Speaker

Dr. Abe Springer
Professor of Hydrology
Northern Arizona University
School of Earth Sciences and Environmental Sustainability

Abe Springer is Professor of Hydrogeology in the School of Earth Sciences and Environmental Sustainability at Northern Arizona University. In 2007, he was the Fulbright Visiting Chair of Water and Environment at the University of Lethbridge, Alberta, Canada studying the ecohydrology of springs of Western Canada. He received his B.A. in Geology from the College of Wooster and his M.S. and Ph.D. in hydrogeology from The Ohio State University. Dr. Springer and his students study local and regional groundwater flow systems and human impacts on them, apply principles of sustainability to aquifer management through models, quantify the hydrological function of groundwater dominated ecosystems, the role of land-use change and disturbance on groundwater flow systems, and restoration of riparian ecosystems. With colleagues, he has developed a new, comprehensive spring classification system which is featured in the recent book Aridland Springs in North America: Ecology and Conservation.

"Watershed Investment Programs: Friend or Foe of Watershed Management and Science?"

Exclusion of fire from fire-adapted pine forests of the Southwestern U.S. has led to overdense tree stands and the threat of catastrophic wildfire with associated flooding. The tree density has increased sublimation and evapotranspiration and has reduced recharge to the underlying aquifers and runoff. Historical vegetation manipulation studies and recent eddy covariance studies in these forests indicate a significant increase in surface-water yield and groundwater recharge from tree stand reduction and a return of a more frequent, low-intensity, fire interval. Single objective hazardous fuels reduction treatments alone do not restore ecosystem resiliency or forest structure. Comprehensive restoration approaches include mechanical thinning to reduce tree densities to levels more consistent with natural conditions coupled with the reintroduction of frequent, low-intensity fire to reduce excess fuel loads on the ground. New management programs are being developed to direct water user funds to support watershed restoration, through what are now referred to as "watershed investment programs". These types of programs derive from the concepts developed in payments for ecosystems services theory. As a result, the City of Flagstaff has recently approved a bond issue to help support evidence-based forest treatments and subsequent improvements in watershed functionality. Monitoring and assessment studies are being designed to be able to evaluate whether or not these types of investments improve watersheds.

Oral Presentation Abstracts

Compensatory Processes Dampen Impacts of Insect-Induced Forest Die-Off on Catchment Water Balance and Biogeochemical Fluxes

Joel A. Biederman, Paul D. Brooks Adrian A. Harpold[1] and David E. Reed[2]

Department of Hydrology and Water Resources
The University of Arizona

Forested montane catchments are a primary source of water in western North America, where mountain pine beetle (MPB) has caused extensive forest die-off. Expected responses include wetter soils, enhanced runoff, and flushing of carbon and nitrogen into streams. Recent studies found reduced interception and increased organic decomposition but minimal responses at larger scales relevant to water resources. Here we quantify 1) fluxes of catchment water balance and 2) the scales of attenuation of biogeochemicals.

We observed forested headwaters catchments of the central Rocky Mountains with varying degrees of MPB infestation using nested observations across scales from plots to 3rd-order catchments. Synthesis of catchment water fluxes with water isotope fractionation indicates large evaporative fluxes compensating for reduced interception and transpiration in dead forests. Chemistry from ~700 solution samples demonstrates that elevated carbon and nitrogen in hillslope water are rapidly attenuated in streams over lengths as small as 10^1 – 10^2 m. Catchment topographic metrics such as flowpath length and slope describe much of the variability in longitudinal stream chemistry, indicating the importance of residence time. These observations offer new understanding of how compensatory vapor losses may prevent increased runoff and of how headwater streams rapidly process elevated inputs of C and N.

[1]Institute for Arctic and Alpine Research
[2]University of Wyoming Department of Botany

Discrimination-Inference to Reduce Expected Cost Technique (DIRECT): Application to Groundwater-Surface Water Investigations

Colin P. Kikuchi and T.P.A. Ferré

Department of Hydrology and Water Resources
The University of Arizona

Reliable characterization of groundwater-surface water interaction is confounded by the complex distribution of subsurface hydraulic properties and system boundaries in both space and time. To address uncertainties arising from these factors, investigations of groundwater-surface water interaction typically require field observations of hydrologic states and fluxes. Uncertainties in system characterization are reduced as more data are collected. However, some hydrologic data may be poorly suited or inadequate to reduce the most critical uncertainties in coupled groundwater-surface water systems. This problem may be avoided by undertaking value-of-data analyses before and during field measurement campaigns. This research seeks to identify data most suited to guide objective-driven characterization of groundwater-surface water systems using Discrimination-Inference to Reduce Expected Cost Technique (DIRECT) – a new framework for merging hydrologic measurement selection with economic cost analysis. DIRECT uses a Data Discrimination Index to assess candidate measurements based upon their ability to elucidate system characteristics most pertinent to objectives such as adequate supply for human uses and protection of in-stream flows. We demonstrate the application of this approach in an alluvial aquifer typical of the basin and range province of the southwestern United States.

A Unified Surface Flow Routing Algorithm for Hydrologic and Hydraulic Applications

Chunshui Yu and Jennifer Duan

Department of Hydrology and Water Resources
The University of Arizona

A novel surface flow routing algorithm is proposed in the research. The algorithm is based the two-dimensional depth-averaged shallow water equations. The shallow water equations have been extensively used in the hydraulic applications, including but not limited to dam-break calculation, tsunami simulation and sediment transportation. However, it is well known that the current algorithm is unstable for the overland flow calculation. In the research, this stability problem has been investigated by a thorough stability analysis. And a novel algorithm based on the Godunov-type finite volume method is developed. The algorithm is accurate and stable for solving both the overland flow and channel flow problems. Several test cases, including hydrologic and hydraulic applications, are shown to demonstrate the accuracy and stability of the new algorithm.

Deep Soil Moisture Control on Land Surface-Atmosphere Interactions in Semiarid Ecosystems

Zulia Mayari Sánchez-Mejía and Shirley A. Papuga

School of Natural Resources and the Environment
The University of Arizona

In semiarid ecosystems, frequent small storms provide ephemeral moisture while larger infrequent storms provide lasting moisture at depth. Deep soil moisture (q_D) indirectly influences land surface-atmosphere interactions via vegetation. Here we address: Q1) What is the influence of q_D on the surface energy budget (SEB) and planetary boundary layer (PBL)?, Q2) What is the effect of q_D on albedo via vegetation?, Q3) What is the response of the SEB and PBL to vegetation change when q_D is available?. We use a conceptual framework based on presence or absence of soil moisture at shallow or deep depth. We link eddy covariance, atmospheric sounding, and field campaign data to (1) generate PDF for use in a grid model to quantify the role of q_D on albedo and (2) use an energy-based land surface model to quantify latent and sensible heat partitioning. We show that albedo is low with shallow moisture regardless of q_D and high when both layers are dry. However, when the shallow layer is dry and the deep layer is wet, the influence on albedo, evaporative fraction, and PBL is evident. As vegetation cover increases albedo decreases when q_D is available. Our results highlight the importance of q_D in land surface-atmosphere interactions.

Fate(s) of injected CO_2 in a coal bearing formation, Gulf Coast Basin: Chemical and Isotopic Tracers of Microbial-Brine-Rock-CO_2 Interactions

Jenna L. Shelton, Jennifer McIntosh and Peter Warwick[1]

Department of Hydrology and Water Resources
University of Arizona

Coalbeds are a promising reservoir for geologic CO_2 sequestration, as CO_2 can strongly adsorb onto organic matter and displace existing adsorbed methane; however, little is known about the long-term fate of CO_2 sequestered in coal. The "2800' sand" of the Olla oil field is a coal-bearing, oil and gas-producing reservoir of the Paleocene–Eocene Wilcox Group in north-central Louisiana. In the 1980s, the 2800' sand was flooded with CO_2 in an enhanced oil recovery (EOR) project, with 9.0×10^7 m^3 of CO_2 remaining in the 2800' sand after injection ceased. This study utilized isotopic and geochemical tracers from co-produced natural gas, oil and brine to determine the fate of the remaining EOR-CO_2, while also testing a previous hypothesis that EOR-CO_2 may have been converted by CO_2-reducing methanogens into methane. Four samples taken from the Olla 2800' sand produced CO_2 gas with δ^{13}C-CO_2 values much lower and CO_2 concentrations much higher than pre-injection conditions, suggesting the presence of EOR-CO_2 and gas-phase trapping as a major storage mechanism. δ^{13}C values of CO_2 and DIC suggest that dissolution is a major storage mechanism for 3 of the 4 samples. Evidence suggests that the minor storage mechanisms were migration and EOR-CO_2 conversion to microbial methane.

[1]U.S. Geological Survey, Reston, Virginia

Evaluation of the Performance of Satellite Precipitation Products over Africa

Manuel Merino, Aleix Serrat-Capdevila[1], Juan B. Valdes[1] and Matej Durcik

Department of Hydrology and Water Resources
The University of Arizona

An analysis of the errors of satellite rainfall estimates over the Africa, in relation to spatial distribution over the continent, as well as their seasonal characteristics, and relation to other spatial features, such as longitude bands, topography and climatic classification is presented.

Three near-real time satellite rainfall products, CMORPH, PERSIANN and TMPA-3B42RT, were compared against a ground truth dataset in order to compute the daily residuals of the remote sensed estimates for a grid of 0.25° by 0.25° over Africa. Different analysis were run to extract patterns that relate the residuals to spatial features, such as latitude bands, climatic classification zones, topographic features, and temporal features, such as month or season. Finally, an analysis of how real-time bias corrections methods could be used to improve satellite precipitation estimates over the continent is presented.

[1]ICIWRaM – International Center for Integrated Water Resources and Management

Impacts of Climate Change and Population Growth on Water Stress in the Tucson Active Management Area

Becky Witte, C.L. Winter and Thomas Maddock III

Department of Hydrology and Water Resources
The University of Arizona

This study assesses the effects of a changing climate and population growth on water resources by modeling groundwater supplies in the Tucson Active Management Area. The finite-difference flow model, Modflow, incorporates agricultural, municipal, and industrial pumping along with natural and artificial recharge. Groundwater conditions and pumping are considered from 1940-2009, and the model predicts pumping and recharge scenarios for 2010-2050.

Climate impacts are reflected in the amount of recharge entering the groundwater system. Since Colorado River water delivered along the Central Arizona Project (CAP) is used in Tucson, local and regional climate conditions are incorporated. A 10% reduction to the mean natural flow in the Colorado River over 50 years is used to predict Colorado River flows. Operational rules fora the CAP water deliveries during shortage conditions are utilized.

The percentage of population growth varies around the current case, which is extrapolated from data provided by Arizona Department of Water Resources. The three population scenarios are limited growth, current case, and high growth.

Results indicate groundwater depletion conditions are significantly worse during the high growth shortage scenarios. This talk will review results from the scenarios of population growth and climate change.

The Importance of Episodic Fluvial Particulate Carbon and Nitrogen Export Following Fire, Relative to Long-Term Fluxes

Katherine E. Condon, P.D. Brooks,
J.D. Pelletier [1], C. Orem[1], K. Lohse[2] and C. Rasmussen[3]

Department of Hydrology and Water Resources
The University of Arizona

Increased erosion following wildfire is well-documented, but less clear is how it affects local carbon and nitrogen budgets. This study investigates fluvial particulate carbon and nitrogen export within New Mexico's Valles Caldera following the 2011 Las Conchas wildfire. Research questions include: (1) How much carbon and nitrogen are fluvially eroded post-fire and retained further down? (2) How do these quantities compare to streamwater particulate export from unburned catchments? (3) What catchment characteristics are associated with greater particulate fluxes? Soil and litter samples were taken at two alluvial fans and three culverts below burned catchments and analyzed for bulk carbon and nitrogen and stable isotopes. Suspended particulate matter was collected at streams in three unburned catchments and analyzed for total mass, bulk carbon and nitrogen, and stable isotopes. Results indicate that litter and ash from burned slopes were re-deposited preferentially along the alluvial fans' outer edges. Total volumes of the fan deposits are approximately 5650 and 4630 m^3. Translocated litter and soil show a mean carbon content of 8.6 ± 2.7%, while finer ash deposits have lower carbon contents (mean = 1.9 ± 1.0%), and slightly but significantly lower $\delta^{13}C$ values. Total carbon and nitrogen flux estimates will also be presented.

[1]Department of Geosciences
[2]Department of Biological Sciences, Idaho State University, Pocatello, ID
[3]Department of Soil, Water, and Environmental Science

Hydrological Response of Semi-Arid Upland Catchments to Changes in Winter Precipitation

Xavier Zapata-Rios, Peter A. Troch, Jennifer McIntosh, Patrick Broxton, Adrian Harpold[1] and Paul Brooks

Department of Hydrology and Water Resources
The University of Arizona

In the mountains of the southwestern United States, the winter snowpack constitutes the main source of regional water supply. Recent studies have shown that the regional snowpack is declining in the southwestern US and drier conditions are predicted. Alterations in the timing and amounts of the snowpack will likely impact water quantity and quality. This study analyzes the hydrologic response of upland semi-arid catchments in northern New Mexico characterized by different terrain aspects over a period of 4 years (2008-2011). During this period runoff production in the catchments varied proportionally to changes in winter precipitation. The most contrasting years with snow pack accumulation were the wet year 2010 and the dry year 2011. Between these two years, there was a reduction in average SWE of about 57%, discharge volume decreased by 65% and storage in the catchments by 90%. There were also observed differences in the hydrological response between the catchments. The catchment with a predominantly north facing aspect had larger magnitude and less variable runoff, larger annual storage, and was more resilient to variable winter precipitation than the other two southeast facing catchments.

[1]Institute for Arctic and Alpine Research, University of Colorado, Boulder, USA

Poster Presentation Abstracts

Using Lidar and Distributed Snow Modeling to Understand Small-Scale Snow Variability

Patrick D. Broxton, Adrian Harpold,
Peter A. Troch and Paul D. Brooks

Department of Hydrology and Water Resources
The University of Arizona

Understanding snow variability in topographically complex, mixed conifer environments is important for estimating the timing and quantity of snow melt, which is of great interest to water managers. In this study, we use a model that we developed, called SnowPALM (Snow Physics and Lidar Mapping), to gain a process-understanding of what influences this variability. SnowPALM is an energy balance snow model that is parsimonious and computationally efficient enough to be able to make use of extensive very high resolution spatial data (1 meter), yet still retain representations of important physical processes involving snow. It has been tested at small (<1= sq. km.) study areas in the Jemez River Basin and the Boulder Creek Critical Zone Observatories using LIDAR estimated snow depths and in situ snow measurements of snow depth and snow density. These simulations allow us to infer which processes (e.g. those related to wind or energy) are influential at each site, as well as to hypothesize about how the interaction of snow processes gives rise to the observed snow distributions.

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[1]University of Arizona Institute for Arctic and Alpine Research, Boulder, CO 80303

Quantifying Mesoscale Soil Moisture with the Cosmic-Ray Rover

Bobby B. Chrisman and M. Zreda

Department of Hydrology and Water Resources
The University of Arizona

Soil moisture acts as a catalyst and a proxy for land-atmosphere interactions. It governs the mass and energy surface fluxes and is a major component in hydrologic predictions, such as flooding and drought. Common measurement techniques capture the soil moisture either at a point or over a large area many kilometers across. The mobile cosmic-ray probe, or cosmic-ray rover, used here is similar to the recently developed cosmic-ray soil-moisture probe, but bigger and mobile. In 2012, soil moisture was mapped 22 times in a 40 km x 25 km survey area of the Tucson Basin; that scale is comparable to a pixel from the Soil Moisture and Ocean Salinity (SMOS) satellite. The soil moisture distribution was observed to be dominantly a function of the climatic variation with the presence of a monsoon season; this resulted in a systematic change in the statistical structure as a function of the mean soil moisture. Two techniques are introduced to utilize the cosmic-ray rover data for hydrologic applications. (1) Interpolation of the 22 surveys into daily soil moisture product, with three sources of data: time series of soil moisture from a stationary COSMOS probe, soil moisture distribution maps from the rover, and local meteorological data. (2) Generation of soil moisture profiles by integrating surface moisture from satellite microwave sensors with deeper measurements from the cosmic-ray rover. The interpolated soil moisture values are within 0.02 m^3m^{-3} error of the rover surveys, result in 87% closure to the basin -wide mass balance, and allow for an improved large-area calculation of evapotranspiration and infiltration.

Hydrologic Structure: Inverse Geochemical Models and Catchment-scale Flowpaths in the Critical Zone, Jemez River Basin, New Mexico

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Direct measurements of water fluxes within high-elevation catchments are not ubiquitously available due to a variety of data collection limitations. More commonly collected measurements (e.g. hydrochemistry) may be used to infer unmeasured water fluxes, expanding our temporal and spatial knowledge of hydrologic flowpaths at the catchment scale. Chemical flux measurements and mineral weathering reactions are used to infer water fluxes in the Jemez River Basin (JRB) in the Valles Caldera, New Mexico. The complex felsic volcanic terrane of the JRB is primarily composed of two mineralogies; tuff and rhyolite. Mineral assemblages were used to define weathering reactions for use in an inverse geochemical reaction path model (IGRPM) to measure hydrochemical connectivity along the assumed vertical flowpath. Hydrochemistry shows higher (approximately three times more concentrated) Ca and K concentrations in rhyolite compared to tuff soil waters. Silica concentrations were similar in the soil waters (0.25 and 0.26 mmol L^{-1} for rhyolite and tuff, respectively), and higher in the groundwater (0.39 and 0.74 mmol L^{-1} for shallow and deep groundwaters, respectively). The IGRPM found hydrochemical disconnection through tuff, which correlates to absence of physical flow, which suggests dominant flowpaths through rhyolitic soils, or inadequate mineralogy of the tuff parent material.

Using Uranium-Series Isotopes to Trace Water Sources to Streamflow and Estimate Soil Formation Rates in a Semiarid Montane Catchment

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Understanding controls on chemical weathering and soil formation rates is important to understanding long term landscape evolution and sustainability of the Critical Zone, the dynamic region of earth's surface where bedrock, water, soil, and life chemically and physically interact to support ecosystems. The La Jara catchment (LJC), part of the Jemez–Santa Catalina Critical Zone Observatory located in New Mexico's Valles Caldera National Preserve, is well suited to study how aspect and lithology control chemical weathering rates. Here we focus on two hillslopes in a zero-order basin within LJC: One southeast-facing hillslope of predominantly tuff lithology and one southwest-facing hillslope of rhyolite lithology. This study uses uranium(U)-series isotopes to calculate soil formation rates and identify dominant controls on chemical and physical weathering processes. We hypothesize the southeast-facing hillslope receives less solar radiation, leading to cooler temperatures and less sublimation of snowpack, resulting in a larger volume of water input to soils and greater soil formation rates than the southwest-facing hillslope. This study also uses U-series isotopes to study modern hydrologic partitioning and trace source water contributions to streamflow seasonally along La Jara stream. We hypothesize that the longitudinal evolution of streamwater chemistry and U-series isotopes will show increasing influence from deeper flowpaths with distance downstream. Results for samples collected during snowmelt 2012 indicate a potential relationship between in-stream U-series composition and residence time. Additional analyses and modeling of soil and stream samples from LJC are in progress.

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Arsenite (III) Treatment of Prostate Cancer Cells Increases Hedgehog Signaling

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Chronic high arsenic in drinking water affects diseases of the urogenital system. We propose that a mechanism of arsenic toxicity is to act as a co-carcinogen in prostate cancer and promote more aggressive disease. In Northern Arizona, including the Colorado Plateau and Verde Valley, residents deal with groundwater sources containing high levels of arsenic; these deposits originate from geologic formations and past mining activities. We found that arsenite (As^{III}) treatment of a differentiated prostate cancer cell resulted in downregulation of the tumor suppressor *PTEN*. We measured Hedgehog activity by transfecting cells with a Gli-luciferase reporter plasmid. This reporter is activated by Gli1, Gli2, and Gli3, which are zinc finger transcription factors. Cells treated with 5μM As^{III} showed higher activity of Gli-luciferase, indicating increased Hedgehog signaling. Arsenite treated cells showed increased expression of *Patched1* and *Gli2* target genes. We propose that As^{III} activation of the Hedgehog pathway is through a novel non-canonical pathway where loss of PTEN results in the nuclear localization of Gli2. This work establishes research between cancer biology and hydrology. Relating the two fields allows for further research to link environment with public health.

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Arsenic Biomineralization and the Role of Sulfate in Landfill Settings

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Volcanic bedrock in Arizona groundwater systems naturally contains arsenic levels higher than EPA standards. Arsenic is a carcinogen that can cause skin legions and death if enough is consumed. Current EPA standards for arsenic disposal do not require any secondary remediation, and leave highly concentrated amounts of arsenic in landfills which are highly volatile environments. Research has shown that the reducing conditions in landfills allow arsenic to dissociate from iron and leach back into groundwater sources at higher concentrations than were previously found. The purpose of this research is to determine the role of biomineralization as a byproduct of sulfate-reducing and iron-reducing bacteria present in landfills, including those in Arizona. Two aqueous chromatography column experiments were set up, each containing set amounts of arsenic/iron sludge, glass beads, and anaerobic digester sludge from Ina Road Wastewater Treatment plant, and fed with a synthetic landfill leachate. Lactates were added to feed the bacteria. Sulfates were added in varying amounts. Determining the role of sulfate in the biomineralization processes is the purpose of this study. Results will be discussed in the poster presentation.

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Hydrologic Characterization of a Boreal Catchment with Modeling and Field Measurements of Active Layer Characteristics

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Hydrologic processes in boreal catchments are complex and poorly understood; furthermore, the properties of these catchments are greatly complicated by permafrost degradation. Hydrologic modeling and field studies at West Twin Creek – a permafrost-affected, experimental headwaters catchment in interior Alaska – have been undertaken to identify the dominant controls upon catchment hydrologic response. A surface water model for the catchment was developed using the Precipitation-Runoff Modeling System (PRMS) and calibrated to several years of streamflow data. Sensitivity analysis revealed that water partitioning in hillslope soils is predominantly controlled by physical characteristics of the soil active layer in the catchment. A suite of measurements was designed to better constrain the properties of the soil active layer at West Twin Creek during a period of maximum thaw depth. Gridded permafrost probing and soil coring were undertaken along several transects through hillslope and riparian areas. Ground-penetrating radar (GPR) surveys were conducted to complement these point measurements, providing spatially continuous information. Soil coring and GPR surveys revealed that soil profiles and frost table depths corresponded largely to surface vegetation. Artificial rainfall experiments at control plots representative of each soil profile type showed that water flow occurs predominantly at the interface between organic and mineral soil horizons.

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How Important are Atmospheric River Events for Flooding in Arizona?

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Atmospheric rivers (ARs) are long, narrow plumes of concentrated water vapor in the lower troposphere. They are considered to be the dominant flood-causing mechanism for the West Coast in the United States (Dettinger, 2011; Ralph et al, 2006). Much of the existing research on ARs has been on how they affect California and other Pacific Coast states in watershed flooding, water management, flood policy, and future risks associated with flooding. Until recently, there has been less research on the impacts, if any, that ARs have on landlocked regions such as Arizona. The latest studies have shown that ARs making landfall through southern corridors can affect landlocked regions of the western United States significantly and may be the cause of record floods in these regions.

This study analyzes the effects of atmospheric river events in Arizona in comparison to other common flood-causing mechanisms in the State. Using satellite imagery from SSMI.com, NCEP-NCAR Reanalysis composites, and flooding information for selected watersheds from the Arizona Flood Database[1], I studied composites and satellite images of known flood dates for the presence of an atmospheric river. The key feature for identification of an AR was a narrow band of atmospheric water vapor of at least 20 mm and ≤4 degrees of width in SSMI imagery. Flood days related to ARs typically occurred with an AR making landfall in the United States at approximately 30±10˚ N latitude. Preliminary findings show that atmospheric rivers affect a small fraction of Arizona floods, with variable frequency per year, and mostly in central Arizona. However, in some cases, an individual AR can cause multiple watersheds to flood and ARs have been responsible for some of the greatest floods recorded (e.g., March 1991, January-February 1993, January 2010).

Understanding Salinity Stress in Citrus

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As soils become more saline, crops will be put in highly saline environments and the development of new salt-tolerant genetic breeds of citrus will become increasingly valuable. Citrus is relatively sensitive to salt stress even when soils have sufficient water; this stress can affect plant-water relations and reduce growth and yield. For eight weeks the physiological responses and growth of 11 citrus varieties were observed and the level of salinity tolerance determined. Net gas exchange, whole plant transpiration, shoot and root growth, and stem water potential were monitored throughout the experiment. To determine the best performing seedlings, the percent reduction from control to salt-treated was calculated; seedlings with lower percentages had higher performing salt-treated varieties. Of all the hybrids only Variety 4 proved to be more salt tolerant than its parents, with only an 18 % reduction in total plant dry weight vs. 22 % in Cleopatra. There was also an 11 % reduction in water potential vs. 36 % in Cleopatra. Carrizo, Cleopatra, Shekwasha, and Variety 4 all demonstrated moderate salt tolerance and consistently ranked highest in growth and performance in response to salt treatment. Finally, photosynthesis was determined to be a good indicator of salinity tolerance.

Investigative Use of an Auto-Sampler to Determine the Water Quality of Secondary Treated Wastewater Delivered to a Constructed Recharge Site

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Secondary treated wastewater is currently being used as the primary water source for the Tucson Water Sweetwater Recharge Facility recharge basins. Historically, water quality delivered to the basins has been assumed to be constant throughout the day. Decreases in infiltration rates in recharge basins have been observed and are likely due to increased algal growth in the basins. Observations of algae blooms do not appear representative of discrete sample water quality data collected in the morning hours. This may be an indication that the water quality is changing throughout the day causing outputs of poorer water quality than previously sampled. This study consisted of 12 samples taken over a 24-hr period for four days as compared to the normal discrete sample taken at 8:00AM each day. Data for these four days of bi-hourly samples were compared to monthly values for the previous year. The bi-hourly auto-sampling data implies that the monthly sample data is not indicative of the daily averages over a 24hr period. In all four sampling periods, minimum concentrations of TKN occur between 8:00AM and 12:30PM. Nine of the eleven parameters had median values greater than the previous year's discrete sample median values. This suggests that monthly sample data is an underestimate for approximately 82% of the tested parameters.

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Generation and Extreme Value Analysis of Sub-Gaussian Random Fields and Processes Subordinated to tfBm or tfGn

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Many earth and environmental (as well as other) quantities vary randomly in space and/or time, possess distributions with heavy tails that sometimes decay with lag, and exhibit long-term correlations, linear or nonlinear power-law scaling in a midrange of lags, and breakdown in such power-law scaling at small and large lags. Most of these phenomena are captured upon viewing them as a mixture of sub-Gaussian random fields or processes subordination to truncated fractional Brownian motion (tfBm) and/ or truncated fractional Gaussian noise (tfGn). Our work addresses a key open question concerning the nature and scaling of corresponding extreme value statistics. In particular, we explore numerically the nature and scaling of real as well as synthetic data that behave in the above manner with focus on the statistics of block maxima and peaks over threshold, both of which are of fundamental concerns to hydrologists.

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Modeling the Sensitivity of a Semi-arid Aquifer to Seasonality and Quantity of Recharge and Evapotranspiration

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The Upper San Pedro River basin aquifer in Southern Arizona has been modeled using MODFLOW several times, most recently by Goode and Maddock (2000) and Pool and Dickinson (2006). It is the last free-flowing river in Arizona and its riparian area serves as habitat for migrating birds and several endangered species. The current model improves upon previous models by switching from the Stream Package to the Streamflow Routing Package, adding a third season to represent the summer monsoon, and thereby creating a seasonalized steady-state oscillatory model. Recharge was seasonalized using an isotope-ratio method (Ajami et al, 2011), and maximum evapotranspiration (ET) was seasonalized according to estimates of riparian groundwater consumption by vegetation in the study area (Scott et al., 2005). The model was run with inputs of 80%, 100% and 120% of base values for recharge and maximum ET rates. This was done in order to assess the sensitivity of river baseflow to the seasonal timing and quantity of recharge and ET. Annual river baseflow was found to increase by 5.8% with each 20% increase in recharge, and to decrease by 10.5% with each 20% increase in ET. The majority of baseflow, 47%, occurred during the wet winter season. 35% occurred during the dry summer, and 18% during the wet summer (monsoon) season, when maximum ET rates peaked. Adapting an older model to use new data and technology is valuable because it will improve model performance and provide better information to water resources decision-makers in the basin.

Examining the Relationship Between Redox Conditions and Methane Production in Coalbeds

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Coalbed methane (CBM) is an important source of low-carbon energy. Interest in microbial CBM has increased due to the possibility of stimulating methanogenesis. Yet, hydrogeochemical conditions and mechanisms for biodegradation of coal and microbial methane production are poorly understood. This study utilizes water and gas samples from monitoring wells near Tongue River, Montana. Wells were installed in a vertical section in multiple coal zones to investigate changes in redox conditions, water chemistry and isotopes, and gas composition and isotopes with depth. A second set of wells, located 100 meters away, was sampled to investigate spatial trends in chemistry at a small scale. Analysis of water chemistry shows a decrease in total dissolved solids with depth, corresponding to a decrease in concentration of all major cations and sulfate. This raises the question of whether the coal beds are hydrologically connected, and if so, what happens to the cations that are lost. In order to address this, data from this study was compared to other monitoring wells across the Powder River Basin to determine if trends observed were consistent across the basin. This data can help to better understand geochemical processes in CBM areas, potentially leading to sustainable stimulation of microbial methanogenesis.

Two- and Three-Dimensional Visualizations of Near-Surface Hydrostratigraphy along the Upper Santa Cruz River between Amado, AZ and the US-Mexico Border

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Over 42,000 people live in the Santa Cruz Active Management Area (AMA) with the population concentrated along the Santa Cruz River and in Nogales, Arizona. The main water source is the aquifer associated with the recent alluvium that underlies the Santa Cruz River. The extent and capacity of the aquifer are currently poorly understood. To help fill this gap in knowledge, a new hydrogeological cross-section was developed that parallels the River between Amado and the US-Mexico border. A cross-section and three-dimensional visualization were created using a combination of ArcGIS and spreadsheet analysis. Logs from 36 wells were compiled and re-classified into six categories: gravel, sand, silt, clay, bedrock, and volcanic rock. These were plotted longitudinally to analyze the hydrostratigraphy of the recent alluvium. Previous reports divided the hydrostratigraphic units into bedrock (including granite), older, and younger alluvium without presenting detailed information on the variation of material properties within these units. The results of this study will help to estimate the hydraulic conductivity and storage properties of the alluvium near the Santa Cruz River for input into coupled ground- and surface-water flow models, and will help clarify how surface water and groundwater interact, and how contaminants are transported in the basin.

Controls on Temporal and Spatial Variations of Nitrogen, Metals and DOC in a Semi-Arid Stream

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In rivers of the southwest stream-aquifer interactions are an important process controlling baseflow water presence and stream chemical composition during baseflow periods. In the San Pedro River, SO_4/Cl show that BGW contribution to streamflow increased with downstream distance and time since flooding, reaching a maximum contribution (50%) 8.4 months post-flood. This ratio also showed that the streamflow concentrations of DOC and potassium decreased consistently with increases in the BGW contribution to streamflow. However, streamflow's mean inorganic nitrogen (N) and calcium (Ca) concentrations initially decreased with increases BGW contribution but this trend reversed when the BGW contribution was highest. Other studies have shown that streambed nitrate concentrations at a gaining location were at least an order of magnitude higher than those in a losing location and that a nitrate enriched zone develops in the shallow streambed during flood recession. Overall, these results suggest that the source of N and Ca in streamflow shifts from terrestrial to aquatic as BGW contribution increases. We propose that the observed shift during late spring/early summer is the result of a decrease in river discharge relative to an increase in groundwater discharge coupled with high respiration and nitrification rates in the streambed and parafluvial zones.

Influence of Understory Greenness on Trace Gas and Energy Exchange in Forested Ecosystems

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Forested ecosystems are important sources and sinks of carbon, water, and energy¾affecting land surface-atmosphere interactions at multiple scales. Forests play a significant role in the global carbon cycle on account of the exchange of carbon between forests and the atmosphere and therefore are important in regulating global climate. For this reason, it is critical to gain an improved understanding of this land-atmosphere exchange and its phenological indicators. However, addressing this need is challenging in forested ecosystems because of their heterogeneity, both vertically and horizontally. In this study, we aim to address the contribution of the understory to ecosystem-scale carbon uptake by using three years (2010–2012) of eddy covariance and digital pheno-cam data from two similar subalpine mixed-conifer ecosystems within the Jemez River Basin–Santa Catalina Mountain Critical Zone Observatory (CZO). Here we present that daily NEE- and understory greenness (I_g), derived from RGB images, are generally synchronized, suggesting that the understory may substantially contribute to ecosystem-scale carbon flux. However, while remotely-sensed vegetation indices and understory I_g are synched at certain times throughout the study period, often they are not. This suggests that relying solely on remotely-sensed products may lead to a skewed estimate of carbon exchange by these ecosystems.

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Modeling the Gravity Response of Infiltration in a Vadose Zone from a Basin Into an Initially Drained Profile Followed by Drainage

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The artificial recharge basins at Southern Avra Valley Storage and Recovery Project (SAVSARP) are a valuable factor in securing Tucson's present and future potable water supply by preventing aquifer overdraft. Storage of Central Arizona Project (CAP) delivered water is efficacious in satisfying the 1980 Groundwater Management Act of Arizona. Gravity monitoring networks offer hydrologists the opportunity to measure the movement of water beneath artificial recharge facilities noninvasively. Gravity can be used to measure the amount of water mass added, as well as capture the correct 'shape' of the water distribution during infiltration and drainage. By interpreting continuously- recording, high-precision gravity data in the context of a flow model in the vadose zone, interpretations can be made about the change in subsurface water mass as well as the soil hydraulic properties. This research presents an innovative approach to conducting coupled hydrogeophysical inversion of time-lapse gravity data. The research will also show how the expected gravity response depends on the soil hydraulic properties for a recharge facility similar to those at SAVSARP.

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The Importance of Flood Heterogeneity for Flood Frequency Analysis in Arizona

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Reliable flood discharge estimates are needed to build safe and cost-effective bridges, delineate floodplains and compute flood insurance premiums. They are currently calculated using the 1982 US Water Resources Council flood frequency analysis guidelines in Bulletin 17b (B17b). Although revisions to these 30-year-old guidelines are underway, incorporating climatic information into flood frequency analysis can be statistically challenging in regions that have noticeable heterogeneity. Nevertheless, B17b encourages further exploration in states that exhibit such behavior. In Arizona flood processes are due to convective thunderstorms, tropical cyclone-enhanced convective activity, or synoptic-scale storms. To explore the influence of flood heterogeneity, US Geological Survey peak-flow records were compiled and classified according to meteorological cause. For selected stations, the three flood-causing populations were identified, separated from the systematic record and analyzed individually. Then, individual and standard B17b probability curves were generated and compared using their 1% and 0.5% annual exceedence probability estimates. Results show that sites in southern and central Arizona exhibit a better fit to the data by using their individual probability curves. Also, synoptic-scale and tropical cyclone-enhanced floods had the largest discharge estimates, especially in southern Arizona. Our analysis demonstrates that flood heterogeneity can impact regional flood frequency estimates in Arizona.

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