The University of Arizona
Department of
Hydrology & Atmospheric Sciences
Presents

El Día del Agua y la Atmósfera

April 20, 2020
Virtual Conference

"Carving the Canyon"
Captured in Zion National Park
By Amy Rosebrough

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Message from HASSA

On behalf of the Hydrology and Atmospheric Sciences Student Association (HASSA) at the University of Arizona, we welcome you to our Annual Student Research Symposium, El Día del Agua y la Atmósfera 2020. This joint symposium is the result of merging two events - El Día del Agua, established by the Department of Hydrology & Water Resources Student Association in 1990, and Atmospheric and Interdisciplinary Research (AIR), established by the graduate students from the Department of Atmospheric Sciences in 1999.

El Día is one of the five symposia held during Earth Week and is managed and organized by students from the Department of Hydrology and Atmospheric Sciences. Moreover, this event is the perfect opportunity for us to present our research and provides all students the opportunity to meet and network with their peers, prospective students, faculty members, alumni, and working professionals in the fields of hydrology, atmospheric sciences, and other disciplines.

The success of El Día is made possible through the continued support of our sponsors, the efforts of students, faculty and staff members, the School of Earth and Environmental Sciences, and the College of Science. This year we would also like to extend a thank you to the planning committee and everyone else who helped transition El Día online and make it accessible in such circumstances.

Enjoy the symposium and thank you for participating in El Día del Agua y la Atmósfera 2020! We hope to see you next year!

HASSA Officers

El Día del Agua y la Atmósfera 2020 Planning Committee

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Social Chair

El Día del Agua y la Atmósfera Agenda

9:30-10:30 am	**Career Panel**—Our panel will include Erin Gray, Rob Howlett, Simona Seastrand, and Rebecca Stolar. Each panel member will give a brief introduction, describing their career path and what they currently do. The panel will then be open to questions from students.
1:00	**Opening Remarks**—Including introduction of moderators and zoom room hosts & note to attendees: only one opportunity (1 1/2 hours) to visit poster presenters today
1:10 1:37 pm	**Q & A Session 1 for Orals** **1:10 Jack Reeves: -** Earth system model sensitivity to ocean surface flux algorithm design **1:17 Yuan-Heng Wang** - Toward improving snowpack prediction and its parameterization in land surface models **1;24 Shweta Narkhede -** Examining effect of plant roots on soil-water interaction in MiniLEO **1:31 Chloe Fandel** - Representing uncertainty with diverse model ensembles: A test case in an alpine karst system
1:38	**Break**
1:48-2:16 pm	**Q & A Session 2 for Orals** **1:48 Mostafa Javadian -** Drought effect on dust storm severity and predictability **1:55 Alexa Marcovecchio -** Impacts of melt season precipitation on early and late Arctic sea ice melt onset **2:02 Reza Ehsani -** Machine learning: A viable option to improve precipitation retrievals in cold regions **2:09 Alireza Arabzadeh** - Global studies of atmospheric rivers precipitation in remote sensing and reanalysis products
2:16	**Break - Transition Time to Poster Session**
2:18-3:48	**Q & A Session for All Posters -** Scheduled from 2:18—3:48 pm - Zoom rooms open approximately 1 1/2 hours in duration.

El Día del Agua y la Atmósfera Agenda (Continue)

3:48 Break - Transition Time to Oral Session

4:00-4:27 Q & A Session 3 for Orals

- 4:00 Geneviee Rose Lorenzo - Fireworks impacts on air quality in Metro Manila, Phillipines during the 2019 New Year revelry
- 4:07 Neha Gupta - Hydrological evaluation of neighborhood-scale green intrastructure in semi-arid nested catchments
- 4:14 R Andres Sanchez - Influence of wildfire on solute mobilization through the critical zone
- 4:21 Garrett Rapp - Sensitivity of simulated mountain-block hydrology to subsurface conceptualization

4:28 Break

4:38-5:06 Q & A Session 3 for Orals

- 4:38 Tiffani Cáñez - PFAS in groundwater at a reclaimed recharge facility
- 4:45 Sean Schrag-Toso - Isotopes, geochemistry, citizen science, and local partnerships as tools to build upon a fractured understanding of the hydrology of the Patagonia mountains
- 4:52 Mohammad A M H Marza - A critical evaluation of strontium isotopes as a tracer of fluids in subsurface reservoirs and possible brine contamination in shallow aquifers related to oil/gas production
- 4:59 Jihyun Kim - The hydrochemical evolution of basinal fluids in the Paradox basin: Implications for sources, flowpaths, and residence time

5:07 Closing Remarks - Including an invitation to tomorrow's Reception & Happy Hour

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Outstanding Poster Presentation in Atmospheric Sciences
Certificate and Award of $400

GeoSystem Analysis, Inc. , Best Virtual Poster Award
Outstanding Poster Presentation
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Outstanding Oral and Poster Presentations
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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. Evaluation of these awards is performed by a panel selected by HWR alumnus Dr. David Hargis, President and CEO. Fellow UA alumnus Dr. Leo Leonhart, Principal Hydrogeologist and Chief Technical Director, annually presents these awards.

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1979 - 2019

Hargis + Associates is an environmental consulting firm specializing in hydrogeology and engineering. Headquartered in San Diego, the company has offices in Sacramento, California and Tucson and Mesa, Arizona. At Hargis + Associates, our mission is to provide proactive: Expert advice and solutions to our clients with integrity and outstanding service. We deliver this mission with an unparalleled level of quality and service, inspired by collaboration and employee-ownership. For 40 years, the outcome has been practical and workable solutions, resulting in long-term client relationships. Learn more about us at www.Hargis.com.

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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.

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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Benjamin M. Herman
Oral Presentation Awards

Benjamin M. Herman was the first PhD student in the newly founded Department of Meteorology at the University of Arizona and went on to become Professor and Chair of the Department of Atmospheric Sciences. He excelled in classroom instruction particularly in teaching atmospheric radiation, remote sensing, and physical meteorology. As a result of his previous experience as an US Air Force meteorological officer, he loved to challenge the Departments students in Synoptic Meteorology.

Ben's research career was at a time when large-scale electronic computers became available at the University of Arizona and precise radiation sensing instruments were being developed for Earth orbiting satellites. He was a noted researcher, developing and applying the first numerical techniques to calculate scattering, emission and absorption of radiation in Earth and planetary atmospheres. Ben was recognized as an international leader in applying these techniques to quantitatively interpret satellite measurements, mentoring his many collaborating students to develop successful careers with NASA, NOAA, and other agencies.

He authored or co-authored over 80 publications in peer reviewed literature, many of which are still cited today. His papers on aerosol size and optical depth, as well as two of his papers on the use of GPS measurements to determine H2O vapor profiles have each been cited over 400 times.

Ben retired in 2005 as a Professor Emeritus, after 45 years of service. In 2006, NASA and DOI bestowed Ben and others with the William T. Pecora Award for satellite techniques to infer O3 and SO2. He also received the Distinguished Public Service Medal by NASA. Ben was a Fellow of the American Meteorological Society.

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.

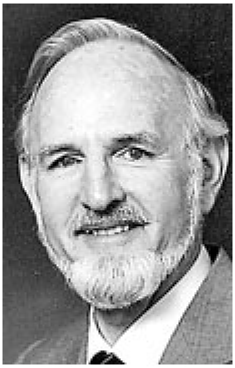
After his retirement in 1985, he remained active in the profession, serving the U.S. Chapter of the International Association of Hydrogeologists as Secretary-Treasurer from 1984-89 and as President from 1989-92. During his tenure as President, he became the Founding Editor and first Editor-in-Chief of 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.

Stanley N. Davis
Poster Presentation Awards



Dr. Simpson's initial goal in life was to be a journalist and so he started his undergraduate career at City College in New York as an English major, during the depression. Soon he perceived a world with a need for technological services and subsequently received his B.S. in civil engineering. After an interlude of building ammunition depots for the Navy, he returned to school for a Master's in geology at Columbia. Upon graduation, Dr. Simpson went to work for the USGS in the water resources division, from 1946 to 1963, where he spent much of his time on the problem of radioactive wastewater underground disposal. During this time he obtained a Ph.D. in geology from Columbia and also spent 2 years at the Belgium Center for Nuclear Research. In 1963, he joined the University of Arizona as a Professor and Founding Faculty for the Department of Hydrology and Water Resources, where he then served as the Department Head. Dr. Davis was internationally recognized expert in the study of ground water. Dr. Davis also served on the faculty of Stanford University, the University of Chile, the University of Missouri--Columbia, and Indiana University--Bloomington. Additionally, over his career, he was a consultant for the United States Bureau of Reclamation, the Kansas and Missouri geological surveys, the Arctic Institute of North America, Princeton University, and the University Oriente and the University de los Andes, both of Venezuela. He also was the recipient of multiple honors throughout his career, in 1989 he was presented with the O.E. Meinzer Award by the Geological Society of America, and in 1996 he was made a Fellow of the American Geophysical Union. Over the course of his career, Dr. Davis was author or coauthor of more than 100 scholarly publications, and coauthor of the seminal textbook "Hydrogeology" with Dr. Roger DeWiest. From 1943-1946, Dr. Davis served in the U.S. Army during World War II in the Pacific Theater.

Dr. Simpson spend his leisure time listening to music, enjoying art, and, hold on to your hats, gliding! Dr. Simpson belongs to the Tucson Soaring Club and spends much of his weekends catching the orographic winds coming up over the Catalina's in the winter, and the large convective cells in the summer, soaring up to 12,000 feet, his limit, as he doesn't carry oxygen. And the answer is yes, he has had a few close calls, but according to him, that's to be expected.

Career Panel ~ 9:30AM —10:30 AM

Our panel will include Erin Gray, Rob Howlett, Simona Seastrand, and Rebecca Stolar. Each panel member will give a brief introduction, describing their career path and what they currently do. The panel will then be open to questions from students.

- **Erin Gray**, a recent HAS alumna, is a hydrologist with the New Mexico Water Science Center, U.S. Geological Survey, in Albuquerque, New Mexico. She received her Bachelor of Science degree in environmental hydrology and water resources (2017) and Master of Science degree in hydrology (2018) from the University of Arizona. She worked as an engineering associate with Tucson Water, City of Tucson, from 2017 to 2019. Since joining the center in 2019, she has been part of the Water Sustainability Unit, where she relies on her background in geochemistry and mapping to support various projects.

- **Rob Howlett,** graduated from Arizona State University in 2013 with a Bachelor of Science degree in meteorology. He worked as an operational forecaster the Bermuda Weather Service from 2014-2016. He joined the National Weather Service in Tucson in 2017.

- **Simona Seastrand**, a HAS alumna, is a senior atmospheric scientist with Saildrone, a private company which designs, manufactures, and operates a global fleet of wind- and solar-powered ocean drones monitoring the state of the planet in real time. Simona completed her Bachelor of Science degree in meteorology (2008) at Northern Illinois University and a Master of Science degree in atmospheric sciences (2012) and a Doctor of Philosophy degree in Climatology/Arid Lands (2015) from the University of Arizona.

- **Rebecca Stolar**, a recent HAS alumna, grew up in Las Vegas, NV. She received her Bachelor of Science degree from the University of Michigan in 2017 where she studied in the Program in the Environment focusing on water, health, and policy. In 2019, she received her Master of Science degree in Hydrology from the University of Arizona after completing her thesis, "Populus fremontii tree ring analysis and semi-arid river water source variability over time, San Pedro River, Arizona," under the direction of Dr. Thomas Meixner. Rebecca now works in Tucson, Arizona as a hydrogeologist at Hargis+Associates, Inc., a hydrogeology and engineering consulting firm.

ORAL

PRESENTATIONS

Oral Presentations (16) ~ In Alphabetical Order

Arabzadeh, Alireza - Global study of atmospheric rivers precipitation in remote sensing and reanalysis products

Cañez, Tiffani - PFAS in groundwater at a reclaimed recharge facility

Ehsani, Reza - Machine learning: A viable option to improve precipitation retrievals in cold regions

Fandel, Chloe - Representing uncertainty with diverse model ensembles: A test case in an alpine karst system

Gupta, Neha - Hydrological evaluation of neighborhood scale green infrastructure in semi-arid nested catchments

Javadian, Mostafa - Drought effect on dust storm severity and predictability

Kim, Jihyun - Hydrogeochemical evolution of formation waters in the Paradox basin: Implications for sources, flowpaths, and residence time

Lorenzo, Genevieve Rose - Fireworks impacts on air quality in metro Manila, Philippines during the 2019 New Year revelry

Marcovecchio, Alexa - Impacts of melt season precipitation on early and late Arctic sea ice melt onset

Marza, Mohammad A M H - A critical evaluation of strontium isotopes as a tracer of fluids in subsurface reservoirs and possible brine contamination in shallow aquifers related to oil/gas production

Narkhede, Shweta - Examining effect of plant roots on soil-water interaction in MiniLEO

Rapp, Garrett - Sensitivity of simulated mountain-block hydrology to subsurface conceptualization

Reeves, Jack - Earth system model sensitivity to ocean surface flux algorithm design

Sanchez, R. Andres - Influence of wildfire on solute mobilization through the critical zone

Schrag-Toso, Sean - Isotopes, geochemistry, citizen science and local partnerships as tools to build upon a fractured understanding of the hydrology of the Patagonia mountains

Wang, Yuan-Heng - Toward improving snowpack prediction and its parameterization in land surface models

Global study of atmospheric rivers precipitation in remote sensing and reanalysis products

Alireza Arabzadeh, Reza Ehsani, Stella Heflin,
and Ali Behrangi

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

Atmospheric rivers (ARs) are elongated narrow corridors of water vapor transport in the low-level jet layer of the atmosphere. ARs are typically longer than 2000 km and less than 1000 km wide and are often made of poleward and lateral moisture transport. Several studies have shown AR's key contribution to total and extreme precipitation at the regional scale. In the present work, and in light of the availability of global data sets, we perform a global analysis of AR precipitation using various products covering an 18-year period (2001 to 2018). More specifically we will: (1) investigate the frequency of AR occurrence, (2) compare precipitation intensity and volume of AR events with Non-AR events, and (3) focus on precipitation extremes and their relationship with the AR events.

Here extreme events are defined as daily precipitation rates larger than 95th percentile of all daily precipitation rates in a year. We study the extreme events globally and zonally using remotely sensing and reanalysis products, then we focus on few selected regions over land where ARs can have a large impact (e.g., due to floods resulted from extreme precipitation).

Here we cross-compare AR precipitation from four widely used precipitation products. We also compare the results with two well -known reanalysis precipitation products to assess potential differences between satellite and reanalysis products with respect to capturing ARs precipitation features such as frequency, intensity, and extremes.

PFAS in groundwater at a reclaimed water recharge facility

Tiffani Cáñez, Mark Brusseau[1], Bo Guo,
Dick Thompson[2], and Jennifer McIntosh

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

Reclaimed water is becoming an increasingly important source of water in arid regions worldwide. In the City of Tucson, Arizona, reclaimed water makes up approximately 10% of the annual water supply. It is used for a variety of purposes that include recharging the local aquifer, creating surface flow in the Santa Cruz River, and irrigating parks, golf courses, and other turf irrigation such as recreational fields. Recently, Tucson Water discovered high concentrations of perfluoroalkyl and polyfluoroalkyl substances (PFASs) in their reclaimed water system. High concentrations of PFASs were detected by Tucson Water in the Sweetwater Recharge Facility (SRF), adjacent to the Santa Cruz River, where reclaimed water is stored underground in the alluvial aquifer. PFASs have gained national attention as emerging contaminants because of their toxicological impact to humans and persistence in the environment, yet little is known about their fate and transport. Initial results from this study show that PFASs in the SRF are most probably sourced from the retired wastewater treatment facility. Lower PFASs concentrations have been observed in the treated wastewater provided by the new treatment facility. Moreover, PFAS concentrations were found to be almost directly related to rising and falling groundwater levels, indicating that PFASs could be trapped in the vadose zone and transported to the aquifer during managed aquifer recharge events.

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

[2]Tucson Water, City of Tucson

Machine learning: A viable option to improve precipitation retrievals in cold regions

Reza Ehsani and Ali Behrangi

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

Machine Learning (ML) is a term in computer science, but recently, it has received tremendous attention from the entire scientific community. Due to the popularity of ML, hydrologist and atmospheric scientists have also started incorporating ML techniques to address challenging issues. Precipitation retrieval has been an exigent topic, especially in high latitudes (i.e. poleward of 50°) and over frozen surfaces. Given the importance of quantifying high-latitude precipitation, and ample challenges that the current precipitation products face over these regions, the present research investigates precipitation retrieval in higher latitudes using several ML algorithms. CloudSat provides direct observations of snow and light rainfall at high latitudes with unprecedented signal sensitivity which can be considered as the baseline for precipitation rate. However, due to its nadir-only observation, it does not provide sufficient temporal sampling. ML techniques can help us to retrieve precipitation rate using brightness temperature from Microwave Humidity Sounder (MHS) and Advanced Very High-Resolution Radiometer (AVHRR), providing a valuable alternative for precipitation estimation in high latitudes. For this purpose, we have matched up Cloudsat, MHS and AVHRR data for the period 2007-2010 to create a database for ML training and testing. Then precipitation rate is retrieved from brightness temperature at different frequencies (~11 to ~190 microns) together with climatic variables such as near-surface air temperature. The results indicate that ML algorithms are capable of both identifying precipitation events and estimating precipitation rates with relatively high accuracy compared to the current physically-based retrieval methods in high latitudes.

Representing uncertainty with diverse model ensembles: A test case in an alpine karst system

Chloé Fandel, T.P.A. Ferré, Zhao Chen, and Nico Goldscheider[1]

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

Karst aquifers are difficult to model because the discrete, heterogeneous nature of groundwater flow through conduits, rather than through distributed pore spaces, leads to high structural uncertainty. Existing models rely either on a detailed conduit map, or on effective flow parameters approximating a porous medium. Neither approach is adequate for most karst systems, where conduits are unmapped, yet flow patterns are fundamentally different from those in porous media. Our approach links three components: 3D geologic modeling with GemPy, an open-source Python package; conduit network generation with the Stochastic Karst Simulator (SKS), a pseudo-genetic structural model; and pipe flow modeling with the EPA Storm Water Management Model (SWMM). We use pre-existing data from a long-term research site, the Gottesacker karst system in the German/Austrian Alps. First, several geologic models are built in GemPy. Each geologic model is fed to SKS, which generates many proposed conduit network maps. For each network, hydraulic parameters are estimated, and the flow behavior is modeled with SWMM. This yields an ensemble of competing models, organized into a model tree recording the geologic structure, conduit network map, and hydraulic parameters for each model. The models in the ensemble will then be ranked based on the fit of model-predicted spring discharge timeseries to observed data. The models that best reproduce discharge behavior can then be compared to the known conduit network, to assess the effectiveness of this approach.

[1]Institute of Applied Geosciences, Karlsruhe Institute of Technology, Karlsruhe, Germany

Hydrological evaluation of neighborhood scale green Infrastructure in semi-arid urban catchments

Neha Gupta, Thomas Meixner, Erika Gallo,
David Dziubanksi, Yoga Korgaonkar[1]

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

Semi-arid cities such as Tucson, Arizona are implementing solutions that capture rainwater as it falls and flows through the streets as stormwater, approaches that are collectively captured in the term green infrastructure. In the City of Tucson, green infrastructure is implemented in a decentralized manner throughout the streets of neighborhoods to reduce flooding impacts, support local plant life, and address urban heat island impacts. Taking advantage of the City of Tucson, Arizona as a living laboratory, this observational study evaluates the cumulative impact of green infrastructure installation in neighborhood streets on stormwater runoff response under varying rainfall regimes and seasonality. This observational study is strongly focused on the development and analysis of high-resolution empirical runoff datasets derived on scales typically underrepresented in data-limited semi-arid urban environments. This study discusses methods and analyses undertaken in order to understand urban hydrologic functioning at the urban subwatershed scale by comparing runoff ratios, runoff volumes, and peak discharge derived for paired events in nested watersheds in two urban neighborhoods in Tucson, Arizona. These runoff characteristics are compared across paired runoff events, and are summarized across rainfall regimes, seasonal distribution of rainfall, green infrastructure implementation levels, and land cover characteristics. Results will be analyzed to assess the emerging hydrological influence of green infrastructure networks in small urban streams, given heterogeneity in installation and performance. Results will also be used to describe influential metrics with regards to landscape composition, a continuing conundrum, which can be used in future semi-arid urban hydrological studies.

[1]School of Geography & Development, University of Arizona, Tucson, AZ.

Drought effect on dust storm severity and predictability

Mostafa Javadian, Ali Behrangi and Armin Sorooshian

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

Dust storms are common meteorological events in arid and semi-arid regions, particularly in Southwest Iran (SWI). Here we study the relation between drought events in Iraq and dust storms in SWI between 2003 and 2018. The HYSPLIT model showed that central and southern Iraq are the main dust sources for SWI. Mean annual aerosol optical depth (AOD) analysis demonstrated that 2008 and 2009 were the dustiest years since 2003 and there is an increased frequency of summertime extreme dust events in the years 2008 and 2009. The Standardized Precipitation Evapotranspiration Index (SPEI) revealed that drought in Iraq significantly affects dust storms in Iran. Similarly, dramatic desiccation of Iraq wetlands has contributed to increasing fall dust events in SWI. AOD in SWI is highly correlated (-0.76) with previous-month vapor pressure deficit (VPD) over Iraq, demonstrating the potential of VPD for dust event forecasting.

The hydrogeochemical evolution of basinal fluids in the Paradox basin: Implications for sources, flowpaths, and residence time

Jihyun Kim, Ambria Dell'Oro, Chandler Noyes, Jennifer McIntosh, Lin Ma[1] and Zheng-Tian Lu[2]

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

The Paradox Basin in the Colorado Plateau has abundant manifestations of paleofluid flow, including sandstone bleaching and ore mineralization, salt tectonics, and hydrocarbon, CO2, and He reservoirs. Formation water and dissolved gas samples were collected to evaluate the hydrochemical composition, sources, and residence time of remnant fluids as an indicator of the long-term evolution of the Paradox Basin fluid-rock system, using major ion and isotopic (δ18O & δ2H –H2O; δ34S & δ18O-SO4; 87Sr/86Sr) signatures of fluids and preliminary radio-krypton (81Kr) dating results from produced gases. Shallow brines near salt anticlines are dominantly derived from dissolution of evaporites by meteoric water and minor mixing with paleo-evaporated seawater (PES). Pennsylvanian Honaker Trail Formation brines (~0.5 Ma; 81Kr water age) are a mixture of (1) Upper Paleozoic formation water from influx of meteoric water that oxidized sulfides and acquired radiogenic Sr from the overlying Permian Cutler siliclastic formations; (2) partially-evaporated seawater; and (3) PES (>1.5 Ma; 81Kr water age). Mississippian and Devonian formation waters (~0.8 Ma; 81Kr water age) were surprisingly young and likely represent PES that was diluted by meteoric recharge, which interacted with radiogenic basement rocks or arkosic sandstones, and dissolved evaporites at the base of the Paradox Formation.

[1]Department of Geological Sciences, El Paso, TX
[2]University of Science and Technology of China, Hefei, China

Fireworks impacts on air quality in metro Manila, Philippines during the 2019 New Year revelry

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Fireworks degrade air quality, reduce visibility, alter atmospheric chemistry and cause short-term health effects. Novel and intensive measurements of chemical, physical and optical properties of particulate matter from fireworks during New Year 2019 in Manila Observatory, Quezon City, Philippines was done through the Cloud, Aerosol and Monsoon Processes Philippines Experiment (*CAMP²Ex*). Forty-eight hour particulate samples were collected with Micro-Orifice Uniform Deposition Impactors (*MOUDI*) samplers before, during, and after the fireworks activities. Ionic and elemental analyses of the particulate samples were done using ion chromatography and triple quadrupole inductively coupled plasma mass spectrometry, respectively. Backscatter and aerosol optical depth measurements were retrieved from a High Spectral Resolution Lidar (HSRL). Species specific to firework activity (Cu, Ba, Sr, K, Al, Pb, and Mg^{2+}) were enriched 5 to 65 times in the accumulation mode during the fireworks event. Multiple water-soluble ions such as SO_4^{2-}, NO_3^-, Cl^-, and Ca^{2+} were also elevated in the accumulation mode due to primary and secondary emissions. Heavy surface aerosol loading associated with aerosol optical depth reaching 1.25 was observed at the peak of the fireworks event. Fireworks emissions were detected in MERRA-2 reanalysis estimations of surface $PM_{2.5}$, and can help resolve the gaps between satellite and surface data.

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Impacts of melt season precipitation on early and late Arctic sea ice melt onset

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This study investigates the impacts of Arctic precipitation (rain, wet snow, and dry snow) on early and late sea ice melt onset during the melting season. It is hypothesized that enhanced precipitation helps to initiate melt onset via the sea ice – temperature – precipitable water vapor feedback loop. For the purposes of this study, we focus on an area bounded by 73º-84º N and 90º-155º E as this area has been identified as having high atmospheric sensitivity to early sea ice melt onset (Huang et al. 2018). Melt onset is derived from Nimbus-7 SMMR and Defense Meteorological Satellite Program (DMSP) SSM/I-SSMIs products over a time period from 1980 to 2014. To account for spatially and temporally sparse Arctic precipitation observations, we compare the impact of different Arctic precipitation products on our perception of the relationship between melt onset and precipitation. MERRA-2, ERA-Interim, and ERA5 reanalysis products are utilized along with the latest version of the Global Precipitation Climatology Project (GPCP). Reanalysis products are also used to analyze variables related to precipitation and applicable sea-ice feedbacks. Preliminary results show that early melt onset is associated with above average precipitation totals while late melt onset is associated with below average precipitation.

A critical evaluation of 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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Both unconventional and conventional oil/gas production have led to instances of brine contamination of near-surface environments from spills of flowback and produced waters. Strontium isotopes ($^{87}Sr/^{86}Sr$) have been used as a tracer of sources of brine contamination in surface waters or shallow aquifers in areas with limited brine sources. Expansion of unconventional oil and gas production has resulted in produced waters from multiple geologic formations that may have similar $^{87}Sr/^{86}Sr$, making it unclear if Sr isotopes are an adequate tracer for brine contamination. This study evaluated the utility of $^{87}Sr/^{86}Sr$ as a tracer of brine contamination in shallow aquifers related to oil/gas production. Strontium isotopes of formation waters were investigated for two major oil and gas producing regions in the United States: the Williston (WB) and Appalachian (AB) basins. Multiple formations with depth in the two basins have overlapping $^{87}Sr/^{86}Sr$ of formation waters based on a non-parametric statistical test (e.g. the Middle Devonian Marcellus and Upper Ordovician Utica shales in the AB). In addition, there is significant spatial-variability in $^{87}Sr/^{86}Sr$ of formation waters across the basins hypothesized to be from changes in lithology. More spatially distributed fluid Sr isotope data are needed to constrain geographic variability in hydrocarbon producing regions.

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Examining effect of plant roots on soil-water interaction in MiniLEO

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Soil moisture variability plays an important role in the simulation of land surface processes, which are nonlinearly related to soil moisture. It is an important parameter that affects land water interactions and water and energy cycles. Soil moisture is also a major factor in determining hydrological response. In critical zone, various factors affect the soil-moisture interactions, one of them being moisture variability. This study discusses methods that can effectively depict the soil moisture variability in critical zone with bare soil as well as the vegetated surface. The effect of presence of plant roots on the interaction of soil and moisture in the critical zone is observed with the help of experiment aided by Biosphere 2 research facility using lysimeter - MiniLEO in controlled conditions. The observed electrical conductivities of the discharge at the outlet of the lysimeter provides information on soil water interaction within lysimeter and potential factors that may affect this interaction. Additionally, this study explores the potential methods that could be used to trace moisture variability within the lysimeter.

Sensitivity of simulated mountain-block hydrology to subsurface conceptualization

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Mountain-block (MB) systems are critical to water resources and have been heavily studied and modeled in recent decades. However, due to lack of field data, there is little consistency in how models represent the MB subsurface. Few studies have evaluated the effect of these conceptualizations on simulated hydrology, and there is a need to compare various representations of the MB subsurface. In this study, we simulate the hydrology of a semi-idealized headwater catchment using six common conceptual models of the MB subsurface. These scenarios include multiple representations of hydraulic conductivity (K) decaying with depth, changes in soil depth with topography, and anisotropic geology. We evaluate flowpaths, discharge, and water tables to quantify the impact of subsurface conceptualization on hydrologic behavior. Our results show that adding higher-K layers in the shallow subsurface concentrates flowpaths, increasing the average saturated flowpath velocities. Increasing heterogeneity by adding additional layers or introducing anisotropy increases the variance in the relationship between the age and length of saturated flowpaths. Discharge behavior is most sensitive to heterogeneity in the shallow subsurface layers. Water tables are less sensitive to layering than they are to the overall K in the domain. Variable soil depth affects simulated hydrology less than adding constant-thickness layers. Anisotropy restricts flowpath depths and controls discharge from storage but has little effect on governing runoff. Overall, some hydrologic variables appear more sensitive to subsurface conceptualizations than others. Results from this analysis can be used to make more informed decisions when building models of MB systems.

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Earth system model sensitivity to ocean surface flux algorithm design

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Fluxes of latent and sensible heat and momentum across the ocean surface are controlled by atmospheric turbulence. Earth System Models cannot resolve turbulence, so they parameterize these fluxes based on bulk quantities like sea surface temperature and wind speed. So-called bulk parameterizations introduce biases and uncertainties into simulations of the atmosphere, ocean and entire coupled system. To better understand these uncertainties, we perform sensitivity analyses of the atmosphere and ocean model components by comparing three different bulk parameterizations in the Energy Exascale Earth System Model. Changing the parameterization affects not only the surface fluxes, but also other aspects of model climate throughout the ocean and atmosphere. As well as assessing the significance of these changes, we test whether the sensitivity analysis procedure itself impacts the apparent results.

Influence of wildfires on solute mobilization through the critical zone

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The increasing number, size and severity of wildfires in forested water-stressed catchments in the western Unites States may affect their hydrology and the hydrochemical signature in the surface water that may prevail for extended periods of time. In 2013, the Thompson Ridge wildfire burned headwater catchments in the Jemez River Basin Critical Zone Observatory (JRB-CZO) within the Valles Caldera in northern New Mexico. This study investigates the impact of the wildfire on solute fluxes to the surface water, specifically we aim to understand what hydrologic and biogeochemical processes control these post-fire solute concentrations within the critical zone. Comparison of pre- and post-fire surface water solute chemistry and annual fluxes show increases in major cations (K^{+}, Ca^{2+}, and Mg^{2+}) and Si following fire. Furthermore, hydrolyzing metals, such as Al, show depleted concentrations after the fire. While pre-fire Al concentrations in stream flow increased significantly during the wet seasons (snowmelt and monsoons), the post-fire observations do not show significant changes with increase in discharge. Research conducted in the JRB-CZO has provided a better understanding of the architecture of the CZ and its connection to the seasonal variability of groundwater contribution to the streams. Understanding structure and dynamics in the deep CZ provided new insights to assess wildfire effects on CZ processes, e.g. mineral weathering, that that drive solute transfer through regolith and fractures of the vadose and deep saturated zones.

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Isotopes, geochemistry, citizen science and local partnerships as tools to build upon a fractured understanding of the hydrology of the Patagonia mountains

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Drought and increasing demand on groundwater resources have resulted in concern about future groundwater availability among residents living within the boundaries of the Sonoita Creek Watershed in Southeastern Arizona. The Northern Patagonia Mountains are home to the municipal watershed for the Town of Patagonia, and are a key contributor to base flow in the Sonoita Creek. To address the concerns of residents living in the area, and advance the hydrologic understanding of the mountains, a two-phase project is proposed. The first phase is analysis of isotope ratios and the geochemistry of springs in the bedrock, alongside wells completed in the alluvial aquifers, to better understand groundwater recharge conditions and movement within the mountain's fracture system. This improved understanding of the hydrology of the mountains will inform the second phase, which includes a training for well owners and the creation of a monitoring plan for residents and a citizen science group working in the area. Ultimately, the findings of the study will be passed on to the Town of Patagonia's Flood and Flow committee, who will facilitate future studies and implement management decisions based on scientific findings.

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Toward improving snowpack prediction and its parameterization in land surface models

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Accurate estimation of snow cover fraction (SCF) and snow water equivalent (SWE) is essential for improving predictions of snowpack state in land surface models (LSMs). This is especially true in the mountainous and semiarid Western U.S where snowpack is important for freshwater runoff generation and groundwater recharge. This research focuses on:

1) A Comparing different SCF related modeling results using the Noah LSM with multiple parameterizations (Noah-MP)

2) Evaluating existing SCF estimation schemes using the University of Arizona (UA) ground-based daily 4-km SWE and snow depth dataset and the Moderate Resolution Imaging Spectroradiometer (MODIS) SCF dataset (Terra, collection 6 version)

3) Evaluating SWE predictions provided by (i) the Noah-MP LSM, (ii) the physically-based National Weather Service River Forecast System (NWSRFS) snow accumulation and ablation model (SNOW-17), and (iii) a data-based long short-term memory network (LSTM), against the UA SWE data product.

These results will be used to diagnose inadequacies in Noah-MP related to snowpack prediction. Future research will investigate scale dependence of existing SCF schemes at various spatial resolutions. Information-theoretic metrics will be used to quantify the information content exploited from data and/or provided by models.

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POSTER

PRESENTATIONS

Poster Presentations (20) ~ In Alphabetical Order

Chen, Sidian - Pore-scale modeling of thermodynamic phase change behaviors of multicomponent fluids in nanoporous

Clabourne, Breanna - Using hydrologic models in the decision making process

De la Fuente, Luis - Robust data splitting for hydrological modeling: Implementation of machine learning techniques

Dicke, Tristan - Using coupled hydrogeophysical modeling to assess the likely value of proposed gravity observations to support water resources decision making

Duy, William - Using machine learning to predicting saturated hydraulic conductivity

Farley, Abram - Developing an interactive groundwater model to increase the accessibility of K-12 groundwater education

Holland, Madeleine - Snowpack drivers and trends over the contiguous United States

Ji, Lin - A machine learning approach to morphometry-extreme flood links in the Lower Colorado River Basin

Kirk, Alyssa - Hydrochemical modeling study to devaluate potential flowpaths to surface water baseflow in Lower Cienega Creek, Pima County, Arizona

Moghaddam, Mohammad A. - Application of ML algorithms to infer streambed flux from subsurface pressure and temperature observations

Ridlinghafer, Jacob - Relating pyrogenic carbon accumulation to modern and historic fire regimes: Using estimates of peak flow rate and USLE to predict erosion

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Solis-Arroyo, Sheila - Modelling the effects of maintenance on artificial recharge basins

Spinti, Rachel - A history of reservoir storage and regional development in the Continental United States

Steyaert, Jen - Developing a national framework for optimizing reservoir operations

Tesfa, Gebremeskel - The source of pumped water in a confined aquifer

Triplett, Amanda - A comparative study of drought response and recovery in two arid and intensely cultivated mountain valley systems

Tritz, Claire - Natural tracer study of mountain block recharge in a headwater catchment: Davidson canyon

Venegas Quiñones, Héctor - Streamflow depletion caused by wells: Understanding and managing the effects of groundwater pumping on streamflow

Yuan, Sunyi - Modeling atmospheric dispersion of pesticide particles in Yuma County and Maricopa County

Pore-scale modeling of thermodynamic phase change behaviors of multicomponent fluids in nanoporous media

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Multiphase fluid flow and multicomponent transport in porous materials are governed by their thermodynamic phase change behaviors, e.g. evaporation and condensation. The phase behavior of a multicomponent mixture in nanoscale pore spaces can significantly deviate from its bulk state, leading to very different triggering pressure and temperature for evaporation and condensation. This 'shifted' phase change behavior due to nanoconfinement—commonly observed during oil and gas recovery from shale formations—has posed significant challenges for accurate prediction of hydrocarbon production. Current theories either underrepresent the pore geometries and pore connectivity by using molecular simulations within a single cylindrical or slit pore, or oversimplify the nanoconfined phase behaviors within the complex pore structures by using Darcy-scale models. These assumptions can cause inconsistent predictions of phase behaviors with experimental and field observations. To bridge the gap, we develop a novel pore-network model to examine how pore geometries and pore connectivity control the thermodynamic phase change behavior of multicomponent mixtures in nanoporous media. The model allows us to derive new constitutive relationships for Darcy-scale continuum models by considering the interactions between phase change behaviors, two-phase flow, multicomponent transport, and the multiscale nanopore structures, which can then be used for quantitative predictions of field-scale hydrocarbon production from complex shale formations.

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Using hydrologic models in the decision making process

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Hydrologic models enable scientists to predict aquifer responses to proposed anthropogenic activities. Models can inform decision-making, but it is not always clear how the interests of multiple stakeholders can be met while satisfying regulatory requirements. In this study, a town and an agricultural developer represent two hypothetical stakeholders with competing interests and a shared water resource. The agricultural developer proposed further use of water for irrigation; they want to minimize their pumping and water delivery costs. The town wishes to minimize drawdown in their municipal well due to the proposed pumping. This study shows how competing interests can be balanced based on predictive modeling. In the model, a pre-existing pumping well represents past, current, and future pumping from the town. For the proposed irrigation well, the pumping rates are fixed at 3000 m3/day,4500 m3/day, and 6000 m3/day for 124 acres of wheat, pistachio, and cotton, respectively. For each of those pumping rates, the irrigation well location is varied over 10 locations within the model. A total of 30 designs for the crop and irrigation well location were analyzed. The utility of the agricultural developer for all of the ten cotton designs was zero dollars. For the wheat and pistachio designs, the utility of the agricultural developer varied from zero to 1,124,643 dollars. The projected water table depth in the town well varied between 10.2 to 11.4 m. Results are shown in a trade-off plot that could be used to negotiate a well location that is acceptable to both parties.

Robust data splitting for hydrological modeling: Implementation of machine learning techniques

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Hydrological modeling is typically characterized by deterioration in model performance when applied to the evaluation period datasets. This situation has only sporadically been studied and, in general, has become accepted as the “norm” when performing hydrological modeling. However, Machine Learning techniques are now available that can help us better deal with and extract information from the data, and that can help us to improve our understanding of the models. Notably, the highly skewed nature of the streamflow data distribution, can result significant differences in the data distributions resulting from the training/validation/testing period split. To explore this hypothesis, we created random subsets of the hydrological data having essentially the same distribution. The original dataset was split into clusters using the K-means algorithm and the Kolmogorov-Smirnov hypothesis test was used to check the consistency in the splits. From those clusters, data values were selected randomly, without replacement, to create three datasets which keep the percentage defined by the user for each period. Besides, the maximum streamflow event of each event was kept in the training period to ensure the maximum information gain in each model. Hundreds of hydrological models were constructed using an autoregressive Random Forest Model and the change in the dispersion between the traditional data split and the new technique was examined. The outcome indicates an improvement in the robustness of the hydrological models identified using the new data-splitting method, what can be very useful for modeling catchments characterized by high skewness, such as those in arid and semi-arid zones.

Using coupled hydrogeophysical modeling to assess the likely value of proposed gravity observations to support water resources decision making

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Decisions regarding the permitting of new groundwater extractions often depend on the perceived impact of those withdrawals on groundwater levels in wells and streamflow. These decisions can be informed using an ensemble modeling approach, which quantifies both the most likely outcome and the associated uncertainty given limits on subsurface hydrogeologic information. Additional data can constrain forecasts and reduce risk, thereby improving decision making. Groundwater levels in wells are one of the most common hydrologic measurements; but, it can be prohibitively expensive to drill wells to add new observation points to inform decision making. Time-lapse gravity measurements provide a proxy method to gain insight into the subsurface hydrologic conditions. While gravity measurements are less direct than groundwater levels, it can be considerably less expensive to add monitoring points. In this study, an ensemble of MODFLOW models is developed for a hypothetical catchment. Forecasts of drawdown in one well due to the addition of another well are the prediction of interest for decision making. The accuracy and uncertainty of the forecasts are calculated with and without added observations (water levels or gravity change). The result is a map of the basin showing the relative value of observations of each type at each location for improving the prediction of interest. This map can be used to choose between water levels and gravity change observations on the basis of effectiveness and cost. The same approach could be extended to consider multiple measurements of both types or other available observation modalities.

Using machine learning to predict saturated hydraulic conductivity

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The purpose of this project was to determine the feasibility of using machine learning to predict the saturated hydraulic conductivity and which observations would be most important for the University of Arizona Tech Park site. This was done by analyzing samples from three boreholes drilled to a depth of 85 feet. The samples were collected in five-foot sections. Each section was split into samples based on variations in physical parameters. The samples were then analyzed to determine initial saturation, particle size distribution, dry bulk density, porosity, and saturated hydraulic conductivity. The data were then split into testing and training data and analyzed with Python coding to determine the R2 value of the predicted K values with all combinations of observations collected. From this analysis it was determined that the point of diminishing returns was reached when using four or five of the collected observations. The models generally show increasing R2 values as more were added, with smaller increases as more variables are added to the model with a maximum value of approximately 0.95. The models agree that while porosity and dry bulk density can be used to help improve the model, particle size distribution data tend to be more important for predicting saturated conductivity values.

Developing an interactive groundwater model to increase the accessibility of K-12 groundwater education

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Despite the importance of groundwater as a water resource, it is often misunderstood by the general public. One of the biggest reasons for this is that groundwater is not emphasized in educational standards. Even when groundwater is taught in a K-12 setting, there are often incorrect conceptual models, which promote misconceptions, insufficient instructor training, and a lack of educational resources for hydrologic processes. Physical aquifer models, often referred to as sandtanks, are a powerful educational tool that can overcome some of these barriers. They are used to teach audiences about hydrologic principles such as contaminant transport, groundwater and surface water connections, and groundwater pumping. While these demonstrations are effective for a wide range of audiences, they require the physical resources and the personnel to instruct the lessons, which limits their application. This project seeks to address this limitation developing a computer sandtank model that can be used then these resources are not available. To accomplish this, an integrated hydrologic model was implemented with a user interface to replicate a physical sandtank model. The dynamic features of the user interface allow for the computer model to achieve the same educational utility of the physical model and additional features. Our application allows users to change subsurface materials and displays meaningful quantitative outputs. The computer sandtank model is available through multiple digital devices using Docker to increase the range of potential end users. Currently a template for the model is being prototyped with the goal of developing additional templates for a variety of educational settings.

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Snowpack drivers and trends over the contiguous United States

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Cycles of snow accumulation and melt are primarily driven by precipitation and temperature, and the impact of these drivers can be influenced by other factors including elevation and canopy cover. While other studies use limited point measurements or rely on model simulations, here we use the University of Arizona daily 4-km snow dataset over the contiguous United States (CONUS) from 1982 to 2017 to investigate snowpack trends and drivers. We explore April 1st snow water equivalent (SWE) as a function of October–March mean temperature and October–March cumulative precipitation. We find that over the Western contiguous United States, particularly at middle and high elevations, precipitation is more important than temperature for predicting year-to-year SWE variability, while temperature is more important for predicting significant observed trends in SWE. Furthermore, the response of April 1st SWE to both winter precipitation and temperature varies by elevation and forest cover. Vegetation height also affects the overall seasonal cycle of snowpack, and the effects differ by elevation. Most notably, at low elevations, SWE in areas with tall vegetation is higher and lasts longer into the spring, while at high elevations, SWE in areas with tall vegetation is lower and melts sooner.

A machine learning approach to morphometry-extreme flood links in the Lower Colorado River Basin

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Extreme flood hazards are common in the Lower Colorado River basin due to the complex terrain and entrenched river channels. Evaluating basin morphometry helps understand the physical behavior of watersheds with respect to extreme floods events. However, extracting basin morphometric characteristics is computationally expensive and time consuming. Conventional approaches lack effective tools that link morphometric indices to extreme floods, and this poses a great challenge for extreme flood prediction. In this study, we extracted 41 basin morphometric parameters for 372 watersheds in the Lower Colorado River Basin from a 10 m DEM using ArcGIS with python script. We then employed the Random Forest (RF) regression with the GridSerachCV algorithm and Out-of- Bag (OOB) error estimation to link these morphometric features to the floods-of-record. The results indicate that the RF model has a better estimation to peak discharge per unit area (UP) than maximum annual peak discharge (MAP). The results also suggest that significant improvement in predicting the MAP is achieved with the relative basin perimeter, total basin area, and length area relation. Similar improvement in predicting UP is achieved using the maximum height of basin, total basin relief, and relief ratio. This initial effort using RF shows that data-driven machine learning can help link basin morphometry to measures of extreme flooding, thereby advancing our understanding of regional large flood behavior and improving flood risk analyses for the Southwestern U.S.

Hydrogeochemical modeling study to evaluate potential flowpaths to surface water in the Lower Cienega Creek Sub-Basin, Pima County, Arizona

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Cienega Creek contains critical habitat for plants and wildlife including threatened and endangered species and has been designated as an "Outstanding Water" by the State of Arizona. With limited surface water and various demands for water in the region, the presence of perennial surface water may be impacted by reduced water in the watershed. Within the groundwater basin, potential impacts include reduced precipitation and increased evaporation related to climate change as well as increased groundwater pumping from development and/or related to potential mining activities. Understanding where surface water is sourced can help inform water management strategies. Previous studies and recently collected data indicate that perennial flow in Lower Cienega Creek is primarily sustained by water from the local basin fill aquifer with contributions from Davidson Canyon. Preliminary data indicates that Davidson Canyon surface flow is primarily sourced from the shallow alluvial groundwater in the Davidson Canyon subwatershed. This study uses water chemistry data from groundwater (basin fill and shallow alluvial aquifers), precipitation, and perennial surface water to model the geochemical evolution of potential source waters to the resulting surface water perennial reaches in the Lower Cienega Creek watershed.

Application of ML algorithms to infer streambed flux from subsurface pressure and temperature observations

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We demonstrate the application of two simple machine learning tools—regression tree and gradient boosting analyses—to a hydrologic inference problem to address two objectives. The first goal was to infer the flux between a river and the subsurface based on high temporal resolution (5-minute) observations of subsurface pressure and temperature. The second goal was to identify an optimal set of observations to support these inferences. Specifically, we examine how many and what type of observations (pressure and/or temperature) were necessary and at what depths. Using synthetic observations and surface fluxes provided by a fully resolved three-dimensional flow and heat transport model, we found that both machine learning tools could identify the flux well using pressure and temperature measurements collected at three depths, even when considerable noise was added to the synthetic observations. Neither method could provide reasonable flux estimates given only noisy temperature data. A shallow, collocated temperature and pressure observations performed as well as the complete data set. The results show the promise of using machine learning tools to design hydrologic measurement networks, both for determining whether a proposed data set can constrain inversion and for optimizing monitoring networks comprised of multiple measurement types.

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Relating pyrogenic carbon accumulation to modern and historic fire regimes: Using estimates of peak flow and USLE to predict erosion

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Since the 1980s, wildfire frequency and severity have increased, which can threaten ecosystem function, personal property, and human lives. Wildfires also lead to increased runoff, erosion, and transport of pyrogenic carbon (PyC) a charred organic byproduct of fire, that can impact downstream water quality. In this study, we analyzed PyC within soils in the Pinaleño Mountains, Arizona to understand how the movement of PyC is influenced by wildfire regime. Historically, the sites experienced different frequencies and severities of wildfire (i.e. wildfire regime). Samples were collected to quantify PyC in soil pits on hillslopes, where we expect portions of landscape to erode. In contrast, samples collected in colluvial hollows were expected to temporarily accumulate sediment. In future work, we plan to use the Curve Number method to estimate peak flow rate and subsequently predict erosion on hillslopes, and The Universal Soil Loss Equation (USLE) to predict PyC loss in colluvial hollows. Results indicate that modern fire regimes characterized by low severity fires have greater PyC accumulation when compared with areas that have typically burned at higher severities. In comparison, PyC accumulation in moderate severity regimes is approximately 70 percent of that in lower severity regimes. At one site, PyC mass showed evidence of net erosion. These preliminary results indicate lower severity fire regimes retain more PyC. This research could be used to improve wildfire land management practices, such as identifying where to perform controlled burns to reduce burn severity, or where to focus reseeding and mulching to reduce erosion.

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A user-friendly groundwater modeling tool to inform decision-making in Arizona-Sonora transboundary aquifers

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Despite the international socioeconomic importance of transboundary aquifers along the Arizona-Sonora border, they are often understudied and lack sufficient data for complex hydrologic modeling due to geographical, political, economic, legal, and communicative obstacles. This study aims to overcome these obstacles through the creation of a generic modeling tool that allows stakeholders to access a model ensemble composed of basic conceptualizations of common Southern Arizona aquifer geometries within a regionally appropriate hydrologic parameter space. This approach allows us to simply and efficiently model fundamental hydrologic behavior in data-poor regions and effectively share the results with stakeholders through a Graphical User Interface (GUI). Stakeholders can interactively view model results within the GUI through toggling common aquifer geometries, boundary conditions, and parameter ranges to best fit their aquifer of interest. For example, stakeholders may alter magnitudes of mountain-front recharge, riparian evapotranspiration, or pumping rates of existing or proposed wells. The response of the system to these scenarios may then be evaluated through viewing plots of groundwater levels, stream flow, and well capture, which are shown as both the mean and variance over the ensemble to understand both system behavior and uncertainties due to limited data availability. The goal of this work is to provide a tool that hydrologists, regulators, and stakeholders can use to inform water-resources decision making for regions with limited available data.

Modelling the effects of maintenance on artificial recharge basins

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Artificial recharge of groundwater consists of infiltrating surface water through a variety of means, such as spreading basins, to recharge subsurface aquifers. Some of the applications of artificial recharge include groundwater storage, natural purification, and replenishment of groundwater levels. Tucson Water manages the Central Avra Valley Storage and Recovery Project (CAVSARP), which includes 11 recharge basins, and the Southern Avra Valley Storage Recovery Project, which has 9 recharge basins. CAVSARP and SAVSARP are a set of intermittent multi-basin systems responsible for the recharge of the Central Arizona Project (CAP) water originating from the Colorado River. One of the biggest impediments to infiltration in recharge basins is the clogging layer that forms on the basin surface due to suspended solids in surface water and anaerobic conditions. In an intermittent recharge system, the recharge period is terminated before clogging has drastically reduced infiltration rates. The dry period then allows the recovery and maintenance of the system to restore infiltration capacities. The purpose of this study is to create an empirically based model of the effects of maintenance on the infiltration rates of CAVSARP and SAVSARP. A simple model was used to compare how infiltration rates vary over time with respect to antecedent wet/dry conditions and maintenance periods. The main hypothesis for this study is that the model could be calibrated and automated, using data over the past 20 years, to provide a better indication of when maintenance should occur for each individual basin.

A history of reservoir storage and regional development in the Continental United States

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Dams and their corresponding reservoirs have segmented river networks in the conterminous United States (CONUS) for centuries. This segmentation has altered natural streamflow dynamics, which has impacted aquatic species, sediment transport, and water quality. As a result, there have been loud calls for the removal of dams; however, many communities rely on dams for flood protection and water resources. This study aims to quantify and map historical reservoir storage change along river networks over the course of human development. The National Hydrography Dataset (NHD) and National Anthropogenic Barrier Dataset (NABD) developed by the United States Geologic Survey (USGS) were used to connect dam storage with their river networks. The aggregate amount of storage contained within each reservoir was quantified for each corresponding river network. The effects of segmentation could subsequently be identified and analyzed by comparing storage and streamflow. Stakeholders can use this research to understand the historical changes in storage to better predict the effects of dam removal and climate change on water resources.

Developing a national framework for historic reservoir operations

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With increasing temperatures and water scarcity, reservoir operations will become more vital to effectively managing water. In the US alone, there are over 91,000 reservoirs that range from 0.5 to 30 meters high and collectively hold 1833979.11 MCM of water. Many researchers have attempted to numerically model reservoir operations to better assess water management in response to climate change. These attempts have increased our understanding of how reservoirs affect our water networks yet have only implemented generic rule curves based on demand. The goal of this study is to develop a framework to more realistically simulate large reservoir operations across the US based on historical data. This approach allows us to assess the differences and similarities in operational policies and their corresponding effect on US water management. To examine this question, this study used the Global Reservoir and Dam database to gather reservoir characteristics and condense the sample size from 91,000 to 2600 according to iCOLD standards for large reservoirs (greater than 15m high and 10 MCM storage). This data on dam characteristics is combined with historical data on reservoir operations. Real time reservoir inflow, outflow and storage data was gathered from The US Army Corps of Engineers and the Bureau of Reclamation. Using this data, we apply optimization codes to determine operating policies. The hope is that this study can be used to better quantify and assess the impact operational policies have had, and will have, on water management strategies throughout the entire US.

The source of pumped water in a confined aquifer

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Addressing where in the aquifer pumped water comes from during a specific pumping period improves hydrogeologists visualization on the transient response of confined aquifers to pumping which will propagate to many areas of hydrology that employ pumping aquifers in its application. The Theis equation was used to develop expressions that describe the distance to the maximum storage release(r), the velocity of propagation of the expanding cylindrical rings of maximum drawdown (u) and magnitude of the local maximum change in volume as a function of pumping time (dv). Hypothetical aquifers of different hydraulic property that encompass the range of variation in the natural environment were used for the analysis. The results showed all the parameters depend on the hydraulic property of the aquifers; r = (2Dt)1/2, u = (2D/t)1/2, and dv = 135(D/t)1/2. where D is the diffusivity of the aquifer. These expressions provide clear insight into the transient response of any confined aquifer. The rings of maximum release from storage expand rapidly early on and slow down with time, while the radial location, r, where maximum storage change occurs is independent of the pumping rate and aquifer thickness. These results were tested for aquifer hydraulic properties that lie outside the bounds of the hypothetical scenarios in this study.

A comparative study of drought response and recovery in two arid and intensely cultivated mountain valley systems

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The Central Valley in California and the Heihe River Basin in Northwestern China are important agricultural producers and population centers. They are hydrologically similar with arid climates and highly productive agricultural valleys supported by snowmelt dominated mountain systems. However, the regions differ in their timeline of development as well as past and present policy. Climate change is likely to increase temperatures, aridity, and water source variability in these regions, increasing their vulnerability to drought. Droughts are costly and damaging to agricultural, municipal, power and ecological systems, making the understanding of drought characteristics in these sensitive regions of paramount importance. This study explores how similarities and differences in these regions can influence drought onset, propagation, severity and recovery. We aim to determine the relative importance of factors such as climate, water source and usage, infrastructure, and management, and the extent to which they govern drought processes. This sets up the ideological framework to study these relationships using integrated hydrologic models. Since these regions are representative of other arid, mountain-valley systems around the world, the findings from these two basins can be generalized to provide better understanding and management of similar regions to increase their drought resilience.

Natural tracer study of mountain block recharge in headwater catchment: Davidson Canyon

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Mountain block recharge (MBR) is known to be an important contributor to adjacent basin-fill aquifer systems in many arid systems. The spatial distribution, quantity, and flow paths of MBR are often poorly constrained, including flow related to surface mountain front recharge through stream channels. This research aims to better characterize MBR and its hydraulic connections to surface flow, shallow alluvial aquifers, and regional basin-fill aquifers by studying a headwater catchment in southeast Arizona, Davidson Canyon. Previous geochemical studies in the northern Santa Rita Mountains suggest that surface flows in Davidson Canyon are a mixture of recent precipitation and older, more chemically evolved groundwater. This study aims to expand upon these by instrumenting the Davidson Canyon watershed, from its headwaters at the edge of the mountain block, to its discharge into Cienega Creek at the basin floor. The instrumentation will include piezometers in the shallow streambed, stream flow auto-samplers, wildlife cameras, and seasonal precipitation collectors. Geochemical analysis, including stable isotopes, major ions, and tritium, will be coupled with the instrumentation to constrain the sources and flow paths of MBR and groundwater-surface water interactions in a headwater catchment.

Streamflow depletion by wells: Understanding and managing the effects of groundwater pumping on streamflow

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Groundwater is an important source of water for many anthropogenic activities. Most of the time, it is the only source of water in arid and semi-arid regions. Streamflow depletions caused by pumping have become an important water-resource management issue because of the negative impacts that reduced flows can have on aquatic ecosystems, the availability of surface water, and the quality and aesthetic value of streams and rivers. However, it is difficult to observe and measure because it depends on the amount of water available in the stream and in local aquifers, as well as the subsurface geology. Over the past decades has made important contributions to the basic understanding of the processes and factors that affect streamflow depletion by wells. In this context, the decision-making process has been playing a significant role in management and political decision to get the most suitable solutions between different stakeholders. In its simplest sense, decision-making is the act to select the best alternatives under multiple and often conflicting criteria by reducing uncertainty which has many different types of sources. In this more extensive process of problem-solving could lead to a conflict between stakeholders. For these reasons, the purpose of this investigation is to use Hantush's analytical solution to determine streamflow depletion caused by pumping wells in complex scenarios to create a suitable and tangible decision-making process between stakeholders.

Modeling atmospheric dispersion of pesticide particles in Yuma County and Maricopa County

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Pesticide particles pose a risk to public health, especially when dispersed from areas having intensive agricultural activities to population centers. Here, we investigate the transport and deposition of these particles from pesticide applications on agriculture fields in Yuma & Maricopa County, Arizona. We use CALPUFF, which is an EPA-supported atmospheric dispersion program, to simulate the time- and space- varying dispersion of these particles. We configure CALPUFF within an ensemble framework by incorporating uncertainties in key parameters that control concentration downwind. In particular, we conduct ensemble simulations by perturbing emissions, chemical lifetimes, and deposition rates, as well as key meteorological inputs (e.g., wind, temperature) in CALPUFF. These simulations will be compared using pesticide measurements collected in 2012 in Yuma County from colleagues in the College of Public Health. Outdoor air, yard soil, and house dust values are available for 21 farm workers' homes for pesticides such as bifenthrin and permethrin. The results are expected to help assess whether dispersion of pesticide particles will increase exposure and health risks to nearby residents.

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