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Accomplishments

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

The overall goals of the Southern Sierra Critical Zone Observatory (SSCZO) include: i) expand process-based understanding of the critical zone in a sensitive, societally crucial ecosystem; ii) provide a platform for long-term physical, biogeochemical and ecological studies; and iii) develop a framework for improving Earth System Models. In addressing these goals, the SSCZO has measurements at five main sites spanning a steep elevation gradient in the southern Sierra Nevada. This spatial climate gradient in critical-zone properties and processes permits predicting effects of climate change by substitution of space for time. Building on our work of the prior years, the SSCZO is focused on a cross-disciplinary approach to understanding: i) the current distribution of CZ properties across the mountain front, ii) the processes governing CZ behavior, and iii) the rates that CZ properties can evolve and change. Our scientific goals are centered on 5 research questions and 3

implications (See Figure 2 in Management Plan).

The SSCZO team is committed to advancing both local-CZO and CZO-network science. Our overall goals extend to the broader area of the CZO network, particularly the rapidly changing and stressed western United States. Our core CZO team is becoming increasingly engaged in network science, while continuing to us the unprecedented data and research capabilities provided by investments in the SSCZO. The team is also committed to the goal of continuing to expand our already large and growing set of collaborators in the research community, both on research at the SSCZO and across the network.

The research questions that continue to guide the SSCZO follow.

1. How do regolith properties and process of formation vary over 10-m to 100-km scales? This question of understanding regolith properties and formation across climate (elevation) gradients is key to prediction of both short- and long-time-scale processes. Regolith development over time depends on both parent material and climate. In the case of the Southern Sierra, climate is much more variable over space than is parent material. However, the combined variability results in significantly different biota across gradients of elevation, climate and parent material.
2. How do physics, chemistry, and biology interact to influence critical-zone function over instantaneous to decadal timescales? Questions of critical-zone function, central to understanding and predicting the response of critical-zone services to disturbance, management actions and climate, must consider the highly variable physical, chemical and biological inputs and processing across the range of regolith properties. A common conceptual framework and model must accommodate the different rates and processes of key inputs in order to predict outputs over time.
3. How quickly do regolith properties change in response to climate and biota? Recognizing the importance of regolith-climate-biota feedbacks, predictions of regolith development, formation and properties must consider the integrated changes in climate and biota. Time scales for and magnitudes of change depend on the processes. One example, erosion over annual to millennial to million-year time scales, depends on extreme climate events, as well as disturbance of biota.
4. How do regolith development and properties control, limit or modulate effects of climate change, forest management or disturbance on hydrology, biogeochemistry and ecology? Modulation of climate and disturbance is an essential regulating service of the critical zone. For example, in semi-arid regions, the amount of subsurface water storage during drought is emerging as a key critical-zone attribute, and predicting how this modulation varies across the landscape a central critical-zone-service question. The capacity for modulation over longer time scale may not reflect shorter-term responses of critical-zone biota and biogeochemistry to change. For example, drought versus wildfire both affect biota, which may respond in quite different ways over seasonal, annual and multi-decadal time scales.
5. What measurements of the critical zone at appropriate spatial and temporal scales, using cutting-edge technology, can best advance knowledge of the critical zone? The foundation for advances in the above questions rests on making appropriate, strategic measurements of the critical zone. Both continuing, baseline measurements, as well as shorter-term project or campaign measurements are part of the CZO network. Advances in measurement technology over the past decade have greatly expanded the available observations and data. These advances in measurement can not only support critical-zone research, but also inform longer-term resource management.

Management implications of particular concern include the effects of forest management on: i) plant production and the cycling of carbon and nitrogen through the system, ii) streamwater quality and iii) forest evapotranspiration and streamflow. Of note, we emphasize that these are large, thematic issues; we recognize that while the SSCZO will advance knowledge on these questions, more-complete answers will emerge over the next several years through cooperation with sister CZOs and the broader community. The current generation of students and postdoctoral researchers who are engaged with the SSCZO are already engaged in broader network collaboration.

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

Major Activities: Activities are described following the structure of the five research questions.

Regolith properties and formation. We sampled deep regolith at 115 sites using a geoprobe, backhoe or hand auger; with 25 of the sites reserved for chemical and physical characterization. This brings the total of regolith-depth measurements to 308. Regolith depth was operationally defined as the thickness of material that could be excavated by auger or probe, and thus, potentially accessible by roots. The intensive hand-augering survey at the 1100-m elevation site involved sampling regolith to a maximum depth of 7.25 m or depth of refusal at 67 locations. At each point, we recorded tree diameter, height, species and density within a 10-m radius of the hole.

Further geophysical measurements are in progress.

We continued to characterize chemical, mineralogical and physical properties of soils and deep regolith with the idea of understanding key ecosystem services: carbon sequestration, water storage, water infiltration, and nutrient cycling. Analyses included particle size, bulk density, water-retention curves (to assess plant available water), selective dissolution of iron, aluminum and silica (to understand pedogenic mineral transformations), clay mineralogy, cation-exchange capacity, pH, available phosphorus, phosphorus sorption capacity, exchangeable potassium, fixed potassium. Synthesis of cosmogenic nuclide and U-series isotope data from stream sediment continued, culminating in a manuscript now in preparation on landscape evolution in the region.

In August 2015, we deployed three arrays of 400 geophones to image the critical zone using ambient seismic energy. In addition, WyCHEG assisted with seismic-refraction and ground-penetrating-radar surveys to help constrain the material properties of regolith and unweathered bedrock. Results reveal a correlation between the degree of weathering and remotely sensed ET, with much greater ET at locations with greater weathering, and vice versa.

In fall 2015 we collected and analyzed bedrock, soil, pine-needle samples, and aeolian dust for chemical composition and 143Nd/144Nd isotopic signatures (εNd). Because the εNd values of the bedrock and dust are different, the εNd values of soils and pine needles can be interpreted to reflect the relative importance of bedrock and dust in nutrient supply to the forest. Our prior research suggests that Sierra Nevada ecosystems receive significant fluxes of phosphorus from aeolain dust; the current aim is to determine how these fluxes influence ecosystem function.

Critical-zone function. We continued measurements and analysis of physical and geochemical data. An eddy-correlation system was redeployed in Long Meadow, to compare measured ET with that estimated from meadow-soil specific-yield values and groundwater fluctuations. We further analyzed geochemical data from meadow wells, snowpack and streams.

We are investigating residence times of water, subsurface water-storage capacity and plant-water strategies at Soaproot and P301 and the integrating sites on P300 and Big Creek. We sampled vegetation, soil, streamwater, precipitation and snowmelt over the course of several seasons for radioactive and stable isotopes. A coupled atmosphere-land-subsurface model (ParFlow) of the SSCZO domain is under development.

Work on annual sediment sources, composition and transport continued, with water and nutrient cycling being tracked in stream and soil water. We investigated nutrient hot spots and hot moments at the 3D grids of ion-exchange-resin capsules. We installed an additional year's-worth of resin for nutrient fluxes. We are using Hydrus 2D to integrate data and determine the role of preferential flow paths on hot-spot and hot-moment formation. We are analyzing soil samples for phosphorus from Short Hair, Soaproot and SJER. Sampling was done multiple times for pre-prescribed fire treatments, including deep soil pits for microbial diversity and function by horizon. DNA has been extracted, and analyses are in progress.

Advances in eco-hydrologic modeling assessed the role of plant-available soil-water storage on both water resources and ecosystem services. We used RHESSys to quantify how spatial variation in soil-water storage can determine whether climate warming will increases or decrease ET and how plant-available soil water and rooting-zone characteristics influence post-disturbance ecosystem recovery. We are also using RHESSys to examine how plant-available water-storage can moderate the loss of snowpack, and influence the partitioning of ET and runoff.

Regolith-climate-biota feedbacks. Using the extensive data noted above, we used our geospatial model to explain relationships between regolith thickness and forest

metrics. This model uses a clustering technique to identify clusters of terrain attributes from input variables, including climate, solar radiation, landform, soil properties (depth, water holding capacity, carbon), and wetness index. The model is being evaluated with field observations of regolith thickness, tree productivity, and tree health metrics. Ultimately we believe that certain combinations of terrain attributes can be used to predict regolith thickness and forest productivity at the watershed scale.

We are analyzing patterns in multi-year soil-moisture measurements, plus RHESSys simulations of those patterns. Data began in 2008 and continue to the present. Simulations focus on effects of vegetation management.

Modulation of climate and disturbance. Our flux-tower measurements at three of the sites provided observations on carbon uptake and ET before and during the drought.

Three papers on scaling the effects of forest thinning and fire on the Sierra Nevada water balance were submitted; they describe how we used RHESSys to integrate multi-year field data and predict effects of vegetation management. We also evaluated how shifts from conifers to shrubs at the rain-snow transition may alter water resources; and we incorporated field data to parameterize species differences in stomatal behavior. A cross-CZO modeling effort was initiated to assess how changes in the timing, rate, and amount of snowmelt influence streamflow production.

An additional cross-CZO research effort was initiated to use flux-tower and other data to assess the variability of the hydrologic response to multi-year dry periods across the mountain west. This includes examining streamflow-subsurface-storage relationships and storage-deficit thresholds across multi-year dry periods.

Measurements of the critical zone. Our catchment-scale time-series measurements of snow, soil moisture, temperature, and matric potential continued, as did streamflow and met-station measurements by the USFS. Additional time-series data came from the flux towers. We resumed operation of Shorthair eddy-flux tower in summer 2015, rebuilding and upgrading sensors. SSCZO data underwent quality assurance and quality control, and were posted in our digital library. The first 5 years were published with a doi. We performed maintenance on the wireless-sensor network and other components.

We installed and initiated operation of a combined optical/thermal imaging system at the P301 flux tower. It is mounted on a pan-tilt mount, which allows nearly 360o sampling. Instruments include a thermal-infrared, near-infrared, and RGB cameras and a terrestrial scanning LiDAR that collects ~10 million observations each run to measure the 3D structure of the site, including snow depth. The entire system is computer controlled and full scans are automatically collected every few hours.

The soil-water sensor network was expanded to include monitoring of water content and water potential in soil and deep regolith (to 250 cm) at all 4 flux-tower sites. We also expanded monitoring of water content to 50-cm intervals in observation wells over the entire deep regolith thickness at each site using a neutron probe.

Specific Objectives:

Objectives are described following the structure of the five research questions.

Regolith properties and formation. We are evaluating trends in soil and regolith thickness across the altitudinal gradient of the SSCZO. The regolith is being imaged by drilling and direct sampling, and also indirect seismic imaging. Our goal is to characterize vertical profiles down to the soil-bedrock contact along the transect and constrain weathering and water-storage potential at depth to: i) expand previous 2D information to 3D subsurface data and modeling; ii) explore connections between lithology and different vegetation types; and iii) investigate the role of subsurface fracturing and weathering on aboveground productivity. Rock type and regolith properties such as porosity and water-storage capacity affect the distribution and

productivity of plants inhabiting surface ecosystems.

We aim to understand geospatial patterns in regolith thickness, and quantify the variability in regolith thickness at two scales: ~10-m scale within catchments and ~100-m scale across the elevation gradient. Through the drilling and analysis program we also aim to document the presence of deep carbon and phosphorus pools in regolith.

Additional goals of ongoing work across the altitudinal gradient include: quantifying the relative importance of dust from various sources in the formation of regolith; determining the climatic and geologic factors that influence variations in tree canopy cover across the landscape; and evaluating the evolution of pedogenic processes (additions, losses, transformations, and translocations) in soils and deep regolith.

Critical-zone function. An overarching question is how to manage forested catchments for water and other ecosystem services. Our studies of water and nutrient cycles across the heterogeneous ecosystems and regolith of the SSCZO improves our ability to predict: i) how soil-water holding capacity affects the partitioning of precipitation and snowmelt between ET and runoff; ii) how species change (i.e. conversion from trees to shrub) influences water fluxes; and iii) how hot spots and moments determines larger-scale, longer-term responses of vegetation, weathering, sediment and nutrient export.

Our work on the presence and amount of carbon in deeper regolith complements ongoing work on density fractionation and development of a 2H technique to determine sources of soil organic matter. Objectives include determining: i) how climate regulates the amount, composition, stability and stabilization mechanisms of deep soil organic matter; ii) how topography regulates amount, composition, stability and stabilization of deep organic matter across different climatic zones; and iii) how climate and topography control stocks, stoichiometry and vertical fluxes of carbon, nitrogen and phosphorous in deep soil. Research is being conducted across 3 CZOs.

We are quantifying how phosphorus stock and availability change with climate and regolith depth. We are extending research on hot spots and moments to explain why they are occurring. Our hypothesis is that precipitation travels through the nutrient-rich O horizon, collecting solutes that are transported through preferential flow paths to subsurface pockets of nutrient-rich soil called hot spots (persist over time) or hot moments. Our approach uses an unsaturated-flow model (Hydrus 2D) with field data. Microbially mediated nutrients may occur as both hot spots and hot moments, while those more abiotically controlled tend to be in hot spots.

We initiated investigations of microbially mediated ecosystem consequences of prescribed fire. We hypothesize that prescribed fire will reduce soil respiration because microbial biomass will decrease due to heat-induced mortality. As a result, carbon chemistry will become more recalcitrant, and the fungal composition will change from saprobic to mycorrhizal. A second hypothesis is that prescribed fire will increase nitrogen leaching because microbial assimilation will decrease due to a decrease in microbial biomass.

We are also characterizing deep-soil microbial diversity, and how diversity and biogeochemical function change with depth. We expect that: i) microbial biomass and functional activity will decrease with lower organic carbon, ii) microbial diversity within a profile will be as great as between profiles, iii) microbial metabolism will change from heterotrophic to chemoautotrophic with lower organic carbon, signaled by changes in functional gene abundance, iv) across sites, similar species will appear in similar horizons rather than depth, and v) enzyme activity will also be influenced by geochemical concentrations.

Regolith-climate-biota feedback. Work to understand the relationship between elevation/climate and exchanges of carbon and water is being undertaken using flux-

tower and other data. An objective is also to determine the relationship between regolith thickness and forest productivity and health across the altitudinal gradient and as a function of bedrock geology. Related to this, we also aim to understand factors that influence the presence/absence of soil and vegetation across the landscape.

We want to understand the seasonal variability of soil moisture and temperature. We will continue to look at detailed changes in soil moisture and temperature patterns due to specific local-in-time events. We are monitoring changes in water storage in soils and deep regolith to understand how soil properties may influence storage of water in deep regolith, and water use by vegetation.

Modulation of climate and disturbance. The ongoing drought has provided the opportunity to increase our emphasis on understanding how the water cycle and vegetation will respond to hotter, drier conditions. We aim to develop an understanding of system resiliency, along the step and variable climate gradient in the Southern Sierra. A more-specific objective is to use the SSCZOs unique, continuous, spatially dense soil moisture and matric potential measurements over the multiyear time period to better understand the cumulative impact of multiple years of drought. These data are also unique in that they are accompanied by coincident measurements of spatially distributed snowpack, solar forcing, temperature, and relative humidity. By developing tools to analyze this data over multiple years, we aim to better understand the cumulative impact of multiple years of drought.

We are extending work on how plant-available water-storage capacity can moderate the loss of snowpack in a warming climate across other CZOs in the western part of the network, i.e. looking at how plant-available water storage affects the partitioning of precipitation into ET and runoff, across the different climates of the network. For example, we are building on current results that suggest that snowmelt rate influences streamflow production via a subsurface mechanism.

Another important relationship we are addressing is between elevation/climate and nutrient cycling. Collaborative efforts of several SSCZO investigators are integrating geophysical measurements of subsurface structure into model parameterization of soil--water holding capacity (and its spatial pattern) into model estimates of vegetation water use and carbon sequestration.

Measurements of the critical zone. One of the hallmarks of the SSCZO has been the development and use of a wireless-sensor network as part of a spatially extensive catchment-scale measurement program. We aim to continue developing improved methods to optimize placements of the sensor clusters, and sensor nodes within the clusters. Through the expanded sensor network and neutron-probe monitoring we aim to reveal trends in regolith water storage in response to forest water use and drought.

Significant Results:

Results are described following the structure of the five research questions. Figures are appended in a pdf file.

Regolith properties and formation. 238U, 234U, 230Th and 10Be in sediment confirm that bare-bedrock slopes erode slower than soil-mantled hillslopes, due to a dominance of physical weathering on bare rock, as expected (Callahan/Riebe). However, bare-bedrock slopes are not common enough in the landscape to explain the “stepped” topography of the region. In addition, patterns of erosion and weathering in the Kings and San Joaquin river basins are inconsistent with the hypothesis that delamination of a dense crustal root in the region has prompted relief growth in the south and relief decline in north.

O’Geen and colleagues found that regolith is thinnest at 400-m elevation, where precipitation is low (Fig. 1). Mean regolith thickness increased at mid elevation (1100 m) where weathering is believed to be highest due to moderately high precipitation and mild temperatures. Mean regolith thickness was lower at 2000-m elevation and even

lower above 3000 m, where glaciation has evidently scoured bedrock, resulting in thinner regolith. These differences in regolith thickness have profound impacts on storage of plant available water, and thus, plant communities and forest density.

Dust fluxes from Asian and Central Valley sources are similar in magnitude, highlighting the importance of long-distance transport and delivery of nutrients such as phosphorus to Sierra Nevada ecosystems (Hart/Riebe). Nd isotopes in pine needles and soil measured by Arvin/Riebe imply that 70-80% of the Nd in the soils and 80-90% of the Nd in pine needles is dust-derived (Fig. 2). We are working on converting the inferred Nd contributions from dust into an estimate of its contribution to the ecosystem nutrient pool.

O'Geen et al. found a significant reservoir for carbon in deep regolith. While the highest concentrations of organic carbon occur in soil, small but measureable amounts detected in deeper regolith translate into large pools at locations where regolith is thick (Table 1). The integrated pool of carbon in deep regolith was therefore similar to the carbon stock of a typical rangeland soil found at 400-m elevation. This finding may partly explain missing terrestrial carbon pools in global models. A complementary finding by Behre points to over 40% of total soil C being located in deeper soil layers (below A horizons).

Critical-zone function. Lucas/Conklin found meadow evapotranspiration to be near potential ET rates during summer. Despite these high rates, meadows account for only a small fraction of catchment ET due to their relatively small relative area. Restoring a degraded system to a "pristine meadow" would only increase water loss in a catchment, due to ET, a fraction of a percent. We have used meadow-soil specific-yield values to calculate meadow ET from groundwater-table fluctuations; and are using these results to constrain the highly variable specific yield in several Sierra Nevada meadow systems where ET is currently not measured, and thus scaling meadow ET estimates.

A cross-disciplinary team (Taylor/Riebe/Goulden/O'Geen) coupled geophysical data on subsurface weathering and porosity with remotely sensed estimates of the overlying forest vegetation to explore the effects of subsurface water-storage potential on above-ground productivity. Initial results show a tight coupling of between remotely sensed ET and a geophysically inferred weathering index (Fig. 3).

Lucas/Conklin used end-member mixing of geochemical data to show how/when meadow and stream waters are comprised of snowmelt, rain and multiple groundwater sources, elucidating how the timing and magnitude of a vertical groundwater gradient at the meadow edge and meadow center are reflected in the makeup of the downstream surface water.

Regolith-climate-biota feedbacks. Thaw/Visser/Conklin showed that very dry soil (during drought) led plants to retain water from spring precipitation. Additionally, the snowmelt isotopic signature was influenced by forest-canopy structure; and capturing the changing signature in hydrologic components over the year is important to characterize the plant-water strategies (Fig. 4). Spring-rain tritium concentrations were higher than winter snow due to the "Spring Leak Phenomena". In August, tritium concentrations in both vegetation and shallow soil were similar and elevated above the annual mean. In contrast, meadow groundwater and streams had low concentrations (Fig. 5). The ratio between tritium in streams and snow indicates a residence time on the order of one tritium half-life (12.3 years) (Fig. 6). Sulfur-35 shows the delayed arrival of recent snowmelt at the watershed outlet. Correlations between tritium and streamflow indicate mixing of varying fractions of recent snowmelt and older water.

Modulation of climate and disturbance. Goulden's flux-tower results show a significant decline in ET during the drought at all elevations, with the greatest reduction at the forested Soaproot site (1100 m) (Fig. 7), just above the shrub-to-forest transition. This elevation is thought to be highly vulnerable to climate change, with warming

expected to shift the shrub-to-forest ecotone upslope. The large drop in ET and photosynthesis, and the marked tree mortality that has occurred there over the last 12 months, provide strong evidence for, and an increased mechanistic understanding of, the vulnerability of lower-montane forest to climate change.

Bart/Tague found that tree-to-shrub conversion in the southern Sierra is likely to increase annual streamflow, and depends on the balance between high stomatal conductivity and deep roots of shrubs, and the greater leaf area of trees. This type conversion could have greater hydrologic impacts than increased temperatures; although temperature increases will have a greater impact on streamflow timing.

Tague's analysis of ET response to historic climate variation and warming demonstrates that plant-accessible water-storage capacity can be a dominant control on spatial patterns of vegetation water use. For many locations within the Sierra, we show that the magnitude and even direction of how vegetation water use may change as climate warms depends strongly on subsurface storage (Fig. 8).

Tague/Moritz show that for locations with relatively shallow soils (assumed low plant available water storage capacity), post thinning or fire recovery leads to increases in plant water use, if neighboring plant roots share water (Fig. 9). With deeper soils, thinning leads to minor declines in total water use, even if plant roots share water.

O'Geen and colleagues found that plant-available water-storage capacity in deep regolith can buffer against drought, but not the ongoing multi-year drought that began in 2011. The significant forest die-off at our 1100-m site was due to the absence of usable water in the upper 4 m of regolith (Fig. 10a). At the mixed-conifer tower site (2000 m) there was more plant-available water stored in regolith (Fig. 10b); although mortality in some species is still being observed. While the storage is similar at the two sites, depletion was much greater at the Pine Oak forest as a result of lower precipitation and higher ET.

Measurements of the Critical Zone. Taylor/Riebe have optimized a method to remotely quantify plant-available water using geophysics. Porosity can be derived from field measured seismic velocities using a rock physics model.

Oroza/Glaser developed a machine-learning algorithm for optimal sensor locations that results in better estimates of areal snow cover than traditional expert placements. The algorithm (a Gaussian mixture model) uses LiDAR to remotely identify the independent variables that affect the spatial distribution of snow, and identifies representative sampling locations in the space of independent variables. Oroza also developed an algorithm to predict wireless connectivity in complex terrain.

Key outcomes or Other achievements:

Outcomes cut across the five research questions.

Some of the more-significant research findings from the past year are highlighted below. Together, these give new, integrated insights into the processes determining the differences in regolith formation, weathering, forest density, forest resilience to drought and implications of expected climate change and management actions along the steep climate-ecosystem gradient covered by the Southern Sierra CZO.

1. We documented the effectiveness of digital soil-mapping techniques in explaining soil variation in the Sierra Foothill region. Our findings show that these tools are very effective in granitic terrain but less so in metamorphic rocks in the north. We also found lithologic variability to be greater than expected. These findings will serve as the rationale to explore digital soil-mapping techniques to predict characteristics of deep regolith.
2. We found that relatively light fuels treatments have little effect on runoff in the southern Sierra, but can increase runoff in the higher-precipitation region of the central Sierra. Precipitation and canopy cover controlled the magnitude of runoff

increases, following a relatively light (8%) reduction in vegetation. High-intensity wildfires that result in greater vegetation reductions and can lead to larger runoff increases. The representation of forest vegetation structure in hydrologic modeling is important to capture, and will affect model results of projected changes in vegetation. Simulating reductions by perturbing only leaf-area index resulted in limited impacts on the water balance. Replicating the same reduction by specifically manipulating canopy-cover patterns resulted in a water-balance response of much greater magnitude.

3. Detailed hydro-ecologic modeling (RHESSys) constrained by distributed observations of forest vegetation thinning, precipitation, snowpack storage, soil-water storage, energy balance and stream discharge provide a confident and useful management tool to constrain the water balance and to further project the effects fuels treatments on runoff. Further, a well-constrained headwater model can be effectively used to determine how annual hydrologic fluxes respond to vegetation changes from treatments and fires in larger firesheds, based on geologic and hydrologic similarities.
4. We developed an approach for estimating plant-available water storage at landscape to regional scales based on inverting remote-sensing estimates of annual ET to infer the amount of regolith water withdrawn during the dry season. These results showed that plant-available water peaks at mid elevation and declines at upper and lower elevations, and that it is greatest in locations with wetter and/or warmer climates.
5. Plant-available water-storage capacity is a key variable of equal importance to climate in determining watershed response to perturbations from climate and disturbance. It exerts major controls on partitioning of precipitation into discharge versus evapotranspiration, buffering drought, and post-disturbance ecosystem recovery.
6. The widespread tree mortality observed in 2015 in the 900-1800 m elevation range of the southern Sierra was associated with 4 years of low precipitation, unsustainably high vegetation densities, high evaporative demand that depleted subsurface moisture and lack of recharge below about 1-m depth. Higher precipitation and deeper recharge provide a multi-year drought buffer for fluxes out of southern Sierra basins (discharge and evapotranspiration) in areas with sufficient regolith storage, mainly at elevations well above about 2200 m.
7. We found that temperature also played a key role in controlling site water balance, the rate of below-ground water depletion during the drought, and hence vegetation mortality. Tree death late in the drought was greatest at the comparatively warm 1100-m Soaproot Saddle site and sparse at the cooler 2000-m site. Analyses of the flux tower data and the controls on ET showed that the higher rates of ET observed at 1100 m relative to 2000 m were attributable almost entirely to this temperature difference. Precipitation amounts at the 1100- and 2000-m sites were broadly similar, and hence the greater rate of below-ground water depletion at 1100 m, and ultimately the greater rate of tree death, were attributable in part to this site's warmer climate.
8. Surprisingly, we found no significant difference in rates of erosion and weathering between the Kings and San Joaquin drainages. This is inconsistent with the hypothesis that delamination of a dense crustal root has prompted relief growth in the south and relief decline in the north due to differential uplift. Our results help us interpret other paired measurements of cosmogenic and U-series nuclides from previous work for an improved understanding of landscape evolution both in the Sierra Nevada and in other granitic mountain ranges around the world.
9. The flux of dust to Sierra Nevada soil is on par with the rate of soil formation from underlying bedrock, implying that the dust-derived flux of nutrients to forest ecosystems of the region is significant. Moreover, Nd isotopes in bedrock, dust, soil, and pine needles from forests in the southern Sierra Nevada show that dust contributes ~80% of the Nd in pine needles. To the extent that Nd uptake reflects phosphorus uptake by plants in the region, our results suggest that dust is an

ecologically significant source of nutrients at sites where fluxes from dust are high relative to fluxes from erosion of underlying bedrock.

10. A global synthesis of modeled dust fluxes and measured erosion rates reveals that the supply of nutrients from exogenous dust is on par with the supply from erosion of underlying bedrock across a surprisingly broad range temperate settings around the world. This significantly expands the range of conditions under which inputs from dust flux can be a significant contributor to ecosystem dynamics, with implications for predicting impacts of climate change and land-use intensification.
11. A 3D passive-source geophysical survey of the subsurface at three study areas spanning a range in forest cover indicate that evapotranspiration (inferred from remote sensing) is regulated by subsurface weathering (inferred from shear wave velocities). To the extent that shear-wave velocities reflect porosity, and thus plant-available water, our results suggest that ecosystem function is mechanistically linked to geological, geochemical, and geomorphological processes that influence subsurface weathering processes.
12. The integrated pool of carbon in deep regolith in southern Sierra forests is similar to the carbon stock of a typical rangeland soil found at 400-m elevation. While the largest organic-carbon contents were in soil, small but measureable amounts were detected in deeper regolith, which corresponded to large pools at locations where regolith was thick. These findings may explain part of the missing terrestrial carbon that has been reported in in global models.

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

Students and postdocs associated with the SSCZO receive both formal and informal training in technical issues, and in science communication. At the undergraduate level, students from UC Merced and partnering universities have worked as field and lab technicians. For example, one student worked with the SSCZO field manager in 2015.

This marks the fifth year for the UC Merced surface water methods workshop course, developed by M. Conklin, and the seventh successive year for the UC Davis field methods course, developed by SSCZO researcher P. Hartsough. The SSCZO site visits with Hartsough and Conklin with the SSCZO staff allow students to learn about research and to collect data for use in class. These classes serve both CZO and non-CZO students.

SSCZO research provided material for other university courses as well. M. Conklin and others are part of an InTeGrate team to develop a critical zone processes course, which she taught in fall 2015.

Baseline CZO RHESSys model implementations were used to develop educational materials for two courses: ESM 237 Climate Change Impacts and Adaptation, a graduate course in the Bren School for Environmental Science and Management and ESM 495 Introduction to hydrologic modeling. RHESSys simulation results from CZO were also integrated into a CUASHI Watershed Hydrology Master Class held at Biosphere 2 in Tucson, Arizona. C. Tague was the hydrologic modeling instructor. This Master Class presents work to Ph.D. students and post-doctoral scholars from around the country; and this year included several participants from South America. See https://www.cuahsi.org/Posts/Entry/27146.

Ph.D. student R. Lucas served as an instructor at the Sierra Nevada Institute organized by the California Institute for Biodiversity. He presented critical-zone science to K-12 teachers, provided them with ways of bringing field techniques, models, and data visualization to their classrooms. Both R. Lucas and Ph.D. student J. Rungee also presented our research to TEAM-E organized by the Merced County Department of Education, in fall 2015. Co-PI M. Conklin is engaged in guiding this enrichment program for K-12 teachers in the local district, which serves a heavily minority population.

Students regularly work with faculty members to brief visitors to campus, and present off campus to both scientific and public audiences (see Products, and also Dissemination, below).

The societal context that the SSCZO provides for our research also provides lessons that the graduate students embrace, and will take with them to their professional careers when they complete their graduate programs. The SSCZO team mentors students in science communication, and both expects and gets high-quality papers and conference presentations. In addition to presenting at the AGU fall meeting, Ph.D. students participated in cross-CZO and other specialty meetings.

Several graduate students, undergraduates and recent Ph.D. graduates are involved with the SSCZO, and are preparing themselves for independent measurement and data analysis work in field hydrology, biogeochemistry, geophysics, and

modeling. The SSCZO places students in a multi-campus team environment, and creates a sense of community that is manifest through shared resources and collaborations (e.g. shard LiDAR, sensor data, field campaigns for soil pits, analytical tools, programming, modeling). Annual meetings are important for giving graduate students insight into what other researchers are doing, what the big questions are in the field, providing valuable feedback from other investigators on the students' work. It should also be stressed that the field research and opportunity for students to do robust tests of their ideas and hypotheses with rich field data sets in a multi-disciplinary environment will be a major influence on their careers as researchers. The wireless-sensor network remains an uncommon approach to gathering remote field data. The network installed at the Southern Sierra CZO consists of 57 wireless nodes, constituting one of the largest wireless networks for this purpose. Through the work on the wireless sensor network, training and experience continues for both investigators and graduate students.

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

As described in our Management Plan, the SSCZO was planned as a resource for the critical-zone research community; and our team has actively engaged other scientists in using this resource. Public education and outreach are equally important. SSCZO team members – investigators, graduate students and staff – share CZO knowledge and findings with several different audiences, targeting both key decision makers and the public.

Science community. Dissemination to the science community includes alerting potentially interested colleagues of our publications and presentations through our web pages and email, attending scientific meetings and workshops and participating in CZO network activities. Over the past year SSCZO team members have organized sessions, given invited talks and contributed presentations based on SSCZO work at annual meetings of the American Geophysical Union, Geological Society of America, Ecological Society of America and Goldschmidt conference. We also participated in regional scientific meetings and smaller specialty conferences. Our team also contributed to CZO network activities at these and other meetings.

Regional stakeholders and the public. Our communication and sharing of scientific products with stakeholders includes frequent talks around the state, briefings to decision makers, hosting of visits to our laboratories and SSCZO site, news articles in local publications, op-ed pieces in newspapers, radio interviews, television reports and web publications. In addition to stakeholders and decision makers, the SSCZO has an active program of education and outreach to K-16 students and educators and the general public using CZO data and results.

Two products from SSCZO have dominated our engagement with regional stakeholders and the public. Conversations around both have heightened because of the drought, and will impact both drought preparedness and sustainability of Sierra ecosystem (critical zone) services.

First, our work is informing the debate around water benefits of forest management, with emphasis on climate change and runoff from the Sierra. Given the unsustainable forest structures in an area that provides about 60% of California's water supply, there is widespread interest in bringing new resources and tools to watershed management. It is also well recognized that the knowledge base for predicting the effects of different management approaches is insufficient. We share our findings about montane forests and their water supplies with resources managers, students, researchers, and stakeholders at local to international scales.

A second major focus has been on working with water leaders in the state to define and develop prototypes for a new water - information system for California that builds on advances in wireless sensor networks developed at the SSCZO, plus parallel advances in cyberinfrastructure and in measurements by satellite and aircraft.

We also hosted meetings with university trustees, members of the business community, university donors, elected officials, agency staff and others. Two highlights from the past year are meetings with leaders of the Sierra Business Council and with members of USAID Afghan projects.

Within California, 48 Integrated Regional Water Management Groups have formed, aiming to implement regional solutions to the state's water challenges. Beginning in 2017, these groups will have access to a billion dollars of grant funds to upgrade infrastructure, address knowledge gaps, adapt for climate change, and meet other 21st century challenges. Our team has engaged with over 10 groups having an interest in the Sierra Nevada and regularly attended meetings, hosted members and collaborated to bring CZO technology to other parts of the Sierra Nevada through state grants. We also engage with multi-agency groups planning and financing forest-restoration activities. E. Stacy continues SSCZO contributions to the Dinkey Landscape Restoration Project; R. Bales and M. Safeeq contribute to the Tulare Basin Watershed Connections group.

In addition to stakeholders and decision makers, the SSCZO has an active program of education and outreach to K-16 students using CZO research topics, data and results. Our presentations and partnership activities align with several aspects of Next Generation Science Standards and Common Core State Standards. In the past year, students from Fresno Christian High School and the Center for Advanced Research and Technology (CART) executed research projects on soil moisture and snowpack in the Sierra Nevada. We describe our annual projects with CART in an article submitted to educational journal *The Earth Scientist.* Other K-12 presentations this year include Southern California Edison's Science Days for K-8 students, at which we have presented since 2011, and the Society of American Foresters High Sierra Chapter's Conservation Days for 4th and 5th graders. At these events SSCZO colleagues facilitated hands-on activities focusing on Sierra hydrology, ecology and soil science.

Our partnerships with educational institutions share research results with educators as well. In September 2015, R. Lucas and J. Rungee presented their work to approximately 60 K-8 teachers who are part of the ongoing TEAM-E Science program. Following up in June, M. Gilmore led additional science-content sessions with TEAM-E on forest-carbon cycling, tree measurement, and ecosystem modeling. L. Sullivan co-led ecosystem modeling activities and presented at another teacher training event the same week, STEM-TRACKS. M. Conklin also remains a member of the NatureBridge Yosemite board, which has provided award-winning, residential outdoor education programs for school groups since 1971.

Public outreach for the SSCZO spans a variety of forms that garner local and national attention, which we frequently share through our Twitter and Facebook accounts. The ongoing drought has brought many requests for media interviews. In February SSCZO was featured in a story on the cover page of the Tuesday Science Times (New York Times), and in an article cross-published in The Desert Sun and USA Today. Many California newspapers have also featured our work, and SSCZO investigators are quoted in national and state press multiple times per month.

Our in-person public engagement has also been active and varied. Graduate student M. Barnes presented artwork inspired by her SSCZO research in two public galleries. K. Moreland, J. Rungee, M. Thaw and M. Gilmore also exhibited at Riverdance Farms' annual Merced River Fair, demonstrating SSCZO instruments and facilitating hands-on soil and water activities. A. O'Geen gives 4-hour Master Gardener short courses in foothill communities each year focused on garden soil management, understanding the variability of soils in mountainous terrain, and documenting vegetative, topographic and lithologic differences that might influence soil variability and properties. He blends SSCZO findings into the courses, in particular topics about deep regolith and its ability supply water and buffer against drought.

Over the next year our outreach using public talks, briefings with decision makers and presentations at scientific meetings will continue along the lines initiated in past years. Some of the additional highlights planned for the next several months follow.

– The Annual Team Meeting will be Aug 2-3 in Shaver Lake. Approximately 30 researchers attend each year to exchange research results, plan field work and strategize for the coming year. Local collaborators join when schedules allow.

– We have been asked by producers to collaborate on a feature film on San Joaquin Valley water and agricultural sustainability.

– California artist Todd Gilens will visit our sites and shadowing our researchers this summer, fall, or winter as part of his ongoing *Confluence* project.

– We will follow up with Merced County educators on incorporating more CZO-related activities in classrooms.

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

The next period will include the balance of year 3 and extend through part of year 4. Several graduate students, postdocs and senior investigators have completed their research, and are submitting papers based on their work. Field research and modeling are proceeding, including several subsurface investigations. The new cohort of graduate students, who joined the SSCZO in fall 2014, which the first full academic year after the cooperative agreement began, should complete field work this year and be well into analysis and modeling. New collaborators are also joining the SSCZO. Plans for research over the next year are described following the structure of the five research questions.

Regolith properties and formation. We will complete instrumenting the excavations in soil and weathered bedrock that were done in summer/fall 2015. Geochemical analyses of samples will continue at three sites along the altitudinal transect. R. Callahan will synthesize geochemical data on weathering with cosmogenic nuclide data on erosion. Work also continues on understanding factors that influence the presence/absence of soil and vegetation across the landscape. We will continue sampling and analysis of aeolian dust. L. Arvin is seeking a mechanistic understanding of the observed bimodality in soil and

vegetative cover controlled by soil chemistry. Grad student N. Taylor will continue exploring critical -zone architecture using the passive-source seismology data.

We will investigate the extent to which soil-forming factors, (time, topography, parent material, organisms, and climate) can explain spatial variability of weathered bedrock characteristics, and which factors are more important. Along with this we will study the degree to which digital soil mapping techniques and their digital proxies (terrain attributes, airborne gamma ray mapping, remote sensing) can explain weathered bedrock thickness and mineralogical, chemical, biological and physical characteristics. We also aim to model how the degree of soil development influence processes in weathered bedrock. This will come together with aboveground landscape characteristics, as we seek a fundamental scaling relationship between the depth of regolith, canopy height, and depth of chemical alteration of bedrock.

Work will also continue work on quantitative models that describe watershed-scale patterns in weathered bedrock and its relationship to forest productivity. With most field sampling complete, much of the next year will focus on analyzing data and modeling. This includes completing three papers on regolith characteristics across the elevation gradient: i) depth trends and water storage, ii) carbon stocks in soils and regolith, and, iii) nutrient pools and mineralogical transformations in regolith relative to overlying soils. Three additional papers are: i) evaluating the relationship between forest die-off, water and regolith thickness in the forested sites, ii) documenting controls on variability in regolith thickness at the 10-m scale, and iii)Lidar and other remote sensing technique to infer below-ground root biomass.

Critical-zone function. We will analyze and disseminate data from the recently deployed remote-sensing package that was developed over the past year at the P301 site. This system includes separate Vis/NIR and thermal-IR cameras, along with a terrestrial-scanning LiDAR. We will continue operating the flux-tower network; and we will continue exploring possible sites above tree-line for a higher-elevation flux tower.

We will complete analysis of surface-groundwater exchange of Sierra Nevada montane meadows in the context of greater watershed processes (R. Lucas). We will collect a second year of stream, vegetation, soil, precipitation and snowmelt samples to examine vegetation-water sources (M Thaw).

We will continue collecting soil samples from the SSCZO transect and developing plans for work in the CJCZO (A. Moreland) and Inyo (M. Barnes) and continuing data analysis on the water samples we have been working on. We will establish productivity plots (for measuring above and belowground productivity and soil respiration) along the SSCZO transect. We will sample soils to evaluate changes in soil microbial communities (focusing on mycorrhizae) 2.5 y after forest disturbance (N. Dove). Graduate student Dove will also visit a series of wildfire sites across the mixed conifer zone of the Sierra looking for suitable sites to expand his mycorrhizal disturbance work. E. McCorkle (SSCZO alum), M. Barnes (new CZO grad student), Newman (REU researcher), Berhe, Hart, and Hunsaker are currently analyzing the steam geochemical data and plan to submit a manuscript focusing on dissolved C and N fluxes.

One modeling focus will be on understanding the effect of plant-available soil-water storage on ET, allowing us to better predict changes in vegetation under a warming climate. We will first look at how precipitation across the Sierra and a range of water storage would impact both the magnitude and direction of ET under climate warming. Second, we are using the same analysis, across all CZOs, to look at how different climates around the U.S. and a range of water storage will impact ET under climate warming. Finally, we plan to use the subsurface mapping of the SSCZO to look at how water storage will affect lateral redistribution of water and ET.

We also consider how hydrologic impacts of thinning are likely to differ across the landscape due differences in subsurface water accessible by trees. We will evaluate the spatial neighborhood defining how individual trees compete for available water (i.e, local versus diffuse competition), which determines whether water made available through the removal of transpiring biomass can be used by nearby remaining trees. We will analyze treatment impacts on water use and forest productivity for a range of biomass mass removal scenarios, across a variation in climate drivers.

Regolith-climate-biota feedbacks. Sediment sampling, soils analyses, and hydrologic/biogeochemical analyses will continue, in concert with tasks described above under regolith properties and formation, and critical-zone function. We will continue sampling of gas wells and soils from the entire climosequence during the summer and fall 2016. We plan to complete a manuscript on based on analysis of 8 years of distributed soil-moisture data, including investigations the rate and seasonality of water infiltration, and drying behavior of the soil and saprock.

Continuing investigations are documenting the role of storage hydrology, and phosphorus pools in Sierra soils. We will document soil phosphorous pools across lithologic and climatic gradients throughout the Sierra Nevada. We are assembling a time series of water balances for major Sierra catchments to assess how storage may influence runoff and forest water use

in response to climate change. Finally, we aim to complement hydrologic research to study how hydrologic monitoring and physical characterization of deep weathered bedrock reflect trends in forest response to drought.

We are developing and testing a fire-effects model, coupling a fire-spread model to RHESSys, to investigate the effects of changes in forest management on forest health and runoff. We will also examine how changes in forest productivity feedback to affect fire-return intervals and forest management by further coupling the firespread/ecohydrologic model with a model of how fuels-treatment decisions are made (collaborative with NSF-HAZARDs).

Measuring the critical zone. The summer months in 2016 are critical to our SSCZO measurement program. Several upgrades were made in 2015, and those will be evaluated and adjusted this summer as needed. One set of soil excavations are planned, and we are assessing broader-scale geologic data from drilling logs to plan for deeper regolith and bedrock drilling. We will continue hydrologic measurements (both fluxes and water chemistry).

Supporting Files

Filename	Description	Uploaded By	Uploaded On
Accomplishments_table_figs3.pdf	Tables and figures for accomplishments section.	Roger Bales	06/29/2016
Additional_2016a.pdf	Additional reporting requirements, including budget information.	Roger Bales	06/29/2016
SSCZO_Mgmt_Plan_2016.pdf	Southern Sierra CZO Management Plan	Roger Bales	06/29/2016

Products

Books

Book Chapters

Inventions

Journals or Juried Conference Papers

Aciego, S. M., Riebe, C. S., Hart, S., Blakowski, M. A., Carey, C., Aarons, S. M., Dove, N., Austin, P., & Aronson, E. (). Dust outpaces bedrock in nutrient supply to forest ecosystems. *Science*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Bart, R., Tague, C., Mortiz, M. (). Effect of tree-to- shrub type conversion in lower montane forests of the Sierra Nevada on streamflow. *PLOS ONE*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Beaudette, D.E. and A.T. O'Geen (2016). Topographic and geologic controls on soil variability in California's Sierra Nevada Foothill Region. *Soil Science Society of America Journal*. 80 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.2136/sssaj2015.07.0251

Blankinship, J.C., McCorkle, E.P., Hart, S.C. (). (in prep.) Moving soils in the rain-snow transition zones: effects on greenhouse gas emissions and nitrogen cycling. *Journal of Geophysical Research Biogeosciences*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Blankinship, J.C., McCorkle, E.P., Meadows, M.W., Hart, S.C. (). (in prep.) Quantifying the legacy of earlier snowmelt on soil greenhouse gas emissions in a high-elevation forest. *Global Change Biology*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Brooks, P. D., Chorover, J., Fan, Y., Godsey,S. E., Maxwell, R. M., McNamara, J. P., Tague, C. (2015). Hydrological partitioning in the critical zone: Recent advances and opportunities for developing transferable understanding of water cycle dynamics. *Water Resources Research*. 51 (9), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer

Reviewed = Yes ; DOI: 10.1002/2015WR017039

Carey, C.J., N.C. Dove, J.M. Beman, S.C. Hart, E.L. Aronson (2016). Meta-analysis reveals ammonia-oxidizing bacteria respond more strongly to nitrogen addition than ammonia-oxidizing archaea. *Soil Biology and Biogeochemistry*. 99 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.soilbio.2016.05.014

Carey, C.J., S.C. Hart, S.M. Aciego, C.S. Riebe, M.A. Blakowski, E.L. Aronson (). Microbial community structure of subalpine snow in the Sierra Nevada, California. *Arctic, Antarctic, and Alpine Research*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Chen, P., Taylor, N. Dueker, K., Keifer, I., Wilson, A., McGuffy, C., Novitsky, C., Spears, A., Holbrook, S. (2016). pSIN: a scalable, Parallel algorithm for Seismic INterferometry of large-N ambient-noise data. *Computers and Geosciences*. 93 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.cageo.2016.05.003

Ferrier, K. L., Riebe, C. S. and Hahm, W. J. (2016). Testing for supply-limited and kinetic-limited chemical erosion in field measurements of regolith production and chemical depletion. *Geochemistry, Geophysics, Geosystems*. . Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2016GC006273

Garcia, E.S., Tague, C.L. (2015). Subsurface storage capacity influences climate–evapotranspiration interactions in three western United States catchments. *Hydrology and Earth System Sciences*. 19 (12), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5194/hess-19-4845-2015

Hayes, J. L., Riebe, C. S., Holbrook, W. S., Flinchum, B. & Hartsough, P. C. (). Porosity production in saprolite: Where volumetric strain dominates over chemical mass loss. *Geology*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

He, T., Liang, S.I., Wang, D.D., Shi, Q.Q., Goulden, M.L. (2015). Estimation of high-resolution land surface net shortwave radiation from AVIRIS data: Algorithm development and preliminary results. *Remote Sensing of Environment*. 167 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.rse.2015.03.021

Kelly, A.E., and Goulden, M.L. (2016). A montane Mediterranean climate supports year-round photosynthesis and high forest biomass. *Tree Physiology*. 36 (4), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1093/treephys/tpv131

Lucas, R.G., Suárez, F. Tyler, S.W., Moran, J.E., Conklin, M.H. (2016). Polymictic pool behavior in a montane meadow, Sierra Nevada, CA. *Hydologic Processes*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: DOI: 10.1002/hyp.10834

Lukens, C. E., C. S. Riebe, L. S. Sklar, and D. L. Shuster (2016). Grain size bias in cosmogenic nuclide studies of stream sediment in steep terrain. *Journal of Geophysical Research: Earth Surface*. 121 (5), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2016JF003859

McCorkle, E.P., Berhe, A.A., Hunsaker, C.T., Johnson, D.W., McFarlane, K.J., Fogel, M.L., Hart, S.C. (2016). Tracing the source of soil organic matter eroded from temperate forest catchments using carbon and nitrogen isotopes. *Chemical Geology*. . Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.chemgeo.2016.04.025

Oroza, C.A., et al. (). (in prep.) Repeater Placement Strategy for Environmental Wireless Sensing. *Undecided Journal*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Oroza, C.A., Zheng, Z., Glaser, S., Bales, R.C. (). VOptimizing embedded sensor network design for catchment-scale snow-depth estimation using LiDAR and machine learning. *Water Resources Research*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Oroza, C.A., Zheng, Z., Glaser, S.D., Tuia, D., Bales, R.C. (). (in prep.) Optimizing embedded sensor network design for catchment-scale snow-depth estimation using LiDAR and machine learning. *Water Resources Research*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Riebe, C.S., Sklar, L.S., Lukens, C.E., Shuster, D.L. (2015). Climate and topography control the size and flux of sediment produced on steep mountain slopes. *Proceedings of the National Academy of Sciences*. 112 (51), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1073/pnas.1503567112

Safeeq, M. and Hunsaker, C. (2016). Characterizing Runoff and Water Yield for Headwater Catchments in the Southern Sierra Nevada. *Journal of the American Water Resources Association*. . Status = ACCEPTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Safeeq, M., Hartsough, P., Bales, R. (). (in prep.) Stand-level variability in water storage and evapotranspiration from a White Fir (Abies concolor). *Undecided Journal*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Saksa, P.C., Conklin, M.H., Battles, J.J., Tague, C.L., Bales, R.C. (). Forest thinning impacts on the water balance of Sierra Nevada mixed-conifer headwater basins. *Water Resources Research*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Saska, P.C., Bales, R.C., Tague, C.L., Battles, J.J., Conklin, M.H. (). Fuels-treatment and wildfire effects on runoff in Sierra Nevada mixed-conifer forests. *Water Resources Research*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Son, K. and Tague, C. (). (in prep.) Importance of soil parameter uncertainty in assessing climate change projections in small two Sierra Nevada watersheds. *Water Resources Research*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Son, K., Tague, C., Hunsaker, C. (). Effects of model spatial resolution on ecohydrologic predictions and their sensitivity to inter-annual climate variability in California's Sierra Nevada watersheds. *Water*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Stacy, E., Hart, S.C., Hunsaker, C.T., Johnson, D.W., and A.A. Berhe. (2015). Soil carbon and nitrogen erosion in forested catchments: implications for erosion-induced terrestrial carbon sequestration.. *Biogeosciences*. 12 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5194/bg-12-4861-2015

Tague, C., and Moritz M. (). (in prep.) Testing common assumptions associated with thinning as a fire-hazard reduction treatment in water limited forests. *Ecological Applications*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Tague, C., Heckman, C., Flint, A. (). How plant accessible water storage interacts with changing snowpacks in Mediterranean Environments. *Nature Climate Change*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Webb, R.W., Fassnacht, S.R., Gooseff, M.N. (2015). Wetting and Drying Variability of the Shallow Subsurface Beneath a Snowpack in California's Southern Sierra Nevada. *Vadose Zone Journal*. 14 (8), . Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.2136/vzj2014.12.0182

Zhang, Z., et al. (). (in prep.) Connectivity Model through Ensemble Regression- Tree on Large-Scale Deployment Traces. *Undecided Journal*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Zhang, Z., Glaser, S., Bales, R., Conklin, M., Rice, R., Marks, D. (). Design and evaluation of a basin-scale wireless sensor network for mountain hydrology. *Water Resources Research*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Zheng, Z., Kirchner, P. B., and Bales, R. C. (2016). Topographic and vegetation effects on snow accumulation in the southern Sierra Nevada: a statistical summary from lidar data. *The Cryosphere*. 10 (1), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: doi:10.5194/tc-10-257-2016

Licenses

Other Conference Presentations / Papers

Aronson, E.L., Carey, C., Riebe, C., Aciego, S., Blakowski, M., Hart, S.C. (2015). *Aeolian and soil microbial communities differ at multiple elevations in the Southern Sierra CZO*. Soil Ecology Society Biennial Meeting. Colorado Springs, Colorado.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Aronson, E., Riebe, C.S., Aciego, S., Blakowski, M., Hart, S.C., Carey, C. (2015). *Aeolian transported and deposited microbial communities differ along an elevation gradient in the Southern Sierra CZO*. Ecology Society of America Annual Meeting. Baltimore, Maryland. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bart, R., Anderson, S., Moritz, M., Plantinga, A., Tague, C. (2015). *An Integrated Model for Identifying Linkages Between the Management of Fuel Treatments, Fire and Ecosystem Services*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Fogel, M., Berhe, A., Williams, E. (2015). *Can δ2H of Organic Matter in Soils be Used for Understanding Organic Matter Sources and Cycling?*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Safeeq, M., Hunsaker, C. (2015). *Characterizing Runoff and Water Yield from Headwater Catchments in the Southern Sierra Nevada*. American Geophysical Union Annual Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tian, Z., O'Geen, A., Hartsough, P., Deng, J. (2015). *Climactic Controls on Soil and Deep Regolith Development in Southern Sierra CZO*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bales, R., Goulden, M., Hunsaker, C., Conklin, M., Hartsough, P., O'Geen, A., Hopmans, J., Safeeq, M. (2015). *Drought effects on evapotransiration and subsurface water storage in the southern Sierra Nevada*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Biederman, J., Scott, R., Goulden, M., Litvak, M., Kolb, T., Yépez, E., Oechel, W., Meyers, T., Papuga, S., Ponce-Campos, G., Krofcheck, D., Maurer, G., Dore, S., Garatuza, J., Bell, T., Krishnan, P. (2015). *Ecosystem carbon balance in a drier future: land-atmosphere exchanges of CO2, water and energy across semiarid southwestern North America*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Berhe, A., Newman, A., Hunsaker, C. (2015). *Erosional distribution of metal oxides and its implication for soil carbon dynamics*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Mazzi, J., Grigsby, S., Goulden, M., Ustin, S. (2015). *Estimating CO2 Fluxes Pre and Post Drought Using Remote Sensing Data in the Sierra Nevada Range*. American Geophysical Union Annual Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Hayes, J., Riebe, C., Holbrook, S., Hartsough, P. (2015). *Generating Porosity in the Critical Zone: Does Volumetric Strain Dominate Chemical Mass Loss?*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Dove, N. (2016). *Geospatial techniques for field-based research: case studies in NW Baja California & Yosemite NP*. California Geographic Information Association Annual Geosummit. Merced CA. Status = PUBLISHED; Acknowledgement of Federal Support = No

Jepsen, S., Harmon, T., Meadows, M., Hunsaker, C. (2015). *Hydrogeologic Influence on Changes in Snowmelt Runoff with Climate Warming: Numerical Experiments on a Mid-Elevation Catchment in the Sierra Nevada, USA*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Lukens, C., Riebe, C., Sklar, L., Shuster, D. (2015). *If Rocks Could Talk: Origin Stories of Stream Sediment Told by Apatite Helium Ages and Cosmogenic Nuclides*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Oroza, C., Zheng, Z., Zhang, Z., Glaser, S., Bales, R., Conklin, M. (2015). *In-situ monitoring of California's drought: Impacts on key hydrologic variables in the Southern Sierra Nevada*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Heckman, C. (2016). *Managing forests in an era of drought*. Graduate Research Advocacy Day. Sacramento, California.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tague, C. (2015). *Modeling the complex interactions among wildfire, fuel treatments and hydrology*. EARSeL Forest Fire Special Interest Group Workshop. Limassol, Cyprus. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Lucas, R., Conklin, M., Goulden, M. (2015). *Montane meadow evapotranspiration: implications for restoration and impacts on downstream flow*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Zheng, Z. (2016). *Multi-platform data fusion for more accurate forecasting of water supply from the Sierra Nevada snow*. Western Snow Conference. Seattle, Washington. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Arvin, L., Riebe, C., Aciego, S., Blakowski, M. (2016). *Nd Isotopes in Soils and Pine Needles Trace Aeolian Inputs to Sierra Nevada Ecosystems*. Goldschmidt Abstracts. Yokohama, Japan. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Oroza, C., Zheng, Z., Zhang, Z., Glaser, S., Bales, R., Conklin, M. (2015). *Optimization methods for multi-scale sampling of soil moisture and snow in the Southern Sierra Nevada*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Safeeq, M., Grant, G. (2015). *Patterns of Hydrologic Sensitivity to Climate in the Western US: Implications for Future Predictions*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Boisrame, G.F.S, Thompson, S.E., Stephens, S., Collins, B., Tague, N. (2015). *Resilience Through Disturbance: Effects of Wildfire on Vegetation and Water Balance in the Sierra Nevadas*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Martin, S., Conklin, M., Liu, F. (2015). *Source Water Flow Pathways In Forested, Mountain, Headwater Streams: A Link Between Sediment Movement Patterns And Stream Water Chemistry*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ferrell, R., Ferrell, P., Hartsough, P., O'Geen, A. (2015). *Spatial Patterns between Regolith Thickness and Forest Productivity in the Southern Sierra CZO*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Hart, S., Barnes, M., Johnson, D., Meadows, M. (2015). *The Median Isn't the Message: Elucidating Nutrient Hot spots and Hot Moments in a Sierra Nevada Forest Soil*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Carey, C.J., Hart, S.C, Riebe, C.S., Aciego, S., Blakowski, M., Aronson, E. (2015). *The role of elevation and time in structuring soil microbial communities in the Sierra Nevada, California*. Ecology Society of America Annual Meeting. Baltimore, Maryland. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Gallery, R., Aronson, E., Fairbanks, D., Murphy, M., Rich, V., Hart, S. (2015). *Tools and perspectives for a unified approach to understanding microbial ecology in the critical zone*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bart, R. R. (2015). *Type Conversion, Fire and Ecosystem Services*. Western Mountain Initiative Annual Meeting. Three Rivers, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Callahan, R., Riebe, C., Dosseto, A. (2016). *Using Cosmogenic and U-Series Nuclides in Stream Sediment to Test Hypotheses About Mountain Landscape Evolution*. Goldschmidt Abstracts. Yokohama, Japan. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Taylor, N., Dueker, K., Riebe, C., Chen, P., Flinchum, B., Holbrook, S. (2015). *Using Three-Dimensional Passive Seismic Imaging to Capture Near-Surface Weathering and Its Influence on Overlying Vegetation*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Visser, A., Thaw, M., Stacy, E., Hunsaker, C., Bibby, R., Deinhart, A.L., Schorzman, K., Egnatuk, C., Conklin, M., Esser,

B. (2015). *Variability of Residence Time tracer Concentrations at the Southern Sierra Critical Zone Observatory during the California Drought.*. American Geophysical Union Fall Meeting.. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

O'Geen, A. T. (2015). *Visions for the future of Soil Survey and soil information delivery*. Soil Science Society of America International Meeting. Minneapolis, Minnesota. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bales, R. (2015). *Water and Sierra Nevada forests*. The State Bar of California Environmental Law Conference at Yosemite. Fish Camp, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Educational aids or Curricula.

Rhodea, J., and Gilmore, M. (2016). *Stomata printing: Seeing the small parts and spaces in plants.* Activities adapted from California Academy of Sciences. Presented at the Merced County Office of Education TEAM-E workshop, June 2016, Wawona CA.

Educational aids or Curricula.

Sullivan, L., and Gilmore, M. (2016). *Grass, Rabbits, and Wolves – Oh My! Understanding Food Chains and Ecosystem Interactions.* Activities adapted from Shodor. Presented at the Merced County Office of Education TEAM-E workshop, June 2016, Merced CA.

Educational aids or Curricula.

Gilmore, M. (2016). *Carbon's adventures around the forest.* Presented at the Merced County Office of Education TEAM-E workshop, June 2016, Wawona CA.

Educational aids or Curricula.

Gilmore, M. (2016). *Tools of the Trade: Methods for Measuring Trees.* Presented at the Merced County Office of Education TEAM-E workshop, June 2016, Wawona CA.

Educational aids or Curricula.

Rhodea, J., and Gilmore, M. (2016). *Invent an Insect!* Activities adapted from California Academy of Sciences. Presented at the Merced County Office of Education TEAM-E workshop, June 2016, Wawona CA.

Artwork.

Barnes, M. (2015). Oak Woodlands at San Joaquin Experimental Range. Oil on canvas. Publicly displayed at Merced Multicultural Arts Center, August 2015, Merced, CA.

Artwork.

Barnes, M. (2015). Soil Madness. Mixed media. Publicly displayed at Merced Art Hop Epekel Gallery, March-April 2016, Merced CA.

Other Presentation.

Bales, R. (2016). *Sierra Nevada tree die-off: Lessons learned & future challenges.* Presented at Tulare Basin Watershed Connections Group, January 10, 2016, Fresno CA.

Other Presentation.

Gilmore, M., Thaw, M., Moreland, K., Rungee, J. (2016). *Where Rock, Soil, Water, Air, and Life Connect: Understanding and Measuring the Critical Zone.* Presented at Riverdance Farms Annual Merced River Fair and Pick 'n' Gather, June 4, 2016, Livingston CA.

Other Presentation.

Lucas, R. (2015). Science Content Seminar. Presented at Merced County Office of Education TEAM-E Science workshop,

September 2015, Merced, California.

Other Presentation.

Rungee, J. (2015). *Sierra in a Box*. Presented at Merced County Office of Education TEAM-E Science workshop, September 2015, Merced, California.

Other Presentation.

Tague, C. (2015). *Fire, Water, and Ecosystems in a Changing Climate*. Presented at Zuckerberg Institute for Water Research (ZIWR), part of the Jacob Blaustein Institute for Desert Research, October 28, 2015, Ben-Gurion University of the Negev, Be'er Sheva, Israel.

Other Presentation.

Tague, C. (2016). *Ecohydrology and Informatics: Seeing water in the Trees!* Presented at Arizona State University, April 13, 2016, Tempe, Arizona.

Other Presentation.

Tague, C. (2016). *Fire, Water, and Ecosystems in a Changing Climate*. Presented at Water Resources Graduate Program Winter Seminar, Oregon State University, February 2016, Corvallis, Oregon.

Other Presentation.

Bales, R. (2015). *Water and Sierra Nevada forests.* Presented at the Tuolumne County Alliance for Resources & Environment Annual Meeting, September 21, 2015, Pinecrest CA.

Other Presentation.

Bales, R. (2015). *Water Information System.* Presented at UC Merced to USAID Group from Afganistan, Dec 7, 2015, Merced CA.

Other Presentation.

Bales, R. (2016). *Water Security in a Changing Climate: California Drought and Sierra Nevada Response*, Presented at Invited Seminar, Lawrence Berkeley National Laboratory, April 14, 2016, Berkeley CA.

Other Presentation.

Bales, R. (2016). *Water & carbon balances in the Southern Sierra: measurements, drought and scaling.* Presented at NASA Jet Propulsion Laboratory, Jan 13, 2016, Pasadena CA.

Other Presentation.

Bales, R., (2015). *Drought impacts on subsurface water storage, evapotranspiration, and vegetation mortality in the Southern Sierra Nevada, 2009-2015.* Presented at the Yosemite Hydroclimate Meeting, Oct 8, 2015, Yosemite Valley CA.

Other Presentation.

Barnhart, T.B., N.P. Molotch, and C. Tague, (2015). *Hydrologic partitioning sensitivity to snowmelt rate, timing, and amount.* Presented at Boulder Creek Critical Zone Observatory Annual Meeting, August 29, 2015, Ward, Colorado. Oral presentation.

Other Presentation.

Blankinship, J. (2016). *The brown belowground.* Presented at University of California Sedgwick Reserve, March 25, 2016, Santa Ynez, California.

Other Presentation.

Blankinship, J.C. (2016). *Soil microbes on a changing world: from quantification to prediction to cooperation*, Presented at

University of Arizona, April 25, 2016, Tucson, Arizona.

Other Presentation.

Gilmore, M., Barnes, M., Rungee, J., Thaw, M., Lash, B., Castro, M., Ayala-Astorga, M. (2016). *How do trees eat, drink, and breathe?* Presented at Southern California Edison Science Days, May 20 and June 3, 2016, Shaver Lake CA.

Other Presentation.

Gilmore, M., Stacy, E., Barnes, M. (2016). *Soil formation, composition, and infiltration.* Presented at Society of American Foresters High Sierra Chapter's Conservation Days, April 21, 2016, Tollhouse CA.

Other Presentation.

Moreland, K. (2016). *Topsoil versus subsoil isotopic carbon and nitrogen along a climosequence.* Presented at University of California Merced EnviroLunch, May 2016, Merced CA.

Other Presentation.

O'Geen, A. T. *Nature and Properties of Soil.* Presented at the Sonora, Tuolume and Calaveras Counties' Master Garderners Programs.

Other Presentation.

Safeeq M. (2016). *Combining in situ and remotely sensed data to understand the interactions between forests and water in the Sierra Nevada.* Presented at Perspectives Across the Hydrologic Cycle, Water Resources Seminar Series, Oregon State University, Corvallis, OR.

Other Presentation.

Safeeq, M. (2015). *Managing water in forested landscapes under climate change: An integrated view.* Presented at Mariposa County Health Department, Mariposa, CA.

Other Presentation.

Safeeq, M. (2015). *Forests and Water in the Sierra Nevada: Kings River Experimental Watershed and Ecosystem Monitoring Project*. Presented to Sierra Nevada Alliance.

Other Presentation.

Safeeq, M. (2015). *Climate Change & Water: Impact and Adaptation for Agriculture.* Presented at Climate & Agriculture Summit, UC Davis, Davis, CA.

Other Presentation.

Safeeq, M. (2015) *Forests and Water in the Sierra Nevada: Kings River Experimental Watershed and Ecosystem Monitoring Project.* Presented at 22nd Annual California Aquatic Bioassessment Workgroup Meeting, October 20-21, 2015, Davis CA.

Other Presentation.

Tague, C., Heckman, C., Flint, A. (2016). *How plant accessible water storage interacts with changing snowpacks in Mediterranean environments*. Presented at CUAHSI Watershed Science Master Class, January 17-22, 2016, Biosphere2, Oracle, Arizona. Poster.

Workshop.

Cross-CZO SAVI Biogeochemistry Workshop held at University of California, Riverside, CA on 28-29 September 2015. Organizing Committee: Emma L. Aronson, Stephen C. Hart, and Rachel E. Gallery. Funded by NSF Science Across Virtual Institutes (SAVI) CZO Network.

Other Publications

Bales, R. (2015). *Roger Bales: Climate talks in Paris are important for the Valley*. Op-ed published in The Fresno Bee.

Status = PUBLISHED; Acknowledgement of Federal Support = No

Bales, R. (2016). *Roger Bales: Sierra is white with snow, but more drought solutions needed*. Op-ed published in The Modesto Bee. Status = PUBLISHED; Acknowledgement of Federal Support = No

Patents

Technologies or Techniques

Neomote Wireless Sensor Network: The Glaser-Bales team has been installing the new generation of wireless sensor stations. The new WSN boards provides a platform that provides the capacity for a wide range of sensors, up to forty analog and/or digital, to be added to the current twelve. The network is comprised of 27 sensor nodes and 30 data relay nodes.

Thesis/Dissertations

Son, K.. *The importance of sub-watershed variability for predicting ecohydrologic response to inter-annual climate variability and climate warming in California's Sierra Nevada watersheds*. (2015). University of California, Santa Barbara. Acknowledgement of Federal Support = Yes

Websites

Critical Zone Observatories Instagram
https://www.instagram.com/criticalzoneorg/

SSCZO contributes photos and captions to the new CZO Instagram account, activated in spring 2016. @CriticalZoneOrg is the offical instagram of all critical zone observatories in the U.S. CZO network. The account currently has 52 followers.

SSCZO Digital Library
https://eng.ucmerced.edu/snsjho/files/MHWG/Field/Southern_Sierra_CZO_KREW

The mjor foci of SSCZO's online presence are the National CZO Program website and the Sierra Nevada San Joaquin Hydrologic Observatory (SNSJHO) digital library. Data, metadata, photos, reports, and other documents are catalogued in the SNSJHO digital library. Access to public data and files is available to anyone. Additional permissions can be obtained through registration and individual requests. Links for viewing and downloading data on criticalzone.org/sierra/data connect to this repository. In spring 2016 we initiated using Google Analytics for page visits and downloads on this site.

SSCZO Facebook
https://www.facebook.com/SSCZO/

The Southern Sierra Critical Zone Observatory maintains a Facebook page. This page is slowly growing with 72 likes. Our Facebook activity reaches a local cross-disciplinary audience of researchers (broader than environmental science, hydrology, or the CZO network), along with some friends and family of SSCZO colleagues. The URL and account name for our Facebook page was updated this year for consistency with our Twitter URL and account name.

SSCZO Twitter
https://twitter.com/SSCZO

The Southern Sierra Critical Zone Observatory was the first CZO in the National CZO Program with an active Twitter account. Now that the network has expanded and other CZOs are active on Twitter, it is a space for SSCZO to connect with other observatories and researchers interested in critical zone science. SSCZO posts events, photos, videos, and links to pertinent stories and blog posts on the Twitter page. This avenue has been useful in reaching researchers, media and other professionals, particularly in publicizing research presentations during professional conferences. A majority of our 292 followers are members of the research community, including researchers unaffiliated with the National CZO Program.

Southern Sierra Critical Zone Observatory
http://criticalzone.org/sierra/

This website is the home of the Southern Sierra Critical Zone Observatory. In the past year, SSCZO staff have worked with National Office staff to publish 28 news articles and opportunities online. Upcoming events and publications lists are regularly updated. Our staff are currently updating static webpage content for improved long-term management and planning to add interactive site maps. We are also part of the CZO network's newly formed Website Committee to continue improving content consistency, layout, features, and accessibility on criticalzone.org.

Twitter - Roger Bales
https://twitter.com/rbalesuc

Since SSCZO PI Roger Bales started a Twitter page in December 2014, he has garnered 731 followers and posted 931 tweets. His page is active in conversations regarding water usage, hydrologic technology and infrastructure, and the ongoing CA drought.

Twitter - SSCZO Researchers
http://twitter.com

Several researchers from SSCZO - students, investigators, and collaborators - actively share SSCZO activities, publications, presentations, upcoming events, and stories and conversations related to the critical zone. Some of our researchers' accounts are listed below:

Lindsay Arvin (@lj_arvin), Ryan R. Bart (@ryanrbart), Asmeret Asefaw Berhe (aaberhe), Russell Callahan (@russ_buss), Rachel Gallery (@rachelgallerys), Steve Holbrook (@WyoGeoProf), Cliff Riebe (@sedimentMatters), Mohammad Safeeq (@safeeqkhan), Naomi Tague (@naomi_eco_hydro), Melissa Thaw (@MelissaThaw).

Supporting Files

Filename	Description	Uploaded By	Uploaded On
SSCZO 2016 Media Coverage_Part2.pdf	Media Coverage of Southern Sierra CZO -- Part 2	Roger Bales	06/29/2016
SSCZO 2016 Media Coverage_Part1.pdf	Media Coverage of Southern Sierra CZO -- Part 1	Roger Bales	06/29/2016

Participants/Organizations

Research Experience for Undergraduates (REU) funding

Form of REU funding support:	REU supplement
How many REU applications were received during this reporting period?	2
How many REU applicants were selected and agreed to participate during this reporting period?	0
REU Comments:	We had REU students in 2015, but not 2016.

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Bales, Roger	PD/PI	2
Conklin, Martha	Co PD/PI	2
Goulden, Michael	Co PD/PI	2
Riebe, Clifford	Co PD/PI	2
Tague, Christina	Co PD/PI	1

Berhe, Asmeret Asefaw	Co-Investigator	2
Glaser, Steven	Co-Investigator	1
Hart, Stephen	Co-Investigator	3
O'Geen, Anthony	Co-Investigator	3
Safeeq, Mohammad	Co-Investigator	1
Bart, Ryan	Postdoctoral (scholar, fellow or other postdoctoral position)	3
Blankinship, Joseph	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Fellows, Aaron	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Jefferson, Jennifer	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Williams, Elizabeth	Postdoctoral (scholar, fellow or other postdoctoral position)	9
Aciego, Sarah	Other Professional	1
Busse, Matt	Other Professional	0
Chen, Po	Other Professional	1
Choate, Janet	Other Professional	1
Davis, Frank	Other Professional	0
Dueker, Ken	Other Professional	1
Esser, Brad	Other Professional	3
Fogel, Marilyn	Other Professional	1
Gilmore, Michelle	Other Professional	9
Graham, Bob	Other Professional	0
Guo, Qinghua	Other Professional	1
Hayes, Jorden	Other Professional	2
Holbrook, Steve	Other Professional	1
Hopmans, Jan	Other Professional	1
Hunsaker, Carolyn	Other Professional	1
Johnson, Dale	Other Professional	1

Kelly, Anne	Other Professional	1
Maxwell, Reed	Other Professional	1
McCorkle, Emma	Other Professional	1
McCormick, Cyril	Other Professional	2
Meadows, Matt	Other Professional	1
Meng, Xiande	Other Professional	10
Son, Kyongho	Other Professional	1
Stacy, Erin	Other Professional	12
Sullivan, Lynn	Other Professional	2
Visser, Ate	Other Professional	3
Womble, Patrick	Other Professional	1
Hartsough, Peter	Staff Scientist (doctoral level)	4
Arvin, Lindsay	Graduate Student (research assistant)	5
Barnes, Morgan	Graduate Student (research assistant)	6
Callahan, Russell	Graduate Student (research assistant)	9
Chen, Xaoli	Graduate Student (research assistant)	2
Collins, Caitlin	Graduate Student (research assistant)	4
Devine, Scott	Graduate Student (research assistant)	3
Dove, Nicholas	Graduate Student (research assistant)	8
Ferrell, Ryan	Graduate Student (research assistant)	6
Flinchum, Brady	Graduate Student (research assistant)	1
Heckman, Christopher	Graduate Student (research assistant)	3
Keifer, Ian	Graduate Student (research assistant)	2
Lucas, Ryan	Graduate Student (research assistant)	6
Lukens, Claire	Graduate Student (research assistant)	4
Moreland. Kimber	Graduate Student (research assistant)	9

Oroza, Carlos	Graduate Student (research assistant)	10
Rungee, Joe	Graduate Student (research assistant)	9
Taylor, Nicholas	Graduate Student (research assistant)	9
Thaw, Melissa	Graduate Student (research assistant)	12
Tian, Zhiyuan	Graduate Student (research assistant)	9
Wilson, Stu	Graduate Student (research assistant)	2
Zheng, Zeshi	Graduate Student (research assistant)	1
Araiza, David	Non-Student Research Assistant	2
Everhart, Anthony	Non-Student Research Assistant	4
Jimenez, Ricardo	Non-Student Research Assistant	1
Ayala-Astorga, Maria	Undergraduate Student	3
Castro, Madeline	Undergraduate Student	2
Dziegiel, Abby	Undergraduate Student	3
Elias, Oscar	Undergraduate Student	3
Huang, Jennifer	Undergraduate Student	3
Vang, Mai	Undergraduate Student	2

Full details of individuals who have worked on the project:

Roger C Bales
Email: rbales@ucmerced.edu
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: PI, oversight, planning, team lead, hydrologic balance

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Martha H Conklin
Email: mconklin@ucmerced.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: CZO coPI, InTeGrate Critical Zone course, groundwatersurface water interactions, especially in meadows

Funding Support: SSCZO, UC Merced, other funding

International Collaboration: No
International Travel: No

Michael L Goulden
Email: mgoulden@uci.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: CoPI, flux towers, development of towertop remote sensing system

Funding Support: SSCZO, UC Irvine, other funding

International Collaboration: No
International Travel: No

Clifford S Riebe
Email: criebe@uwyo.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: CoPI, geophysics, regolith formation and erosion, vegetation-landscape interactions

Funding Support: SSCZO, U. of Wyoming, other funding

International Collaboration: No
International Travel: No

Christina Tague
Email: ctague@bren.ucsb.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: CoPI, system modeling especially with RHESSys

Funding Support: SSCZO, UC Santa Barbara, USGS, WSU

International Collaboration: No
International Travel: No

Asmeret Asefaw Berhe
Email: aaberhe@ucmerced.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Sediment transport & nutrient cycling

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Steven Glaser
Email: glaser@berkeley.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Berkeley; Investigator; monitoring technology

Funding Support: UC Berkeley

International Collaboration: Yes, France
International Travel: No

Stephen Hart
Email: shart4@ucmerced.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 3

Contribution to the Project: Sediment transport, nutrient cycling

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Anthony O'Geen
Email: atogeen@ucdavis.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 3

Contribution to the Project: Controls on weathering & regolith formation

Funding Support: other funding

International Collaboration: No
International Travel: No

Mohammad Safeeq
Email: msafeeq@ucmerced.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Adjunct Professor on the project, working collaboratively between UC Merced and Pacific Southwest Research Station (Forest Service)

Funding Support: other funding

International Collaboration: No
International Travel: No

Ryan Bart
Email: ryanrbart@berkeley.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 3

Contribution to the Project: Post-doctoral student working with Tague and collaborator M. Moritz on shrubs, modeling,

and vegetation-water interactions

Funding Support: SSCZO, WSU, SESYNC

International Collaboration: No
International Travel: No

Joseph Blankinship
Email: joseph.blankinship@lifesci.ucsb.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 1

Contribution to the Project: UC Santa Barbara; former UC Merced Hart lab group member; soil biogeochemistry; preparing findings for publication

Funding Support: other funding

International Collaboration: No
International Travel: No

Aaron Fellows
Email: afellowswork@gmail.com
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 1

Contribution to the Project: Analysis and data QA/QC for flux tower data

Funding Support: Others

International Collaboration: No
International Travel: No

Jennifer Jefferson
Email: jejeffer@mymail.mines.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 1

Contribution to the Project: Colorado School of Mines PhD alumna, current postdoctoral researcher with Maxwell; hydrologic modeling

Funding Support: Lawrence Livermore National Laboratory, other funding

International Collaboration: No
International Travel: No

Elizabeth Williams
Email: ewilliams22@ucmerced.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 9

Contribution to the Project: Postdoctoral researcher working with senior personnel Berhe and collaborator Fogel on project for OM retention and stabilization in the subsurface

Funding Support: Other funding

International Collaboration: No

International Travel: No

Sarah Aciego
Email: aciego@umich.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: U. of Michigan; isotope geochemistry, Sierra Nevada dust analysis

Funding Support: external

International Collaboration: No
International Travel: No

Matt Busse
Email: mbusse@fs.fed.us
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 0

Contribution to the Project: USFS Pacific Southwest Research Station, advisory board

Funding Support: Other; CZO funds for travel for Advisory Board duties

International Collaboration: No
International Travel: No

Po Chen
Email: pchen@uwyo.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: U. of Wyoming collaborator; pSin seismic data cross-correlation and processing code

Funding Support: other funding

International Collaboration: No
International Travel: No

Janet Choate
Email: jsc.eco@gmail.com
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Santa Barbara; Techno II/Tague Lab Manager; RHESSys technical support staff

Funding Support: SSCZO, USGS, WSU, other NSF funding

International Collaboration: No
International Travel: No

Frank Davis
Email: fd@bren.ucsb.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 0

Contribution to the Project: Advisory Board; University of California, Santa Barbara

Funding Support: Other; CZO funds for travel for Advisory Board duties

International Collaboration: No
International Travel: No

Ken Dueker
Email: dueker@uwyo.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: U. Wyoming; geophysical seismic array

Funding Support: other funding

International Collaboration: No
International Travel: No

Brad Esser
Email: esser1@llnl.gov
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 3

Contribution to the Project: LLNL collaboator; isotope geochemistry and hydrology

Funding Support: Lawrence Livermore National Laboratory

International Collaboration: No
International Travel: No

Marilyn Fogel
Email: mfogel@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: UC Merced faculty; ecology and biogeochemistry

Funding Support: other funding

International Collaboration: No
International Travel: No

Michelle Gilmore
Email: mgilmore2@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 9

Contribution to the Project: full-time staff, outreach manager; began September 28, 2015; outreach facilitation and coordination for multiple audiences; website and social media management; annual meeting coordination; external and internal communications

Funding Support: SCZO

International Collaboration: No

International Travel: No

Bob Graham
Email: robert.graham@ucr.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 0

Contribution to the Project: University of California, Riverside; advisory board

Funding Support: Other; CZO funds for travel for Advisory Board duties

International Collaboration: No
International Travel: No

Qinghua Guo
Email: qguo@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Merced; Collaborator; remote sensing and GIS

Funding Support: UCM, other funds

International Collaboration: No
International Travel: No

Jorden Hayes
Email: hayesjo@dickinson.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: U. of Wyoming PhD; began new position at Dickinson College in spring 2016; geophysical analysis of near-surface processes, including chemical and physical weathering and landscape evolution

Funding Support: other funding

International Collaboration: No
International Travel: No

Steve Holbrook
Email: steveh@uwyo.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: U. of Wyoming; geophysics and seismology

Funding Support: external

International Collaboration: No
International Travel: No

Jan Hopmans
Email: jwhopmans@ucdavis.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Davis; Collaborator, Alumni Investigator

Funding Support: Other funds

International Collaboration: No
International Travel: No

Carolyn Hunsaker
Email: chunsaker@fs.fed.us
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: USFS Pacific Southwest Research Station; Sr. Personnel; stream and watershed ecology and hydrology

Funding Support: Forest Service

International Collaboration: No
International Travel: No

Dale Johnson
Email: forestrangesoils@gmail.com
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: University of Nevada, Reno; Collaborator, Alumni Investigator

Funding Support: Other funds

International Collaboration: No
International Travel: No

Anne Kelly
Email: a.kelly@uci.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: Previous graduate student, writing and preparing papers for publication

Funding Support: other funding

International Collaboration: No
International Travel: No

Reed Maxwell
Email: rmaxwell@mines.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: Colorado School of Mines collaborator; ParFLow hydrologic modeling

Funding Support: Lawrence Livermore National Laboratory, other funding

International Collaboration: No
International Travel: No

Emma McCorkle
Email: mccoemma@isu.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: Determining sources of carbon in eroded sediments and nutrient (carbon and nitrogen) fluxes of natural waters; Working on publication preparation

Funding Support: other funding

International Collaboration: No
International Travel: No

Cyril McCormick
Email: mccormic@uci.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: UC Irvine project engineer; Goulden research group instrumentation

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Matt Meadows
Email: mmeadows@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: Former SSCZO staff; continuing work on publication preparation

Funding Support: other funding

International Collaboration: No
International Travel: No

Xiande Meng
Email: xmeng@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 10

Contribution to the Project: SSCZO Staff - Data Manager

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Kyongho Son
Email: kson@bren.ucsb.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: UC Santa Barbara PhD alumnus; core CZO measurements, data management and

integration; working on publications

Funding Support: other funding

International Collaboration: No
International Travel: No

Erin Stacy
Email: estacy@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 12

Contribution to the Project: SSCZO Staff, Field Manager; Covered outreach duties until 28 September 2015

Funding Support: SSCZO

International Collaboration: No
International Travel: No

Lynn Sullivan
Email: lsullivan3@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: Part-time staff for Outreach and Education projects through September 2015; volunteer for outreach programs through present

Funding Support: other funding

International Collaboration: No
International Travel: No

Ate Visser
Email: visser3@llnl.gov
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 3

Contribution to the Project: Lawrence Livermore National Laboratory collaborator; Isotope hydrology

Funding Support: Lawrence Livermore National Laboratory

International Collaboration: No
International Travel: No

Patrick Womble
Email: pwomble@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Merced; occasional field assistance at SSCZO; primarily other projects in SNRI

Funding Support: UCM, other funds

International Collaboration: No
International Travel: No

Peter Hartsough
Email: phartsough@ucdavis.edu
Most Senior Project Role: Staff Scientist (doctoral level)
Nearest Person Month Worked: 4

Contribution to the Project: Relationships between soils and weathered bedrock in the O'Geen lab

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Lindsay Arvin
Email: larvin@uwyo.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 5

Contribution to the Project: U. of Wyoming PhD student; geochemical linkages between vegetation, bedrock, and erosion

Funding Support: NSF GRFP

International Collaboration: No
International Travel: No

Morgan Barnes
Email: mbarnes@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Graduate student in the Hart lab, phosphorus in the subsurface

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Russell Callahan
Email: rcallaha@uwyo.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 9

Contribution to the Project: U. of Wyoming PhD student; regolith formation, chemical weathering, and erosion rates

Funding Support: SSCZO

International Collaboration: No
International Travel: No

Xaoli Chen
Email: xiaoli_chen@umail.ucsb.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: UC Santa Barbara graduate student; ecohydrologic systems modeling with RHESSys

Funding Support: SSCZO, WSU, USGS, NSF

International Collaboration: No
International Travel: No

Caitlin Collins
Email: collins@mymail.mines.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Colorado School of Mines graduate student; ParFLow hydrologic modeling

Funding Support: Lawrence Livermore National Laboratory; other funding

International Collaboration: No
International Travel: No

Scott Devine
Email: smdevine@ucdavis.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: UC Davis; soil hydrology characterization

Funding Support: other funding

International Collaboration: No
International Travel: No

Nicholas Dove
Email: ndove@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 8

Contribution to the Project: Graduate student in the Hart lab, mycorrhizal study

Funding Support: SSCZO, UCM, other funding

International Collaboration: No
International Travel: No

Ryan Ferrell
Email: rmferrell@ucdavis.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Graduate student in O'Geen lab, work on neutron probe, saprock investigations, and others

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Brady Flinchum
Email: bflinch1@uwyo.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: U. Wyoming PhD student; seismic data collection and interpretation

Funding Support: other funds

International Collaboration: No
International Travel: No

Christopher Heckman
Email: checkman@bren.ucsb.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: UC Santa Barbara; ecohydrologic modeling

Funding Support: SSCZO, USGS

International Collaboration: No
International Travel: No

Ian Keifer
Email: ikeifer@uwyo.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: U. of Wyoming graduate student; geophysical data processing code

Funding Support: other funding

International Collaboration: No
International Travel: No

Ryan Lucas
Email: rlucas@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: UC Merced PhD student; Suface-groundwater interactions

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Claire Lukens
Email: clukens@uwyo.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Regolith formation and erosion; near-surface geophysics; vegetation-landscape interactions

Funding Support: other funding

International Collaboration: No
International Travel: No

Kimber Moreland
Email: kmoreland@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 9

Contribution to the Project: Graduate student in the Hart and Berhe labs working on nitrogen in the subsurface

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Carlos Oroza
Email: coroza@berkeley.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 10

Contribution to the Project: Graduate student on developments for the wireless sensor network and site selection

Funding Support: SSCZO, other funding

International Collaboration: Yes, France
International Travel: Yes, France - 0 years, 2 months, 0 days

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Joe Rungee
Email: jrungee@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 9

Contribution to the Project: University of California, Merced; Ecohydrology, data modeling

Funding Support: UC Merced, other funding

International Collaboration: No
International Travel: No

Nicholas Taylor
Email: ntaylor9@uwyo.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 9

Contribution to the Project: Graduate student at U. of Wyoming, geophysics and subsurface remote sensing

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Melissa Thaw
Email: mthaw@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: Graduate student in the Conklin lab; isotope hydrology, ecohydrology

Funding Support: SSCZO, Lawrence Livermore National Laboratory, UC Merced, Southern California Edison, others

International Collaboration: No
International Travel: No

Zhiyuan (Tina) Tian
Email: ztian@ucdavis.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 9

Contribution to the Project: Graduate student in O'Geen group, neutron probe, spatial work, soil chemistry, and others

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Stu Wilson
Email: stuwilson@ucdavis.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: Graduate student at UC Davis; soil characterization and chemistry

Funding Support: Other funding

International Collaboration: No
International Travel: No

Zeshi Zheng
Email: zeshi.z@berkeley.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: Graduate student work on LiDAR ground-truthing, Wireless data at Providence

Funding Support: Other funding

International Collaboration: No
International Travel: No

David Araiza
Email: daraiza@ucmerced.edu
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 2

Contribution to the Project: UC Merced research assistant in Fogel lab

Funding Support: other funding

International Collaboration: No
International Travel: No

Anthony Everhart
Email: aeverhart@ucmerced.edu
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 4

Contribution to the Project: volunteer January-June 2016; part-time employee as of 6 June 2016; soil, snow, precipitation, and vegetation sampling with M. Thaw

Funding Support: other funding

International Collaboration: No
International Travel: No

Ricardo Jimenez
Email: ricardoj@uci.edu
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 1

Contribution to the Project: UC Irvine junior specialist research assistant; Goulden research group

Funding Support: SSCZO, other funding

International Collaboration: No
International Travel: No

Maria Ayala-Astorga
Email: mayalaastorga@ucmerced.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: undergraduate field assistant, summer 2016

Funding Support: SSCZO

International Collaboration: No
International Travel: No

Madeline Castro
Email: mcastro29@ucmerced.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: outreach program assistant; website updates, outreach materials drafting and event assistance, data entry

Funding Support: SSCZO

International Collaboration: No
International Travel: No

Abby Dziegiel
Email: adziegiel@ucmerced.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Undergraduate student assistant for Hart

Funding Support: CZO & other

International Collaboration: No
International Travel: No

Oscar Elias
Email: oelias2@ucmerced.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: undergraduate assistant in Hart Lab

Funding Support: other funding

International Collaboration: No
International Travel: No

Jennifer Huang
Email: jhuang26@ucmerced.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Undergraduate assistant in Hart Lab

Funding Support: other funding

International Collaboration: No
International Travel: No

Mai Vang
Email: mvang25@ucmerced.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Undergraduate assistant in Hart Lab

Funding Support: other funding

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Lawrence Livermore National Laboratory	Other Organizations (foreign or domestic)	Livermore, CA
US Forest Service, Pacific Southwest Research Station	Other Organizations (foreign or domestic)	Fresno, CA

Full details of organizations that have been involved as partners:

Lawrence Livermore National Laboratory

Organization Type: Other Organizations (foreign or domestic)
Organization Location: Livermore, CA

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research

More Detail on Partner and Contribution: Collaboration with Co-PI M. Conklin on SSCZO meadows

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US Forest Service, Pacific Southwest Research Station

Organization Type: Other Organizations (foreign or domestic)
Organization Location: Fresno, CA

Partner's Contribution to the Project:
In-Kind Support
Facilities
Collaborative Research

More Detail on Partner and Contribution:

What other collaborators or contacts have been involved?

Molly Blakowski [U. of Michigan grad student] with Sarah Aciego

Singleton Thibodeaux-Yost; Daniel Carlson; Bethany Soto [California Regional Water Quality Control Board] – Post-fire monitoring plan for Rough Fire area (S Fork Kings River, Hume Lake, Mill Flat Creek) with an emphasis on water quality on turbidity, DO, EC, temperature, pH, metals, and nutrients; potential collaboration with Forest Service too. Spoke/emails (Feb 16, 2016) with them about available CZO data, connected with KREW (Hunsaker, Safeeq) regarding KREW data as a baseline.

Joost Iwema [graduate student, University of Bristol, United Kingdom] – using data from tower/Irvine soil sensors in conjunction with COSMOS evaluation, especially at Soaproot. (Emails, Feb 2016)

Yufang Jin and Toby O'Geen [UC Davis] – parameterizing cost-effective rangeland biomass measurement tool (remote sensing), at SJER; help from CZO staff with permitting and scouting

Sarah Hall [Faculty, College of the Atlantic] – establishing undergraduate environmental field course that will spend 1-2 days at SSCZO in summer 2017; scouted in June 2016

NASA Cal/Val – groundtruthing satellite near-surface water quantification; adding additional soil moisture sensors; 2017 implementation?

Jeff Lauder [grad student, UC Merced] and Emily Moran [faculty, UC Merced] – vegetation productivity, vegetation surveys, and pine species adaption to climate change and elevation movement (Providence, Soaproot, Short Hair – inquiries with SCE and private landowners about research there)

Jill Marshall [postdoctoral scholar, UC Berkeley] Tree root instrumentation and root pressures at root-rock interface. Instrumentation depending on my budget and time (dime-sized force sensors at the root-rock interface, maybe data loggers and maybe wind sensors and tilt meters (Providence, Soaproot– inquiries with SCE and private landowners about research there).

Impacts

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

From the outset the Southern Sierra CZO was planned as a resource for the critical-zone research community, and our team has actively engaged others in using this resource. Three levels of users are represented at the Southern Sierra CZO: the core CZO team, research collaborators and cooperators. Our core team represents six universities plus the USFS. Over 20 research groups are collaborators. These collaborator groups are not formally part of the Southern Sierra CZO grant, but work with the core team using largely other resources and are an important part of the SSCZO. In addition, several additional cooperators use Southern Sierra CZO data, collect samples at the Southern Sierra CZO or make use of other CZO resources in their own work.

Modeling holds an important role in disseminating research results. Modifications by C. Tague to the Regional HydroEcologic Simulation System (RHESSys) serve as mechanisms for encoding advances made by our field based analyses. Ongoing refinement of the RHESSys code and RHESSYs parameterization are part of the CZO, and provide tools that are made accessible to a broader earth-system-science modeling community. RHESSys code and parameter libraries are made available through github (https://github.com/RHESSys/RHESSys). In this 2015-16 year we emphasized:

a) the development of new physiological parameters for chaparral and conifer species derived from field measurements, and

b) development of new routines within RHESSys that support testing of different assumptions about how neighboring trees share water.

We note that RHESSys is used by eco-hydrologists throughout the world – and results from this tool development will be particularly useful for researchers in other semi-arid and snow-dominated systems.

A. O'Geen, C. Riebe and colleagues are implementing empirical geophysical modeling, which will also be linked with the RHESSys modeling.

In collaboration with the Wyoming Center for Environmental Hydrology and Geophysics (WyCEHG), we have developed a workflow can be applied to other landscapes across the world to study the link between regolith properties and ecosystem processes. Optimizing and integrating geophysical methods allowed us to model the subsurface composed of various weathered rock types and quantify the water holding capacity and plant available water used by Sierra Nevada vegetation. These rock properties were compared to remotely sensed and ground-truth ET values. We observed a correlation between bedrock lithology and plant productivity, as indicated by ET. The data suggest that environments with a relatively thin weathered zone cannot support plant life, even if the climate is ideal for vegetation growth.

What is the impact on other disciplines?

We used a seismic geophysical method, known as ambient seismic interferometry, combined with an adapted Hertz-Mindlin rock physics model to image porosity in 3-D across three compositionally distinct granites that underlie a gradient in vegetation cover and evapotranspiration (ET). The integration of these methods provided a foundation for future studies of deep critical zone structure, currently difficult and expensive to model with more traditional methods (e.g. drilling).

We collaborate with work carried out on several other research grants, including three other NSF awards at UC Merced:

– WSC Category 3: Propogating climate-driven changes in hydrologic processes and ecosystem functions across extreme biophysical and anthropogenic gradients, Award 1204841, PI: T. Harmon.

– MRI: Development of a basin-scale water balance instrument cluster for hydrologic, atmospheric and ecosystem science, Award 1126887, PI:R. Bales.

– REU Site: Yosemite environmental science research training, Award 1263407, PI:S. Hart.

It is planned that the proposed NEON core site and relocatable sites be co-located with the SSCZO; and permitting and planning work is underway by NEON.

The SSCZO works with the U.S. Forest Service and U.S. Park Service as they plan and implement forest- restoration strategies for the Sierra Nevada. Our work is central to informing the water-cycle impacts, drought resilience and other aspects of how the forest will respond to management actions and disturbance.

Tague received a SESYNC (National SocioEnvironmental Synthesis Center) grant that supports a two-year working group on integrating economic and biophysical models to examine pre and post ecosystem service impacts of wildfire and fuel treatment (title: Wildfire Management, Ecosystem Dynamics, and Climate: The Role of Risk Salience in Driving Ecological Outcomes).The SESYNC working group uses several Western U.S. case-study sites, including the SSCZO. RHESSys is the core biophysical model used in coupled analysis, and its parameterization and application is being based on the CZO. Model-based analysis of the sensitivity of forest hydrology and carbon cycling to climate variability and to forest management is increasingly of interest to both forest managers and water-resource managers in the Sierra. Both the SESYNC working group and a dissertation supervised by Tague (Kastl) explicitly involve resource management stakeholders. Kastl is investigating how science-based model presentation influences how stakeholders understand the complex watershed dynamics studied by scientists at the CZO. The SESYNC working group will involve forest managers from agencies as well as communication expertise through COMPASS a group that specializes in science based communication for the public (http://www.compassonline.org/).

Our spatially dense soil-moisture and matric-potential measurements over an 8-yr time period, plus the coincident measurements of snowpack, solar forcing, temperature, and relative humidity will be analyzed to better understand the multi-sector, cumulative impact of multiple years of drought in CA.

We believe the discovery of deep carbon in weathered bedrock will have a significant impact on the knowledge base of carbon stocks in terrestrial environments.

We have made several advances in wireless-sensor-network optimization, which are both important to the CZO network and have applications well beyond the CZOs. Existing algorithms in computer science do not have the data necessary to inform real-world deployments of wireless monitoring technologies. We have shown that field-hardened optimization needs to incorporate the long term evolution of signal strength (RSSI) and packet delivery ratio (PDR) along each link in the wireless network, as well as understanding how environmental factors (such as trees, changes in humidity etc.) impact wireless performance. By analyzing historical signal strength data from the CZO and combining with classification algorithms, graph theory etc., we were able to produce an approach that combines insights from multiple disciplines to create a standard approach to establishing new wireless observatories. We worked with our collaborators at INRIA Paris (French National Lab) to develop a new data architecture for remote environmental monitoring systems. This architecture simplifies the data coming across wireless-sensor networks by dividing each packet into a "sensor object" with a defined type and MAC address. These packets can be easily transmitted through base station and unpacked at remote servers. SOL has the potential to be used across multiple disciplines in environmental sensing and our collaborators at INRIA are working to make the system open source so anyone can use and develop upon it. The SOL architecture will facilitate real-time data transfer and archiving. Our collaborators are also working on real-time data visualization and archiving tools for the SOL architecture based on InfluxDB, Grafana, and Google maps, which I am currently working to adapt for the SSCZO wireless-sensor network.

We have integrated techniques from machine learning to develop more-rigorous approaches to observatory design. Specifically, we employed unsupervised and semi-supervised learning algorithms (a Gaussian Mixture model and Gaussian Process, respectively) to find representative sensor locations for spatially distributed snow observatories. We then analyze the long-term accuracy of these methods using shared SSCZO data and collaboration with LiDAR data. Our results suggest that adopting these techniques can result in observatory designs that produce more accurate estimates of spatially distributed variables such as snowcover (relevant to the primary disciplines of Hydrology/Environmental Sensing). These techniques are not limited to snowcover or wireless sensor networks; they can be applied broadly in the field of environmental sensing.

P. Chen’s pSin code, initially written to run cross-correlations on our SSCZO seismic data, will provide services to other researchers attempting to process large-scale data (several terabytes). The code was published in *Computers and Geosciences* and is available to the public.

What is the impact on the development of human resources?

SSCZO staff and students have engaged in four curriculum-development or teacher training partnerships this year. Members of our team have given interactive presentations to, among others, TASTES, a local teacher training program; and at STEM Tracks, a two-year teacher-development program covering three mountain counties. The interactive Next Generation Science Standards activities included field trips through forests and several climatic biomes in the Sierra Nevada. It should be noted that UC Merced is a Hispanic Serving Institution, and the region around UC Merced has a very high proportion of underrepresented students who could be the first in their family to attend college.

SSCZO student R. Lucas was an instructor at the California Institute for Biodiversity (CIB) Climate Change Workshop. He

communicated CZO science in the context of climate change to K-12 teachers that attended the workshop. He also participated in an additional institute through CIB that focused on bringing field investigations into K-12 classrooms in the intent to help facilitate the implementation of Next Generation Science Standards. [ems1] M. Goulden used CZO research results to help train K-12 instructors attending a summer workshop at UC Irvine.

An activity simulating water resource management decisions, developed by R. Lucas and E. Stacy, was adapted for the American Geosciences Institute for teachers, and distributed by the National office in June 2014. We have answered inquiries from teachers making use of the exercise in their classroom. In conjunction with D. Duggan Haas, (CZO National Office), a SSZCO Virtual Field Experience was created to stimulate a field visit and present results. Instructors are able to take their students to the SSCZO P301 site and, using an inquiry approach, acquire information regarding our most pressing scientific questions.

SimWater products were updated by E. Stacy and M. Gilmore after R. Lucas testing the existing exercise material with the UC Merced Critical Zone class taught by M. Conklin.

What is the impact on physical resources that form infrastructure?

The Glaser-Bales team has been installing the new generation of wireless sensor stations. The new WSN boards provide a platform that provides the capacity for a wide range of sensors, up to forty analog and/or digital, to be added to the current twelve. The network is comprised of 27 sensor nodes and 30 data relay nodes. Through an NSF MRI grant, plus state and local support, that technology is being applied at the river-basin scale (American River basin) in the Sierra Nevada. The wireless-sensor network can be viewed as a platform for real-time, spatially distributed environmental monitoring. It is flexible, in that we can add different types of sensors to it, and nodes can be moved around if researchers ever want to use it for more than the current applications of snowcover, energy-balance and soil monitoring.

What is the impact on institutional resources that form infrastructure?

The SSCZO infrastructure and data are a resource for both UC and the community. We receive frequent requests for access to both the data and site. We are planning to make the data availability sustained over the long term.

What is the impact on information resources that form infrastructure?

Data and information. Data-management policies and procedures for the SSCZO are laid out in the management plan. The SSCZO continues to maintain a current and thorough digital library. This is the main repository for data, metadata, protocols, photos and presentations. Raw data are freely available after upload at multiple points per year, and processed data are made available according to CZO data policies. The SSCZO team also participates in the CZO data-management project.

SSCZO Digital Library data catalog

https://czo.ucmerced.edu/dataCatalog_sierra.html and direct link to files:
https://eng.ucmerced.edu/snsjho/files/MHWG/Field/Southern_Sierra_CZO_KREW

Web and social media. Online efforts complement our written and oral presentations. The main SSCZO online presence is through the CZO website and the SNSJHO digital library. Facebook and Twitter accounts provide an informal counterpart where we share field activities, real time information on conference presentations, and pertinent updates on research and current events. Descriptions for each site follow.

Southern Sierra Critical Zone Observatory (www.criticalzone.org/sierra). This website is the home of the Southern Sierra CZO. In the 2015-2016 year, SSCZO staff expanded the research field areas, added data, posted multiple opportunities, and regularly updated field and research activities. In the coming months, we will focus on …...

SSCZO Facebook (www.facebook.com/SouthernSierraCZO). The Southern Sierra CZO is the only active CZO Facebook page that we are aware of. This page is slowly growing, and reaches a local cross-discipline audience (broader than environmental science, hydrology, or the CZO network). The audience is more location based, centered around Merced.

SSCZO Twitter (https://twitter.com/ssczo). The Southern Sierra CZO was the first CZO in the network with an active Twitter account. Now that the network has expanded and other CZOs are active on Twitter, it is a space for the SSCZO to connect with others observatories and researchers interested in critical zone science. Southern Sierra CZO posts events, photos, and links to other pertinent stories and blog posts on the Twitter page. This avenue has been useful in reaching researchers, media and other professionals, particularly in publicizing research presentations during professional conferences

R. Bales Twitter (https://twitter.com/rbalesuc). PI R. Bales also uses Twitter regularly to disseminate and comment on issues related to the SSCZO and the CZO network.

What is the impact on technology transfer?

The Southern Sierra CZO has a high profile with resource-management stakeholders in California and the broader region. Our research addresses fundamental knowledge gaps around management of water supplies, forests, hydropower and integrated ecosystem services. The enhanced predictive capabilities that we are developing provide much needed tools to understand the effects of management actions, disturbance and climate warming on ecosystem services. Adapting to climate change basically involves managing ecosystem services, with water related ecosystem services being an early if not primary focus. Having a CZO with major capability to inform and influence adaptation around water supply in California is very timely given the state's global leadership role in implementing climate solutions.

California is grappling with many challenges at the intersection of water, forests and climate. Water security is the reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water related risks. Water security in semiarid regions is founded on adequate water storage. Four consecutive dry years have emphasized the significance of the problem in California. In some cases, management actions can in part offset the effects of climate warming, and can lower the risk of severe disturbance, e.g. wildfire. Both the knowledge and technology developed by the SSCZO are informing decision making around water storage and ecosystem services.

In addition to broad outreach to resource managers and stakeholders, the SSCZO attends to other audiences. The general public is the audience for many of our communications, including press reports and newspaper opinion pieces. We have given public talks in local communities, as well as presentations to civic organizations. The Southern Sierra CZO has been employing internet tools as part of its outreach program. SSCZO presences on Twitter and Facebook have gained more followers. These social-media platforms are available to the public, and also provide a way to disseminate information about events and activities to CZO and non-CZO researchers and students. E. Stacy has organized a monthly Science Café for the City of Merced, drawing on SSCZO as well as other science issues of public interest. SSCZO PI R. Bales, Co-PI M. Conklin, collaborator M. Safeeq and others have presented to local groups in the region and across the state.

We are making make the wireless-sensor network methods we're developing open source so anyone can use them, including the sensor-placement algorithm, the SOL architecture for wireless-sensor networks, and the tool to predict RSSI discussed above. See http://github.com/realms-team/sol.

What is the impact on society beyond science and technology?

Building on the success of the SSCZO in bringing a multi-campus collaboration to address knowledge gaps that are critical to California and the Western United States, several UC faculty from 5 campuses, including 3 SSCZO investigators, last year started the UC Water Security and Sustainability Research Initiative (http://ucwater.org) that links headwater research under the SSCZO with complementary research on valley groundwater systems and water policy. UC Water is supported by the UC Office of the President, and aims to focus UC resources on key problems and working alongside California's water leaders to achieve a water-secure future and build the knowledge base for better water-resources management. This multi-campus initiative blends UCs technical advances in water resources with parallel innovations in policy analysis and decision support to meet the state's water-security challenges. Three elements of water security underpin the research. First, salient, credible and legitimate water information at the proper spatial and temporal scale is a bottleneck for sound decision making. UC Water will develop innovative, quantitative water accounting and analysis methods that replace century-old technology and provide the foundation for better decisions under increasing uncertainties. Embedding modern information systems into both natural and engineered infrastructure is feasible, affordable and timely. Second, understanding the way water flows through the natural environment, and how it is extracted, conveyed and stored in built and natural infrastructure is fraught with uncertainties. UC Water will make immediate research contributions by developing understanding of land-cover changes on source-water areas, and tools and techniques for better groundwater management. Third, water-management institutions in California have not kept pace with yesterday's scientific and engineering developments, let alone developed the capacity to adapt to 21stcentury stressors. UC Water will tightly weave legal and policy research through its scientific agenda to create an integrated whole. Through integration of measurement and modeling technologies, and drawing on UC expertise across disciplines, UC Water aims to make rapid progress towards filling the gaps.

Our SSCZO results developing a viable method to quantify groundwater storage over a large-scale area (several acres) could influence water policies towards more sustainable practices.

Changes/Problems

Changes in approach and reason for change

The California drought has led the SSCZO to focus more directly on understanding related to the resiliency of California's critical Sierra Nevada headwaters. Essentially all aspects of the CZO research agenda, as outlined in the five areas presented in the Accomplishments section, are contributing to the focus.

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

Our subsurface drilling plans were postponed from year 1 until geophysical surveys could be completed to inform the drilling effort. A particularly insightful round of geophysical surveys was completed in summer and fall 2015, in work led by a graduate student who started in fall 2014. The geophysical work was supplemented by Geoprobe coring and by trenching of large soil pits, allowing us to obtain direct observations of physical and chemical properties of the subsurface. Though most cores were collected and most pits were completed last fall, some of this work was postponed until this spring and summer owing to wildfires and early snow in the area.

Together, results from the coring, pit digging, and geophysical imaging have helped us focus on several exciting new questions about how regolith thickness and development vary across landscapes and how they influence overlying ecosystems. For example, the data collected thus far are consistent with the hypothesis that evapotranspiration, and thus ecosystem productivity, is coupled to the depth and degree of weathering of regolith across mountain slopes spanning a wide range in land cover, from bare rock to dense forest. As trees continue to die in the ongoing California drought, our data may also help us test the hypothesis that the sensitivity of ecosystems to water stress is ultimately regulated by water holding capacity in the subsurface, which is in turn influenced by regolith thickness and degree of weathering.

In the next year, with the help of the remaining drilling funds – which we will need to carry over into year 4 – we plan to conduct a deeper-reaching program of drilling to explore the emerging hypothesis that regolith thickness is set by the interaction of topographic and tectonic stress fields, which allow fractures to open in the subsurface. Thus, our use of the drilling funds has evolved into a test of the exciting hypothesis that tectonic stresses in Earth's crust influence ecosystem response to drought stress at Earth's surface through their effects on regolith thickness.

Changes that have a significant impact on expenditures

We postponed hiring of a postdoc due to the longer-recruitment needed to bring in someone with the well-developed integrated-modeling background and skills needed. This will result in the need for carryover funds, as it was budgeted for year 3.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.