THE UNIVERSITY OF ARIZONA®
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Department of Hydrology
and Water Resources
Presents
The 22nd Annual

El Dia del Agua

March 28, 2012

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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 22nd 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-five research posters and two guest speakers. This symposium is an event ***for the students, by the students*** which facilitates direct feedback from fellow hydrologists. Throughout the years, university faculty and professional hydrologists have supported and attended EDDA. This tradition serves to strengthen the hydrology community, as well as to facilitate knowledge transfer between academia and the professional community. Furthermore, EDDA is a great place for prospective students to learn about the wide range of interesting research opportunities available to HWR students. The success of EDDA is possible thanks to the joint efforts of HWR faculty, administration, students, and sponsors. We are grateful to all of them for their time and generosity.

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

HWRSA Officers

HYDROLOGY & WATER RESOURCES STUDENT ASSOCIATION OFFICERS

From Left to Right

Jake Knight, Social Chair
Becky Witte , Vice President
Courtney Porter, Treasurer
Jeffrey Gawad, President
~
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 Jeffrey Gawad, 2011-2012 President, Hydrology and Water Resources Student Association

9:00-9:45 **Oral Presentations ~ Moderator Becky Witte,** 2011-2012 Vice President, Hydrology and Water Resources Student Association, and the 2011 El Dia del Agua Recipient of the Hargis Award for Poster Presentation

9:00-9:15, Biederman, Joel A. ~ *"The Fate of Mountain Snowpacks in Forested Catchments Infested by Mountain Pine Beetle"*

9:15-9:30, Nicholas, Hillary D**. ~** *"Estimating Infiltration Rates and Volumes Using Temperature and Electrical Resistance Methods for Intermittent Streams in the Semiarid Southwest"*

9:30-9:45, Kikuchi, Colin P. ~ *"Discrimination-Inference to Reduce Expected Cost Technique (DIRECT): A new method for improving measurement selection"*

9:45-11:00 Poster Session

11:00-11:45 **Oral Presentations ~ Moderator Joel Biederman,** 2011 El Dia del Agua Recipient of the Hydrology and Water Resources Award of Excellence for Poster Presentation

11:00-11:15, Casavant, Libby ~ *"The Effects of Increased Fertilizer Use on Nitrate Pollution in the Mississippi Watershed"*

11:15-11:30, Nearing, Grey ~ *"Estimating Thermal Inertia with a Maximum Entropy Boundary Condition"*

11:30-11:45, Pantano, Christopher ~ *"Hydrogeochemical Controls on Microbial Coalbed Methane Accumulations in the Williston Basin, North Dakota"*

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

El Dia del Agua ~ Program Schedule ~ Continued

12:00-1:30 Buffet Luncheon located in the South Ballroom

A Tribute to Nathan Buras, Professor and Past Department Head, by Regents Professor Shlomo Neuman.

Dr. Thomas Meixner, Associate Department Head, Associate Professor, Hydrology and Water Resources, and El Dia del Agua Chair ~ Introduction to Lunch Speaker, Seton Claggett, HWR Alum (MS '01), founder and owner of TriSports.com in Tucson, Arizona ~ *The Business of Hydrology: Forging a path to an environmentally sustainable business."*

1:30-2:00 Poster Session

2:00-2:45 **Oral Presentations ~ Moderator Ingo Heidbuechel,** 2010-2011 President, Hydrology and Water Resources Student Association, 2011 El Dia del Agua Recipient of the Hydrology and Water Resources Awards of Excellence for Oral Presentation, and the 2009 El Dia del Agua Recipient of the Montgomery Prize for Best Oral Presentation

2:00-2:15, Stielstra, Clare M. ~ *"Quantifying the Role of Hydrologic Variability in Soil Carbon Efflux"*

2:15-2:30, Broxton, Patrick D. ~ *"Improving Distributed Snow Modeling with LIDAR Data"*

2:30-2:45, Yu, Chunshui, ~ *"A Numerical Model for Turbulent Shallow—Water Flow over Arbitrary Topography"*

2:45-3:30 Poster Session

3:30-4:30 Dr. Larry Winter, Department Head and Professor, Hydrology and Water Resources ~ Introduction to Keynote Speaker, Dr. Walter Illman (PHD '99), Associate Professor, Department of Earth and Environmental Sciences, University of Waterloo, Canada. ~ *"Capturing Aquifer Heterogeneity: Accomplishments to Date and Challenges Ahead."*

4:30-5:30 Award Presentations ~ Refreshments & Appetizers
Montgomery Prize ~ By Elizabeth León Mora
Hargis Awards ~ By Leo Leonhart
HWR Awards ~ By Larry Winter
Donald R. Davis Award ~ By Thomas Meixner
Eugene S. Simpson Undergraduate Poster Award - By Thomas Meixner
Aqua-Person Award ~ By Jeffrey Gawad

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Becky Witte ~ Vice-President
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Jake Knight ~ Social Chair

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El Dia del Agua ~ Awards Evaluation Committee

Montgomery Prize
Best Oral Presentation
Certificate and Award of $2,000
Elizabeth León Mora ~ Deqiang Mao ~ Don W. Young

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
Certificate and Award of $400
Adrian Harpold ~ Graciela Schneier ~ David Vinson

Hydrology & Water Resources
Award of Excellence for Poster Presentation
Certificate and Award of $400
Michael Bradley ~ Kim Beisner
Tim Corley ~ Francina Dominguez
Matej Drucik ~Trenton Franz
Greg Leonard ~ Russ Scott

Donald R. Davis
Undergraduate with Distinction
Certificate and Award of $400
Thomas Meixner

Eugene S. Simpson
Undergraduate Poster Award
Certificate and Award of $400
Thomas Meixner

The Montgomery Prize

The Department of Hydrology and Water Resources would like to thank Errol L. Montgomery & Associates, Inc. for their support of the 22nd 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 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
- Contaminant assessment and remediation
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- Hydrologic monitoring
- Satellite image analysis
- Groundwater flow and solute transport modeling

The firm's principal office is located in Tucson, Arizona, and branch offices are maintained in Scottsdale, Arizona, 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 El Dia del Agua. This year, Dr. Leo Leonhart 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 hydrogeology and engineering consulting firm founded in Tucson in 1979. The firm specializes in consultations in water resources, environmental assessment and remediation, litigation support, and mining. Headquartered in San Diego, California, the firm also has offices in Tucson and Phoenix, Arizona.

Donald R. Davis
Undergraduate with Distinction Award

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

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

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

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

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

Eugene S. Simpson
Undergraduate Poster Award

Professor Eugene Simpsoaan 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.

El Dia Del Agua ~ Lunch Speaker

Seton Claggett, Founder and CEO, TriSports.com

"The Business of Hydrology: Forging a path to an environmentally sustainable business."

Seton Claggett came up with the idea of TriSports.com, not on the back of a napkin, but during a 120 mile bike ride while training for an Ironman triathlon. Combining his love of the sport with his interest in business, Claggett has developed one of the most successful triathlon stores in the world. While his background includes a BS & MS in Hydrology from the University of Arizona, he also earned a degree from the Entrepreneurship Program, giving him the resources he needed to successfully launch TriSports.com in April 2000. Over the last 13 years, Claggett has turned his idea into a multi-million dollar company, selling his wares to people in all 50 states and over 80 countries, spanning all 7 continents. What has really distinguished TriSports.com from the competitors that have sprung up through the years is TriSports.com focus on customer service, commitment to the sport and the environment. Online shopping is faceless and nameless, but the entire TriSports.com team strives to get to know their customers on a personal level and deliver service that is unparalleled in today's marketplace.

El Dia Del Agua ~ Keynote Speaker

Dr. Walter Illman, Associate Professor
Department of Earth and
Environmental Sciences
University of Waterloo

"Capturing aquifer heterogeneity:
Accomplishments to date
and challenges ahead"

Dr. Walter Illman is an Associate Professor of Hydrogeology at the University of Waterloo (UW) in Waterloo, Ontario, Canada. He is registered as a Professional Geologist in the Province of Ontario. Prior to his arrival at the UW, he taught and conducted research at the University of Iowa from 2001 - 2007.

His current research interests include field and laboratory investigations of subsurface heterogeneity in both porous and fractured geologic media, DNAPL source zone characterization and investigations of contaminant plume transport in heterogeneous media, unsaturated zone hydrology, and surface water/groundwater interaction. He is considered one of the pioneers in developing hydraulic tomography, a new subsurface characterization method to image heterogeneities of hydraulic conductivity and specific storage. Prof. Illman is the author of over 35 publications in peer-reviewed journals and is currently serving as an Associate Editor of *Water Resources Research*. Other notable published work includes a book on *Bioremediation and Natural Attenuation: Process Fundamentals and Mathematical Models*, published by John Wiley & Sons, Inc. of which he is a coauthor. He has been married to Carla (Frascari) Illman since 1999 and they have four children. His hobbies are exercising, flyfishing, and studying international economics/finance.

Oral Presentation Abstracts

The Fate of Mountain Snowpacks in Forested Catchments Infested by Mountain Pine Beetle

Joel A. Biederman, Paul D. Brooks and Adrian A. Harpold

Department of Hydrology and Water Resources
The University of Arizona

Snowpacks are a primary water source in western North America, where Mountain Pine Beetle (MPB) has caused extensive tree die-off. Vegetation influences how montane catchments partition snow, but impacts of large-scale mortality are poorly understood. We hypothesized that decreased interception leads to increased snowpack. We studied headwaters catchments of the Rocky Mountains with variable MPB infestation. Observations for two winters include continuous depth in 20 plots, snow surveys near peak accumulation (n = 8,000), water isotopes for fresh and evolved snow, and onsite meteorology. Interception decreased when comparing healthy forests to those dead for 3-4 years. However, distributed snow surveys found no difference in the snowpack remaining at winter's end. Sublimation modeling using water isotopes indicated 15% greater snowpack vaporization from MPB-infested catchments. This suggests increased sublimation from snowpack compensating for reduced canopy sublimation, attributed to diminished shelter from solar radiation and wind. In ongoing work, we follow the snowmelt pulse into the soil, where water isotopes in MPB-infested catchments indicate increased soil evaporation relative to healthy forest. Increased vaporization of both snowpack and soil water appear to compensate for reduced interception and transpiration. A first-order approximation is that annual catchment water inputs will be unaffected by MPB.

Estimating Infiltration Rates and Volumes Using Temperature and Electrical Resistance Methods for Intermittent Streams in the Semiarid Southwest

Hillary D. Nicholas and T. Meixner

Department of Hydrology and Water Resources
The University of Arizona

There is growing knowledge of the ecological importance of ephemeral streams and how variable flow affects arid environments. Our quantitative analysis explores how intermittent stream hydrology varies across geomorphic (mountain streams to desert washes) and climatic gradients (200 -400 mm Precipitation) in Southern Arizona. By investigating how frequently these streams experience flow and infiltration, it may be possible to predict how changing precipitation patterns will affect groundwater and ecological resources and resilience. Stream channels in Arizona were instrumented with vertical profiles of temperature sensors in the channel subsurface, and electrical resistance sensors on the bed surface. The ER sensors capture presence of flow while the temperature sensors provide a proxy for infiltration fluxes based on heat propagation. Using HYDRUS for unsaturated flow modeling, and identifying hydrologic, topographic, and climatic differences across each stream reach, it is possible to find linkages across a distinct gradient. The study has yielded annual flow frequency that varies from 8% to 88% of the year, and infiltrated flow volumes ranging from tens of thousands to millions of cubic meters per kilometer per year. The investigation is paired with vegetation analyses and entomological studies to better approach land management on Department of Defense properties.

Discrimination-Inference to Reduce Expected Cost Technique (DIRECT): A new method for improving measurement selection

Colin P. Kikuchi and Ty P.A. Ferré

Department of Hydrology and Water Resources
The University of Arizona

Hydrologic models are evaluated and refined based on their ability to explain available data. Optimization of model performance based upon mismatch between model predictions and real world observations has been studied extensively. There is often an inherent assumption that the model must be modified to match the data. However, model/data mismatch also depends on the selections of location, timing, type, and number of observations. Therefore, careful selection of hydrologic observations has the potential to significantly improve the representativeness of models and the accuracy of their predictions, with direct benefits to water resources management. In this research, we seek to improve model prediction accuracy through optimization of data collection. A new tool – Discrimination Inference to Reduce Expected Cost Technique (DIRECT) – was developed to address this challenge. In this approach, multiple hydrologic models are developed and treated as competing hypotheses. Potential new data are then evaluated on their ability to discriminate between competing hypotheses. This approach was applied in a solute transport problem to select optimal locations of sequential concentration measurements. In comparison with an exhaustive search of all possible observation sequences, DIRECT consistently selects observation sequences which lead to the greatest reduction in model prediction error.

The Effects of Increased Fertilizer Use On Nitrate Pollution in the Mississippi Watershed

Libby Casavant, Jerald Schnoor[1] and Emma Stapleton[1]

Department of Hydrology and Water Resources
The University of Arizona

Reduction of nitrate pollution in the Mississippi Watershed is essential to improving water quality and reducing the formation of a hypoxic zone (also known as a dead zone) in the Gulf of Mexico. Further concern about nitrate pollution has been caused by the speculation that increased food demands will bring about an increase in fertilizer use per hectare. This research seeks to examine a typical creek in southeastern Iowa called Clear Creek. By measuring the nitrate levels in this creek, the amount of nitrate leached throughout the Clear Creek watershed can be estimated. From this data, it is also possible to investigate the effect that increased fertilizer application will have on nitrate pollution. This prediction gives a worst–case-scenario of what may happen if farming practices are not altered in a way that will decrease the leaching of nitrates from fertilized soil to waterways. Preliminary results indicate that a ten percent increase in fertilizer application could result in an additional 3,600 kilograms of nitrate in the Clear Creek watershed during a single summer month.

[1]University of Iowa, Department of Environmental Engineering

Estimating Thermal Inertia with a Maximum Entropy Boundary Condition

Grey Nearing and Susan Moran[1]

Department of Hydrology and Water Resources
The University of Arizona

Thermal inertia, P [$Jm^{-2}s^{-1/2}K^{-1}$], is a physical soil property which determines soil surface resistance to temperature change. Thermal inertia varies with moisture content and can be used to estimate soil moisture. We estimate thermal inertia of the land surface using satellite measurements of surface temperature by modeling a 1-D soil heat flux column with a ground heat flux (G) boundary condition derived using a maximum entropy production (MEP) partitioning of net radiation (*Wang and Bras, 2011*)[2]. Adding a model of soil heat diffusion to the MEP partitioning reduces the number of free MEP parameters from two to one, and we suggest an appropriate parameterization for estimating P. The technique was demonstrated using both in situ and remote sensing data at the Walnut Gulch Experimental Watershed. We found good agreement between measured and estimated P values as well as good agreement between estimated P values and measured 5 cm soil moisture.

[1]Southwest Watershed Research Center; USDA-ARS

[2]Wang, J.F. & Bras, R.L. (2011). A model of evapotranspiration based on the theory of maximum entropy production. *Water Resources Research, 47.*

Hydrogeochemical Controls on Microbial Coalbed Methane Accumulations in the Williston Basin, North Dakota

Christopher P. Pantano and Jennifer C. McIntosh

Department of Hydrology and Water Resources
The University of Arizona

Coalbed methane (CBM) production is a rapidly growing industry worldwide. Extensive research has been conducted in numerous CBM basins; however, the Williston Basin (WB) remains largely unexamined due to the absence of natural gas production despite large coal reserves. Occurrences of shallow gas in North Dakota coalbeds have been reported, but there has been no systematic study of the gas origin and distribution, or hydrogeochemical controls on gas generation to date. This study aims to determine differences in water chemistry between groundwaters with and without the presence of CH_4 to gain better understanding on the potential environmental factors affecting microbial methanogenesis. Molecular and isotope chemistry of groundwater and dissolved gases reveal that shallow gas accumulations in WB coalbeds are microbial in origin and likely formed via CO_2 reduction. Results indicate that CH_4 is commonly associated with Na-HCO_3 type groundwater with SO_4 concentrations less than 1 mmole/L. Groundwater with these characteristics typically occurs in the deeper units of the Fort Union Formation, underlying multiple beds of coal, suggesting that CH_4 is present in waters having relatively long contact times with organic strata which have undergone extensive redox reactions and geochemical processes like sulfate reduction and cation exchange.

Quantifying the Role of Hydrologic Variability in Soil Carbon Efflux

Clare M. Stielstra, Paul D. Brooks and Jon Chorover[1]

Department of Hydrology and Water Resources
The University of Arizona

Soil carbon is the largest terrestrial carbon pool. While inputs to the soil carbon system via primary productivity are well constrained, soil C efflux remains poorly understood. The O/A horizon, typically rich in organic carbon, experiences extremes in wetting and drying, and previous studies have shown that soil carbon dynamics are critically linked to moisture availability. The goal of this study is to quantify the role of hydrologic variability in the mobilization of carbon as gaseous and dissolved fluxes from near-surface soils, and to determine how these fluxes relate to soil type, vegetation and climate. Observed values of DOC leachate, are low at all sites; however in contrast, CO_2 fluxes are large (from 0.22gC/m^2/d to 5.27gC/m^2/d) and vary with soil type and between years. There is a positive relationship between soil moisture and CO_2 efflux during the growing season when autotrophic respiration is likely to be high. During winter CO2 efflux from fine-grained soils displays a continuous, negative relationship with soil moisture while that from coarse soils exhibits a threshold response. Our results suggest that soil type controls soil moisture and together with vegetation regulates the response of soil CO_2 efflux to climate variability.

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

Improving Distributed Snow Modeling with LIDAR Data

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

Department of Hydrology & Water Resources
The University of Arizona

Snow modeling is an important tool for providing estimates of snow water equivalent (SWE), sublimation, and snow melt across a landscape. Such distributed estimates of snow are important for hydrologic studies involving snow-influenced environments and for people who rely on water supplies originating from snow. Many snow models accurately simulate the dynamics of snow accumulation and melt, though they often lack the ability to integrate state of the art landscape data and to accurately represent small scale snow dynamics. In this study, we have developed an energy-balance snow model system that is informed with LIDAR-derived estimates of vegetation canopy and topography information and evaluated with LIDAR-derived estimates of snow depth. These spatial data, which have a resolution of 1 meter, allow for the simulation (and evaluation) of small-scale snow dynamics in a topographically complex, mixed-conifer landscape, which is difficult for many operational snow models. The model has been evaluated in the Valles Caldera, NM and at Niwot Ridge, CO in areas that are instrumented with winter precipitation and SWE measurements. These efforts provide improved estimates of snow in these areas, and they demonstrate improvements from incorporating high resolution vegetation data into distributed snow models.

A Numerical Model for Turbulent Shallow-Water Flow over Arbitrary Topography

Chunshui Yu and Jennifer Duan[1]

Department of Hydrology and Water Resources
The University of Arizona

A two-dimensional numerical model is developed to simulate turbulent shallow-water flow. The model is based on two-dimensional depth-averaged Navier-Stokes equations. A second-order Godunov-type upwind finite volume scheme with HLL Riemann solver is implemented. The conservative variables near the edges of cells are linearly reconstructed by the MUSCL scheme. The reconstructions are based on the primitive variables. The time marching scheme is second-order TVD Runge-Kutta scheme which can prevent the occurrence of oscillation in every intermediate stage. The model uses first-order approximations for the wet-dry fronts and boundaries which make the solution as robust as possible. An additional flux is calculated to keep the scheme well-balanced. To provide body-fitted mesh, the Cartesian cut-cell method is adopted. The parabolic turbulence model is implemented which is more robust and more stable than k-epsilon model. The model is tested against several laboratory experiments and field measurements. In all test cases, the simulated results agree well with the observations.

[1]Department of Civil Engineering and Engineering Mechanics, The University of Arizona

Poster
Presentation
Abstracts

DIRECT: Discrimination-Inference to Reduce Expected Cost Technique A Multi-Model Example for Optimization of Data Collection and Determination of Alternative Concentration Limits at a Uranium Mine

Timothy W. Bayley, Paul A. Ferré, and Tim Leo[1]

Department of Hydrology and Water Resources
The University of Arizona

The Discrimination-Inference to Reduce Expected Cost Technique (DIRECT) is a new method that utilizes Monte Carlo style simulations to determine the value of additional data and reduce total cost. An example from a groundwater contamination site is presented. In the current example, 16 conceptually unique numerical finite difference flow and transport models were developed in MODFLOW. Each of the 16 models was run 1000 times sampling a distribution of property values for each parameter zone. Model results were weighted based on their likelihood and importance. Model likelihood was determined based on the RMSE of model results and collected data. Model importance was determined based on whether the models were likely to result in exceedances at site boundaries. These two factors were combined into a Data Discrimination Index (Kikuchi, et al. 2012). Data points that are most likely to discriminate between models were identified. Data will be collected in these locations. Probabilistic alternative concentration limits will be determined after re-weighting models based on new data.

[1]E.L. Montgomery and Associates, Tucson, Arizona

The Effects of Increased Fertilizer Use On Nitrate Pollution in the Mississippi Watershed

Libby Casavant, Jerald Schnoor[1] and Emma Stapleton[1]

Department of Hydrology and Water Resources
The University of Arizona

Reduction of nitrate pollution in the Mississippi Watershed is essential to improving water quality and reducing the formation of a hypoxic zone (also known as a dead zone) in the Gulf of Mexico. Further concern about nitrate pollution has been caused by the speculation that increased food demands will bring about an increase in fertilizer use per hectare. This research seeks to examine a typical creek in southeastern Iowa called Clear Creek. By measuring the nitrate levels in this creek, the amount of nitrate leached throughout the Clear Creek watershed can be estimated. From this data, it is also possible to investigate the effect that increased fertilizer application will have on nitrate pollution. This prediction gives a worst–case-scenario of what may happen if farming practices are not altered in a way that will decrease the leaching of nitrates from fertilized soil to waterways. Preliminary results indicate that a ten percent increase in fertilizer application could result in an additional 3,600 kilograms of nitrate in the Clear Creek watershed during a single summer month.

[1]University of Iowa, Department of Environmental Engineering

Quantifying the Erosion, Translocation and Deposition of Soil Organic Carbon Following Wildfire

Katherine E. Condon, P.D. Brooks, J. Chorover, J.D. Pelletier, C. Rasmussen, T. Meixner, and J. McIntosh

Department of Hydrology and Water Resources
The University of Arizona

Increased erosion following wildfire is well-documented, but less clear is how translocation of organic material affects local carbon budgets. Post-fire, soil organic matter (SOM) is preferentially eroded compared with inorganic materials, deposited and retained lower in the watershed, potentially sequestering organic carbon at depth. The recalcitrant nature of biochar, or "black carbon", suggests that this retained organic matter may affect the longer-term carbon cycle. Currently, we are investigating the translocation of organic carbon from nested catchments within the Valles Caldera National Park in northern New Mexico's Jemez River Basin following the 2011 Las Conchas fire. Preliminary research questions include: (1) How much organic carbon is eroding from burned slopes and depositing below in debris fans? (2) Do the characteristics of the deposited translocated carbon vary over vertical profiles, and can we identify specific runoff and depositional events? (3) How do the translocated carbon's characteristics compare with what is retained on burned slopes, or eroded from nearby unburned slopes? Samples were taken March 2012 and are being analyzed for water content, bulk density, total organic and inorganic carbon, total nitrogen, and black carbon percentage of organic carbon. The preliminary results and next steps for our research are reported here.

Predicting Regime Shifts in Flow of the Gunnison River Under Changing Climate Conditions

Gina DeRosa[1], W. Paul Miller[1] and Subhrendu Gangopadhyay[2]

Department of Hydrology and Water Resources
The University of Arizona

Streamflow projections by the U.S. Bureau of Reclamation (Reclamation) and other water management agencies are traditionally based upon historical streamflow records, and have assumed that past observations of streamflow are characteristic of future conditions. Under changing climate conditions, the assumption that past hydrology is representative of future conditions may no longer be valid. In this study, the distribution of changing regimes derived from paleo-reconstructions of streamflow is compared to the distribution of changing regimes from projections of future streamflow within the Gunnison River Basin (GRB). Paleo-reconstructions of streamflow indicate persistent dry and wet regimes that may impact water supply and management for Colorado River stakeholders and specifically Reclamation. The GRB contributes approximately 16% of the annual natural streamflow to the Upper Colorado River Basin. Current studies indicate that under projections of future climate, streamflow over the GRB may decrease on the order of 15% through the year 2099. In this study, past regime change characteristics over the GRB are compared to 112 projections of future regime change to better understand how the frequency and duration of persistent dry and wet periods may change as the impacts of climate change are realized over the GRB.

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Headwater storage capacity: links between water quantity, quality and climate change in alpine catchments

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The majority of water resources in the Southwest are derived from snowmelt. The quantity and quality of these resources from headwater catchments may be threatened by limited storage capacity which reduces the resiliency of these catchments in the face of directional climate change. Weathering processes dampen the variability of catchment water quality; the hydrochemical contribution from stored waters is relatively consistent compared to the deposition-dependent hydrochemistry of event water. Mineral weathering reactions contribute solute concentrations to waters that are representative of the storage reservoir material (e.g. talus, soil). A mass-balance inverse geochemical model was used to determine weathering reactions between input and output waters in two catchments (coastal and continental). This model was run for two years; one relatively wet and one relatively dry year at each catchment. Results show the coastal catchment response was hydrochemically similar for both years, indicating similar contribution from storage and hydrologic structure for both years. The continental catchment showed greater hydrochemical difference between input and output waters during the dry year, indicating a greater contribution from storage for that year relative to the wet year. The larger talus reservoir capacity in the continental catchment may be responsible for this difference.

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Tracking variations of catchment storage with stable water isotopes

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Hydrologic response functions (HRF) describe how fast a catchment responds to precipitation events. Transit time distributions (TTD) determine how long water spends in a catchment. HRF and TTD are more or less different from each other depending on how storage varies. We can reverse the logic and track storage in a catchment by determining how both HRF and TTD vary in time. The difference in the shape of the functions informs us whether water is being released from or added to storage. If a catchment reacts very fast to a precipitation event (short HRF) but particle response is delayed (long TTD), it means that a large fraction of the outflowing water is pre-event water released from storage. If a catchment reacts more slowly, then the shapes of the HRF and the TTD are more similar and a higher fraction of outflow is event water. The HRF can be determined by comparing water fluxes into and out of the catchment; the TTD is most easily measured by using stable water isotopes as tracers. We used isotope and water flux data from a small mountainous semi-arid catchment with high variability in total catchment storage to demonstrate that the method yields reasonable results.

Analysis of Chemical Weathering Rates as a Function of EEMT in the Critical Zone

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Climate change caused by anthropogenic release of CO_2 to the atmosphere is expected to impact development of the critical zone, the dynamic region of earth's surface where bedrock, water, soil, and life chemically and physically interact. Understanding how climate change will affect chemical weathering and soil formation rates is important to critical zone sustainability and control of soil erosion worldwide. The University of Arizona's Critical Zone Observatory has three sites in the Catalina Mountains of similar lithology and aspect, but varying Effective Energy and Mass Transfer (EEMT) values, a climate driven measure of the amount of energy available for weathering. These sites, Marshall Gulch, a high-elevation site with high EEMT values, Oracle Ridge, a mid-elevation site with moderate EEMT values, and Biosphere 2 Desert site, with low EEMT values, are well suited to study how climate affects chemical weathering rates. We hypothesize that sites with higher EEMT values will experience greater solute fluxes and chemical weathering and soil formation rates. In order to test this hypothesis I will use major ion chemistry and dissolved inorganic and organic carbon measurements of soilwaters and precipitation at each site as well as U-series isotope measurements in soil profiles at Marshall Gulch and Oracle Ridge.

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Automated Delaunay Triangulation of Stochastically Generated Discrete Fracture Networks

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Discrete Fracture Networks (DFN) models are important alternatives to continuum approximations to fluid flow and transport in fractured rock. Generation of high-quality meshes on stochastically generated DFNs is challenging because the resulting geometric features (fractures, fracture intersections, spaces between fracture intersections, etc.) that must be resolved typically span a wide range of spatial scales. Previous approaches to generating meshes on DFNs often deformed the DFN to align its features with a mesh through various techniques including redefining lines of intersection as stair step functions and distorting the edges of the fractures. Instead of distorting a stochastically generated DFN, we constrain the stochastic generation of the DFN to ensure that a high quality conforming Delaunay triangulation of reasonable size can be generated. The method is based on rejection; any stochastically generated fracture that would cause a measurable feature whose length is less than a specified minimum length scale is rejected. Details of this novel approach are provided and statistics of the resulting meshes analyzed. The computational tool FEHM is used to solve the flow equations and demonstrate the quality of the solutions resulting from computation on the mesh.

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COSMOS Neutron Data and Hydraulic Conductivity Determination

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Given the limitation of direct measurements, K is normally quantified at a point and is not representative of the large scale at which models typically operate. The objective of this research is to determine an unsaturated K value using Cosmic-ray Soil Moisture Observing System (COSMOS) probe data. The COSMOS probe gives average soil moisture for a circular area of approximately 660 m in diameter to a depth up to 0.5 m by evaluating the neutron counts from cosmic-ray interactions with soil moisture. An unsaturated K value will be calculated from neutron fluxes measured by the COSMOS probe at the San Pedro site in southern Arizona. This calculated value will be compared to several point saturated K estimates from around the footprint using a Reynold's Tank. In addition, experiments using the UMS HYPROP on undisturbed samples will be used to determine unsaturated K values and compare them to COSMOS estimates. From these experiments, we hope to be able to compare direct measurements of K at the point with area-average estimates using COSMOS. Depending on the accuracy of the results, COSMOS data may be used to estimate effective K values for the COSMOS footprint.

Litter Dam Evolution and Impact on Erosion of Recently Grazed Rangeland

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Erosion prevention is an important factor in long-term rangeland sustainability. Several parameters, including rainfall intensity and ground cover govern the erosion process. This research examines the effect of litter dams in the erosion process. Litter dams are bands of organic debris and plant litter oriented normal to the slope of a hillslope. As water flows down a slope containing litter dams, sediment is carried and trapped behind them. During rainfall simulations on two recently-grazed rangeland sites, an abundance of litter dams were observed. The two sites were analyzed, one dominated by warm season bunch grass and the other by sod grass. Using high-resolution digital photographs and spatial analysis through ArcGIS, properties of the litter dams were quantified and an estimate of sediment trapped behind the dams was calculated. The bunch grass site showed larger amounts of available litter and greater density of litter dams. Results indicate that a majority of the soil detached by raindrop impact or overland flow was deposited behind the litter dams for both sites. These results suggest that litter dams may be a significant factor in the erosion process on recently grazed rangeland or sites containing substantial amount of litter and organic debris.

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Intercalation of TCE by Sediment-Associated Clay Minerals and Implications for Low-Concentration Elution Tailing and Back Diffusion

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Pump-and-treat systems are used to remediate hazardous waste sites with TCE (trichlorethene)-contaminated groundwater. Removal of contaminant mass by pump and treat becomes less effective over time, with persistent mass discharge causing greatly extended operational periods. One mechanism potentially responsible for persistent mass discharge is "back diffusion", wherein dissolved contaminant stored in lower-permeability layers diffuses into higher-permeability zones that are more readily swept via pump and treat. Because lower-permeability layers typically contain high fractions of clay minerals, a question of great interest is whether contaminant-clay interactions influence back-diffusion. Intercalation of TCE into interlayer spaces of clay minerals could exacerbate diffusive mass-transfer limitations. The primary objectives of this research were to evaluate the long-term elution of TCE from aquifer sediments, and to examine the potential for TCE intercalation. Sediment samples were collected from TCE-contaminated field sites. Specimen clay controls were also used. Miscible-displacement experiments were conducted to characterize TCE elution behavior. X-ray diffraction, conducted with a controlled environment chamber, was used to characterize smectite interlayer d-spacing for three treatments (bulk dry sample, sample mixed with synthetic groundwater, sample mixed with TCE-saturated synthetic groundwater). Extensive elution tailing occurred during column experiments. XRD analysis indicated greater d-spacings for all samples treated with TCE-saturated synthetic groundwater.

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Estimating Energy and Greenhouse Gas Emissions Embedded in Metered Water at the University of Arizona

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The population here in Arizona and at the University of Arizona is growing, which translates to an increase in water demands. With the limited supply of the Tucson Basin, we have become dependent on the importation of water from the Colorado River via the Central Arizona Project (CAP). This water travels 300 miles east and 2000 feet up to get to us. The purpose of this project is to find the embedded carbon emission cost of water transport to and usage at the University of Arizona and how it has changed over the last 25 years as reclaimed water and CAP water were added in 1995 and 2001, respectively. Even though the annual volume of water used has remained fairly constant since 1987, an average of 1562.87 acre-feet/year, carbon emissions have been steadily increasing since 2002. Emissions changed 505.41 MT/year from 2000 to 2010, emitting the highest volume in 2010 of 3634.61 MT of CO_2. While fostering growth in Tucson is economically beneficial, we need to be conscious of the unseen negative effects on the atmosphere. These increases in carbon emissions represent increases across the entire Tucson metropolitan area, not just the UA.

[1]UA Office of Sustainability

Application of Biostimulation for Remediation of Sulfate-Contaminated Groundwater at a Mining Site

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There is growing concern regarding sulfate contamination of groundwater. One innovative in-situ remediation option under investigation is biostimulation through addition of electron-donor amendments to enhance sulfate reduction. Two pilot-scale ethanol-injection tests were conducted at a former uranium mining site that is contaminated with sulfate and nitrate, and for which there appears to be minimal natural attenuation of sulfate. The first test was a push-pull test and the second test was a single-well injection test. For both tests, sulfate concentrations began to decline within a few weeks of injection, after nitrate was consumed. Concurrently, aqueous concentrations of manganese, iron, and hydrogen sulfide increased from background. Monitoring over many months revealed that the declines in sulfate concentration conformed to exponential decay, with first-order decay rates of approximately 0.01 d^{-1}. Analysis of sulfur stable isotope data indicated that the decrease in sulfate concentrations was microbially mediated. The results also indicated that sulfides formed during sulfate reduction may have undergone partial re-oxidation. This study illustrates the feasibility of using ethanol injection for remediation of sulfate-contaminated groundwater. However, re-oxidation of sulfides (both metal sulfide precipitates and hydrogen sulfide gas) is a potential issue of significance that would need to be addressed.

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Extreme Value Analysis on Air Permeabilities Measured on a Block of Tuff

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Permeability of porous media and rocks is one of basic properties of geological formations. However, it is never easy to precisely characterize permeability of natural media. In order to describe it clearly, more investigations on permeability in various aspects are definitely needed. *Siena* et al. (2012) used three methods of moments to analyze multi-scale log air permeability data collected by *Tidwell and Wilson* (1997) on the faces of a laboratory-scale block of Topopah Spring tuff; the results verify power law scaling behaviors in these data. Here we utilize extreme value analysis tools to investigate the same data. Analysis of Variance (ANOVA) is used to identify sources of variance: block face, location, measurement support and so on. Three different models are used to explore the statistical characteristics of log permeability measurements: Generalized Extreme Value (GEV), Generalized Pareto Distribution (GPD) and Point Process (PP). The result implies that GEV fits the data nicely, but has large errors due to insufficient use of information; shape parameters of GEV are basically negative, suggesting Weibull distribution fits the data; GPD and PP characterize the data better.

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A Utility Metric for Data Assimilation Observing System Simulation Experiments

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We demonstrate an approach to estimating potential uncertainty reduction due to probabilistic data assimilation in an observing system simulation experiment presuming a nonlinear, non-Gaussian smoother. This allows for delineation between effects of improper filter or smoother assumptions and effects due to the model and observations. Currently there is no general method for quantifying the effects of filter assumptions, and this will be valuable for choosing an appropriate data assimilation strategy.

A nonlinear dynamical system simulator is formulated as a hidden Markov model and data assimilation is defined as a process of improving estimates of simulator state by Bayesian conditioning on indirect observations. Uncertainty is quantified as Shannon entropy and the Thiel index, which is the ratio of the mutual information between simulator states and observations to the state entropy, is the expected value of the reduction in state uncertainty. Since no filter or smoother performs perfectly in the general setting, the difference between the Thiel index and the actual reduction in uncertainty after filtering is due to filter assumptions. The Thiel index can be estimated from a simulator ensemble and the efficiency of any given filter or smoother can be estimated in a consistent manner to allow for direct comparison between assimilation approaches. The method is demonstrated on an agricultural productivity model.

Modeling the Impact of Climate and Population Change Scenarios in a Semi-arid Aquifer

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The Upper San Pedro River 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 native species. Understanding how the river will respond to future climate and population change is critical for the successful management of this resource. We improve upon previous models by adding a third season to represent the summer monsoon, changing the model domain to include only the basin fill to minimize error, and using newer MODFLOW packages such as SFR to more accurately model the riparian system. GMS was used to produce the initial MODFLOW files, which were then edited to modify the boundaries.

Once the new regional model was developed, we changed inputs to the model to observe the effects of changes in regional precipitation and temperature due to climate change, as well as changes in pumping for human use on the system. 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.

Determining solute inputs to soil and stream waters in a seasonally snow-covered mountain catchment in northern New Mexico using Ge/Si and $^{87}Sr/^{86}Sr$ ratios

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The “critical zone” is an open system where interacting biological, chemical, and physical processes contribute to long-term evolution of the Earth’s surface and the structure of life on Earth. Mineral weathering is an important process in the “critical zone”, which produces base cations that are essential nutrients to support the biotic foundation of ecosystems. This study investigates how changes in hydrologic conditions affect subsurface flowpaths, thereby altering weathering influences on stream chemistry in a seasonally snow-covered headwater catchment in the Jemez Mountains in northern New Mexico. Germanium/silicon ratios, Sr isotope ratios, major ions and dissolved carbon species are utilized to trace base cation cycling in the catchment. Major cations display chemostatic behavior despite fluctuations in the hydrograph implying that subsurface flowpaths are the dominant influence on streamwater composition. Major ion concentrations in streamwaters are most comparable to groundwater. Silicon, calcium, and sodium are prevalent in streams, consistent with plagioclase weathering. Low ion concentrations in precipitation and direct runoff would result in a dilution trend that is not observed. Therefore, solute fluxes are governed by equilibrium with primary and secondary minerals, and the rate at which solutes are transported by water out of the system.

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Modeling Agriculturally-Derived Groundwater Capture within the Tongue River Basin, Wyoming

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On May 2nd, 2011, the U.S. Supreme Court ruled in opposition to Montana's Bill of Complaint against Wyoming. In a 9-1 decision, the court ruled that Wyoming irrigators' practice of decreasing agricultural return flows by means of increased irrigation efficiency through switching from flood to sprinkler irrigation systems was not in violation of the agreed terms of the states' Yellowstone River Compact. However, if Wyoming irrigators' decreased return flows were proven to directly reduce the streamflow to the point that pre-1950 river allocations in Montana were compromised, Wyoming could be in direct violation of the conditions of the compact.

The Tongue River of northern Wyoming is arguably the most contentious tributary of the Yellowstone River and ongoing case. MODFLOW 2005 provided the means to create a 12 x 24 mile groundwater model domain that encompassed the majority of the watershed south of the Montana border. The model was used to simulate the return flows and river discharge that resulted from increased irrigation efficiencies. The model exhibited that increased irrigation efficiencies, coupled with a recent surge of groundwater pumping near the river, captured enough groundwater to decrease the river's baseflow to the point of possible compact violation.

Hydrologic indicators of the extent of coal biodegradation under different redox conditions and coal maturity

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Coalbed methane (CBM) is an important source of relatively low-carbon energy. Approximately 20% of the world's coalbed methane is microbial in origin. Interest in microbial CBM has increased recently due to the possibility of stimulating methanogenesis. Despite increasing interest, the hydrogeochemical conditions and mechanisms for biodegradation of coal and microbial methane production are poorly understood. This study utilizes water and gas samples collected from CBM wells, monitoring wells, and domestic water wells in the Williston Basin, ND, Powder River Basin, WY/MT (USA), and the Elk Valley Basin, BC (Canada). These three basins contain different thermal maturities (ranks) of coal. In order to explore redox processes related to methanogenesis and attempt to determine conditions under which methanogenesis is likely to occur, and the relationship between these processes and coal rank, samples were analyzed for major ion chemistry, trace metals, isotopes of water, methane and CO_2, and gas composition. Data were examined to understand differences between areas where methanogenesis occurs and areas of denitrification and sulfate reduction. A better understanding of geochemical processes in CBM areas may potentially lead to sustainable stimulation of microbial methanogenesis.

Water and Urban Sprawl in the Tucson Basin Region

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Eliza Benites and Graciela Schneier-Madanes

UMI 3157 CNRS / The University of Arizona
Partner University Fund Program

Water and urban development are a major challenge for sustainability in arid regions. Particularly urban sprawl results in significant pressure on water resources and water supply networks. How to tackle the ever growing need for water and relieve the pressure on resources? The poster presents the main findings of an international **state of art** on the subject, and the three axes selected to study **water and urban sprawl** interactions**: Water Resources and the Environment** (groundwater riparian areas, quantity and quality, imperviousness), **Infrastructure** (water supply, wastewater, reclaimed water) and **Governance** (conflicts, policies and regulations). The Tucson Basin, as part of the Arizona urban corridor, provides selected case studies.

In collaboration with The Office of Arid Lands Studies and The Pima County Regional Wastewater Reclamation Department.

Determining the Fate of Carbon Dioxide Injected Into a Coal-Bearing Formation, Gulf Coast Basin

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Coalbeds are one of the most promising reservoirs for geologic CO_2 sequestration, as CO_2 can strongly adsorb onto organic matter; however, little is known about the long-term fate of CO_2 sequestered in coal. This research investigates CO_2 sequestration in a sand located 854 meters (~2800 feet) below the surface, which is interbedded with coal. The "2800' formation" is an oil and gas-producing layer of the Paleocene-Eocene Wilcox Group of north-central Louisiana. It was flooded with CO_2 in the 1980s; $9.0x10^7$ m^3 remained in the sand following an enhanced oil recovery attempt. Additionally, coal in the Wilcox Formation has been shown to contain microorganisms that naturally convert CO_2 and hydrogen gas into CH_4. This study aims to determine the ultimate fate(s) of the remaining CO_2 (mineral trapping, dissolution, methanogenesis, absorption, and/or migration) by using isotopic and geochemical data from collected formation waters and gases. Using field-collected data and known isotopic fractionation factors, biogeochemical models were created to predict the changes in the isotopic values of carbon reservoirs (DIC, CO_2, CH_4) with the presence of injected CO_2. Initial results show injected CO_2 in 5 of the sampled wells, with the other 9 wells being isotopically similar to background levels (no introduced CO_2).

The Effect of Wildfire on Rangeland Sustainability in the San Rafael Valley

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Wildfire has a different effect on different landscapes, catastrophic in some cases, and positive in others. On the rangelands of southeastern Arizona, fire can be a desirable, natural occurrence. It has a positive effect on the sustainability of warm-season grassland in terms of rangeland health. The response and recovery from fire are different for areas vegetated by grasses or by woody shrubs. Understanding this difference can give further insight into land degradation and recovery. This study analyzes data collected from several plots at two different sites in the San Rafael valley in Southern Arizona. Plots were chosen to represent grass-dominated areas and shrub-dominated areas, in both recently burned and unburned conditions. Through the use of a rainfall simulator, the surface runoff and sediment yield from these plots have been quantified for several years following a fire. Analysis suggests that within four years of recovery, burned areas of both vegetation types showed positive changes to the sediment transport regime.

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An Empirical Model for Predicting Flow Permanence on the San Pedro River, Arizona

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In semi-arid river systems stream-aquifer interactions are an important process controlling the quality, quantity and permanence of streamflow. Since 1999, on the third Saturday in June (statistically the driest day of the year) a survey of flow permanence has been conducted along the San Pedro River National Conservation Area. During this survey the locations of wet and dry river sections have been recorded by volunteers spearheaded by The Nature Conservancy and the Bureau of Land Management. The data shows that there is a significant positive correlation between the river wetted-fraction, precipitation and streamflow. A model was created using a logistic regression approach and the following variables were found to be important in predicting the wet/dry status of a given stream location: depth to bedrock, flow accumulation area, channel sinuosity, average daily streamflow from September to March, surface curvature, flood plain width, and surface slope. Currently, the model correctly predicts 75-80% of the wet/dry locations in the river when 52.8% (31.5% wet and 21.3% dry) of its wet/dry status remained constant during calibration. This model will enable us to predict the presence, distribution and extent of surface water in the San Pedro River based on future climatic and hydrologic scenarios.

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Fluid Dynamics Modeling of Flow through a Bypass Pipe for Predicting Power Generated by a Micro-Turbine

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Using a micro-turbine, small amounts of power can be created from excess head in water pipe systems. Water loss monitoring systems can potentially be powered by electricity produced from a micro-turbine in a bypass placed in an existing water line. Modeling of water flow through a bypass from a 80 mm pipe was performed with the computational fluid dynamics software ANSYS-CFX to determine the possible power generated by a micro-turbine located in the bypass. The software was used to model several extensions of the bypass inlet and altered pipe geometries that would increase flow into the bypass, with a focus on those that could be installed by tapping. Modeling shows that adding a bypass with a micro-turbine by tapping to an existing 80 mm line would not produce power in excess of 100 mW. Power in the range of 800 mW can be produced if the main pipe between the bypass inlet and outlet is reduced to approximately 30 mm.

[1]University of the Federal Armed Forces Munich, Institute of Hydrosciences

Water Storage Dynamics in High Elevation Semi-Arid Catchments

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Catchments are complex systems that evolve as a result of the interaction between climate, biota and landscape. Water storage capacity is a particular catchment descriptor that can provide insight on the evolution of catchments and their hydrologic and biogeochemical processes. In the snow-dominated catchments draining Redondo Peak (3432m) within the Valles Caldera National Preserve, New Mexico, precipitation seeps through highly permeable volcanic soils. In this area, perennial streams are sustained by subsurface water contributions as overland flow is almost negligible. As part of the University of Arizona Critical Zone Observatory four small catchments (<3.5 Km^2) with similar bedrock and physical characteristics, but with main differences in aspect were instrumented for the determination of water fluxes and water chemistry. The main objective of this research is to understand the role of aspect on the temporal and spatial variability of storage dynamics in high elevation catchments. Data collected during the last four water years were analyzed using various methodologies: a water balance, a streamflow recession analysis, and tritium analysis of springs and streams. During the last four water years, annual precipitation ranged from 500mm to 680 mm. The water year 2008-2009 was the wettest and 2010-2011 the driest. Annual runoff ratios in the catchments (discharge/precipitation) varied from 0.07 to 0.25.

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