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## Preview of Award 1331408 - Annual Project Report

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### Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1331408
Project Title:	Transformative Behavior of Energy, Water and Carbon in the Critical Zone II: Interactions between Long- and Short-term Processes that Control Delivery of Critical Zone Services
PD/PI Name:	Jon D Chorover, Principal Investigator David D Breshears, Co-Principal Investigator Jennifer C McIntosh, Co-Principal Investigator Jon D Pelletier, Co-Principal Investigator Craig Rasmussen, Co-Principal Investigator
Recipient Organization:	University of Arizona
Project/Grant Period:	10/01/2013 - 11/30/2020
Reporting Period:	10/01/2018 - 09/30/2019
Submitting Official (if other than PD\PI):	Jon D Chorover Principal Investigator
Submission Date:	10/06/2019
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Jon D Chorover

### Accomplishments

#### \* What are the major goals of the project?

The Catalina-Jemez (C-J) CZO project aims to improve our understanding of the mechanisms underlying quantitative relations between climatic forcing and critical zone evolution in water-limited systems by focusing on linkages between long time-scale climate/lithology interactions and short time-scale ecological/geological feedbacks, and how both affect CZ services.

This goal motivates the proposal's central thematic questions:

- 1) How do the long-term drivers of CZ structure and function (EEMT and tectonics) alter parent material to control current CZ structure and response to perturbation?
- 2) How is long-term CZ evolution affected by ecosystem process controls, including especially localized plant and microbial activities?
- 3) What is the impact of CZ structure on buffering climate- and disturbance-driven variability in water, soil and vegetation resources and how does this translate into changes in CZ services?

We postulate that the climatic forcing of subsurface CZ evolution is predicted on the basis of effective energy and mass transfer (EEMT), which combines into a single climatic term the energy transferred to the CZ as effective precipitation (precipitation in excess of evapotranspiration) and reduced carbon (i.e., net primary production).

The CZO site focus is on the water-limited (semi-arid to sub-humid) southwestern US. A broader impact of our research is, therefore, to improve societal understanding of processes that govern water resource delivery and quality in this region. Mountain block and mountain front recharge serves as the principal source of all freshwater resources to human inhabitants in this part of the world, and hence our project focuses strongly on factors affecting this aspect of the water cycle, including the partitioning of water delivered (as a result of orogenic forcing) to higher elevation catchments, and the influence of hydraulic throughput on CZ geochemical and geomorphic evolution. We are investigating how event-based partitioning of water and carbon feeds back to affect the development of hydrologic flow paths, landscape structure and (bio)geochemical heterogeneities.

Our approach involves a combination of field-based observational measurements, controlled experimentation, and conceptual/numerical modeling at each of two principal research sites in the water-limited southwestern US - Santa Catalina Mountains (SCM, AZ) and Jemez River Basin (JRB, NM). In year 4 of the CZO grant, we have initiated and completed several activities and made substantive progress in each of these areas.

Our transdisciplinary research approach interrogates CZ process dynamics and structure along four integrated lines of inquiry: (i) Ecohydrology and Hydrologic Partitioning; (ii) Subsurface Biogeochemistry; (iii) Surface Water Dynamics; and (iv) Landscape Evolution. By building bridges across these four lines of inquiry, we address linkages between short time-scale (e.g., hydrologic) events and long time-scale (e.g., geomorphic) evolution of the CZ.

In addition to the goals we have for testing hypotheses given in the proposal, the Catalina-Jemez CZO is active in pursuit of CZO network goals. Transformative, network-level science findings should result from comparably quantified structural properties and process rates at multiple sites. By doing so, we can, as a network, assess CZ coupled-process trends and test response hypotheses across the wider climate-lithology parameter space afforded by the network. For these reasons, Chorover has led cross-CZO (X-CZO) development of "common measurements" conceptual frameworks for the CZO network, along with several collaborators.

**\* What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities:

**Ecohydrology and Hydrologic Partitioning**

- Maintained data streams for flux towers, sap flow systems, soil moisture sensors, groundwater monitoring wells, and surface water flumes at all sites.
- Building on the new findings from the snow hydrology research in the Catalina-Jemez to develop transferrable knowledge across western CZO locations and other instrumented sites.
- Expanding the forest ecohydrology-disturbance-landscape work from Catalina-Jemez to other locations.
- Initiating coupled modeling that integrates climate forcing, vegetation, and topographical and geological structure.
- Expanding partnerships with management agencies to transfer new knowledge of CZ structure and function in to management decisions.

- Continued synthesis activities and collaborations that made further advances on understanding the drivers of widespread tree mortality.

### **Subsurface Biogeochemistry**

- Maintained data streams for regularly scheduled sampling and analysis of soil pore waters and groundwater monitoring wells.
- Completed quantitative mineralogical and geochemical analyses of the full set of samples represented by the three deep cores (to 45 m in depth) collected from the Jemez mixed conifer ZOB site.
- Data analysis of microbial biogeochemistry dataset comparisons for north facing (Upper Jaramillo) and south facing (La Jara) as a function of season and hydrologic event status.
- Completion of pyrogenic carbon analyses for mixed conifer zero order basin (MC ZOB) and its redistribution in the three years following the Thompson Ridge wildfire of 2013.
- Completion of aqueous geochemical analyses for the mixed conifer zero order basin (MC ZOB) and its redistribution in the three years following the Thompson Ridge wildfire of 2013.
- Synchrotron X-ray spectroscopy analyses of samples from the deep CZ (Fe, Mn layered interfaces, C-NEXAFS/STXM analyses).

### **Surface Water Dynamics**

- Bi-weekly sampling of stream waters in the MC ZOB, La Jara, History Grove, Upper Jaramillo catchments for time-series hydrologic and biogeochemical data were continued throughout the year. Similar samples were collected in the SCM CZO sites (Marshall Gulch weir, Granite ZOB, Schist ZOB, Oracle Ridge and B2 Desert Sites).
- Higher resolution (daily) surface water samples were collected in the Bigelow ZOB during spring snowmelt.
- Monitoring wells in the MC ZOB were sampled by field staff every two to four weeks for major ions, trace metals, stable isotopes, uranium and strontium isotopes, and carbon content. Monitoring wells were sampled weekly during spring snowmelt.
- All water samples were analyzed for field parameters (pH, Temp, EC, DO), major and minor ions, trace metals, REE, DOC, DIC, TN, and stable water isotopes.
- Neutron probe surveys were conducted (Oct 2017, Feb 2018, May 2019?) in monitoring wells in the MC ZOB to measure seasonal propagation of wetting fronts with depth.
- Final groundwater, surface water, and spring samples were analyzed for U and Sr isotopic composition at the University of Texas at El Paso (UTEP) to extend groundwater time series and fill in data gaps of surface water time series (Mar 2018 and June 2019).
- Groundwater, surface water, and vadose zone data were integrated for a manuscript focused on the physical hydrology of JRB-CZO submitted to HESS (March 2019).
- Environmental data from the JRB and SCM CZO were compiled and utilized in a cross-CZO comparison manuscript being led by cross CZO Postdoc Adam Wlostowski.
- Precipitation, surface, soil and ground water, and plant water data from Marshall Gulch and Bigelow CZO sites were integrated for a series of manuscripts submitted as part of Ravindra Dwivedi's dissertation (successfully completed in 2019).

### **Landscape Evolution**

- Quantified the spatial and temporal hydrologic and geomorphic variability of a 90-km-long reach of the San Pedro River (San Pedro River) in southeastern Arizona and compared that variability to numerical models designed specifically to honor the spatial and temporal variability of alluvial channel systems in nature.

### **Education and Public Outreach**

- Developed and taught a new "Critical Zone Science" course for lower division undergraduate students in the Earth and Environmental Science majors at University of Arizona. Course focuses on the use of the CZ conceptual model as a system of integrated environmental study.
- Merged the Earth Science Discovery mentorship program (i.e., undergraduate instructors working with the Flandrau Science Center K-12 hands-on museum visit) with the new "Critical Zone Science" course now being taught at the undergraduate level in the Department of Environmental Science at University of Arizona. As a result, undergraduate students taking the CZ science course become instructors in CZ science for the elementary school students that visit the Flandrau Science Center and the "Welcome to the Critical Zone" exhibit.

Specific Objectives:

### **Ecohydrology and Hydrologic Partitioning**

Significant Results:

- Two new papers document the interactions between climate and critical zone structure in controlling snow accumulation and ablation in western US. Tenant et al. (WRR) document spatial patterns in snow cover using LiDAR-derived data-sets in multiple western CZO sites. This paper was named an editors choice. Harpold and Brooks (PNAS) document the differential role that atmospheric humidity and latent play in determining snowpack response to warming climate.
- Love et al. (WRR) and Tai et al. (WRR) both document the role that subsurface water storage and redistribution play in determining the response of forest vegetation to warming climate specifically documenting that the underlying CZ structure creates a mosaic of sensitivity and resilience to climate not captured in current assessments of forest change. Fan et al. (WRR) relies on these and related findings to emphasize the importance of including landscape/ CZ structure in Earth Surface Modeling designed to address the effects and feedbacks of land surface – atmosphere exchanges under a changing climate.
- Gabor et al. (EST), Nielson et al. (WRR), Follsted-Shah et al. (JAWRA), and Perdrial et al. (Biogeochemistry) demonstrate the importance of variable subsurface residence times and flowpaths, resulting from subsurface CZ structure, have on solute export and water quality in both CZO and non-CZO locations in the Western US.
- We developed a new bioclimatic envelope specific to pinyon pine mortality (Law et al. 2019), documented how access to deeper vadose zone moisture and isolation from bark beetles post die-off allowed remaining trees in a refugia to persist hotter drought (McDowell et al. 2018), summarized existing metrics and modifiers of mortality for pinyon pine estimated to date (Breshears et al. 2018), provided an assessment of climate change effects including tree die-off and wildfire for the U.S. Southwest (Gonzalez et al. 2018), and summarized how broad-scale tree-die off events will profoundly impact biodiversity (Breshears et al. 2019).

### **Subsurface Biogeochemistry**

- Sanchez-Canete et al (Sci. Rep.) uses combined measurements of CO<sub>2</sub> and O<sub>2</sub> diffusion into and out of the CZ (apparent respiratory quotient) to reveal that a large fraction of soil respiration induced CO<sub>2</sub> production is not returned locally to the atmosphere. Therefore, ecosystem respiration occurring within a flux tower footprint may significantly underestimate CO<sub>2</sub> return to atmosphere (if degassing occurs downgradient).
- Olshansky et al (JGR-Biogeoscience) highlights the importance of this difference (revealed from ARQ measurements) to show that a significant fraction of CO<sub>2</sub> produced by soil heterotrophic and autotrophic respiration is consumed in silicate mineral weathering reactions during deep and lateral hydrologic transport in the CZ.
- Olshansky et al (Front. Earth Sci.) indicates that deep percolation of CO<sub>2</sub> drives silicon dissolution, and principal components analysis revealed distinct groupings of solutes that can be categorized on the basis of their concentration-discharge behaviors (both power law slopes and hysteresis indices).

## • Surface Water Dynamics

- A review paper on mountain system recharge was submitted to WRR, including current understanding from our JRB and SCM CZO sites.
- Using long-term hydrologic fluxes and stable water isotope data we were able to identify vegetation source waters for the Marshall Gulch CZO site
- In contrast to existing methods, such as the time-convolution integral approach for catchment-scale transit time distribution estimation, which require gap-less tracer time-series data, we proposed an improved practical method for catchment-scale response function (transit time and evapotranspiration time distributions) estimation that does not require gap-less tracer time-series data. We also proposed a novel mathematical framework to compare two important metrics, such as fraction of young water and transit time distribution for better understanding subsurface storages that support streamflow for the Marshall Gulch CZO catchment. Finally, we examined the fractal scaling behavior in various water balance components for the Marshall Gulch site. Manuscripts on these results are currently in review.
- In the JRB CZO, utilizing the recently installed deep CZ monitoring wells, we discovered that there are multiple separate stores of groundwater in the subsurface with distinct flowpaths, geochemistries, and water residence times. A perched aquifer resides in a disconnected landslide deposit of different geology from the other wells, is geochemically different from La Jara stream water, and does not respond to the pressure pulse associated with increasing streamflow and rising water table in the deep fractured aquifer, which suggests that the perched aquifer does not contribute significantly to La Jara streamflow. Deep groundwater from the deep fractured aquifer are more chemically-representative of waters (lower  $\text{Ca}^{2+}/\text{Mg}^{2+}$  molar ratios and lower DIC concentrations) that contribute to La Jara stream and more representative of the structure (tuff rock type, fractured aquifer, deep groundwater) and function (hydrologic response, solute fluxes, and water routing) of the whole catchment.
- The U-series isotope signature of La Jara surface water is most similar to that of groundwater from the deep fractured aquifer, which again suggests that deep groundwater from the fractured tuff aquifer sustains surface flow while the perched aquifer does not contribute substantially to streamflow.
- Surface water from each of the three catchments (La Jara, Jaramillo, History Grove) within the JRB-CZO has distinct U-series and Sr isotope signatures.
- Springs within the JRB-CZO that emanate from fault zones have lower U-series activity ratios and more radiogenic Sr isotopes while springs that emerge from matrix in the absence of faults have higher U-series activity ratios and less radiogenic Sr isotope signatures, suggesting that differences in flow paths (fast fracture flow versus slower matrix flow) control isotopic signatures.
- Isotope signatures of surface waters from all catchments resemble the lower U-series and more radiogenic Sr isotopes of springs emerging from fault zones, which again suggests that deep groundwater from fractured aquifers sustain surface water flow within the JRB-CZO.
- Using long-term hydrologic fluxes and stable water isotopes data, we were able to identify vegetation source waters for a mountainous ecosystem.
- In contrast to the existing method such as time-convolution integral approach for catchment-scale transit time distribution estimation which require gap-less tracer timeseries data, we proposed an improved practical method for catchment-scale response function (e.g., transit time distribution and evapotranspiration time distribution) estimation that did not requires gap-less tracer time series data.
- We proposed a novel mathematical framework to compare two important metrics such as fraction of young water and transit time distribution for better understanding subsurface storages that support streamflow for a mountainous ecosystem.

## Landscape Evolution

- Williams et al. (2019) demonstrated that the distribution of alluvial channel structure in the San Pedro River is consistent with self-affine fractal variations of the depth to bedrock and the channel longitudinal profile. At large spatial scales, spatial variations in depth to bedrock control the accommodation space for groundwater, which, in turn, controls spatial variations in surface water discharge. At small spatial scales, the longitudinal profile controls spatial variations in surface water discharge by changing the distance between the channel bed and the water table. These results underscore the complex spatiotemporal behavior of dryland alluvial rivers and the tight coupling that is possible between hydrologic and geomorphic processes in such systems.

Key outcomes or Other achievements: See "Significant Results".

**\* What opportunities for training and professional development has the project provided?**

- CZO faculty at the University of Arizona have developed a new undergraduate course entitled "*Critical Zone Science*" (ENVS 270). This course is now required for all undergraduate Environmental Science majors. Unlike our existing graduate course in critical zone science, this course leverages the interdisciplinary nature of the field (i.e., the need to resolve interactions among geology, hydrology, ecology, and geomorphology) to help understand how the earth's land surface functions, and how it evolves over geological time scales. As opposed to requiring prior coursework in each of the parent disciplines in order to motivate their integration, this course begins with the premise that understanding how the land surface environment functions requires a systemic approach, and then introduces the key concepts of geology, hydrology, geomorphology, soil science, and ecology that are needed to initiate further studies. By doing so, the intent is also to excite students about further, deeper, coursework in one or more of these study areas.
- A new interdisciplinary Hydrology and Water Resources Graduate Certificate program was developed at the University of Utah, informed by the successful cross campus CZO activities at UA. This program is open to both matriculated graduate students as well as non-matriculated professionals from the community who are seeking advanced training without needing or wanting a degree. The program is housed under the Office of Sustainability and incorporates coursework from six departments across four colleges providing the diverse training and exposure that defines CZ science.
- Three new courses have been developed at University of Utah that bring the diverse CZ perspective to hydrologic partitioning and landscape structure. These courses are cross listed among multiple departments.
- A new introductory course, Wasatch in the Field, has been developed at UU combining Geophysics, Geochemistry, Minerology, Geomorphology, and Hydrology in an experiential framework. The course was designed to attract majors to earth science disciplines and is already over subscribed during the second year of implementation.
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- All CZO graduate students in this CZO cohort are quite far along in their programs at this time, and they are in the process of completing their degree programs, and on the job market. Several are and are actively engaged in participation in national and international meetings, including giving oral presentations and organizing sessions. For examples:
- All CZO graduate students have been giving opportunities to serve as graduate teaching assistants during their tenure. This not only increases the mileage that we get from the CZO assistantship funding, but it also provides the CZO graduate students with teacher training that assists them in the future careers and enhances their competitiveness on the job market.
- Alissa White, CZO PhD student, presented her research in the JRB CZO at several academic conferences, which helped strengthen her communication skills and further developed her technical skillset with trips to the University of Texas at El Paso (UTEP) to process samples and analyze samples running the multi-collector mass spectrometer.
- CZO PhD student Ravindra Dwivedi attended several national and international meetings to present his work in the SCM CZO. He has recently begun a postdoctoral position in watershed science at University of Vermont.
- CZO PhD student Brian Moravec co-organized a highly successful CZ science symposium at the 2018 Geological Society of America National Meetings in Indianapolis, where he also gave a talk.
- CZO PhD student Dawson Fairbanks organized a well attended CZ science symposium at the AGU meetings in Washington D.C., and gave a talk at the same national meeting.
- CZO postdoctoral scientist, Yaniv Olshansky, gave oral presentations at the national SSSA and AGU meetings, and was recently offered a faculty position at Auburn University.
- Luke Wilson participated in the B2 REU program summer 2018 and investigated the effects of heat waves of tree seedling mortality along the Catalina gradient from Mount Bigelow to Biosphere 2

**\* How have the results been disseminated to communities of interest?**

- We have partnered with non-CZ researchers on research projects related to water supply in the western US, forest mortality due to drought, and on white papers describing critical issues in Earth System Science. In all cases, the cross-disciplinary approach, guided by findings from within the CZ network, is being used to inform both basic and applied research in related disciplines. This work has been funded by NSF-IOS, NSF-EPSCoR, and state and local agencies.
- We contributed to media responses following the release of the Vol. II. Fourth U.S. National Climate Assessment with regards to the Southwest. By one count, the assessment's release was featured on the front page of more than 140 newspapers around the country.
- Several CZO faculty have given Science Cafe presentations highlighting societal relevance of CZ science (topics including water sustainability, soil fertility, impacts of wildfires, earth microbiome) in open public forums over the past two years.
- Several CZO faculty have once again participated in the writing of new book chapters pertaining to CZ science. The publication of these chapters will occur in FY20, and so is not reported in the current annual report.
- Paul Brooks continues to serve on the science advisory teams for Healthy Headwaters Initiative, Salt River Project, Salt Lake Public Utilities, Mountain Accord, and Carpe Diem West. These groups represent public utilities, natural resource managers, and NGO's focused on improving resource management in western North America.
- Results from our forest, water, and climate work are being incorporated into forest management activities within the watersheds of the Salt River Project (SRP) and the Wasatch Front (Salt Lake Public Utilities) in partnership with local water utilities. We continue collaborations with western ski areas on snow management for the critically important early season (Thanksgiving to New Year holidays).
- We have partnered with collaborators at Western Water Assessment to evaluate climate vulnerability of Weber Basin Water Conservancy District. Together with our work with Salt Lake City Public Utilities and Salt River Project we are helping to inform water management decisions for agencies serving millions of citizens in AZ and UT.

**\* What do you plan to do during the next reporting period to accomplish the goals?**

**1. Continue research on established CJ CZO science themes and complete ongoing critical zone science investigations of student and postdoctoral personnel.**

- a) Uranium and strontium isotope behavior in the volcanic critical zone (*McIntosh, White – Ph.D. student*);
- b) Characterization of surface to deep CZ solid-water interfaces (*Chorover, Moravec – Ph.D. student*);
- c) Equilibrium hydrogeochemistry as a function of weathering depth (*Chorover, Moravec – Ph.D. student*).
- d) Seasonal changes in linkage between microbial community composition and fluid biogeochemistry (*Gallery, Fairbanks – Ph.D. student*);
- e) Superimposed event- and landscape location controls on biogeochemistry: Hot moments in hot spots (*Gallery, Fairbanks – Ph.D. student*);
- f) Impacts of the 2013 Thompson Ridge wildfire on catchment chemical denudation (*Meixner, Sanchez – Ph.D. student*).
- g) Topographic shading control over CZ evapotranspiration (*Niu, Chang – Ph.D. student*);
- h) Coupling ecosystem water and carbon dynamics in the TIMS model of Marshall Gulch (*Niu, Chang – Ph.D. student*);
- i) Impacts of 2013 Thompson Ridge wildfire on black carbon redistribution at the catchment scale (*Chorover, Pohlmann – Ph.D. student*);
- j) CZ solute concentration profiles following wildfire (*Chorover, Pohlmann – Ph.D. student*).
- k) Postfire recovery of net ecosystem exchange fluxes of carbon and water (Litvak, Schaefer – MS student);
- l) Model integration of ParFlow-TREES with SnowPALM to simulate soil-plant hydraulics with physics-based groundwater and microclimate modeling (*Brooks, Tai – postdoctoral scientist*).

**2. Maintain regular measurements, sampling, analyses, and hence data streams that are central to the efforts of the CZO site.**

The Catalina-Jemez CZO maintains heavily instrumented research sites in the Catalina Mountains north of Tucson, AZ (Catalina) and in the Jemez Mountains north of Albuquerque, NM (Jemez). Each of these two research sites contains

several instrumented zero order basins or “ZOBs” that are equipped with sensor-sampler arrays that include (listed as extending from the upper CZ boundary to the lower CZ boundary): (i) eddy flux towers, (ii) precipitation and throughfall collectors, (iii) meteorological stations, (iv) soil moisture, temperature and matric potential sensors, (v) soil solution samplers, (vi) piezometers, (vii) groundwater monitoring wells, and (viii) surface water flumes and weirs. Arrays at each site are associated with dataloggers and autosamplers. Full time research technical staff are required to collect samples and data streams from the sites.

### 3. Continue established education and public outreach (EPO) activities.

The *Earth Science Discovery* (ESD) program at Flandrau Science Center & Planetarium continues to engage hundreds of school children annually from grades 3-6 with a basic understanding of the Critical Zone and related Earth science concepts. Many of those school groups come from underserved communities, and often, thanks to the bus funding provided in the CZO grant, the ESD fieldtrip is the first time students have visited the Science Center and the UA campus.

### 4. Ensure data accessibility and preservation, including continuing to make data available on the criticalzone.org website, and continuation of collaboration with other CZO sites on common data management and synthesis efforts.

Data collected from the sensor arrays are downloaded by internet transmission (or manual downloads by field technical personnel) to the CZO data manager, Dr. Matej Durcik, who conducts rigorous QA/QC analyses before uploading the data to the criticalzone.org website. Sample analyses are entered into a google.doc permitted to laboratory personnel, which is then transmitted to Durcik for uploading to the criticalzone.org website. Durcik’s time dedicated to the CZO project is crucial to making the CZO data publicly available. He is also actively engaged in publishing CZO data with associated DOIs in a timely fashion. Finally, Durcik is one of a network-wide group of CZO data managers that is working on developing cross-CZO data products. Durcik’s contribution has been to develop a cross-CZO data product on CZ gas phase composition (CO<sub>2</sub> and O<sub>2</sub>) that compares the depth profiles of these gasses across the network. These efforts will be continued and completed during the supplement period.

### 5. Complete projects of current graduate students and postdoctoral scientists, including associated theses, and submit manuscripts for publication.

Our CZO grant supports six Ph.D. and one M.S. students who are on track to defend their dissertations during the one year supplement period. These students include Liling Chang, Dawson Fairbanks, Bryan Moravec, Michael Pohlmann, Andres Sanchez, Alissa White, and Ryan Shaeffer. The focus of the work that they will each complete prior to their graduation is indicated above.

This cohort of Ph.D. students and postdoc will complete manuscripts to be submitted for publication prior to 11/30/20 that correspond to each of the topics discussed under part 1 of the work summary above.

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## Products

### Books

#### Book Chapters

Breshears D.D., Field J.P., Law D.J., Villegas J.C., Allen C.D., Cobb N.S., and Bradford J.S. (2019). Rapid broad-scale ecosystem changes and their consequences for biodiversity. [Chapter 7]. *Biodiversity and Climate Change: Transforming the Biosphere* T. E. Lovejoy & L. Hannah, Eds.. Yale University Press. 80-90. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Gonzalez P., Garfin G.M., Breshears D.D., Brooks K.M., Brown H.E., Elias E.H., Gunasekara A., Huntly N., Maldonado J.K., Mantua N.J., Margolis H.G., McAfee S., Middleton B.R., and Udall B.H. (2018). Southwest [Chapter 25]. *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment* Volume 2. Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.). U.S. Global Change Research Program. Washington, DC, USA. 1101-1184. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Heckman, K, LT Strand, C Rasmussen (2017). Role of mineralogy and climate in the soil carbon cycle. *Developments in Soil Science* 35. WR Horwath and Y Kuzyakov. Elsevier. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes



Heckman, K. and C. Rasmussen (2018). Mineral and climate controls on soil carbon stabilization.. *Climate Change Impacts on Soil Processes and Ecosystem Properties* W.R. Horwath and Y. Kuzyakov. Elsevier. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

## Inventions

### Journals or Juried Conference Papers

Barnard, D., J. Knowles, H. Barnard, M. Goulden, J. Hu, M. Litvak, and N. Molotch (2018). Reevaluating growing season length controls on net ecosystem production in evergreen conifer forests. *Nature Scientific Reports*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1038/s41598-018-36065-0

Breshears D.D., Carroll C.J.W., Redmond M.D., Wion A., Allen C.D., Cobb N.S., Meneses N., Field J.P., Wilson L.A., Law D.J., McCabe L.M., and Newell-Bauer O. (2018). A dirty dozen ways to die: Metrics and modifiers of mortality driven by drought and warming for a tree species.. *Frontiers in Forests and Global Change*. 1 (4), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.3389/ffgc.2018.00004

C. Rasmussen, H. Throckmorton, G. Liles, K. Heckman, S. Meding and W.R. Horwath. (2018). Controls on soil organic carbon partitioning and stabilization in the California Sierra Nevada. *Soil Syst*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER: <https://doi.org/10.3390/soilsystems2030041>

C. Rasmussen, K. Heckman, WR Wieder, M Keiluweit, CR Lawrence, Asmeret Asefaw Berhe, JC Blankinship, SE Crow, JL Druhan, CE Hicks Pries, E Marin-Spiotta, AF Plante, C Schädel, JP Schimel, CA Sierra, A Thompson, R Wagai (2018). Beyond clay: towards an improved set of variables for predicting soil organic matter content. *Biogeochemistry*. 137 297-306. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Chang, L.-L., Dwivedi, R., Knowles, J. F., Fang, Y.-H., Niu, G.-Y., Pelletier, J. D., et al. (2018). Why Do Large-Scale Land Surface Models Produce a Low Ratio of Transpiration to Evapotranspiration?. *Journal of Geophysical Research: Atmospheres*. 123 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER: <https://doi.org/10.1029/2018JD029159>

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- Ravindra Dwivedi, Thomas Meixner, Jennifer McIntosh, Paul A. "Ty" Ferré, Christopher J. Eastoe, Guo-Yue Niu, Rebecca L. Minor, Greg Barron-Gafford, and Jon Chorover (2019). Hydrologic functioning of the deep Critical Zone and contributions to streamflow in a high elevation catchment: testing of multiple conceptual models. *Hydrological Processes - Special issue: Water in the Critical Zone*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/hyp.13363

## Licenses

### Other Conference Presentations / Papers

Dwivedi, R., T. Meixner, J. McIntosh, P. A. T. Ferre, C. Eastoe, C. Castro, W. E. Wright, G.-Y. Niu, R. Minor, J. Knowles, G. A. Barron-Gafford, N. Abramson, B. Mitra, M. Stanley, and J. Chorover (2018). *An improved and practical approach for estimating catchment-scale response functions through power spectral analysis*. AGU Fall meeting. Washington, D. C.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

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## Other Products

### Databases.

Dataset usage: 1453 unique users downloaded 19725 data files from the Catalina-Jemez datasets published on the CZO website for one-year period from 7/1/2018 to 6/30/2019.

Last year were collected, quality controlled and processed from sensors and chemical analysis more than 20 million data values. More than 161 million data values are currently stored in the database.

*Fig The number of data values collected and stored in the Catalina-Jemez database every year.*

67 datasets have been published on the Catalina-Jemez website (<http://criticalzone.org/catalina-jemez/data/>), which includes: 4 new datasets added last year (shallow wells depth and temperature data from the 2011 and 2103 Burned ZOBs, the 2013 Burned ZOB deep wells depth, temperature, and ground water chemistry) and 7 CZO Network (National) datasets. These datasets include combined common data variables from all CZOs and were assembled by data managers from each CZO in summer 2017.

88 new data files were added to the CZO data website last and totally 719 data files were published in the CZO data display format and GIS standard formats such as ArcGIS shapefile and GeoTIFF. All published datasets are periodically updated after data are processed and quality controlled.

4939 samples were registered in the SESAR (the System for Earth Sample Registration, <http://www.geosamples.org/>) and assigned IGSNs (International Geo Sample Number). These samples include 2 cores, 19 core sections, 79 terrestrial sections, 1093 individual samples, 11 specimens, 3653 liquid samples, 19 chemical fractions and 63 sites.

13 geochemistry and soil solution chemistry datasets were published and assigned DOI in the EarthChem Library (<http://www.earthchem.org/library>) which includes 2 new datasets published last year. The total number of downloads for Catalina-Jemez datasets from the EarthChem library was 43.

More than 9.7 million data values for 17 sites were uploaded to the ODM2Admin managed by CUAHSI (<http://odm2admin.cuahsi.org/CJCZO/mapdata.html>).

Previously published in data:

More than 12.8 million data values have been added to the CUAHSI HIS HydroClient (<http://data.cuahsi.org/>). These data are available for download via the CUAHSI HIS HydroClient or 2 Catalina-Jemez CZO registered data services ([http://hiscentral.cuahsi.org/pub\\_network.aspx?n=158](http://hiscentral.cuahsi.org/pub_network.aspx?n=158) and [http://hiscentral.cuahsi.org/pub\\_network.aspx?n=177](http://hiscentral.cuahsi.org/pub_network.aspx?n=177)).

Previously published datasets in data repositories with DOI:

One Jemez stream water chemistry dataset was published in the HydroShare (<https://www.hydroshare.org/>),

3 Jemez River basin LiDAR datasets were published in the OpenTopography (<http://www.opentopography.org/>).

3 Valles Caldera (Jemez River basin) flux tower datasets were added to the AmeriFlux network (<http://ameriflux.lbl.gov/>).

## Other Publications

## Patents

### Technologies or Techniques

#### Thesis/Dissertations

1. Dwivedi, R.. *An improved understanding of ecohydrological and geochemical functioning of a mountainous site using multiple methods and multiple tracers.* (2019). Hydrology and Atmospheric Sciences, University of Arizona.

Acknowledgement of Federal Support = Yes

Dwivedi, R. *An improved understanding of ecohydrological and geochemical functioning of a mountainous site using multiple methods and multiple tracers.* (2019). The University of Arizona. Acknowledgement of Federal Support = Yes

Christopher Shepard. *Understanding Quaternary soil formation using a synthesis of soil chronosequences.* (2018). University of Arizona. Acknowledgement of Federal Support = Yes

Shepard, C.. *Understanding soil formation and survival in Southeastern Arizona.* (2018). The University of Arizona.

Acknowledgement of Federal Support = Yes

#### Websites

##### CZO Website

<http://criticalzone.org/catalina-jemez/>

The CZO website (<http://criticalzone.org/catalina-jemez/>) usage: 5817 opened sessions by 4378 users which includes 3938 new users for one year period from 7/1/2018 to 6/30/2019. Users viewed 13358 webpages.

Topmost viewed webpages are: data and dataset listings (15.4 %), publications (13.9%), infrastructure and field areas (11.9%), homepage (9.3 %), and models (2.9%).

The CZO website is accessed by users from around the world and mostly from these countries: USA (2094), India (210), UK (201), China (163), Brazil (119), and Germany (89).

## Participants/Organizations

### What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Chorover, Jon	PD/PI	1
Breshears, David	Co PD/PI	1
McIntosh, Jennifer	Co PD/PI	1
Pelletier, Jon	Co PD/PI	1
Rasmussen, Craig	Co PD/PI	1
Barron-Gafford, Greg	Co-Investigator	1
Ferré, Ty P.A.	Co-Investigator	1
Meixner, Thomas	Co-Investigator	1
Niu, Guo-Yue	Co-Investigator	1

<b>Name</b>	<b>Most Senior Project Role</b>	<b>Nearest Person Month Worked</b>
Schaap, Marcel	Co-Investigator	1
Brooks, Paul	Faculty	1
Castro, C	Faculty	1
Fidel, Rivka	Faculty	1
Gallery, Rachel	Faculty	1
Hu, Jia	Faculty	1
Litvak, Marcy	Faculty	1
Papuga, Shirley	Faculty	12
Plant, Bill	Faculty	1
Potts, Daniel	Faculty	1
Reed, Shipherd	Faculty	1
Rich, Virginia	Faculty	1
Biederman, Joel	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Field, Jason	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Harpold, Adrian	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Knowles, J.F.	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Law, Darin	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Maurer, Gregory	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Mitra, Bhaskar	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Mitra, Bhaskar	Postdoctoral (scholar, fellow or other postdoctoral position)	12



<b>Name</b>	<b>Most Senior Project Role</b>	<b>Nearest Person Month Worked</b>
Nesbitt, Lindsey	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Olshansky, Yaniv	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Sanchez-Canete, Enrique	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Swetnam, Tyson	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Trostle, Kyle	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Villegas, Juan	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Abramson, Nathan	Other Professional	12
Castle, Richard	Other Professional	12
Dhakal, Prakash	Other Professional	12
Evans, Michael	Other Professional	12
Fields, Jen	Other Professional	12
Fontes, Shiloe	Other Professional	12
Kobilka, Sara	Other Professional	12
Long, Robert	Other Professional	12
Losleben, Mark	Other Professional	12
McNamee, Gergory	Other Professional	12
McSweeney, Neil	Other Professional	12
Parmenter, Robert	Other Professional	12
Ruiz, Ruben	Other Professional	12
Hamann, Lejon	Technician	12
Minor, Rebecca	Technician	12

<b>Name</b>	<b>Most Senior Project Role</b>	<b>Nearest Person Month Worked</b>
Stanley, M.	Technician	12
Wright, W. E.	Technician	12
Durcik, Matej	Staff Scientist (doctoral level)	12
Eastoe, Christopher	Staff Scientist (doctoral level)	12
Furst, Jonathan	Staff Scientist (doctoral level)	12
Hensley, Noel	Staff Scientist (doctoral level)	12
Balocchi, Francisco	Graduate Student (research assistant)	6
Barnes, Mallory	Graduate Student (research assistant)	6
Cao, Rong	Graduate Student (research assistant)	6
Chang, Liling	Graduate Student (research assistant)	6
Coe, Michelle	Graduate Student (research assistant)	6
Colella, Tony	Graduate Student (research assistant)	6
Dwivedi, Ravindra	Graduate Student (research assistant)	6
Espinosa, Noelle	Graduate Student (research assistant)	6
Fairbanks, Dawson	Graduate Student (research assistant)	6
Fang, Yuanhao	Graduate Student (research assistant)	6
Fenerty, Brendan	Graduate Student (research assistant)	6
Howe, Amanda	Graduate Student (research assistant)	6
Kidder, Amy	Graduate Student (research assistant)	6
Kopp, Emily	Graduate Student (research assistant)	6
Logie, Cianna	Graduate Student (research assistant)	6
Lybrand, Rebecca	Graduate Student (research assistant)	6
Mann, Sarina	Graduate Student (research assistant)	6
McClure, Brianna	Graduate Student (research assistant)	6

<b>Name</b>	<b>Most Senior Project Role</b>	<b>Nearest Person Month Worked</b>
Paras, Ben	Graduate Student (research assistant)	6
Pohlmann, Michael	Graduate Student (research assistant)	6
Sanchez, Rodrigo	Graduate Student (research assistant)	6
Shepard, Christopher	Graduate Student (research assistant)	6
Solis, Jesus	Graduate Student (research assistant)	6
White, Alissa	Graduate Student (research assistant)	6
Wilson, Zinnia	Graduate Student (research assistant)	6
Wu, Runjian	Graduate Student (research assistant)	6
Yuanhao, Fang	Graduate Student (research assistant)	6
Law, Darin	Non-Student Research Assistant	12
Aldama, Phoenix	Undergraduate Student	3
Bergeron, Hannah	Undergraduate Student	3
Blackett, Daniel	Undergraduate Student	3
Bloodsworth, Jasper	Undergraduate Student	3
Blum, Aidan	Undergraduate Student	3
Bohlman, Melissa	Undergraduate Student	3
Bojorquez Ochoa, Mirsa	Undergraduate Student	3
Boyer, Jessica	Undergraduate Student	3
Braun, Zev	Undergraduate Student	3
Caballero-Reynolds, Marci	Undergraduate Student	3
Cagle, Curtis	Undergraduate Student	3
Callahan, Nick	Undergraduate Student	3
Canez, Tiffani	Undergraduate Student	3

<b>Name</b>	<b>Most Senior Project Role</b>	<b>Nearest Person Month Worked</b>
Carrera, Anahi	Undergraduate Student	3
Chen, Zhao	Undergraduate Student	3
Cook, Chelsea	Undergraduate Student	3
Custer, Joy	Undergraduate Student	3
Fennie, Elizabeth	Undergraduate Student	3
Garlant, James	Undergraduate Student	3
Green, Katlyn	Undergraduate Student	3
Griffin, Nakayla	Undergraduate Student	3
Guan, Janelle	Undergraduate Student	3
Hall, Becky	Undergraduate Student	3
Hamann, Lejon	Undergraduate Student	3
Harders, Sara	Undergraduate Student	3
Herndon, Carly	Undergraduate Student	3
Heydorn, Katherine	Undergraduate Student	3
Hoskinson, Joshua	Undergraduate Student	3
Iniguez, Isaiah	Undergraduate Student	3
Keifer, Violeta	Undergraduate Student	3
Kelly, Andrew	Undergraduate Student	3
Kong, Tianshu	Undergraduate Student	3
Lark, Callie	Undergraduate Student	3
Madinger, Alyssa	Undergraduate Student	3
Mello, John	Undergraduate Student	3
Perez, Angela	Undergraduate Student	3
Reynoso, Erick	Undergraduate Student	3

<b>Name</b>	<b>Most Senior Project Role</b>	<b>Nearest Person Month Worked</b>
Riedel, Catherine	Undergraduate Student	3
Rincon, Michelle	Undergraduate Student	3
Schwartz, Dina	Undergraduate Student	3
Smith, Rebecca	Undergraduate Student	3
Snyder, Maria	Undergraduate Student	3
Sorrentino, Lexie	Undergraduate Student	3
Taylor, Bridget	Undergraduate Student	3
Thompson, Mychel	Undergraduate Student	3
Valenzuela, Allie	Undergraduate Student	3
Van Dop, Molly	Undergraduate Student	3
Weber, Nicole	Undergraduate Student	3
Weber, Adam	Undergraduate Student	3
Wilson, Luke	Undergraduate Student	3
Wilson, Charles	Undergraduate Student	3
Wolsiffer, Sarah	Undergraduate Student	3
Yang, Julia	Undergraduate Student	3

#### Full details of individuals who have worked on the project:

**Jon D Chorover**

**Email:** chorover@email.arizona.edu

**Most Senior Project Role:** PD/PI

**Nearest Person Month Worked:** 1

**Contribution to the Project:** PI

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

**David D Breshears**

**Email:** daveb@email.arizona.edu

**Most Senior Project Role:** Co PD/PI  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Co-PI

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Jennifer C McIntosh**

**Email:** mcintosh@hwr.arizona.edu  
**Most Senior Project Role:** Co PD/PI  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Co-PI

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Jon D Pelletier**

**Email:** jdpellet@email.arizona.edu  
**Most Senior Project Role:** Co PD/PI  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Co PI

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Craig Rasmussen**

**Email:** crasmuss@cals.arizona.edu  
**Most Senior Project Role:** Co PD/PI  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Co-PI

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Greg Barron-Gafford**

**Email:** gregbg@email.arizona.edu  
**Most Senior Project Role:** Co-Investigator  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Assistant Professor and Ecosystem Ecologist

**Funding Support:** NSF and other

**International Collaboration:** No  
**International Travel:** No

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**Ty P.A. Ferré**

**Email:** tyferre@gmail.com

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Professor and Hydrogeophysicist

**Funding Support:** NSF and other

**International Collaboration:** No

**International Travel:** No

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**Thomas Meixner**

**Email:** tmeixner@email.arizona.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Professor and Catchment Hydrologist/Biogeochemist

**Funding Support:** NSF and other

**International Collaboration:** No

**International Travel:** No

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**Guo-Yue Niu**

**Email:** niug@email.arizona.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Assistant Professor and Land-Atmosphere Exchange Modeler

**Funding Support:** NSF and other

**International Collaboration:** No

**International Travel:** No

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**Marcel Schaap**

**Email:** mschaap@cals.arizona.edu

**Most Senior Project Role:** Co-Investigator

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Associate Professor and Soil Physicist

**Funding Support:** NSF and other

**International Collaboration:** No

**International Travel:** No

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**Paul Brooks**

**Email:** paul.brooks@utah.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Snow hydrology

**Funding Support:** DOE and this award

**International Collaboration:** Yes, Sweden

**International Travel:** No

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**C Castro**

**Email:** ccastro@email.arizona.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Professor

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Rivka Fidel**

**Email:** rfidel@email.arizona.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Instructor for a new CZ Science course in Environmental Science Department

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Rachel Gallery**

**Email:** rgallery@email.arizona.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Soil microbial ecologist

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Jia Hu**

**Email:** jiahu@email.arizona.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Assistant Professor

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Marcy Litvak****Email:** mlitvak@unm.edu**Most Senior Project Role:** Faculty**Nearest Person Month Worked:** 1**Contribution to the Project:** Eddy covariance measurements**Funding Support:** Ameriflux Core support (160 hours), DOE TES (80 hours), NSF LTER (80 hours)**International Collaboration:** No**International Travel:** No**Shirley A Papuga****Email:** shirley.papuga@wayne.edu**Most Senior Project Role:** Faculty**Nearest Person Month Worked:** 12**Contribution to the Project:** Associate Professor**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Bill Plant****Email:** wplant@email.arizona.edu**Most Senior Project Role:** Faculty**Nearest Person Month Worked:** 1**Contribution to the Project:** Education and outreach**Funding Support:** NSF and other**International Collaboration:** No**International Travel:** No**Daniel Potts****Email:** pottsdl@buffalostate.edu**Most Senior Project Role:** Faculty**Nearest Person Month Worked:** 1**Contribution to the Project:** Daniel has performed work in the area of plant ecophysiology - developing an understanding of the physiological constraints of the tree community around the Mt. Bigelow eddy covariance tower site.**Funding Support:** Daniel is faculty of Buffalo State College**International Collaboration:** No**International Travel:** No**Shipherd Reed****Email:** shipherd@email.arizona.edu**Most Senior Project Role:** Faculty**Nearest Person Month Worked:** 1**Contribution to the Project:** Education and Public Outreach Lead

**Funding Support:** NSF and other

**International Collaboration:** No

**International Travel:** No

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**Virginia Rich**

**Email:** virginia.isabel.rich@gmail.com

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Microbial ecologist

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Joel Biederman**

**Email:** joel.biederman.ua@gmail.com

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Research scientist

**Funding Support:** NSF & Other

**International Collaboration:** No

**International Travel:** No

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**Jason Field**

**Email:** jpfield@email.arizona.edu

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** postdoctoral scientist

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Adrian Harpold**

**Email:** adrian.harpold@gmail.com

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** postdoctoral scientist

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**J.F. Knowles**

**Email:** johnknowles@email.arizona.edu

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Postdoctoral researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Darin J Law**

**Email:** djlaw@email.arizona.edu

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Gregory Maurer**

**Email:** gregmaurer@gmail.com

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Has performed work in the area of keeping the flux towers running and data processed.

**Funding Support:** Ameriflux Core support

**International Collaboration:** No

**International Travel:** No

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**Bhaskar Mitra**

**Email:** ghaskar.mitra6@gmail.com

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Post doctoral research scientist

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Bhaskar Mitra**

**Email:** bhaskar.mitra6@gmail.com

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** postdoc

**Funding Support:** NSF and other

**International Collaboration:** No  
**International Travel:** No

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**Lindsey Nesbitt**

**Email:** lindseychr@gmail.com

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Coupled water and biogeochemical modeling

**Funding Support:** DOE and other NSF

**International Collaboration:** No  
**International Travel:** No

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**Yaniv Olshansky**

**Email:** yanivo@email.arizona.edu

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Postdoctoral researcher

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Enrique Sanchez-Canete**

**Email:** enripsc@ugr.es

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** staff scientist

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Tyson Lee Swetnam**

**Email:** tswetnam@email.arizona.edu

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** postdoctoral scientist LiDAR analysis

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Kyle Trostle**

**Email:** ktrostle@email.arizona.edu

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** CZO postdoc led concentration-discharge analyses and aqueous geochemistry.

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Juan Camilo Villegas**

**Email:** villegas@email.arizona.edu

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Research Scientist Drought Effects on Trees

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Nathan Abramson**

**Email:** nabramso@email.arizona.edu

**Most Senior Project Role:** Other Professional

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Field Technician for the SCM site

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Richard Castle**

**Email:** rcastle@email.arizona.edu

**Most Senior Project Role:** Other Professional

**Nearest Person Month Worked:** 12

**Contribution to the Project:** exhibit support (Flandrau Science Center and Planetarium)

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Prakash Dhakal**

**Email:** dhakal@email.arizona.edu

**Most Senior Project Role:** Other Professional

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Laboratory Director

**Funding Support:** Other funding

**International Collaboration:** No

**International Travel:** No

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**Michael Evans****Email:** maevans@email.arizona.edu**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 12**Contribution to the Project:** Media technician (School of Journalism)**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Jen Fields****Email:** fieldsj@email.arizona.edu**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 12**Contribution to the Project:** Giving advice as Staff, Director of Education for CZ Discovery development meetings, we provided CZ activities for some of the UA Fusion summer camps that she manages. Has performed work by providing advice and expertise on K-12 educational activities for the CZ Discovery program.**Funding Support:** Staff at Flandrau Science Center, no CZO funding, volunteered her time.**International Collaboration:** No**International Travel:** No**Shiloe Fontes****Email:** sfontes@email.arizona.edu**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 12**Contribution to the Project:** graphic design/exhibit support (Flandrau Science Center and Planetarium)**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Sara Kobilka****Email:** kobilka@email.arizona.edu**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 12**Contribution to the Project:** Provided coordination with schedule and camp counselors to pilot some of the CZ Discovery activities. She is staff, summer camp coordinator.**Funding Support:** Staff at UA Fusion Camp (Flandrau summer camp), no CZO funding. Volunteers time.**International Collaboration:** No**International Travel:** No**Robert Long****Email:** bobby@nearsightgraphite.com**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 12

**Contribution to the Project:** exhibit support/illustration

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Mark Losleben**

**Email:** losleben@email.arizona.edu

**Most Senior Project Role:** Other Professional

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Field Research Technician for JRB site

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Gergory McNamee**

**Email:** gregorymcnamee@gmail.com

**Most Senior Project Role:** Other Professional

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Science writer (Economics Dept)

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Neil McSweeney**

**Email:** mcsweene@email.arizona.edu

**Most Senior Project Role:** Other Professional

**Nearest Person Month Worked:** 12

**Contribution to the Project:** exhibit support (Flaundrau Science Center and Planetarium)

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Robert Parmenter**

**Email:** bparmenter@vallescaldera.gov

**Most Senior Project Role:** Other Professional

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Project Site coordination, presentation of results from CZO group to agencies and general public.

**Funding Support:** As a Federal Employee (Director, Scientific Services Division VCNP) salary is covered by the U.S. Government.

**International Collaboration:** No

**International Travel:** No

**Ruben Ruiz****Email:** rubelruiz@gmail.com**Most Senior Project Role:** Other Professional**Nearest Person Month Worked:** 12**Contribution to the Project:** classified part-time staff - videography**Funding Support:** NSF and other**International Collaboration:** No**International Travel:** No

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**Lejon Hamann****Email:** lejonhamann@gmail.com**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 12**Contribution to the Project:** Hydrologic Technician**Funding Support:** NSF**International Collaboration:** No**International Travel:** No

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**Rebecca Minor****Email:** rminor@email.arizona.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 12**Contribution to the Project:** Research Technician Eddy Covariance in SCM**Funding Support:** NSF**International Collaboration:** No**International Travel:** No

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**M. Stanley****Email:** lemmonh2o@aol.com**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 12**Contribution to the Project:** Water Manager**Funding Support:** NSF**International Collaboration:** No**International Travel:** No

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**W. E. Wright****Email:** wew@email.arizona.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 12**Contribution to the Project:** Staff in the Laboratory of Tree-Ring Research



**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Matej Durcik**

**Email:** mdurcik@email.arizona.edu

**Most Senior Project Role:** Staff Scientist (doctoral level)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Data manager

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Christopher J Eastoe**

**Email:** eastoe@email.arizona.edu

**Most Senior Project Role:** Staff Scientist (doctoral level)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Insert

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Jonathan Furst**

**Email:** jfurst@unm.edu

**Most Senior Project Role:** Staff Scientist (doctoral level)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Has performed work in the area of keeping the flux towers running and data processed.

**Funding Support:** Ameriflux Core support

**International Collaboration:** No

**International Travel:** No

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**Noel Hensley**

**Email:** mnhensley@email.arizona.edu

**Most Senior Project Role:** Staff Scientist (doctoral level)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Education Program Coordinator

**Funding Support:** NA

**International Collaboration:** No

**International Travel:** No

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**Francisco Balocchi**

**Email:** fbalocchi@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Is working on understanding the hydrologic processes operating during snowmelt that induce either infiltration or runoff.

**Funding Support:** Funded by the nation of Chile.

**International Collaboration:** Yes, Chile

**International Travel:** No

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**Mallory Barnes**

**Email:** mallorybarnes@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Rong Cao**

**Email:** rongcao@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Graduate student - research assistant

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Liling Chang**

**Email:** lchang@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** graduate research assistant

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Michelle Coe**

**Email:** macoe@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Michelle Coe has performed work towards our Broader Impacts in terms of leading in-class activities with elementary students.

**Funding Support:** NASA Space Grant Fellowship

**International Collaboration:** No

**International Travel:** No

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**Tony Colella**

**Email:** tonycollella@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Ravindra Dwivedi**

**Email:** ravindradowivedi@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Has worked on understanding the origins and mechanisms for residence time distribution functions in fractured rock systems

**Funding Support:** This award and teaching assistantship

**International Collaboration:** No

**International Travel:** No

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**Noelle Espinosa**

**Email:** noellee@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Dawson Fairbanks**

**Email:** dawsonfairbanks@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Has contributed outreach experience and topic expertise to the development of the CZ Discovery activities, will give time to activity delivery. Also has performed work in the area of soil microbial ecology including a number of field campaigns to CZO sites to characterize and collect soils samples, laboratory assays of microbial exoenzyme activity, microbial biomass Carbon and Nitrogen quantification, DNA extractions and quality control, data analysis, and manuscript preparation.

**Funding Support:** She is a grad student on CZO. Sloan Indigenous Graduate Partnership Fellowship.

**International Collaboration:** No

**International Travel:** No

**Yuanhao Fang****Email:** yhfang@email.arizona.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** Has performed modeling of the topographic shading effects on snow and runoff**Funding Support:** Chinese National Science Foundation (CNSF) visiting scholar**International Collaboration:** Yes, China**International Travel:** No

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**Brendan Fenerty****Email:** bfenerty@email.arizona.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** student researcher**Funding Support:** NSF**International Collaboration:** No**International Travel:** No

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**Amanda Howe****Email:** amandahowe@email.arizona.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** Insert**Funding Support:** NSF**International Collaboration:** No**International Travel:** No

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**Amy Kidder****Email:** akidder@email.arizona.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** Ecohydrological assessment of changes in distribution of endangered Pima Pineapple Cactus, including potential migration across Catalinas of Jemez-Catalina gradient.**Funding Support:** Raytheon**International Collaboration:** No**International Travel:** No

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**Emily Kopp****Email:** ekopp@optics.arizona.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6**Contribution to the Project:** SWES graduate student

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Cianna Logie**

**Email:** clogie@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** M.S. student

**Funding Support:** NSF and other

**International Collaboration:** No

**International Travel:** No

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**Rebecca Lybrand**

**Email:** rlybrand@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D. student, now faculty at OSU

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Sarina Mann**

**Email:** sarinanmann@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Graduate research assistant

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Brianna McClure**

**Email:** briannamcclure@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Has worked on impact of fire on DOM indices and whether fire effects DOM quality and quantity.

**Funding Support:** teaching assistantship

**International Collaboration:** No

**International Travel:** No

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**Ben Paras**

**Email:** bkp@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Subsurface imaging with geophysics

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Michael Pohlmann**

**Email:** mapohlmann@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D. student focused on fire effects

**Funding Support:** NSF and other

**International Collaboration:** No

**International Travel:** No

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**Rodrigo Andres Sanchez**

**Email:** andressanchez@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** MS student

**Funding Support:** Other

**International Collaboration:** No

**International Travel:** No

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**Christopher Shepard**

**Email:** cbs9h@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Has performed work in the area of soil modeling

**Funding Support:** NSF and University Fellows program through UA graduate college

**International Collaboration:** No

**International Travel:** No

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**Jesus Solis**

**Email:** solisleo@email.arizona.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Graduate research assistant

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Alissa White**

**Email:** alissawhite@email.arizona.edu  
**Most Senior Project Role:** Graduate Student (research assistant)  
**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D. student

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Zinnia Wilson**

**Email:** zinnia.wilson@utah.edu  
**Most Senior Project Role:** Graduate Student (research assistant)  
**Nearest Person Month Worked:** 6

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Runjian Wu**

**Email:** wurunjian@email.arizona.edu  
**Most Senior Project Role:** Graduate Student (research assistant)  
**Nearest Person Month Worked:** 6

**Contribution to the Project:** graduate student

**Funding Support:** NSF and other

**International Collaboration:** No  
**International Travel:** No

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**Fang Yuanhao**

**Email:** yuanhao.fang@outlook.com  
**Most Senior Project Role:** Graduate Student (research assistant)  
**Nearest Person Month Worked:** 6

**Contribution to the Project:** Ph.D. student

**Funding Support:** NSF and other

**International Collaboration:** No  
**International Travel:** No

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**Darin Law**

**Email:** dlaw@email.arizona.edu  
**Most Senior Project Role:** Non-Student Research Assistant  
**Nearest Person Month Worked:** 12

**Contribution to the Project:** Co-author on critical zone services papers (Vadose Zone Journal and Eos); led installation of microclimate array at Mt. Bigelow

**Funding Support:** Arizona Agricultural Experiment Station

**International Collaboration:** No

**International Travel:** No

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**Phoenix Aldama**

**Email:** pjea121299@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student instructor

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Hannah Bergeron**

**Email:** hlberg12@gmail.com

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** undergraduate research technician

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Daniel Blackett**

**Email:** dblackett@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** research

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Jasper Bloodsworth**

**Email:** bloodsworth@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Insert

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Aidan Blum****Email:** aidanblum@email.arizona.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** Processing water samples for the CZO project. Also raqn samples for water stable isotopes on the isotope analyzer.**Funding Support:** NSF and TRIF**International Collaboration:** No**International Travel:** No**Melissa Bohlman****Email:** mbohlman1@email.arizona.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** student researcher with critical zone discovery**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Mirsa Bojorquez Ochoa****Email:** m.holly.boom@gmail.com**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** Undergraduate student researcher with critical zone discovery**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Jessica Cait Boyer****Email:** jcboyer@email.arizona.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** student researcher**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Zev Braun****Email:** braunzev@grinnell.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** undergrad student

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Marci Caballero-Reynolds**

**Email:** marcicr@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Research

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Curtis Cagle**

**Email:** curtiscagle@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** research

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Nick Callahan**

**Email:** nrcallahan@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Tiffani Canez**

**Email:** tiffanicanez@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** undergraduate student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Anahi Carrera**

**Email:** anahicarrera@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Zhao Yang Chen**

**Email:** chenzhaoyang@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** research

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Chelsea Cook**

**Email:** cmcook@email.arizona.eu

**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Joy Custer**

**Email:** joycuster@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Elizabeth Fennie**

**Email:** efennie@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**James Garland**

**Email:** garlant@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate contributing to Ecohydrology Theme - looking at sources of plant water use in our SCM Mixed Conifer Site at Mt. Bigelow.

**Funding Support:** This research is supported in salary by NSF Career Award

**International Collaboration:** No  
**International Travel:** No

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**Katlyn Green**

**Email:** katlyngreen@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Nakayla Griffin**

**Email:** nakaylagriffin@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student instructor

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Janelle Guan**

**Email:** jguan@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** undergraduate student

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Becky Hall**

**Email:** beckyh@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** post B.S. volunteer

**Funding Support:** other

**International Collaboration:** No

**International Travel:** No

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**Lejon Hamann**

**Email:** lejonhamann@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Sara Harders**

**Email:** saraharders@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Carly Herndon**

**Email:** carlyherndon@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Katherine Heydorn**

**Email:** kheydorn@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** undergrad student researcher

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Joshua Hoskinson**

**Email:** jhoskinson@emai.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Has performed work in the area of soil minerology

**Funding Support:** NASA Space Grant

**International Collaboration:** No  
**International Travel:** No

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**Isaiah Iniguez**

**Email:** isaiahininguez@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student instructor

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Violeta Keifer**

**Email:** vkeifer@bates.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student researcher

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Andrew Kelly**

**Email:** akelley1@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student instructor

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Tianshu Kong**

**Email:** tianshukong@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student instructor

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Callie Lark**

**Email:** callielark@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student instructor

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Alyssa Madinger**

**Email:** amadinger@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**John Mello**

**Email:** melloj@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student instructor

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Angela Perez**

**Email:** angelaiperez@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student instructor

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Erick Reynoso****Email:** edreynoso@miners.utep.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** undergraduate student researcher**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Catherine Riedel****Email:** catherineridel@email.arizona.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** student researcher**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Michelle Rincon****Email:** michellerincon@email.arizona.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** student researcher**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Dina Schwartz****Email:** dschwartz4@email.arizona.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** Undergraduate student instructor**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Rebecca Smith****Email:** rkramersmith@gmail.com**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** Laboratory and data analyses**Funding Support:** DOE and other NSF



**International Collaboration:** No  
**International Travel:** No

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**Maria Snyder**

**Email:** msnyder2@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** research

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Lexie Sorrentino**

**Email:** lexiesorrentino@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student instructor

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Bridget Taylor**

**Email:** bridgettaylor@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Insert

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Mychel Thompson**

**Email:** m.thompson@student.navajotech.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No  
**International Travel:** No

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**Allie Valenzuela**

**Email:** allievalenzuela@email.arizona.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Undergraduate student instructor

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Molly Van Dop**

**Email:** mvandop@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** undergraduate student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Nicole Weber**

**Email:** nweber@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** student researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Adam Weber**

**Email:** adamweber@email.arizona.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** research

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Luke Wilson**

**Email:** luk2@okstatemail.oks

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** researcher

**Funding Support:** NSF

**International Collaboration:** No

**International Travel:** No

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**Charles Wilson****Email:** cawilson@email.arizona.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** student researcher**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Sarah Wolsiffer****Email:** sarahwolsiffer@email.arizona.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** student researcher**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**Julia Yang****Email:** juj.yang@gmail.com**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** undergraduate student researcher**Funding Support:** NSF**International Collaboration:** No**International Travel:** No**What other organizations have been involved as partners?**

<b>Name</b>	<b>Type of Partner Organization</b>	<b>Location</b>
Arizona State University	Academic Institution	Tempe, AZ
Center for Earth and Environmental Isotope Research (CEEIR)	Academic Institution	University of Texas at El Paso
Los Alamos National Laboratory	Industrial or Commercial Firms	New Mexico
Miranda Redmond	Academic Institution	Colorado State University
Northern Arizona University	Academic Institution	Flagstaff, AZ
Stanford Synchrotron Radiation Lightsource (SSRL)	Academic Institution	Stanford University
State University of New York	Academic Institution	Buffalo, NY

Name	Type of Partner Organization	Location
Travis Huxman	Academic Institution	University of California, Irvine
Tucson Unified School District	School or School Systems	Tucson, AZ
USDA-Agricultural Research Services Southwest Watershed	State or Local Government	Southwest
USGS	State or Local Government	New Mexico
University of Georgia	Academic Institution	Athens, GA
Cornell University	Academic Institution	Ithaca, NY
University of New Mexico	Academic Institution	Albuquerque, NM
University of Texas at El Paso	Academic Institution	El Paso, Texas
University of Utah	Academic Institution	Utah
Valles Caldera National Preserve	Other Organizations (foreign or domestic)	Jemez Springs, NM
Hartwick College	Academic Institution	Hartwick, NY
Institut de Physique du Globe de Paris	Academic Institution	France
J Craig Venter Institute	Academic Institution	Rockville, MD
John Bradford	State or Local Government	Flagstaff, AZ
Kyoto Prefecture University	Academic Institution	Kyoto, Japan
LacCore	Academic Institution	University of Minnesota
Los Alamos National Laboratory	Other Organizations (foreign or domestic)	Los Alamos, NM

#### Full details of organizations that have been involved as partners:

##### Arizona State University

**Organization Type:** Academic Institution

**Organization Location:** Tempe, AZ

##### Partner's Contribution to the Project:

Collaborative Research

Personnel Exchanges

**More Detail on Partner and Contribution:** ASU personnel including Arjun Heimsath and coworkers are conducting collaborative research in the SCM CZO.

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**Center for Earth and Environmental Isotope Research (CEEIR)****Organization Type:** Academic Institution**Organization Location:** University of Texas at El Paso**Partner's Contribution to the Project:**

Facilities

**More Detail on Partner and Contribution:** U-series and Sr isotope analysis was conducted at Dr. Lin Ma's lab.

---

**Cornell University****Organization Type:** Academic Institution**Organization Location:** Ithaca, NY**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Through PI Louis Derry, Cornell University is conducting geochemical research at the SCM-JRB CZO.

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**Hartwick College****Organization Type:** Academic Institution**Organization Location:** Hartwick, NY**Partner's Contribution to the Project:**

Personnel Exchanges

**More Detail on Partner and Contribution:** Dr. Zsuzsanna Balogh-Brunstad, Associate Professor in Geosciences and Chemistry, is conducting her sabbatical at the University of Arizona, working in the CZO. Her research focus is on fungal mediated weathering processes.

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**Institut de Physique du Globe de Paris****Organization Type:** Academic Institution**Organization Location:** France**Partner's Contribution to the Project:**

Facilities

Collaborative Research

**More Detail on Partner and Contribution:** Collaboration on the use of silicon isotopes for weathering processes in the critical zone

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**J Craig Venter Institute****Organization Type:** Academic Institution**Organization Location:** Rockville, MD**Partner's Contribution to the Project:**

Facilities

**More Detail on Partner and Contribution:** Collaboration on microbial genomics analyses

**John Bradford**

**Organization Type:** State or Local Government

**Organization Location:** Flagstaff, AZ

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** ecohydrological modelings

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**Kyoto Prefecture University**

**Organization Type:** Academic Institution

**Organization Location:** Kyoto, Japan

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Dr. Atsushi Nakao, professor from the Department of Geosciences at KFU is conducting his sabbatical at University of Arizona and focusing his research on the CZO. His focus is on the role of climate in mica weathering processes.

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**LacCore**

**Organization Type:** Academic Institution

**Organization Location:** University of Minnesota

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Detailed analysis of cores.

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**Los Alamos National Laboratory**

**Organization Type:** Other Organizations (foreign or domestic)

**Organization Location:** Los Alamos, NM

**Partner's Contribution to the Project:**

Facilities

Collaborative Research

Personnel Exchanges

**More Detail on Partner and Contribution:** Los Alamos National Laboratory loans field based equipment to the JRB-SCM CZO that is associated with our eddy covariance and ecohydrologic studies.

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**Los Alamos National Laboratory**

**Organization Type:** Industrial or Commercial Firms

**Organization Location:** New Mexico

**Partner's Contribution to the Project:**

Facilities

**More Detail on Partner and Contribution:**

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**Miranda Redmond****Organization Type:** Academic Institution**Organization Location:** Colorado State University**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** pinyon pine mortality synthesis

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**Northern Arizona University****Organization Type:** Academic Institution**Organization Location:** Flagstaff, AZ**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** experimental synthesis

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**Stanford Synchrotron Radiation Lightsource (SSRL)****Organization Type:** Academic Institution**Organization Location:** Stanford University**Partner's Contribution to the Project:**

Facilities

**More Detail on Partner and Contribution:** Quantitative mineralogy of cores

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**State University of New York****Organization Type:** Academic Institution**Organization Location:** Buffalo, NY**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

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**Travis Huxman****Organization Type:** Academic Institution**Organization Location:** University of California, Irvine**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** experimental synthesis

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**Tucson Unified School District****Organization Type:** School or School Systems**Organization Location:** Tucson, AZ

**Partner's Contribution to the Project:**

Facilities

**More Detail on Partner and Contribution:**

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**USDA-Agricultural Research Services Southwest Watershed****Organization Type:** State or Local Government**Organization Location:** Southwest**Partner's Contribution to the Project:**

Facilities

**More Detail on Partner and Contribution:**

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**USGS****Organization Type:** State or Local Government**Organization Location:** New Mexico**Partner's Contribution to the Project:**

Facilities

**More Detail on Partner and Contribution:**

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**University of Georgia****Organization Type:** Academic Institution**Organization Location:** Athens, GA**Partner's Contribution to the Project:**

Personnel Exchanges

**More Detail on Partner and Contribution:** Summer field course session at Jemez CZO

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**University of New Mexico****Organization Type:** Academic Institution**Organization Location:** Albuquerque, NM**Partner's Contribution to the Project:**

Financial support

Facilities

Collaborative Research

Personnel Exchanges

**More Detail on Partner and Contribution:** Professor Marcy Litvak is a subcontracted PI focusing on eddy covariance research at the JRB site.

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**University of Texas at El Paso****Organization Type:** Academic Institution**Organization Location:** El Paso, Texas



**Partner's Contribution to the Project:**

Facilities  
Collaborative Research  
Personnel Exchanges

**More Detail on Partner and Contribution:** Collaborative research on uranium isotopes in the critical zone. Field course visit from UTEP to Jemez CZO.

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**University of Utah**

**Organization Type:** Academic Institution

**Organization Location:** Utah

**Partner's Contribution to the Project:**

Facilities

**More Detail on Partner and Contribution:**

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**Valles Caldera National Preserve**

**Organization Type:** Other Organizations (foreign or domestic)

**Organization Location:** Jemez Springs, NM

**Partner's Contribution to the Project:**

Collaborative Research  
Personnel Exchanges

**More Detail on Partner and Contribution:** Dr. Robert Parmenter of VCNP (US Forest Service) is a subcontractor on the project and assists through provision of hydrologic technician support and collaborative research.

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**What other collaborators or contacts have been involved?**

Water Resources Research Center, University of Arizona

Geological Society of America

American Geophysical Union

Salt Lake City Public Utilities

Salt River Project

Carpe Diem West

Healthy Headwaters Initiative

Weber basin Water Conservancy District

Western Water Assessment

Wassatch-Cache and Ashley National Forests

Miguel Leon - Luiquillo CZO, University of Pennsylvania

Dan Shapick - Shale Hill CZO, Pennsylvania State University

Will Cook - Calhoun CZO, Duke University

Eric Parrish - Boulder CZO, INSTAAR

David Lubinski - National CZO, INSTAAR

Collin Bode - Eel CZO, University of California

Luigi Marini - IML CZO, University of Illinois

Xiande Meng - Sierra CZO, UC Merced

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## Impacts

### What is the impact on the development of the principal discipline(s) of the project?

- The surprising finding in the JRB-CZO that deep groundwater from a fractured aquifer, rather than shallow subsurface flow from a perched aquifer, sustains stream baseflow emphasizes the necessity to better characterize the deep subsurface of high-elevation mountain systems. The physical hydrology research also highlights the need to describe such complex and specific systems to build a more robust and inclusive understanding of hydrologic systems around the world.
- The fact that most CO<sub>2</sub> evolved soil respiration is transported down gradient in dissolved form, either weathering the deep CZ or degassing upon discharge into streams, is an important result that derives from integration of flux tower measurements (Ecohydrology theme) with subsurface biogeochemistry research, and improved methods of surface water dynamics measurements.

### What is the impact on other disciplines?

- Physical hydrology research in the JRB-CZO emphasizes the utility of interdisciplinary research to discern the distribution of groundwater stores, their connection to streamflow, and the underlying impact of CZ architecture on hydrologic response to climatic drivers. Furthermore, work within the JRB-CZO serves as an integrated example of how to apply several methods to simultaneously examine both, CZ architecture and CZ hydrology, through hydrometric, geophysical, geochemical, and residence time analyses.
- Findings pertaining to soil respiration measurements have broader impacts on net ecosystem exchange measurements more generally. In so far as these measurement approaches (flux tower datasets) pertain to ecosystem sciences, the findings have implications for ecosystem scientists conducting flux tower research (also relevant to interpretations for data from NEON sites, etc.).

### What is the impact on the development of human resources?

- Catalina-Jemez CZO graduate students and postdocs, who received their primary training on our project, are now found to be highly competitive for academic and national laboratory positions. Most of our graduates have successfully secured positions in the field.

### What is the impact on physical resources that form infrastructure?

- The Catalina-Jemez Critical Zone Observatory represents a significant NSF investment in the capacity to make continuous, real time, and in situ measurements across the depth and lateral distances associated with the critical zone comprising watershed systems.
- The resources that form CZO infrastructure have been leveraged in multiple collaborative investigations, including several projects being spearheaded by PIs that are not funded by the CZO program per se. As a result, the infrastructure is being leveraged in multiple other grants and collaborative research projects.

### What is the impact on institutional resources that form infrastructure?

- The C-J CZO is utilized in multiple ways, for both research and teaching, by faculty, staff, and students at University of Arizona, University of New Mexico, University of Utah, and University of Texas at El Paso.
- The CZO sites have been primary foci of earth science field courses taught at several universities in the southwestern U.S.

## What is the impact on information resources that form infrastructure?

- The CZO website (<http://criticalzone.org/catalina-jemez/>) usage: 5817 opened sessions by 4378 users which includes 3938 new users for one year period from 7/1/2018 to 6/30/2019. Users viewed 13358 webpages.
- Topmost viewed webpages are: data and dataset listings (15.4 %), publications (13.9%), infrastructure and field areas (11.9%), homepage (9.3 %), and models (2.9%).
- The CZO website is accessed by users from around the world and mostly from these countries: USA (2094), India (210), UK (201), China (163), Brazil (119), and Germany (89).
- Dataset usage: 1453 unique users downloaded 19725 data files from the Catalina-Jemez datasets published on the CZO website for one-year period from 7/1/2018 to 6/30/2019.
- Last year were collected, quality controlled and processed from sensors and chemical analysis more than 20 million data values. More than 161 million data values are currently stored in the database.
- 67 datasets have been published on the Catalina-Jemez website (<http://criticalzone.org/catalina-jemez/data/>), which includes: 4 new datasets added last year (shallow wells depth and temperature data from the 2011 and 2103 Burned ZOBs, the 2013 Burned ZOB deep wells depth, temperature, and ground water chemistry) and 7 CZO Network (National) datasets. These datasets include combined common data variables from all CZOs and were assembled by data managers from each CZO in summer 2017.
- 88 new data files were added to the CZO data website last and totally 719 data files were published in the CZO data display format and GIS standard formats such as ArcGIS shapefile and GeoTIFF. All published datasets are periodically updated after data are processed and quality controlled.
- 4939 samples were registered in the SESAR (the System for Earth Sample Registration, <http://www.geosamples.org/>) and assigned IGSNs (International Geo Sample Number). These samples include 2 cores, 19 core sections, 79 terrestrial sections, 1093 individual samples, 11 specimens, 3653 liquid samples, 19 chemical fractions and 63 sites.
- 13 geochemistry and soil solution chemistry datasets were published and assigned DOI in the EarthChem Library (<http://www.earthchem.org/library>) which includes 2 new datasets published last year. The total number of downloads for Catalina-Jemez datasets from the EarthChem library was 43.
- More than 9.7 million data values for 17 sites were uploaded to the ODM2Admin managed by CUAHSI (<http://odm2admin.cuahsi.org/CJCZO/mapdata.html>).
- Previously published in data:
- More than 12.8 million data values have been added to the CUAHSI HIS HydroClient (<http://data.cuahsi.org/>). These data are available for download via the CUAHSI HIS HydroClient or 2 Catalina-Jemez CZO registered data services ([http://hiscentral.cuahsi.org/pub\\_network.aspx?n=158](http://hiscentral.cuahsi.org/pub_network.aspx?n=158) and [http://hiscentral.cuahsi.org/pub\\_network.aspx?n=177](http://hiscentral.cuahsi.org/pub_network.aspx?n=177)).
- Previously published datasets in data repositories with DOI:
- One Jemez stream water chemistry dataset was published in the HydroShare (<https://www.hydroshare.org/>),
- 3 Jemez River basin LiDAR datasets were published in the OpenTopography (<http://www.opentopography.org/>).
- 3 Valles Caldera (Jemez River basin) flux tower datasets were added to the AmeriFlux network (<http://ameriflux.lbl.gov/>).

## What is the impact on technology transfer?

We have developed a new "smart pore water sampling" system. Patent in progress.

## What is the impact on society beyond science and technology?

- The CZ Discovery program and "Welcome to the Critical Zone" exhibit introduce elementary school kids, many of them from underserved (Title 1) schools, to the concept of the Critical Zone, how cycles and systems interact in the CZ to support terrestrial life, and how the CZ provides clean air and water for people and agriculture.
- The "Mt. Lemmon Science Tour" free smartphone audio guide has introduced the general public (over 115,000 downloads and counting) to the concept of the Critical Zone, and to integrated Earth Science like the cycles, systems, layers, and time scales that are part of CZ processes and CZ services.

## Changes/Problems

### Changes in approach and reason for change

None to report

### Actual or Anticipated problems or delays and actions or plans to resolve them

None to report

**Changes that have a significant impact on expenditures**

None to report

**Significant changes in use or care of human subjects**

Not applicable

**Significant changes in use or care of vertebrate animals**

Not applicable

**Significant changes in use or care of biohazards**

Not applicable