i. **CZO Participants**

A large group of active researchers comprises the Southern Sierra CZO team (listed in Table 1). As a part of implementing our management plan this year, we established an Advisory Board. Several graduate students are starting with the team in fall 2014, as is a post-doctoral scholar. Four students defended graduate degrees in the past year, and one of them continues to work with the SSCZO for his doctorate degree. More than 40 researchers (Table 2) have collaborated with the SSCZO and many new projects are in development.

Table 1. Southern Sierra CZO Team

Name	Institution	Status	
Matt Busse	USFS Pacific Southwest Research Station	Advisory Board	
Frank Davis	University of California, Santa Barbara	Advisory Board	
Bob Graham	University of California, Riverside	Advisory Board	
Roger Bales	University of California, Merced	Investigator, Primary	
Martha Conklin	University of California, Merced	Investigator	
Steven Glaser	University of California, Berkeley	Investigator	
Michael Goulden	University of California, Irvine	Investigator	
Cliff Riebe	University of Wyoming	Investigator	
Christina Tague	University of California, Santa Barbara	Investigator	
Asmeret Asefaw Berhe	University of California, Merced	Sr. Personnel	
Marilyn Fogel	University of California, Merced	Sr. Personnel	
Stephen Hart	University of California, Merced	Sr. Personnel	
Carolyn Hunsaker	USFS Pacific Southwest Research Station	Sr. Personnel	
Anthony O'Geen	University of California, Davis	Sr. Personnel	
Samuel Traina	University of California, Merced	Sr. Personnel	
Jan Hopmans	University of California, Davis	Collaborator, Alumni Investigator	
Dale Johnson	University of Nevada, Reno	Collaborator, Alumni Investigator	
Joshua Clegg	University of California, Merced	Staff	Field Technician
Jeff Laird	University of California, Merced	Staff	Previous field technician
Matthew Meadows	University of California, Merced	Staff	Field Manager
Xiande Meng	University of California, Merced	Staff	Data Manager
Michael Pickard	University of California, Merced	Staff	Primarily other projects in SNRI
Jason Smith	University of California, Merced	Staff	Previous field technician
Erin Stacy	University of California, Merced	Staff	Outreach Mgr, Interim Field Mgr
Lynn Sullivan	University of California, Merced	Staff	Outreach/Educator
Gesha Uminskiy	University of California, Merced	Staff	Previous field technician
Patrick Womble	University of California, Merced	Staff	Primarily other projects in SNRI
Ryan Bart	University of California, Santa Barbara	Postdoc Researcher	New Fall 2014
Otto Alvarez	University of California, Merced	Student	Primarily LiDAR, with Q. Guo
Paige Austin	University of California, Merced	Student	New Fall 2014
Morgan Barnes	University of California, Merced	Student	New Fall 2014
Alexandre Caillat	University of California, Santa Barbara	Student	New Fall 2014
Nicholas Dove	University of California, Merced	Student	New Fall 2014
Jacob Flanagan	University of California, Merced	Student	Primarily LiDAR, with Q. Guo
W Jesse Hahm	University of Wyoming	Student	Graduated 2013
Barbara Jessup	University of Wyoming	Student	Departed program 2011
Anne Kelly	University of California, Irvine	Student	Graduated 2014
Peter Kirchner	University of California, Merced	Student	Graduated 2013
Ryan Lucas	University of California, Merced	Student	Graduated 2013, continuing
Armen Malazian	University of California, Davis	Student	

Sarah Martin	University of California, Merced	Student	Primarily SNAMP, some CZO
Emma McCorkle	University of California, Merced	Student	
Kimber Moreland	University of California, Merced	Student	New Fall 2014
Carlos Oroza	University of California, Berkeley	Student	
Heather Rogers	University of Wyoming	Student	Departed program 2013
Katya Roudneva	University of California, Davis	Student	
Philip Saksa	University of California, Merced	Student	Primarily SNAMP
Kyongho Son	University of California, Santa Barbara	Student	
Melissa Thaw	University of California, Merced	Student	New Fall 2014
Casandra Woodward	University of Nevada, Reno	Student	Graduated 2012
Ian Wrangham	University of California, Irvine	Student	New Fall 2014
Zeshi Zhang	University of California, Berkeley	Student	

Table 2. Collaborators and Cooperators for the Southern Sierra Critical Zone Observatory. Collaborators working on active projects or actively exploring new projects are marked by an asterisk.

Name	**Institution**	**Status**	
Sarah Aciego	University of Michigan	Collaborator	*
Emma Aronson	University of California, Irvine	Collaborator	*
Sara Baguskas	University of California, Santa Barbara	Collaborator	*
Joseph Blankinship	University of California, Santa Barbara	Collaborator	*
Rick Bottoms	USFS Pacific Southwest Research Station	Collaborator	*
Chelsea Carey	University of California, Riverside	Collaborator	*
Jeff Diez	University of California, Riverside	Collaborator	*
Anthony Dosseto	University of Wollongong	Collaborator	*
Brad Esser	Lawrence Livermore National Lab	Collaborator	*
Qinghua Guo	University of California, Merced	Collaborator	*
Thomas Harmon	University of California, Merced	Collaborator	*
Peter Hartsough	University of California, Davis	Collaborator	*
W. Steven Holbrook	University of Wyoming	Collaborator	*
Susan Hubbard	Lawrence Berkeley National Laboratory	Collaborator	*
Steven Jepsen	University of California, Merced	Collaborator	*
James Kirchner	Swiss Federal Institute of Technology	Collaborator	*
Nicole Molinari	University of California, Santa Barbara	Collaborator	*
Noah Molotch	University of Colorado at Boulder	Collaborator	*
Jean Moran	CSU East Bay and LLNL	Collaborator	*
Max Moritz	UC Berkeley	Collaborator	*
Bob Rice	University of California, Merced	Collaborator	*
Kristina Rylands	NatureBridge at Yosemite	Collaborator	*
Carl Steefel	Lawrence Berkeley Lab	Collaborator	*
Friedhelm von Blanckenburg	GFZ, Helmholtz Center Potsdam	Collaborator	*
Eric Waller	UC Berkeley	Collaborator	*
Ken Williams	Lawrence Berkeley Lab	Collaborator	*
Steve Wilson	Center for Advanced Research & Technology	Collaborator	*
Jane Leslie Hayes	USFS Pacific Southwest Research Station	Collaborator	
Aniela Chamorro	Texas A&M	Collaborator	
Yihsu Chen	University of California, Merced	Collaborator	
Estelle Eumont	University of California, Davis	Collaborator	
Benjamin Houlton	University of California, Davis	Collaborator	
Branko Kerkez	University of Michigan	Collaborator	
Fengjing Liu	University of California, Merced	Collaborator	

Wally Miller	University of Nevada, Reno	Collaborator
Keith Musselman	University of California, Los Angeles	Collaborator
Shawn Serbin	NASA	Collaborator
Stephen Welch	University of California, Berkeley	Collaborator
Elizabeth Boyer	Pennsylvania State University	Cooperator
Mukesh Kumar	Duke University	Cooperator
Allan James	University of South Carolina	Cooperator
Marco Maneta	University of Montana	Cooperator
Steven Margulis	University of California, Los Angeles	Cooperator
Ahmad Moradi	University of California, Davis	Cooperator
Paolo Nasta	Universià Degli Studi Di Napoli Federico II	Cooperator
Ray Ram	University of California, Merced	Cooperator
Jeorg Rings	University of California, Davis	Cooperator
Tom Whitenack	San Diego Supercomputer Center	Cooperator
Ilya Zaslavsky	San Diego Supercomputer Center	Cooperator

ii. **CZO Participants**

Note: please also see Supplement A (Figures)

The goals of the Southern Sierra Critical Zone Observatory (SSCZO) include: i) expanding process-based understanding of the CZ in a sensitive, societally crucial ecosystem; ii) providing a platform for long-term physical, biogeochemical and ecological studies; and iii) developing a framework for improving Earth System Models. In addressing these goals, the SSCZO has installations and measurements at four main sites spanning a steep elevation gradient in the southern Sierra Nevada. This spatial climate gradient in CZ properties and processes permits predicting effects of climate change by substitution of space for time. Building on our work of the first six 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 (Fig. 1). These research questions are:

1. How do regolith properties and process of formation vary over 10-m to 100-km scales?
2. How do physics, chemistry, and biology interact to influence critical-zone function over instantaneous to decadal timescales?
3. How quickly do regolith properties change in response to altered climate and 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?
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?

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 5 years through cooperation with sister CZOs and the broader community.

Summary Since October 2013, the SSCZO had several significant findings. Hydrologic and nutrient-cycling modeling has been applied across the full transect and results are being interpreted. Geophysical techniques demonstrated that the bedrock weathering front was as deep as 30-40 m in some locations. Erosion rates on a long-term time scale (geologic scale measured through cosmogenic isotopes) are nearly 100x short-term rates based on recent measurements of sediment discharge. Differences in

bedrock nutrient concentrations play a role in vegetation cover of the landscape, where exposed domes and unvegetated spaces have lower P concentrations than nearby dense forests. The combined depth of soil and regolith may relate to the water reserves accessible by vegetation. Evapotranspiration across three sites has been progressively attenuated in relation to soil depth during the past 3 years. This is one of several CZ processes that the ongoing California drought has illuminated. Another unexpected result is the continued groundwater discharge point in the studied meadows. Warmer temperatures will accelerate snowmelt, as seen in our snowmelt manipulation experiment; this impacts shallow soil moisture 2-4 months after snowmelt.

Drilling, sampling, & imaging regolith Three published papers are based on the results from the Providence site (at 2000 m elevation) that were collected over the first 6 years of the project. This includes one on factors that influence the presence/absence of soil and vegetation across the landscape. This paper reports strong evidence in support of our hypothesis that the notable bimodality in soil and vegetative cover is regulated by differences in the geochemistry of underlying bedrock (Fig. 2).

Controls on weathering & regolith formation Work focused on understanding relationships between characteristics of soils (top 1.5 m) and weathered bedrock (>1.5 m). We sampled soils and weathered bedrock to the depth of refusal using a Geoprobe across the elevational gradient at two of the four catchments [oak savannah/400 m elev., and pine-oak forest/1100 m elev.]. The 2700 m elev. site was not sampled because it has little weathered bedrock due to glaciation. The mixed-conifer (2000 m elev.) forest site had been sampled previously. Across 3 sites, chemical and physical properties were measured from more than 170 core subsamples; analyses included saturated hydraulic conductivity, texture, bulk density, pH, total C and N, cation exchange capacity, extractable base cations, available P, and mineralogical characteristics.

Two projects are evaluating erosion controls. On a geologic time scale, cosmogenic-based sediment tracing work includes an analysis of (U-Th)/He ages in apatite from sediment in streams draining the east side of the Sierra Nevada. The goal is to use the bedrock ages to constrain the source elevations of stream sediment, which is ultimately generated from rock on slopes and thus carries a geochemical fingerprint of the source. To assess the short-term scale of sediment sources, soils from stream banks and hillslopes were analyzed for stable isotopes. Soil samples were sent off for analysis for ^{13}C and ^{15}N, and radiocarbon. Results to date suggest the majority of sediments are mostly surficial with some carving occurring in established channels (Fig. 3).

Relationship between elevation/climate & exchanges of carbon and water Our work on the eddy-covariance flux towers has led to a paper that is in revision at PNAS, as well as three chapters from A. Kelly's dissertation that should be submitted in the coming months. Mean ET projected for 2085-2100 for different scenarios (for a constant precipitation and warming) shows a marked increase at higher elevations compared to current conditions ET (Fig. 4). Other work on the flux towers involved the design, fabrication, and preliminary lab testing of a down-looking, tower-top, remote-sensing package that will be deployed at the P301 site. This system includes separate Vis/NIR and thermal IR cameras, along with a terrestrial scanning LiDAR. This will provide information on vegetation structure, health, and gas exchange; foliage and biomass temperature, to better understand the controls on winter photosynthesis and summer stress; and the 3D structure of the canopy, as well as the patterns of snow accumulation and melt.

We are investigating surface-groundwater exchange of Sierra Nevada montane meadows in the context of greater watershed processes. Monitoring wells and piezometers located in our meadows show that the meadow center continues to be a groundwater discharge point, even after two low precipitation years (Fig. 5). Results for analysis of the water for S-35, an isotope with a 90-day half-life, indicate that the water is over a year old.

The discrepancy between vertical gradients at the edge versus center of the meadow is reflected in the horizontal groundwater gradient. During snowmelt, the horizontal gradient exhibits flow more toward the center of the meadow (Fig. 6), becoming more parallel to streamflow later in the season (Fig. 7). This is indicative of shallow subsurface water discharging from the hillslope during snowmelt. As snowmelt subsides, the shallow subsurface source is diminished. Hence the vertical gradient at the meadow edge changes from groundwater discharge to recharge and the change in horizontal gradient seen in Figures 6 and 7.

Endmember-mixing analysis on streamwater chemistry is supportive, showing spring streamwater more closely resembles the snow endmember and moves toward the groundwater endmember as the season progresses. Streamwater deviates from this pattern when fall rain events occur (Fig. 8). The local meteoric water line differs slightly from the global meteoric water line (Fig. 9).

In order to tie this work together, we have started building a HYDRUS 2-D model of the upper P301 watershed using our knowledge of the meadow system, our collaborator knowledge of the adjacent forest hydrology, and the conceptual model proposed by Holbrook et al. (2014) based on geophysical work in the watershed.

Relationship between elevation/climate & nutrient cycling Completed drafts of three papers summarize baseline RHESSys model simulation (Fig. 10) and establish spatial resolution requirements (Fig. 11) and the importance of soil parameter uncertainty for ecohydrologic estimates (Fig. 12). We also extended existing RHESSys implementation to include all four flux towers at the Southern Sierra CZO. Our preliminary modeling study showed that the model captured observed ET flux at P301 flux tower, and the effects of spatial resolution of model on estimating annual ET and NPP were minor. We also found that annual ET and NPP estimates are more sensitive to root-zone, water-holding-capacity parameters than drainage parameters.

Effect of forest management on water & nutrient cycling Water and nutrient cycling are also being tracked in discharge and soil flows. Water samples from the Forest Service archives were analyzed in house for TC, TOC, TN, pH, and aromatic C from WY 2009. A small subset of the same samples were analyzed for common cations and anions to compare agreement with FS data. Investigation of nutrient hot spot and hot moments at two plots in Providence include separate horizontal grids of ion-exchange resin capsules located at multiple depths. Resin capsules are collected after first precipitation in autumn and post-snowmelt in spring. Nutrients analyzed include: Ca, Mg, Na, NH_4^+, NO_3^-, and PO_4^{3-}. Resins have been extracted and all chemical analyses completed for the last three sampling dates (from 2012 and 2013). Following previous datasets from these plots (Johnson et al. 2011 and Johnson et al. 2014), these data will help distinguish hot spots (persistence of high nutrient concentrations at a single location over multiple time periods) from hot moments (episodically high nutrient concentrations at a single location).

iii. **Education and Outreach Activities**

Our communication and sharing of scientific products with stakeholders includes frequent talks around the state, 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. A 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 presented a snippet of our research to Congressman Jim Costa and German Ambassador Peter Ammon during their visit to UC Merced. Our presentation highlighted the use of our wireless sensor network providing real-time *in situ* measurements and our meadow eddy correlation measurements. Since the start of the current cooperative agreement in fall 2013, SSCZO PI R. Bales and Co-PI M. Conklin have

briefed the California State Board of Food and Agriculture, Delta Stewardship Council, 3 Integrated Regional Water Management authorities, the National Park Service, the Sierra Water Work Group, and presented at the UC Legislative Drought Summit, and the multi-agency Fire Ecosystem Forest Management & Water Yield Symposium, California Water Policy Conference 23, Urban Water Institute's Spring Water Conference and other symposiums. Investigator C. Tague presented the current RHESSys model-based analysis of the linkages between forest hydrology and carbon cycling with climate variability at the stakeholder meeting of the California Forest Pest Council 62nd Annual Meeting. Staff E. Stacy has been collaborating with large stakeholder groups as part of the Dinkey Landscape Restoration Project and a regional Watershed Connections group.

In addition to stakeholders and decision makers, the Southern Sierra CZO has an active program of education and outreach to K-16 and the general public using CZO data and results. Some of the most-successful education and outreach activities over the past year include building relationships with schools and local organizations. These activities are designed to meet new common-core standards for analytical thinking and problem solving. Partnerships with NatureBridge Yosemite, the Center for Advanced Research and Technology, and other institutions will share research results with educators and students alike. NatureBridge has provided award-winning, residential outdoor education programs in Yosemite National Park (YNP) for school groups since 1971. Approximately 13,000 California students cycle through this program every year. Two SSCZO researchers presented to NatureBridge teachers this past year, and SSCZO Co-PI M. Conklin remains a member of the NatureBridge Yosemite board. SSCZO researchers and education staff also present to grade school students multiple times per year.

New partnerships this year include four curriculum development or teacher training partnerships. SSCZO staff E. Stacy, L. Sullivan, and M. Conklin have given interactive presentations to, among others, California Agricultural Teachers Association; TASTES, a local teacher training program; and STEM-Tracks, a two-year teacher development program covering three mountain counties. SSCZO student R. Lucas was an instructor at the California Institute for Biodiversity (CIB) Climate Change Workshop. He communicated CZO science, namely in the context of climate change, to K-12 teachers that attend the workshop. This summer, he will participate in an additional institute through CIB that will focus on bringing field investigations into K-12 classrooms in the intent to help facilitate the implementation of Next Generation Science Standards. An activity simulating water resource management decisions, developed by R. Lucas and E. Stacy, was adapted for the American Geosciences Institute for teachers,

Other K-12 partnerships include presenting each year at Southern California Edison's Science Days (4th year presenting) and the American Association of University Girls Science Camp (5th year presenting). At these events CZO colleagues facilitate hands-on activities for students that focus on how Sierra Nevada hydrology impacts California's water resources. Our high school partnership with the Center for Advanced Research and Technology (CART) in Clovis, CA, continued, with CZO staff mentoring teams of CART students to conduct a comprehensive snow survey research project (3rd consecutive year).

Dissemination to the research community included alerting potentially interested colleagues publications and presentations through our web pages and email, attending scientific meetings and workshops, and participating in CZO-network activities. Improvements to our digital library and engagement with CZO-network data-sharing activities were also carried out. At the 2013 American Geophysical Union Fall Meeting, the 2013 Geological Society of America and the 2014 Goldschmidt conference, SSCZO PIs, graduate students and research staff presented talks and posters (15 at AGU and several at GSA and Goldschmidt). The national CZO program was an exhibitor throughout the duration of both AGU and GSA conferences, providing information on all CZO sites, and investigators contributed to Town Hall at the 2013 AGU Fall Meeting, a student session at the 2014 Goldschmidt conference, and

will host a session at the Mountain Research Initiative Global Fair and Workshop on Mountain Observatories in Reno, NV, July 2014.

Staff and researchers have organized two major field trips for researchers this year, and hosted workshops and sessions at the Geological Society of America meeting, the annual meeting of American Geophysical Union, and the Mountain Research Initiative Global Fair and Workshop on Mountain Observatories. The Southern Sierra CZO is actively planning the 2014 All Hands Meeting for the CZO Network in September 2014, where we will host researchers from the other 9 observatories, as well as prominent researchers from outside the network and country. The meeting will provide a venue for presenting research results; we anticipate several hard products from this researcher meeting, including outlines for journal articles, workshop ideas, and modeling approaches.

At the undergraduate level, students from UC Merced and partnering universities have worked as field and lab technicians. Using supplemental funds from NSF, two REU students are working at the SSCZO this year. One is focusing on soil nutrient cycling while the other works on meadow water balance. This marks the third year for the UC Merced surface water methods, developed by M. Conklin, and the fifth 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 allows students to learn about research and to collect data for use in class. SSCZO research provided material for other university courses as well. Currently M. Conklin and E. Stacy are part of an InTeGrate team to develop a critical zone processes course. 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 new CUASHI Watershed Hydrology Master Class held at Biosphere in Tuscon Arizona. Investigator C. Tague was the hydrologic modeling instructor.

Modeling holds an important role in disseminating research results. Modifications by C. Tague to the Regional Hydro-Ecologic Simulation System (RHESSys) serve as mechanisms for encoding advances made by our field-based analyses. RHESSys is made freely available to the community and regular user training is provided.

Other products

- *Educational aids or Curricula.*

For InTeGrate (Interdisciplinary Teaching about Earth for a Sustainable Future), M. Conklin and E. Stacy worked with a cross-CZO team of researchers to create curriculum for a Critical Zone university-level course. Course materials, including activities, lesson plans, and assessments, will be available through the Science Education Resource Center at Carleton College.

- *Educational aids or Curricula.*

The CZOs have cooperated for the past two years with the American Geosciences Institute (AGI) to create hands-on learning exercises using CZO data for use in secondary education classrooms. The one-page double-sided exercises were included in AGI's Earth Sciences Week packets and sent to 16,000 teachers nationwide in June 2014. The exercises are attached to this news story and are also available at the National Education and Outreach K-12 portion of criticalzone.org.

Presentations to researchers, stakeholder groups, students, and other outreach audiences:

- Bales, R. (2014). *Can Forest Management to reduce fire risk in the high Sierra result in more stream-flow at the mountain front?* Presentation at Sierra Nevada Research Institute 2014 Research Symposium. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

- Conklin, M. (2014). *Climate Change & Drought in the Sierra*. Opening Plenary, day 2 of Sierra Water Work Group Summit. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bales, R. (2014). *Current Science: Water impacts*. Presentation at Water-Forestry Forum. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bales, R.C. (2014). *Drought & the Sierra Nevada in a changing climate*. Sierra Water Work Group Annual Meeting. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bales, R. (2014). *Forest Water Management*. Presentation at How Green Is Your Valley? Your Voice, Your Future. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Stacy, E. M. (2014). *Forest Water Research Updates*. Presented to California Native Plant Society. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bales, R (2014). *Forest management and stream flows in the Sierra*. Presentation at University of California Drought Summit. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Stacy, E.M (2013). *Forest management presentation at the San Joaquin Region Road Show*. Presentation to agriculture and science teachers. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bales, R. (2014). *Forests, water, climate and disturbance in the Sierra Nevada: critical knowledge gaps*. Fire Ecosystem Forest Management & Water Yield Symposium. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Kingsbury, J., J. Branham, R.C., Bales, and M.H. Conklin (2014). *Futuristic Watershed Management- A Case Study*. Presentation at Urban Water Institute's Spring Water Conference. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Stacy, E.M., L. Sullivan, and J. Clegg (2014). *How forest water needs and forest fire behavior interact with forest density*. Activity for elementary school kids, grades 1-8. at Southern California Edison Science Days. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bales, R. (2014). *Hydrology, Forest Management and Water Security in the Sierra Nevada*. Presentation at Hydrologic Sciences Research Symposium (Water: Our Global Solvent). Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Tague, C. (2013). *Managing water in forest landscapes*. Presentation for 2013 Meeting of the CA Forest Pest Council. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Stacy, E.M., and J. Clegg (2014). *Merced River Fair*. Demonstrations with groundwater and watershed models. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bales, R. (2014). *Mountain hydrology, forest management & water security in the Sierra Nevada*. Presentation at Stanford Research Seminar. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Delgado, O., and R. Bales (2014). *Natural Capital and Ecosystem Evaluation*. Presentation at Marin Municipal Water District Annual Board Planning Retreat. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Stacy, E.M. (2014). *Overview of the Southern Sierra CZO research within the framework of climate change in the region*. NatureBridge Afternoon Seminar Series Presentation. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bales, R. (2014). *Rain, Snow and Temperature*. Presentation for Sequoia & Kings Canyon National Parks, NRCA Symposium Agenda. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

- Meadows, M. and Stacy, E.M (2014). *Snowpack monitoring research & techniques*. Center for Advanced Research and Technology (CART): talks and student mentoring. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Meadows, M. (2014). *Southern Sierra Critical Zone Observatory*. Presentation & panel participation at Dinkey Landscape Restoration Collaborative Meeting. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Stacy, E.M. (2014). *Southern Sierra Critical Zone Observatory*. Presentation at Watershed Connections. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Stacy, E.M., C. Riebe, and J. Clegg (2014). *Southern Sierra Critical Zone Observatory field tour*. Southern Sierra Critical Zone Observatory field tour prior to Goldschmidt 2014 for 8 visiting scientists. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Sullivan, L. (2014). *TASTES teacher training*. Presentation and curriculum presentation with teachers. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Sullivan, L., and M. Conklin (2014). *University Friends Circle Yosemite SNRI Field Trip*. Field trip to Yosemite Valley for approximately 45 University Friends Circle members. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Conklin, M.H. (2014). *Water Yield changes from Forest Treatment Methods*. Presentation at Fire Ecosystem Forest Management & Water Yield Symposium. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

iv. **Cross-CZO Activities**

Several graduate students, undergraduates and recent Ph.D. graduates are involved with the CZO, and are preparing themselves for independent measurement and data analysis work in field hydrology, biogeochemistry, geophysics, and modeling. 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. In addition, two undergraduate students are gaining firsthand experience in field work and data analysis through the Research Experience for Undergraduates program, funded through a supplemental grant from NSF. They will present on their summer projects in August.

Other training opportunities have been organized through open workshops. In the past year, C. Riebe has actively worked as PI on a grant to organize and NSF-sponsored workshop on Drilling, Sampling, and Imaging the Depths of the Critical Zone. The workshop occurred over the period October 24–26, 2013, in Denver, CO and featured an international group of speakers and attendees (49 attendees). A report has been published online, on the criticalzone.org website. Investigators R. Bales and S. Glaser are working with CUAHSI to host a multi-day Wireless Boot Camp, August 2014 in Berkeley.

- Riebe, C.S., and J. Chorover. Report on Drilling, Sampling, and Imaging the Depths of the Critical Zone, an NSF Workshop. Open Project Report to the CZO Community. October 24-26 2013, Denver, CO.

v. **Activities initiated by the CZO-NO**

In the past year, C. Riebe has actively worked as PI on a grant to organize and NSF-sponsored workshop on Drilling, Sampling, and Imaging the Depths of the Critical Zone. The workshop occurred over the period October 24–26, 2013, in Denver, CO and featured an international group of speakers and attendees (49 attendees). A report has been published online, on the criticalzone.org website.

Investigators R. Bales and S. Glaser are working with CUAHSI to host a multi-day Wireless Boot Camp, August 2014 in Berkeley.

The SSCZO community is planning to host the 2014 All-Hands Meeting, the first in more than three years. Five CZO network investigators (R. Bales, M. Conklin, S. Anderson, J. Chorover, and W. Silver) and SSCZO staff E. Stacy are developing the meeting agenda in collaboration with the National Office with input from NSF program officers. Three field trips to CZ installations in the region will be a part of the program.

vi. **Performance Metrics**

Performance metrics for the SSCZO fall under three categories: output metrics, outcome metrics, and impact metrics. Output metrics include the publication of data and results online in our digital library and through peer-reviewed publications. The amount of data and number of publications are tracked.

During the first three quarters of the first year of this cooperative agreement 12 journal papers citing the SSCZO were published (see Section vii), with an equal number of additional manuscripts submitted for publication. SSCZO research was also presented in over 22 conference abstracts and talks (see Section vii), and many more ad hoc presentations. We are implementing tracking for publications by collaborating and cooperating investigators, but those data are not yet available.

Data are housed in an online digital library that is hosted on UC Merced servers and also accessible through the new website portals. Core measurements including water-balance instrument clusters, soil-moisture, and flux-tower data are posted in raw format promptly after retrieval from the field. Processed data, including full QA/QC procedures are posted at least annually for core measurements. SSCZO staff (the data manager and the education/outreach coordinator) help coordinate the compilation of data and appropriate metadata in the digital library. In accordance with the cross-CZO data-management policy, data from all projects will be posted within two years, with the possibility of restricting access for a third year if needed by the investigator for the purposes of publishing. During the last year we met these goals.

As part of our effort to measure *outcomes*, we tracked citations of our peer-reviewed papers, use of our data, and online reach. For 40 articles published since 2008, number of citations ranged from 0-107, with an average of 14 citations per paper despite several new publications. We also track the number of scientists interested in coordinating with the SSCZO. As listed under Section (i), there are more than 25 collaborators working on active projects or pursuing new projects with the SSCZO team.

The depth and breadth of our reach online is tracked through several metrics, including use of our data from Google Analytics for our main website, tracking activity on Twitter and Facebook, and the use of data from the digital library. As an online resource, the Sierra Nevada-San Joaquin Hydrologic Observatory (SNSJHO) digital library is accessed not only by SSCZO team members but also by the broader population of researchers online. We now have a total of 63 registered users for SSCZO data on the digital library; eight of those users registered since our last annual team meeting. The survey of data users, initiated in January 2013, has been delayed this year but will be repeated before the coming annual meeting.

Since we started tracking website activity with Google Analytics in September 2013, we have had more than 2,800 page views, 447 unique visitors, and an average site visit time of 4:22. The majority (69%) of our site views originate as organic searches. The Southern Sierra CZO is maintaining a Facebook page. The page has 33 likes. Since October 2013, 72 posts have reached a total of 340 people. Through Twitter, the SSCZO connects with others observatories and researchers interested in critical zone

science. Since beginning early in 2013, we have 86 followers, have posted a total of 178 tweets and 25 photos, and 13 re-tweets and 23 favorites.

We also track the adoption of our technology at other sites. The wireless sensor network developed at the SSCZO has been implemented in the American River Basin project west of Lake Tahoe. Work planned for this summer will complete the instrumentation at each of the sites in the American River Basin project. Water and power utilities in the Southern Sierra Nevada also have a vested interest in snowpack distribution and water runoff. Further proposals to expand these systems are pending with state and local agencies.

Impacts include better decision making because of our research findings, and improvements to the research process. To achieve broader impacts, we have developed an extensive dissemination network. Our dissemination strategy reaches stakeholders and resource managers as well as researchers. To that end, we have published opinion pieces in local newspapers, produced video and radio segments through collaborations with regional television and radio stations, presented at numerous stakeholder meetings, and hosted visits to our field sites and laboratories. We have communicated with everyone from foresters and other resource managers, to legislative staff and policy makers at the state and Federal level. In aggregate, SSCZO investigators average at least bi-weekly presentations to public audiences.

vii. **Publications and Products**

During the first three quarters of the first year of this cooperative agreement 12 journal papers citing the SSCZO were published (see below), with an equal number of additional manuscripts submitted for publication. SSCZO research was also presented in over 22 conference abstracts and talks (see below), and many more ad hoc presentations. Peer-reviewed articles published from the SSCZO since 2008 have been cumulatively cited 567 times. We are implementing tracking for publications by collaborating and cooperating investigators, but those data are not yet available.

Book chapters

- Granger, D. E. & Riebe, C. S. (2014). Cosmogenic Nuclides in Weathering and Erosion. *Treatise on Geochemistry: Surface and Ground Water, Weathering, and Soils* 7. J. I. Drever. Elsevier. London. 401. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Conference papers and presentations

- Son, K. and C. Tague. (2013). A framework for improving the predictions of ecohydrologic responses to climate change in Sierra Critical Zone Observatory watersheds. Abstract H23F-1333. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Riebe, C.S. W.J. Hahm; and C. Lukens (2013). Bedrock composition limits mountain ecosystem productivity and landscape evolution (Invited). Abstract B13L-02. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Jepsen, S.M., S. Coles, and T.C. Harmon (2013). Catchment Scale Streamflow Response to Climate Variability in the Rain-Snow Transition Zone of California's Sierra Nevada Mountains. Abstract H31H-1314. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Hartsough, P.C., A.I. Malazian, M. Meadows, A.T. O'Geen, J. W. Hopmans (2013). Characterization of Water Use Patterns in the Deep Vadose Zone through Geoprobe Drilling into Weathered Bedrock. GSA Cordilleran Section Meeting. Fresno, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

- Riebe, C.S., L.S. Sklar, C.E. Lukens, and D. Shuster (2013). Climate and Topography Control the Size and Flux of Sediment Produced on Steep Mountain Slopes. GSA Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Tague, C., K. Son, T. Brandt, and A.L. Dugger. (2013). Climate warming and eco-hydrology of forested watersheds in the California Sierra (Invited). Abstract EP11A-07. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Rogers, H. E.; Riebe, C. S.; Granger, D. E. (2013). Cosmogenic 10Be in quartz and magnetite: Using the same nuclide in multiple minerals to quantify differential weathering. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Brantley, S.L., White, T.S., Anderson, S.P., Bales, R.C., Chorover, J., McDowell, W.H. (2013). Critical Zone Science and Observatories Town Hall: TH15D-01. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Zhang, Z., C. Oroza, S.D. Glaser, R.C. Bales and M.H. Conklin. (2013). Developing a robust wireless sensor network structure for environmental sensing. Abstract C41B-0630. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Kirchner, P., R.C. Bales, and T.H. Painter (2013). Estimating forest snow accumulation with LiDAR derived canopy metrics, southern Sierra Nevada, California. Abstract H13J-1507. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Lukens, C., C.S. Riebe, L.S. Sklar, and D.L. Shuster. (2013). Evidence for climatic and topographic control of the size and flux of eroded sediment across a steep mountain catchment. Abstract EP52A-05. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Saksa, P.C., R.L. Ray, R.C. Bales, and M.H. Conklin. (2013). Impacts of forest thinning and climate change on transpiration and runoff rates in Sierra Nevada mixed-conifer headwater catchments. Abstract GC11B-0990. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Kelly, A.E., M. Goulden, and A.W. Fellows (2013). Interactions between cold and water limitation along a climate gradient produce sharp thresholds in ecosystem type, carbon balance, and water cycling. Abstract B23D-0585. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Berhe A.A., E.M. Stacy, E.P. McCorkle, D.W. Johnson, C.T. Hunsaker, and S.C. Hart (2013). Mineral-organic matter associations in eroding hillslopes: findings from headwater catchments in the Southern Sierra Nevada (Invited). Abstract B21H-02. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Lucas, R.G., and M.H. Conklin (2013). Montane meadows and hydrologic connections between forests and streams in the Sierra Nevada, California. Abstract H43K-01. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Riebe, C. S. and Chorover, J. (2014). Report on Drilling, Sampling, and Imaging the Depths of the Critical Zone, an NSF Workshop. Open Project Report to the Critical Zone Community. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

- Driscoll J.M., Meixner T., Steven J., Molotch N., Williams M.W., Sickman J.O. (2013). Role of storage on hydrologic and chemical flux in soil-limited alpine catchments in the Southwestern USA. AGU Chapman Conference on Soil-mediated Drivers of Coupled Biogeochemical and Hydrological Processes Across Scales. Biosphere 2, Tucson, Arizona. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Hopmans, J.W. (2013). Soil and Tree Water Status Dynamics in a Mixed-Conifer Forest of the Southern Sierra Critical Zone Observatory. GSA Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Hahm, W.J., C.S. Riebe, C.E. Lukens, and S. Araki (2013). Strong Lithologic Control on Mountain Ecosystem Productivity and Landscape Evolution. GSA Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bales R.C., Brooks P.D., Molotch N.P. (2013). The strength of strategically placed in situ networks: The Critical Zone Observatory Program (Invited). Abstract H53L-02. Fall Meeting, American Geophysical Union, December 2013. San Francisco, CA. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Meadows, M.W., R.C. Bales, M.H. Conklin, M. Goulden, P.C. Hartsough, J.W. Hopmans, C.T. Hunsaker, R.G. Lucas and A.I. Malazian. (2013). Timber harvest effect on soil moisture in the southern Sierra Nevada: Is there a measurable impact? Abstract H11B-1165. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- McCorkle, E.P., A.A. Berhe, C.T. Hunsaker, M.L. Fogel, and S.C. Hart (2013). Using stable isotopes to determine sources of eroded carbon in low-order Sierra Nevada catchments. Abstract B13G-0604. Fall Meeting, American Geophysical Union. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Journals

- Blankinship, J.C., Meadows, M.W., Lucas, R.G., and Hart, S.C. (2014). Snowmelt timing alters shallow but not deep soil moisture in the Sierra Nevada. WRR. 50 (2), 1448. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; DOI: 10.1002/2013WR014541
- Dixon, J. L., Riebe, C. S. (2014). Tracing and pacing soil across landscapes. Elements. Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes
- Goulden, M.L., R.C. Bales (). Mountain runoff vulnerability to increased evapotranspiration with vegetation expansion. Proceedings of the National Academy of Sciences. Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes
- Hahm, W.J., C.S. Riebe, C.E. Lukens, and S. Araki. (2014). Bedrock composition regulates mountain ecosystems and landscape evolution. PNAS. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; DOI: 10.1073/pnas.1315667111
- Holbrook, W.S., C.S. Riebe, M. Elwaseif, J.L. Hayes, K. Reeder, D. Harry, A. Malazian, A. Dosseto, P.C. Hartsough, J.W. Hopmans (2014). Geophysical constraints on deep weathering and water storage potential in the Southern Sierra Critical Zone Observatory. Earth Surface Processes and Landforms. 39 (3), 366. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; DOI: 10.1002/esp.3502
- Johnson, D.W., C. Woodward, M.W. Meadows (2014). A Three-dimensional View of Nutrient Hotspots in a Sierra Nevada Forest Soil. Soil Science Society of America Journal. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; DOI: 10.2136/sssaj2013.08.0348

- Kirchner, P.B., Bales, R.C., Molotch, N.P., Flanagan, J., Guo, Q. (). LiDAR measurement of seasonal snow accumulation along an elevation gradient in the southern Sierra Nevada, California. Hydrology and Earth System Science. Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Riebe, C. S., Hahm, W. J., Brantley, S. L. (2014). Going deep to quantify limits on weathering in the Critical Zone. Earth Surface Processes and Landforms.. Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes
- Riebe, C.S., Sklar, L.S., Lukens, C E.* & Shuster, D.L (). Climate and topography control the size and flux of sediment produced on steep mountain slopes. Proceedings of the National Academy of Sciences. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes
- Shaw, G.D., M.H. Conklin, G.J. Nimz, and F. Liu. (2014). Groundwater and surface water flow to the Merced River, Yosemite Valley, California: 36Cl and Cl− evidence. Water Resources Research. 50 (3), 1943. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; DOI: 10.1002/2013WR014222
- Son, K. and Tague, C. (). Importance of soil parameter uncertainty in assessing climate change projections in small two Sierra Nevada watersheds. Water Resources Research.. Status = SUBMITTED; Acknowledgment of Federal Support = Yes
- Woodward, C., Johnson, D.W., Meadows, M.W., Miller, W.W., Hynes, M.M., and Robertson, C.M. (2013). Nutrient Hot Spots in a Sierra Nevada Forest Soil: Temporal Characteristics and Relations to Microbial Communities. Soil Science. 178 (11), 585. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; DOI: 10.1097/SS.0000000000000023

Technologies or techniques

- A new generation of wireless NeoMotes was developed under a spin-off company, Metronome Systems.
- Additional improvements were made to the RHESSys eco-hydrologic model for the full transect of instrumented sites, including refinements to the strategic sampling protocol, as well as evaluating the effects of DEM resolution and soil parameter uncertainty. Model adjustments will aid the models in becoming more adaptable for catchments across the region.

Theses

- Hahm, W. Jesse. *Bedrock composition regulates ecosystems and landscape evolution in the sierra Nevada Batholith, California*. (2013). University of Wyoming. Acknowledgement of Federal Support = Yes
- Kelly, Anne E. *Climate controls on ecosystem production, biomass, and water cycling.* (2014). UC Irvine: Earth System Science. Acknowledgement of Federal Support = Yes
- Kirchner, Peter B. *Snow Distribution Over An Elevation Gradient and Forest Snow Hydrology of the Southern Sierra Nevada, California*. (2013). UC Merced: Environmental Systems. Acknowledgement of Federal Support = Yes
- Lucas, Ryan Geoffrey. *Polymictic pool behavior in a montane meadow, Sierra Nevada, CA*. (2013). UC Merced: Environmental Systems. Acknowledgement of Federal Support = Yes

viii. **Engaging the Broader Community**

Both our core team and our extended network have grown this past year. We established our three person Advisory Board in the first year of the Cooperative Agreement. At the first Annual Team Meeting, to be held in the first week of August 2014, several active collaborators are attending to coordinate with the core SSCZO team.

The SSCZO actively contributes to cross-CZO activities. SSCZO Investigator C. Riebe was one of the main organizers for the Drill-the-Ridge workshop, October 2013, in Denver, CO. Riebe and J. Chorover published the workshop report with a summary of the workshop and recommendations for moving forward. Multiple researchers and students from across the CZO network are registered for the Wireless Sensor Bootcamp, scheduled August 11-13 in Berkeley, CA. This wireless sensor workshop was originally scheduled for Year 5, but moved earlier due to demand for training in this field.

Outside the CZO network, the broader community is reached through a variety of means. A primary focus of our work is on the interplay of forest management, water resources, and the impact of a changing climate on the activity and behavior of these systems. The results of such studies are pertinent not just to resource managers and legislators, but also to those whose livelihoods depend on the ongoing health of the forest. 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 CZO, plus parallel advances in cyberinfrastructure and in measurements by satellite and aircraft. Our communication and sharing of scientific products with stakeholders and researchers includes frequent talks around the state and hosting visits to our laboratories and CZO site. Since the Southern Sierra CZO began, we have worked with producers on television and radio features and online educational videos , had multiple editorial pieces in San Joaquin Valley newspapers, briefed a U.S. Senator and other federal legislative staff. Other outreach efforts include public field trips, presentations to grade school students, and partnerships with local high school programs.

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 2013-2014 year, SSCZO staff expanded the research field areas, added data, posted multiple opportunities, and regularly updated field and research activities. In May 2014, staff completed a website content inventory that will direct strategic, regular, and diverse updates on news, photos and data, among other items. In the coming months, we will focus on adding further links to data, interactive maps, more photo galleries and news stories, and centralizing information for CZO presentations at upcoming conferences.

- *SSCZO Facebook* (www.facebook.com/SouthernSierraCZO)

The Southern Sierra CZO is the only known active CZO Facebook page. 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* (twitter.com/sszco)

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.

ix. Results of Evaluation Forms

We have employed evaluation forms to assess multiple events. Among these are the 2013 Annual Meeting, the 2013 public field tour, and visiting researchers. Feedback from the 2013 Annual Meeting has directly informed agenda structure and logistics for the 2014 meeting. For the field trip, we had nine responses from 19 attendees. A mix of public, university associates, and people in legislative and resource management specialties responded. Positive changes were reported for knowledge about Southern Sierra CZO and environmental hydrology. The change in knowledge about wireless sensor networks was more variable, as attendees had widely variable points in starting knowledge.

Response rate from visiting researchers is low. The one form we received about an exploratory trip was positive but sparse. Evaluation forms will certainly be included as part of the approaching Wireless Boot Camp and All Hands Meeting.

x. Additional Funding that Impacts the CZO

CZO investigators routinely leverage funding to support students and postdocs, install equipment, engage collaborators and initiate complementary research. All of the students listed in Table 1 were supported at least in part by non-CZO funds, and most were largely supported by non-CZO funds. Leveraging with the USDA Forest Service is also important, and the SSCZO is in part co-located with Forest Service research programs.

xi. Unanticipated Collaborations

See Table 2 (Section i). Most of these collaborators and cooperators contacted the SSCZO regarding collaboration or use of data and facilities.

xii. Other Impacts of CZO Activities

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 but 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 and Co-PI M. Conklin have presented to local civic groups (including Merced City Council and Rotary Club), California Partnership for the San Joaquin Valley, UC Merced trustees, and the University Friends Circle, and other public audiences. SSCZO staff E. Stacy contributed a research perspective to two region-wide meetings of watershed managers, non-profit groups, and interested parties.

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 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.

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 semi-arid regions is founded on adequate water storage. Three 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 Southern Sierra CZO are informing decision making around water storage and ecosystem services.

xiii. **Data Management**

Data management policies of the Southern Sierra CZO are laid out in the management plan. The Southern Sierra CZO continues to maintain a 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 is made available according to CZO data policies. The SSCZO team also participates in the CZO data management project.

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

xiv. **Comparison of Expenditures versus Budget**

See Supplement B (Year 1 Project Expenditure Summary by Account).

xv. **Plan for Remedial Action**

One planned effort for deep-subsurface drilling was postponed until additional geophysical work can be completed to inform the drilling effort; this geophysical work is planned for summer and fall 2014. Delaying this drilling until year 2 also allows better coordination with the other CZOs, based on the outcomes and recommendations from the deep-drilling workshop. We expect that a coordinated plan for the CZO network as a whole will emerge this fall.

We have advanced the Wireless Boot Camp for other CZOs into year 1. This was done to accommodate the needs of the CZO program as a whole, as the other CZOs are interested in installing or upgrading wireless networks at their sites. The cost impact of this is an expenditure of up to $15,000 direct cost. We were also able to partner with CUAHSI to co-sponsor the workshop, and open it up to the broader community.

xvi. **Problems Likely to Delay Accomplishment of Annual, Strategic Goals**

None identified.

xvii. **Goals and Objectives for Upcoming Year**

The next reporting period will include the balance of year 1 (through Sept 30) and extend for one year, through part of year 2. Some of the work in progress is described above, with a summary of key activities provided here. Three main types of activities are summarized. First, several graduate students have completed their research and papers based on their work are being submitted for publication. SSCZO and cross-site papers describing research being carried out by Co-PIs and postdocs are also being wrapped up and submitted. Second, field research is proceeding, with several upgrades and subsurface investigations enabled by the new cooperative agreement. New collaborators are also joining the SSCZO. Third, many of the outreach activities described for 2013-14 are continuing, with additional activities being added for the coming year.

With the new award in fall 2014 and completion of several graduate students this year, the Southern Sierra Critical Zone Observatory has recruited 10 new students, to work with SSCZO investigators at the SSCZO. Some are working this summer and others will join in the fall.

Modeling, data analysis and publication preparation activities build on the first 6 years of SSCZO research. Some of the near-term work that is maturing, in addition to the many activities described earlier in this report, follow.

- We are synthesizing the geochemical data on weathering with the cosmogenic nuclide data on erosion that we have been collecting over the years.
- Modeling of the effects of recent vegetation treatments on catchment hydrologic processes will be completed for the P301 and P303 catchments this summer, with results extended to other catchments based on detailed parameterization developed for these sites. The RHESSys model is being used for this.
- Also using the RHESSys model, we will compare ecophysiological and drainage parameter sensitivity at the P301 flux tower (rain-snow transition site) with results for towers at higher and lower elevations. These results can be used to infer how underlying geological properties influence climate responses along our CZO elevation gradient. In particular, in the next year we will focus on data assimilation of vegetation structural and physiological information into RHESSys estimates and use this improved parameterization to estimate implication of changing vegetation structure (growth, thinning, fire) and type (shrub, grass, tree species) on water use and carbon cycling. We combine existing CZO measurements with new leaf water potential measurements made by collaborator M. Moritz.
- Further papers on water balance, incorporating COSMOS and wireless-sensor-network soil moisture data, flux-tower evapotranspiration measurements, and other distributed data are in progress and should be submitted in late summer or early fall. This work explores effects of drought on water storage and fluxes, and resiliency of the forest given subsurface properties.
- Data from last summer's meadow eddy-covariance deployment are being analyzed. The station is being redeployed to pick up a second growing season's worth of data. Data from the eddy-correlation instrumentation will allow us to better measure and constrain evapotranspiration from the meadow. Additionally, this instrumentation will give us the opportunity to quantify carbon fluxes in the meadow.

The coming three months (before the close of the first year of the Cooperative Agreement), are critical to our fieldwork. Planned field activities are outlined below.

- Updates to the wireless sensor network, including installation of more resilient hardware, updated firmware, and testing long-range telemetry from the tower
- Installing and testing a tower-mounted remote sensing apparatus

- More geophysical work at multiple sites in preparation for the drilling program
- Reassigning P301 sapflow/soil moisture equipment at other Sierra CZO locations
- Deployment of the eddy correlation station in Long Meadow (SEKI NP)
- Continued data hydrologic collection (both fluxes and water chemistry, including S-35 isotopes) in P301 meadows and Long Meadow (SEKI NP).
- Installation of additional passive dust traps between June and August, so that we have a sufficient number of collectors at each of the four sites along the transect to sufficient dust for analysis.

Our outreach using public talks, briefings with decisionmakers 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.

- A field trip is planned for July 20-22 following the MRI Global Fair and Workshop on Mountain Observatories; this is a collaborative effort with the U.S. Forest Service and the National Park Service that will discuss long-term monitoring in two national forests, Yosemite National Park, and at Mono Lake. SSCZO staff E. Stacy is the primary organizer for this trip.
- The Annual Team Meeting will be held August 4-5 in Fresno, CA. Approximately 25-30 researchers attend each year to exchange research results, plan field work, and strategize for the coming year. Local collaborators (in California) join us when schedules allow.
- The Wireless Sensing Boot Camp will be held August 11-13, 2014 in Berkeley, CA. Sponsored by CUAHSI and CZO, this workshop will cover theory to practice of radio design, network synchronization, equipment deployment, and other aspects of wireless sensor networks.
- The SSCZO Annual Team Meeting is scheduled for August 4-5, 2014.
- The SSCZO community is planning to host the 2014 All-Hands Meeting, the first in more than three years. Five CZO network investigators (R. Bales, M. Conklin, S. Anderson, J. Chorover, and W. Silver) and SSCZO staff E. Stacy are developing the meeting agenda. Three field trips to CZ installations in the region will be a part of the program.

xviii. **Projected Budget**

Please see budget and justification submitted with proposal; plus see spreadsheet in Supplement C (Year 2 budget).

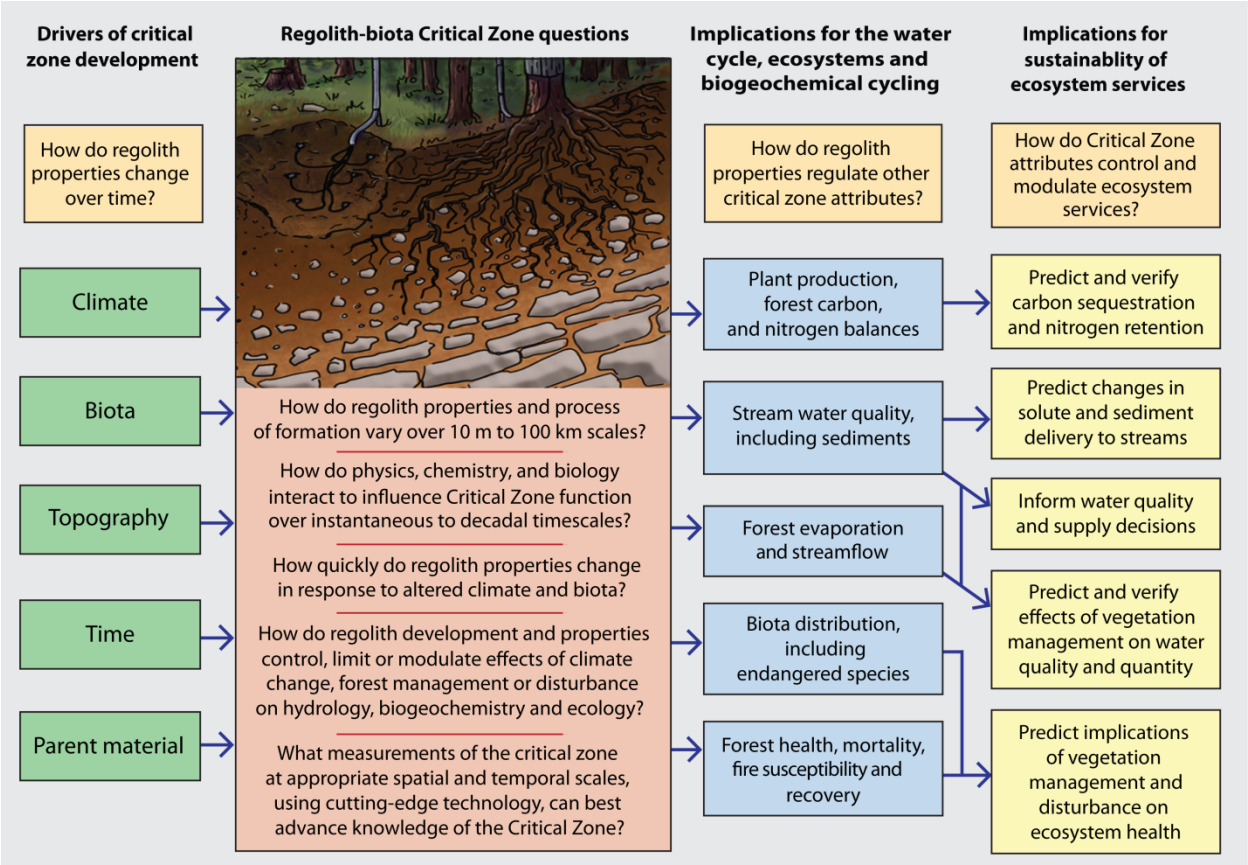

Figure 1—Science goals are organized within this schematic of relationships among drivers of critical-zone development, science questions that guide SSCZO research, implications for critical-zone attributes and implications for CZ services and sustainability.

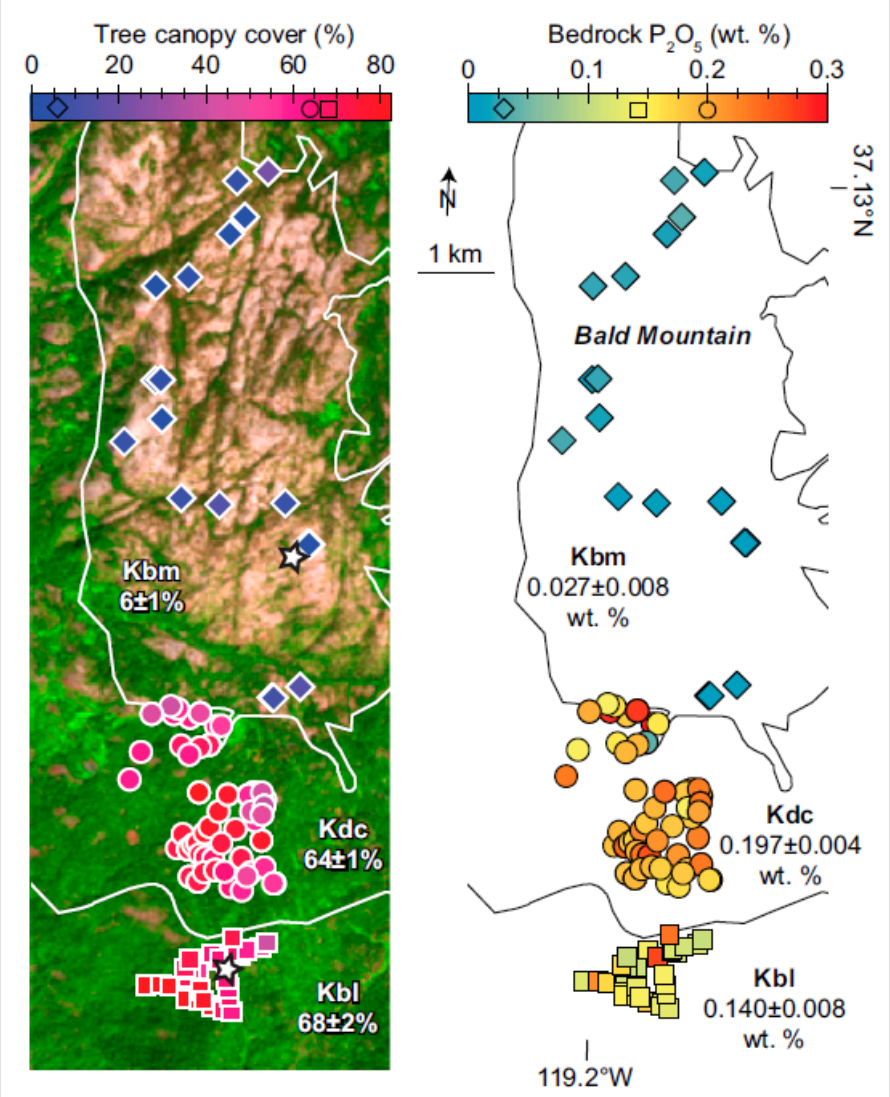

Figure 2—Distribution of vegetation across bedrock with differing phosphorus content. (Left) False-color Landsat image of CZO vicinity with georeferenced bedrock contacts from simplified geologic map shown at Right (after ref. 14). Symbol colors match colorbar scales of Landsat-derived, remotely sensed tree-canopy cover (16; Dataset S3 and SI Text) a proxy for primary productivity (Left), and bedrock P concentrations (Right). Vegetated-unvegetated ecotone coincides with boundary of Bald Mountain Granite (Kbm; diamonds) a desert in bedrock P relative to more heavily forested Dinkey Creek Granodiorite (Kdc; circles) and Bass Lake Tonalite (Kbl; squares). Labels show average (±SEM) tree-canopy cover (Left) and bedrock P concentration (Right) by rock type. Stars at Left pinpoint productivity surveys (SI Text). From *Hahm et al. 2014.*

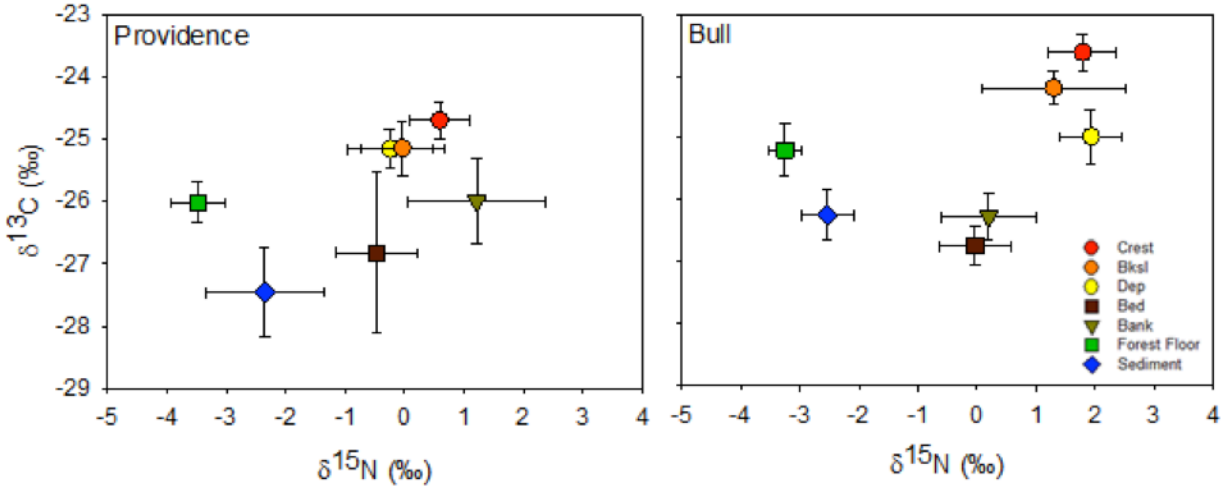

Figure 3—Results to date show that the majority of sediments collected within the two watersheds (P303 and B203) analyzed are derived from forest floor and stream bank materials. This shows that the erosion present is mostly surficial with some carving occurring in established channels.

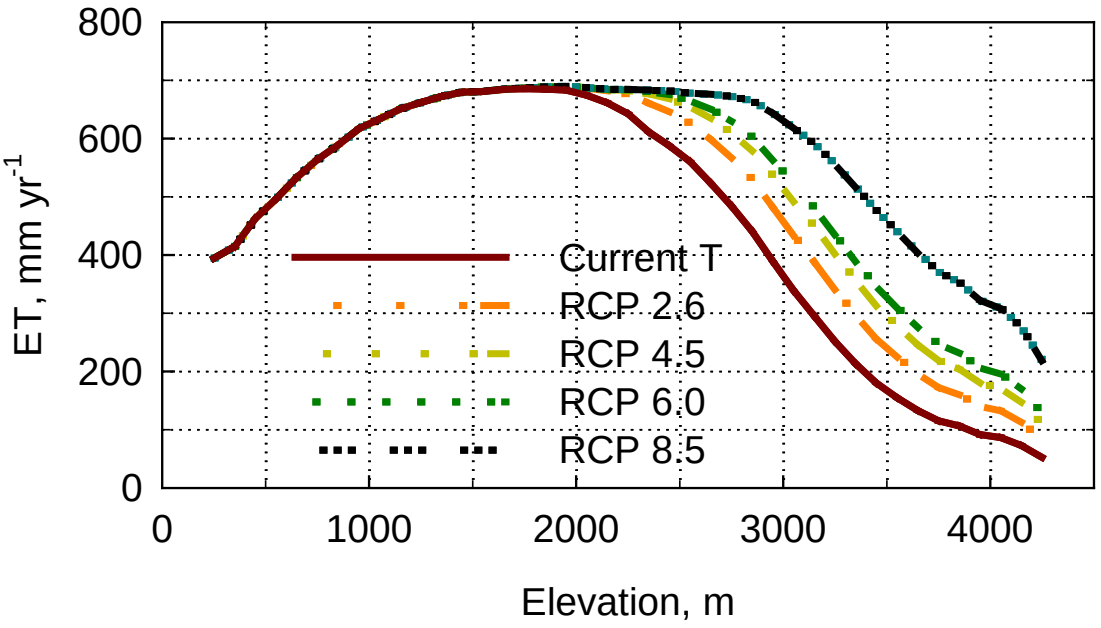

Figure 4—Relationships between elevation (m above sea level) and mean ET for a constant precipitation and warming projected for 2085-2100 with the four Representative Concentration Pathways (RCP). ET under current conditions was calculated using the climate regressions applied to the 1981 to 2010 PRISM Normals. ET under a warmer climate was calculated using the climate regressions and the elevation dependent warming predicted for each RCP. The mean 2085-2100 temperature increase in the atmosphere's lower 4 km above central California ranged from 1.3°C for RCP 2.8 to 4.1°C for RCP 8.5. From *Goulden and Bales, in review.*

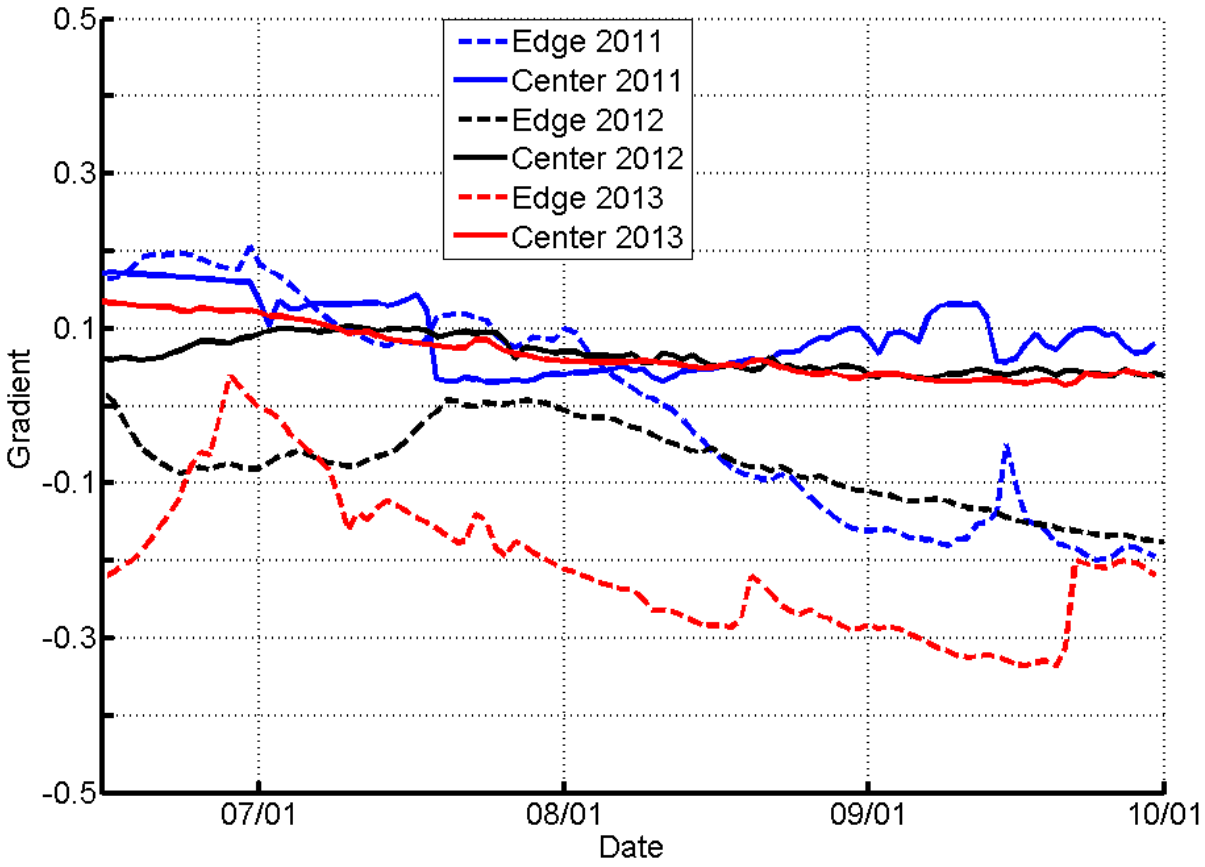

Figure 5—Vertical hydraulic gradient at the meadow edge and meadow center for the relatively wet water year (WY 2011) and two subsequent very dry years (WY2012-2013). Vertical gradient at the meadow edge is consistently negative—indicative of groundwater recharge) in the late summer and fall; while vertical gradient at the meadow center is persistently positive—indicative of groundwater discharge—even after two very dry years.

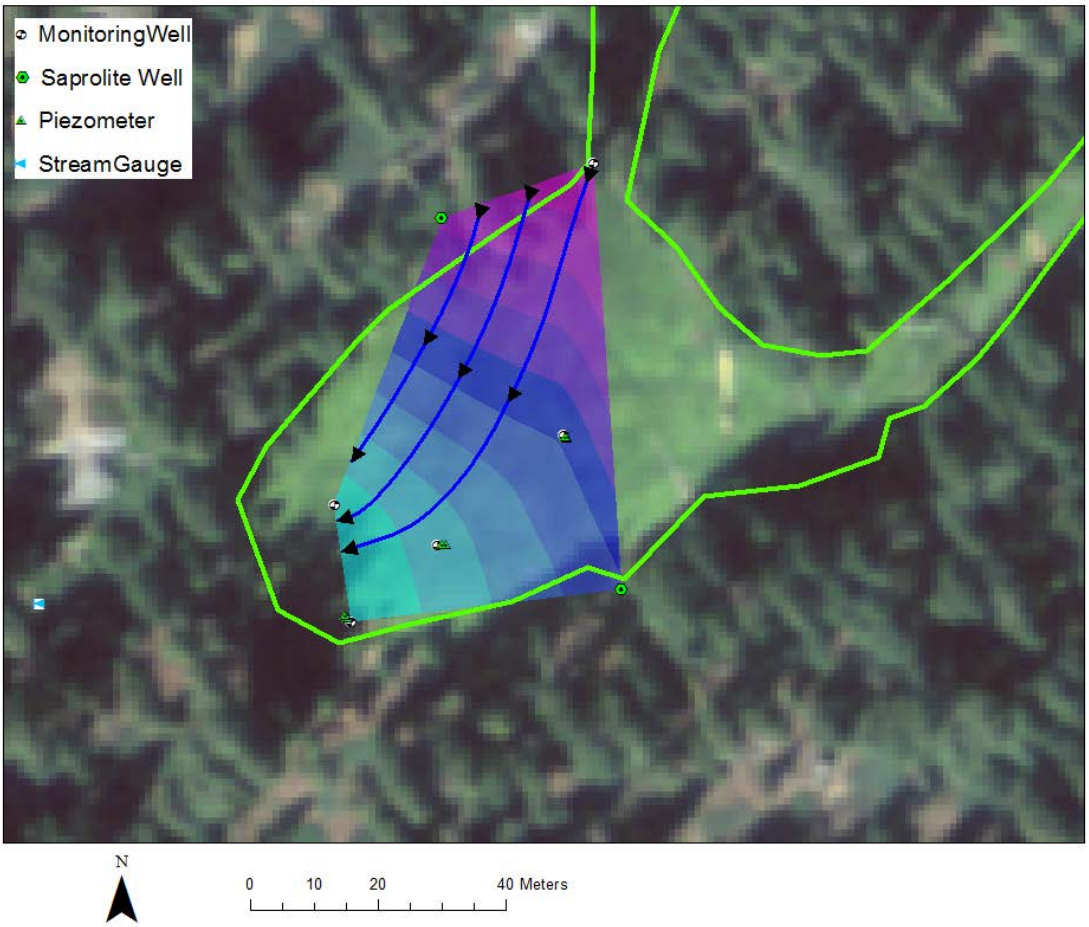

Figure 6—Groundwater elevation map generated from P301 Middle Meadow monitoring wells on for April 1, 2013. Equipotential lines reflect the horizontal groundwater gradient.

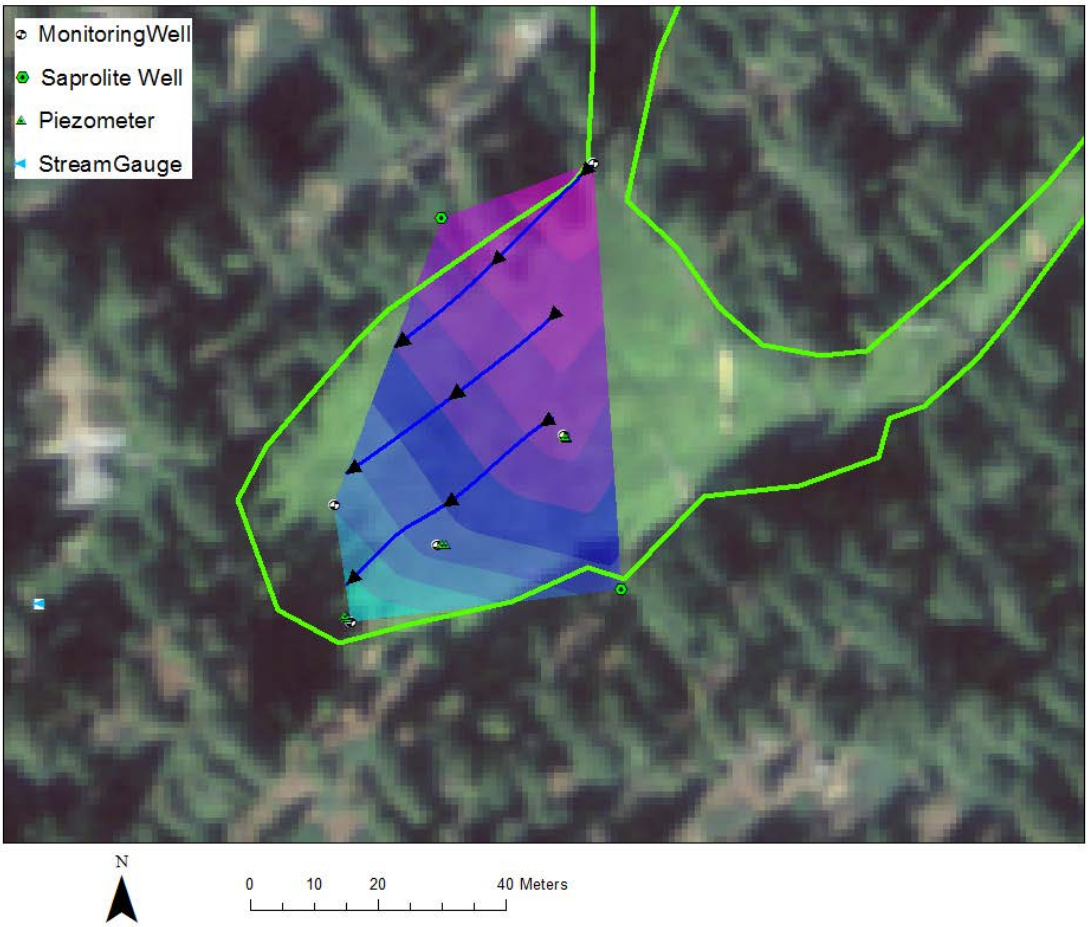

Figure 7—Groundwater elevation map generated from P301 Middle Meadow Wells for September 30, 2013. Equipotential lines represent the horizontal groundwater gradient. Horizontal gradient for this date flows much more parallel to the surface water and local stream flow than the horizontal gradient generated for April 1, 2013 (Figure 3).

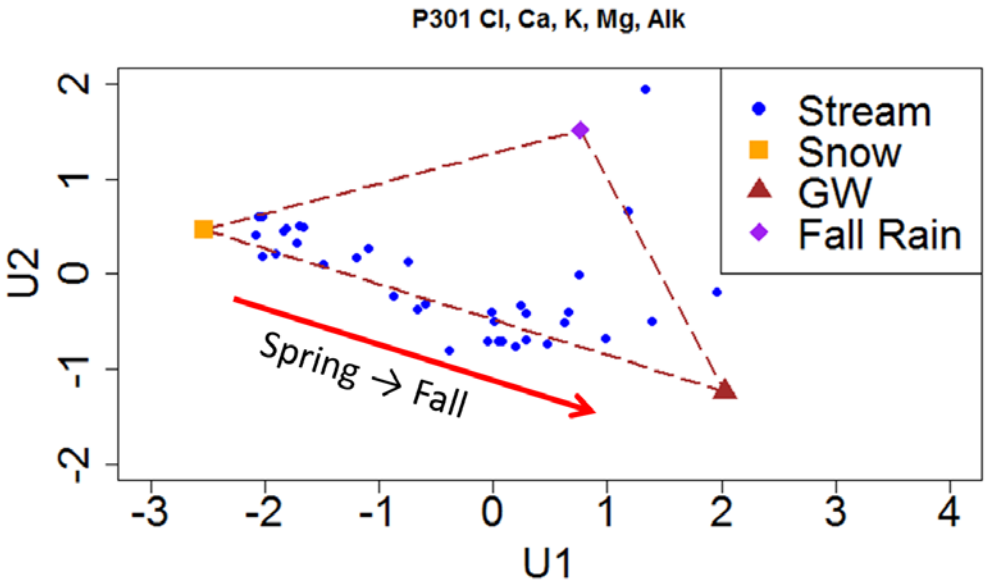

Figure 8—End Member Mixing Analysis for the P301 Meadow surface water discharge. Stream chemistry generally follows the Spring→Fall evolution moving from the Snow end member to the Groundwater end member. Stream chemistry deviates from this evolution when influenced by fall rain events.

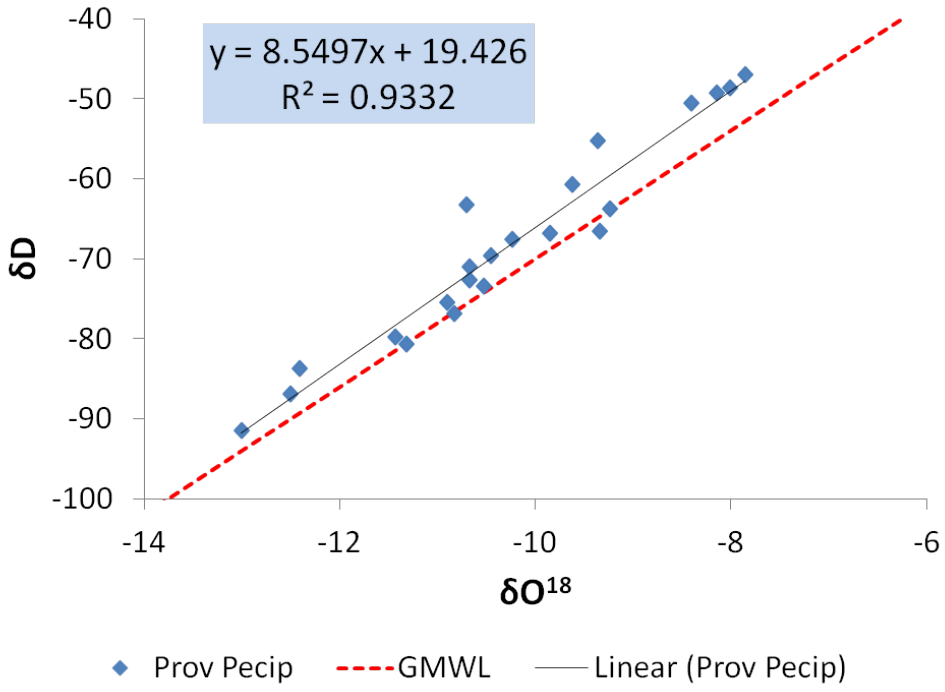

Figure 9—Providence Creek snow and precipitation samples plotted with a linear regression representing the Local Meteoric Water Line (LMWL). The LMWL has a slope of 8.5 and an intercept of 19.4; this compares to the global meteoric water line (GMWL)—dashed red line—that has a slope of 8 and an intercept of 10.

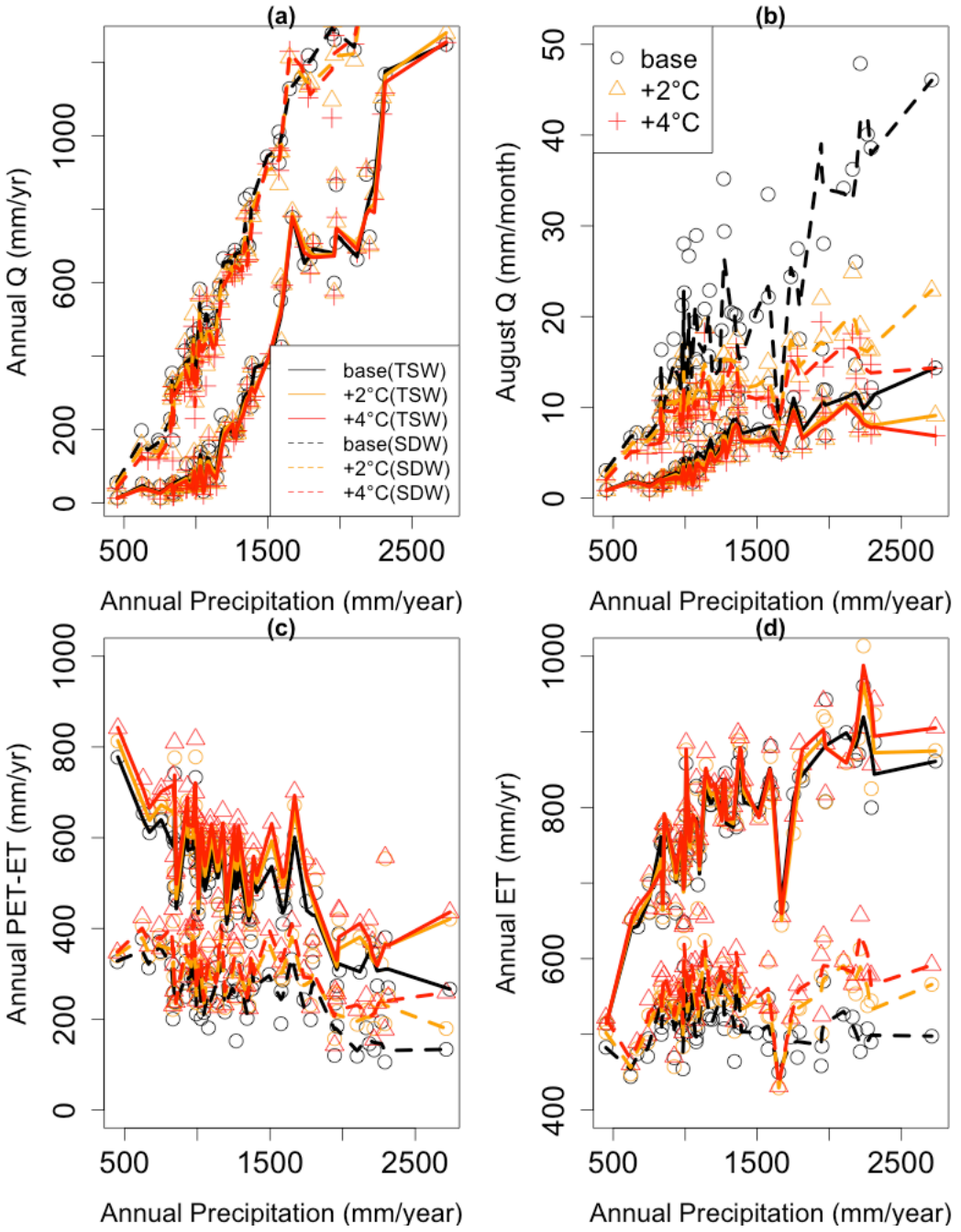

Figure 10—The relationship among annual precipitation, annual streamflow, August streamflow, annual moisture deficit (PET-ET) and annual ET of a transient snow watershed (TSW, P303) and a snow-dominated watershed (SDW, B203) during climate warming scenarios: (a) annual flow, (b) August (summer) flow, (c) annual ET, and annual moisture deficit (PET-ET) and (d) The three lines (black, orange, and red) were created by using LOESS (local polynomial regression fitting algorithm), and the interpolated line is used for only guiding visually the general pattern of model estimates and is not necessarily statistically significant.

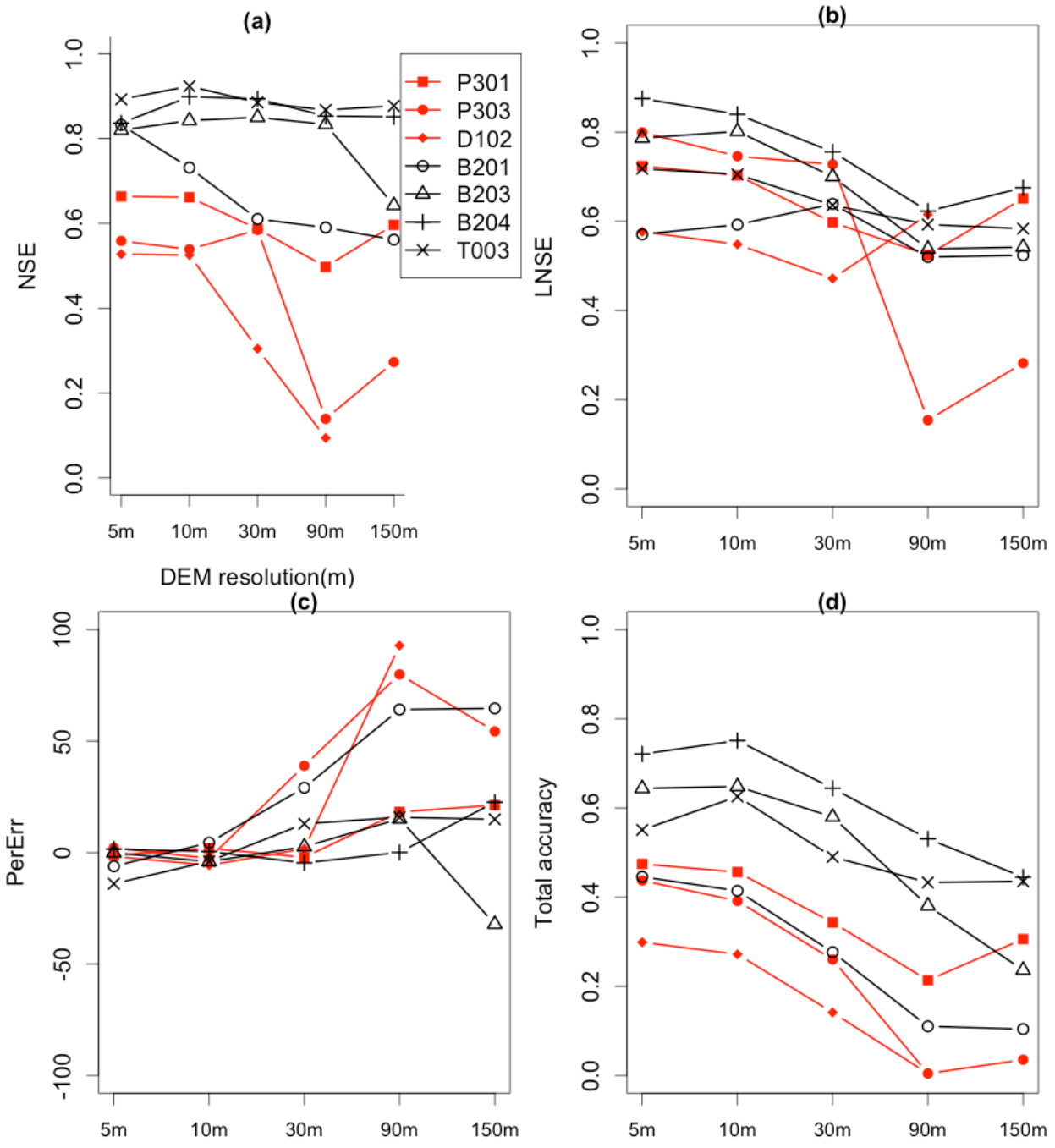

Figure 11—The model performance of streamflow prediction with different DEM resolutions: (a) NSE (Nash-Sutcliffe Efficiency of streamflows), (b) LNSE (Nash-Sutcliffe Efficiency of log-transformed streamflows), (c) PerErr (Percent Error), and (d) Total accuracy measure combing NSE, LNSE and Percent Error.

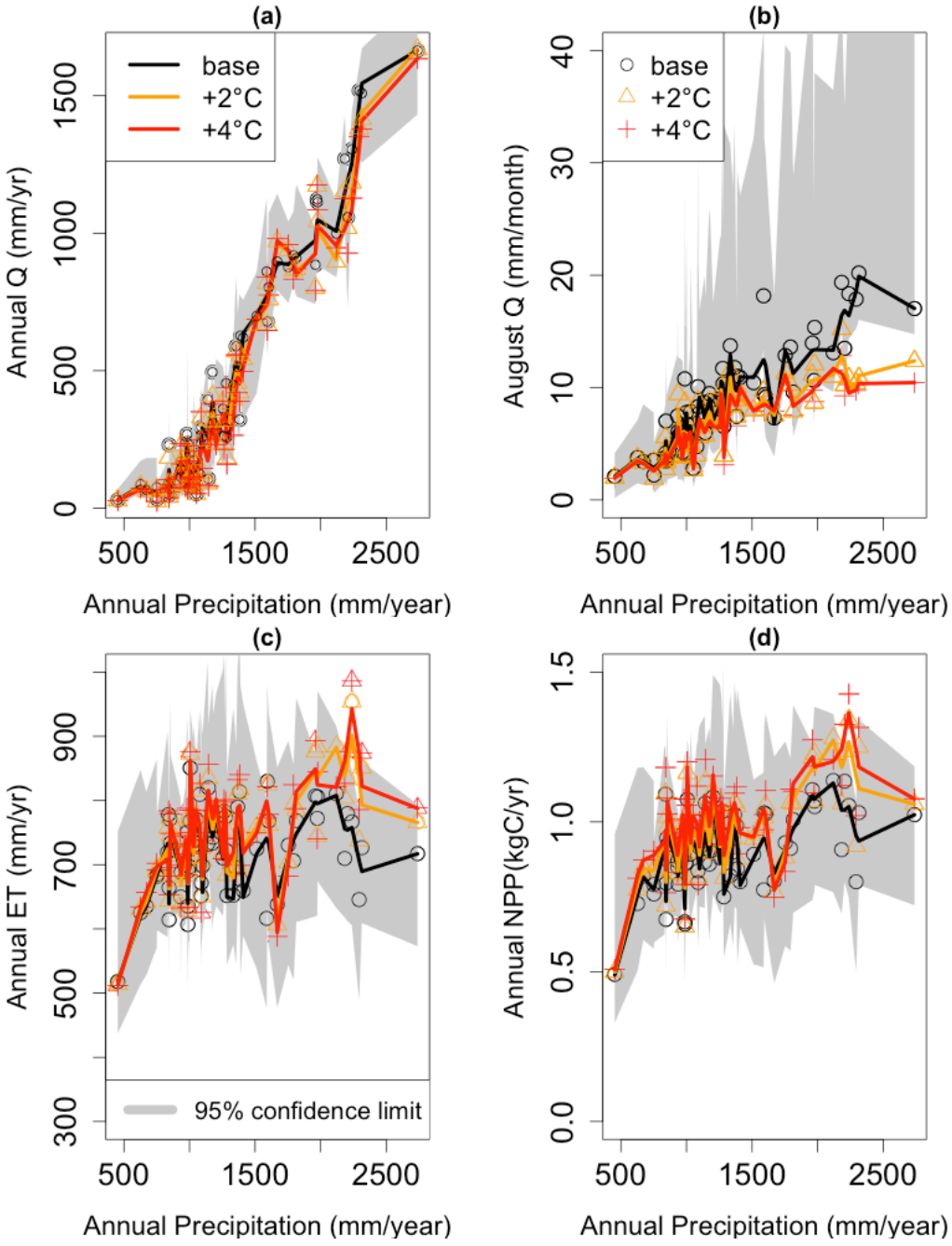

Figure 12—Comparison between climate warming and soil parameter uncertainty effects on ecohydrologic responses in TSW (P301) for: (a) annual streamflow (Q), (b) summer (August) streamflow (Q), (c) annual ET and (d) annul NPP. The three lines (black, orange, and red) were created by using LOESS (local polynomial regression fitting algorithm), and the interpolated line is used for only guiding visually the general pattern of model estimates and is not necessarily statistically significant. Gray shaded area refers to estimated model uncertainty range across behavioral soil parameters.

Year 1 Project Expenditure Summary by Account

Supplement B

CZO-Core/Main					
Budget Element	**Budgeted**	**Current Expenditures**	**Commitments through 9/30/2018**	**Balance**	**Comments**
Participant Costs	**8,000**	**450**	**14,500**	**(6,950)**	Carry negavive balance forward
Cross-Site Modeling Meetings, Seed Funding, PI Meetings					
Subcontracts*	**312,719**	**87,561**	**225,158**	**(0)**	To be expended by end of yr 1; billing can lag expenditures by several months
UC Berkeley, UC Irvine, UC Davis, UC Santa Barbara, Univeristy of Wyoming					
Other Direct Costs	**60,000**	**-**	**-**	**60,000**	Expense deferred to yr 2, pending CZO network planning
Drilling Subcontract					
Indirect Costs	**37,400**	**247**	**7,975**	**29,178**	
Account Total	**418,119**	**88,259**	**247,633**	**82,227**	

**Current Expenditures are from Invoices received.*

CZO-Project Integration and Management					
Budget Element	**Budgeted**	**Current Expenditures**	**Commitments through 9/30/2018**	**Balance**	**Comments**
Senior Personnel	**132,008**	**72,607**	**34,123**	**25,278**	Field engineer left late May; balance to be split between P. Hartsough at UCD & replacement now being recruited
Principal Investigator, Data Manager, Research Engineer, Undergraduate Asst.					
Fringe Benefits	**39,939**	**28,995**	**10,937**	**7**	
Equipment	**57,311**	**15,910**	**-**	**41,401**	To be expended summer 2014
Tower Rebuild, Equipment Replacement					
Domestic Travel	**7,648**	**-**	**2,000**	**5,648**	Vehicle charges being billed; summer travel pending
Travel to Field-Site & Meetings					
Other Direct Costs	**11,700**	**2,949**	**-**	**8,751**	
Supplies, Teleconferences, Battery Replarement, Equipment Calibration, Snowmobile Equipment Costs					Billing of charges in progress; summer expenses pending
Indirect Costs	**105,212**	**57,503**	**25,883**	**21,826**	
Account Total	**353,818**	**177,964**	**72,943**	**102,911**	

CZO-Education and Outreach					
Budget Element	**Budgeted**	**Current Expenditures**	**Commitments through 9/30/2018**	**Balance**	**Comments**
Senior Personnel	**51,792**	**-**	**10,207**	**41,585**	Recruitment in progress for a 1-yr postdoc to synthesize CZO results in a water resources context -- 2 papers
Co-Investigator, Staff					
Fringe Benefits	**16,697**	**-**	**2,435**	**14,262**	
Domestic Travel	**1,600**	**-**	**-**	**1,600**	Billing of charges in progress; summer expenses pending
Travel to Field-Site & Meetings					
Other Direct Costs	**1,600**	**-**	**-**	**1,600**	Billing of charges in progress; summer expenses pending
Supplies, Teleconferences					
Indirect Costs	**39,429**	**-**	**6,953**	**32,476**	
Account Total	**111,118**	**-**	**19,595**	**91,523**	

CZO-Research					
Budget Element	**Budgeted**	**Current Expenditures**	**Commitments through 9/30/2018**	**Balance**	**Comments**
Senior Personnel	**22,639**	**-**	**18,093**	**4,546**	Rebudget to other direct costs for summer 2014
Principal Investigators					
Fringe Benefits	**2,491**	**-**	**2,171**	**320**	
Domestic Travel	**8,800**	**-**	**-**	**8,800**	Billing of charges in progress; summer expenses pending
Travel to Field-Sites & Meetings					
Other Direct Costs	**9,262**	**-**	**-**	**9,262**	Billing of charges in progress; summer expenses pending
Supplies, Teleconferences, Publication Costs					
Indirect Costs	**23,754**	**-**	**11,145**	**12,609**	
Account Total	**66,946**	**-**	**31,410**	**35,536**	

PROJECT TOTALS	**950,001**	**266,223**	**371,581**	**312,197**

Year 2 budget

	Cost Element	Y1 Budgeted	Y1 Expenses as of 6/12/2014	Y1 Commitments thru 9/30/2014	Y1 Projected Balance	Y2 Budgeted	Y2 Budgeted + Carryover	Comments regarding Yr 1 projected balance
Senior Personnel								
A.1	Principal Investigator Bales	25,472	-	15,596	9,876	26,235	36,111	Rebudget to other direct costs for summer 2014
A.2	Co-Investigator Conklin	11,922	-	12,556	(634)	12,280	11,646	
A.3	Co-Investigator Hart	6,489	-	6,617	(128)	6,683	6,555	
A.4	-	-	-	-	-	-	-	
A.5	-	-	-	-	-	-	-	
A.6	-	-	-	-	-	-	-	
A.7	Total Personnel	**43,883**	**-**	**34,769**	**9,114**	**45,198**	**54,312**	
Other Personnel								
B.1	Post-Docs	-	-	-	-	-	-	
B.2	Other Professionals	154,831	72,607	27,655	54,569	175,024	229,593	Field engineer left late May; balance to be split between P. Hartsough at UCD & replacement n
B.3	Graduate Students	-	-	-	-	-	-	Recruitment in progress for a 1-yr postdoc to synthesize CZO results in a water resources conte
B.4	Undergraduate Students	7,725	-	-	7,725	7,957	15,682	Student hirred, but payroll not yet posted
B.5	Clerical	-	-	-	-	-	-	
B.6	Other	-	-	-	-	-	-	
Total Salaries and Wages		**206,439**	**72,607**	**62,424**	**71,408**	**228,179**	**299,587**	
C.	Fringe Benefits	59,126	28,995	15,543	14,588	66,342	80,930	
Total Salaries, Wages, and Fringe		**265,565**	**101,602**	**77,967**	**85,996**	**294,521**	**380,517**	
D.	Equipment Replacement	27,311	15,910	-	11,401	8,000	19,401	To be expended summer 2014
	Tower Rebuild	30,000	-	-	30,000	-	30,000	To be expended summer 2014
Total Equipment		**57,311**	**15,910**	**-**	**41,401**	**8,000**	**49,401**	
E.1	Domestic Travel	18,048	-	2,000	16,048	23,748	39,796	Vehicle charges being billed; summer travel pending
E.2	Foreign Travel	-	-	-	-	-	-	
Total Travel		**18,048**	**-**	**2,000**	**16,048**	**23,748**	**39,796**	
F.1	PS Stipends	-	-	-	-	-	-	
F.2	PS Travel	-	450	9,500	(9,950)	-	(9,950)	
F.3	PS Subsistence	-	-	-	-	-	-	
F.4	PS Other	8,000	-	5,000	3,000	2,000	5,000	
Total Participant Support		**8,000**	**450**	**14,500**	**(6,950)**	**2,000**	**(4,950)**	Carry negative balance forward
G.1	Materials and Supplies	21,362	2,949	-	18,413	21,020	39,433	Billing of charges in progress; summer expenses pending
G.2	Publication Costs	1,200	-	-	1,200	1,200	2,400	Manuscripts in review
G.3	Consultant Svcs	-	-	-	-	-	-	
G.4	Computer Services	-	-	-	-	-	-	
G.5	Subawards	312,719	87,561	225,158	-	461,142	461,142	To be expended by end of yr 1; billing can lag expenditures by several months
G.6	Other (Drilling Subcontract)	60,000	-	-	60,000	-	60,000	Expense deferred to yr 2, pending CZO network planning
Total Direct Costs		**395,281**	**90,510**	**225,158**	**79,613**	**483,362**	**562,975**	
H.	**Total Direct Costs**	**744,205**	**208,472**	**319,625**	**216,108**	**811,631**	**1,027,739**	
I.	**Indirect Costs**	**205,796**	**57,751**	**51,957**	**96,088**	**188,369**	**284,457**	
J.	**Total Direct & Indirect Costs**	**950,001**	**266,223**	**371,582**	**312,196**	**1,000,000**	**1,312,196**	
K.	**Residual Funds**	**-**	**-**	**-**	**-**	**-**		
L.	**Amount of Request**	**950,001**	**266,223**	**371,582**	**312,196**	**1,000,000**	**1,312,196**	

**Expenditure Data as of 6/12/2014*

Supplement C

Supplement C

ow being recruited

xt -- 2 papers