The University of Arizona
Department of
Hydrology & Atmospheric Sciences
Presents

El Día del Agua y la Atmósfera

March 27, 2017
Student Union Grand Ballroom

"The temple of granite amidst the meadow"
Alpine Junction, Wyoming
By Ryan Dennis

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Message from HASSA

On behalf of the Hydrology and Atmospheric Sciences Student Association (HASSA) at the University of Arizona, we would like to welcome you to our Annual Student Research Symposium, El Día del Agua y la Atmósfera, 2017. This joint symposium is the result of merging El Día del Agua, established by the Department of Hydrology & Water Resources Student Association (HWRSA) in 1990, and AIR, established by the graduate students from the Department of Atmospheric Sciences (ATMO) in 1999.

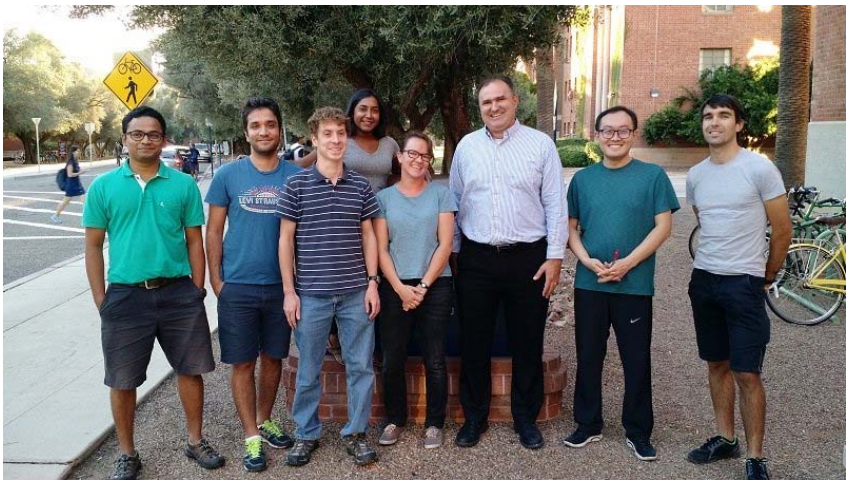
El Día del Agua y la Atmósfera (EDDAA) is one of five symposia to be held during EarthWeek 2017, a collaborative conference organized by the School of Earth and Environmental Sciences (SEES). EDDAA is organized and managed in part by students from the Department of Hydrology and Atmospheric Sciences (HAS) and is the perfect opportunity for them to present their current work. It provides students with the opportunity to meet and network with their peers, prospective students, faculty members, alumni, and working professionals from within the fields of hydrology, atmospheric sciences, and other related disciplines.

The success of El Día is made possible through the continued support of our sponsors, the efforts of HAS students, faculty, and staff members, the School of Earth and Environmental Sciences, and the University of Arizona College of Science.

We hope you enjoy the symposium and thank you very much for attending El Día del Agua y la Atmósfera, 2017.

HASSA Officers

HASSA Officers



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Tom Meixner, Faculty Advisor
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Back Row:
Mekha Pereira, Undergraduate Representative

El Día del Agua y la Atmósfera 2017 Schedule

8:00-9:00 Conference Registration, Breakfast and Opening

8:00-8:45 Registration and Breakfast

8:45-8:55 Opening and Welcome: Eric Betterton, Department Head, Hydrology & Atmospheric Sciences

8:55-9:00 HASSA President Welcome: Tirthankar Roy

9:00-10:00 Oral Session 1: Moderator: Victoria Hermosilla

9:00-9:15 Kilian Ashley: Deuterium as a quantitative tracer of enhanced microbial coalbed methane production

9:15-9:30 Furrukh Bashir: Explaining the Karakoram Anomaly

9:30-9:45 Colin Clark: Effective conductivity in highly heterogeneous composite media

9:45-10:00 Ravindra Dwivedi: Multi-tracer approach coupled with numerical models to characterize water sources and flowpaths contributing to streamflow in a high elevation mountain catchment

10:00-11:00 Poster Session 1: Poster Session—All Hydrology and Atmospheric Science Fields (Catalina Room)

Morning Refreshments: North Ballroom

11:00-12:00 Oral Session 2: Moderator: Alissa White

11:00-11:15 Yiyi Huang: The footprints of 16-year trends of Arctic springtime cloud and radiation properties on September sea-ice retreat

11:15-11:30 Tyler Kranz: Thunderstorm and terrain interactions over the Grand Canyon region

El Día del Agua y la Atmósfera 2017 Schedule (continued)

11:00-12:00 Oral Session 2: Continued

11:30-11:45 Tyler Rockhill: Investigating the relationship between hydrology and biogeochemistry in semi-arid urban green infrastructure

11:45–12:00 Rachel S. Tucci: Using isotopes and solute tracers to infer groundwater recharge and flow in the Cienega Creek Watershed, SE Arizona

12:00-1:00 Luncheon: Buffet Lunch in the South Ballroom

12:20-1:00 Luncheon Speaker Amber Sullins: "Houston, we have a problem..." It's the curse of knowledge: How we can more effectively communicate science to society

1:00-2:00 Poster Session 2: All Hydrology and Atmospheric Science Fields (Catalina Room)

2:00-3:00 Oral Session 3: Moderator: Mekha Pereira

2:00-2:15 Rodrigo Valdés-Pineda: Multi-ensemble and multi-model seasonal hydrological streamflow forecasting for the Upper Zambezi, Africa

2:15-2:30 Alissa White: Investigating hydrologic and environmental controls on uranium isotopes in a natural mountainous environment

2:30-2:45 Yu-Li Wang: Characterizing subsurface hydraulic heterogeneity of alluvial fan using riverstage fluctuations

2:45-3:00 Daile Zhang: Cross-validation Study of the U.S. National Lightning Detection Network and Lightning Imaging Sensor

El Día del Agua y la Atmósfera 2017 Schedule (continued)

3:00-4:00 **Round Table Session:** Students and scientist participate in roundtable discussions and provide summary of group findings. (Rincon Room)

Afternoon Refreshments: North Ballroom

4:00-5:00 **Keynote Speaker: A. Scott Denning:** "Simple, Serious, and Solvable: The Three S's of Climate Change" (North Ballroom)

5:00-5:30 **Presentation of Awards and Prizes:**
Montgomery Prize
Hargis Awards
HAS Best Oral and Best Poster Presentation
Donald R. Davis Undergraduate with Distinction
Eugene S. Simpson Best Undergraduate Poster
HAS Scholarship Awards
HAS Most Outstanding Instructor Awards, Aqua Person

6:00-8:00 **Post-Award Reception and Social** at No Anchovies, 870 E. University Boulevard, for all El Día attendees, students, faculty and visitors.

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Earthweek Plenary Session

Wednesday, March 29, 2017
Student Union North Ballroom
2:00-3:30 PM

Graduate Student Chloé Fandel
Representing the Department of
Hydrology & Atmospheric Sciences
with her talk from
2:00 - 2:15 pm

"Full STEAM ahead! Scientific illustration as an avenue for including art in STEM education"

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Awards and Prizes ~ Evaluation Committees

Students are recognized for their superior achievement in oral and poster presentations by juried committees. We are most grateful to the judges for volunteering their time and expertise in selecting award winners. Their energy, enthusiasm, and constructive feedback inspire us all to achieve our personal best.

Montgomery Prize

Best Oral Presentation ~ Certificate and Award of $2,000
Judges: Jon Whittier, Martha Whitaker, Austin Carey

Hargis Awards

Best Technical Presentation via Visual Communication
First Place Poster, Certificate and Award of $1,000
Second Place Poster, Certificate and Award of $400
Judges: Leo Leonhart, Dennis Scheall, Tim Corley

HAS Awards of Excellence

Best Oral and Poster (excluding Montgomery and Hargis winners)
Certificate and Award of $400 for each award
Oral Judges: Hsin-I Chang, William Holmgren, Dick Thompson
Poster Judges: Matej Drucik, Peter Hazenberg, Suzy Stillman, Yang Cao

Donald R. Davis Undergraduate Distinction Award

Outstanding Undergraduate Award (Academic or Research)
Certificate and Award of $400
Judges: James Washburne and Thomas Galarneau

Eugene S. Simpson Undergraduate Poster Award

Best Undergraduate Poster in Hydrogeology, Subsurface Hydrology, or Groundwater
Certificate and Award of $400
Judges: James Washburne and Thomas Galarneau

High School Student Poster Presenters

Certificates for Participation
Evaluators: Rachel Tucci and Rodrigo Valdés-Pineda

Aqua Person Awards

HAS Most Outstanding Instructor Awards
Judges: HAS Students

The Montgomery Prize

We would like to thank Errol L. Montgomery & Associates, Inc., a

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for their support. For many years, Montgomery & Associates has sponsored the premier cash award, *The Montgomery Prize*, for the Best Oral Presentation at our annual student research symposium.

This "best of the best" prize is made in addition to the departmental Awards of Excellence for best oral and best paper presentations and is presented to the winner by a representative from 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.

MONTGOMERY & ASSOCIATES
Water Resource Consultants

Errol L. Montgomery & Associates, Inc., founded by HWRS Alumnus Errol L. Montgomery, 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:

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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

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for their support. For many years, Hargis+Associates has sponsored two generous cash awards, The Hargis Awards, for the First and Second Place Best Poster Presentations at our annual student research symposium.

Evaluation of these awards is performed by a panel selected by HWR Alumnus Dr. David Hargis, President and CEO of Hargis+Associates, Inc., in San Diego, California. Hargis and his fellow HWRS Alumnus Dr. Leo Leonhart, Principal Hydrogeologist and Chief Technical Director, Hargis+Associates, Inc., in Tucson, annually present these awards. The Hargis Awards are made in recognition of the need for excellence in technical communication 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., established in 1979 by HWRS Alumnus David Hargis, is an environmental consulting firm specializing in hydrogeology and engineering. The company is headquartered in San Diego, California, and has 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.

Donald R. Davis
Undergraduate Distinction Award

Donald R. Davis joined the UA Department of Hydrology and Water Resources in 1972 and was one of the most senior members of the faculty at the time of his death in February 2009. 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.

During the last decade of his life, even though the halcyon days of funded research were behind him, Don was still actively engaged in independent statistical studies with individuals both inside and outside the university. He continued to serve on MS and PHD exams and to advise masters and especially doctoral students who were majoring or minoring in Hydrology with the statistical aspects of their research projects. He was an active faculty examiner for the doctoral qualifying examinations 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 Environmental Hydrology and Water Resources. He taught the year-long Senior Capstone and Senior Honors Thesis courses and, when the department was part of the College of Engineering, was a rotating instructor for the COE's freshman course, Engineering 102. 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.

Upon his death, he left an endowment to the Department of Hydrology and Water Resources specifically for undergraduates whom he especially supported and encouraged.

The evaluation for the Davis Undergraduate Distinction Award is made by a committee appointed by the department and recognizes an outstanding undergraduate who demonstrates excellence in writing, speaking, or technical communication or provides outstanding service through volunteerism or extracurricular activities that benefit the department or the profession.

Don will be remembered not only for his academic and advising contributions, but also for his love of the undergraduate program he nurtured.

Eugene S. Simpson Undergraduate Poster Award

Eugene S. 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 to pursue 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 HWR 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.

In March 2012, the inaugural Eugene S. Simpson Undergraduate Poster award was made for the best undergraduate poster with priority given to hydrogeology, subsurface hydrology, or groundwater content, Simpson's areas of expertise. Evaluation for the award is made by a committee appointed by the department.

The department would like to thank the family, friends, and former students of Eugene S. Simpson for their continued support and contributions to this endowment fund.

Hydrology & Atmospheric Sciences
Scholarship Awards
2016 - 2017

John W. Harshbarger Scholarship in Hydrology

John and Margaret Harshbarger established the Harshbarger Doctoral Fellowship in Hydrogeology, an annual stipend award made to recognize the most outstanding doctoral student studying hydrogeology in the department. John Harshbarger had high expectations for the Fellows, and they have met and exceeded that challenge. John W. Harshbarger was the original department head of the Department of Hydrology and Water Resources from 1966-1968. He earned his B.S. in Mining Engineering from Texas College of Mines (now the University of Texas-El Paso) in 1942. He then went on to earn an M.S. in 1948 and Ph.D. in 1949, both in Geology at the University of Arizona. Harshbarger, through a combination of vision, persuasiveness, and professional reputation, contributed significantly to the practice of groundwater hydrology in Arizona. To call him the original and founding father of Hydrology at the University of Arizona would be an accurate but highly incomplete description of his influence and importance to the institution. He served as a professional role model, mentor, teacher, colleague, and friend to students and faculty alike.

Sol D. Resnick Scholarship for Graduate Research Programs in Hydrology

Sol D. Resnick was a professor in the Department of Hydrology and Water Resources from its inception until his retirement in 1984; he was also the director of Arizona's Water Resources Research Center (WRRC) for nearly 20 years. He specialized in the areas of water resources conservation, augmentation, and management in arid and semi-arid areas, and worked to develop village irrigation projects in India, Brazil, Thailand, and Israel for the U.S. Agency for International Development (USAID), World Bank, and other agencies. Resnick's career in water resources began in the early 1940s with the Tennessee Valley Authority. In the late 1940s he taught hydrology at Colorado A & M (now Colorado State University). From 1952 to 1957, he worked for USAID in India, later chronicling his experiences in the book – "Irrigating India", a book coauthored with his wife, Elaine. He arrived at the UA in 1957. Colleagues and former students have consistently praised Resnick for both his sensible, practical approaches to hydrology problems worldwide, and his human qualities of sensitivity, warmth, and humor. Elaine M. Resnick established this scholarship in hydrology in memory of her late husband Sol D. Resnick.

Kisiel Fellowship for Graduate Research on Applications of Statistics in Hydrology

This endowed scholarship fund was established by the estate of Donald Ross Davis to reflect Don's nearly 40 years of service to Hydrology at the University of Arizona and to honor his colleague Chester Kisiel. The award recognizes a student's focus on the application of statistical methods in Hydrology. Kisiel was born in western Pennsylvania and worked at a steel mill to help his family make ends meet. After serving the Air Force during the Korean War he pursued his Bachelors, MS and PhD degrees at the University of Pittsburgh. In 1966 he joined the Hydrology program at the University of Arizona. Kisiel's research focused on the application of systems, statistical, and engineering methods to Hydrologic Science. At his untimely death on a handball court in 1973 he was a Full Professor in Hydrology and Water Resources and in Systems Engineering.

Donald R. Davis Undergraduate Scholarship

This endowed scholarship fund was established by the estate of Donald Ross Davis to reflect Don's nearly 40 years of service to the students in the Hydrology and Water Resources Department at the University of Arizona. Don obtained his PhD in Systems Engineering in 1969. He was hired as an assistant professor in Hydrology one year later. Don's research career focused on the use of Bayesian techniques to best reflect our state of knowledge about hydrological processes in surface and subsurface hydrology. In his teaching generations of graduate and undergraduate alumni of the department have Don to thank for a deep sense of the meaning of a "random variable" and how that influences the questions we can answer in hydrologic science and application. Don's research career in his later years mostly focused on helping graduate students with the use of statistical methods in their research. This bequest of Don's was made possible by Don's scrupulous frugality -- for example, he lived in the same studio apartment for 40 years raising his own rent payments whenever he received a raise from the University. Don never owned a house as doing so would be too risky since a house only exists in one place and instead he invested his surplus income in a diversified range of stocks and bond through an investment club he participated in. Beyond hydrology, Don loved trains, playing bridge, sailing and doting on his nieces and nephews. The award goes to undergraduates of excellence who also have financial need and unique life stories.

El Día del Agua y la Atmósfera
Luncheon Speaker
12:20 - 1:00 pm
Student Union South Ballroom

Amber Sullins
KNXV-TV ABC 15 News, Phoenix, Chief Meteorologist and HAS Advisory Board Member

Amber Sullins attended the University of Arizona and earned a Bachelor's of Science degree in Atmospheric Science with a double minor in Math and Journalism. Amber worked at the National Weather Service while attending the U of A and interned at KOLD-TV in Tucson. She started her television career at KVIA-TV in El Paso, Texas. Amber was honored with two back-to-back Texas Associated Press Broadcasters Awards there for Best Weathercasts in 2007 and 2008. She was also recognized again at the Texas Legislature for these awards in May of 2009 when a house resolution was passed in her honor.

"Houston, we have a problem…" It's the curse of knowledge: How we can more effectively communicate science to society

Scientists are generally good at communicating with each other, but perhaps not with everyone else. We often forget that most people don't know what we know. We make assumptions and use scientific terms they are not familiar with. So, in a time when mistrust of the scientific community is front and center, it is imperative we become better communicators to bridge the gap between "us" and "them" and influence change.

El Día del Agua y la Atmósfera
Keynote Lecturer
4:00 - 5:00 pm
Student Union North Ballroom

Dr. A. Scott Denning
Monfort Professor of
Atmospheric Science
Colorado State University

Scott Denning is Monfort Professor of Atmospheric Science at Colorado State University. He also serves as Director of Education and Diversity for CMMAP, the Center for Multiscale Modeling of Atmospheric Processes, working to enhance understanding of global climate. He is author of over 100 publications in the peer-reviewed climate literature, is a former editor of the Journal of Climate, and served for five years as founding Science Chair of the North American Carbon Program. He has served on advisory panels for NASA, NOAA, the US Department of Energy, and the National Science Foundation.

Denning leads a group of graduate students and scientists using many kinds of observations and models to understand the metabolism of the Earth's biosphere. A key contribution of their work is the identification and prediction of sources and sinks of carbon dioxide in the atmosphere using new satellite instruments. In addition to using global satellite imagery, he uses data from the woods of Wisconsin, the farms of Iowa, the Oklahoma prairie, the African Savanna, and the Amazon rainforest.

Denning takes special delight in discussing the subject of climate change with hostile audiences and has twice been a featured speaker at the Heartland Institute's annual conference.

See next page for Seminar Abstract.

"Simple, Serious, and Solvable: The Three S's of Climate Change"

Climate Change is Simple. Heat in minus heat out equals change of heat. When Earth absorbs more heat than it emits, the climate warms. When it emits more than it absorbs, the climate cools. This simple principal explains why day is warmer than night, summer is warmer than winter, and Miami is warmer than Minneapolis. It also explains why adding CO2 to the air causes global warming. The absorption of thermal infrared radiation by CO2 was first measured 150 years ago, has since been confirmed thousands of times by labs all over the world, and is extremely well understood. There is no doubt at all that adding CO2 reduces Earth's heat emission and therefore causes global warming.

Climate Change is Serious. Warmer average temperatures are associated with dramatic increases in the frequency of extremely hot weather. Warmer air evaporates more water from soils and vegetation, so even if precipitation doesn't change the demand for water will increase with warmer temperatures. Adding water vapor to the air also means there is more water available for heavy rains when the right conditions occur: this means that in addition to more drought, a warmer climate will include heavier rainfall during extreme events. Warmer ice sheets release more water the oceans, which also expand as they get warmer. These two influences raise sea levels, threatening coastlines everywhere. Higher seas imply much more frequent coastal flooding, requiring abandonment long before mean sea level reaches coastal infrastructure. Without strong policy, these impacts will become more and more severe almost without bound, growing to become the most serious problems in the world and lasting for many centuries after fossil fuels are abandoned. The consequences of unchecked climate change to the global economy are unacceptable.

Climate Change is Solvable. Preventing catastrophic climate change will require abundant and affordable energy to be made available to people everywhere without emitting any CO2 to the atmosphere. This will require both the development of energy efficient infrastructure and very rapid deployment of non-fossil fuel energy systems, especially in the developing world. From an engineering perspective, both objectives are eminently feasible with mature technologies. Economically, the clean energy transition will be expensive, involving roughly 1% of the global economy. This cost is comparable to previous development achievements such as indoor plumbing, rural electrification, the global internet, and mobile telecommunications. Our descendants will live better lives by developing and improving their infrastructure just as our ancestors did.

Round Table Session

Rincon Room from 3:00-3:45

The Departments of Hydrology and Atmospheric Science students will participate in a roundtable session related to communicating science to the public. There are no concurrent oral or poster sessions during this time so all HAS graduate and undergraduate students are encouraged to participate.

This year's roundtable will ask the broader question: "Do we, as scientists and future practitioners of science, need to do anything differently to communicate our knowledge of climate change to decision makers and the general public?"

Round Table Subtopics:

1. Should we be moving towards more applied sciences to better address society challenges? (Moderators: Chris Castro and Pieter Hazenberg)

2. Do we need to change the way scientists are educated (e.g., broaden, add more "soft skills" or social science)? (Moderators: Hoshin Gupta and Jen McIntosh)

3. To what extent do scientists need to be involved in decision making? (Moderator: Tom Meixner and Ty Ferré)

4. How much responsibility do scientists hold for increasing public understanding of scientific/environmental issues? (Moderators: Martha Whitaker and Brittany Ciancarelli)

Presentation by Round Table Group Leaders

Rincon Room 3:45-4:00

Groups will come together at the end of the session to discuss their conclusions and ideas for research in these areas. Representatives from each round table discussion will comment briefly on their group's findings.

ORAL PRESENTATIONS HAS STUDENTS

Deuterium as a quantitative tracer of enhanced microbial coalbed methane production

Kilian Ashley[1], Katie Davis[2], Anna Martini[3], Matthew Fields[2], Jennifer McIntosh[1]

[1]*Department of Hydrology and Atmospheric Sciences, The University of Arizona, Tucson, Arizona*

[2]*Center for Biofilm Engineering, Montana State University, Bozeman, Montana*

[3]*Department of Geology and Environmental Studies, Amherst College, Amherst, Massachusetts*

Microbial production of natural gas in subsurface organic-rich reservoirs (e.g. coal, shale, oil) can be enhanced by the introduction of limiting nutrients to stimulate microbial communities to generate "new" methane resources on human timescales. The few successful field experiments of Microbial Enhancement of Coalbed Methane (MECBM) relied on relatively qualitative approaches for estimating the amount of "new" methane produced during the stimulation process (i.e. extrapolation of pre-stimulation gas production curves). We have developed a tracer, initially in the laboratory, to more directly quantify the amount of "new" methane generated and the effectiveness of MECBM stimulation approaches.

Microorganisms, formation water, and coal were obtained during a previous drilling project in the Powder River Basin, Birney, Montana. We used these materials to set up a series of benchtop stimulation experiments where we added incremental amounts of deuterated water to triplicate sets of stimulated microbes (methanogens). We hypothesized that as MECBM progresses, methanogens will incorporate the heavy water into new methane produced, as methanogens naturally uptake hydrogen during methanogenesis to produce methane. The amount of hydrogen from water incorporated into methane is dependent on the methanogenic pathway (CO2 reduction vs. acetate fermentation). During the experiments, we saw a shift in the methanogenic pathway (i.e. more acetate fermentation), which was indicated by a consistent shift in the enrichment of deuterium in the methane produced. The enrichment of the methane as compared to the deuterium content of the water the microbes used followed a narrowly confined, statistically significant range of values. This predictable enrichment of the methane allows us to quantify the amount of methane produced, as we can compare the change in the overall deuterium content of the methane with the known value before the stimulation. The success of our proof-of-concept laboratory experiments suggests that deuterium may be used as a tracer of "new" natural gas resources in field- to commercial-scale MECBM projects. In addition, deuterium may also be useful in bioremediation projects (e.g. oil spills) or microbial enhanced oil recovery.

Explaining the Karakoram Anomaly

Furrukh Bashir

Department of Hydrology and Atmospheric Sciences,
The University of Arizona, Tucson, Arizona

The glaciers residing in the mountain ranges of the eastern Hindukush, western Karakoram and northwester Himalaya centered in Northern Pakistan are not responding to the global warming as their counterparts elsewhere. Their retreating trend is less than the global average, and in some cases, they are either stable or growing. This anomalous behavior is termed as 'The Karakoram Anomaly'. The role of climatic factors in the establishment of the Karakoram Anomaly is in question. Here we analyze climatic and novel synoptic observations for the last five decades reported from the meteorological observatory network of Pakistan. These data have not been available before. We find that over this period an increase in humidity, cloud cover, and precipitation and decrease in net-radiation, near-surface wind speed, potential evapotranspiration and river flow, especially in the summer season, are facilitating the anomalous behavior of the glaciers at regional scale. Our findings confirm the existence of the Karakoram Anomaly and show that it is a regional response to the changes in energy, mass and momentum due to the global warming. Moreover, gridded observed and reanalysis datasets that have been used to understand the hydroclimatology of the Karakoram glaciers do not reflect long-term observational trends.

Effective conductivity in highly heterogeneous composite media

Colin Clark[1], Larry Winter[2]

[1]*Department of Mathematics,*
The University of Arizona, Tucson, Arizona

[2]*Department of Hydrology and Atmospheric Sciences,*
The University of Arizona, Tucson, Arizona

We investigate the effect of percolation on the effective conductivity of highly heterogeneous, irregular, composite porous media. Composite media consists of different materials (e.g. sand and clay) that have been deposited by geologic processes into disjoint configurations where each material has a different hydraulic conductivity. The effective conductivity is a single parameter that represents the aggregate behavior of the conductivity field for the equation. When the values of conductivity vary by several orders of magnitude, the irregular geometry and topology of the configuration influences the flow and for volume fractions near the percolation threshold, the event of percolation marks a transition between two different regimes. We develop a phenomenological model to describe the effect of heterogeneity and volume fraction near the percolation threshold. We use probabilistic arguments to motivate the model and numerical simulation for validation.

Multi-tracer approach coupled with numerical models to characterize water sources and flowpaths contributing to streamflow in a high elevation mountain catchment

Ravindra Dwivedi[1], Paul A. "Ty" Ferré[1], Thomas Meixner[1], Jennifer McIntosh[1], Jon Chorover[2], G. -Y. Niu[1], Marisa M. Earll[3], Chloé Fandel[1], Alissa M. White[1], Nicole Weber[1]

[1]*Department of Hydrology and Atmospheric Sciences, The University of Arizona, Tucson, Arizona*

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Groundwater in fractured bedrock aquifers is the essential component of mountain-block recharge, which is considered as the principal source of water for adjacent alluvial basins (e.g., Tucson Basin). Montane groundwater systems also sustain ecosystems and biological activity in surface through spring discharges and they drive chemical weathering processes within the deep Critical Zone. Given the long time scales of storage and flow in groundwater systems, groundwater plays a critical role in climate change resiliency. Despite its significance, our ability to characterize deep groundwater systems is limited, especially fractured bedrock aquifer systems in mountainous regions, due to remoteness of such areas and their steep topography.

We combined a multi-tracer approach with numerical modeling to determine the sources, flowpaths, and transit times of water to an ephemeral stream in a high elevation catchment (Marshall Gulch) in the Santa Catalina Mountains, Tucson, AZ, where there are no deep monitoring wells. Our results, such as seasonal water balance analysis and tritium model ages, indicate that stream baseflow is mostly composed of soil water and contributions from perched aquifers. The deeper fractured bedrock aquifers contribute to streamflow only during wet conditions such as snowmelt. Furthermore, the stable water isotope values, chloride concentrations and TIMS model results indicate that transpiration is the dominant mechanism of evapotranspiration water loss. In this way, our results have implications for not only predicting vulnerability of mountain systems to climate change, but they also suggest a need to reexamine our standard streamwater sampling procedure for better characterizing contributions from groundwater in fractured bedrock groundwater.

The footprints of 16-year trends of Arctic springtime cloud and radiation properties on September sea-ice retreat

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The most prominent September Arctic sea-ice decline over the period of 2000-2015 occurs over the Siberian Sea, Laptev Sea, and Kara Sea. The satellite observed and retrieved sea-ice concentration (SIC) and cloud/radiation properties over the Arctic (70°-90°N) have been used to investigate the impact of springtime cloud and radiation properties on September SIC variation. Positive trends of cloud fractions, cloud water paths and surface downward longwave flux at the surface over the September sea-ice retreat areas are found over the period of March 1st to May 14th, while negative trends are found over the period of May 15th to June 28th. The spatial distributions of correlations between springtime cloud/radiation properties and September SIC have been calculated, indicating that increasing cloud fractions and downward longwave flux during springtime tend to enhance sea-ice melting due to strong cloud warming effects. Surface downward and upward shortwave fluxes play an important role from May to June when the onset of sea-ice melting occurs. The comparison between linearly detrended and non-detrended of each parameter indicates that significant impact of cloud and radiation properties on September sea-ice retreat occurs over the Chukchi/Beaufort Sea at interannual time-scale, especially over the period of March 31st to April 29th, while strongest climatological trends are found over the Laptev/ Siberian Sea.

Thunderstorm and terrain interactions over the Grand Canyon region

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Thunderstorms are common over the complex terrain of the southwest U.S. during the monsoon season (15 July – 30 September). In northern Arizona, these thunderstorms interact with the complex topographic features that make up the Grand Canyon region (defined here as 35.0 – 37.0° N and 111.0 – 114.0° W). This region is of interest because (i) thunderstorms move over terrain that features an abrupt drop in elevation over a short horizontal distance, and (ii) thunderstorms present a significant hazard to tourists that congregate near the rim of the canyon. Analysis of radar reflectivity imagery for 400 separate thunderstorm events suggests that approximately 90% of thunderstorms weaken as they move over the rim of the canyon and experience an abrupt drop in terrain elevation of 1000 – 1500 m over a horizontal distance of < 500 m. Observations from the National Lightning Detection Network (NLDN) reveal that the occurrence of cloud-to-ground (CG) lightning also decreases as these thunderstorms weaken over the canyon floor. This presentation aims to address the following science question: is lightning preferentially attaching to the canyon rims, or are thunderstorms dissipating over the canyon floor?

To address this question, we will focus on two geographic regions that are subsets of the Grand Canyon. The first domain ranges from 35.7 – 36.2° N and 112.2 – 111.5° W. This region captures the section of the canyon that separates the South Rim from the North Rim – the widest portion of the canyon (~15 km). The second domain spans most the Grand Canyon, ranging from 36.0 – 36.8° N and 112.0 – 113.5° W. Both domains are used to study the morphology of thunderstorms that traverse the Grand Canyon during the monsoon season by establishing a spatial radar climatology and a CG lightning climatology. The CG lightning climatology was created using all NLDN-detected CG stroke counts from the years 2000 – 2015 while the radar climatology used the 2006 - 2015 monsoon seasons.

Investigating the relationship between hydrology and biogeochemistry in semi-arid urban green infrastructure

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Disproportionate population growth and urbanization in semi-arid and arid regions has led to alterations in the water, carbon (C), and nitrogen (N) cycles (Gallo et al. 2014), prompting demands for mitigation strategies. Green Infrastructure (GI) is one of the methods used in urban storm water mitigation that delays and attenuates stormwater runoff by storing water in vegetated depressions. In the Southwest these depressions, also called bioswales, also have the potential to act as biogeochemical hot spots, encouraging nutrient cycling, infiltration, plant growth, and microbial activity (McClain et al. 2003). The influx of water to GI initiates a combined physical and microbial process that result in increased CO2 efflux and Nitrogen mineralization known as the Birch Effect. This study examines GI in Tucson, AZ through inducing an artificial precipitation regime and determining how soil properties, GI design, and biogeochemical characteristics influence the response. In natural systems it has been shown that soil moisture, soil properties, organic matter, length of dry period, nutrients such as Carbon and Nitrogen, and microbial biomass influence soil respiration and nitrogen mineralization [Wang et al. 2015, McClain et al. 2003, Gallo et a. 2014, McIntyre et al. 2009]. However, soils in manmade GI are inherently different, and the water chemistry, quantity, and sediment entering the GI are also developed differently than in a natural system. The purpose of this study is to examine the Birch effect in urban GI due to wetting in a similar manner as natural ephemeral streams. Additionally we seek to determine how soil and nutrient properties and precipitation regime affect the amplitude of the response. The results of this study lend insight into how GI functions in an urban stormwater setting, which can be used to influence the design characteristics and spatial distribution of GI. Specifically GI can be used to mitigate many of the issues associated with Urban Stream Syndrome (USS) such as flashier hydrography response, increased nutrient and contaminant concentrations, increased erosion, altered channel morphology and reduced biodiversity (Meyers et al. 2005). Knowledge about the nonlinear nature of biogeochemical hot spot reactions could be utilized to improve urban storm water quality and mitigate USS.

Using isotopes and solute tracers to infer groundwater recharge and flow in the Cienega Creek Watershed, SE Arizona

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Reaches of Cienega Creek and Davidson Canyon in the Cienega Creek Watershed (CCW) are registered as "Outstanding Arizona Waters," and wetlands in the Las Cienegas National Conservation Area support several threatened and endangered species. The lack of baseline hydrologic and water quality studies in the CCW leave important land management questions unanswered, such as how increases in urbanization, ranching, agriculture, or possible mining might impact groundwater resources. To help address these questions, this study investigates the hydrologic connection between recharge in the surrounding mountain blocks and basin groundwater, which is contained in alluvial and Cretaceous aquifers and wetlands (cienegas) in the central portion of the basin. Specifically, we aim to determine: (1) What are the flow paths, seasonality and elevation of groundwater recharge? (2) What is the residence time of groundwater across the basin? And (3) What is the source of water in the cienegas, and the possible influence of monsoon floodwater recharge?

Groundwater samples from domestic water supply and previous mining exploration wells, springs, and alluvial aquifers were collected along a broad transect from the Santa Rita Mountains eastward across the basin to Cienega Creek. Samples were analyzed for major ion chemistry, stable isotopes ($\delta^{18}O$, δD, $\delta^{13}C$, $\delta^{34}S$) and radioactive isotopes (3H, 14C). Initial results indicate springs and alluvial aquifers are dominantly sourced year-round from basin groundwater, and $\delta^{18}O$ values and sulfur to chloride ratio values indicate little infiltration of summer monsoon floodwaters. Most of the basin groundwater samples analyzed for tritium are below detection limit or lower than modern precipitation values for the region, and 14C values were low (3.33-77.09 pMC), which indicates recharge occurred prior to the 1950's. The low sulfate concentrations and $\delta^{34}S$ of basin groundwater, springs, and alluvial aquifers are typical of local rainwater values consistent with the lack of sulfate sources in basin sediments. The lack of recent recharge even in shallow alluvial aquifers beneath the washes and near Cienega Creek suggests that groundwater throughout the basin is a fossil resource, and that future increases in groundwater pumping may impact the cienegas.

Multi-ensemble and multi-model seasonal hydrological streamflow forecasting for the Upper Zambezi, Africa

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Seasonal Hydrological Streamflow Forecasting (SHSF) is a powerful tool aimed to provide information to water resources managers. SHSF incorporates information provided by coupled atmosphere-ocean-land general circulation models (CGCMs) into hydrologic models to produce seasonal daily streamflow forecasts. In this presentation we show the development and validation of a Multi-ensemble and Multi-model Seasonal Hydrological Streamflow Forecasting System for the Upper Zambezi River Basin (UZRB) in Africa. Three distributed hydrologic models: the HyMod model, the HBV model; the Variable Infiltration Capacity (VIC) model are used to generate SHSF for the UZRB (up to 180 days ahead). The SHSF for the UZRB are generated using seasonal forecasts of precipitation and temperature obtained from the North American Multi-Model Ensemble (NMME). To provide uncertainty levels of the forecasts, a sampling of the NMME ensembles is used. The streamflow forecasts are provided in a monthly basis to serve as decision support to improve water and food security, adaptive capacity, and sustainable development of water resources and services in the Zambezi River basin. The forecasts are available in a website-based platform developed as a collaborative effort between the SERVIR Water Africa-Arizona Team (SWAAT) and the SERVIR Program of NASA and USAID.

Investigating hydrologic and environmental controls on uranium isotopes in a natural mountainous environment

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Hydrologic processes in snowmelt-dominated regions of the semi-arid mountainous west are not well understood, yet those regions rely most heavily on mountain recharge for water. In the Jemez River Basin Critical Zone Observatory (JRB-CZO) in a remote NM headwater catchment within the Valles Caldera National Preserve, water isotopes and solute chemistry have shown that snowmelt infiltrates and is stored before later discharging into springs and streams via subsurface flowpaths that change seasonally. Therefore, water transit times (WTT) and water-rock interactions are expected to also change seasonally as hydrologic flowpaths vary. Uranium-series isotopes have recently been shown to be a novel tracer of water-rock reactions and source water contributions; therefore, this study seeks to understand how uranium isotope signatures evolve along different water flowpaths. More specifically, this work examines the relationship between seasonality, WTT, and U-series isotopes in several catchments within the JRB-CZO.

In order to determine the effect of WTT on the U isotopic composition of natural waters within the Valles Caldera, samples from ten springs, for which WTT are already known from tritium analysis, were collected during the dry seasons of 2015 and 2016 and analyzed for U and strontium isotopes. Preliminary results do not suggest that WTT can fully explain the variability of U (1.60 to 3.09) and Sr (0.70704 to 0.70817) isotope composition in springs throughout the JRB-CZO. Water samples were also collected from streams within three catchments across three water years to establish how seasonality controls water's isotopic composition. U (1.97 to 2.06) and Sr (0.70737 to 0.70844) isotope values vary through changing seasons; however, those changes are not constant between catchments suggesting that differences in the mineralogy and structure of the deep Critical Zone likely also control isotopic variability. Ongoing work investigating the distribution of U-series isotopes in solid phase core samples with depth beneath the surface will be vital for the characterization of hydrogeologic controls on isotopic composition in this complex lithologic terrain. Understanding the controlling factors of U-series isotope variations in natural waters largely devoid of human interaction in the JRB-CZO will provide an important natural baseline for future U isotope studies and geochemical modeling efforts in geologically complex mountainous regions.

Characterizing subsurface hydraulic heterogeneity of alluvial fan using riverstage fluctuations

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The objective of this study is to demonstrate the ability of riverstage tomography to estimate 2-D spatial distribution of hydraulic diffusivity (D) of Zhuoshui River alluvial fan, Taiwan, using groundwater level data from 65 wells and stream stage data from 5 gauging stations. In order to accomplish this objective, wavelet analysis is first conducted to investigate the temporal characteristics of groundwater level, precipitation, and stream stage. The results of the analysis show that variations of groundwater level and stream stage are highly correlated over seasonal and annual periods while that between precipitation is less significant. Subsequently, spatial cross-correlation between seasonal variations of groundwater level and riverstage data is analyzed. We found that the correlation contour map reflects the pattern of sediment distribution of the fan. This finding is further substantiated by the cross-correlation analysis using both noisy and noise-free groundwater and riverstage data of a synthetic aquifer, where aquifer heterogeneity is known exactly. The ability of riverstage tomography is then tested with these synthetic data sets to estimate D distribution. Finally, the riverstage tomography is applied to the alluvial fan. The results of the application reveal that the apex and southeast regions of the alluvial fan are areas with relatively high D and the D values gradually decrease toward the shoreline of the fan. In addition, D at northern region of the alluvial fan is slightly larger than that at southern. These findings are consistent with the geologic evolution of this alluvial fan.

"Evaluation Study of the Lightning Imaging Sensor on-board the TRMM Satellite"

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Lightning has been observed by a ground-based network called the National Lightning Detection Network (NLDN) that was developed over three decades ago within the ATMO Dept. at the University of Arizona. This network, based on electromagnetic wave discrimination in the very low frequency band, has been carefully calibrated and is used in a wide variety of applications across the United States. NASA's satellite-based optical Lightning Imaging Sensor (LIS) detects lightning in different ways than the NLDN. Comparison of the two sensors requires matching in time and space so that future mapping of lightning from satellites can benefit from past ground- and satellite-based sensors.

In this study, a cross-validation between the NLDN and LIS was examined. The main results show that in time, the LIS discharges were normally reported about 2 ms later than the correlated NLDN discharges. A spatial matching found a roughly 5-km location shift/offset of the LIS-reported discharges relative to the correlated NLDN discharges, which is due to the regular TRMM satellite yaw maneuvers.

A further examination of the LIS-reported illumination areas of the optical signals from lightning discharges were conducted within the NLDN detection domain. It shows that those discharges with large illumination areas have a preference of being positively charged. Positive charges typically are more intense and damaging if they touch the ground than their negative counterparts.

In addition, initial comparison with the ground-based lightning mapping systems indicates that the satellite observations can spatially map horizontally extensive lightning flashes that occur frequently in mature storms, and reflect very large regions of moisture transport into the upper troposphere.

POSTER PRESENTATIONS
HAS STUDENTS

Urban bioswale characterization and design evaluation

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As bioswales become increasingly prevalent in urban settings there is increasing demand to measure their hydrologic and soil properties for large scale modeling and estimation of runoff sequestration. Many studies have been conducted to determine the effectiveness of these bioswales at filtering and trapping pollutants and large particles, but these experiments have been applied to a limited number of basins with little spatial or temporal distribution. By looking at a wide variety of bioswales, with considerable differences in age and location, a classification scheme for semi-arid bioswales can be developed to enable future research efforts to bypass the time-consuming process of sample collection and analysis. After analyzing a variety of geophysical and hydraulic properties, a method for estimating key parameters (such as infiltration rate) has proven to be effective and is a tool that could give urban planners a better idea of what bioswale designs will best match their runoff sequestration and neighborhood aesthetic needs.

Addressing "The Karakoram Anomaly" through in-situ observations and reanalysis datasets

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The glaciers residing in the mountain ranges of the eastern Hindukush, western Karakoram and northwestern Himalaya centered in Northern Pakistan are not responding to the global warming as their counterparts elsewhere. Their retreating trend is less than the global average, and in some cases, they are either stable or growing. This anomalous behavior is termed as 'The Karakoram Anomaly'. The role of climatic factors in the establishment of the Karakoram Anomaly is in question. Here we analyze climatic and novel synoptic observations for the last five decades reported from the meteorological observatory network of Pakistan. These data have not been available before. We find that over this period an increase in humidity, cloud cover, and precipitation and decrease in net-radiation, near-surface wind speed, potential evapotranspiration and river flow, especially in the summer season, are facilitating the anomalous behavior of the glaciers at regional scale. Our findings confirm the existence of the Karakoram Anomaly and show that it is a regional response to the changes in energy, mass, and momentum due to the global warming. Moreover, gridded observed and reanalysis datasets that have been used to understand the hydroclimatology of the Karakoram glaciers do not reflect long-term observational trends.

Catchment-scale groundwater recharge and vegetation water use efficiency

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It is often difficult, if not impossible, to predict groundwater recharge at the catchment scale, but such estimates often require the use of complex numerical groundwater models whose results can be biased due to large uncertainty in model parameters at the large scale. Here we present an alternative and a much simpler method for estimating large-scale groundwater recharge for gauged and ungauged catchments, assuming that long-term median (50th percentile) streamflow can be used to approximate groundwater recharge. We employed catchment-scale water balance & baseflow separation methods for estimating maximum total and deep storages from water years 1980-2002 for 247 Model Parameter Estimation Experiment (MOPEX) catchments across the conterminous USA. We then compute a vegetation water use efficiency metric, the Horton index (HI; the ratio of catchment-scale vaporization to wetting) for the same dataset. Our results show that the HI is strongly (negatively) correlated (R^2=0.77) to deep storage and to the 50th percentile flow in the flow duration curve so that it can be used for estimating long-term groundwater recharge at the catchment scale. Furthermore, we found that our HI-based groundwater recharge estimates are similar to the groundwater recharge map published by the USGS (R^2=0.69) for the conterminous USA. Finally, our method suggests that the vegetation water use efficiency is a sound predictor for groundwater recharge in gauges and ungauged catchments located across different climates.

Evaluation of Greenland near surface air temperature datasets

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Near-surface air temperature (SAT) over Greenland has important effects on mass balance of the ice sheet, but it is unclear which SAT datasets are reliable in the region. Here extensive in-situ SAT measurements (~ 1400 station-years) are used to assess monthly mean SAT from seven global reanalysis datasets, four gridded SAT analyses, one satellite retrieval and two dynamically downscaled reanalyses. Strengths and weaknesses of these products are identified, and their biases are found to vary by season and glaciological regime. MERRA2 reanalysis overall performs best with mean absolute error less than 2 degrees Celsius in all months. Ice sheet-average annual mean SAT from different datasets are highly correlated in recent decades, but their 1901–2000 trends differ even in sign. Compared with the MERRA2 climatology combined with gridded SAT analysis anomalies, thirty-one earth system model historical runs from the CMIP5 archive reach ~5 ℃ for the 1901–2000 average bias and have opposite trends for a number of sub-periods.

Using water isotopes and SO_4/Cl Ratios to Investigate the hydrology of wetlands in the Las Cienegas

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Wetlands are surface water systems that support diverse habitats which are frequently integral parts of regional ecosystems. Analysis of water stable isotopes and solute chemistry can reveal the nature and seasonality of the hydrologic connection between wetlands and basin groundwater. This research uses water stable isotopes and sulfate to chloride ratios to investigate the seasonal sources of water and degree of evaporation in wetland complexes (cienegas) and associated surface- and ground-water within the Las Cienegas National Conservation Area (LCNCA) in Southern Arizona. Surface water, springs, and shallow groundwater from piezometers within the multiple cienegas in the LCNCA were sampled seasonally and analyzed. Preliminary results suggest the main source of shallow groundwater and wetlands in the LCNCA is basin groundwater, with little ephemeral input from either direct winter or summer precipitation. There is little evidence of seasonal changes in water source, indicating that basin groundwater sustains these ecosystems year-round. Their apparent reliance on basin groundwater implies that the cienegas may be impacted by increased groundwater pumping. This insight, as well as the baseline hydrologic data that this research provides, will aid research efforts and help inform future LCNCA management decisions.

Interdisciplinary dialogue to assess coupled natural and human systems

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This study reviews socioecological linkages found in coupled natural and human systems of urban water governance. Coupled natural and human systems (CNH) are systems in which human and natural components are intertwined. Urban areas, in particular, are natural laboratories for CNH systems, and can be used to assess a number of issues such as the impact of stormwater infrastructure upon hydrological functioning. A study of CNH systems can unveil dynamic interactions between social components such as local governance and natural components such as hydrological responses to intense rainfall, in order to assess the impact of green infrastructure (GI) installation in urban areas. Evidence from these assessments informs policy and governance decisions designed to enhance sustainability, and can be adapted to suit the needs of various urban settings.

Coupling within CNH systems also takes place across nested scales, ranging from the sub-lot scale to the regional and global scale (Liu et al., 2007). Understanding hydrologic functioning at the lot scale through the watershed and regional scale is of particular importance when developing models to inform policy makers and community groups. Relevant stakeholders at local, regional, and state levels can use this knowledge to coordinate and address ecosystem challenges spanning jurisdictional boundaries. Furthermore, policies and strategies informed by scientific evidence can benefits economic and social structures included in natural resource management.

Temporal dynamics of source water contributions to evapotranspiration from sky island ecosystems with ephemeral snow pack: A case study using *Pseudotsuga menziesii* (Douglas Fir)

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In the water-limited desert southwest, ephemeral snow pack in sky island ecosystems is a primary water resource to communities lower in the watershed. Because evapotranspiration (ET) is the largest component of the water budget in these regions, changes in ET will have major downstream implications. Climate scientists predict more intense and less frequent precipitation events in the southwestern US, which will alter the soil-plant-atmosphere continuum. Understanding how water currently moves within that continuum is imperative in preparing for these predicted changes. Currently, information is lacking on (1) where trees retrieve water and 2) whether that source varies with season. We hypothesize that trees in sky island ecosystems use deep moisture during the snowmelt season and shallow moisture during the summer monsoon season. We present a preliminary analysis of two years of water stable isotope ($\delta^{18}O$ and δD) data from the Santa Catalina Mountains CZO. We highlight the probable source waters for Douglas Fir and how they vary throughout the year. A shift in precipitation could alter the source water of these trees such that they may become increasingly water stressed which will have important consequences for water resources in this region if they are unable to continue to thrive.

Enhancing the NOAA National Water Center WRF-Hydro model architecture to improve representation of the Midwest and Southwest CONUS climate regions

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The NOAA National Water Model (NWM), which is based on the WRF-Hydro architecture, became operational in the summer of 2016 to produce streamflow forecasts nationwide. In order to improve the physical process representation of NWM/WRF-Hydro, a parameterized channel infiltration function is added to the Muskingum-Cunge channel routing scheme. Representation of transmission losses along streams was previously not supported by WRF-Hydro, even though most channels in the southwest CONUS have a high depth to groundwater, and are consequently a source for recharge throughout the region. The LSM, routing grid, baseflow bucket model, and channel parameters of the modified version of NWM/WRF-Hydro are calibrated using spatial regularization in selected basins in the Southwest CONUS. WRF-Hydro is calibrated and tested in the Verde and San Pedro basins. The model is forced with NCEP Stage-IV and NLDAS-2 precipitation for calibration, and the effects of ephemeral channel infiltration on model performance are considered. This work advances the regional performance of WRF-Hydro through process enhancement and calibration that is highly relevant for improving model fidelity in semiarid climates.

Evaluating strontium isotopes as a tracer of fluids in subsurface reservoirs and possible brine contamination in shallow aquifers related to oil/gas production

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Several recent studies have suggested that strontium isotopes, combined with water stable isotopes and ion chemistry (including bromide) are useful to determine rock-water interaction, subsurface fluid migration pathways, and sources of brine contamination in shallow aquifers. Strontium isotopes do not fractionate in nature and fluids retain the 87Sr/86Sr ratio of the aquifer or confining unit materials that they have interacted with in the subsurface. Therefore, Sr isotopes can provide information about rock-water interaction along flow paths from depth into the Critical Zone or mixing of formation waters between reservoirs, and thus compartmentalization of fluids in subsurface formations.

This study has two main goals: 1) to synthesize existing data and evaluate if Sr isotopes are indeed an optimum tracer for brine contamination in shallow aquifers; and 2) to apply Sr isotopes in a case study to trace the sources of high salinity measured in the shallow aquifers overlying the Raudhatain oil field, one of the largest in Kuwait. For the first part of the study, we are planning to compile all available strontium isotopes, major ion chemistry data (including bromide), and water stable isotopes from four major sedimentary basins in the United States: Williston, Appalachian, Permian, and Illinois basins. Specifically, we will evaluate how unique Sr isotope signatures are between fluids in hydrocarbon-bearing formations to determine if Sr isotopes can be used as a tracer of brine contamination from specific oil/gas reservoirs.

Kuwait Oil Company plans to drill more oil wells in the Raudhatain oil field each year for the foreseeable future to increase oil and gas production. Previous studies in other areas have reported higher numbers of accidental brine spills due to infrastructure failures in areas with high number of oil/gas wells. Brine contamination in shallow aquifers can also come from re-injection of seawater or produced brine to maintain reservoir pressures, contamination due to infiltration of brines stored in surface, and/or the natural upward movement of deep formation water. In this study 87Sr/86Sr ratios of shallow saline aquifers and the different sources of possible contamination in the Ruadhatain area will be measured. If the different sources of contamination and the shallow aquifers have a distinctive 87Sr/86Sr ratio then we can fingerprint the source and origin of contamination in the shallow aquifer.

The importance of initial size on the size and structure of tropical cyclones

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Empirical observations show that the structure and size of tropical cyclones (TCs) have dramatic impacts at landfall, including wind damage and storm surge. TCs have been observed to change size under a variety of environmental conditions. Several numerical studies conducted within the last decade have looked at the environmental conditions and associated physical mechanisms that likely cause TC size changes. For example, Stovern and Ritchie (2016) found that cooling (warming) the environmental temperature resulted in larger (smaller) TCs mostly because of the changes in the resulting surface energy fluxes. Initial size of the cyclone is also an important factor behind rapid change of structure and size of the storm (Stovern and Ritchie 2016). This modeling study was designed to further investigate how the environment affects the size and structure of real TCs.

This study examines historical TC cases where the wind field expanded or contracted during its lifetime. Size changes are evaluated using the North Atlantic Hurricane Database second generation (HURDAT2) data set, which contains the maximum radial extent of the 64-, 50- and 34-kt wind in four quadrants. The average 34-kt wind radius (R34) is used as an indicator of the size of the TC. For the purposes of this study the environment of a TC is investigated if the wind field either expanded or contracted in size at least 15 n mi radially in a 12-hour period. The model used is the Weather Research and Forecasting-Advanced Research WRF (WRF-ARW) developed at NCAR. WRF is configured with multiple nests with the finest resolution of the inner nest being 2km, the WRF double-moment cloud microphysics scheme, Mellor-Yamada planetary boundary layer. Both inner meshes are vortex following and initial and boundary conditions are derived from the 6-hourly NCEP FNL data set. In this presentation, we will use simulations of Hurricanes Igor (2010) and Katrina (2005) as they undergo size changes to explore how environmental forcing affect TC size and structure.

A study of improved quality effluent discharged from Agua Nueva Water Reclamation Facility to the Lower Santa Cruz River

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Reclaimed water is an important renewable resource in Tucson and helps conserve potable water used to meet outdoor water demand. Pima County's water treatment facilities discharge effluent (highly treated wastewater) to the Santa Cruz River where it contributes to a managed aquifer recharge project. Water that infiltrates in-stream earns recharge credits, which are withdrawn from the reclaim system when needed. Since 2014, an upgraded facility- Agua Nueva (AN)- produces Class-A effluent, which infiltrates quickly due to its improved quality. This study aimed to gain better resolution on infiltration rate of the effluent as it progressed downstream in order to verify recharge credits. Such data is also important for modeling water demand of future projects utilizing effluent.

Divers (pressure transducers with integrated data loggers) were used to monitor surface water conditions. A mass balance approach using flow measurements, used to find difference in discharge between transects, was used to estimate recharge. Because of high temporal variability in AN outflow, this downscaled mass balance provided inconclusive results. The study resulted in an effective way to temporarily deploy divers to monitor surface water in streams with unstable flow conditions. The hydraulic head data gathered provided insight to the unique nature of effluent flow in the river.

Post-processing aerosol optical depth outputs from WRF-Chem model using MODIS satellite AOD retrievals: A demonstration of analog based kalman filter approach

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Particulate matter (PM) concentrations are one of the fundamental indicators of air quality. Earth-orbiting satellite platforms acquire column aerosol abundance that can in turn provide information about the PM concentrations. One of the serious limitations of column aerosol retrievals from low earth-orbiting satellites is that these algorithms are based on clear sky assumptions.

In this study, we demonstrate a method to fill in gaps in Moderate Imaging Resolution Spectroradiometer (MODIS) aerosol optical depth (AOD) retrievals based on ensembles generated using an analog-based kalman filter approach (KFAN). It provides a probabilistic distribution of AOD using historical records of model simulations of meteorological and chemical predictors such as AOD, relative humidity, mass concentrations of chemical species, and past observational records of MODIS AOD at a given target site. We use simulations from two models: 1) a coupled community regional weather forecasting model with chemistry (WRF-Chem) run at 36km, and 2) a global community atmosphere model with chemistry (CAM-Chem) run at a coarser resolution. Analogs selected from the model simulations and corresponding observations are used as a training dataset. Then, missing AOD retrievals in MODIS pixels in the last two weeks of the selected period are estimated. We use MODIS retrievals that were not used for optimization and an independent set of AOD retrievals from AERONET stations for evaluating analog estimates. KFAN is an efficient approach to generate an ensemble as it involves only one model run and provides an estimate of uncertainty that complies with the physical and chemical state of the atmosphere.

Development and analysis of a new standard operating procedure for measuring evaporation pond leakage into observation wells of unusual geometry at TEP Sundt Generating Station

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The current procedure for measuring the rate of leakage from evaporation ponds at TEP's Sundt Generating Station lacks accuracy, and safety measures could be improved. A new procedure has been developed with the intention of improving accuracy, safety, and efficiency. The original method relies upon the transport of heavy equipment and regular contact with the fluid in observation wells located adjacent to the evaporation ponds. It also required employees to engage in strenuous work conditions in close proximity to the evaporation ponds, which increased the risk of falling into the ponds. The new, proposed procedure uses simple geometry and standard water-depth measurement techniques that may result in more accurate measurements and safer working conditions.

One challenge in the development of the new procedure is determining the dimensions of the observation wells, which are not consistently cylindrical from top to bottom. Direct measurement of observation well diameters is difficult because of restricted access to the well interior. To address this challenge, a device was designed and built to obtain accurate diameters of the observation wells. After the new procedure is tested and analyzed, the volumetric rate of pond leakage will be calculated using both methods to determine whether improved accuracy is achieved.

Sensitivity analysis of convective clouds and precipitation to biomass burning aerosols in the Maritime Continent

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The role of aerosols emitted from biomass burning activities remains to be a challenge despite observational and modeling efforts, especially in Indonesia, a large contributor to aerosol emissions from fires due to a rapidly changing landscape, complex topography, and maritime influence. The studies on the interaction between fire aerosols, convective clouds and precipitation are very limited in the Maritime Continent. This study is to investigate the dominant large-scale interactions of aerosols in the region by using available satellite retrievals of meteorology and aerosols properties from VIIRS and TMI (TRMM), MODIS, MISR, and CALIOP, and modeled simulations and analysis from MERRA-2. The study will conduct sensitivity analyses of convective clouds and precipitation to biomass burning aerosols in Sumatra and Borneo based on a hypothesis that biomass-burning aerosols reduces precipitation during warm ENSO years but generate more cloudy conditions due to cloud longer lifetime. This work leverages on methodologies and approaches reported from a few studies in the region and in other fire regions. The study will combine several satellite observations to quantify emergent patterns of these interactions under a probabilistic framework. The study first conducts a set of cluster analysis on fire events occurring during the dry season (May to December) from 2000 to 2016 through a series of hierarchical classification according to the following variables: a) magnitude of fire occurrence; b) spatial and temporal distribution of aerosol loading; c) magnitude of liquid water path; c) presence of convective clouds; d) dominant climatic conditions (warm versus cold ENSO); e) cloud properties; and f) magnitude of rain rates. Statistical summaries (PDFs) of these variables will be produced. Second, the study will carry out multiple regression and principal component analyses on each cluster to investigate the covariations of the dominant modes of variations between these variables within a cluster and across clusters. Inference will be based on probabilistic understanding of these events and supplemented by joint sensitivity estimates between variables. Third, the study will compare and contrast these sets of clusters and the sensitivities derived from satellite data analyses with MERRA-2 model output. Comparison and evaluation of MERRA-2 shall focus on emergent relationships (sensitivities) to assess the ability of MERRA-2 to capture these large-scale interactions.

Comparison of two bias correction schemes in the context of climate change impacts assessment in the Mara River basin

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In this study, we compare two bias correction schemes in the context of climate change impacts assessment, namely power law transformation (PLT) and distribution-free adjusted quantile mapping (AQM-DF). The monthly biases in the high-resolution climate dataset, Agricultural Modern-Era Retrospective Analysis for Research and Application (AgMERRA), are corrected using the fine-resolution (0.05°) satellite and in-situ observation-based merged dataset, Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS). The study is carried out for the Mara River basin in Africa, which faces several difficult water resources management challenges. Results from the preliminary assessment of the hydrologic forecasts generated using the bias corrected forcings are also presented.

Examine the impact of wildfire on solute release in forest catchments

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Wildfires represent one of the largest disturbances in forested areas. The number, size and severity of wildfires have significantly increased in the western United States since 1990. High occurrence of wildfires are observed during the summer months where mean temperatures are elevated. It has been predicted that the frequency, severity, and area burned by wildfires will increase in the Southwest United States with progressive increasing of temperatures and drought. When a fire occurs, nutrients that were taken up by the biomass (e.g. vegetation) are released from the burned vegetation and transported downstream via washoff and shallow subsurface flow. After fire, ash deposits on hillslopes may form a large store of particulate carbon and contain elevated concentrations of various nutrients, trace elements, as well other potential contaminants that are constantly released into the surface water.

It is crucial to understand how those fires affect the flux of solutes available from these sources in the critical zone, which is the area ranging from the top of the vegetation canopy to the bottom of free flowing groundwater where mass and energy are exchanged between the regolith, biosphere, and atmosphere. The main focus on this study is to understand how these wildfires affect the overall water quality of surface water and groundwater in forest catchments.

Investigating combustion and emission trends in megacities through synthesis of combustion signatures using multiple datasets

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Combustion and its associated emissions are important consequences of urbanization. However, accurate monitoring and quantitative assessment of these consequences, especially in rapidly developing regions, are hindered by the lack of information regarding combustion activities and efficiencies. There is a unique opportunity to augment our observational capability by using multiple datasets from ground, aircraft, and satellite products as well as emission databases and chemical transport models (CTM) and associated reanalysis. In particular, joint analysis of CO, CO2 and NOX which are co-emitted provide a unique perspective to study anthropogenic combustion given the availability of satellite retrievals for these combustion products. Here, we analyze these three species, including their associated ratios and long-term trends using satellite observations (Measurement of Pollution In The Troposphere, Ozone Monitoring Instrument, Tropospheric Emission Spectrometer and Greenhouse gases Observing Satellite, Orbiting Carbon Observatory), available reanalysis, and emissions from EDGAR and RCPs in all major cities in US. We then apply similar methodology to all megacities around the globe. We also compare results from various data sources (ground and aircraft measurements) for verification of our trend analysis. Temporal evolution within one city and comparison between cities provide knowledge on how the city and its natural/ artificial environment interact. Our initial results show that: 1) There are obvious differences in trends between satellite-based and emission-based data. 2) Distinct patterns are found in bulk characteristics in regions with clear fire or fossil fuel combustion. 3) CO/NOx generally decreases with time; this ratio is lower in developed countries than developing countries, with the exception of rapidly urbanizing regions in China where both CO and NOx are significantly high. We will couple our results with socio-economic indicators of urbanization such as population, GDP, economic structure, and development patterns to provide an integrated perspective to city evolution and interaction between urbanization, anthropogenic activity, and our environment.

Effects of the 2013 Thompson Ridge Wildfire on La Jara Creek's discharge system through stable isotope analysis

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Analyses of stable isotopes deuterium (δD) and oxygen-18 (δ18O) provide insight on changes in a rivers discharge sources. This study investigated the effects of the 2013 Thompson Ridge Wildfire on La Jara Creek, located in the Valles Caldera National Preserve in New Mexico's Jemez River Basin Critical Zone Observatory (JRBCZO). This area has an array of protected biodiversity. The pre-fire data (2011 through May 2013), indicate that the creek water had been dominated by contributions from groundwater year-round. Previous studies show that the effects of wildfire on this semi-arid area may have caused the soil to become hydrophobic. This study will quantify the isotopic signature of runoff in stream samples to test the hypothesis that post wildfire infiltration had been minimized. Sample collection of precipitation, groundwater, and stream water follow United States Geological Survey (USGS) standard protocol. Pre-fire samples were analyzed with a Model DLT-100 (Version 2) Isotopic Water Analyzer by Los Gatos Research with post-fire samples waiting to be analyzed in the same manner.

POSTER PRESENTATIONS
HIGH SCHOOL STUDENTS

Rainwater harvesting plan for The Gregory School in Tucson, AZ

Yuyao Catherine Hu, Erika L. Gallo
The Gregory School, Tucson, Arizona

The urban footprint and human population of cities in water limited regions is expected to grow in the coming decades. This expansion will further stress already scarce local water resources. In response, municipalities across the Southwest have encouraged the on-site retention of rain water and storm run-off to offset municipal water demand for irrigation purposes. Here we present a plan to expand and improve the current stormwater management system at The Gregory School in Tucson, AZ. We have designed a school-wide rainwater harvesting system that: 1) uses the stormwater infrastructure that is already in place; 2) takes into account the characteristics of seasonal rainfall; 3) works with the microtopography of the school as identified using LiDAR data, and 4) carefully incorporates the use of common areas for varied purposes. We have designed infiltration basins that alleviate flooding in specific areas of the school and basins that enhance watering of existing vegetation. Finally, we have identified locations for tree plantings that will enhance the shade canopy and diminish the urban heat island effect at our school. The first phase of this long-term plan will be executed during the first week in April of 2017.

Proving the practical application of filtering Pb^{2+} using freshwater algae

Amanda Minke
Immaculate Heart High School, Oro Valley, Arizona

Much of the world's drinking water is not safe. Flint, a small town in Michigan, has tap water so badly contaminated with lead it is considered toxic waste. This project, spanning the past four years, has been to design and build a filter prototype using algae to remove lead from water. The work has resulted in a basic understanding of how one gram of algae removes 71ppb lead from one liter of water. This next phase is for the author to build a commercial scale demonstration filter that allows the system to be used in actual situations around the world. The goal is to filter enough water to provide a rural village residence with a steady source of clean water. The process does not require electricity or chemicals. This last phase focuses on system efficiency, process flow rate, time required for complete lead removal, and proving that the resulting water is potable. The project will determine optimal design features, manufacturing costs, and durability as well as demonstrate operational sustainability. This dream started in the author's carport and has evolved to use wet algae filtration system to better serve a basic human necessity of clean water.

Comparison of countertop hydroponic systems for small-scale food production

Mackenzie Reagan, Lillian Smith, Nina Armstrong
The Gregory School, Tucson, Arizona

Over 17 million Americans live in food deserts: areas lacking access to "fresh, healthy and affordable foods". In Pima County, 16% of the population is food insecure. Our project aims to address food deserts through the design of a self-sustaining countertop hydroponic system that allows access to fresh food at a low cost with minimal maintenance. We designed three hydroponic systems using fish tanks of the same dimensions: 1) a "media in" tank, 2) a "media -flow through" tank and 3) a "media over" tank. We grew Lemon Balm, Peppermint and Romaine Lettuce in hydroponic media in each tank design. We measured water pH, temperature and heights of the plants associated in each tank every week. We also tracked nutrients, fish health and collected media samples to quantify the development of biofilms. The greatest challenge in this study has been keeping the fish healthy and alive. Of the 3 plants tested, romaine lettuce has performed best and grew 8.9 cm on average. While there have been numerous unforeseen challenges, our lettuce growth data suggest that with further study and development, we may be able to create a low cost hydroponic system that can provide alternative choices to people living in food deserts.

Quantifying stream channel water fluxes in the southwestern US

Tianyi Zhu, Erika L. Gallo
The Gregory School, Tucson, Arizona

Ephemeral and intermittent streams comprise over 90% of the regional waterways in the southwestern US, provide substantial ground-water recharge to regional aquifers, and are critical components of desert ecosystems. Yet much remains unknown about their basic hydrologic function. The larger objective of this study is to address some of these knowledge gaps by using heat as a tracer to estimate streambed water exchanges in ungauged channels of the southwestern US. We use Hydrus-1D and a vertical array of temperature sensor data to model vertical water exchanges in hyper-arid and semi-perennial stream channels. This presentation focuses on Hydrus-1D model parameterization and performance assessment. Preliminary results indicate that there is good agreement between the observed and the modeled temperatures ($r2 > 0.8$, $p < 0.05$) in the hyper-arid channels. Analyses of the observed data residuals indicate that modeling performance varies over time, with residual departures being large during the initial time steps of the model run, decreasing and then increasing over time.

EARTHWEEK PLENARY SESSION
Wednesday, March 29, 2017
Student Union North Ballroom
2:00-3:30 PM

HAS Speaker ~ Chloé Fandel
From 2:00 - 2:15 pm

Full STEAM ahead! Scientific illustration as an avenue for including art in STEM education

Chloé Fandel

Department of Hydrology and Atmospheric Sciences,
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Scientists illustrate to record observations in the lab or field, to diagram and clarify their own ideas, and to explain ideas to others. Illustrating helps hone observational skills, which are at the core of science, by requiring the pencil-holder to pay close attention to the subject. Illustrating is also an integral part of understanding and communicating science, but it is often left out of science education. Encouraging students to think visually about their world could provide a foundation in observation and analysis that enables them to engage more deeply with it. It is also an entryway to science for students who may not think of themselves as "good at science." Over the course of this year, I have been conducting a NASA Space Grant outreach effort in middle & high school classrooms in Tucson, at K-12 teacher professional development events, and with graduate & undergraduate students at the University of Arizona. Efforts have consisted of scientific illustration workshops intended to build students' observational skills and engage them in a creative approach to the scientific method. The response from both students and teachers has been positive. Based on these experiences, I have compiled a set of resources & guidelines for both science teachers and researchers on how to use scientific illustration to teach and communicate science.

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